SOIL SURVEY OF THE TOLEDO AREA, OHIO.

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LOCATION AND BOUNDARIES OF THE AREA.

The area surveyed comprises about 403 square miles, and includes parts of the counties of Lucas, Wood, and Ottawa, in Ohio, and of Monroe, in Michigan. The parts of the counties included are

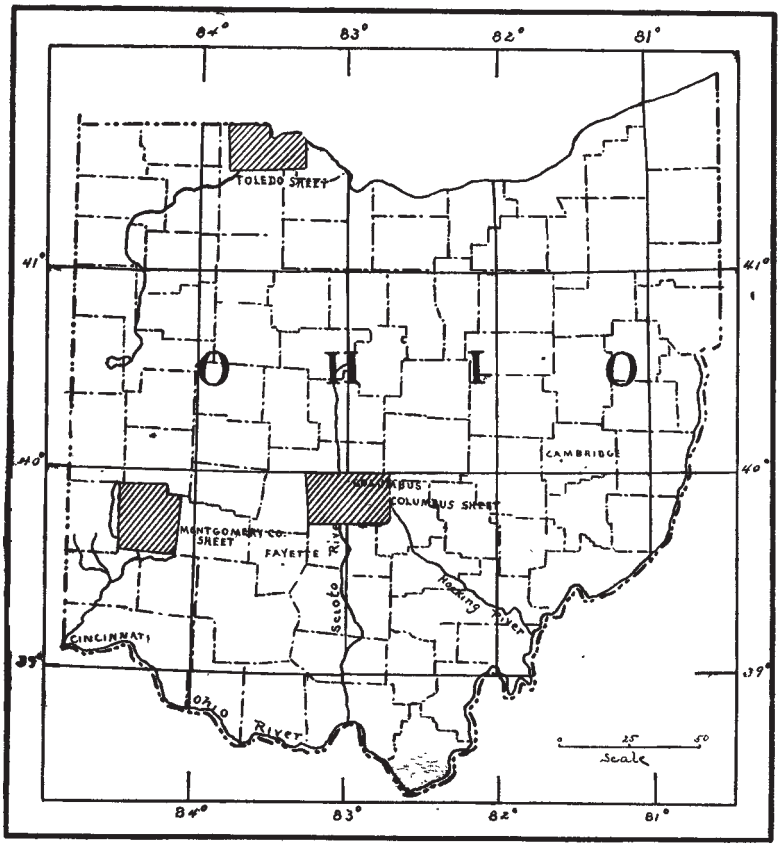

FIG. 10.—Sketch map showing areas surveyed in Ohio.

approximately, the eastern half of Lucas, the northern fourth of Wood, the western third of Ottawa, and about 20 square miles of the southern edge of Monroe. The area is rectangular in form, with a

north and south width of about 17 miles and a length east and west of about 25 miles. The area lies between north parallels 41° 30′ and 41° 45′ and meridians 83° 15′ and 83° 45′ west from Greenwich. (See fig. 10.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The region in which is situated the area covered by the present survey was explored by French missionaries as early 1673, being claimed by France as a result of this exploration. Following the first entrance of the whites into what was a rich possession and a stronghold of the Indians there is a century and a half, during which the sovereignty of the territory passed from France to England, and from England to the United States, and the actual possession of the land from the Indian cultivator to the early pioneers from New England and the other States to the east. Each of these changes was the result of more or less sanguinary struggles. Even after the close of the Revolutionary war, until as late as 1795, England still occupied fortifications at the foot of the rapids on the Maumee River, near the site of the present town of Maumee, making more difficult by her presence the overthrow of the Indians.

General Wayne, in the battle of Fallen Timber, 1794, broke the Indian power and the rich valley of the Maumee was opened to settlement by the whites. Pioneers from New England, Pennsylvania, and Virginia were the first to come. They first located, within the area surveyed, in the vicinity of Maumee, laid out as a village in 1817. They brought their cattle, implements, and methods with them, but because of the distance to markets and the lack of communication the early agriculture was almost as primitive as that of the Indians, and was supplemented by hunting and fishing.

In these early days it was useless to produce except for home consumption, and prices of all commodities were ridiculously low. Burkett, in his History of Ohio Agriculture, gives the prices of agricultural products between 1800 and 1820. The price of wheat fell as low as 25 cents a bushel; corn brought 12 to 15 cents; oats, 10 cents; potatoes, 10 to 12 cents; while the price of a good cow was only $6 or $8, and of a horse from $24 to $40.

If there is one thing connected with the agricultural development of the area brought out in the first half century of growth more clearly than another it is the fact of its utter dependence upon means of communication. With each improvement in the roads, the extension of the national turnpike, the building of canals, and later the laying of the railroads the industry is seen to receive new impetus. Thus during the period from 1826 to 1836, marked by the extension of the national road from Cumberland, Md., to Wheeling, W. Va., and then to Columbus, Ohio, there was a large increase in the rate of immigration, the settlers taking up 80 to 160 acre tracts by purchase from the

Government. The completion of the Erie Canal to Buffalo, giving water connection with Albany and the East, and of the Wabash and Erie from Cincinnati to Toledo, were also very effective factors in increasing the prices of farm products and stimulating production.

The agriculture of the area has passed through many different phases. At one time the growing of grain for shipment has been the most prominent, at another the fattening of cattle for market, at another dairying, especially as connected with the manufacture of butter and cheese. As early as 1803—in the early part of which year Ohio was admitted to the Union as a State—it was known as a cattle-raising section, and the interest in all forms of animal industry has always been keen. As a result many notable improvements in live stock have been made in the State, in some of which the area surveyed has assisted more or less directly.

