DEPARTMENT OF THE INTERIOR
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UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

GEOLOGIC ATLAS
OF THE
UNITED STATES

COLCHESTER–MACOMB FOLIO

ILLINOIS

BY

HENRY HINDS

SURVEYED IN COOPERATION WITH
THE GEOLOGICAL SURVEY OF ILLINOIS

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COLCHESTER–MACOMB FOLIO
NO. 208

GEOLOGIC ATLAS OF THE UNITED STATES.

The Geological Survey is making a geologic atlas of the United States, which is being issued in parts, called folios. Each folio includes topographic and geologic maps of a certain area, together with descriptive text.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds—(1) inequalities of surface, called *relief*, as plains, plateaus, valleys, hills, and mountains; (2) distribution of water, called *drainage*, as streams, lakes, and swamps; (3) the works of man, called *culture*, as roads, railroads, boundaries, villages, and cities.

Relief.—All elevations are measured from mean sea level. The heights of many points are accurately determined, and those of the most important ones are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to delineate the outline or form of all slopes, and to indicate their grade or steepness. This is done by lines each of which is drawn through points of equal elevation above mean sea level, the vertical interval represented by each space between lines being the same throughout each map. These lines are called *contour lines* or, more briefly, *contours*, and the uniform vertical distance between each two contours is called the *contour interval*. Contour lines and elevations are printed in brown. The manner in which contour lines express altitude, form, and grade is shown in figure 1.

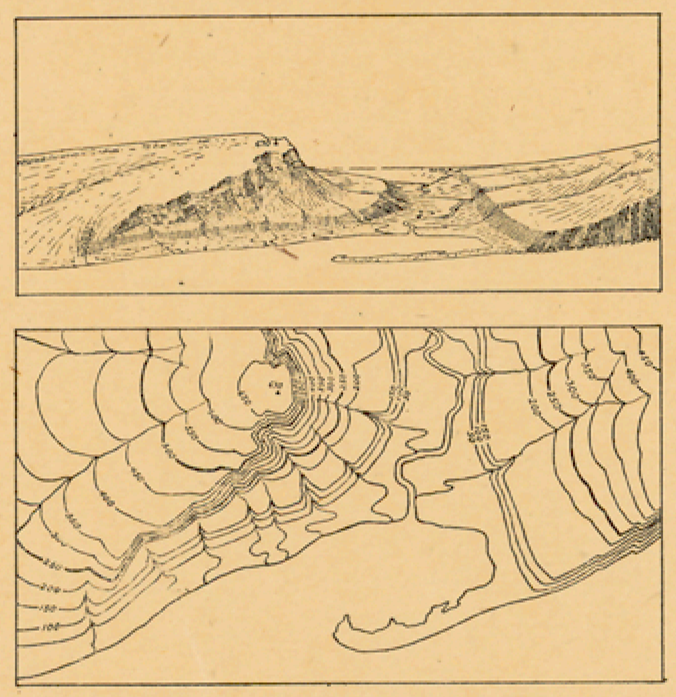

FIGURE 1.—Ideal view and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay that is partly closed by a hooked sand bar. On each side of the valley is a terrace. The terrace on the right merges into a gentle hill slope; that on the left is backed by a steep ascent to a cliff, or scarp, which contrasts with the gradual slope away from its crest. In the map each of these features is indicated, directly beneath its position in the sketch, by contour lines. The map does not include the distant portion of the view. The following notes may help to explain the use of contour lines:

1. A contour line represents a certain height above sea level. In this illustration the contour interval is 50 feet; therefore the contour lines are drawn at 50, 100, 150, and 200 feet, and so on, above mean sea level. Along the contour at 250 feet lie all points of the surface that are 250 feet above the sea—that is, this contour would be the shore line if the sea were to rise 250 feet; along the contour at 200 feet are all points that are 200 feet above the sea; and so on. In the space between any two contours are all points whose elevations are above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, and that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 150 but less than 200 feet above the sea. The summit of the higher hill is marked 670 (feet above sea level); accordingly the contour at 650 feet surrounds it. In this illustration all the contour lines are numbered, and those for 250 and 500 feet are accentuated by being made heavier. Usually it is not desirable to number all the contour lines. The accentuating and numbering of certain of them—say every fifth one—suffices and the heights of the others may be ascertained by counting up or down from these.

2. Contour lines show or express the forms of slopes. As contours are continuous horizontal lines, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing around spurs or prominences. These relations of contour curves and angles to forms of the landscape can be seen from the map and sketch.

3. Contour lines show the approximate grade of any slope. The vertical interval between two contours is the same, whether they lie along a cliff or on a gentle slope; but to attain a given height on a gentle slope one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and near together on steep ones.

A small contour interval is necessary to express the relief of a flat or gently undulating country; a steep or mountainous country can, as a rule, be adequately represented on the same scale by the use of a larger interval. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is in regions like the Mississippi Delta and the Dismal Swamp. For great mountain masses, like those in Colorado, the interval may be 250 feet and for less rugged country contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. For a perennial stream the line is unbroken, but for an intermittent stream it is broken or dotted. Where a stream sinks and reappears the probable underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are represented by appropriate conventional signs in blue.

Culture.—The symbols for the works of man and all lettering are printed in black.

Scales.—The area of the United States (exclusive of Alaska and island possessions) is about 3,027,000 square miles. A map of this area, drawn to the scale of 1 mile to the inch would cover 3,027,000 square inches of paper and measure about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and a linear mile on the ground by a linear inch on the map. The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 63,360 inches in a mile, the scale "1 mile to the inch" is expressed by the fraction $\frac{1}{63,360}$.

Three scales are used on the atlas sheets of the Geological Survey; they are $\frac{1}{250,000}$, $\frac{1}{125,000}$, and $\frac{1}{62,500}$, corresponding approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale of $\frac{1}{62,500}$ a square inch of map surface represents about 1 square mile of earth surface; on the scale of $\frac{1}{125,000}$, about 4 square miles; and on the scale of $\frac{1}{250,000}$, about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three ways—by a graduated line representing miles and parts of miles, by a similar line indicating distance in the metric system, and by a fraction.

Atlas sheets and quadrangles.—The map of the United States is being published in atlas sheets of convenient size, which represent areas bounded by parallels and meridians. These areas are called *quadrangles*. Each sheet on the scale of $\frac{1}{250,000}$ represents one square degree—that is, a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ represents one-fourth of a square degree, and each sheet on the scale of $\frac{1}{62,500}$ one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles, though they vary with the latitude.

The atlas sheets, being only parts of one map of the United States, are not limited by political boundary lines, such as those of States, counties, and townships. Many of the maps represent areas lying in two or even three States. To each sheet, and to the quadrangle it represents, is given the name of some well-known town or natural feature within its limits, and at the sides and corners of each sheet are printed the names of adjacent quadrangles, if the maps are published.

THE GEOLOGIC MAPS.

The maps representing the geology show, by colors and conventional signs printed on the topographic base map, the distribution of rock masses on the surface of the land, and, by means of structure sections, their underground relations, so far as known and in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. On the geologic map they are distinguished as igneous, sedimentary, and metamorphic.

Igneous rocks.—Rocks that have cooled and consolidated from a state of fusion are known as *igneous*. Molten material has from time to time been forced upward in fissures or channels of various shapes and sizes through rocks of all ages to or nearly to the surface. Rocks formed by the consolidation of molten material, or magma, within these channels—that is, below the surface—are called *intrusive*. Where the intrusive rock occupies a fissure with approximately parallel walls it is called a *dike;* where it fills a large and irregular conduit the mass is termed a *stock*. Where molten magma traverses stratified rocks it may be intruded along bedding planes; such masses are called *sills* or *sheets* if comparatively thin, and *laccoliths* if they occupy larger chambers produced by the pressure of the magma. Where inclosed by rock molten material cools slowly, with the result that intrusive rocks are generally of crystalline texture. Where the channels reach the surface the molten material poured out through them is called *lava*, and lavas often build up volcanic mountains. Igneous rocks that have solidified at the surface are called *extrusive* or *effusive*. Lavas generally cool more rapidly than intrusive rocks and as a rule contain, especially in their superficial parts, more or less volcanic glass, produced by rapid chilling. The outer parts of lava flows also are usually porous, owing to the expansion of the gases originally present in the magma. Explosive action, due to these gases, often accompanies volcanic eruptions, causing ejections of dust, ash, lapilli, and larger fragments. These materials, when consolidated, constitute breccias, agglomerates, and tuffs.

Sedimentary rocks.—Rocks composed of the transported fragments or particles of older rocks that have undergone disintegration, of volcanic ejecta deposited in lakes and seas, or of materials deposited in such water bodies by chemical precipitation are termed *sedimentary*.

The chief agent in the transportation of rock débris is water in motion, including rain, streams, and the water of lakes and of the sea. The materials are in large part carried as solid particles, and the deposits are then said to be mechanical. Such are gravel, sand, and clay, which are later consolidated into conglomerate, sandstone, and shale. Some of the materials are carried in solution, and deposits of these are called organic if formed with the aid of life, or chemical if formed without the aid of life. The more important rocks of chemical and organic origin are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the kinds of deposit named may be separately formed, or the different materials may be intermingled in many ways, producing a great variety of rocks.

Another transporting agent is air in motion, or wind, and a third is ice in motion, or glaciers. The most characteristic of the wind-borne or eolian deposits is loess, a fine-grained earth; the most characteristic of glacial deposits is till, a heterogeneous mixture of bowlders and pebbles with clay or sand.

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These layers are called *strata*, and rocks deposited in such layers are said to be stratified.

The surface of the earth is not immovable; over wide regions it very slowly rises or sinks, with reference to the sea, and shore lines are thereby changed. As a result of upward movement marine sedimentary rocks may become part of the land, and most of our land areas are in fact occupied by rocks originally deposited as sediments in the sea.

Rocks exposed at the surface of the land are acted on by air, water, ice, animals, and plants, especially the low organisms known as bacteria. They gradually disintegrate and the more soluble parts are leached out, the less soluble material being left as a *residual* layer. Water washes this material down the slopes, and it is eventually carried by rivers to the ocean or other bodies of water. Usually its journey is not continuous, but it is temporarily built into river bars and flood plains, where it forms *alluvium*. Alluvial deposits, glacial deposits (collectively known as *drift*), and eolian deposits belong to the *surficial* class, and the residual layer is commonly included with them. Their upper parts, occupied by the roots of plants, constitute soils and subsoils, the soils being usually distinguished by a notable admixture of organic matter.

Metamorphic rocks.—In the course of time, and by various processes, rocks may become greatly changed in composition and in texture. If the new characteristics are more pronounced than the old such rocks are called *metamorphic*. In the process of metamorphism the constituents of a chemical rock may enter into new combinations and certain substances may be lost or new ones added. A complete gradation from the primary to the metamorphic form may exist within a single rock mass. Such changes transform sandstone into quartzite and limestone into marble and modify other rocks in various ways.

From time to time during geologic ages rocks that have been deeply buried and have been subjected to enormous pressures, to slow movement, and to igneous intrusion have been afterward raised and later exposed by erosion. In such rocks the original structures may have been lost entirely and new ones substituted. A system of planes of division, along which the rock splits most readily, may have been developed. This structure is called *cleavage* and may cross the original bedding planes at any angle. The rocks characterized by it are *slates*. Crystals of mica or other minerals may have grown in the rock in such a way as to produce a laminated or foliated structure known as *schistosity*. The rocks characterized by this structure are *schists*.

As a rule, the oldest rocks are most altered and the younger formations have escaped metamorphism, but to this rule there are many important exceptions, especially in regions of igneous activity and complex structure.

FORMATIONS.

For purposes of geologic mapping rocks of all the kinds above described are divided into *formations*. A sedimentary formation contains between its upper and lower limits either rocks of uniform character or rocks more or less uniformly varied in character, as, for example, an alternation of shale and limestone. Where the passage from one kind of rocks to another is gradual it may be necessary to separate two contiguous formations by an arbitrary line, and in some cases the distinction depends almost entirely on the contained fossils. An igneous formation contains one or more bodies of one kind, of similar occurrence, or of like origin. A metamorphic formation may consist of rock of uniform character or of several rocks having common characteristics or origin.

When for scientific or economic reasons it is desirable to recognize and map one or more specially developed parts of a varied formation, such parts are called *members*, or by some other appropriate term, as *lentils*.

AGES OF ROCKS.

Geologic time.—The time during which rocks were made is divided into *periods*. Smaller time divisions are called *epochs*,

DESCRIPTION OF THE COLCHESTER AND MACOMB QUADRANGLES.

By Henry Hinds.[1]

INTRODUCTION.

GENERAL RELATIONS.

The Colchester and Macomb quadrangles are bounded by parallels 40° 15′ and 40° 30′ and by meridians 90° 30′ and 91° and have a combined area of 455 square miles. They are in western Illinois (see fig. 1) and include parts of McDonough, Hancock, and Schuyler counties. Macomb, the principal town in the area, is in the northwestern part of the Macomb quadrangle.

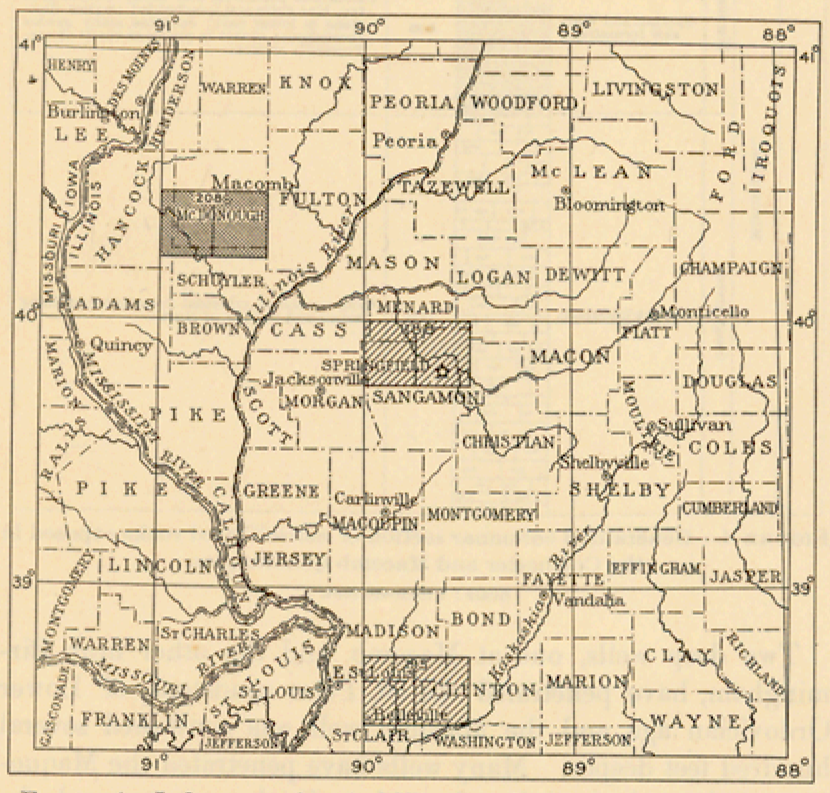

FIGURE 1.—Index map of central Illinois and parts of adjacent States.
The location of the Colchester and Macomb quadrangles (No. 208) is shown by the darker ruling. Published folios describing other quadrangles, indicated by lighter ruling, are Tallula-Springfield (188), Belleville-Breese (195).

GEOGRAPHY AND GEOLOGY OF THE SURROUNDING REGION.

TOPOGRAPHY.

In their general geographic and geologic relations the quadrangles form a part of the Glaciated Plains, a province characterized by a surface formed largely of unconsolidated glacial drift left by the great ice sheets that invaded the region in the Pleistocene epoch. These plains lie between the Appalachian province on the southeast, the Ozark province on the southwest, and the Great Plains on the west, and extend northward beyond the boundary of the United States. (See fig. 2.) Broadly considered, they include most of the United States north of Ohio and Missouri rivers, and their southern boundary is the southern limit of glaciation.

Even before glaciation northern and central Illinois and neighboring areas were not without many striking topographic features. Glaciation reduced the relief, for it filled the valleys with till and wholly or partly obliterated them. After each ice invasion the drainage was forced to adapt itself to new conditions and to begin the excavation of many new valleys on the poorly drained plains. Large parts of areas reached by comparatively recent ice sheets are still imperfectly drained and contain broad, flat divides that lie between shallow valleys. These features may be seen in most of Illinois, including the Colchester and Macomb quadrangles. Southern Iowa and northern Missouri were reached by the earlier glaciers only, so that erosion has had sufficient time to excavate many valleys and to narrow the divides. An area of about 10,000 square miles in the northwest corner of Illinois and adjacent parts of Wisconsin and Iowa was not glaciated and lacks some of the characteristics of neighboring glaciated sections, though it is considered part of the Glaciated Plains because much of its history is similar to that of surrounding territory.

The general altitude of the Glaciated Plains is 500 to 1,500 feet above sea level, but the local relief in few places exceeds 400 feet and is commonly much less, especially in most of Illinois. The valley of Mississippi River is one of the principal features of the region; for the stream flows between flat bottom lands that are generally 3 to 6 miles wide and are bounded by bluffs 200 to 400 feet high.

A large part of Illinois is drained by Rock, Illinois, Kaskaskia, and Big Muddy rivers, which flow southwestward to the Mississippi. Northern Missouri is drained by tributaries of Missouri River, the largest of which are Chariton and Grand rivers. Eastern Iowa lies chiefly in the basins of Turkey, Maquoketa, Wapsipinicon, Iowa, Skunk, and Des Moines rivers, all tributaries of the Mississippi.

The average annual discharge of the Mississippi just above the mouth of the Missouri is about 125,000 second-feet and that of the Missouri at its mouth is about 100,000 second-feet. Computations based on the amount of mineral matter carried by the upper Mississippi and on the size of its drainage basin show that the basin is being lowered by erosion at an average rate of 1 inch in about 1,000 years, and this is probably close to the average rate in western Illinois and neighboring areas. In proportion to the area drained the Missouri carries a much larger amount of mineral matter but derives most of it from the western part of its basin.

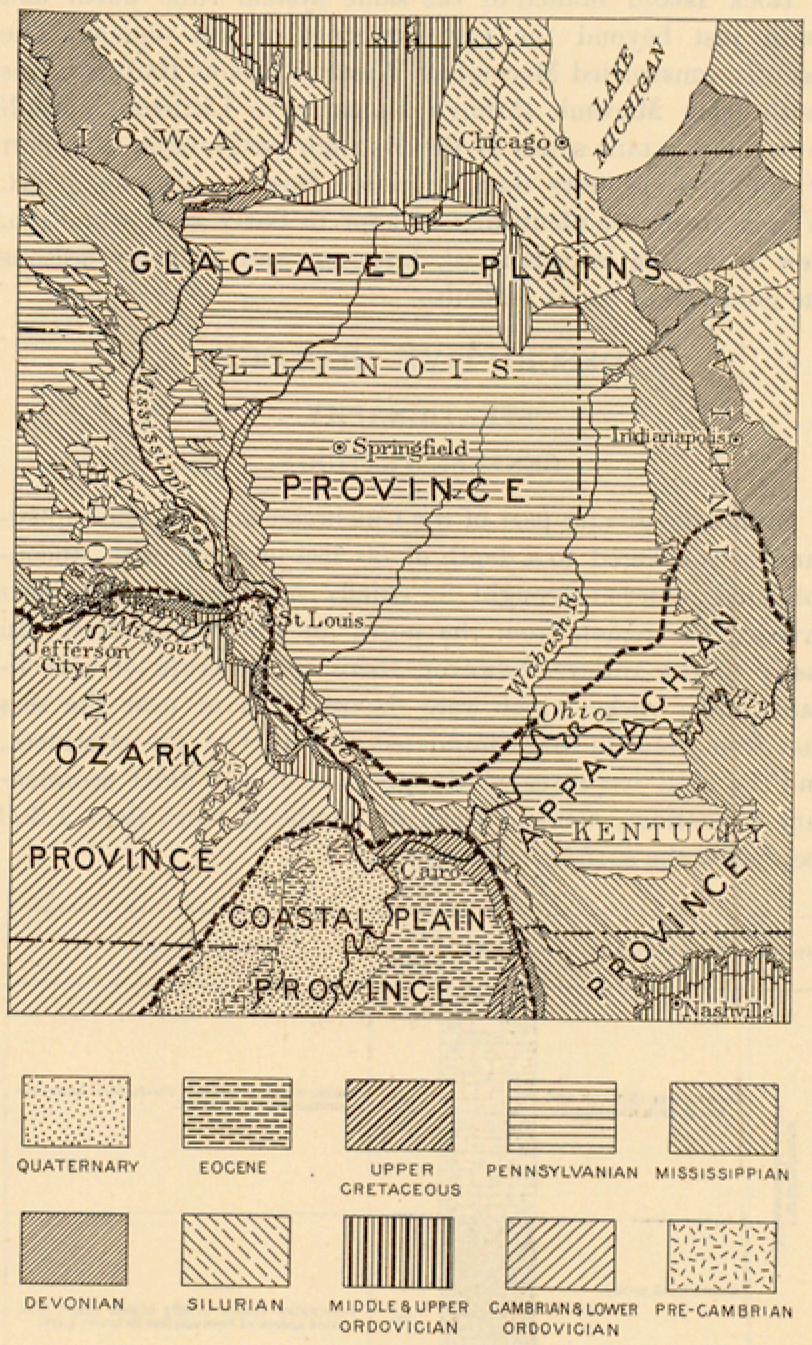

FIGURE 2.—Geologic map of Illinois and surrounding regions. Shows also physiographic provinces.
The indefinite boundary between the Ozark and Appalachian provinces coincides approximately with the southeast boundary of Illinois. Geologic map copied from maps of North America in U. S. Geol. Survey Prof. Paper 71, 1911.

CLIMATE AND VEGETATION.

The climate of the Colchester and Macomb quadrangles and neighboring areas is of the continental type—the type characteristic of the interiors of continents in the Temperate Zone. The temperature is below or just above the freezing point during the greater part of winter, and is uncomfortably hot during short periods in summer. The chief farm crop is corn, but wheat, oats, rye, and similar crops can be raised easily, and grasses of various types grow rapidly and fairly luxuriantly. The rainfall is nearly 40 inches a year; more than half of which falls during the growing season, supplying ample moisture except during unusual droughts. Most of the upland and part of the alluvial bottom land is open prairie under cultivation. The woodland tracts are confined mainly to the sides of the valleys and, though not extensive, are valuable for local fuel supplies, fence posts, and similar purposes.

GEOLOGY.

Stratigraphy.—The rocks underlying Illinois and neighboring areas are of many varieties and range in age from pre-Cambrian to Recent. Many geologic epochs, however, are unrepresented by beds of rock, and few epochs are completely represented by formations that underlie the whole region, for there have been many shifts from deposition to erosion and from erosion to deposition.

The pre-Cambrian formations are made up chiefly of igneous and metamorphic rocks having a complex structure. They outcrop in the St. Francis Mountains of southeastern Missouri and in parts of Wisconsin, Michigan, Minnesota, and Iowa, and doubtless underlie the entire province. Upon their deeply eroded and planated surface rest all later formations — the shales, sandstones, limestones, and the relatively recent unconsolidated rocks.

Lower and Middle Cambrian time seems not to be represented by strata in most of the region, but Upper Cambrian beds probably lie at or near the base of the unmetamorphosed sedimentary rocks in a large part of it. The Upper Cambrian series is generally more than 1,000 feet thick and consists principally of sandstone and shale, limestone forming only a subordinate part of the whole.

The Ordovician system consists largely of dolomite and limestone but generally includes a sandstone formation, the St. Peter, in its lower half and considerable shale near its top. The Silurian system is made up chiefly of limestone and dolomite and in places is thin or absent. The Devonian system in this general area is commonly thin and represented chiefly by limestone deposits; like the Silurian it is in places very thin or is absent.

The Mississippian series of the Carboniferous system consists of some shale at the base and of thick limestones and a little interbedded shale above. The highest group in the series, the Chester, includes considerable sandstone but is probably not present in northern and central Illinois and neighboring areas. The Pennsylvanian series of the Carboniferous system consists of interbedded shale and sandstone, some limestone, and many coal beds. It is particularly important because it contains the only workable coal deposits in the central United States, where it now lies in separate basins—one occupying most of Illinois and part of western Indiana and Kentucky; another most of southern Iowa, northern Missouri, and parts of Kansas, Oklahoma, Arkansas, and Texas; and a third a part of southern Michigan.

There are no extensive Cretaceous deposits in or near Illinois, and the only representatives of the Tertiary are bodies of gravel and sand scattered here and there on the divides.

The Quaternary system covers a very large area. It consists of glacial, eolian, lacustrine, and fluviatile deposits, almost wholly unconsolidated, which mantle the Glaciated Plains, effectually concealing the indurated rocks, except in some of the valleys and in a few districts where outcrops of the older rocks are plentiful.

Structure.—The structure of most of the region is comparatively simple. Few complicated folds or faults lie at or near its surface except in the southern tip of Illinois, where there are a number of east-west folds, which pass into faults on the east. The principal structural features of the region are the following:

1. A basin that occupies southwestern Indiana and most of Illinois. It is shaped much like the bowl of a spoon, its deepest parts being along an axis extending from the southwest corner of Indiana to north-central Illinois.

2. A still broader basin that occupies southern Iowa, northern Missouri, and neighboring areas on the west and southwest. In southern Iowa the beds dip southwest toward its center and in northern Missouri west and northwest.

3. A broad arch that affects Wisconsin and Minnesota.

4. A dome in the Ozark region that passes northward into a low, broad anticline. This anticline continues to southeastern Iowa, the axis lying close to the Mississippi, and separates the two basins just mentioned.

Each of the two basins contains a great coal field, and these fields are known respectively as the eastern and western regions of the Interior province. Around each basin the strata crop out in concentric belts, the youngest forming the inner belts and the oldest the outer border. Beds that lie 1,000 feet above sea level in northern Illinois are more than 3,000 feet below sea level in the south-central part of that State, and if all the beds found in Illinois were extended to the north the upper ones would be several thousand feet above sea level in central Wisconsin.

A smaller structural feature of great local importance is the La Salle anticline, which is essentially parallel to the axis of

[1] Surveyed in cooperation with the Illinois State Geological Survey.

the Illinois basin and is only a short distance east of it. Because of this anticline early Ordovician strata are exposed at the surface in the vicinity of Oregon and La Salle.

TOPOGRAPHY.

RELIEF.

General features.—The Colchester-Macomb district is one of comparatively slight relief and, notwithstanding its situation in the interior of the continent, does not lie far above sea level. Its highest point is on the prairie 5 miles north of Colchester, where the surface is about 730 feet above sea level, and its lowest point is where Crooked Creek crosses the southern boundary of the Colchester quadrangle at an altitude of about 470 feet, so that its relief is only 260 feet. The district is a nearly flat plain modified by narrow valleys and containing no conspicuous topographic features. Its mean altitude is about 30 feet higher that that for all Illinois, which is only 625 feet, the lowest in the North Central States.

Three topographic types are found in the district—upland prairies, erosion slopes, and bottom lands.

Upland prairies.—Considerably more than half the district consists of unforested level plains that form wide divides between the valleys. These nearly flat prairies occupy by far the greater part of the Macomb quadrangle, especially its eastern half. In the Colchester quadrangle also there are wide stretches of prairie, but a larger proportion of the higher land is cut into comparatively narrow interstream areas by more closely spaced valleys. Although much of the upland prairie gives to the eye an impression of absolute flatness, most of it is in reality broadly and gently rolling, sloping very gradually toward the larger valleys and forming divides that are not so high between the lower courses of streams as between their headwaters. The average altitude of the prairie is 660 to 680 feet in the Macomb quadrangle and also near Colchester, Tennessee, and Fandon, in the Colchester quadrangle. Near Plymouth the altitude averages about 640 feet; and in much of the gently rolling country west and southwest of St. Mary it is less than 600 feet. The upland is lower near Crooked Creek than elsewhere.

Low swells near Macomb and a long low ridge in Eldorado Township rise slightly above 700 feet. In a region of greater relief these features would be inconspicuous, but on these prairies they are rather prominent. Their sides slope gently and merge into the surrounding plains with no topographic break.