Dairying, which is now the paramount interest of the area, has always held a place in the husbandry from the days of the first settlers who led their cows in from far-away New England. The earliest dairying, in a sense comparable to the industry as existing to-day, probably began about 1848, although home-made cheese was sold in Southern markets as early as 1820, bringing 25 or 30 cents per pound. It is only within the last decade that the highest stage of the industry has been reached. Now finely equipped cooperative factories dot the area, while large herds of high-bred dairy cattle are seen on every hand.

The sheep industry has also played an important part in the development of the area. At present the sheep raised are mainly mutton breeds, usually Shropshire, Southdown, and Cotswold grades. In 1860 fully 90 per cent of the sheep were of the fine-wooled Merino breed, first introduced into Ohio in 1801. The change from a wool to a mutton sheep began about 1872, and is due to low prices of wool prevailing at and since that time. The Merino sheep were largely sold to Western ranchers.

Many hogs are raised in the area. These are usually well bred and of Poland China or Chester White blood. The former breed was originated in Ohio.

The area has had its periods of depression, perhaps the greatest and most persistent of which has been the result of competition with the newer West, but it seems at present as if this danger had passed, and that a permanent readjustment between this area and the region of which it is a part and the country east and west had been reached. At least the agricultural industries prosper, and the agriculturists as a rule are contented.

CLIMATE.

The following table, compiled from records of the Weather Bureau, gives the normal monthly and annual temperature and precipitation at three stations situated in or near the area surveyed:

Normal monthly and annual temperature and precipitation.

Month.	Temperature.			Precipitation.		
	Toledo.	Napoleon.	Rocky-ridge.	Toledo.	Napoleon.	Rocky-ridge.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*
January	25.7	25.7	25.2	1.97	2.19	2.40
February	26.9	24.7	26.8	2.07	1.62	1.53
March	35.8	37.9	35.8	2.20	3.06	2.84
April	48.2	48.9	49.5	2.22	2.82	2.56
May	59.2	61.2	62.2	3.34	3.16	2.48
June	69.1	70.7	70.1	3.13	2.72	2.64
July	72.5	73.0	72.3	3.17	3.76	2.99
August	71.4	70.8	72.2	2.63	1.46	2.35
September	64.0	64.5	66.4	2.28	2.41	2.95
October	53.1	51.6	53.3	2.27	1.97	2.01
November	39.6	38.6	40.4	2.80	2.95	3.96
December	29.5	30.7	30.5	2.28	2.73	2.56
Year	49.9	49.8	50.4	30.36	30.85	31.27

The figures show little difference in the records of these stations, and it is safe to conclude that conditions are comparatively uniform throughout the area, excepting the probability—no records are available to substantiate it definitely—that the rainfall is somewhat heavier and that there is greater immunity from frosts in the vicinity of the lake.

The area surveyed is situated outside of the usual path of the general storm centers, which almost invariably pass to the north or south. For this reason destructive wind storms are less frequent here, and the rainfall is not quite as heavy as in the northern and southern part of the State.

From one-third to one-half the rainfall in each of the summer months comes in one rainfall, the remainder in scattered showers of from 1 to one-half inch or less. Soil moisture experiments have shown that one-half inch or less of rainfall does not moisten the soil sufficiently to benefit crops, but that on the other hand it may even cause the drying of the soil by putting the surface in a condition which favors the rapid upward capillary movement of the ground water, resulting in a greater loss of the reserve soil water by evaporation than would have taken place had no shower fallen. It is interesting to note that the greater part of the precipitation occurs in a manner that favors the absorption of a large part of it by the soil and its conservation for crop uses. These rains are usually sufficient for the heavier soils, but sometimes the lighter, sandier soils suffer from drought toward the

latter part of the season. Usually there is moisture enough to ripen fruits and the small grains and corn, but sometimes the soil is too dry for the proper germination of the fall-seeded grain.

The lowest recorded temperature is −16° F. and the highest 99° F. The usual range in temperature for winter is from zero to about 50° F., and for summer from 55° F. to 95° F. The annual relative humidity averages 70.8 per cent, the winter average being 75 per cent and the summer average 69 per cent. A relative humidity as low as 18 per cent has been recorded, but the minimum is normally about 40 per cent. July and August are the hottest months. The winter season covers the months of December, January, and February, during which the soil is frozen to the depth of from 4 to 8 inches and ice from 6 inches to 1 foot in thickness forms on the lake and streams. The snowfall is usually light in the early winter, while by February the weather is so far moderated that snow does not remain on the ground long at a time. The lack of snow covering is sometimes damaging to winter grain.

Injury from frosts occur here, but not to the extent reported elsewhere. The earliest killing frost in fall usually occurs the first week in October, and the last in spring during April, though there is on record such a frost occurring June 6. Usually the danger of killing frosts in spring is passed by the middle of April.

The percentage of sunshine during the winter and early spring ranges from 30 to 50 per cent, while during the summer months it ranges from 65 to 70 per cent.

PHYSIOGRAPHY AND GEOLOGY.

The area surveyed is a rather level plain, lying from 580 to 700 feet above sea level. It is intersected by many narrow streams, the largest of which is the Maumee River. The latter has eroded its channel in places to a depth of possibly 60 feet, while the smaller streams have cut their courses from 10 to 40 feet below the general level of the plain.