Erosion slopes.—Although the valleys have not been cut deeply into the plains left by the glaciers the transition from the upland prairies to eroded land near the streams is rather abrupt, so that many of the valleys are somewhat steep sided. The difference between this variety of topographic form and the others is accentuated by the fact that many of the valley slopes are forested. The belts of eroded lands along most of the streams are narrow, as lateral drainage is not extensively developed, but in the southwest and southeast corners of the Macomb quadrangle there is a dendritic network of drainage lines, and the topography is comparatively rugged. Much rough land lies along East Fork of Crooked Creek, in the Colchester quadrangle, for that stream has carved its way through the highest part of the upland prairies and, along most of its course, into the indurated rocks beneath the unconsolidated surface deposits. Near the headwaters of Troublesome, Camp, and Grindstone creeks, in the Macomb quadrangle, the land bordering the streams is only slightly dissected and the valley slopes merge into the upland prairie.

Bottom lands.—All the main creeks and many of their tributaries flow through bottom lands that they have built up during flood stages. Even near the heads of most drainage lines the alluvial lands are a few rods wide, and along most of Crooked Creek they are in places a mile or more wide. The bottom lands appear to be almost perfectly flat, but they really slope slightly from the streams up to the valley sides and have an even gradient down the valleys. Many parts of the streams flow in ditchlike trenches 10 to 20 feet below the level of the flood plains.

DRAINAGE.

With the exception of a small area in the southeast corner the entire Colchester–Macomb district is drained by Crooked Creek and its tributaries. Crooked Creek flows southeast across the Colchester quadrangle to join Illinois River below Beardstown. East Fork rises in the northeast quarter of McDonough County and flows in a deep, narrow valley across the north half of the Colchester–Macomb region to its junction with the main stream. Across the Colchester quadrangle Crooked Creek has an average gradient of 1.7 feet to the mile and is a rather small sluggish stream. It is well named, as throughout its course it meanders strongly and in places remarkably, especially in Hancock Township. Its principal tributaries are Bronson and Flour creeks from the west and Rock, Cedar, East Fork, Troublesome, and Camp creeks from the east. It is noteworthy that much of the drainage tributary to Crooked Creek is along parallel lines trending southwest. (See fig. 11, p. 9.)

The drainage of 27 square miles in the southeast corner of the Macomb quadrangle is tributary to Sugar Creek, a small stream that flows southeastward to join Illinois River about 5 miles above Beardstown.

CULTURE.

The Colchester–Macomb region includes a large area of exceptionally fertile land. Most of the inhabitants are occupied in farming, chiefly in raising corn; a number, however, are engaged in manufacturing clay products at Macomb and others in mining coal and clay near Colchester and elsewhere. There are no other important manufacturing enterprises. The principal town in the region is Macomb, which has a population of about 6,000. It is the county seat of McDonough County and an educational and industrial center. Colchester, with 1,445 inhabitants, Plymouth, with 829, and Industry, with 580, rank next in population.

The main line of the Chicago, Burlington & Quincy Railroad crosses the area from northeast to southwest, and the St. Louis & Rock Island branch of the same system runs north and south just beyond the east boundary of the region. The recently constructed Macomb & Western Illinois Railroad runs south from Macomb through Industry to Littleton, a small town about a mile south of the Macomb quadrangle. No part of the area is more than 15 miles from a shipping point. Wagon roads are plentiful and kept in fairly good condition. Few roads are macadamized, however, and in rainy seasons the mud makes travel difficult.

DESCRIPTIVE GEOLOGY.

STRATIGRAPHY.

GENERAL FEATURES.

By far the greater part of the Colchester and Macomb quadrangles is covered to a depth of 50 feet or more with unconsolidated material brought in chiefly by the ice sheets that invaded the region from the north in Pleistocene time. In many of the valleys, however, there are outcrops of consolidated, older rocks, which were deposited in or near the seas that from time to time inundated this part of the continent, and the drill has revealed the presence of still older sedimentary formations, some of them at depths of more than 1,600 feet below the surface. (See fig. 3.)

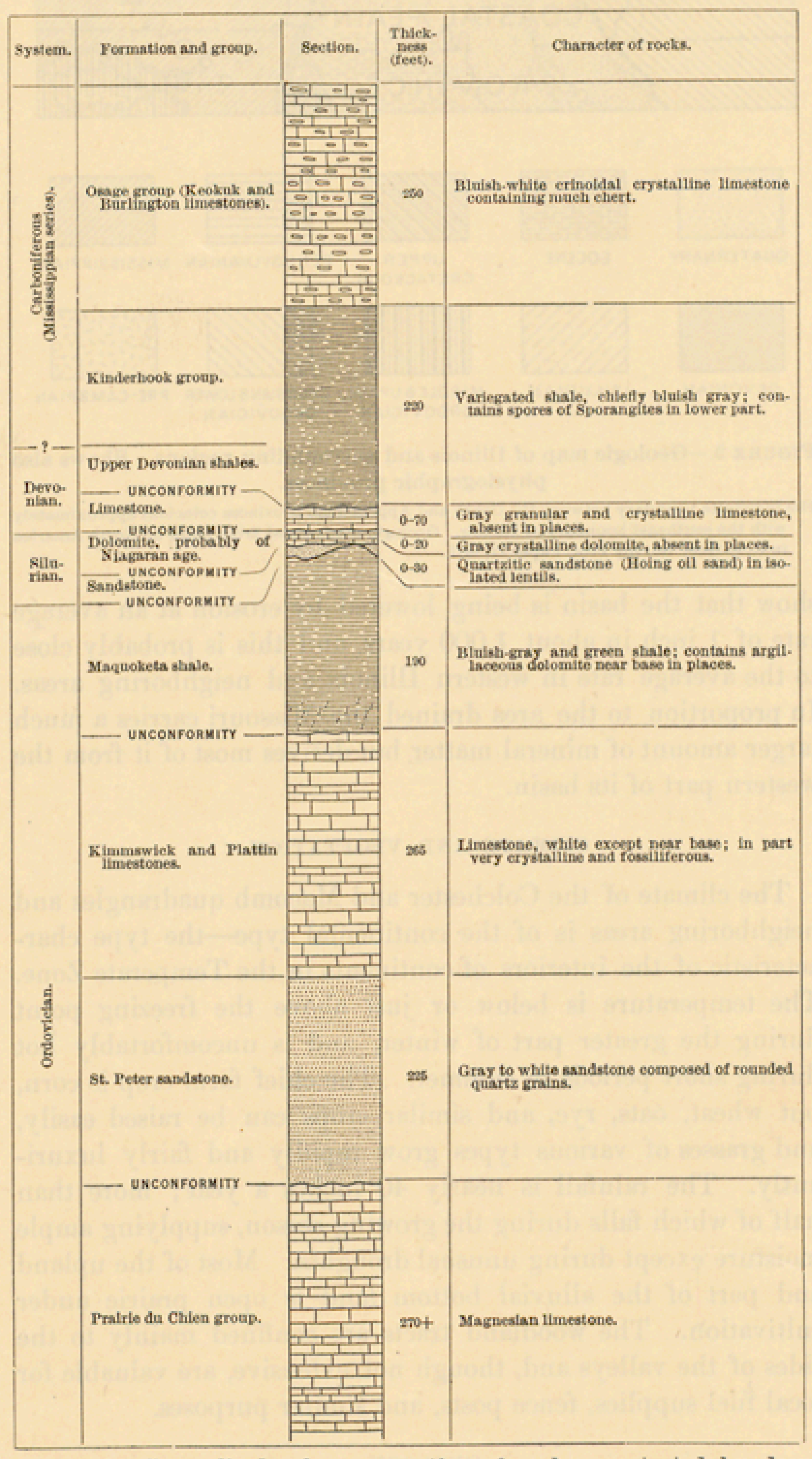

FIGURE 3.—Generalized columnar section of rocks penetrated by deep wells in the Colchester and Macomb quadrangles.

Scale: 1 inch=200 feet.

The strata that outcrop in the area include rocks lying between the lower part of the Keokuk limestone of the Mississippian series and the middle part of the Carbondale formation of the Pennsylvanian series. (See fig. 4.) Outcrops are sufficiently extensive to show clearly the character of the rocks.

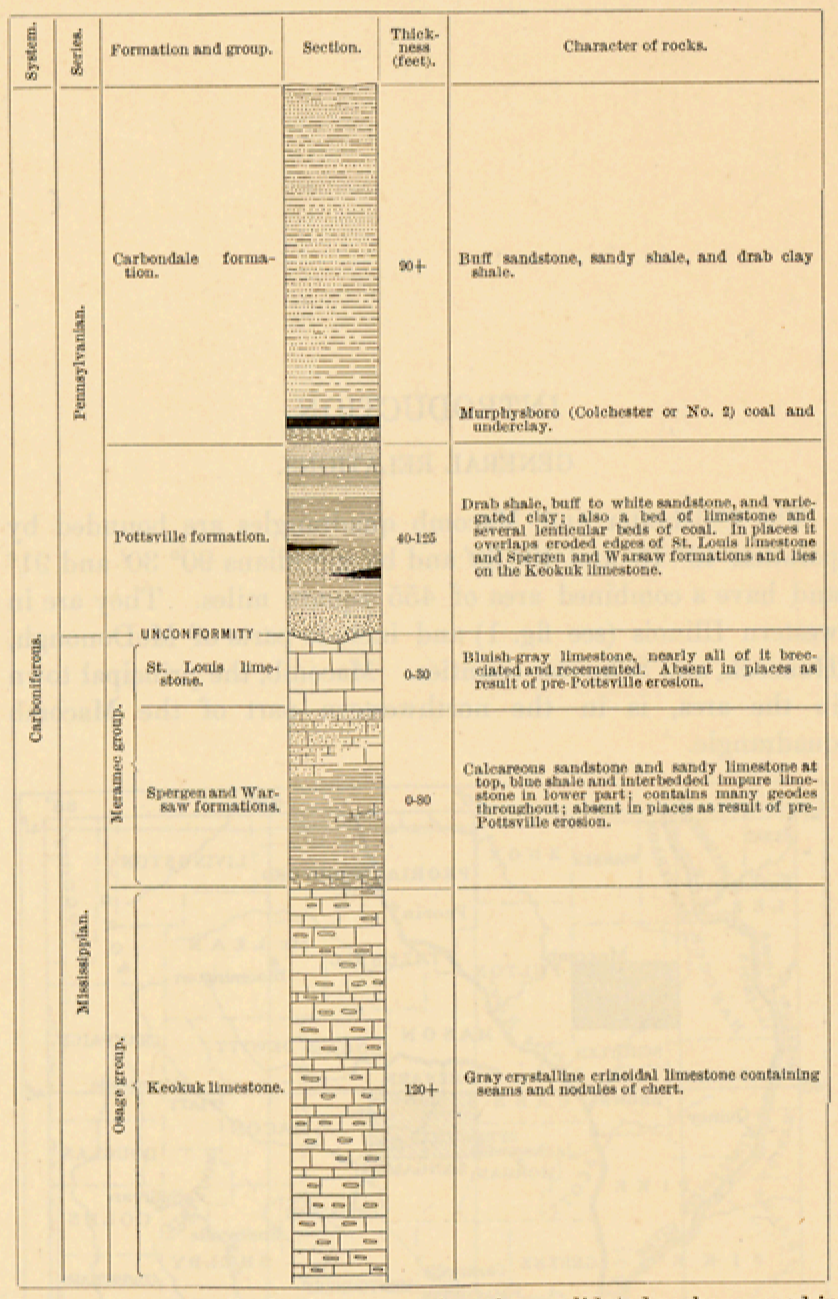

FIGURE 4.—Generalized columnar section of consolidated rocks exposed in the Colchester and Macomb quadrangles.

Scale: 1 inch=50 feet.

Two deep wells, one at Macomb and the other near Birmingham, have penetrated the St. Peter sandstone, of Lower Ordovician age, and the Macomb well was continued several hundred feet deeper. Many wells have penetrated the Maquoketa shale and overlying formations in the recent search for oil. The identification and correlation of the strata penetrated are rendered uncertain by two factors—(1) the absence of complete sets of samples from the two deepest wells and of reliable drillers' logs showing the thickness of each kind of rock sampled, and (2) the presence of a number of unconformities, so that a stratum found in one boring may be lacking or much thinner or thicker in another not far distant. In western Illinois, as shown by the deeper wells, more than 1,500 feet of limestone, sandstone, and other sedimentary rocks lie between the lowest beds reached at Macomb and the floor of pre-Cambrian crystalline rocks.

Many wells have been drilled in and near the Colmar oil field, southeast of Colmar and northeast of Plymouth, in the Colchester quadrangle. In most of them drilling stopped in the upper part of the Maquoketa shale, but in the Griggsby No. 1 well, one of the first drilled, the underlying limestones were penetrated.

Log of Griggsby No. 1 well, in the W. ½ SE. ¼ sec. 20, T. 4 N., R. 4 W.

[Surface 576 feet above sea level.]

	Thickness.	Depth.
	Feet.	*Feet.*
Quaternary system:		
Recent and Pleistocene series:		
Soil and clay	26	26
Carboniferous system:		
Mississippian series:		
Keokuk and Burlington limestones:		
Limestone, gray	10	36
"Mud"	10	46
Limestone, white and gray; water at 115 feet	134	180
Mississippian series (Kinderhook group) and Upper Devonian (?) shales:		
Shale, white	30	210
Shale, brown	10	220
Shale, white	40	260
Shale, brown	10	270
Shale, white, sandy in lower part	108	378
Shale, brown	7	385
Shale, white, sandy	15	400
Devonian and Silurian (?) systems:		
Limestone, gray; showing of oil at 425 to 432 feet	34	434
Ordovician system:		
Maquoketa shale:		
Shale	187	621
Kimmswick and Plattin limestones:		
Limestone, white	29	650
Limestone, brown	155	805

Most of the limestone recorded from 400 to 434 feet is of Devonian age. In most of the producing wells in the field this limestone is underlain by a thin porous dolomitic limestone of Silurian age. Between this Silurian limestone and the Maquoketa shale there are thin lenses of a sandy bed termed the Hoing oil sand, which is the productive formation of the oil field. The Mississippian limestones are commonly called the First lime by local oil men, and the Devonian and Silurian limestones the Second lime.

The relation of the St. Peter sandstone to the beds found in the Griggsby No. 1 well is shown by drillings from the deep well bored 2 miles southwest of Birmingham by the Schuyler Oil & Gas Co. No complete log was preserved, but samples were carefully examined by J. A. Udden. A brief summary[1] of his determinations follows, the correlations being those of the writer:

Log of Schuyler Oil & Gas Co.'s No. 1 well, 2 miles southwest of Birmingham, in the NE. ¼ SW. ¼ sec. 9, T. 3 N., R. 4 W.

[Surface 560 feet above sea level.]

	Depths at which samples were taken (feet).
Carboniferous system:	
Mississippian series:	
Keokuk and Burlington limestones:	
Limestone, bluish white, crinoidal; much fossiliferous chert	50, 60
Chert, chiefly, and dolomite, straw colored; a few small drusy geodes	70, 80
Limestone, white; much fossiliferous chert	90, 200, 220
Limestone, snowy white, largely crinoidal; little chert	235
Mississippian series (Kinderhook group) and Upper Devonian (?) shales:	
Shale, light blue; much pyrite and many calcareous fragments	246, 280, 292
Shale, greenish; little pryrite	295, 302, 310, 320
Shale, greenish gray to light gray; contains *Sporangites*	330, 340, 345, 355 365, 400, 415
Shale, black to dark brown, highly bituminous; burns with a flame for a moment when thoroughly ignited	511
Devonian (?) system:	
Limestone, highly bituminous; some fragments burn for several seconds; many fragments of rhombic calcite. Label partly illegible	5?1
Ordovician system:	
Maquoketa shale:	
Shale, green	600, 683
Kimmswick and Plattin limestones:	
Limestone, white, chalklike; a breccia of small organic fragments	685, 710, 730
Limestone, white; an organic breccia containing thin curved plates of bituminous matter; emits bituminous odor when heated	750
Limestone, white, pure; some white chert	800, 850
Limestone, dark to black; minute specks of bituminous matter	930
Limestone, yellowish gray	950
St. Peter sandstone:	
Sandstone, gray to white, poorly cemented; clean rounded grains of medium coarseness	955, 958, 1125

A complete set of samples, obtained from the recently drilled Shannon No. 1 well, 2 miles north of Macomb, was examined by the Illinois Geological Survey. The record is as follows:

Log of Shannon No. 1 well, 2 miles north of Macomb, in the center of the SE. ¼ sec. 19, Macomb Township.

[Surface about 600 feet above sea level.]

	Thickness.	Depth.
Carboniferous system:	*Feet.*	*Feet.*
Pennsylvanian series:		
Sandstone, fine grained	20	20
Shale, black	22	42
Mississippian series:		
Keokuk and Burlington limestones:		
Chert, gray to drab; some pyrite	30	72
Shale, gray	3	75
Chert, white to gray; pyrite	20	95
Chert, white, and limestone, cream-colored, crystalline	20	115
Limestone, gray, crystalline and crinoidal; chert fragments	45	160
Mississippian series (Kinderhook group) and Upper Devonian (?) shales:		
Shale, bluish gray, slightly sandy in lower part	40	200
Shale, dark; contains spores of *Sporangites* mixed with bluish-gray shale	60	260
Shale, dark; contains *Sporangites*	90	350
Shale, gray; some pyrite	45	395
Shale, gray, and gray limestone	2	397
Devonian system:		
Limestone, gray, granular; shale and pyrite	8	405
Limestone, gray, granular in upper part	20	425
Limestone, gray, crystalline	25	450
Limestone, gray; much chert	15	465
Ordovician system:		
Maquoketa shale:		
Shale, bluish gray; pyrite	35	500
Shale, bluish gray, dark	10	510
Shale, black to gray; pyrite	15	525
Shale, gray; granular dolomite	25	550
Dolomite, gray, granular	20	570

The Macomb city well was drilled more than 20 years ago in the public square, a block north of the courthouse. A driller's log was preserved and samples were saved and apparently carefully identified from depths of 145, 150, 160, 170, 175, 235, 245, 260, 275, 300, 322, 340, 350, 390, 400, 645, 700, 725, 750, 875, 990, 1,010, 1,090, 1,135, 1,160, 1,245, and 1,360 feet. It is very difficult, however, to correlate the strata reported from this well with those in the Shannon well. Probably there are inaccuracies in the Macomb record, and very little weight can be given to correlations based on its upper half.

Log of Macomb city well in public square.

[Surface 700 feet above sea level.]

	Thickness.	Depth.
Quaternary system:	*Feet.*	*Feet.*
Recent and Pleistocene series:		
Unconsolidated material, no samples taken	145	145
Mississippian series:		
Keokuk and Burlington limestones:		
Limestone and sand	5	150
Limestone	10	160
Limestone and flint; some iron pyrites	100	260
Limestone and flint	140	400
Undifferentiated:		
"Blue shale" in driller's log, but probably includes some limestone or dolomite. No samples taken	245	645
Ordovician system:		
Maquoketa shale and Kimmswick and Plattin limestones:		
Shale, "rotten"	55	700
Limestone	50	750
Limestone, with "sulphur and lead"	125	875
Limestone	215	1,090
Limestone, darker	45	1,135
St. Peter sandstone:		
Sandstone, almost pure "pebble glass"	225	1,360
Prairie du Chien group:		
Limestone, magnesian, very hard	270	1,630

ROCKS NOT EXPOSED.

ORDOVICIAN SYSTEM.

The Macomb city well, the deepest in the quadrangles, did not reach the base of the Ordovician, as drilling ceased at about the middle of the Prairie du Chien group, probably near the base of the Shakopee dolomite. In the Crapo Park well, at Burlington, Iowa, which penetrated all of the system and 800 feet of sandstone and other strata of Cambrian age beneath it, the Prairie du Chien group was found to be 565 feet thick, the entire Ordovician system being 1,050 feet thick. In early geologic reports the Prairie du Chien group was often termed the "Lower Magnesian limestone."

The St. Peter sandstone, a widespread and easily recognized deposit of remarkable purity and evenness of grain, is the principal water bearer in a large part of the northern Mississippi basin. Although it lies unconformably upon the underlying dolomites it maintains a fairly uniform thickness throughout large areas. At Macomb it is 225 feet thick and at Burlington 120 feet.

The Kimmswick and Plattin limestones are chiefly white or light gray, somewhat crystalline, and in part nonmagnesian in this area. In the deep well near Birmingham they are 270 feet thick, the upper, highly fossiliferous limestone between the St. Peter and the Maquoketa representing the Kimmswick, and the lower part the Plattin, the boundary between the two being probably just below the bituminous limestone at a depth of 750 feet. These limestones are often referred to by drillers as the "Trenton."

The Maquoketa shale is of Richmond age and is separated from both the underlying and the overlying formations by unconformities. It commonly consists chiefly of bluish or greenish shale. In the Colmar oil field it is 180 to 200 feet thick, but well records from 6 or 8 miles farther north indicate that it may be thinner in that district. North of the Colmar field and near Macomb the Maquoketa contains beds of argillaceous and thin-bedded dolomite.

SILURIAN AND DEVONIAN SYSTEMS.

The existence of notable unconformities between the Ordovician, Silurian, Devonian, and Carboniferous systems, as well as within all the systems themselves, makes very difficult the identification of Silurian and Devonian strata in some drill records, and the difficulty is accentuated by the lack of strong lithologic distinction between some formations. The oldest Silurian stratum in this area is the Hoing oil sand, named by Blatchley from the first producing well in the Colmar oil field. It is a round-grained quartzitic sandstone a few inches to slightly more than 30 feet thick and is the porous rock that has acted as a reservoir for oil. The Hoing sand is by no means continuous, however, for it lies only in isolated lenses in depressions on the uneven upper surface of the Maquoketa shale. Overlying the Hoing sand unconformably in many places there is a gray crystalline dolomitic limestone of Silurian and probably of Niagaran age; and overlying this, also unconformably, is a gray nonmagnesian limestone, averaging about 25 feet thick and thought to belong to the Devonian; the two together are rarely more than 50 feet thick. Drillers often fail to distinguish between the dolomitic Silurian and the nondolomitic Devonian limestones. One or both of them are lacking in many places in the quadrangles, the Silurian limestone being especially irregular in distribution.

In places in the Mississippi Valley the youngest Devonian rocks are Upper Devonian shales, and it is thought that they are present in this area. As the Devonian shales are overlain by Mississippian shale that is lithologically similar but belongs to the Kinderhook group it is difficult to define their upper limit, and no attempt has been made to do so in this folio.

CARBONIFEROUS SYSTEM.

GENERAL FEATURES.

The Carboniferous system, which is economically the most important of the major stratigraphic divisions in west-central Illinois, includes a large proportion of the indurated rocks outcropping at the surface or lying immediately beneath the glacial drift. The system is divided into two series separated by a great unconformity and in general contrasting strongly in lithology. The lower or Mississippian series contains considerable crystalline limestone, much blue shale, and very little sandstone. The upper or Pennsylvanian series contains a very little limestone, all of which is fine grained and noncrystalline, a large proportion of drab shale, considerable sandstone and clay, and beds of coal. In a broad sense the Mississippian consists of large units of homogeneous rock, and the Pennsylvanian is composed of comparatively thin beds, even a short stratigraphic section generally comprising several different kinds of rock. Because of the sharp contrast between the upper part of the Mississippian with its preponderance of limestone and the Pennsylvanian with its large proportion of shale and sandstone, even the layman can easily discriminate the two series in the Colchester-Macomb region. The determination of the upper limit of the Mississippian in borings and outcrops is of great economic significance, for no coal of commercial quality and thickness has been found in Illinois below the Pennsylvanian series.

MISSISSIPPIAN SERIES.

KINDERHOOK GROUP.

Above the Silurian and Devonian limestones and below the lowest Mississippian limestones there are about 190 to 270 feet of variegated shales, chiefly blue to light gray. The upper and perhaps the greater part of these shales belongs to the Kinderhook group of the Mississippian series, but their basal part may belong to the Upper Devonian. It has been contended that the presence of *Sporangites* demonstrates the Devonian age of the beds in which it is found, but this contention has not yet been proved.

OSAGE GROUP.

In the Mississippi Valley north of St. Louis the Osage group is divided into two formations, the Burlington limestone at the base and the Keokuk limestone at the top. In the Colchester-Macomb area the group is about 250 feet thick and consists almost entirely of limestone and chert.

BURLINGTON LIMESTONE.

At its nearest outcrops, in the southeast corner of Iowa and along Mississippi River in Illinois, the Burlington limestone is coarse grained, crystalline, and crinoidal and contains considerable chert—characteristics shown also in samples from wells in the quadrangles. The lithologic characteristics of the Burlington and Keokuk limestones are so similar, however, that it is not practicable to differentiate the formations on the evidence of drill records alone. According to Keyes[2] a particularly siliceous phase of the Osage group, called by him the Montrose cherts, marks the top of the Burlington in southeastern Iowa, but it is probable that the proportion of chert to limestone at any horizon differs from place to place and is only locally of stratigraphic significance.

ROCKS EXPOSED.

CARBONIFEROUS SYSTEM.

MISSISSIPPIAN SERIES.

OSAGE GROUP.

KEOKUK LIMESTONE.

The upper part of the Osage group, known as the Keokuk limestone, outcrops in the Colchester quadrangle along Crooked and Bronson creeks and the lower parts of most of their tributaries. The formation is below the surface in all parts of the Macomb quadrangle.

Character and distribution.—The formation consists of light-gray to bluish-gray coarse-grained crystalline limestone containing many fossils, especially the stems and plates of crinoids. Irregular seams and lentils of chert, 2 feet or less in thickness, are interstratified with parts of the limestone, and chert nodules are abundant in the limestone beds. Chert is more abundant in some parts of the formation than in others, yet it does not appear to be particularly characteristic of any definite horizon or horizons nor to have any marked stratigraphic significance. Many chert lenses are completely surrounded by

[1] For complete description see Illinois Geol. Survey Bull. 24, pp. 66-68, 1914.

[2] Keyes, C. R., Geology of Lee County: Iowa Geol. Survey, vol. 3, p. 341, 1895.

limestone that is unbroken by bedding planes, and some long, thin lenses of crystalline limestone are completely surrounded by chert. In places the boundary between the limestone and the chert is not sharp, and the chert bears traces of fossils similar to those found in the limestone. These facts and the general aspect of the formation indicate that the chert was not laid down as an original deposit at the time the limestone was formed, but that it is the product of the concentration of siliceous matter at a later date. The limestone is in greater part regularly bedded, mostly in beds less than 2 feet thick that are separated by thin layers of shale or chert or lie in contact. (See fig. 5.) The interbedded shale layers are most numerous near the top, though nowhere constituting more than a small proportion of the formation.

FIGURE 5.—Keokuk limestone in small quarry 2 miles northwest of Plymouth.

The Keokuk is best exposed just south of Crooked Creek, northeast of Plymouth, where an anticline has brought to the surface beds lower than those exposed elsewhere in the region. A mile north of North School crystalline Keokuk limestone is exposed as high as 595 feet above sea level, and similar rock outcrops at lower levels in many small valleys in the vicinity, and in the bank of Crooked Creek near the railroad crossing and under Lamoine Bridge at altitudes as low as 490 to 495 feet. Fossils found at the exposure at Lamoine Bridge are undoubtedly of Keokuk age. The Keokuk is at least 100 feet thick in this region and it is probable that the lowest beds exposed lie near the base of the formation.

Fossils.—Collections of fossil invertebrates from the upper part of the Keokuk limestone were made at the small quarries near Plymouth, in the SE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 20, T. 4 N., R. 4 W., the NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 25, and the NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 26, T. 4 N., R. 5 W. The following species were identified by Stuart Weller:

Zaphrentis centralis Milne-Edwards and Haime.
Amplexus fragilis White and St. John.
Monilopora beecheri Grabau.
Metablastus wortheni Hall.
Halysiocrinus tunicatus Hall.
Barycrinus tumidus Hall.
Dorycrinus sp. undet. (spines).
Dizygocrinus biturbinatus Hall.
Agaricocrinus americanus var. tuberosus Hall.
Actinocrinus lowei Hall.
Spirorbis sp. undet.
Fistulipora spergenensis Rominger.
Fistulipora asteria Prout.
Stenopora americana Ulrich.
Stenopora angularis Ulrich.
Lioclema punctatum Hall.
Fenestella serratula Ulrich.
Hemitrypa proutana Ulrich.
Archimedes negligens Ulrich.
Archimedes owenana Hall.
Polypora maccoyana Ulrich.
Rhombopora sp. undet.
Bactropora simplex Ulrich.
Cystodictya lineata Ulrich.
Glyptopora keyserlingi Prout.
Practopora trifolia Rominger.
Orthotetes keokuk Hall.
Rhipidomella dubia Hall.
Productus ovatus Hall.
Productus setigerus Hall.
Productus punctatus Martin.
Spirifer keokuk Hall.
Spirifer suborbicularis Hall.
Spirifer tenuicostatus Hall.
Spirifer neglectus Hall.
Reticularia pseudolineata Hall.
Eumetria verneuiliana Hall.
Composita trinuclea Hall.
Cleiothyridina roissyi L'Eveille.
Cleiothyridina incrassata Hall.
Platyceras equilateralis Hall.
Myalina keokuk Worthen.
Conocardium cf. C. indianense Miller.

Weller says:

These three faunules are typically Keokuk, being characterized by the large *Zaphrentis centralis*, *Amplexus fragilis*, numerous crinoids, *Orthotetes keokuk*, etc. *Rhipidomella dubia*, commonly reported to be characteristic of the Spergen, is a rather common species in two of the localities, and these Keokuk specimens are indistinguishable from good Spergen examples.

MERAMEC GROUP.

In southern Illinois the Meramec group embraces the Warsaw formation at the base, the Spergen limestone in the middle, and the St. Louis limestone at the top. In the Colchester and Macomb quadrangles the maximum thickness of the entire group is much reduced, being less than 100 feet, and the Spergen and Warsaw can not be differentiated with certainty on the basis of the stratigraphic succession or fossil content of the rocks exposed in the area. In this folio, therefore, these two formations are treated as a unit.

SPERGEN AND WARSAW FORMATIONS.

Names and correlation.—The strata between the top of the Keokuk limestone and the base of the St. Louis limestone have been diversely grouped. Several early writers considered all or part of them to belong with the St. Louis limestone or "group"; whereas Hall applied the name Warsaw limestone to at least part of their apparently stratigraphic equivalent at Warsaw, Ill. Weller[1] has stated that the sandy limestone immediately subjacent to the brecciated St. Louis limestone at Warsaw is of Spergen ("Salem") age and that the name Warsaw should be restricted to the beds below it and above the Keokuk. Although Warsaw is only 20 miles west of the Colchester quadrangle and stratigraphic sections made there by Hall, Worthen, and Weller agree closely with the succession in the Colchester-Macomb district, no faunules of typically Warsaw character were found in this district. With one or two doubtful exceptions all the invertebrates collected from above the Keokuk and below the St. Louis limestone in the Colchester quadrangle were considered by both Weller and Girty to have a Spergen aspect, though some Warsaw types were found in a few collections. It is not known whether the apparent faunal discrepancy between the rocks exposed at Warsaw and in the Colchester and Macomb quadrangles is due to the early appearance of Spergen types in the Warsaw formation of the latter area or to the fact that the Spergen formation is thicker in these quadrangles than at Warsaw and includes in its lower part beds that closely resemble part of the Warsaw formation at its type locality.

Recent work in southeastern Iowa and western Illinois by Van Tuyl and Weller has demonstrated unconformities between the Warsaw and the Spergen formations and at the top of the Spergen. No direct evidence of similar unconformities was obtained in these quadrangles, though certain peculiar types of false bedding in the upper part of the formations might be mistaken for an unconformity. (See fig. 6.) The sandy bed at the top of the formations appears to underlie the St. Louis limestone conformably, and its irregular thickness might be due either to a real though slight unconformity at its base or to contemporaneous erosion. The rather wide range in the thickness of the interval between the St. Louis and the Keokuk limestones may be the result of an unconformity somewhere within it.

FIGURE 6.—Cross-bedding or false bedding of limestone in the Spergen and Warsaw formations exposed on Flour Creek, 1 mile south of Plymouth.

The "geode bed" at the base of the formations has been considered part of the Keokuk limestone by many geologists, but recent paleontologic work in other areas has shown that it is part of the Warsaw formation. In the Colchester-Macomb area the "geode bed" is not well defined, for geodes may be found in all the beds between the Keokuk and the St. Louis limestones, though they are most abundant in the blue shale immediately overlying the Keokuk. In this area this lower geodiferous shale is unfossiliferous and is not separated from the overlying shales and limestones by any persistent bed.

Distribution.—The distribution of the formations is irregular because of both pre-Pennsylvanian and post-Pennsylvanian erosion. The most complete exposures are on Panther and Flour creeks, and there are many others on tributaries of Bronson Creek, and on lower East Fork, Grindstone Creek, and elsewhere.

Character.—The formations, where complete, consist of 30 to 80 feet of shale, with thin intercalated beds of limestone, most of them yellowish drab and impure and one very sandy. Their upper limit is clearly defined by the easily recognizable St. Louis limestone and their lower by the Keokuk limestone.

The lower 10 to 30 feet of the formations consists of blue shale and argillaceous limestone containing many geodes and often referred to in geologic literature as the "geode bed." In many exposures this bed is composed almost entirely of blue geodiferous shale; in other places it includes one or more beds of light-gray earthy limestone that are without conspicuous bedding planes or jointing and that scale off on exposure. The earthy limestone is most abundant in the lower part of the "geode bed" and in places is interbedded with crystalline limestone at the base. More commonly, however, even the lower part of the bed is so predominantly shale that it is distinct from the underlying crystalline beds of the Keokuk limestone.

The geodes are chiefly hollow spheroids from the size of a marble to that of a football or even larger. Most of them consist of an outer shell of silica lined with quartz or calcite crystals or botryoidal chalcedony, though pyrite, dolomite, aragonite, sphalerite, gypsum, and other minerals are also present. In some the central cavity is large and is either empty or is filled with mineralized water; in others the crystals completely fill the interior. Many geodes, especially those in overlying beds and in the Keokuk limestone, are irregularly shaped masses or simply drusy cavities. A number of hypotheses, some of them rather fantastic, have been advanced to account for the origin of geodes. The one that best accounts for the geodes here under discussion is that of Van Tuyl, who holds that they are the result of the development of concentric shells of siliceous material around calcareous nodules, followed by the solution of the calcareous matter and the deposition of minerals within the empty siliceous shells. Mineral matter may have been derived from the strongly mineralized water that is common in the lower strata of this region and that was checked in its upward migration by the relatively impervious shales of these formations.

The most persistent member of the formations lies at the top and is a brownish sandy limestone or calcareous sandstone a few inches to 28 feet thick. This bed is evidently the equivalent of the sandy stratum that immediately underlies the St. Louis limestone at Warsaw and that has been described by Weller as the only representative of the Spergen ("Salem") at that place. Although far from uniform in lithologic character it can usually be recognized on careful examination and is absent in only two small exposures. The proportion of sand it carries is very inconstant, and at a few places it is a sandstone with only a little lime cement. Where the sand content is high and the St. Louis limestone is absent it is not everywhere easy to distinguish between this stratum and the basal sandstones of the Pennsylvanian. The member is commonly even bedded, but the more sandy phases are in part massive or cross-bedded. Conspicuous cross-bedding may be seen in a hollow northwest of Eagle School, in the center of the N. $\frac{1}{2}$ sec. 20, T. 4 N., R. 3 W., and the massive phase in cliffs along neighboring parts of Camp Creek (see fig. 7) and on East Fork northwest of Colchester. The contact of this member with the St. Louis limestone above is commonly sharp but apparently conformable; in two places a little blue shale separates them.

Between the "geode bed" and the sandy bed just described a series of blue and drab shales includes irregularly interbedded limestone strata of uneven thickness, though commonly thin. Most of the limestone is yellowish, fine grained, and impure, but in places, notably along Flour Creek and in the hollows west of Plymouth and Tennessee, there are one to three thin beds of pure crystalline limestone, containing many lacelike Bryozoa and other fossils, that resemble the Keokuk beds. Geodes and chalcedonic masses are distributed irregularly through the beds, though the geodes are not so plentiful as in the "geode bed."

FIGURE 7.—Massive phase of the top bed of the Spergen and Warsaw formations, exposed on Camp Creek near Eagle School, Bethel Township.

The following complete section of the formations is exposed in a small tributary of Panther Creek near the center of the W. $\frac{1}{2}$ sec. 28, T. 4 N., R. 5 W., and on Panther Creek under 10 feet of St. Louis limestone and above Keokuk limestone:

[1] Weller, Stuart, The Salem limestone: Illinois Geol. Survey Bull. 8, pp. 81-102, 1908.

Section of Spergen and Warsaw formations near Panther Creek.

	Feet.
Sandstone, buff, shaly, very thin bedded	4
Concealed	7
Shale, blue, very calcareous in lower part	8
Limestone, blue to drab, argillaceous, in part massive	6
Shale, blue	6
Chiefly shale, poorly exposed	11
Shale, blue; contains geodes	7
Limestone, earthy	3
Shale, blue, geodiferous	11
	63

A good section is exposed on a small tributary of East Fork, near Tennessee, in the E. ½ SW. ¼ sec. 16, T. 5 N., R. 4 W. It underlies St. Louis limestone, and its two lowest members are probably part of the "geode bed."

Section of Spergen and Warsaw formations 1½ miles northwest of Tennessee, Ill.

	Feet.
Sandstone, very calcareous	½
Shale, blue	7
Limestone, white, sandy, thin bedded	1½
Shale, blue	1
Limestone, blue to yellow, semicrystalline, thin bedded, fossiliferous; 1½ feet of shale in middle	15
Shale, blue	2½
Limestone, blue, massive, impure, fine grained; basal part grades into shale laterally	9
Shale, blue	3
	39½

The formation is exceptionally thin in Rattlesnake Den Hollow, in southwestern Tennessee Township. The basal Pennsylvanian sandstone caps the following section, the St. Louis being absent. Keokuk limestone outcrops near the mouth of the hollow, subjacent to the section.

Section of Spergen and Warsaw formations in Rattlesnake Den Hollow.

	Feet.
Sandstone, blue to brown, calcareous, fine grained, even bedded	4
Shale, dark blue	6
Concealed	5
Limestone, bluish gray, thin bedded; contains many bryozoa	1
Shale, dark drab to blue	7
Limestone, bluish gray, fine grained, impure; small geodes near base	8
Shale, light blue	7
	38

Fossils.—Many parts of the formations are without fossils, but collections were made from eleven beds at nine different localities and were examined by Stuart Weller and G. H. Girty. The fossiliferous beds ranged from 10 to 38 feet below the St. Louis limestone. None of the collections are of typical Warsaw faunas and at least half are characteristically Spergen. Several collections have a faint Warsaw aspect rather by lacking typical Spergen forms than by possessing those characteristically Warsaw. Furthermore, the horizons of some collections of Warsaw aspect are apparently stratigraphically higher than those of some of Spergen aspect.

The following species, collected on Flour Creek 1½ miles southeast of Plymouth, in the SW. ¼ SW. ¼ sec. 6, T. 3 N., R. 4 W., were examined by Stuart Weller and pronounced characteristically Spergen in all respects:

Lower bed, 38 feet below St. Louis limestone.

Fenestella, many fragments.	Worthenopora spinosa.
Stenopora sp. undet.	Productus biseriatus.
Hemitrypa proutana.	Tetracamera subcuneata.
Cystodictya lineata.	

Upper bed, 17 feet below St. Louis limestone.

Pentremites conoideus.	Cystodictya lineata.
Oligoporus sp. undet.	Cyclopora fungia.
Archaeocidaris (plates).	Cycloporella spinifera.
Stenopora tuberculata.	Worthenopora spinosa.
Fenestella serratula.	Productus altonensis.
Fenestella tenax.	Rhipidomella dubia.
Hemitrypa proutana.	Tetracamera subcuneata.
Polypora varsoviensis.	Spirifer tenuicostatus.
Polypora simulatrix?	Eumetria verneuiliana.
Rhombopora attenuata.	Composita trinuclea.
Streblotrypa radialis.	Cleiothyridina hirsuta.

The following species, collected 3½ miles west of Tennessee, in the NW. ¼ SW. ¼ sec. 19, T. 5 N., R. 4 W., from a bed 16 feet below the St. Louis, were examined by G. H. Girty and pronounced to be intermediate between typical Warsaw and Spergen facies:

Lithostrotion canadense.	Fenestella tenax.
Triphlophyllum? sp. undet.	Archimedes negligens.
Syringopora monroensis?	Archimedes aff. distans.
Monilopora beecheri.	Rhipidomella dubia.
Ceratopora sp. undet.	Spirifer tenuicostatus.
Echinocrinus sp. undet.	Spirifer keokuk var.?
Glyptopora sagenella.	Spirifer plenus?
Meekopora sp. undet.	Cleiothyridina? n. sp.
Lioclema punctatum.	Platyceras acutirostre.
Rhombopora incrassata?	

Species found at other localities and not included in the lists above were: *Fenestella tenuissima?*, *Stenopora tuberculata*, *Stenopora* n. sp., *Rhombopora bedfordensis?*, *Bactropora simplex*, *Glyptopora plumosa*, *Archimedes wortheni*, *Productus indianensis*, *Productus ovatus*, *Spirifer bifurcatus*, *Spirifer neglectus*, and *Cypricardina indianensis*.

ST. LOUIS LIMESTONE.

The youngest Mississippian formation in the quadrangles is the St. Louis limestone. Only part of the formation is present, pre-Pennsylvanian erosion having removed the upper part and left the rest with a very uneven upper surface. The average thickness is 10 or 15 feet and the greatest thickness exposed is 30 feet. In several areas, notably north and west of Plymouth, the St. Louis has been completely removed and Pennsylvanian beds rest on older formations.

The St. Louis, owing to its resistant character, is well shown in many outcrops, however, appearing at many points on East Fork, Flour, Camp, Panther, Cedar, and Rock creeks and elsewhere in the Colchester quadrangle and on Grindstone Creek in both quadrangles.

The formation is composed entirely of pure bluish-gray limestone, so fine grained that it is often referred to as "lithographic stone." At some places it contains a few seams or pockets of clay and some lenses of chert. Its lower 18 inches to 3 feet is commonly massive or rather evenly bedded, but the remainder of the formation is generally brecciated throughout, being, in fact, composed of a mass of fragments in a relatively inconspicuous matrix of similar material. (See fig. 8.) Most of the fragments are sharply angular, though a few are slightly rounded, and some are as much as 5 feet long and 2 feet thick. This brecciation is unique, and by it the St. Louis may be easily identified.

FIGURE 8.—Outcrop of St. Louis limestone east of Birmingham, showing brecciation.

Fossils are rare in the formation, the only common one being the large coral *Lithostrotion basaltiforme*, known popularly as "petrified hornets' nest." *Lithostrotion canadense*, *Composita trinuclea?*, and an undetermined species of *Dielasma* were also found.

PENNSYLVANIAN SERIES.

POTTSVILLE FORMATION.

The Pottsville formation includes the strata from the base of the Pennsylvanian to the base of the underclay of the Murphysboro (Colchester or No. 2) coal bed. It comprises thin beds of shale and of sandstone that are variable both horizontally and vertically, a single bed of thin but fairly persistent limestone near the top, from one to three thin and comparatively unimportant coal beds, and a few thin streaks of clay ironstone. The Pottsville rests unconformably upon Mississippian formations, commonly on the St. Louis limestone but in many places on the Spergen or Warsaw formation or even on the Keokuk limestone. (See fig. 10, p. 8.)

Thickness and distribution.—The thickness of the Pottsville in the area ranges from 40 to 125 feet, the difference being due largely to the unconformity at its base. In districts where the highest beds of the formation outcrop the lowest beds lie on St. Louis limestone or the upper part of the Spergen limestone, so that the greatest thickness of Pottsville found in any single series of exposures was not more than 70 feet. The maximum thickness of 125 feet given above is an estimate based on the facts that Pottsville beds lie in places on the Keokuk and that the Murphysboro coal was apparently laid down approximately parallel to the Mississippian beds.

The formation is best exposed in the valley of East Fork and its tributaries from a point west of Tennessee to a point near Bardolph and also in the rugged country in the southwest quarter of the Macomb quadrangle. The lower strata outcrop, however, in nearly every part of both quadrangles in which there are any exposures of indurated rocks. The Pottsville is the youngest formation beneath the unconsolidated Pleistocene deposits of much of the upland prairies, especially near Tennessee and Plymouth, in the Colchester quadrangle, and along East Fork in the Macomb quadrangle.

Character.—The general character of the formation is best shown by the accompanying sections. Other sections are given in the account of the economic geology of the clay deposits.

Section of Pottsville formation in ravines near Colchester, in the SW. ¼ sec. 12, T. 5 N., R. 4 W.

	Feet.
Shale; includes layers of red sandstone in places; top is 4 feet below the Murphysboro coal	8
Limestone, dark blue to bluish gray, fine grained, nodular; surface knobby and irregular; in some places a regular stratum but in others consists only of isolated lenses or boulders; locally marcasitic and in part brecciated	2
Clay and shale	6
Sandstone, yellow	2
Shale, variegated	7
Clay, variegated, in part very sandy; carbonaceous streaks near bottom; horizon of stoneware clay	8
Sandstone, thin bedded to quartzose; weathers buff or with black coatings; thickness irregular	7
Shale, bluish black; rests on St. Louis limestone; contains small lenses of clay ironstone; absent in places	4
	44

Section of Pottsville formation in Wigwam Hollow, northwest of Macomb, in secs. 23 and 26, T. 6 N., R. 3 W.

	Feet.
Sandstone, buff, fine grained, micaceous, thin bedded; top is 3 feet below Murphysboro coal	5
Shale, light drab	4
Limestone, bluish gray, fine grained; as lenses and boulders	
Shale and white clay	10
Shale, drab and blue	15
Sandstone, yellowish white, quartzose, irregularly bedded; contains root and stem impressions	3–8
Shale, variegated, sandy	6
Shale, yellowish drab at top, black at base; contains thin lenses of clay ironstone	11
	54–59

Section of Pottsville formation a quarter of a mile north of Eagle School, near middle of east line of sec. 20, T. 4 N., R. 3 W.

	Feet.
Concealed interval below Murphysboro coal	15
Shale, blue to white at top, drab at base	9
Clay, bluish white, sandy	5
Sandstone, white, weathering to light buff, quartzose, thin bedded	5
Interval, chiefly blue-black shale	20
Sandstone, white, weathering to dark drab, quartzose; contains partings of blue-black shale	4
Shale, in part very calcareous and filled with carbonized stems	3
Concealed strata resting on Spergen and Warsaw formations	6
	67

Section of Pottsville formation in southeast corner of Macomb quadrangle, near center of sec. 10, T. 3 N., R. 1 W.

	Feet.
Shale, dark drab; top is 4 feet below Murphysboro coal	4
Sandstone, buff, micaceous, massive in places, thin bedded in others	4½
Clay, white	1½
Limestone, bluish, nodular, fine grained	2½
Interval including clay and shale	7½
Clay, white, very plastic; contains some shale	3
Sandstone, buff	4
Shale, dark gray to bluish black, very sandy	15
	42

The earliest Pottsville sediments consist chiefly of coarse-grained sandstone and irregularly interbedded shale. These deposits are far from uniform in character, are thickest where the Pottsville lies on Keokuk beds, and extend upward 20 or 40 feet above the horizon of the base of the St. Louis limestone. Most of the sandstone is notably quartzose, consisting almost entirely of subangular grains of translucent quartz, and is commonly white when fresh and reddish or brownish on weathered surfaces. The shale is generally drab and rather sandy. Conglomerate is surprisingly scanty, occurring only in very thin layers interbedded with the lowest Pottsville sandstone and containing fragments of chert, St. Louis limestone, geodes, and other débris of Mississippian rocks. Where the Pottsville lies upon St. Louis limestone or on rocks only a short distance below that limestone its lowest stratum is commonly a massive sandstone of the pure quartzose type just described and is in places known as the "glass sand." This stratum outcrops at many places along East Fork near Colchester, where it averages about 10 feet thick, and forms low vertical walls in the head of Rattlesnake Den Hollow, where it is as much as 35 feet thick.

Above the basal sandstone and shale and constituting much the greater part of the Pottsville formation above the horizon of the highest Mississippian strata is a series of clays and shales, with subordinate beds of sandstone, limestone, and coal. The characteristics of this series are best shown in the typical sections that have been given and in those to be given in the account of the geology of clay and shale as mineral resources. (See pp. 10 and 11.) The sediments include a much larger proportion of fine material than those in the lower part of the Pottsville, and the change from one kind to another is rather abrupt. The stratification of the higher beds is more regular, and individual beds may here and there be recognized with some certainty. The horizon of the well-known stoneware clays of the region is on an average 30 to 40 feet below the top of the Pottsville and is marked nearly everywhere by some clay or shale, though it is disguised in places by the presence of intercalated sandstone.

The Pottsville contains no very thick coal beds in these quadrangles. In most localities it carries only one coal bed, which is commonly known as No. 1, though the No. 1 of one district may not be the exact stratigraphic equivalent of the No. 1 of another. The most persistent coal horizons are just above and just below the stoneware clays, but in many places they are marked by no coals or only by coaly streaks a few inches in thickness. These conditions are well illustrated near Colchester. At the Johnson clay pits $1\frac{1}{2}$ miles southwest of the town the only coal bed is very irregular in thickness and lies just above the stoneware-clay horizon and about 38 feet below the Murphysboro coal. Under the prairie between Tennessee and Colchester the only coal bed lies below the stoneware-clay horizon and about 45 feet below the Murphysboro coal horizon. In the ravines near the clay mines a short distance northwest of Colchester the only signs of Pottsville coal are carbonaceous streaks at the base of the stoneware clay.

The most easily recognized and reliable stratigraphic marker in the Pennsylvanian series is the thin limestone at the top of the Pottsville formation. By their relation to it the horizons of both the Murphysboro coal above and the stoneware clay below may be readily determined in the field. The limestone (see sections, p. 5) is bluish gray, fine grained, and either brecciated or nodular, so that it weathers with a characteristically uneven surface. In its brecciation, texture, and general aspect it somewhat resembles the St. Louis limestone but can be discriminated from it by the nature of contiguous beds. It has no regular bedding or cleavage. In places it contains many crystals of marcasite or pyrite, which on weathering give it a reddish tinge. It lies 5 to 20 feet, generally less than 10 feet, below the Murphysboro coal, from which it is separated by shale, locally interbedded with sandstone, and is overlain by clay forming the basal member of the Carbondale formation. In some outcrops it is a continuous ledge rarely as much as 5 feet thick; in others it is represented only by rows of "boulders" in clay or by inconspicuous calcareous shale; and in still others it is altogether wanting.

Correlation.—The ferns, lycopods, and seeds found fossil in the clays and in the shale overlying the thin coals of the Pottsville in this region, are characteristic of the uppermost Pottsville, namely, the Mercer group and the Homewood sandstone in the bituminous coal fields of the Appalachian region, the equivalents of the Mercer in the anthracite regions, the Kanawha formation of southern West Virginia, and the beds below the Bevier coal in Missouri. It is thus demonstrated that the transgression on this part of the shore line by the advancing Pennsylvanian sea did not occur until the last stage of Pottsville time, long after the deposition of the lower sandstones, shales, and coals of the Pottsville in Johnson, Pope, Saline, and Williamson counties.

CARBONDALE FORMATION.

Character and distribution.—All the regularly stratified rocks above the Pottsville formation in the quadrangles are included in the Carbondale formation, only the lower part of which has escaped removal by preglacial erosion. The greatest thickness now remaining is 90 feet, found in the south-central part of the Macomb quadrangle. In other districts the formation is less than 50 feet thick except locally. It consists of sandstone and shale, one coal bed, and one very thin non-persistent limestone. It lies conformably upon the Pottsville and is overlain unconformably by glacial till and other unconsolidated deposits.

The formation outcrops in many places near Colchester, in the rough country bordering Gin and Center ridges, and along Sugar Creek—that is, in the northeastern part of the Colchester quadrangle and in the southwestern and south-central parts of the Macomb quadrangle. Elsewhere preglacial erosion has removed all or most of it.

Murphysboro (Colchester or No. 2) coal and overlying shale.—The base of the underclay of a very persistent and regular coal bed, the Murphysboro, averaging a little over 2 feet thick, marks the base of the Carbondale. In earlier geologic reports this coal bed was termed No. 2 in some parts of the State, because it was supposed to be the second above the base of the coal measures. Much confusion has arisen from the practice of numbering coal beds, however, as the second bed in one district or field may not be the same as the second in another. Recently, therefore, geographic names have been adopted for the principal coal beds in Illinois, and the name Murphysboro was assigned to No. 2 because of the commercial importance of this coal in the district near Murphysboro in southern Illinois. In the Colchester district the bed is called the Colchester coal. The characteristics of this bed in the Colchester-Macomb region are described in detail under "Mineral resources" (p. 11).

Lying on the Murphysboro coal bed is a blue to drab shale, which reaches a maximum thickness of 55 feet, but is locally absent. It is a fairly pure clay shale near the base and more sandy at the top. Its irregular thickness is due chiefly to the uneven base of the overlying sandstone. The shale is best developed near Colchester, where it is 55 feet or less in thickness. North of East Fork near Colchester it averages 20 feet or less, and in many outcrops in the southern half of the Macomb quadrangle it is absent or is only a few inches thick. Along parts of Grindstone and Willow creeks and their tributaries, however, there is as much clay shale as near Colchester.

No trace was found of coal "No. 3," reported by Worthen to be 30 to 50 feet above coal "No. 2," in Schuyler and Fulton counties, and the only limy beds found are thin calcareous lenses that crop out at only three places. A section at one of these exposures, showing also an exceptional thickness of clay shale, follows:

Section on Center Ridge, in the middle of sec. 2, T. 3 N., R. 3 W.

	Ft.	In.
Carbondale formation:		
Shale, argillaceous; contains red ferruginous nodules	23	0
Limestone, black to blue or gray, not regularly bedded, fossiliferous		4
Shale, argillaceous, blue to drab	30	0
Coal (Murphysboro)	2	4
Clay, variegated, sandy near base	7	0
Pottsville formation:		
Limestone, blue to gray, fine grained, nodular	2	0
Clay, blue and white	3	0

Vergennes sandstone member and associated beds.—Above the clay shale of the Carbondale is a brownish to buff medium-grained loosely cemented micaceous sandstone that evidently corresponds stratigraphically and lithologically to the Vergennes sandstone member described by Shaw in the Murphysboro quadrangle. This sandstone is commonly massive, at least near the base, is conspicuously cross-bedded in places, and is locally thin bedded. During or just before the deposition of the Vergennes the shale below it was slightly eroded, so that the base of the sandstone member is uneven. The distance between the Murphysboro coal bed and the sandstone ranges from 55 feet in a few places near Colchester to 1 foot or less in the southern part of the Macomb quadrangle. In many places in the latter area the sandstone rests directly on the coal.

Near the headwaters of Sugar Creek and Honey Branch the Vergennes sandstone is massive, lies on or near the Murphysboro coal bed, and is 20 to 40 feet thick. It grades upward into shaly sandstone and sandy shale that are irregularly interbedded and 50 feet or less thick. The following sections illustrate the relations of the Vergennes sandstone elsewhere:

Section of Carbondale formation on Gin Ridge, in the NW. ¼ NE. ¼ sec. 25, T. 4 N., R. 3 W.

	Feet.
Sandstone, buff to gray, thin bedded (Vergennes member)	39
Shale, argillaceous; contains ferruginous nodules	10
Coal (Murphysboro)	$2\frac{1}{2}$
Clay.	

Section of Carbondale formation at Colchester, in the northwest corner of the SW. ¼ sec. 7, T. 5 N., R. 3 W.

	Feet.
Sandstone (Vergennes member), buff, thin bedded, calcareous in places near top; contains shale partings	21
Shale, blue to light drab, argillaceous	24
Coal (Murphysboro)	$2\frac{1}{2}$
Clay.	

Section of Carbondale formation in Atkinson coal shaft, in the NE. ¼ SW. ¼ sec. 33, T. 6 N., R. 3 W.

	Feet.
Sandstone (Vergennes member), in part thin bedded	54
Shale, argillaceous	5
Coal (Murphysboro)	$2\frac{1}{2}$
Clay.	

Fossils.—The only fossil invertebrates collected from the Carbondale formation were obtained about 6 miles southwest of Industry, in the S. ½ NE. ¼ sec. 2, T. 3 N., R. 3 W., from a 4-inch limestone lying 30 feet above the Murphysboro coal. The following species were identified by G. H. Girty:

Crania n. sp.?
Lingulidiscina missouriensis.
Chonetes mesolobus.
Chonetes mesolobus var. decipiens.
Productus cora.
Marginifera muricata.
Ambocoelia planiconvexa.
Nucula parva.
Anthraconeilo taffiana.
Aviculipecten pellucidus?
Edmondia gibbosa?
Astartella concentrica.
Bucanopsis meekana.
Patellostium montfortianum.
Phanerotrema grayvillense.
Aclisina robusta.
Sphaerodoma brevis?
Meekospira peracuta.
Metacoceras cornutum?