The sides of the stream valleys are usually abrupt and not far removed from the present stream beds. Narrow but quite well defined first and second terraces, lying from 5 to 20 feet above the water level, occur along the Maumee River, and here and there along the smaller streams.

The area of clay soil which occupies largely the eastern part of the area surveyed and the area lying adjacent to and west of the Maumee River are more regular and more level than the lighter, sandier soils along the Maumee River. The surface there is undulating, the ridges ranging from 5 to 20 feet in height. Sometimes these undulations are fashioned into quite prominent knolls and ridges, and sometimes they are entirely absent, giving place to extensive low-lying areas of

sand. Throughout the area occasional swampy depressions occur, but these are rapidly being added to the cultivated area through reclamation by drainage, and so are losing their importance as a physiographic feature.

Geologically the area consists of a sheet of glacial material, somewhat modified, having a thickness ranging from 10 to 180 feet, and resting on a limestone formation. A general section of this material beginning at the bottom, shows the following stratification:

1. Bowlder clay, laid down during the glacial phase of the Glacial epoch, consisting of moraines and other deposits of clay mixed with bowlders.

2. Erie clay, which is a mottled bluish to grayish clay laid down during the iceberg phase of the Glacial epoch, during which time the greater part of the area was submerged to a depth of about 180 feet.

3. The lacustrine clays and beach sands, generally yellowish in color, which were laid down at the close of the iceberg period.

The Erie and lacustrine clays have weathered into a friable clay loam, which forms the basis of the extensive and important soil type described in this report as Miami black clay loam. The lacustrine clays are well adapted to brick and tile making, for which purpose they are extensively used. The lacustrine sands and mixtures of sands and clays form the basis of the two soil types described respectively as the Miami sand and the Miami sandy loam. No very pronounced exposures of bowlder clay were found in the area, and consequently this material does not figure to a great extent in the formation of any of the soil types.

The underlying hydraulic and carboniferous limestone crops out as narrow ridges and knobs in the northwestern and southern parts of the area—notably west and northeast of Sylvania and near Rockyridge. Usually the soil in the vicinity of the outcrops is stony, and such areas are indicated on the soil map by symbol. Where convenient to the surface the limestone is quarried for road ballast and building purposes and for the manufacture of lime. Owing to the presence of silica and magnesia some of the rock is unfit for lime burning, nor is it good for building purposes, because of its rapid crumbling upon exposure to the weather. In places this limestone bed is 300 feet thick.

Below the limestone is a brown shale, and below this occurs an oil-bearing stratum of sand which lies at a depth of from 800 to 1,200 feet or more below the surface. The economic importance of this oil-bearing stratum, which seems to underlie a large part of the area, is too well known to need more than a mere mention. Probably 400 wells are sunk into this sand, and others are constantly being driven.

SOILS.

Five soil types occur in the Toledo area, all of which have been found in earlier surveys—the Miami black clay loam, Miami clay loam, Miami loam, Miami sand, and Miami sandy loam. The following table gives the extent of the several types in the Toledo area:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami black clay loam	165,056	63.95	Miami loam	5,504	2.13
Miami sand	36,672	14.21	Total	258,112	.....
Miami sandy loam	20,352	11.83			
Miami clay loam	20,352	7.88			

MIAMI BLACK CLAY LOAM.

The Miami black clay loam is one of the most extensive soils of the area. It consists of from 4 to 8 inches of a friable dark-colored clay loam, underlain by a mottled yellow clay. Nearly the whole of the area east of the Maumee River consists of Miami black clay loam, while about one-third of the area west of the river is also of this type, making in all about 258 square miles, or nearly 64 per cent of the area surveyed. The surface is an almost level plain, varied only by narrow stream valleys and slight undulations rising from a few inches to 3 or 4 feet above the general level. In the depressions the soil is stained a darker color, and the color extends to a greater depth, because of the swampy conditions that once prevailed there. In such situations, also, the texture inclines more toward a loam, though the admixture of sand is not generally sufficient to warrant the establishing of a separate type. The amount of organic matter also varies considerably, being greatest in the areas more recently under water, and but recently converted to the use of agriculture by thorough drainage. This organic matter has been derived from the decay of the rank aquatic vegetation and the dropping foliage of the hard-wood forests that formerly throve in these more or less swampy spots.

The Miami black clay loam, no matter what the variation, must be thoroughly drained before it will admit of profitable cultivation. Large open ditches from 6 to 8 feet deep are dug along the roads or natural drainage depressions. These lead into some of the many streams that intersect the area, and serve as outlets for the network of tile drains running through the fields. Nearly the whole of this type is thus ditched and tiled.

The Miami black clay loam is derived from the weathering of glacial clay—a modified glacial drift material—under more or less swampy conditions, during which process often large amounts of vegetable remains were thoroughly mingled with the mineral particles. The

color and fertility of this soil type is due in large part to this organic matter.

The range of moisture conditions under which this soil may betilled is remarkably wide for a clay soil. The surface, from 4 to 8 inches, seems to be made up of granular aggregations of clay, giving to the soil a loamy character that is not apparently warranted by its texture, as shown in mechanical analysis. In general the soil scours well on the moldboard and implements under normal moisture conditions. The subsoil is quite sticky and impervious to water, but upon thorough drainage it, too, becomes more friable. When turned up by the plow and exposed to weathering for some time, it crumbles into cubical aggregations about the size of buckshot, suggesting the "buckshot" clays of the Mississippi River alluvium. The large percentage of lime, together with the organic matter in the soil, probably helps to produce its unusually friable texture, as compared with other soils of high clay content.

This is the typical corn and grass land of the area, and it is used for wheat, though this and other small grain crops are apt to lodge where the soil is blackest and richest. (See Pl. XXII.) It is also well adapted to raising beef cattle and dairying. Considerable truck is grown; and of such crops onions are perhaps the leading product, thriving particularly well on the heavier darker colored areas of the soil. The yield of wheat ranges from 15 to 25 bushels per acre. Oats yield from 30 to 60 bushels per acre, and corn gives from 40 to 140 bushels, with an average of possibly 55 bushels per acre. Large yields of potatoes are secured, ranging between 100 and 500 bushels per acre, but the quality of the product of this soil is said to be much inferior to that of the lighter soils. The potatoes are apt to be watery and to rot more readily than those grown on the sandy soils. Some sugar beets are grown. Peaches and small fruits, such as currants, raspberries, and strawberries, seem to thrive on this type. Plums and apples also seem to do well, but not quite as well as peaches. The areas of heavier soil, where the content of organic matter is highest, would doubtless prove excellent for celery.

The size of the farms on the Miami black clay loam ranges from 40 to 140 acres, and the fields, fences, and farm buildings generally present a tidy appearance, indicative of thrift and prosperity. Almost all the type is under improvement of some kind, what is not tilled usually supporting groves of maple, oak, and elm. Such reserves are usually husbanded with a view to maintaining the supply of forest products from year to year.

The following table gives the texture of the soil and subsoil of this type, as determined by a series of mechanical analyses of typical samples secured in different parts of the area:

Mechanical analyses of Miami black clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7149	4 miles SE. of Perrysburg.	Dark clay loam, 0 to 8 inches.	8.03	0.64	2.64	3.54	14.68	12.44	36.26	29.04
7153	2 miles W. of Yondota.	Dark clay loam, 0 to 10 inches.	5.14	.24	2.76	2.46	6.60	6.00	47.10	34.54
7150	Subsoil of 7149.....	Mottled bluish-yellow clay, 8 to 36 inches.	1.55	.68	2.70	2.80	8.96	9.90	35.64	39.18
7154	Subsoil of 7153.....	Mottled yellow clay, 10 to 36 inches.	.72	.14	.64	.64	2.38	5.44	49.70	41.08
7152	½ mile N. of Bono ..	Mottled yellow clay, 12 to 36 inches.	1.29	.04	.48	.30	1.08	4.06	37.98	55.12

MIAMI CLAY LOAM.

The Miami clay loam consists of from 6 to 10 inches of light-yellow loam, underlain by a mottled-yellow clay. The lighter, friable texture of the top soil is due both to the effects of weathering and to the leaching away of the finer clay particles. There is some variation in texture of the soil, which is heavier in the flatter areas where drainage is less effective.

The area of Miami clay loam found in the present survey is about 8 per cent of the total area surveyed. In the Montgomery County and Columbus areas, also in this State, this is the most extensive soil type, forming between 70 and 80 per cent of the land surface. In the Toledo area the soil occurs as knolls and ridges in the Miami black clay loam areas and also in well-drained places bordering the Maumee River and the smaller streams.

The surface of the Miami clay loam is sometimes flat, but usually it is sufficiently rolling to be naturally well drained. The type is derived through the weathering of the yellow glacial clay, which is believed to have been laid down at the close of the lake stage of glaciation. The subsoil probably represents approximately the original character of the clay, and the top soil was at first identical in texture with this. The differences existing between soil and subsoil as found to-day are the result of chemical and mechanical changes, the addition of some organic matter, and the removal of some of the original constituents by the leaching and washing effects of rain water.

This soil is well adapted to general farm crops, especially to corn, wheat, oats, and the grasses. It also makes good pasture land, and is therefore a good soil for dairying. Fruit can be successfully pro-

duced on this type. The texture of the soil is somewhat heavy and sticky, and cultivation is often difficult, but this is fully compensated for by the fact that with proper management a higher degree of fertility can be maintained than is possible in soils of lighter and more open texture.

The following table shows the texture of this soil type:

Mechanical analyses of Miami clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6542	5 miles SW. of Toledo.	Friable clay loam, 0 to 8 inches.	1.99	0.13	1.65	9.05	17.30	5.29	38.20	26.50
7163	3 miles N. of Stonyridge.	Dark clay loam, 0 to 8 inches.	5.84	.50	2.78	2.78	9.76	10.24	46.56	26.76
7161	3¼ miles NE. of Maumee.	Dark-yellow loam, 0 to 10 inches.	2.33	.24	1.10	1.10	4.00	7.62	52.42	32.62
6543	Subsoil of 6542.....	Mottled yellow clay, 8 to 30 inches.	.55	.00	1.39	6.92	14.12	5.99	42.20	29.58
7164	Subsoil of 7163.....	Yellow clay, 8 to 36 inches.	.84	.74	2.70	2.14	7.60	9.20	42.06	34.82
7162	Subsoil of 7161.....	Mottled yellow clay, 10 to 36 inches.	.93	Tr.	.78	.74	2.60	4.90	44.16	45.48

MIAMI SANDY LOAM.