The shales immediately overlying the Murphysboro coal are here, as in most other parts of the State, filled with an abundant and somewhat varied flora. Among the species collected at the mines in or near Colchester, the following have been identified by David White:

Sphenopteris hymenophylloides Brongniart (not (Weiss) Sterzel).
Mariopteris callosa (Lesquereux) D. White.
Pecopteris mazoniana (Lesquereux) D. White.
Pecopteris dentata Brongniart (not Williamson).
Pecopteris unita Brongniart.
Pecopteris squamosa Lesquereux.
Alethopteris gibsoni Lesquereux—aquilina (Schlotheim) Goeppert.
Gallipteridium sullivantii (Lesquereux) Weiss.
Neuropteris rarinervis Bunbury.
Neuropteris rogersi Lesquereux (not Kimball).
Neuropteris decipiens Lesquereux.
Neuropteris clarksoni Lesquereux.
Linopteris rubella (Lesquereux) D. White.
Dolerophyllum.
Taeniophyllum sp.
Calamites ramosus Artis.
Asterophyllites equisetiformis (Schlotheim) Brongniart.
Annularia stellata (Schlotheim) Wood.
Annularia sphenophylloides (Zenker) Gutbier.
Macrostachya Schimper.
Lepidodendron brittsii Lesquereux.
Lepidodendron lanceolatum Lesquereux.
Lepidodendron simplex Lesquereux.
Lepidostrobus geinitzii Schimper.
Lepidophyllum ovatifolium (Lesquereux) D. White.
Ulodendron elongatum Lesquereux.
Pachytesta jacksonensis (Lesquereux) D. White.
Pachytesta sp.
Naiadites and insect wings.

Correlation.—According to White the fossil plants present in the roof of the Murphysboro coal in the vicinity of Colchester comprise a flora characteristic of that accompanying the Murphysboro coal at other places along the western border of the Illinois coal field. The comparison of this flora with that of the Appalachian trough shows it to belong to the Clarion group of the bituminous coal fields of the northern Appalachian trough, it being probably most closely related to the plant life attending the deposition of the Brookville coal. For the latter reason the base of the Carbondale formation, which is approximately equivalent to the Allegheny in time, is placed beneath the Murphysboro coal. This flora appears to be a very little younger than that found in the Missouri coal field, in the roof of the Bevier coal. The writer believes that stratigraphic evidence strongly indicates that the Murphysboro and Bevier coals are of the same age. Floral evidence, however, indicates that the Bevier coal is possibly of Pottsville age and lies at the horizon of the Tionesta coal of western Pennsylvania and northern Ohio. In the coal fields of western Europe the Murphysboro flora finds its close representative, a large number of the species being identical, at the top of the Westphalian of the continent and in the transition series following the middle Coal Measures of Great Britain.

QUATERNARY SYSTEM.

The surficial deposits of the region, which conceal the indurated strata on all the upland prairies and in many of the valleys, consist chiefly of clay, sand, and silt, and include glacial drift, interglacial sand and soil, loess, and alluvium.

PLEISTOCENE SERIES.

GENERAL FEATURES.

The Pleistocene deposits, which include by far the greater part of the unconsolidated materials that cover the region, consist of Kansan (?) glacial drift, Yarmouth (?) interglacial deposits, Illinoian glacial drift, the greater part of the loess, and certain stream terrace deposits. As much of the present upland surface is nearly flat, the differences in the thickness of the Pleistocene deposits depend largely on the form of the surface upon which the drift was laid down. Before the glaciers invaded this region from the north and covered it with drift, the surface of the country had been eroded so as to produce divides and valleys much like those of the present, though not agreeing with them in position or slope. Many such valleys (see fig. 11, p. 9) traversed areas that are now unbroken upland prairies with no surface indications of their presence, and in such localities the drift is thickest. Near Colchester and near the southern border of the Macomb quadrangle the drift averages only 30 to 50 feet thick; but 8 miles south of Colchester, 1 to 4 miles south of Macomb, 5 miles southeast of Bardolph, and 5 miles east of Industry wells penetrated 180 feet of drift without reaching its base. Pleistocene deposits are more than 100 feet thick in many places over the preglacial lowlands shown in figure 11.

KANSAN (?) DRIFT.

No till older than Illinoian was positively identified in outcrops, though a few exposures in the northwest quarter of the Colchester quadrangle may be of Kansan age. The differentiation of the Illinoian and the earlier drift sheets in this part of the Mississippi Basin is very difficult, owing in part to the fact that the later drift contains material derived from the earlier. In wells on the upland logs, twigs, and other vegetal matter are reported, with pebbly drift clay both above and below. Some, at least, of these vegetal deposits and some of the thick sand layers found in other wells are probably interglacial, and the pebbly clay below them is therefore probably older than the Illinoian till above. In the vicinity of Spring Creek some glacial till was found beneath quartz sands similar to the pre-Illinoian interglacial sands outcropping in that district, but not where interglacial soils were present. These till exposures are not certainly pre-Illinoian, as frozen lenses of the interglacial sands were transported short distances by the Illinoian ice and were left surrounded by Illinoian till.

Any pre-Illinoian till that may be found in the district is probably Kansan and not part of an older drift sheet, for it is known that Kansan ice once covered the region, whereas older drift has not yet been identified southeast of Fort Madison, Iowa. Definite proof is, however, lacking.

YARMOUTH (?) SAND AND SOIL.

At several places in the quadrangles a thin but clearly defined old soil is overlain by Illinoian till and invariably underlain by orange-colored sand. The soil and underlying sand deposits are thought to have been formed during one of the interglacial stages that preceded the Illinoian ice invasion, probably during the Yarmouth, as indicated by general considerations, the absence of advanced weathering, and the relations of the deposits. The writer's opinion on this subject was confirmed by Leverett,[1] who visited a few exposures late in 1913.

The significant features are most clearly shown in the northwest corner of the Macomb quadrangle (see fig. 9), where the

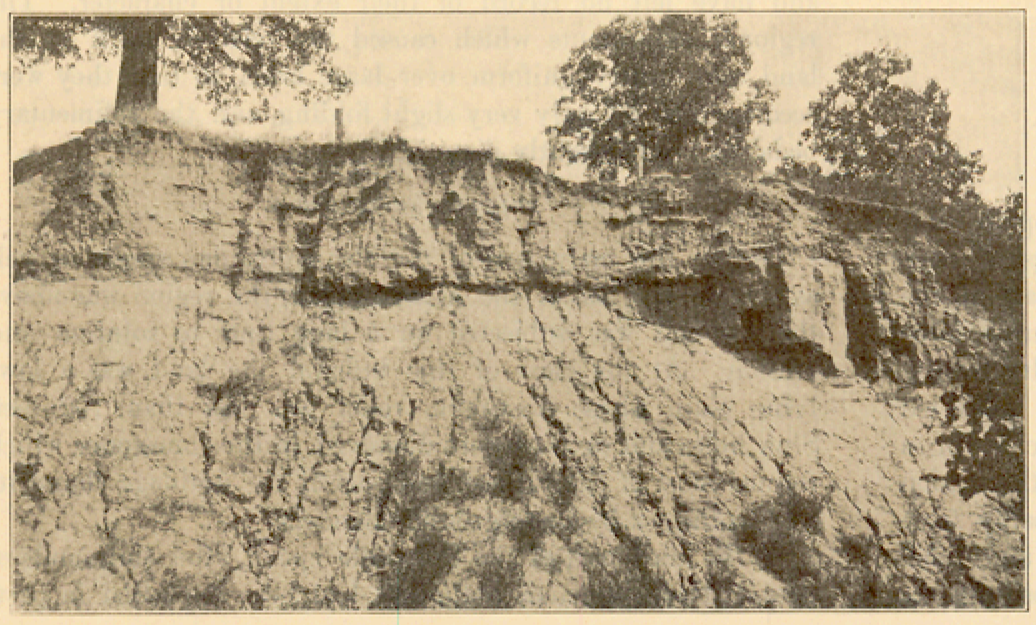

FIGURE 9.—Exposure of Yarmouth (?) orange-colored sands (in slope) separated from Illinoian till (at top) by thin soil zone in road cut near Spring Creek.

following section is exposed in a deep road cut on Spring Creek, in the SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 28, T. 6 N., R. 3 W.:

Section of Pleistocene deposits northwest of Macomb.

	Feet.
Illinoian:	
Clay, pebbly; till; small pockets of sand	7
Yarmouth (?):	
Zone containing very thin streaks of black muck with fragments of plants	2
Sand, orange colored, dirty white, yellowish; small and uniform grains; few pebbles, distinctly stratified in places and in part cross-bedded; partly cemented in places	31
Interval; sand at top and probably in middle; bluish silty sand at base; to Spring Creek	17

The zone of soil or muck near the top of the section has rather distinct upper and lower boundaries and consists largely of clay but contains lenses of sand near its base. It is horizontal in the northern part of the exposure but dips down at the east end and is irregular on the south side of the road. A short distance up Spring Creek, in the same quarter section, 19 feet of gray and red clay outcrops beneath the orange-colored sand. The sand may be traced farther up Spring Creek, and in the road a quarter of a mile south of the center of sec. 21 it is 14 feet thick, contains small crystalline pebbles of northern derivation, and is so well consolidated as to resemble a conglomeratic sandstone. The orange-colored sand also extends more than a mile south and southeast of the deep road cut, appearing beneath Illinoian till in many of the small valleys in secs. 27, 28, 33, and 34. In places there is variegated clay beneath the sand; in other places pockets of sand appear to have been transported and included in the base of the Illinoian drift sheet.

Another suggestive exposure lies beside a small watercourse near Pennsylvania School, southwest of Fountain Green, in the NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 5, T. 5 N., R. 5 W.:

Section of Pleistocene deposits southwest of Fountain Green.

	Feet.
Loess or loesslike silt, yellowish gray, sandy, extremely fine grained	18
Sand, orange to red, coarse, chiefly pure quartz; contains small lenses of black material roughly stratified; slightly cross-bedded (Yarmouth?)	10

A fairly persistent layer of carbonized plant remains and black muck, only a few inches thick, sharply separates the loess from the underlying sand. The loess outcrops at intervals for half a mile up the creek and at the last exposure is separated from Illinoian pebbly till above it by a thin black film of carbonaceous matter. Still further proof that the loess-like material is older than the Illinoian drift is afforded by the Huston well a mile distant, in the NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 5, T. 5 N., R. 5 W., which penetrated 43 feet of very fine slate-colored sand, "like Portland cement," under 150 feet of blue pebbly clay.

Thin interglacial soils are rather poorly exposed at several other localities in the Colchester and Macomb quadrangles and are reported from several wells. Small outcrops of orange-colored sands similar to those that underlie old soils, and therefore probably also pre-Illinoian, are very common, especially in the eastern third of the Colchester quadrangle, along tributaries of Troublesome Creek near Fandon, and in the southeastern part of the Macomb quadrangle. Illinoian ice and the waters accompanying it transported and redeposited some of this sand, so that portions of the basal Illinoian drift are sandy and slightly reddish, and lenses of orange-colored sand are embedded in till. In the head of a draw just east of the center of sec. 26, T. 6 N., R. 5 W. is an exposure of at least 25 feet of white and yellow pure quartz sand, whose relations are not quite clear. In the Gilliam well on the upland near Fandon, in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 6, T. 4 N., R. 3 W., 100 feet of sand was penetrated under 37 feet of pebbly drift, and much sand was also encountered in the Miller well half a mile southeast. Considerable sand was reported from wells in the quadrangles, but in most of them it was impossible to distinguish between interglacial deposits and sand pockets in the drift.

Exposures of Yarmouth (?) interglacial deposits have so little areal extent that they are not mapped separately but are included with the Illinoian drift.

ILLINOIAN DRIFT.

Except the thin mantle of loess, the deposit which forms the surface of the entire upland area and a large proportion of the slopes is Illinoian drift. The upper surface of the Illinoian—that in contact with the loess—is remarkably even, but the lower surface conforms to the uneven topography developed by erosion before the advent of Illinoian ice. The thickness of this drift sheet is therefore very irregular. The impossibility of distinguishing between the different Pleistocene deposits in most of the well records obtained prevents the exact determination of the thickness of the Illinoian in most areas, and it can only be estimated from the thickness of the Pleistocene as a whole. In general, however, the Illinoian includes practically all the Pleistocene where the latter is comparatively thin and most of it where it is thick, except in a few localities in which interglacial sand is exceptionally thick.

The Illinoian drift consists chiefly of till, though it includes numerous pockets or lenses of sand, especially in its lower part. The till is a yellow or yellowish-brown clay for 20 feet or more near the surface but changes to blue clay at greater depths where it has not been oxidized. Some surprising departures from this general rule occur, however, for in some places blue clay appears close to the surface and in others the blue and yellow phases alternate to considerable depths. In parts of the quadrangles the till is made reddish and sandy by material derived from the Yarmouth (?) deposits.

The clay contains scattered pebbles, like plums in pudding, and boulders. Many of the pebbles are angular on one or more sides and some are striated. The boulders are not very plentiful, and most of them are small, few measuring more than a foot and the largest only 6 feet across. Many of the boulders are striated.

There is very little limestone among either the pebbles or boulders in the upper 8 to 10 feet of till. Below this leached zone the till is calcareous and contains limestone pebbles. Sandstone and other material of local derivation occurs plentifully only south or southwest of preglacial ridges or hills, in situations which indicate that it was not moved far by the ice. In most exposures probably 70 per cent or more of the pebbles and boulders are of siliceous varieties, such as are common in the Lake Superior region. Of 139 pebbles exceeding half an inch in diameter, collected from leached till at the base of the Illinoian drift, 3½ miles northwest of Macomb, 80 were jasper, flint, or chert, 36 quartzite, 12 greenstone, 6 granite, 4 sandstone, and 1 schist. Part of these, as well as much of the basal Illinoian till in the region, was probably derived from Kansan drift that was overridden by Illinoian ice.

In the northern part of Eldorado Township, near the eastern boundary of the Macomb quadrangle, a long, narrow ridge, the highest point of which is about 700 feet above sea level, rises 15 to 30 feet above the surrounding prairie. It is a rather conspicuous feature in an area that is otherwise so flat. No wells have been driven more than a few feet into it and there are no natural exposures of the rocks composing it, so that its constitution is unknown. It lies, however, with its long axis parallel to the direction in which the Illinoian ice advanced and is probably drumloidal. Other more or less similar low ridges have been described by Leverett in the territory just east of the quadrangles. Very low hills with irregular outlines rise slightly above the general prairie level in the area southeast of Macomb, between that city and Troublesome Creek.

TERRACE DEPOSITS.

West of Macomb rather sandy silt covers the slopes on the south side of East Fork as high as 650 feet above sea level, and here and there small remnants of one or more terraces appear. These terraces were probably formed during the interval that elapsed between the retreat of Illinoian ice and the end of Pleistocene time, while the deepening of this part of East Fork was checked by the resistance of sandstone beds near Colchester which lie at comparatively high altitudes. The terraces have been almost entirely destroyed, and their constituents have been spread over the slopes below.

Other reworked terrace deposits of probable Pleistocene age form a thin veneer over the slopes on the upper part of East Fork and other streams, but their boundaries are so indistinct and they are so obscured by loess that they are not mapped.

LOESS.

The loess mantles practically the entire region. On the uplands it averages 5 to 10 feet in thickness and conceals the underlying Illinoian till. On the upper parts of the valley slopes it is as thick as on the uplands, but near the stream levels it is a mere veneer. Plant material has changed the upper part to a dark soil. At most places, especially on the uplands, no well-developed soil line or pebbly zone lies between the loess and the drift, though here and there both the upper part of the till and the lower few inches of the loess show red stains due to oxidation. The gradation from loess to till is well shown in the clay pits at Industry, Littleton, and on the western edge of Macomb. No change in the chemical or physical behavior of the clay has been noted by clay-workers in passing from the pebbleless loess at the top through clay containing a very few pebbles down into till with abundant pebbles.

The loess is commonly dirty yellow but is in places blue-gray. It is a very sandy clay, composed of very fine particles, and is characterized by a uniform texture and a coherency that cause it to stand for a long time with vertical faces in stream or artificial cuts. It is only slightly calcareous in this region. The loess on the valley sides seems coarser and more porous than that on the upland prairies.

Geologists now generally agree that most of the loess was deposited by wind. There is no good evidence that the loess in the Colchester and Macomb quadrangles was water-laid; on the contrary, its distribution and character strongly suggest the action of wind. The common occurrence of loess in the lower parts of stream valleys that were evidently excavated in comparatively recent time indicates that some of this eolian deposition has continued since Pleistocene time, for many of these deposits are so situated that they could not have washed or slumped down from loess lying on the upland or on the upper parts of the valley slopes. The relations of the loess to different drift sheets in other areas, however, show that much of it was laid down before the Wisconsin glacial stage. The writer believes that the deposition of loess by wind has continued more or less intermittently in this region from the retreat of the Illinoian ice to the present day.

RECENT SERIES.

ALLUVIUM.

Alluvium has been deposited along most of the streams, even near their headwaters and on the smaller tributaries. It is composed of dark plastic clay derived largely from the erosion of till and loess. Along the smaller streams the alluvium is only about 10 feet thick and 200 or 300 feet wide. Along Crooked Creek the alluvial flats are in places a mile wide and rise 20 feet above low-water level. At some points near the main streams, as at St. Mary and below Birmingham, where there are recently abandoned flood plains known as second bottoms, the alluvial deposits are more than 30 feet thick.

STRUCTURE.

STRUCTURE CONTOURS.

Delineation.—In a region like western Illinois, where there are no steep dips or complicated folds, the altitude of strata is best shown by lines called structure contours. These lines are drawn to represent the position of some important stratum and are so constructed that all points on a given line correspond in position to points on the chosen stratum that lie at equal elevations above sea level. Each contour therefore marks the intersection of the stratum with a horizontal plane having a certain altitude.

Use.—On the geologic maps of the Colchester and Macomb quadrangles structure contours representing vertical intervals of 20 feet are drawn on the base of the Murphysboro coal bed as a key stratum. In order to determine the depth from the surface

[1] Leverett, Frank, personal communication.

to this coal bed at any point where a surface contour is crossed by a structure contour it is only necessary to subtract the altitude of the coal, as shown by the structure contour, from the altitude of the surface, as shown by the contour in brown. At points between structure contours the altitude of the coal is intermediate between that shown by the contours on either side. Similarly the altitude of any other stratum, above or below the coal, may also be determined by adding or subtracting, respectively, to or from the altitude of the base of the coal the vertical interval (shown in the stratigraphic sections on p. 2) between the coal and the stratum.

In addition to showing the depth and the altitude of any stratum, structure contours necessarily delineate the main features of the structure and the direction and the steepness of the dip. The dip in feet per mile can be read directly from the map; the dip in degrees can be calculated, but it is usually so small in this region as to be of no practical value. Undulations of less amplitude than the contour interval can not be shown.

Accuracy.—Errors in delineating structure may arise from inaccurate determination of the altitudes of outcrops, shafts, and borings, from insufficient data, and from irregularity in stratigraphic intervals.

The topographic maps of the Colchester and Macomb quadrangles are modern and accurate and show numerous bench marks. With such maps it is possible to hand-level from points of known altitude to almost any point whose altitude it is desired. Errors arising from inaccurate determination are so small as to be negligible for most purposes.

Where there are few outcrops of indurated strata and few wells, borings, or shafts that have penetrated beds whose stratigraphic horizon may be determined, it is obviously impossible to delineate the structure accurately. Outcrops and borings are fairly numerous in most of the Colchester quadrangle. In part of the Macomb quadrangle, however, conditions are different; for there are only three or four outcrops in Chalmers, Scotland, Mound, New Salem, and Eldorado townships, and very few borings have been sufficiently deep to reach indurated strata. In these townships, therefore, the structure contours are much generalized and may be in error 30 or 40 feet vertically. Dashed lines are used for structure contours where data are insufficient.

to it on the northeast is the Lamoine structural terrace, which includes a small area of nearly level beds, in which accumulations of oil have recently been discovered. Plymouth is built on a similar terrace, and a larger one lies west of St. Mary. The structure of outcropping rocks in this region is a reliable guide to at least the larger structural features of lower beds.

In the greater part of the quadrangles the strata lie very nearly level over large areas. South, north, and west of Tennessee the beds at the horizon of the Murphysboro coal lie practically level for long distances; in the southern third and probably in all but the northwest quarter of the Macomb quadrangle, also, they change very little in level.

Many minor irregularities are too small to affect the position of the structure contours. These small wavelike rolls are especially common in Pennsylvanian strata and are apparently due to unequal settling of the clays of the Pottsville formation and other sediments and perhaps also to deposition upon a slightly uneven surface. Such features are particularly noticeable in coal mines, where the underground haulage is made difficult by even very slight dips. The structure is rather exceptional near Industry, where the coal in old workings close to the Ellis shaft, in the SW. ¼ NE. ¼ sec. 16, T. 4 N., R. 2 W., dips 17 feet to the north or northwest in a distance of only 100 yards. Faults are rare and none of more than 2 feet vertical displacement was seen or reported.

GEOLOGIC HISTORY.

PALEOZOIC ERA.

EARLY PERIODS.

The only information concerning pre-Mississippian time obtained in these quadrangles is deduced from logs of deep wells, which furnish a record of only the early part of the Ordovician period. The rock exposures in other areas, however, show that the central Mississippi basin was dry land at the beginning of the Paleozoic era and had been subjected to erosion by streams and other denuding agencies for a very long time. Late in the Cambrian period the region was gradually submerged by a sea, advancing probably from the south, in which thick deposits of sandstone and limestone, chiefly sandstone, were laid down on a subsiding sea

the sea floor was furnished by crinoids and other lime-secreting organisms which flourished at that time. This deposition of limestone-forming materials continued through the Burlington and Keokuk epochs but was interrupted for a comparatively short time while the muds that became part of the Spergen and Warsaw formations were laid down. In neighboring regions, and perhaps also in this one, there is evidence of emergence and slight erosion during and succeeding the Spergen and Warsaw epochs. The life of these epochs was characterized by great numbers of branching and lacelike bryozoans, which, although delicate in structure, were the chief constituents of some thin limestones.

The last record of the Mississippian epoch left in the rocks of the region is the St. Louis limestone, during whose deposition the waters were fairly clear, though probably shallow. It appears probable that in this area much of this limestone was formed in low reefs and tidal flats by lime-secreting organisms. Waves broke off masses of the calcareous growths and piled them as talus accumulations around the reef margins, where alternating solution and precipitation firmly cemented them in a homogeneous matrix.

Late in the Mississippian the continental interior sea shrank and finally withdrew from the whole central Mississippi basin. Just when it left the Colchester-Macomb region is unknown, as the last strata formed were afterward removed by erosion and have left no record of their extent or character. The regional movements which caused the relative uplift of the land were nearly uniform over large areas, so that they were accompanied by only very slight folding, and the sedimentary beds were only slightly disturbed.

PENNSYLVANIAN EPOCH.

During the early part of the Pennsylvanian epoch, as well as during the last of the Mississippian, the region was above the sea and was subjected for a long time to solution and erosion. At the close of this interval the land was a low-lying plain whose maximum relief was less than 100 feet. Sink holes and caverns were dissolved in the limestones which formed most of the surface, and part of the drainage found its way to the sea by underground channels.

In the later part of the Pottsville epoch, after thousands of feet of Pennsylvanian sediments had been deposited in parts

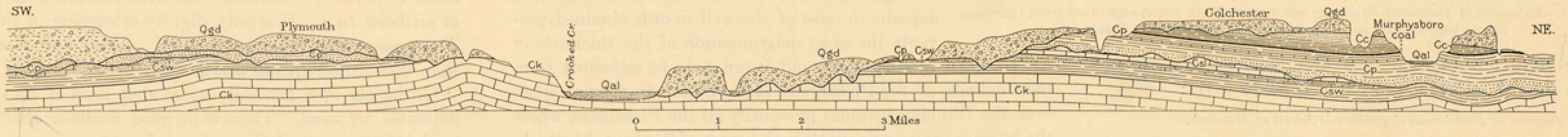

FIGURE 10.—Generalized cross section in the Colchester quadrangle through Plymouth and Colchester. Shows the eroded Colmar anticline between Plymouth and Crooked Creek.
Qal, Alluvium; Qgd, glacial drift; Cc, Carbondale formation; Cp, Pottsville formation; Csl, St Louis limestone; Csw, Spergen and Warsaw formations; Ck, Keokuk limestone. Vertical scale, 25 times the horizontal scale.

A source of error in this region is irregularity in the stratigraphic section. The structure contours are based on the altitudes of three horizons—the Murphysboro coal bed itself, the base of the St. Louis limestone, and the top of the Keokuk limestone. In districts in which the coal has been removed by erosion it is assumed that the Murphysboro horizon lies at an average distance of 75 feet above the base of the St. Louis limestone and 125 feet above the Keokuk limestone. Although there are unconformities between these limestones and the coal, all the available evidence points to the essential parallelism of Mississippian and Pennsylvanian beds, and it is thought that no serious errors may be due to unconformities. In a number of sections measured the distance from the coal to the base of the St. Louis varied only from 65 to 78 feet. The irregularity in the vertical distance between the St. Louis and the Keokuk limestone—from 20 to 70 feet—may lead to greater errors. Recent drilling has shown that the Hoing oil sand, which lies at the base of the Silurian system, is also parallel, in a broad sense, with higher beds. The interval between this sand and the Murphysboro horizon is only 535 feet south of Industry and is as much as 640 feet southwest of Birmingham; elsewhere the average interval so far as known, is about 590 feet. The altitude of the Hoing sand is used in determining the position of the Murphysboro bed east, west, and south of Colmar, in the Colchester quadrangle, where other evidence is lacking or uncertain.

Probably no large errors have been made in the contours for the districts in which the Murphysboro coal and the stoneware clays of the Pottsville formation lie below the surface.

STRUCTURE OF THE QUADRANGLES.

The dominant structural feature in the quadrangles is a well-defined anticline between Plymouth and Colmar (see fig. 10) and a general dip southeast toward the center of the basin in central Illinois. There is also a smaller dome near Macomb. The maximum range in altitude of the key horizon is from 750 feet on the Colmar anticline to 570 feet near the headwaters of Sugar Creek and on Camp Creek northwest of Industry, a dip of 180 feet in about 14 miles. The strata rise gently to the crest of the Colmar anticline, no dips being sufficiently strong to be evident in individual outcrops. Close

floor. The formation of the lowest rocks penetrated in the quadrangles began after the deposition of about 1,500 feet of such strata.

During the early part of the Ordovician period the sea became clear and thick beds of limestone were formed. Later, however, a homogeneous and widespread deposit of sand—the St. Peter—was made and reworked by water and wind. Later still the conditions again became suitable for the formation of limestone, and finally the period was closed by the deposition of the muds that are now the Maquoketa shale. At least parts of the central Mississippi basin were land areas just preceding the formation of both the St. Peter and the Maquoketa. At the close of the Ordovician the sea withdrew from the region, and erosion acting on the low-lying land which made its appearance caused the removal of some of the last Ordovician beds deposited.

During early Silurian time the sea shifted back and forth in southern Illinois but did not return to west-central Illinois until about the middle of the period. The Silurian sea contained abundant animal life, which aided in the production of thick beds of limestone. Later in the Silurian the sea withdrew, not to return until after about half of the Devonian period had elapsed.

The first deposits of the Devonian sea in this region were limestone. Muds were laid down later, but the sea gave place to the land both before and after their deposition. In each of the intervals during which the region was above water and exposed to the action of erosive agents, part of the sediments previously formed were washed away. As a result the rocks now underlying the region do not constitute a complete record of the deposition that took place during submergence, and parts of the geologic history are obscure.

CARBONIFEROUS PERIOD.

MISSISSIPPIAN EPOCH.

Early in the Mississippian epoch a widespread submergence began in the continental interior. The first Mississippian sediments were muds that now form the shale of the Kinderhook group. When less material was contributed by surrounding land areas a greater proportion of the accumulations upon

of the Appalachian trough and in Arkansas and Oklahoma, the sea slowly advanced toward the region from the south and southeast, the subsidence taking place without notable warping, folding, or faulting. Along its beaches sands spread by the waves filled the depressions in the subsiding land surface. At about this time another sea, which had been advancing across Missouri from the west and southwest, united with that in the Illinois basin around the northern end of the Ozarks.