The Miami sandy loam consists of from 8 to 20 inches of sandy loam underlain by a mottled yellow clay that is in some cases very sticky and free from sand and in other cases quite sandy. In texture it is intermediate between the heavy clay and yellow beach sands which figure respectively in the Miami black clay loam and the Miami sand, between areas of which it is usually found. The local variations are often quite wide. Adjacent to the Miami black clay loam the soil consists of about 8 inches of fine sandy loam, often dark in color, which grades rapidly into a heavy mottled clay subsoil, while bordering the Miami sand it consists of from 20 to 30 inches of yellow sandy soil, medium to coarse in texture, passing sometimes into a rather loose sandy clay substratum and sometimes into a stiff mottled clay.

The Miami sandy loam generally has a higher elevation than the Miami black clay loam or the Miami clay loam. The surface, which is rolling, is somewhat rougher than that of the latter types. The elevation ranges from 600 to 700 feet above the sea, usually being about 620 feet. The undulations rise in easy slopes from 5 to 10 feet above the general level. The soil on the knolls and ridges is usually lighter in color and sandier in texture than the soil in the depressions.

This type possesses fair natural drainage, because of its undulating surface and the presence of many small streams and draws. Artificial drainage, however, is resorted to in order to insure good tilth for the depressions.

This soil is derived from the weathering of the glacial clay and beach sand. The glacial clay, which is mottled in appearance, enters principally into the subsoil, while a mixture of the beach sand and clay forms the surface soil of the type.

Because of its sandy nature, this soil plows readily and is tillable under a wide range of moisture conditions. Grain, grass, corn, and truck are grown with success, the type as a whole being best adapted to corn and truck. Owing to prolonged droughts that not infrequently occur in this type, the grass and small grains suffer. Especially in a dry, open winter, wheat is often injured to even a greater extent than it is on the heavier soil. The yield of wheat ranges from 10 to 25 bushels, and averages about 18 bushels per acre. Oats range from 20 to 50 bushels per acre and corn from 35 to 70 bushels per acre. Strawberries and other small fruits, apples, plums, and peaches also do quite well. The quality of the crops grown is generally quite good. The potatoes especially are superior to those produced on the heavier soils, being more mealy and of better keeping quality.

The farms range in size about the same as those noted on the Miami clay loam, namely, from 40 to 140 acres, and by the general appearance of the fields, fences, and buildings the thrift and prosperity of the farmers is not less than on that type.

The following table gives mechanical analyses of this soil:

Mechanical analyses of Miami sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7145	2½ miles W. of Toledo.	Dark sandy loam, 0 to 12 inches.	2.31	0.10	0.72	3.10	28.38	18.20	40.98	8.40
7147	6 miles N. of Maumee.	Black sandy loam, 0 to 8 inches.	4.89	.22	.66	2.18	34.16	25.74	26.98	10.06
7146	Subsoil of 7145.....	Sandy clay, 12 to 36 inches.	.66	.02	.60	1.18	10.90	15.98	58.50	12.56
7148	Subsoil of 7147.....	Dark bluish clay, 8 to 36 inches.	1.08	.44	1.26	2.80	33.16	22.90	25.64	13.76

MIAMI SAND.

The Miami sand consists of 3 feet of yellowish sand resting on a substratum of the same texture with a thickness of from 8 to 20 or more

feet. The sand is of medium grade and contains very little clay, except sometimes in the depressions or in areas adjoining some of the heavier soils. On the whole the soil is characterized by a loose, sandy texture. It is easily tilled and is workable in all kinds of weather. Occasionally at from 3 to 8 feet below the surface the sand rests on a substratum of clean white quicksand. Over such areas fruit trees or other plants that root deeply do not seem to grow well.

The Miami sand is found principally in the western part of the area. It extends in an area 4 or 5 miles wide parallel to the Maumee River, from which it is about 3 miles distant. This type ranges in elevation from 600 to 700 feet above the level of the sea, its average elevation being slightly greater than that of the other types. Its surface is also marked by greater depressions and elevations, consisting of knolls and ridges from 10 to 30 feet above the general level, with expanses of lowland between them. In some cases these flat areas are quite extensive, possessing occasionally a swampy character until artificially drained. Owing to the undulations, the open texture of the soil, and the presence of streams, this soil is in the main naturally well drained. The flatter areas are frequently drained, but artificial drainage has not been employed to so great an extent as in the other soil types, and there are large areas of swampy lands yet in virgin forest. Such areas when drained are the most productive of the type because of the large amount of organic matter mixed with the sand.

The Miami sand is derived from the beach sand laid down at the close of the iceberg stage of the Glacial epoch. The sand is thought to mark an ancient shore line of Lake Erie.

Grass, corn, wheat, truck, and fruit are grown on this soil. The quality of these is good and in some cases better than the produce grown on the other soils of the area, but the yield is usually from 15 to 30 per cent less, and crops sometimes are cut short or fail because of the susceptibility of this soil to drought. The yield of wheat ranges from 10 to 20 bushels per acre, and of corn from 20 to 45 bushels per acre. Grass and winter grain do only moderately well, being subject to winter killing if the season be open and dry. This soil yields from 75 to 120 bushels per acre of an excellent quality of potatoes. The Miami sand is the typical truck soil of the area. Of the fruits, apples, plums, and strawberries seem best adapted to it.

The very deep sandy areas are not much tilled, but are left in their native growth of scrub oak. Such lands are called "oak openings." A great quantity of stable manure would be required to make these areas productive. Quite a number of thrifty-looking farms are found on the lower-lying and heavier phases of this type, but on the other lands the improvements are less substantial and not in as good repair. The lighter soil brings from $5 to $20 per acre, while the heavier soil, similarly situated, brings from $30 to $100 per acre.

The following table of mechanical analyses shows the texture of soil and subsoil of this type:

Mechanical analyses of Miami sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7143	3 miles W. of Toledo.	Dark sand, 0 to 12 inches.	2.53	0.20	1.64	7.08	37.66	33.54	15.60	2.54
7141	3 miles S. of Sylvania.	Dark-yellow sandy soil, 0 to 8 inches.	3.38	.64	8.50	24.74	51.34	5.50	5.64	3.46
6544	5 miles W. of Toledo.	Brown sand, 0 to 36 inches.	.93	.10	3.74	20.15	51.00	15.92	5.45	3.59
7142	Subsoil of 7141.....	Yellow sand, 8 to 36 inches.	.70	.50	9.18	26.74	53.70	4.62	1.70	2.38
7144	Subsoil of 7143.....	Yellow sand, 12 to 36 inches.	.57	.00	1.36	6.20	37.98	37.60	11.90	4.78

MIAMI LOAM.

The Miami loam is a black loam with an average depth of 12 inches, underlain by a subsoil slightly heavier in texture. There are some local variations in character, the soil being slightly more sandy on the elevations and more clayey in the depressions. Occasionally small areas contain rounded gravel and more angular rock fragments. This soil type occupies the stream bottoms. Along the Maumee River it is found on two distinct terraces, the lower between 2 and 8 feet and the higher between 10 and 20 feet above water level. Along the other streams the terraces are less distinct. They are usually quite narrow, the widest, occurring along the Maumee River, being about one-third of a mile wide.

The surface of this soil is generally flat, but with sufficient undulation to give good natural drainage. Artificial drainage is rarely resorted to.

Geologically this type is the youngest in the area. It is derived from the glacial drift, modified by stream action occurring during its transportation and redeposition in the formation of the terraces.

The Miami loam is one of the more fertile soils of the area. Some of the fields, tilled for more than half a century and only moderately manured, still produce abundantly. Corn and other grains, truck, and fruit thrive on this soil, the last especially on the higher terraces. Corn yields from 40 to 100 bushels per acre, with the average production probably about 75 bushels, and wheat from 20 to 35 bushels per acre. The fields usually appear well kept and productive. Except on

the higher terrace, farm buildings are not found on this soil. They are usually situated on the adjacent higher and drier uplands.

The following table of mechanical analyses of typical samples of the Miami loam shows the texture of this soil:

Mechanical analyses of Miami loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7157	2¼ miles W. of Toledo	Dark sandy loam, 0 to 10 inches.	2.91	Tr.	0.64	1.24	21.64	27.14	39.92	9.28
7159	Perrysburg	Dark-brown loam, 0 to 12 inches.	4.95	0.60	3.50	5.08	20.64	18.96	36.24	15.06
7158	Subsoil of 7157.....	Dark-brown clay loam, 10 to 36 inches.	1.56	Tr.	.64	1.06	17.18	27.64	41.26	12.24
7160	Subsoil of 7159.....	Reddish-brown loam, 12 to 36 inches.	1.90	.64	6.22	8.24	22.60	19.20	27.06	15.78

DRAINAGE.

Ohio has a comprehensive drainage law. It is incorporated in the organic law of the State, and has been held constitutional by the supreme court on the ground that drainage promotes the "public health, convenience, and welfare." The law permits the construction of a drain through property not especially needing drainage, and against the wishes of the owner, in order to permit the drainage of lands beyond which may be in just need of drainage. Provision is made for the payment of damages to the owners of lands not benefited and for the assessment of the cost of construction against lands benefited. A drain is procured on the petition of citizens, secured by bond sufficient to pay preliminary expenses, which is addressed to the township officer, in case the drain lies wholly within the township, or to the county commissioners if it pass through two or more townships. The survey and construction of the drain and the prosecution and defense of any legal issues involved are all attended to by the State.

The drains usually consist of an open ditch 2 feet wide at the bottom with sides sloping at an angle of 40 degrees. The average depth is estimated as about 4 feet, the depth ranging from 3 feet to 8 or 10 feet The average cost of excavation is about 7 cents per cubic yard of earth moved and the cost per mile on this basis amounts to about $450.

The drains are dug by contractors, or by the farmers themselves in

lieu of payment of assessment. The owner of land through which the drain passes is always given the opportunity to dig the ditch himself if he so desires. The fact that many farmers take advantage of this opportunity is the reason for the small rate per cubic yard for excavation.

The shallower ditches, those not exceeding 2 or 3 feet in depth, are sometimes dug with ditching plows, which have been found to be economical. A ditch dredging machine, the invention of a Toledo man, is used for digging tile drains. It is said to save one-fifth the expense of hand work.

The large open ditches in the flat black clay (Miami black clay loam) areas usually run alongside the public roads. As the roads within the limit of this survey generally run on section lines, and most of them have drainage ditches by their sides, some idea of the extent of these public drains may be formed. Into these open ditches the tile drains from the adjacent fields empty. In the Miami black clay loam areas the tile drains are placed at intervals of about 100 feet. The tiles used in these lateral drains are usually 3 or 4 inches in diameter, but when branches or laterals are extended from these outlet drains, the size of the tile in the main drain varies from 5 to 8 inches in diameter.