Near the close of the Pottsville, when the neighboring lands became relatively lower and contributed a smaller proportion of coarse material, sandy muds and clays became the prevailing types of deposit. The conditions of sedimentation were not so stable as they had been in most of the preceding epochs, however, and the deposits formed are conspicuously lacking in vertical homogeneity. Nevertheless, some very thin deposits had a remarkable horizontal range, indicating that conditions were uniform over wide areas for comparatively short intervals. At times parts of the region were above water, and rather small marshes became the habitat of vegetation that afterward formed coal beds.

Soon after the beginning of the Carbondale epoch vegetation flourished on very low lying land in a remarkable swamp that covered much of central and southern Illinois, northern Missouri, and adjacent areas. After the accumulation of many feet of peat, now compressed and modified to form the Murphysboro coal bed, a rapid incursion of salt or brackish water from the sea killed the vegetation and brought in silt and mud. A change in ocean currents or in the relations of neighboring lands to the region then caused deposition of sand and sandy mud in more or less disturbed waters.

As only the lower part of the Carbondale sediments have been spared by subsequent erosion, there is no sedimentary record in this region of the last part of that epoch or of the McLeansboro epoch, which closed the Pennsylvanian. It is known, however, that deposition similar to that of the earlier Pennsylvanian continued for a long time, the region lying under a very shallow sea part of the time and just above sea level during shorter intervals. The sea withdrew near the end of the Pennsylvanian epoch and has never returned to the region.

MESOZOIC ERA.

The disturbances which caused the withdrawal of the sea near the close of the Pennsylvanian continued during the remainder of the Paleozoic era and into the early part of the Mesozoic era. In many parts of the world these earth movements were profound; they resulted, for instance, in uplift of the Appalachian Mountains on the east and of the Ozark and Ouachita mountains on the southwest. The Colchester-Macomb region, however, was not much disturbed and was left as a nearly level plain without notable topographic features.

The region was a land area subjected to erosion during the whole Mesozoic era. The first effect of this erosion was the development of valleys and divides and a gradual accentuation of relief. The details are unknown, but in the natural course of events another stage would be begun after the main streams had been graded and their tributaries had cut back far into the divides. In this stage more material would be removed from the higher lands than from the lowlands, and the entire region would be slowly reduced to a more uniform level. Should earth movements result in relative uplift from time to time, however, the last stage would be greatly delayed and might never be reached.

In the Mesozoic and Cenozoic eras several relative uplifts affected the Appalachians, the Ozarks, and other more or less mountainous regions. The effects of these movements probably extended in some degree to the Colchester-Macomb region, though the absence of much folding in that region indicates that the changes there were slight.

CENOZOIC ERA.

TERTIARY PERIOD.

The history of early Tertiary time in this area can be roughly inferred from that of other parts of the continent. Some sand deposits on the upland southwest of the quadrangles are thought to be of Tertiary age, but they were probably laid down on the land and not in the sea. At some time late in the period the last stage of an erosion cycle was reached, and the area was reduced to a practically level plain. Later the streams were rejuvenated, and valleys were being deepened when the ice invasions of the Quaternary period developed a new topography.

The general character of the topography at the end of the Tertiary and the beginning of the Quaternary is revealed in the configuration of the bedrock upon which the glacial and interglacial deposits lie. The surface at that time was somewhat more uneven than that of the region today, and the maximum relief was more than 280 feet. Broad lowland areas, in which flowed the principal streams, lay east and west across the middle of the quadrangles and across districts that are now in greater part upland prairies. (See fig. 11.) Some of the valleys were deeper than any at the present time, as shown by two wells west of Shanghai School, in Lamoine Township, which did not reach bedrock at a depth of 400 feet. The principal upland areas were nearly flat plains in the northeast quarter of the Colchester quadrangle and the southwest quarter of the Macomb quadrangle, where the preglacial surface averaged only 30 to 40 feet below the present upland. The country near Plymouth and small areas elsewhere were also comparatively high.

QUATERNARY PERIOD.

PLEISTOCENE EPOCH.

During the Quaternary period at least four and perhaps five great continental glaciers extended southward into the northern States from their centers of accumulation in Canada. Each of these picked up and transported great quantities of clay, pebbles, and boulders. Part of this drift lodged here and there beneath the ice along the way, and the rest was deposited when the ice melted. As much of the glacial débris was left in the old valleys and the ice action tended to lower hills, the topographic effect of glaciation in most areas was to smooth out irregularities.

It is not known that the first great glacier ever reached the Colchester-Macomb region, though it covered part of Iowa. One of the early glaciers, probably the second, the Kansan, invaded western Illinois from a little west of north and is known to have crossed the quadrangles, though its effect upon their surface may not have been profound. During the interglacial stage that followed the melting of the Kansan ice, the drift was in part removed by erosion, and sands, perhaps derived from Tertiary remnants not far distant, were left in the main valleys. This stage, known as the Yarmouth, probably continued for as long a time as has elapsed since the region was last freed from ice. Plants flourished and developed a soil, some of which is still preserved.

The third glaciation, the Illinoian, gave to this region its chief topographic characteristics. The ice came from a center in Labrador, bringing with it pebbles of rock common in that and intermediate territory and picking up and redepositing much of the material brought in by the Kansan glacier. The Colchester-Macomb region is near the western limit reached by the glacier, where the direction of ice movement was S. 60° W., as shown by fine striae on bedrock in the NW. ¼ SW. ¼ sec. 24, T. 4 N., R. 4 W. The effect of Illinoian glaciation was to fill up the valleys existing in Yarmouth time and to leave the region a nearly featureless plain. This plain was not absolutely flat, however, for the present relief of the upland surface is probably much the same as it was at the end of Illinoian time. The low prairies near Colmar, St. Mary, and in the vicinity of some other parts of Crooked Creek are probably little lower now than then, though they are 150 feet lower than the upland several miles north of Colchester. The main drainage of the region after the retreat of the ice took advantage of this surface slope and escaped by way of Crooked Creek.

Streams flowing under the ice toward its front, and consequently in the direction of glacial movement, eroded shallow valleys. One of the largest of these streams appears to have flowed S. 65° W. in a remarkably direct line from Bushnell along the site of the present valley of East Fork to Crooked Creek, thence along that of Middle Creek (reversed) to the divide between the drainage of the Illinois and the Mississippi. In its passage across this divide it cut a valley fully 40 feet deep and more than half a mile wide, now known as the "Big Meadow."[1] The valley continued down Big Meadow Creek to a headwater tributary of Bear Creek, thence down the course of that creek (reversed) to the divide between it and the Mississippi, and down Rock Run to the Mississippi. East Fork of Crooked Creek, Cedar, Troublesome, Camp, and Grindstone creeks, and many smaller streams now flow approximately in the direction of movement of the Illinoian glacier and have developed a remarkable parallelism of drainage. (See fig. 11.) These streams evidently took advantage of depressions produced during glacial occupation perhaps in whole or in part by subglacial streams.

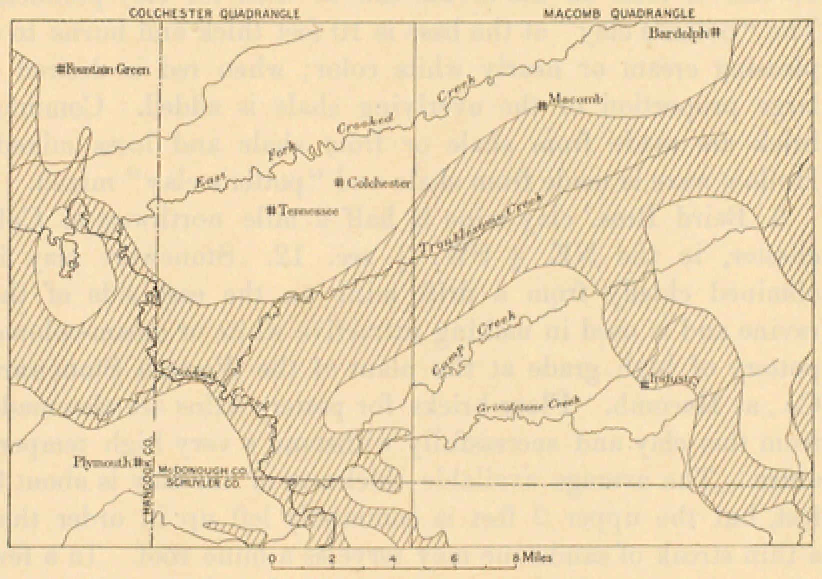

FIGURE 11.—Sketch map of Colchester and Macomb quadrangles showing generalized preglacial topography.

Unshaded areas represent uplands of the bedrock surface now 550 to 680 feet above sea level; shaded areas represent lowlands of the bedrock surface now less than 550 feet above sea level.

The region was not again glaciated after the Illinoian ice disappeared, although at least one other ice invasion affected territory not far north. During the remainder of the Pleistocene epoch the greater part of the present drainage system was developed and most of the loess was distributed by winds.

RECENT EPOCH.

The deepening, widening, and lengthening of the valleys continued during the Recent epoch to the present time. Nearly 55 per cent of the surface of the quadrangles still remains much as it was left by the last invading glacier, though solution has tended to lower it all slightly and deposition of loess to raise it a few feet.

Although the streams that began the work of erosion on the drift-covered prairie were at first on equal terms as regards the material they excavated, those which crossed preglacial hills soon reached hard rock and thereafter cut more slowly and in narrower valleys. A conspicuous example is East Fork, which first flows in a broad valley with gentle sides cut mostly in drift and then enters a deep, narrow valley north of Colchester, where it first encountered an exceptionally high preglacial upland. Other conspicuous examples of the restricting effect of indurated rocks on the width of valleys may be seen in several places along Crooked Creek. A small but striking example is furnished by Panther Creek, for the stream flows through a narrow valley with rock walls except in the SE. ¼ sec. 29, T. 4 N., R. 5 W., where broad bottom lands mark the crossing of a preglacial channel now filled with unconsolidated materials.

At least one interesting case of stream piracy has probably occurred in the Recent epoch. Just northeast of Scott Church, in Bethel Township, a low divide rises only about 20 feet above the level of Camp Creek. West of the divide is a valley too wide to have been excavated by the small stream in it, even if the stream followed the course of an ancient valley buried in glacial drift behind a dam of hard rocks. Until drained by a ditch recently the broad part of this valley contained a swamp in which water was in places waist-deep. It seems clear that Grindstone and upper Camp creeks formerly lay north of Scott Church and flowed westward through this valley until they were captured by what is now the lower part of Camp Creek and their waters were diverted to the southwest. Other stream captures will occur in the near future (near in terms of geologic time), for the present drainage network is far too young to have become well adjusted to the present topography.

[1] Leverett, Frank, The Illinois glacial lobe: U. S. Geol. Survey Mon. 38, p. 481, 1899.

MINERAL RESOURCES.

The chief mineral resources of the Colchester and Macomb quadrangles are clay and shale, coal, oil and gas, stone, sand, and lime and cement materials. Water is easily obtained nearly everywhere. Iron, zinc, and other metals are comparatively unimportant.

CLAY AND SHALE.

STATUS OF THE CLAY INDUSTRY.

Coal mining was formerly the chief mineral industry of the region, but during recent years the mining and manufacture of clay has increased until the annual output of clay products is now valued at more than half a million dollars. Macomb is one of the principal clay-manufacturing centers of the State, and Colchester is one of the best-known clay-mining localities. Some of the clay and shale mined from the Pottsville formation is shipped to Monmouth and other places, but by far the greater part is utilized in the large plants at Macomb.

Draintile and common brick were made at Colchester and elsewhere at an early date and are still made for local use in plants at Colchester, Macomb, and Industry. Shops were erected at Bardolph in 1870 for the manufacture of crocks, jugs, jars, and other stoneware and about 1875 for the making of draintile, common brick, and fire brick. Brick and pottery were produced at Tennessee for a number of years. No clay products, however, are now made at either Bardolph or Tennessee.

Five large plants at Macomb are now burning clay and shale from Colchester and Macomb. The Macomb Sewer Pipe Co. ships annually about 3,000 cars of sewer pipe, water pipe, culvert pipe, and similar products from two large plants in which a total of 32 downdraft kilns are in operation. The Western Stoneware Co. operates two large plants for making jugs, jars, crocks, and other stoneware pottery. The Buckeye Pottery Co. also ships considerable quantities of stoneware pottery. The Illinois Electric Porcelain Co. has a plant for making insulators and other electric supplies. Some sagger clay from the Johnson farm, near Colchester, is the only local material it uses, kaolin being obtained from Georgia, ball clay from the State of Tennessee, ground silica from Oregon, Ill., and feldspar from Maine and Canada.

Although the clay industry is flourishing and produces a great variety of stoneware pottery, it has not yet utilized all the raw materials available. Tests of clay and shale from near Macomb, Colchester, and Tennessee indicate that some of the Pottsville deposits can be used for terra cotta, paving brick, and No. 2 fire brick, articles which are not now produced and for which a market might be found or made.

SOURCES AND CHARACTERISTICS.

The clay products are made from materials derived from three formations—(1) common brick and tile from loess and glacial drift; (2) brick, tile, and silo blocks from shale in the Carbondale formation; and (3) stoneware, sewer pipe, and similar articles from clay and shale in the Pottsville formation. The Pottsville deposits are by far the most valuable. Some of the blue Mississippian shale is supposed to be valuable, but most of it is too calcareous to compete with the better materials of Pennsylvanian age.

LOESS AND DRIFT CLAYS.

Two tile and brick plants near Colchester use a mixture of surface materials and Pennsylvanian clay and shale. Two yards in the Macomb quadrangle and one at Littleton, just beyond its southern boundary, supply the local demand for common brick and draintile by burning the surface deposits alone. The loess, which overlies all other deposits on the uplands and on by far the greater part of the valley slopes, is a fine-grained sandy clay, buff to gray in color and 5 to 20 feet thick. It is uniform in its physical features, though it is somewhat coarser and more sandy on the slopes of the main valleys than on the uplands. The loess contains small round iron-bearing concretions, which aid in giving the product a deep-red color, and local segregations of calcium carbonate, which change to lime in burning and afterward tend to slack and swell, causing the surface to spall or peel off if the lime is in large pieces. The burning shrinkage of the upland loess is high, so that careful burning is essential to prevent cracking. In spite of these drawbacks, however, fairly good common brick and tile can be made from the loess, and its widespread distribution makes it available for use practically everywhere. Glacial till could also be used in the same way but for the number of pebbles it includes.

Price & Gunning have a small two-kiln brick and tile factory in the north part of Industry, in the SW. ¼ NE. ¼ sec. 15. Surface materials from a pit beside the factory are used. The upper foot exposed in the pit is a very fine ashy loess; the rest of the deposit is chiefly pebbleless drab to yellow clay. A few pebbles are embedded in the clay in the bottom of the pit and the number increases with increasing depth. Although the pebbleless portion is probably loess and the lower part probably glacial till, the physical appearance and working qualities of the clay are the same. The upper limit of the pebbles differs greatly at different places, and the transition from pebbleless to abundantly pebble-bearing clay is very gradual.

Half a mile west of Macomb, in the NW. ¼ SW. ¼ sec. 36, P. H. Tiernan makes red building brick during the warmer months in four downdraft kilns. The present pit, a few rods north of the yard, shows 2 feet of gray loess at the top and 5 feet of pebbleless clay beneath. The floor of the pit is gravelly till, the gradation between it and the loess being about the same as in the Price & Gunning pit.

SHALE IN CARBONDALE FORMATION.

In many parts of the region the drab shale immediately above the Murphysboro coal is sufficiently thick (see p. 6) to form an important resource, and it is occasionally mixed with Pottsville materials and used for the more common clay products. It could probably be used for making sewer pipe and paving brick, either alone or mixed with loess and with clay from the Pottsville formation. Near Colchester 30 feet or more of clayey shale could be conveniently stripped, and the underlying material could also be used. North of East Fork and in the southern part of the Macomb quadrangle massive sandstone or very sandy shale lies so near the top of the Murphysboro coal that the intervening shale at many places is too thin to be used. Even in the southern part of the Macomb quadrangle, however, there are many exposures of 15 feet or more of clayey shale belonging to the Carbondale formation. In an easily accessible ravine southwest of Industry, in the NE. ¼ sec. 2, T. 3 N., R. 3 W., more than 50 feet of only moderately sandy shale rests on the Murphysboro coal bed.

CLAY AND SHALE IN POTTSVILLE FORMATION.

Practically all the argillaceous sediments between the Murphysboro coal and the basal Pennsylvanian sandstone have been used at one time or another for making clay products, but the most valuable stratum lies at the potter's or stoneware clay horizon just above the sandstone and 30 to 40 feet below the coal. This stratum furnishes all the clay used for making sewer pipe and pottery at Macomb. The following detailed mention of past and present pits, prospects, and mines shows the nature of the deposits where commercial tests have been made.

1. Clay in the Pottsville formation was formerly mined extensively 2 miles west of Bardolph, in the NE. ¼ sec. 22, most of it being taken from an open cut about 60 feet wide and 150 feet long and some of it from drifts. The product was hauled over a tramway to the factories at Bardolph, where it was made into brick, draintile, and pottery. No work has been done at this place for many years, and the clay is now almost completely concealed. Similar clay was found also in the draw half a mile west of Bardolph, but it is said that a trial shaft 70 feet deep at Bardolph did not penetrate it.

2. The largest producer in the region is the Macomb Clay Products Co., whose open-pit work 3 miles northeast of Macomb, in the E. ½ NW. ¼ sec. 20, is removing an entire hill. At present 24 feet of stripping, consisting of 16 feet of loess, 2 feet of gravel and till, 4 feet of white sandstone, and 2 feet of white clay, is removed by a steam shovel and thrown on the dumps. Another steam shovel follows the first and recovers 2 feet of white, rather thin bedded sandstone and 10 to 12 feet of light to dark blue, very sandy, compact clay that rests on dark-blue shale containing clay-ironstone concretions. The base of the clay is 609 feet above sea level and 21 feet above East Fork. The output of the second shovel, except parts of the sandstone that are pitted with numerous specks of weathered pyrite, is loaded on a spur and shipped to the Macomb Sewer Pipe Co.'s plant at Macomb. The stripping shovel can not keep pace with the other, and at times the shortage of raw material is made up with clay from the Johnson farm, near Colchester.

3. For about 20 years clay for Macomb sewer-pipe plants was obtained from the S. Russell farm, a mile north of Macomb, in the NW. ¼ NE. ¼ sec. 25. Large open pits were made, and drifts were run from which was excavated clay that lies about 15 feet above low water in the creek. Work has been so long discontinued that the exposures are now very poor, but Mr. Russell reports the succession to be as follows:

Section on S. Russell farm, a mile north of Macomb.

	Feet.
Shale, replaced by drift on the north	8-25
Sandstone, pure white to light buff, massive, composed of translucent quartz grains	2- 8
Clay, cream-white; a coarse fire clay	4
Clay, variegated; reported a good stoneware clay	8
Coal ("No. 1")	½

4. An abandoned pit 2 miles northwest of Macomb, in the NE. ¼ SW. ¼ sec. 26, is reported to have furnished shale for the paving brick used on certain Macomb streets. The shrinkage is said to have been too high for sewer pipe and similar products. About 21 feet of light-drab to blue shale and a little clay and sandstone is now exposed under 8 feet of loess and till. Near its base (altitude about 610 feet) are 2 feet of black shale and a few inches of coal ("No. 1") and under it a massive sandstone that has been quarried.

5. The Colchester Brick & Tile Co. burns building brick, draintile, silo blocks, and sidewalk pavers in four kilns half a mile north of Colchester, in the SW. ¼ NE. ¼ sec. 12. In the pits on the sides of the ravine beside the plant the following section (illustrated in fig. 12) is exposed:

Section at plant of Colchester Brick & Tile Co., near Colchester.

	Ft.	in.
Carbondale formation:		
Shale, gray	15	0
Coal (Murphysboro)	2	4
Clay, white, calcareous	4	0
Pottsville formation:		
Shale, drab, sandy; contains a few flat concretions of ferruginous sandy limestone in lower half	8	0
Shale, blue and yellow, sandy at top	12	0
Shale, white; has carbonaceous streaks near base	5	0
Sandstone, argillaceous, compact	1	0
Clay ("potter's clay"), gray to blue; has carbonaceous streak near top	10	0
Sandstone, yellowish to bright red, thin bedded	5	0
	63	4

All the argillaceous material shown in the sections and about 10 feet of loess on the divide can be used for clay products. The "potter's clay" at the base is 10 feet thick and burns to a pleasing cream or nearly white color; when red is desired a large proportion of the overlying shale is added. Common brick are made from shale or from shale and loess mixed. Hollow ware is made from shale and "potter's clay" mixed.

6. Baird Bros.' clay mine is half a mile northwest of Colchester, in the NE. ¼ SW. ¼ sec. 12. Stoneware clay is obtained chiefly from a drift mine on the east side of the ravine and is used in making attractive white or cream-colored pottery of high grade at the plant of the Western Stoneware Co., at Macomb. Floor bricks for pottery kilns are also made from this clay and successfully withstand a very high temperature. The average available thickness of the clay is about 8 feet, but the upper 2 feet is commonly left up in order that a thin streak of sandstone may serve as a mine roof. In a few places the clay mined is as much as 12 feet thick. It is dark gray, contains black carbonaceous streaks near the bottom, has subconchoidal fracture, and is nearly free from iron. A layer a foot thick and 2 feet from the bottom is so sandy and firmly cemented that it is usually thrown in the gob.

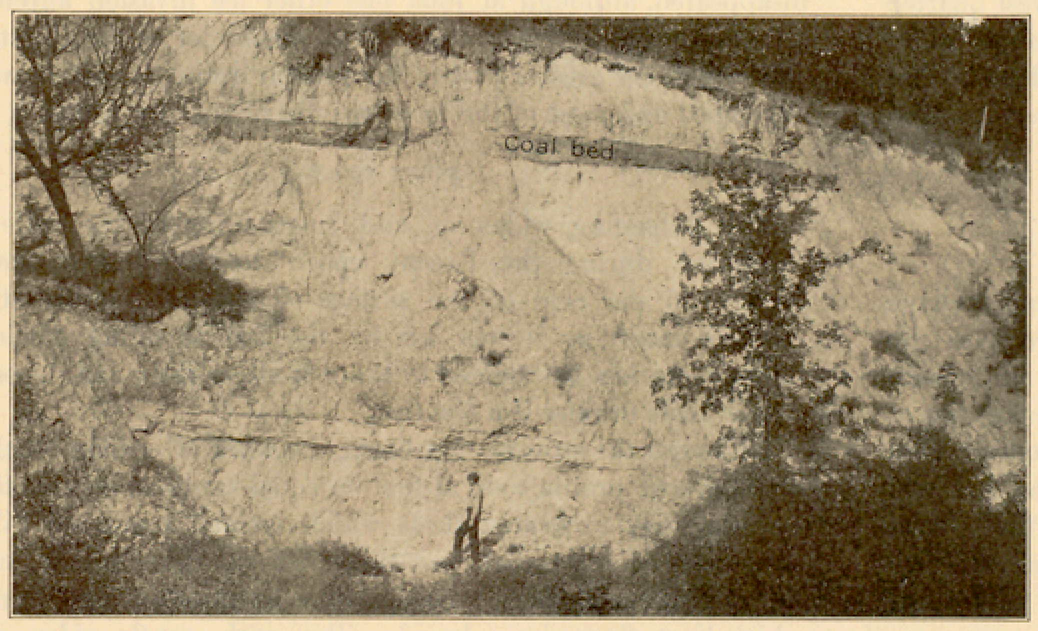

FIGURE 12.—Murphysboro (Colchester or No. 2) coal and underlying beds in pit of Colchester Brick & Tile Co., Colchester.

A few rods down the ravine, on its west side, a short drift and a small strip pit yield material from the base of the stoneware clay to a point within 12 feet of the Murphysboro coal bed. The succession and thickness of the strata at this place are shown by the sections of the Pottsville formation. The shale and clay taken from the strip pit are shipped to Monmouth and made into sewer pipe.

7. The B. F. Myers drift is only a short distance southwest of the Baird mine, on the opposite side of a narrow divide, in the SW. ¼ SW. ¼ sec. 12. The clay in this mine is in every way similar to that at the Baird drift. It is 8 feet thick on the south side and 6 feet thick and of better quality on the north side. The product is shipped to Macomb, where it is used by the Buckeye Pottery Co. for making stoneware pottery.

8. The Northwestern Terra Cotta Co., of Chicago, has prospected and purchased a tract of land a mile northwest of Colchester with the intention of utilizing Pottsville sediments for terra cotta and other clay products but has not yet begun active operations. At their pit in the SE. ¼ SE. ¼ sec. 11 there are exposed 39 feet of clay and shale, including about 3 feet of sandstone. The top of the pit is close to the Murphysboro coal horizon and the bottom is less than 15 feet above the St. Louis limestone.

9. On the farm of Charles Johnson, 2 miles southwest of Colchester, in the E. ½ sec. 23, clay and shale have been obtained by shafting, drifting, and stripping and have been shipped to Monmouth, Macomb, and elsewhere. Sewer pipe is made from a mixture of the shale above "coal No. 1" and the clay below it. Some of the clay below "coal No. 1" can be used alone for stoneware, but clay from parts of the bed must be mixed with other clays before it can be used for that purpose. This clay is said to be the most refractory and plastic in the district. The section exposed in the strip pits in the NE. ¼ SE. ¼ sec. 23 is as follows:

Section on farm of Charles Johnson, 2 miles southwest of Colchester.

	Feet.
Pottsville formation:	
Sandstone, bluish white to brown and deep buff; in places thin bedded and containing shale partings, in others massive (top 20 feet below Murphysboro coal horizon)	8
Shale, drab, sandy at top, clayey below	10
Coal, thickness irregular, average	1½
Clay, white, sandy, indurated	3
Clay, dark gray to blue, slightly sandy	6
Clay, white, sandy, indurated	4
Interval to St. Louis limestone less than	5

10. Some years ago Abraham Newland operated a brick and pottery plant at Tennessee, using material from deposits north of Tennessee and from a shaft sunk beside the railroad halfway between Tennessee and Colchester, in the SE. ¼ SW. ¼ sec. 14, T. 5 N., R. 4 W.

Section in Newland shaft, between Tennessee and Colchester.

	Thickness.		Depth.	
	Ft.	in.	Ft.	in.
Surface deposits:				
Soil and yellow clay	11	0	11	0
Gravel	4	0	15	0
Carbondale formation:				
Shale	16	0	31	0
Shale (Murphysboro)	2	3	33	3
Shale, black, carbonaceous ("slate")		9	34	0
Pottsville formation:				
Clay, reported to make nearly white fire brick of good quality	6	0	40	0
Clay, reported to make good terra cotta, etc.	5	0	45	0
Clay, dark blue, containing limestone boulders	9	0	54	0
Sandstone, clayey, firmly cemented	2	6	56	6
Clay, reported fine quality for stoneware	10	0	66	6
Shale, black, slaty, very carbonaceous	3	0	69	6
Shale, blue	5	0	74	6
Sandstone, dark gray, very firmly cemented	4	0	78	6
Coal	1	0	79	6

Mr. Newland states that practically every bed of shale and clay indicated in this section was used at one time or another. After the Murphysboro coal was mined out and the pillars were pulled, the overlying shale was used for brick and red draintile. The clay that underlies the coal in most places produces good fire brick, although tests of this bed at several other places near Colchester have been unsuccessful. The lower clays appear to have been very similar to those now mined northwest of Colchester.

11. A well recently dug and bored on the land of F. W. Whalin, 2 miles west of Colchester, in the NE. ¼ NE. ¼ sec. 15, penetrated strata nearly identical with those in the Newland shaft. Clay from the stoneware horizon has been taken from this land for use in the plants at Tennessee and elsewhere.

12. Clay was formerly dug by shafting, drifting, and stripping on the farm of J. C. McClure, 1½ miles north of Tennessee, in the SW. ¼ sec. 10, and was hauled in wagons to Tennessee, where much of it was burned and the rest shipped to other points. The sections in the pits are now poor but are reported to comprise 8 to 12 feet of stoneware clay. The clay is underlain by white sandstone that in turn is underlain by the St. Louis limestone. The quantity that could be easily stripped with a steam shovel is large.

13. Lee McClure, in a small clay plant 2¼ miles north of Tennessee, in the SE. ¼ NE. ¼ sec. 3, makes a faintly red draintile from a mixture of loess and clay from the stoneware-clay horizon of the Pottsville. The clay is obtained in the hollow southeast of the plant, in the SW. ¼ sec. 2.

AREAL DISTRIBUTION.

The areal distribution of the shale of the Carbondale formation and of loess and till clays has been described, but that of the high-grade clays and shales of the Pottsville formation deserves additional notice.

In two districts the Pottsville deposits have been proved by commercial developments to be of considerable value. One district includes most of a strip about a mile wide on the north side of the East Fork of Crooked Creek that extends northeastward from the west line of sec. 26, T. 6 N., R. 3 W., to the north boundary of the quadrangle. The area from a quarter of a mile to 2 miles west of Bardolph, on the south side of the creek, is virtually part of the same district. The second district includes strips on both sides of East Fork from a point north of Colchester to one north of Tennessee, and it also includes the divide between Colchester and Tennessee and the deposits on the Johnson farm, southwest of Colchester. These two districts contain sufficient high-grade clay and shale to supply demands for many years to come.

In addition to the two producing districts the clay and shale horizons of the Pottsville formation underlie all the area mapped as containing the Murphysboro coal and a marginal area beyond the limits of that bed. Probably nearly all this area contains the raw materials for many clay products, but as outcrops of the Pottsville are poor or lacking in most of it only systematic prospecting can demonstrate the position of the best deposits. Outcrops ranging from the stoneware clay horizon to 33 feet above the Murphysboro coal bed in the extreme southeast corner of the Macomb quadrangle indicate the absence of pottery material, though shale for commoner clay products is abundant.

In the southwest quarter of the Macomb quadrangle the Pottsville is exposed in a number of places. In general the strata above the horizon of the stoneware clay contain more sandstone than those near Colchester and Macomb, a factor that might be detrimental in extensive stripping operations. The stoneware clay is well exposed in several bluffs on Camp and Grindstone creeks in secs. 11, 15, 23, and 24 (?), and in ravines in the N. ½ sec. 26 and the SW. ¼ sec. 28, all in T. 4 N., R. 3 E. It is likely that careful prospecting would reveal on and near these streams and also on Willow Creek easily accessible deposits that equal in quality and thickness those now being developed near East Fork. The greater the proportion of shale and clay in the section the fewer are the natural exposures, so that the outcrops now visible are hardly fair indices of the real value of the Pottsville in this area. The following section includes material that appears to be especially promising:

Section of Pottsville formation in bluff on Camp Creek in the NW. ¼ SW. ¼ sec. 15, T. 4 N., R. 3 W.

	Ft.	in.
Concealed, chiefly shale and the underclay of the Murphysboro coal bed	10	0
Clay, white and yellow, sandy; has sandstone layer near middle	6	6
Shale, drab, clayey, plastic	9	0
Shale, bluish black, carbonaceous	1	6
Coal ("No. 1")		4
Clay, drab	1	6
Shale, bluish gray, micaceous, very sandy; has iron concretions in places and sandstone lenses near base	3	0
Clay and shale, very carbonaceous near middle	4	0
Clay, yellow and light blue, very sandy; extends to water in Camp Creek	3	0

The clay at the base of this section lies at the horizon of the stoneware clay. Probably its full thickness is shown, as sandstone appears at the creek level a short distance downstream.

LABORATORY TESTS.

In 1908 E. F. Lines, of the Illinois Geological Survey, examined and sampled the clay and shale pits and mines and the best outcrops near Macomb, Colchester, and Tennessee. Tests of the samples, all of which came from the Pottsville formation, were made in the ceramic laboratories of the University of Illinois and showed that the raw clays and shales required 18 to 25 per cent of tempering water and had a drying shrinkage of 5 to 7 per cent and a porosity of 25 to 30 per cent. They behaved well in the burning tests.

Six samples collected in 1904 in the same localities have also been subjected to mechanical and chemical analysis and various burning tests.[1] One sample was fairly fine grained, two were coarse, and the others were of medium grain. None of the samples were very plastic. Briquets made by the "stiff mud" process burned a fine light buff at 1,120° C. and were very porous. All the samples were comparatively low in iron content, and their relative fusibility corresponded or was roughly proportioned to their content of fluxing ingredients other than iron, chiefly SiO_2—which ranged from 56 to 83 per cent—and to their fineness of grain. The tests showed that the clays belong to the refractory group, though the vitrification point is rather low. The tests, as well as actual commercial practice, show that the clays are adapted to the manufacture of stoneware, terra cotta, and No. 2 fire brick, though one sample burned too coarse for use in pottery.

[1] Purdy, R. C., and DeWolf, F. W., Preliminary investigations of Illinois fire clays: Illinois Geol. Survey Bull. 4, pp. 162–165, 1907.

COAL.

OCCURRENCE.

MURPHYSBORO (COLCHESTER OR NO. 2) COAL BED.

The only coal bed of known economic importance in the quadrangles is the Murphysboro, in this area called the Colchester or No. 2, at the base of the Carbondale formation. This bed has an average thickness of 28 inches (see fig. 13) and is at few places more than 5 inches thicker or thinner than the average. It is therefore too thin to compete aggressively with the thicker beds mined in other parts of Illinois. It contains no persistent partings of incombustible matter, but at some places it carries a few short lenses and small nodules of iron pyrites ("sulphur"), films of mother coal, calcite, and gypsum, and streaks of bone an inch or less thick. It is jet-black, except for a few intercalated bands of duller luster, has a hackly fracture, and shows no well-developed vertical or horizontal cleavage. The bed is exceptionally clean and undisturbed, carrying comparatively few horsebacks, clay slips, rolls, or potholes in the roof.

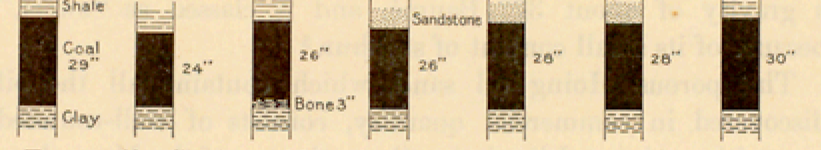

FIGURE 13.—Sections of Murphysboro (Colchester or No. 2) coal bed.

Scale: 1 inch=5 feet.

1. Atkinson shaft, NE. ¼ SW. ¼ sec. 32, T. 6 N., R. 3 W.
2. Harpe & Fenten drift, NE. ¼ NW. ¼ sec. 2, T. 5 N., R. 4 W.
3. Colchester Coal Co. shaft, NW. ¼ SE. ¼ sec. 13, T. 5 N., R. 4 W.
4. Stoneking drift, NE. ¼ SE. ¼ sec. 33, T. 4 N., R. 3 W.
5. Jennings shaft, SW. ¼ SE. ¼ sec. 20, T. 4 N., R. 2 W.
6. Runkle drift, NE. ¼ SE. ¼ sec. 12, T. 3 N., R. 3 W.
7. Morell drift, NW. ¼ SW. ¼ sec. 11, T. 3 N., R. 2 W.

The Murphysboro bed underlies two main areas and several smaller ones. The best-known area surrounds Colchester, the coal underlying the town and being replaced within about a mile east, south, and west by glacial drift. The coal has been eroded from the valley of East Fork, but it outcrops on the north side of the stream. So far as can be judged from the few wells that are sufficiently deep to reach the Murphysboro horizon the coal area stretches northwestward and northward to the boundary of the Colchester quadrangle. In the area mapped as coal land there are doubtless some tracts from which the coal has been removed by preglacial erosion; and outside this area, near its borders, there may be small patches of coal that are surrounded by deep deposits of glacial drift. Wells dug on the prairies and cuts made by streams have shown, however, that very little coal lies outside the area mapped in the Colchester quadrangle.

The second main coal area includes the southwestern and south-central parts of the Macomb quadrangle, the Murphysboro being exposed along Grindstone and Willow creeks, Honey Branch, and the upper part of the West Branch of Sugar Creek. This constitutes an important coal reserve that has scarcely been touched. In the part of the Macomb quadrangle lying north of this area only small patches of coal have been found. One such patch, a mile northwest of Industry, supports small mines. Several patches lie near Camp Creek, but their cover of indurated rock is very thin. Outcrops were found in the SW. ¼ SW. ¼ sec. 10, the N. ½ SE. ¼ sec. 11, and the N. ½ SE. ¼ and the northwest corner of sec. 15, Bethel Township. Coal that extends some distance beyond the limits of the quadrangle outcrops in its extreme southeast corner. In the SE. ¼ sec. 4 and the E. ½ sec. 7, Oakland Township; the W. ½ NW. ¼ sec. 34, Eldorado Township; the SW. ¼ and NE. ¼ sec. 6, Industry Township; and the NW. ¼ SW. ¼ and NW. ¼ NE. ¼ sec. 1, the NE. ¼ sec. 14, and the S. ½ SE. ¼ and E. ½ NE. ¼ sec. 15, Bethel Township, rocks only a few feet below the coal horizon crop out, but no coal is visible. There still remains some coal, but with little or no solid cover, in the SW. ¼ NE. ¼ sec. 8, Oakland Township, and the S. ½ sec. 23 and N. ½ sec. 26, Emmet Township. The old Eddington shaft mine, in the SW. ¼ SW. ¼ sec. 32, Scotland Township, probably worked a small area of Murphysboro coal, though it may be a bed 20 feet lower.

Although it is possible to ascertain definitely whether or not the coal is present where streams have cut below the level of its horizon, it is very difficult to determine whether it lies beneath the prairies and the shallower valleys of the Macomb quadrangle. The evidence derived from the records of several hundred farm wells in this area shows that there is no coal in the greater part of it. Three wells reported coal, one finding 24 inches at 90 feet in the NE. ¼ NW. ¼ sec. 21, Eldorado Township; the second finding 21 inches at 40 feet in the NE. ¼ NE. ¼ sec. 23, Industry Township; and the third 24 inches at 30 feet in the NE. ¼ SE. ¼ sec. 21, New Salem Township.

Near Colchester the Murphysboro bed varies only a few inches from an average thickness of 28 inches. North of East Fork and near Tennessee it is somewhat thinner in places. The roof is a fairly strong light-drab clay shale ("soapstone"). The underclay is soft and 3 to 4 feet thick, but a firmer sandy clay lies about 18 inches below the coal on the north side of the fork. West of Colchester a thin layer of "slate," a black carbonaceous clay with coal streaks, appears at the base of the coal and thickens to 10 inches northeast of Tennessee.

In the coal area in the southern part of the Macomb quadrangle, including the Gin Ridge district on the west and the Littleton district farther east, the coal also averages about 28 inches thick. In many places a massively bedded sandstone rests directly on the coal; in others a few inches to 15 feet or more of clayey or sandy shale intervene. In the mines near Industry the roof is either shale or sandstone, and the coal is 29 to 32 inches thick, though where it is thickest the lower 2 to 3 inches is commonly dirty.

About 39,500 acres are underlain by the Murphysboro coal bed in the two main coal areas, one in the northeastern part of the Colchester quadrangle and the other in the southwestern part of the Macomb quadrangle. Since 1 acre of coal 1 foot thick contains 1,800 tons, the total quantity of Murphysboro coal, estimating its average thickness as 28 inches, is 165,900,000 tons. In this total are included several million tons that have been mined out near Colchester, but not the Murphysboro coal lying in patches outside the two main coal areas, nor the comparatively small quantity of workable coal in other beds. Under present mining methods 60 to 95 per cent of the total quantity can be mined and utilized.

OTHER COAL BEDS.

Two or more thin coal beds in the Pottsville formation have in general proved too thin or too impure to be mined at a profit. A little coal has been taken from them at a place a short distance southwest of Colchester, where they are irregular in thickness, ranging from mere streaks to beds 3 feet thick, and from a place northwest of Macomb, in the NW. ¼ sec. 25, where they are reported to measure 2 feet and less. Short drifts have been driven in a Pottsville bed in the southeast corner of the Macomb quadrangle, in the SE. ¼ sec. 4, T. 3 N., R. 1 W., where the coal was reported to be 30 inches thick but on the outcrop shows less than 1 foot of coal, interbedded with carbonaceous shale. A Pottsville coal bed is reported 16 to 18 inches thick on East Fork west of Bardolph, in the NW. ¼ NW. ¼ sec. 22, T. 6 N., R. 2 W. A coal lying 37 feet below the Murphysboro bed is said to be 4 feet thick in a well 1½ miles southeast of Industry, in the NE. ¼ NE. ¼ sec. 23, T. 4 N., R. 2 W., but thick sandstone immediately above and below it indicates that it may lie in only a small basin. Although undoubtedly workable in a few small areas Pottsville coals can not be considered an important resource in these quadrangles.

No trace of coal beds higher than the Murphysboro was found in outcrops, and it is evident that the bed termed No. 3 by Worthen and considered by him to lie 30 to 60 feet above No. 2 in Schuyler and Fulton counties is not present in by far the greater part of the Colchester-Macomb district. A 2-foot bed reported 30 feet below the surface in a well a mile southwest of Adair may possibly be No. 3, which may underlie very small areas along the eastern edge of the Macomb quadrangle.

QUALITY.

The following analyses show that the coal mined in this district compares very favorably with that of other fields in Illinois and neighboring States:

Analyses of Murphysboro coal from the Colchester-Macomb district.

Laboratory No.	Air-drying loss.	Form of analysis.[a]	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
14972	11.3	A	14.6	37.3	42.2	5.9	3.37						
		B	3.7	42.0	47.6	6.7	3.80						
		C		43.6	49.4	7.0	3.95						
		D		46.9	53.1		4.25						
14973	10.3	A	14.3	38.2	41.9	5.6	2.92						
		B	4.4	42.6	46.7	6.3	3.25						
		C		44.6	48.8	6.6	3.41						
		D		47.7	52.3		3.65						
14974	10.8	A	14.5	37.5	42.2	5.76	3.16	5.97	63.07	1.17	20.87	6,445	11,600
		B	4.1	42.1	47.3	6.46	3.54	5.35	70.71	1.31	12.63	7,225	13,010
		C		43.9	49.4	6.74	3.70	5.10	73.77	1.37	9.32	7,540	13,570
		D		47.0	53.0		3.97	5.47	79.10	1.47	9.99	8,085	14,550
15117	9.5	A	12.9	38.6	43.0	5.5	2.41					6,620	11,920
		B	3.7	42.7	47.5	6.1	2.66					7,315	13,170
		C		44.3	49.3	6.4	2.77					7,600	13,680
		D		47.3	52.7		2.96					8,115	14,610
15118	10.6	A	13.5	37.0	41.9	7.6	3.23					6,360	11,450
		B	3.3	41.4	46.9	8.4	3.61					7,115	12,810
		C		42.8	48.5	8.7	3.74					7,360	13,240
		D		46.9	53.1		4.10					8,065	14,510
15119	10.1	A	13.3	37.7	42.6	6.4	2.88	5.91	63.84	1.20	19.76	6,497	11,695
		B	3.5	42.0	47.4	7.1	3.20	5.33	71.01	1.34	11.99	7,227	13,009
		C		43.5	49.1	7.4	3.32	5.11	73.61	1.38	9.19	7,492	13,486
		D		47.0	53.0		3.58	5.52	79.48	1.49	9.93	8,090	14,562
5232 (I.G.S.)	15.9	A	19.4	31.7	40.6	8.3	2.31						10,392
		B	4.1	37.7	48.3	9.9	2.75						12,358
		C		39.3	50.4	10.4	2.87						12,898
5233 (I.G.S.)	12.5	A	16.5	33.9	42.5	7.1	1.71						11,064
		B	4.6	38.8	48.5	8.1	1.95						12,639
		C		40.6	50.8	8.5	2.04						13,246
5234 (I.G.S.)	12.8	A	16.4	34.3	41.4	8.0	2.04						10,977
		B	4.1	39.3	47.4	9.2	2.34						12,585
		C		41.0	49.5	9.6	2.44						13,130

[a] A=as received, B=air dry, C=moisture free, D=moisture and ash free.

Samples for analysis were obtained according to the standard regulations adopted by the United States Geological Survey and the Bureau of Mines. A freshly mined face of coal was carefully cleaned, and a channel of uniform width and depth was cut from top to bottom so as to obtain equal proportions of coal from all parts of the bed. Pyrite lenses more than half an inch thick were excluded, for they are usually discarded by the miners. The coal fragments were caught on a waterproof blanket and crushed until all would pass through a sieve of $\frac{1}{2}$-inch mesh. The sample was then thoroughly mixed and quartered several times, alternate quarters being thrown away until only about 4 pounds remained. This was placed in an air-tight can and was hermetically sealed in the mine. In the table on page 11 Nos. 5232–5234 are from the shaft mine of the Colchester Coal Co., at Colchester, and were sampled by F. H. Kay and analyzed by the Illinois Geological Survey. The other samples were collected by the writer and analyzed by the Bureau of Mines. Samples 14972 and 14983 are from the Willis Stoneking drift on Gin Ridge, in the NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 33, T. 4 N., R. 3 W., and samples 15117 and 15118 from the Frank Burdick shaft near Industry, in the SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 16, T. 4 N., R. 2 W. Analysis 14974 was made from a composite of samples 14972 and 14973, and analysis 15119 from a composite of samples 15117 and 15118.

PRODUCTION, MINES, AND MINING METHODS.

The annual production of coal in the quadrangles is now comparatively insignificant, though in former years it was much larger. Worthen states that the shipments from Colchester alone for the years 1866 and 1867 were about 500,000 short tons per annum. The Federal Census for 1880 credits 82,304 tons to McDonough County, by far the greater part of whose output then, as now, came from Colchester and the district south of Macomb. The largest recorded output since 1880 was 189,350 tons in 1883. According to the Illinois Bureau of Labor Statistics the production for McDonough County was 109,723 tons in the fiscal year 1885, 83,401 tons in 1890, 49,709 tons in 1895, 64,822 tons in 1900, 43,944 tons in 1905, and 28,926 tons in 1913. Almost as much coal is now mined within the quadrangles in the northern part of Schuyler County as is mined outside them in McDonough County. Most of the best coal near Colchester has been mined out, and the prairie near the town is dotted with many dump heaps from old mines, each of which worked out about 20 acres.

All the mines now in operation are small openings in the Murphysboro bed and supply neighboring towns and farming country. The only mine reached by a railroad is that of the Colchester Coal Co., which ships one or two cars a week to Macomb. Most of the mines reach the coal by drifting in from its outcrop. The Colchester Coal Co., Charles Atkinson, and William Robinson hoist by steam power, but the product of the other shaft mines is hoisted by horse whims. The coal is hauled underground by men or, at a few mines, by powerful dogs, as the drifts are not made high enough to permit the use of mules. The room and pillar plan of mining is followed, for the longwall plan is said to be unsatisfactory because of the heaving of the underclay, the breaking through of the roof where the drift lies near the coal, and the brittleness of the roof. If the working faces were advanced rapidly, longwall mining might be made profitable. Few timbers are used. The general practice is to undercut the coal a short distance and then wedge it down. Very little powder is used, as it shatters the coal and roof too badly.

OIL AND GAS.

DISCOVERY OF OIL.

At the time the geologic survey of the quadrangles was completed, in 1912, only five deep wells had been drilled in them. One of these was the city water well at Macomb, and the other four were made near Birmingham by the Schuyler Oil & Gas Co. No oil or gas had been found in commercial quantities, though there were small showings of oil in the three wells near Flour Creek, in sec. 9, T. 3 N., R. 4 W., and it was reported that about two barrels could be bailed out daily from the well on the flood plain of Crooked Creek, in the SE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 2, T. 3 N., R. 4 W., which was shot at 435 feet, near the base of a 20-foot "oil sand." As was pointed out by the writer [1] none of the Birmingham wells were favorably located, and the geologic structure indicated a more promising area on the Colmar anticline, northeast of Plymouth.

Two wells were drilled on the Colmar anticline in the SE. $\frac{1}{4}$ sec. 20, T. 4 N., R. 4 W., early in 1914, but found only a little oil. On April 30, 1914, oil was found in commercial quantities on the J. Hoing farm, in the SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 16, T. 4 N., R. 4 W., in nearly flat-lying rocks on the northeastern side of the anticline. Soon after this discovery the Colmar oil field, as it was termed, sprang into prominence. Of the first 180 wells drilled in the region more than 130, in secs. 15 and 16, and the south halves of secs. 9 and 10, T. 4 N., R. 4 W., were productive. A well in the SW. $\frac{1}{4}$ sec. 24, T. 4 N., R. 5 W., and one in the SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 14, T. 4 N., R. 4 W., were the only commercially productive wells brought in outside the first four sections mentioned above. The oil field was studied in 1914 by W. C. Morse. In 1915, after Mr. Morse had prepared his report, new wells were visited and mapped by F. H. Kay, of the Illinois Geological Survey.

[1] Hinds, Henry, Oil and gas in Colchester and Macomb quadrangles: Illinois Geol. Survey Bull. 23 (extract), pp. 12–13, 1914.

These wells show that the first productive area—that in secs. 9, 10, 15 and 16, T. 4 N., R. 4 W.—has been extended into the SW. $\frac{1}{4}$ sec. 14 and into some parts of secs. 17, 21, and 22 that are close to sec. 16. (See geologic map of Colchester quadrangle.) Unsuccessful tests were made on all sides of this area, near the productive well in sec. 24, T. 4 N., R. 5 W., and in other places. New productive areas were discovered in sec. 19, the S. $\frac{1}{2}$ sec. 18, the S. $\frac{1}{2}$ sec. 20, and the N. $\frac{1}{2}$ sec. 30, T. 4 N., R. 4 W. One productive well was drilled at Colmar, in the NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 18.

The field was described in a report of the Illinois Geological Survey,[2] from which many of the data given below are summarized.

The daily yield of the first productive oil well drilled was about 40 barrels, flowing under a rock pressure of about 75 pounds. The initial production of other wells ranged from a few barrels to 150 barrels daily, but the output of some has declined rather rapidly and pumping is often necessary. The cost of drilling is low because of the slight depth to the oil sand—413 to 515 feet in the productive area—and the easy accessibility of the field. The oil is green, is without gas, has a gravity of about 37° Baumé, and is classed as "sweet," because of its small content of sulphur.[3]

The porous Hoing oil sand, which contains all the oil discovered in commercial quantity, consists of well-rounded quartzitic grains and lies in lentils on the top of the Maquoketa shale and commonly under Silurian dolomite. It accumulated in depressions on the top of the Maquoketa and was reworked by the Silurian sea, so that its age is Silurian. In places the Silurian dolomite is wanting, and Devonian limestone lies upon the sand. Owing to the conditions under which it was deposited and in part to subsequent erosion the Hoing sand is irregularly distributed and is absent in many districts; in its largest productive area it ranges from 5 to 30 feet and averages 14 feet in thickness.

CONDITIONS GOVERNING ACCUMULATION.

The conditions essential for the accumulation of oil in commercial quantities are a source from which oil may be derived; a porous stratum in which it may accumulate; an impervious cover, commonly a shale, to overlie the porous stratum and prevent the escape of at least part of the oil to the surface; and a rock structure that is favorable to the formation of pools. In this area the oil may have originated in the Kimmswick and Plattin limestones, which, in many places, are composed largely of shells that show that the formations originally contained organic matter. In some cuttings and outcrops in neighboring areas these limestones evidently contain a little oil, and a showing of oil was found in the deep wells southwest of Birmingham. The oil may have lost its sulphur content by filtration in passing slowly up through the Maquoketa shale. The Hoing sand is the porous rock in which the oil gathered and was prevented from further migration by relatively impervious beds at the sides and a short distance above.

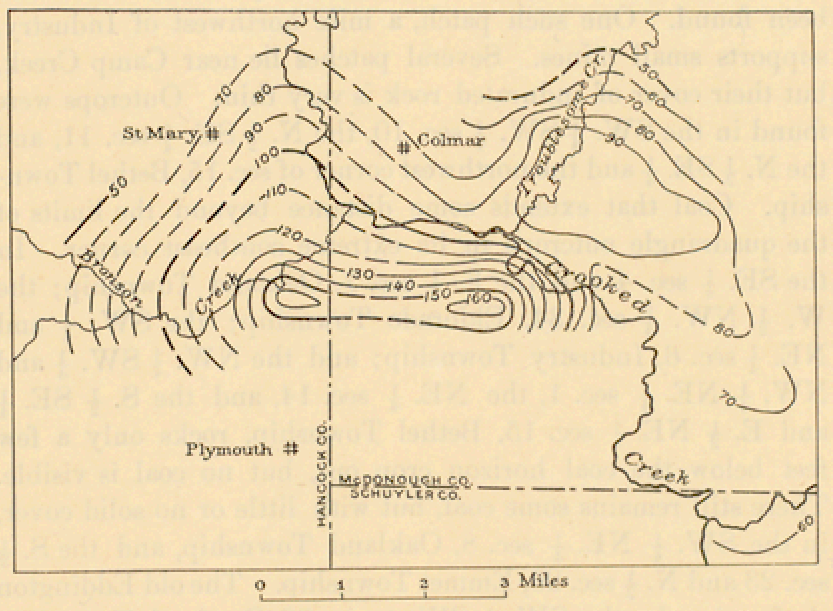

FIGURE 14.—Structure contours on the top of the Hoing oil sand, showing the Colmar anticline in the southern part of the Colchester quadrangle. Contours determined by well borings.

Contour interval, 10 feet. Contours are broken where position is doubtful. After Morse, W. C., Illinois Geol. Survey Bull. 31, pl. 3, 1915.

Where the deep-lying rocks are nearly saturated with water any oil present commonly lies on top of the water, and both liquids move upward through the porous rocks until stopped by an impervious stratum. If the beds are not perfectly level and if the permeable bed is widespread and continuous the oil moves up the dip until it reaches a place where the direction of the inclination changes and where continued movement in any direction in the porous stratum would necessarily be to lower levels. Under these conditions accumulation takes place near the crests of the anticlines. One such anticline northeast of Plymouth has already been described as the Colmar anticline.

The conditions in the Colchester and Macomb quadrangles are not quite the same as those just outlined. The rocks are

[2] Morse, W. C., and Kay, F. H., The Colmar oil field: Illinois Geol. Survey Bull. 31, pp. 37–55, 1915.

[3] Blatchley, R. S., The Plymouth oil field: Illinois Geol. Survey Bull. 23 (extract), p. 5, 1914.

not completely saturated, and the permeable stratum lies in lentils separated by relatively impervious beds, so that conditions in each lentil are more or less independent of those in others. Because the sand is absent, the oil did not accumulate in the highest part of the east end of the Colmar anticline, but was held in the Lamoine structural terrace on its northeastern side. (See fig. 14.) Oil has been found in high parts of the anticline where the Hoing sand is present, as in the productive area $3\frac{1}{2}$ miles south of Colmar and in the Roberts No. 1 well, in sec. 24, T. 4 N., R. 5 W.

EXTENSION OF THE FIELD.

The Kimmswick and Plattin limestones have yielded gas and a little oil at Beardstown, on Illinois River, and are a possible source in the quadrangles. In this area, however, the limestones are pure and may not be sufficiently porous to act as good reservoirs. They have been penetrated without success by one well on the Colmar anticline, by another at Macomb, and by two southwest of Birmingham. The Hoing sand and the Kimmswick and Plattin limestones are thought to be the only formations likely to contain oil.

Oil is more likely to be found in commercial quantities in anticlines or other structural features that are favorable to its accumulation but in this region only where the porous Hoing sand is present. Aside from the Colmar anticline and the Lamoine terrace the only particularly favorable structure in the quadrangles is the dome near Macomb, but the water well at Macomb and two oil prospect wells nearer the center of the dome found no oil. As shown on the geologic maps many wells in other parts of the quadrangles have also been barren, though, because of the irregular distribution of the sand, it is possible that successful wells may be made near unsuccessful ones. Morse and Kay infer that some productive areas may be found southwest and west of Colmar, between secs. 1 and 24, in T. 4 N., R. 5 W. The writer believes that any district in which the Murphysboro coal horizon is more than 680 feet above sea level is a legitimate field for prospecting, though the operator should realize that any well outside producing areas is much more likely to be dry than it is to be productive.

The altitude of the Hoing sand above sea level in any locality can be roughly estimated from the structure contours on the Murphysboro horizon, which is 535 to 640 feet above the sand.

GAS IN SURFACE DEPOSITS.

Pockets of gas in sandy portions of the Pleistocene deposits are common in Illinois. Several have been found in this region. The accumulations are probably derived from the decomposition of vegetal matter in the surface deposits themselves and do not have any necessary connection with deep-seated oil or gas. They can be used to heat and light a few houses, but their yield is too small for commercial purposes. G. E. Flint bored two wells at opposite corners of his house, 5 miles south of Colchester, in the SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 6, T. 4 N., R. 3 W., each to a depth of 87 feet in glacial clay underlain by sand. Gas under considerable pressure came from the sand and was used for cooking and lighting in Mr. Flint's house for more than two years, until the wells became choked with sand. A well at the Price & Gunning clay plant at Industry is reported to have struck gas at a depth of 90 feet under pressure sufficient to throw mud 20 feet into the air. A few other wells in the region have encountered small quantities of gas at shallow depths, presumably in surface deposits.