The cost of tile, which is made at local factories from the mottled clay underlying the greater part of the area,[a] is from 20 to 50 cents per rod for 3 to 6 inch tile, while the cost of laying the tile is about as much more, making the total cost of the tile laid in the land range from 40 cents to $1 per rod. The tile is laid at depths varying from 18 to 30 inches. In all the drains and ditches the fall is about one-tenth of a foot per 100 feet. The soil in the area most in need of draining is the Miami black clay loam, while all of the types are benefited to a greater or less extent. Before drainage but very little of the Miami black clay loam could be cultivated because of the water that stood over it nearly the whole summer through. This type comprises much of the area referred to as the "Black Swamp" in some of the earlier agricultural reports of the State. Since it has been drained nearly all of it is under cultivation and its value has risen until the asking price ranges between $60 and $100 per acre. It is rarely that tax sales of this soil occur. The Miami clay loam and Miami sandy loam are also tiled to a considerable extent, especially where the areas lie in depressions, and much better crops are grown in such areas. It is estimated that the increase in yield and improvement in quality due to drainage of the soils has resulted in an increase of from 10 to 30 per cent in the value of the crops, while the Miami black clay loam, producing practically nothing

[a] For further discussion of the manufacture of tile, as well as some notes on the history of tiling and benefits arising from tile draining, see Columbus area this report, p. 418.

until drained, is now the most fertile and most productive soil in the area. (See Pls. XXI and XXIII.) The black, sandy, and sometimes swampy depressions in the Miami sand are also drained with much benefit to crops. The Miami loam, occurring as it does along the streams as terraces, as has been said, has good natural drainage and is rarely drained artificially.

Experience in drainage in this area shows the following benefits arising from thoroughly tiling and ditching the soils: The quicker warming of the soil in the spring, the better and more uniform distribution of soil water at all times, as well as the carrying off of the excess of water, the better yield and quality of crops, the greater certainty of the crops, the increased value of the land, and the better health of the community.

AGRICULTURAL CONDITIONS.

The farmers of the Toledo area are prosperous. During the last four years there has been a constant improvement in the conditions. Mortgages are being reduced, and permanent improvements—new houses, barns, and fences—are being made throughout the area.

The greater number of the farms in the Toledo area are tilled by the owners, but there are also a large number rented. According to the Twelfth Census of the United States, 72.5 of the Ohio farmers own their farms, 8.7 pay a money rental, and 18.8 farm on shares. These figures are thought to represent with fair accuracy the condition in the Toledo area. Some of the rented farms of the area are owned by well-to-do, retired farmers, while others are the property of bankers and money lenders who have come into possession through mortgage foreclosure. Such foreclosures were all too common a few years ago, during the period of low prices and general commercial depression, but with the better times of the last four or five years sales to satisfy mortgages have been comparatively rare.

The size of the farms ranges from 20 acres, or even less near the towns and cities, to 150 acres farther away—30, 40, 50, and 80 acre farms being the sizes more commonly met with in this area. The valuation per acre ranges from $200 near Toledo and the smaller towns down to $30 in places more removed. Some land is held at as low as $8 per acre, but such cases are the exception and the result of both poverty of soil and disadvantages of location and topography.

The houses are usually plain, frame buildings worth from $500 to $3,000, with an average value ranging perhaps between $1,000 and $1,500. The barns have about the same range in value, with the average value possibly a little less. The old worm rail fences are gradually giving way to wire fences of different kinds.

The condition of the area with respect to labor is fair, but at times, especially during the harvest season, labor is scarce. The hired hands are made up in part of farmers' sons and in part of transients obtained

in the cities and towns. Wages average from $16 to $18 per month with board. Day labor is paid during the rush of harvest from $1.25 to $1.75. The farm laborer is generally an intelligent man and the quality of service is above the average, taking the country at large. The farmers are largely of German, English, and Irish extraction, and the laborer, also, is usually of some one or a mixture of these nationalities.

One or two decades ago much attention was devoted to the growing of wheat and other grains for shipment. Recently this has been changed, largely to the growing of crops of this character—grain, grass, corn, etc.—for home consumption, converting them into more condensed products, such, for instance, as butter, cheese, and beef. It will be seen that all these products are of a character to give a substantial revenue without taking away from the farm much, if any, of the fertility of the soil. It is asserted by some, identified many years with the dairy business, that the farmers of this section are 20 per cent better off than they were before the dairy industry had been so generally introduced. This is not only because of the direct profit to be made in the sale of milk, butter, and cheese, but also because of the increase in the fertility of the soils managed under the dairy system. Much of the fertility lost under the earlier system of hay and grain farming has been restored on these dairy farms, and that without the aid of artificial fertilizers, which are very little used in the area, except by truck farmers. The rotation commonly practiced is corn, followed by grain, and then grass. Some have sought to eliminate grain, but have found that better results are secured by retaining it in the rotation.

The dairy industry of this area has passed through many changes in the last twenty-five years. First came the period of home dairying, when cream was gathered by the gravity system. Following this came the building of private factories and the purchase of cream from the producers; then the imitation creamery factories, under which system each farmer churned his own butter and delivered it to the factory uncolored, where it was worked over and colored in imitation of June butter. After this came the manufacture of oleomargarine and later butterine, which nearly ruined the dairy industry before it was checked by legislation. The invention of the separator and cream tester were the next steps in the evolution, and the cream-gathering system was again begun. The factories this time were erected by the manufacturers of separators as a preliminary to the sale of hand separators to the farmers, but owing to the costliness of the machines and the hard times prevailing at that time this was not as successful as it was thought it should be. The farmers gradually becoming interested in the factories as stockholders, the present cooperative system was the outcome.