STRUCTURAL MATERIALS.

SANDSTONE.

The sandstone at or near the base of the Pennsylvanian affords a fairly good building stone in places, though in many localities it is too massive or too irregularly bedded to be easily quarried. Considerable sandstone was taken some years ago from quarries only a few feet above water level in East Fork and 2 miles northwest of Macomb. Part of this was massive, grayish buff to white, and 7 to 12 feet thick. The upper part was more thinly bedded and was often pried up in slabs 1 to 3 feet thick. The stone was durable and was used for foundation walls, well curbing, and flagging. At one time a factory was in operation for the manufacture of grindstones from it, and a number were shipped to different parts of the country. Some stone has also been taken from a small quarry in the southeast corner of the Macomb quadrangle, in the SE. $\frac{1}{4}$ sec. 4, T. 3 N., R. 1 W., where there are 20 feet of drab thick-bedded sandstone. Small quantities of sandstone have also been obtained from outcrops near Colchester and elsewhere.

LIMESTONE.

The only quarries that have furnished much limestone in recent years are in Mississippian beds. The upper part of the crystalline limestone beds of the Keokuk yield a fine quality of building stone, its chief drawback being a slight tendency to split after long exposure to the atmosphere. There is little demand for building stone except for foundations and curbing, and most of the rock quarried is crushed for concrete material and road metal. The best stone lies 10 to 30 feet below the top of the limestone, the higher-lying rock being cherty and thinly and irregularly bedded and the lower-lying rock containing a very large proportion of chert. Most of the layers are less than 2 feet thick and can be easily separated along thin clay partings. These beds have been quarried at several places, but recently at only two—at the end of the bridge over Brunces Creek, 2 miles northwest of Plymouth, in the NE. ¼ NW. ¼ sec. 26, and 1½ miles north of Plymouth, in the NE. ¼ NW. ¼ sec. 25, where there is a small crusher and where the following section is exposed:

Section at quarry north of Plymouth.

	Ft.	in.
Limestone, bluish gray, crystalline; contains small lenses of chert; in beds of 8 inches or less, with shale partings of 5 inches or less; several good quarry layers, though thin	13	
Limestone, in one bed; contains a little chert		12–16
Limestone, one bed; contains a very little chert	2	1
Limestone, thin bedded; has shale partings		10
Limestone, one bed; no chert	1	11
Limestone, one bed; no chert	1	3

Crushed rock of commercial value can also be obtained from the St. Louis limestone but with difficulty. Several of the impure limestone beds in the Spergen and Warsaw formations contain a durable building stone. Considerable rock has been taken from one of these beds 3 miles northwest of St. Marys, in the SW. ¼ SE. ¼ sec. 33, T. 5 N., R. 5 W., where there is 15 feet of bluish-buff argillaceous thick-bedded limestone that weathers yellowish.

SAND.

Sand and some gravel can be obtained from the beds of many creeks and their tributaries, the sand having been derived mostly from interglacial deposits and the gravel from the main body of the till. It would also be possible to obtain remarkably pure sand on a large scale by stripping a small overburden of glacial till. On Spring Creek, 4 miles northwest of Macomb, in the SW. ¼ NE. ¼ sec. 28, a road cut exposes 31 feet of orange-colored and white sand composed almost entirely of quartz grains of uniform size. About 17 feet more of this sand lies between the base of the cut and the level of the creek, making a total of 48 feet of excellent material. Other notable sand deposits lie in the northwest corners of both the Macomb and the Colchester quadrangle and on and near Troublesome Creek. Near the head of a small draw 2 miles northeast of Fountain Green, in the SW. ¼ NE. ¼ sec. 26, T. 6 N., R. 5 W., at least 25 feet of pure-white and yellow quartz sand bearing a few quartz and flint pebbles could be taken out very cheaply.

GLASS SAND.

Considerable attention has been drawn to the possibility that parts of the basal sandstone of the Pennsylvanian may be available for use as glass sand, and private tests are said to have been satisfactory. Several deposits of massive sandstone, 20 feet or more thick, consist of translucent angular grains of quartz of medium and uniform size, flakes of muscovite, and a few small crystals of zircon, apatite, and other minerals. When fresh the sandstone is commonly almost white, but on exposed surfaces it has a thin reddish to dark coating apparently formed of oxidized iron. This rock is suitable for making green bottle glass. Limestone (the St. Louis) that could be used with it is also available. It is doubtful, however, whether these deposits could compete with the St. Peter sandstone, which is now extensively used in north-central Illinois and east-central Missouri, as the expense of quarrying and grinding would be greater and the glass produced would probably be restricted to a few varieties.

LIME ROCK.

The brecciated St. Louis limestone, 25 feet thick, is a superior stone for making lime, as it contains a large percentage of calcium carbonate. The Keokuk limestone can also be used, though its percentage of impurities is slightly higher and more variable.

CEMENT ROCK.

Analyses of St. Louis, Spergen, and Keokuk limestone samples obtained near the Colchester and Macomb quadrangles show that these rocks are in greater part suitable for making cement.[1] Only a few deposits of suitable clay or shale crop out near exposures of the Keokuk limestone, but the St. Louis limestone can be obtained from pits adjacent to deposits of clay and shale in the Pottsville formation near Colchester and Tennessee. Where it is not too sandy the shale in the upper part of the Pottsville and that above the Murphysboro coal bed could be used for making cement. The clays at the stoneware-clay horizon are low in fluxes and might require a temperature too high for practical working. Analyses of three samples of these clays from places north of Macomb, show that they contain a ratio of silica to alumina of more than 5 and hence are too high in silica; one from Colchester has a ratio of only 1.9 and hence is too low in silica; and another from Colchester and one from Tennessee have ratios of about 3 and hence contain the two substances in proper proportion. The proportion of silica to alumina in the clay used may, however, depend on the composition of the limestone used with it, for clay that is used with a siliceous limestone may have a lower ratio of silica to alumina than that used with a pure limestone.

[1] Illinois Geol. Survey Bull. 17, pp. 98–100, 1912.

METALLIC ORES.

IRON ORE.

Ferruginous nodules are common in the Pennsylvanian shales, and layers of iron carbonate appear at several horizons in the Pottsville formation. Worthen states that some of these layers in Schuyler County yielded 52 per cent protoxide of iron, which is equivalent to about 40 per cent of metallic iron. None of them is more than 6 inches thick, however, and there is little probability that workable deposits exist.

ZINC ORE.

There are persistent rumors that zinc and lead ores occur in this area, but no valuable deposits are known to the writer. Attention has been drawn chiefly to outcrops on a tributary of Grindstone Creek near the west boundary of the Macomb quadrangle, in the SW. ¼ sec. 28, T. 4 N., R. 3 W., where small quantities of both lead and zinc minerals are reported to have been found. On this land blue-black shale about 10 feet thick lies 30 to 40 feet below the Murphysboro coal horizon and is separated from the St. Louis limestone by a few feet of sandstone. The shale contains one or two thin concretionary layers of dark-blue clay ironstone, which is covered with a bright-red coating on weathered surfaces. The interiors of many of the concretions are filled with crystals of sphalerite (zinc blende or black jack), apparently deposited in shrinkage fissures. At this same horizon, which is approximately that of the stoneware clays of the Pottsville, there are similar occurrences of sphalerite in several localities but none that is sufficiently extensive to be of economic importance.

OTHER METALLIC ORES.

Native copper and even gold and other valuable minerals are frequently found associated with the pebbles and boulders of the glacial till and among the stream gravels. As the ledges from which these minerals were derived lie far to the north, the discoveries have no economic significance beyond the intrinsic value of the individual specimens. The hollow interiors of the geodes are lined with a great variety of minerals such as quartz, calcite, sphalerite, and iron pyrites; but they have no value except as museum or cabinet specimens.

WATER.

WELLS.

Shallow wells.—In many parts of the quadrangles water sufficient for domestic and farm uses can be easily obtained from shallow dug wells. Of hundreds of wells investigated a large proportion were 30 feet or less in depth and ended in the unconsolidated Pleistocene deposits. In many on the upland prairie water stands within 10 feet of the surface. Most of the water for household use in all the towns and villages except Macomb comes from shallow wells that are exposed to dangerous pollution, especially as these settlements are without adequate sewerage. Most of the farm wells, except those too near barns and outhouses, yield pure water.

Wells of moderate depth.—When it is desired to obtain a more reliable water supply than that furnished by dug wells in times of drought wells are drilled to depths rarely exceeding 200 feet. Where the glacial drift is thick, as in most of the northern two-thirds of the Macomb quadrangle and elsewhere, the water bearer is commonly a sand pocket in the glacial drift. As the pockets are not connected by porous strata and are distributed irregularly through the drift, it is impossible to predict the exact depth to which it is necessary to drill in order to reach them. Where there are thick deposits of interglacial sand, as near Fandon and in the northwest corner of the Macomb quadrangle, the water sinks to the bottom of the sand and the wells must be driven to that level.

Where the Carbondale formation is the highest indurated rock beneath the surface abundant water of excellent quality may usually be obtained from the sandstone that commonly lies a short distance above the Murphysboro coal bed. Near Colchester, however, the excavation of coal shafts and the removal of the coal have caused the water table to fall to the thin sandstone bed that commonly lies a few feet below the Murphysboro horizon. Where the Pottsville is the highest indurated rock water may usually be found in the sandstones near the base of that formation. Where Pennsylvanian beds are absent and there is not sufficient water in the Pleistocene surface deposits many supplies have been obtained from fissures and cavities in the Keokuk and Burlington limestones, though not all waters from those sources are suitable for domestic use.

Deep wells.—Water in large quantities is contained in the deep-lying strata in this region, but it is unfortunately highly charged with minerals. The chief water-bearer is the St. Peter sandstone, but the limestones next above it are also commonly saturated with water that is more strongly mineralized than that of the St. Peter. The water in these lower formations is under pressure that raises it to an altitude of about 650 feet.

The well at Macomb, whose log has already been given (p. 3), was drilled in the public square years ago to a depth of 1,630 feet, 270 feet below the St. Peter sandstone, for a city water supply. When the drill penetrated the top of the limestones, at a depth of 700 feet, water stood within 70 feet of the surface of the ground. At 1,150 feet water from the upper part of the St. Peter stood within 40 feet of the surface, and after the well was completed strongly mineralized water was within 55 feet of the surface. As it was thought that much of the mineral matter came from above the St. Peter a tight casing was inserted to the top of the sandstone and the lower part of the well was filled in to the level of the base of that stratum. Thereafter all the water was derived from the St. Peter, but it was still unfit for ordinary purposes, as is shown by the first analysis in the accompanying table. The other analyses, by the Illinois Water Survey,[2] give the composition of several other waters at Macomb and indicate the general difference in quality throughout these two quadrangles between water from the St. Peter and that from horizons nearer the surface. The water from moderately deep wells is of the calcium carbonate type, fairly high in mineral content and very hard, but carrying little sulphate or chloride.

Chemical composition of ground waters at Macomb, Ill.

[Parts per million.]

	1	2	3	4	5	6
Silica (SiO_2)	10.0	6.6	6.2	7.1	11.0	6.1
Iron (Fe)	1.3	5.6	.9	2.8	[a]15.0 (Fe and Al together)	.6
Aluminum (Al)	.7	2.3	.6	1.8		.2
Calcium (Ca)	158.0	184.0	176.0	81.0	87.0	244.0
Magnesium (Mg)	67.0	72.0	74.0	36.0	30.0	71.0
Sodium (Na)	809.0	669.0	948.0	80.0	29.0 (Na and K together)	19.0
Potassium (K)	24.0	94.0	8.7	7.5		3.8
Ammonium (NH_4)	----	1.2	2.1	----	----	----
Carbonate radicle (CO_3)	395.0	----	----	319.0	243.0	192.0
Sulphate radicle (SO_4)	999.0	996.0	937.0	.9	.7	600.0
Nitrate radicle (NO_3)	----	1.6	5.3	1.0	.3	.3
Chlorine (Cl)	542.0	935.0	1,148.0	4.4	1.0	3.4
Total solids	[b]3,006.0	3,222.0	3,567.0	530.0	418.0	1,256.0

[a] $Fe_2O_3 + Al_2O_3$. [b] Ti, none; PO_4, none.

1. City well; water from St. Peter sandstone.
2. Well of A. McLean, 1,325 feet deep; water from St. Peter sandstone, Aug. 4, 1900.
3. Well of W. Thompson, 1,360 feet deep; water from St. Peter sandstone, Aug. 27, 1901.
4. Well of A. Fisher, 225 feet deep; water from rock, Jan. 14, 1902.
5. Well of E. Pollock, 78 feet deep; water from sand and gravel, Jan. 25, 1902.
6. Well of A. Krauser, 60 feet deep; water from sand, July 28, 1902.

A well recently sunk in search of oil or gas near Birmingham, in the SE. ¼ SW. ¼ sec. 9, T. 3 N., R. 4 W., stopped 170 feet below the top of the St. Peter sandstone. The water that flows from the hole in a large stream is highly mineralized and has the characteristic odor of hydrogen sulphide. Curative properties are claimed for this water.

SPRINGS.

There are not a great number of flowing springs in the quadrangles and only a few are utilized. Vishnu Spring, 4 miles northwest of Tennessee, in sec. 7, T. 5 N., R. 4 W., yields a strong flow of mineralized water, for which medicinal value is claimed. A small sanatorium was formerly conducted in the ravine near the spring.

SURFACE WATER.

There are many small streams in the quadrangles, in which water flows during all or most of the year. The city water supply of Macomb is now pumped from a reservoir made by damming East Fork north of the city. The water is filtered through washed sand and is considered of good quality. The Chicago, Burlington & Quincy Railroad maintains a dam and pumping station on East Fork to supply its tanks at Colchester.

None of the streams has sufficient fall or volume to be used for the production of much water power. A 5-foot dam across Crooked Creek at Birmingham formerly furnished power for a small mill, and before adequate transportation facilities were available several small water mills were utilized for grinding grain in the country districts.

SOILS.

The soils of the quadrangles are their most valuable mineral resource. They have been divided into upland prairie soils, upland timber soils, and swamp and bottom-land soils.[3]

[2] Bartow, Edward, and others, The mineral content of Illinois waters: Illinois State Water Survey Bull. 4, pp. 136–137, 1908.

[3] McDonough County soils: Illinois Univ. Agr. Exper. Sta. Soil Rept. 7, 1913.

The upland prairie soils form the surface of more than half the area, covering practically all the flat or gently rolling, undissected prairie between stream valleys. They are rich in organic matter derived from the remains of prairie grasses. Before the advent of the white man the tops of the native grasses usually burned or decayed, but the network of roots was protected from complete decay by imperfect aeration, and after it had partly decayed it formed the humus of the dark prairie soils. An acre of virgin sod 7 inches thick contains about 14½ tons of roots. The most common type of soil of this class is the brown silt loam, which contains 10 per cent or more of clay, 8 to 20 per cent of sand, chiefly of the finer grades, and 3 to 5 per cent of organic matter, averaging about 42 tons to the acre. Another type is the black clay loam or "gumbo," a sticky though granular soil formed in low places where organic matter accumulated in large quantity and where clay and fine silt were washed in from slightly higher adjoining lands. Other types of soil of this class found in the area are brown-gray silt loam on light clay and black silt loam on clay.

The upland timber soils include the areas along stream courses over which forests once extended. These soils contain much less organic matter than the soils of the upland prairie because the roots of trees and the surface accumulations of leaves, twigs, and fallen trees have been burned by forest fires or almost completely decayed. At present there are no dense forests in the area, and trees are confined to the steeper parts of valley sides and to small farm wood lots. Formerly, however, forests reached farther back toward the outer borders of many valleys. The most common type of upland timber soils and the second among all types is the yellow silt loam, which covers hilly or badly eroded land in narrow irregular strips in the valleys. Because of its topographic position, this soil washes and gullies readily, so that it is used largely for pastures and meadows. The other type of soil of this class is the yellow-gray silt loam, consisting of incoherent, mealy, non-granular material occupying some of the rolling land on the valley borders.

The swamp and bottom-land soils are derived from material washed from the upland in this or neighboring areas. They form the alluvium in the flood plains of the streams. These soils differ from those of the upland in being more varied in composition, and in this area they consist chiefly of a deep brown silt loam containing 4 per cent of organic matter.

June, 1915.

TOPOGRAPHY

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U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

STATE OF ILLINOIS
GOVERNOR EDWARD F. DUNNE, T. C. CHAMBERLIN, E. J. JAMES, COMMISSIONERS
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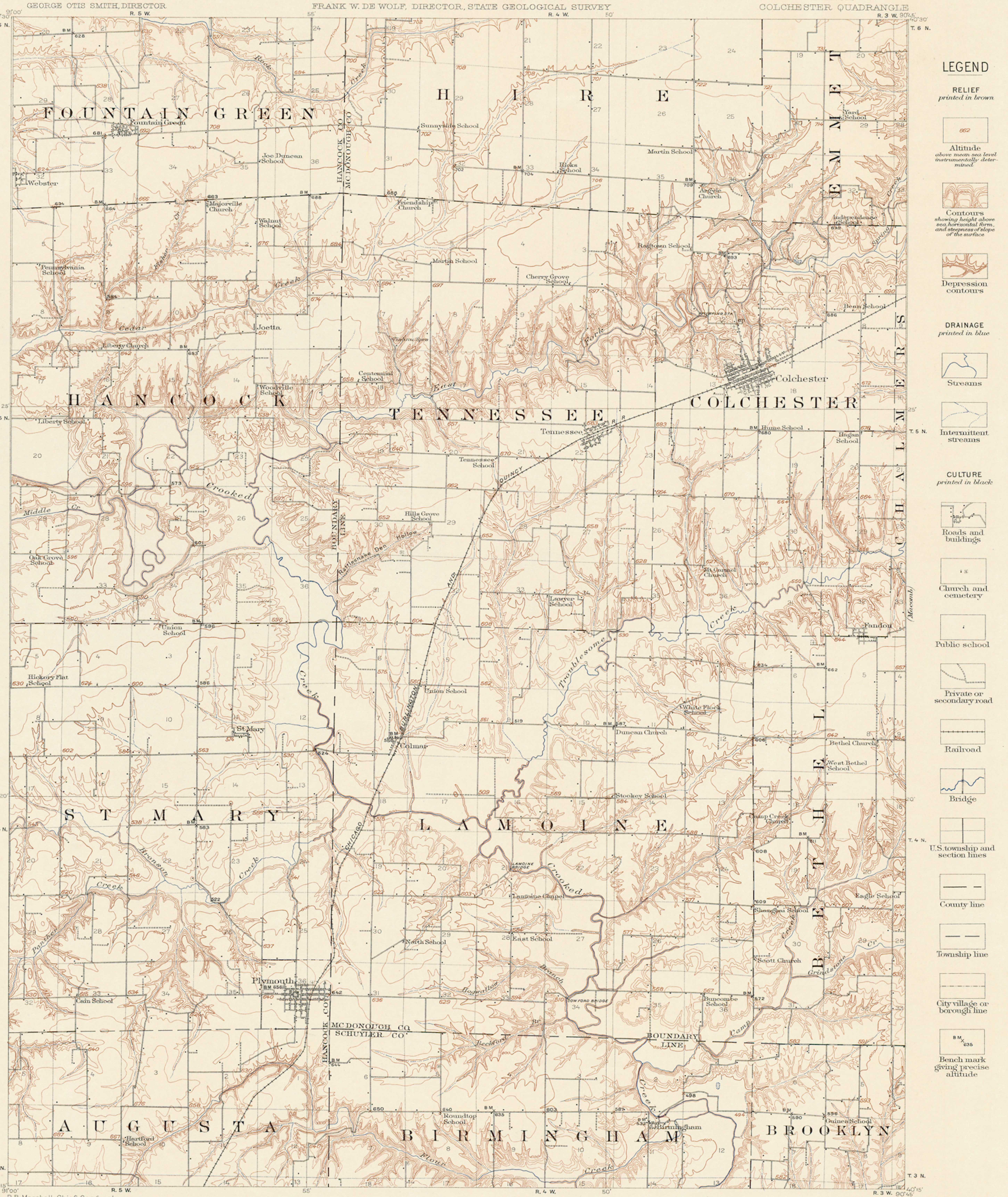
ILLINOIS
COLCHESTER QUADRANGLE



R. B. Marshall, Chief Geographer.
W. H. Herron, Geographer in charge.
Topography by Frank Tweedy and W. S. Gehres.
Control by C. B. Kendall, S. R. Archer, and E. M. Bandli.
Surveyed in 1911.

SURVEYED IN COOPERATION WITH THE STATE OF ILLINOIS.

Scale $\frac{1}{62500}$

Contour interval 20 feet.
Datum is mean sea level.

APPROXIMATE MEAN DECLINATION 1911.

Edition of Apr. 1913, reprinted Aug. 1916.

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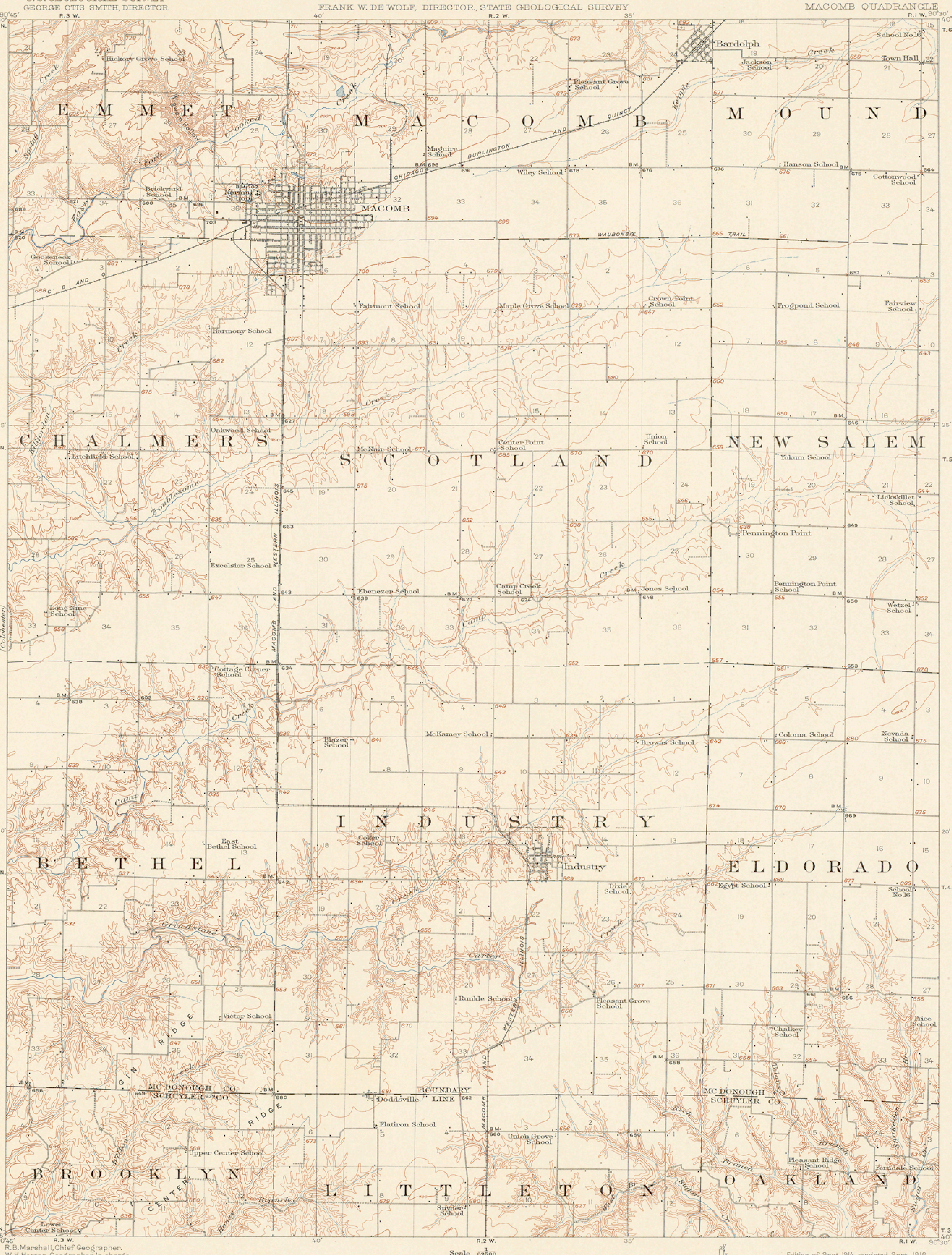
MACOMB QUADRANGLE



LEGEND

RELIEF
printed in brown

Altitude
above mean sea level instrumentally determined

Contours
showing height above sea, horizontal form, and steepness of slope of the surface

Depression contour

DRAINAGE
printed in blue

Streams

Intermittent streams

Lake or pond

CULTURE
printed in black

Roads and buildings

Church and cemetery

Public school

Private or secondary road

Railroad

County line

Township line

U.S. section lines

City, village or borough line

Triangulation station

Bench mark giving precise altitude

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Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.

TRUE NORTH
MAGNETIC NORTH
5½°
APPROXIMATE MEAN DECLINATION 1911.

Edition of Sept. 1914, reprinted Sept. 1916.

DEPARTMENT OF THE INTERIOR
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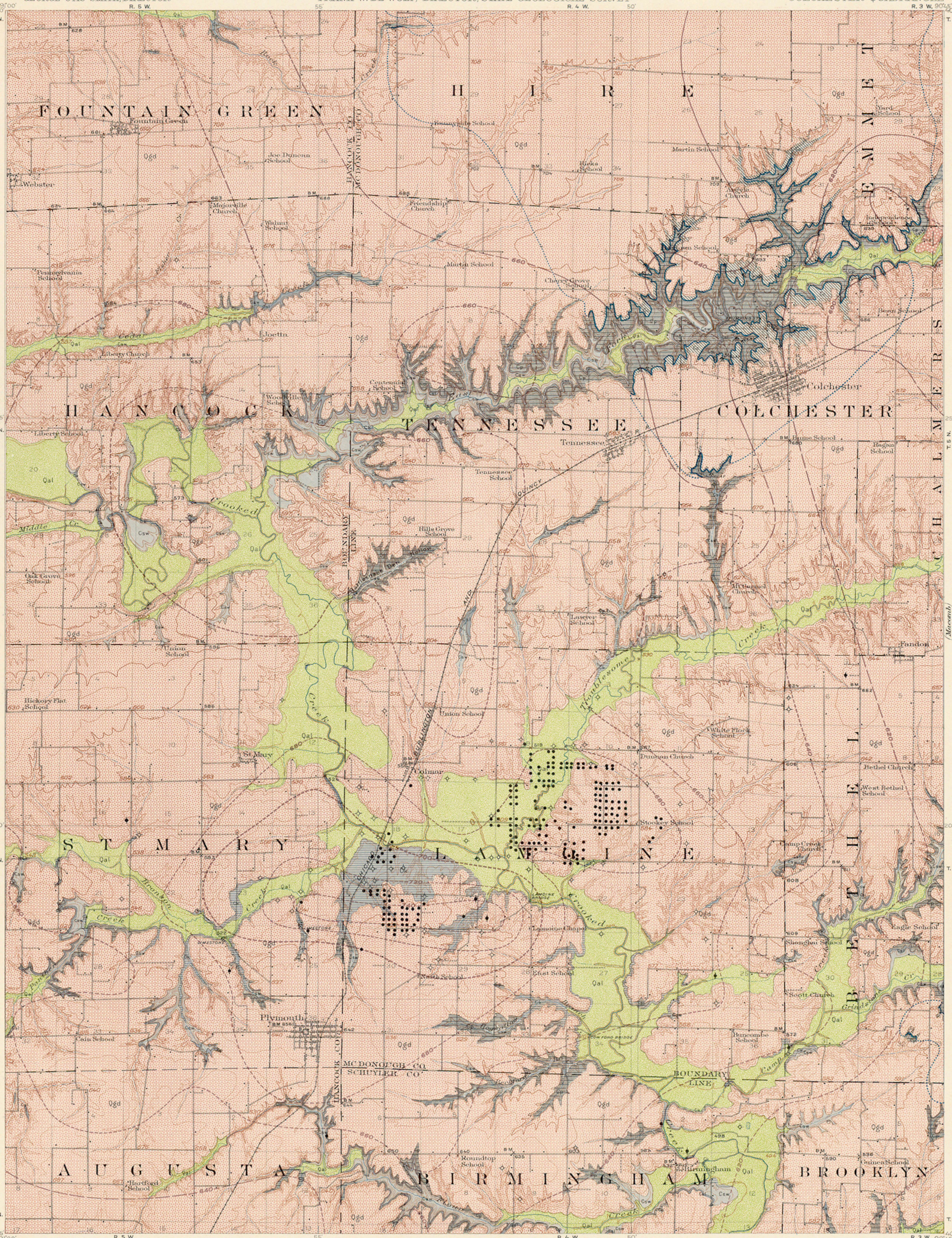
AREAL GEOLOGY

STATE OF ILLINOIS
GOVERNOR EDWARD F. DUNNE, T. C. CHAMBERLIN, E. J. JAMES, COMMISSIONERS
FRANK W. DE WOLF, DIRECTOR, STATE GEOLOGICAL SURVEY

ILLINOIS
COLCHESTER QUADRANGLE



LEGEND

SEDIMENTARY ROCKS

(Areas of subaqueous deposits are shown by patterns of parallel lines, subaerial deposits by patterns of dots and circles)

QUATERNARY

Recent series

Qal — Alluvium *(in flood plains of present streams, only larger deposits mapped)*

Pleistocene series

Qtd — Terraced stream deposits *(chiefly silt, only the larger remnants mapped)*

Qgd — Glacial drift overlain by thin loess *(pebbly clay and pockets of sand, a few outcrops of Yarmouth interglacial sand and soil are included in mapping)*

CARBONIFEROUS

Pennsylvanian series

Cc — Carbondale formation *(shale and sandstone with Murphysboro (Colchester) coal at base)*

Cp — Pottsville formation *(shale, sandstone, and clay, a little limestone, and a few lenticular coal beds)*

UNCONFORMITY

Mississippian series *(Meramec group)*

Csl — St. Louis limestone *(fine-grained limestone, in greater part brecciated)*

Csw — Spergen and Warsaw formations *(shale and impure limestone in thin lenticular beds, contains many geodes)*

Osage group

Ck — Keokuk limestone *(crystalline crinoidal limestone)*

ECONOMIC AND STRUCTURE DATA

Outcrop of Murphysboro (Colchester) coal bed at base of Carbondale formation *(approximate location beneath glacial drift shown by dotted line)*

Structure contours showing altitude of Murphysboro (Colchester) coal bed where known to be present *(contour interval 20 feet, datum, mean sea level)*

Structure contours showing altitude of Murphysboro (Colchester) coal bed where largely removed by erosion *(long dashes indicate that exact position of coal horizon is doubtful and some coal may be present, short dashes indicate that coal bed is all removed by erosion and its former elevation is estimated from position of Pottsville and older formations)*

- *Coal mine shaft*
- *Coal mine drift*
- LIMESTONE *Quarry*
- CLAY *Clay mine*
- *Clay or shale pit*
- *Productive oil wells*
- *Wells having slight show of oil*
- *Dry oil wells*

Note: *The outcrop and altitude of the Murphysboro coal, the only important coal bed in the area, are shown on the map. Pottery clay occurs in the Pottsville formation 30 to 40 feet below the Murphysboro coal horizon. Clays and shales suitable for other clay products are abundant in the Pennsylvanian and Quaternary formations. Limestone for lime and cement manufacture and stone and sand for building and concrete can also be obtained from appropriate formations in the quadrangle. Oil is locally obtained from Silurian rocks by deep drilling.*

R. B. Marshall, Chief Geographer.
W. H. Herron, Geographer in charge.
Topography by Frank Tweedy and W. S. Gehres.
Control by C. B. Kendall, S. R. Archer, and E. M. Bandli.
Surveyed in 1911.
SURVEYED IN COOPERATION WITH THE STATE OF ILLINOIS.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1911.

Scale $\frac{1}{62500}$
1 ½ 0 1 2 3 4 Miles
1 ½ 0 1 2 3 4 5 Kilometers
Contour interval 20 feet.
Datum is mean sea level.
Edition of Oct. 1916.

Geology by Henry Hinds.
Surveyed in 1912.
Oil wells located chiefly by W. C. Morse, 1914, with additions by F. H. Kay in 1915.
SURVEYED IN COOPERATION WITH THE STATE OF ILLINOIS.

DEPARTMENT OF THE INTERIOR
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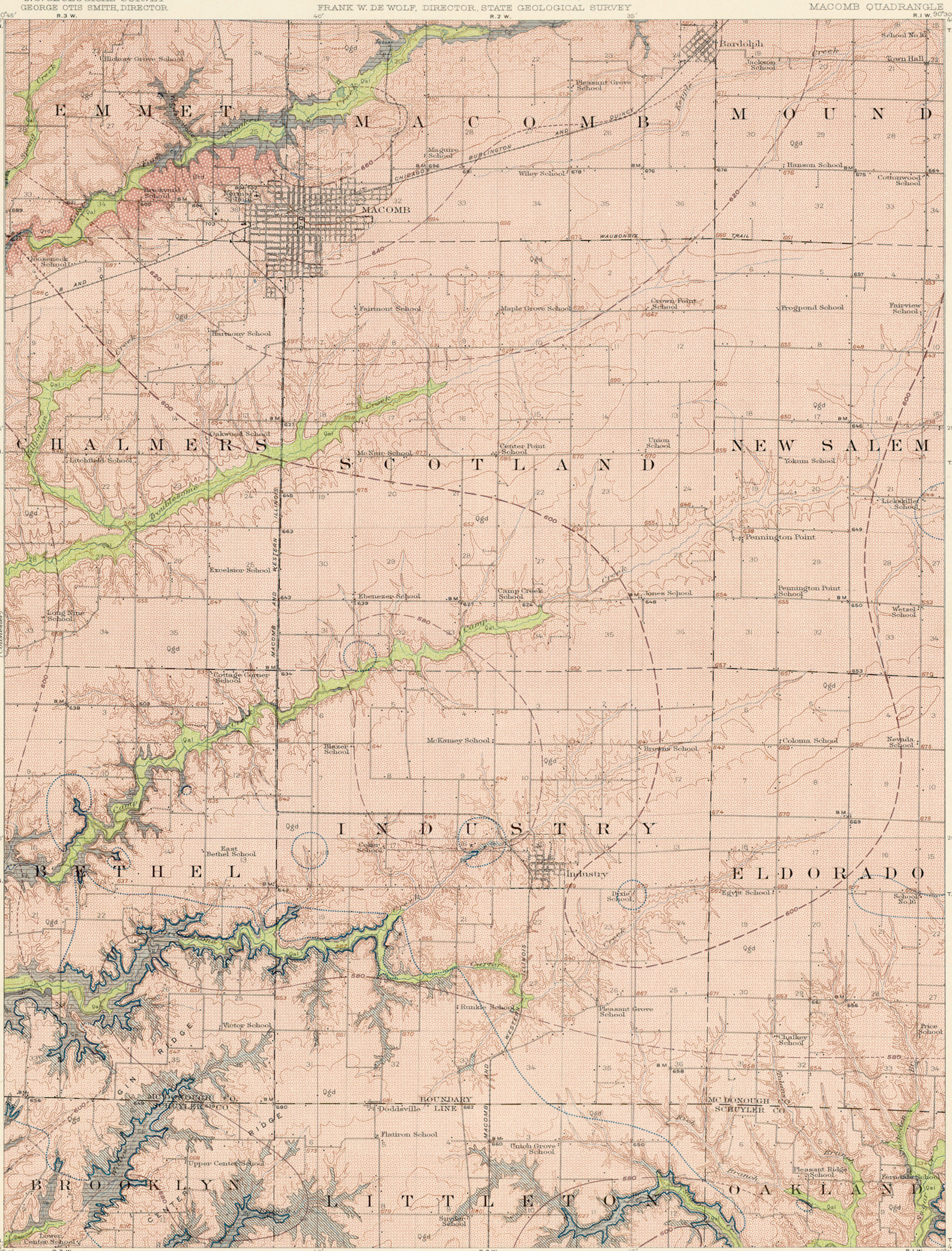

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- *Coal mine shaft*
- *Coal mine drift*
- *Clay or shale pit*
- *Dry oil wells*
- *Deep well for water*

Note: The outcrop and altitude of the Murphysboro coal, the only important coal bed in the area, are shown on the map. Pottery clay occurs in the Pottsville formation 30 to 40 feet below the Murphysboro coal horizon. Clays and shales suitable for other clay products are abundant in the Pennsylvanian and Quaternary formations. Limestone for lime and cement manufacture and stone and sand for building and concrete can also be obtained from appropriate formations in the quadrangle. Oil is locally obtained from Silurian rocks by deep drilling.

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TRUE NORTH — MAGNETIC NORTH
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1 ½ 0 1 2 3 4 Miles

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Contour interval 20 feet.
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Edition of Oct. 1916.

Geology by Henry Hinds, assisted by G.S. Rogers.
Surveyed in 1912.
Oil wells located by W.C. Morse, 1914.

SURVEYED IN COOPERATION WITH THE STATE OF ILLINOIS.

and still smaller ones *stages*. The age of a rock is expressed by the name of the time interval in which it was formed.

The sedimentary formations deposited during a period are grouped together into a *system*. The principal divisions of a system are called *series*. Any aggregate of formations less than a series is called a *group*.

Inasmuch as sedimentary deposits accumulate successively the younger rest on those that are older, and their relative ages may be determined by observing their positions. In many regions of intense disturbance, however, the beds have been overturned by folding or superposed by faulting, so that it may be difficult to determine their relative ages from their present positions; under such conditions fossils, if present, may indicate which of two or more formations is the oldest.

Many stratified rocks contain *fossils*, the remains or imprints of plants and animals which, at the time the strata were deposited, lived in bodies of water or were washed into them, or were buried in surficial deposits on the land. Such rocks are called fossiliferous. By studying fossils it has been found that the life of each period of the earth's history was to a great extent different from that of other periods. Only the simpler kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived peculiar forms, which did not exist in earlier times and have not existed since; these are *characteristic types*, and they define the age of any bed of rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present. Where two sedimentary formations are remote from each other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first. Fossil remains in the strata of different areas, provinces, and continents afford the most important means for combining local histories into a general earth history.

It is in many places difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can in general be ascertained by observing whether an associated sedimentary formation of known age is cut by the igneous mass or is deposited upon it. Similarly, the time at which metamorphic rocks were formed from the original masses may be shown by their relations to adjacent formations of known age; but the age recorded on the map is that of the original masses and not that of their metamorphism.

Symbols, colors, and patterns.—Each formation is shown on the map by a distinctive combination of color and pattern and is labeled by a special letter symbol.

Patterns composed of parallel straight lines are used to represent sedimentary formations deposited in the sea, in lakes, or in other bodies of standing water. Patterns of dots and circles represent alluvial, glacial, and eolian formations. Patterns of triangles and rhombs are used for igneous formations. Metamorphic rocks of unknown origin are represented by short dashes irregularly placed; if the rock is schist the dashes may be arranged in wavy lines parallel to the structure planes. Suitable combination patterns are used for metamorphic formations known to be of sedimentary or of igneous origin. The patterns of each class are printed in various colors. With the patterns of parallel lines, colors are used to indicate age, a particular color being assigned to each system.

The symbols consist each of two or more letters. If the age of a formation is known the symbol includes the system symbol, which is a capital letter or monogram; otherwise the symbols are composed of small letters.

The names of the systems and of series that have been given distinctive names, in order from youngest to oldest, with the color and symbol assigned to each system, are given in the subjoined table.

Symbols and colors assigned to the rock systems.

System.		Series.	Symbol.	Color for sedimentary rocks.
Cenozoic	Quaternary	Recent; Pleistocene	Q	Brownish yellow.
	Tertiary	Pliocene; Miocene; Oligocene; Eocene	T	Yellow ocher.
Mesozoic	Cretaceous		K	Olive-green.
	Jurassic		J	Blue-green.
	Triassic		Ꞧ	Peacock-blue.
Paleozoic	Carboniferous	Permian; Pennsylvanian; Mississippian	C	Blue.
	Devonian		D	Blue-gray.
	Silurian		S	Blue-purple.
	Ordovician		O	Red-purple.
	Cambrian		Ꞓ	Brick-red.
	Algonkian		A	Brownish red.
	Archean		Æ	Gray-brown.

SURFACE FORMS.

Hills, valleys, and all other surface forms have been produced by geologic processes. For example, most valleys are the result of erosion by the streams that flow through them (see fig. 1), and the alluvial plains bordering many streams were built up by the streams; waves cut sea cliffs and, in cooperation with currents, build up sand spits and bars. Topographic forms thus constitute part of the record of the history of the earth.

Some forms are inseparably connected with deposition. The hooked spit shown in figure 1 is an illustration. To this class belong beaches, alluvial plains, lava streams, drumlins (smooth oval hills composed of till), and moraines (ridges of drift made at the edges of glaciers). Other forms are produced by erosion. The sea cliff is an illustration; it may be carved from any rock. To this class belong abandoned river channels, glacial furrows, and peneplains. In the making of a stream terrace an alluvial plain is first built and afterward partly eroded away. The shaping of a marine or lacustrine plain is usually a double process, hills being worn away (*degraded*) and valleys being filled up (*aggraded*).

All parts of the land surface are subject to the action of air, water, and ice, which slowly wear them down, and streams carry the waste material to the sea. As the process depends on the flow of water to the sea, it can not be carried below sea level, and the sea is therefore called the *base-level* of erosion. Lakes or large rivers may determine local base-levels for certain regions. When a large tract is for a long time undisturbed by uplift or subsidence it is degraded nearly to base-level, and the fairly even surface thus produced is called a *peneplain*. If the tract is afterward uplifted, the elevated peneplain becomes a record of the former close relation of the tract to base-level.

THE VARIOUS GEOLOGIC SHEETS.

Areal geology map.—The map showing the areas occupied by the various formations is called an *areal geology map*. On the margin is a *legend*, which is the key to the map. To ascertain the meaning of any color or pattern and its letter symbol the reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. If it is desired to find any particular formation, its name should be sought in the legend and its color and pattern noted; then the areas on the map corresponding in color and pattern may be traced out. The legend is also a partial statement of the geologic history. In it the names of formations are arranged in columnar form, grouped primarily according to origin—sedimentary, igneous, and crystalline of unknown origin—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology map.—The map representing the distribution of useful minerals and rocks and showing their relations to the topographic features and to the geologic formations is termed the *economic geology map*. The formations that appear on the areal geology map are usually shown on this map by fainter color patterns and the areas of productive formations are emphasized by strong colors. A mine symbol shows the location of each mine or quarry and is accompanied by the name of the principal mineral mined or stone quarried. If there are important mining industries or artesian basins in the area special maps to show these additional economic features are included in the folio.

Structure-section sheet.—In cliffs, canyons, shafts, and other natural and artificial cuttings the relations of different beds to one another may be seen. Any cutting that exhibits those relations is called a *section*, and the same term is applied to a diagram representing the relations. The arrangement of rocks in the earth is the earth's *structure*, and a section exhibiting this arrangement is called a *structure section*.

The geologist is not limited, however, to natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of formation of rocks and having traced out the relations among the beds on the surface, he can infer their relative positions after they pass beneath the surface and can draw sections representing the structure to a considerable depth. Such a section is illustrated in figure 2.

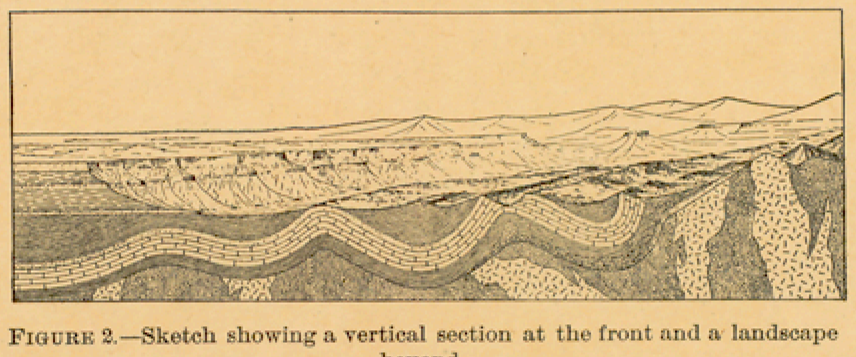

FIGURE 2.—Sketch showing a vertical section at the front and a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground on a vertical plane, so as to show the underground relations of the rocks. The kinds of rock are indicated by appropriate patterns of lines, dots, and dashes. These patterns admit of much variation, but those shown in figure 3 are used to represent the commoner kinds of rock.

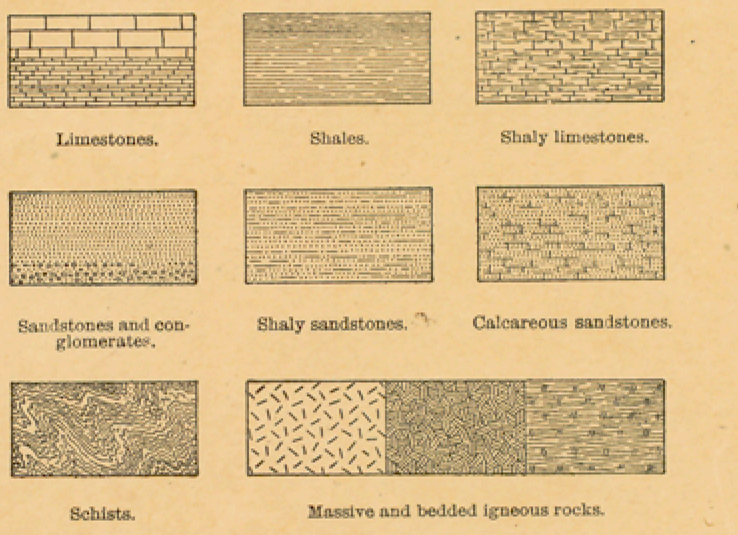

FIGURE 3.—Symbols used in sections to represent different kinds of rocks.

The plateau shown at the left of figure 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes. The broad belt of lower land is traversed by several ridges, which are seen in the section to correspond to the outcrops of a bed of sandstone that rises to the surface. The upturned edges of this bed form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shale.

Where the edges of the strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred. The direction of the intersection of a bed with a horizontal plane is called the *strike*. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called the *dip*.

In many regions the strata are bent into troughs and arches, such as are seen in figure 2. The arches are called *anticlines* and the troughs *synclines*. As the sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets, the fact that they are now bent and folded is proof that forces have from time to time caused the earth's surface to wrinkle along certain zones. In places the strata are broken across and the parts have slipped past each other. Such breaks are termed *faults*. Two kinds of faults are shown in figure 4.

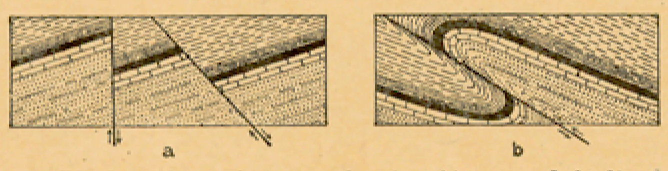

FIGURE 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* or *reverse* fault.

At the right of figure 2 the section shows schists that are traversed by igneous rocks. The schists are much contorted and their arrangement underground can not be inferred. Hence that portion of the section delineates what is probably true but is not known by observation or by well-founded inference.

The section also shows three sets of formations, distinguished by their underground relations. The uppermost set, seen at the left, is made up of sandstones and shales, which lie in a horizontal position. These strata were laid down under water but are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's mass has been uplifted. The strata of this set are parallel, a relation which is called *conformable*.

The second set of formations consists of strata that have been folded into arches and troughs. These strata were once continuous, but the crests of the arches have been removed by erosion. The beds, like those of the first set, are conformable.

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second set shown at the left of the section. The overlying deposits are, from their position, evidently younger than the underlying deposits, and the bending and eroding of the older beds must have occurred between their deposition and the accumulation of the younger beds. The younger rocks are *unconformable* to the older, and the surface of contact is an *unconformity*.

The third set of formations consists of crystalline schists and igneous rocks. At some period of their history the schists were folded or plicated by pressure and traversed by eruptions of molten rock. But the pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that a considerable interval elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists were metamorphosed, they were disturbed by eruptive activity, and they were deeply eroded. The contact between the second and third sets is another unconformity; it marks a time interval between two periods of rock formation.

The section and landscape in figure 2 are ideal, but they illustrate actual relations. The sections on the structure-section sheet are related to the maps as the section in the figure is related to the landscape. The profile of the surface in the section corresponds to the actual slopes of the ground along the section line, and the depth from the surface of any mineral-producing or water-bearing stratum that appears in the section may be measured by using the scale of the map.

Columnar section.—The geologic maps are usually accompanied by a *columnar section*, which contains a concise description of the sedimentary formations that occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thickness of the formations, and the order of accumulation of successive deposits.

The rocks are briefly described, and their characters are indicated in the columnar diagram. The thicknesses of formations are given in figures that state the least and greatest measurements, and the average thickness of each formation is shown in the column, which is drawn to scale. The order of accumulation of the sediments is shown in the columnar arrangement—the oldest being at the bottom, the youngest at the top.

The intervals of time that correspond to events of uplift and degradation and constitute interruptions of deposition are indicated graphically and by the word "unconformity."

GEORGE OTIS SMITH,
Director.

May, 1909.

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			Cents.
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‡16	Knoxville	Tennessee-North Carolina	
‡17	Marysville	California	
‡18	Smartsville	California	
‡19	Stevenson	Ala.-Ga.-Tenn	
20	Cleveland	Tennessee	5
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23	Nomini	Maryland-Virginia	5
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‡37	Downieville	California	
‡38	Butte Special	Montana	
‡39	Truckee	California	
‡40	Wartburg	Tennessee	
‡41	Sonora	California	
‡42	Nueces	Texas	
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‡55	Fort Benton	Montana	
‡56	Little Belt Mountains	Montana	
‡57	Telluride	Colorado	
‡58	Elmoro	Colorado	
‡59	Bristol	Virginia-Tennessee	
‡60	La Plata	Colorado	
‡61	Monterey	Virginia-West Virginia	
‡62	Menominee Special	Michigan	
‡63	Mother Lode District	California	
‡64	Uvalde	Texas	
65	Tintic Special	Utah	5
‡66	Colfax	California	
‡67	Danville	Illinois-Indiana	
‡68	Walsenburg	Colorado	
‡69	Huntington	West Virginia-Ohio	
‡70	Washington	D. C.-Va.-Md.	
‡71	Spanish Peaks	Colorado	
‡72	Charleston	West Virginia	
‡73	Coos Bay	Oregon	
‡74	Coalgate	Oklahoma (Ind. T.)	
75	Maynardville	Tennessee	5
‡76	Austin	Texas	
‡77	Raleigh	West Virginia	
78	Rome	Georgia-Alabama	5
‡79	Atoka	Oklahoma (Ind. T.)	
‡80	Norfolk	Virginia-North Carolina	
‡81	Chicago	Illinois-Indiana	
‡82	Masontown-Uniontown	Pennsylvania	
‡83	New York City	New York-New Jersey	
84	Ditney	Indiana	5
85	Oelrichs	South Dakota-Nebraska	5
86	Ellensburg	Washington	5
87	Camp Clarke	Nebraska	5
88	Scotts Bluff	Nebraska	5
‡89	Port Orford	Oregon	
90	Cranberry	North Carolina-Tennessee	5
91	Hartville	Wyoming	5
92	Gaines	Pennsylvania-New York	5
93	Elkland-Tioga	Pennsylvania	5
‡94	Brownsville-Connellsville	Pennsylvania	
95	Columbia	Tennessee	5
96	Olivet	South Dakota	5
97	Parker	South Dakota	5
98	Tishomingo	Oklahoma (Ind. T.)	5
99	Mitchell	South Dakota	5
100	Alexandria	South Dakota	5
‡101	San Luis	California	
102	Indiana	Pennsylvania	5
103	Nampa	Idaho-Oregon	5
104	Silver City	Idaho	5
105	Patoka	Indiana-Illinois	5
106	Mount Stuart	Washington	5
107	Newcastle	Wyoming-South Dakota	5
108	Edgemont	South Dakota-Nebraska	5
109	Cottonwood Falls	Kansas	5
110	Latrobe	Pennsylvania	5
‡111	Globe	Arizona	
112	Bisbee (reprint)	Arizona	25
113	Huron	South Dakota	5
114	De Smet	South Dakota	5
‡115	Kittanning	Pennsylvania	
‡116	Asheville	North Carolina-Tennessee	
117	Casselton-Fargo	North Dakota-Minnesota	5
118	Greeneville	Tennessee-North Carolina	5
119	Fayetteville	Arkansas-Missouri	5
‡120	Silverton	Colorado	
‡121	Waynesburg	Pennsylvania	
‡122	Tahlequah	Oklahoma (Ind. T.)	
123	Elders Ridge	Pennsylvania	5
‡124	Mount Mitchell	North Carolina-Tennessee	
‡125	Rural Valley	Pennsylvania	
‡126	Bradshaw Mountains	Arizona	
‡127	Sundance	Wyoming-South Dakota	
‡128	Aladdin	Wyo.-S. Dak.-Mont	
‡129	Clifton	Arizona	
‡130	Rico	Colorado	
‡131	Needle Mountains	Colorado	
‡132	Muscogee	Oklahoma (Ind. T.)	
‡133	Ebensburg	Pennsylvania	
‡134	Beaver	Pennsylvania	
‡135	Nepesta	Colorado	
136	St. Marys	Maryland-Virginia	5
‡137	Dover	Del.-Md.-N. J	
‡138	Redding	California	
‡139	Snoqualmie	Washington	
‡140	Milwaukee Special	Wisconsin	
‡141	Bald Mountain-Dayton	Wyoming	
‡142	Cloud Peak-Fort McKinney	Wyoming	
143	Nantahala	North Carolina-Tennessee	5
‡144	Amity	Pennsylvania	
‡145	Lancaster-Mineral Point	Wisconsin-Iowa-Illinois	
‡146	Rogersville	Pennsylvania	
‡147	Pisgah	N. Carolina-S. Carolina	
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‡149	Penobscot Bay	Maine	
‡150	Devils Tower	Wyoming	
‡151	Roan Mountain	Tennessee-North Carolina	
152	Patuxent	Md.-D. C	5
‡153	Ouray	Colorado	
‡154	Winslow	Ark.-Okla. (Ind. T.)	
155	Ann Arbor (reprint)	Michigan	25
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‡157	Passaic	New Jersey-New York	
158	Rockland	Maine	5
‡159	Independence	Kansas	
‡160	Accident-Grantsville	Md.-Pa.-W. Va.	
‡161	Franklin Furnace	New Jersey	
‡162	Philadelphia	Pa.-N. J.-Del	
‡163	Santa Cruz	California	
‖164	Belle Fourche	South Dakota	5
‖165	Aberdeen-Redfield	South Dakota	5
‡166	El Paso	Texas	
‡167	Trenton	New Jersey-Pennsylvania	
‖168	Jamestown-Tower	North Dakota	5
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‖170	Mercersburg-Chambersburg	Pennsylvania	5
‖171	Engineer Mountain	Colorado	5
‖172	Warren	Pennsylvania-New York	5
¶173	Laramie-Sherman	Wyoming	5
¶174	Johnstown	Pennsylvania	5
‡175	Birmingham	Alabama	
‖176	Sewickley	Pennsylvania	5
‡177	Burgettstown-Carnegie	Pennsylvania	
‖178	Foxburg-Clarion	Pennsylvania	5
‖179	Pawpaw-Hancock	Md.-W. Va.-Pa	5
‖180	Claysville	Pennsylvania	5
‖181	Bismarck	North Dakota	5
‖182	Choptank	Maryland	5
‖183	Llano-Burnet	Texas	5
‖184	Kenova	Ky.-W. Va.-Ohio	5
§185	Murphysboro-Herrin	Illinois	25
§186	Apishapa	Colorado	5
§187	Ellijay	Ga.-N. C.-Tenn	25
§188	Tallula-Springfield	Illinois	25
189	Barnesboro-Patton	Pennsylvania	25
§190	Niagara	New York	50
§191	Raritan	New Jersey	25
192	Eastport	Maine	25
§193	San Francisco	California	75
194	Van Horn	Texas	25
195	Belleville-Breese	Illinois	25
196	Philipsburg	Montana	25
§197	Columbus	Ohio	25
198	Castle Rock	Colorado	25
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200	Galena-Elizabeth	Illinois-Iowa	25
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203	Colorado Springs	Colorado	25
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