All the various systems except the first have been more or less failures as far as the manufacturer is concerned. The weak point in the present system is the difficulty of securing among many widely scattered producers the absolute cleanliness necessary to the manufacture of the best quality of butter. The carelessness of one person may taint an entire churning.

There is now a movement on foot to concentrate these small cooperative factories into large concerns so located that they might have shipped to them on fast trains the cream from farms even 100 or 200 miles distant. It is thought by some that this plan will fail, because of the greater chance of uncleanliness on the part of the producers. With the local factory system there is more likelihood that the dairyman will be personally interested in the quality of product, and he who might be lax is also under a closer scrutiny of the factory authorities, which can not but have a wholesome effect on his methods. These large factories plan to offset the effect of poor cream by renovating the butter when it is tainted; but laws are being enacted requiring renovated butter to be labeled as such, which injures its standing in the market. The present local cooperative system will probably continue. There is little doubt that the cooperative system is better for the individual welfare of a given locality, and therefore, on the whole, much more to be desired than the system of greater centralization.

In the area surveyed it is estimated that there is one dairy factory to about every 100 square miles, or one to every three townships. Some of these factories make butter exclusively; others make either butter or cheese. Butter is the more stable product in the market, the price averaging the last few years 25 cents per pound, while the price of cheese fluctuates widely, ranging from 3 to 12 cents per pound. Hence butter is made the year round, while cheese is made only a part of the year, or at such periods as good prices prevail.

Ohio has a State milk-inspection law which requires milk sold to private consumers to contain 3.25 per cent of butter fat.

Fattening cattle for beef is also a part of the husbandry of the area, but it is not as profitable as dairying, owing to the competition with the range-fed cattle of the Western plains.

While the area is distinctively a dairying section, recently there has been a considerable development in fruit growing for both the local and distant markets. There is apparently no reason why the production of fruit could not be made a more important part of the husbandry of the area. The fruits chiefly grown are the peach, grape, raspberry, and apple, and the most extensive orchards and vineyards are found near the Maumee River, Maumee Bay, and Lake Erie, where both the soils and climate seem better adapted to the industry. Farther away from these waters some fruit is grown, especially apples.

Sugar beets are grown to some extent on the Miami black clay loam

in the eastern part of the area. There are no beet sugar factories within the limits of the present survey, but there are two near it, one at Monroe, Mich., and the other at Fremont, Ohio. The price paid for sugar beets varies from $4 to $7 per ton, delivered at the factory, depending on percentage of sugar and abundance of the crop.

On the low-lying areas of Miami black clay loam near Lake Erie large quantities of onions are grown. Beds of onions may be seen there half a mile or more in length. Large quantities of potatoes and cabbage are grown there also.

The adaptability of soils to crops has already been brought out in the separate descriptions of the soil types. The matter is here repeated to emphasize the differences of the several types in crop production, and to enable a more ready comparison of their individual characteristics than is possible where statements are scattered about on different pages.

The Miami black clay loam in its natural state produced little of value except coarse marsh grasses. As it is to-day, thoroughly drained and well tilled, it is suited to the production of a variety of crops. Among these may be mentioned corn, winter grain, grass, orchard and small fruits, truck—especially onions, potatoes, and cabbage—and sugar beets. The Miami clay loam is used for about the same crops as the Miami black clay loam, but is rather better than that type for wheat and fruit.

The Miami sandy loam is also suited to the general farm crops, but is better adapted to certain of the truck crops, which its texture will suggest, and to fruit. Of the last, the apple and plum appear to give the best results. The Miami sand is still less a general farming type, though used for that purpose in places too remote from market and transportation facilities to make the growing of truck, to which industry it is best adapted, profitable.

Finally, the Miami loam, occurring as well-drained terrace and bottom lands, seems adapted, like the Miami black clay loam, to the general farm crops, fruit, and truck.

A general view of the soils of the area shows less marked differences in adaptation than might be expected from the differences in the character of the soils. In other words, there is room for a much nicer distinction in the crop value of the soils and the wider introduction of special crop interests.

A source of revenue to some of the farmers peculiar to this section lies in the oil wells. On many of the farms in the area there are from one to four or more wells in active operation. From these the farmer receives a royalty amounting to $1 or more per day, while he tills his fields as usual on the portion of the land not occupied by the oil-well operators. In the whole area there are about 400 oil wells at present in operation.

The transportation facilities of the area are very good. Some 20 lines of railroad center at Toledo, several of them being main-line transcontinental roads. Toledo, which lies about 10 miles inland from Lake Erie, is also a point of large shipment for lake traffic, the Maumee River being navigable for the largest lake boats. There are large grain elevators, iron works, bridge works, and other manufacturing and wholesale business interests located in the city and dependent upon the low freight rates which the competition of the many lines of communication centered there promotes.

The area is also well supplied with trolley lines, some of them connecting with distant cities. These lines handle freight as well as passenger traffic, and are a great convenience to the producers of commodities for local consumption.

The wagon roads are usually well kept. Some are surfaced with clay or gravel and some are macadamized.

The city of Toledo, with its population of about 132,000, is the chief market, but a score of smaller towns also consume a considerable part of the products of the area. There is no difficulty in reaching any of the distant markets east or west.

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