DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

GEOLOGIC ATLAS

OF THE

UNITED STATES

BELLEVILLE-BREESE FOLIO

ILLINOIS

BY

J. A. UDDEN AND E. W. SHAW

SURVEYED IN COOPERATION WITH
THE GEOLOGICAL SURVEY OF ILLINOIS

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BELLEVILLE-BREESE FOLIO
NO. 195

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.

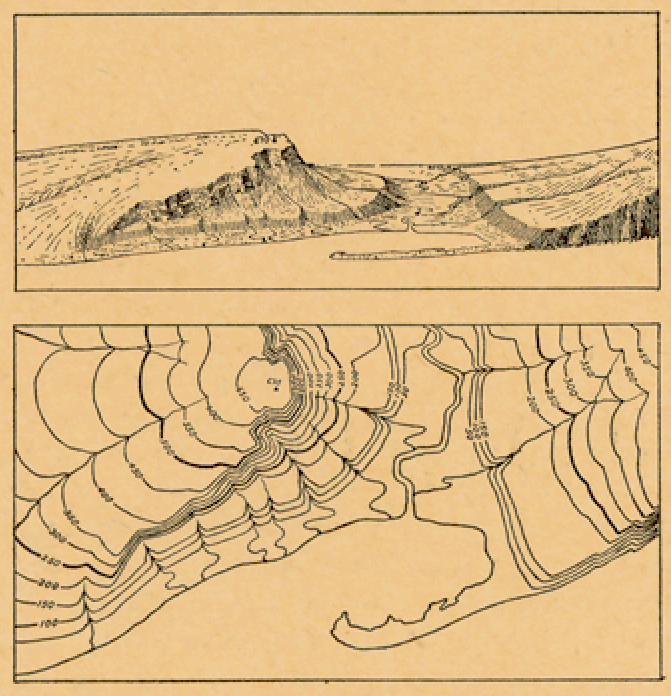

FIGURE 1.—Ideal view and corresponding contour map.

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 BELLEVILLE AND BREESE QUADRANGLES.[1]

By Johan August Udden and Eugene Wesley Shaw.

INTRODUCTION.

POSITION AND GENERAL RELATIONS.

The Belleville and Breese quadrangles are bounded by meridians 89° 30′ and 90° and parallels 38° 30′ and 38° 45′ and thus include one-eighth of a square degree of the earth's surface, an area, in that latitude, of 466.56 square miles. They lie in southwestern Illinois (see fig. 1), a few miles directly east of St. Louis, and comprise considerable portions of Clinton, Madison, and St. Clair counties, and a small part of Bond County. Belleville, from which the Belleville quadrangle is named, is in the southwest corner of the area.

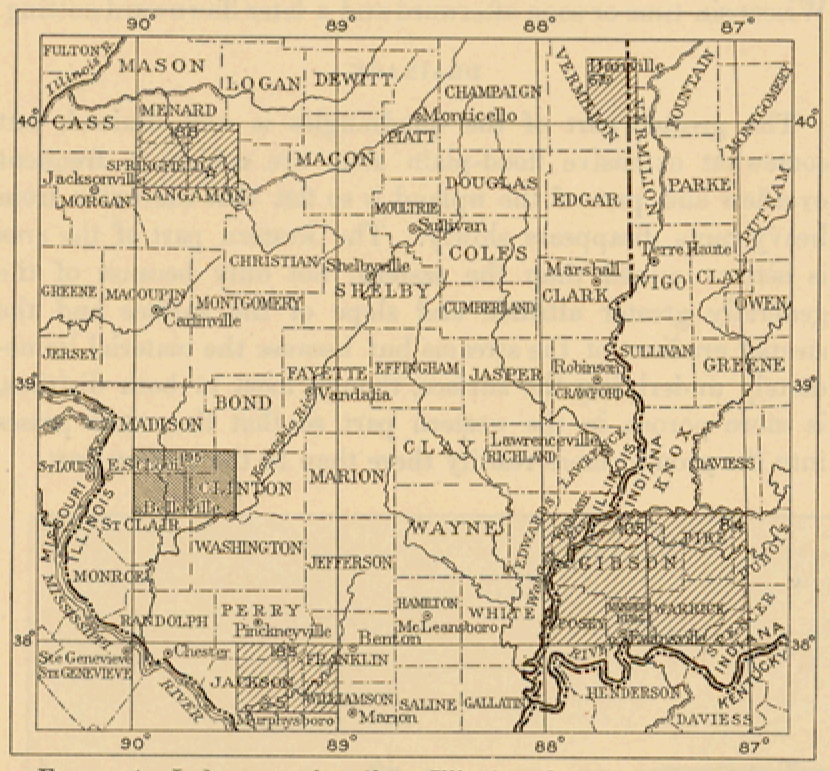

FIGURE 1.—Index map of southern Illinois and portions of adjacent States.

The location of the Belleville and Breese quadrangles (No. 195) is shown by the darker ruling. Published folios describing other quadrangles, indicated by lighter ruling, are the following: Nos. 67, Danville; 84, Ditney; 105, Patoka; 185, Murphysboro-Herrin; 188, Tallula-Springfield.

In their general geographic and geologic relations the quadrangles form a part of the Glaciated Plains province, all parts of which have had a general history in common, recorded in the rocks and in the topography.

OUTLINE OF GEOGRAPHY AND GEOLOGY OF THE GLACIATED PLAINS.

Definition.—The Glaciated Plains province (see fig. 2) extends from the Appalachian province on the east and southeast to the Great Plains on the west and from the Ozark province on the south to and beyond the northern boundary of the United States. It is limited by the boundary of the glaciated area of the Central States except at the western border of the plains, where, for convenience, the 2,000-foot contour is used as its limit, and at the eastern border, where the Pennsylvania-New York State line forms a convenient boundary. The boundary between the Appalachian and the Glaciated Plains provinces is not sharply defined, for parts of the typical Appalachian region were covered with ice and parts of the Glaciated Plains are characterized by surface features of Appalachian type and origin. Near the middle of the province is an area of about 10,000 square miles that was not covered by glacial ice and contains no drift, but as this driftless region is comparatively small and has had a history similar in other respects to that of the surrounding territory it is regarded as a part of the Glaciated Plains.

Relief.—The Glaciated Plains province is in general a broad rolling plain developed on low-lying, nearly horizontal rocks, though it shows considerable diversity in the form of its surface in its different parts. The surface generally lies from 500 to 1,500 feet above sea level, but the low-water surface of the Mississippi on the south side of the province is only about 300 feet above sea level, and a few places in the Upper Peninsula of Michigan and the western border of the province in North Dakota rise to a height of about 2,000 feet.

In some parts of the province the relief is less than 100 feet; in others it is 600 to 800 feet. One of the principal features is the valley of the Mississippi, which is fairly regular in shape and is flat bottomed, steep sided, and generally 3 to 6 miles wide and 200 to 400 feet deep. On the other hand, most of the tributaries of the Mississippi, being less powerful eroding agents, flow in valleys that are irregular in width and depth and have indirect courses.

Drainage.—The northern and northeastern parts of the Glaciated Plains lie in the basin of the Great Lakes and the upper St. Lawrence and the remainder in the basin of the Ohio and upper Mississippi. The divide between the two drainage basins is irregular and somewhat indefinite and is so low as to be scarcely perceptible.

The province contains several sheets of glacial drift, formed in as many different ice epochs. The narrow irregular belt along the western and southern sides of the province that was not covered by the later ice sheets is well drained, but the area of the later drift includes swampy tracts, many streams having irregular courses, and numerous lakes. The poor drainage of this area is due to its relatively recent occupation by ice, which

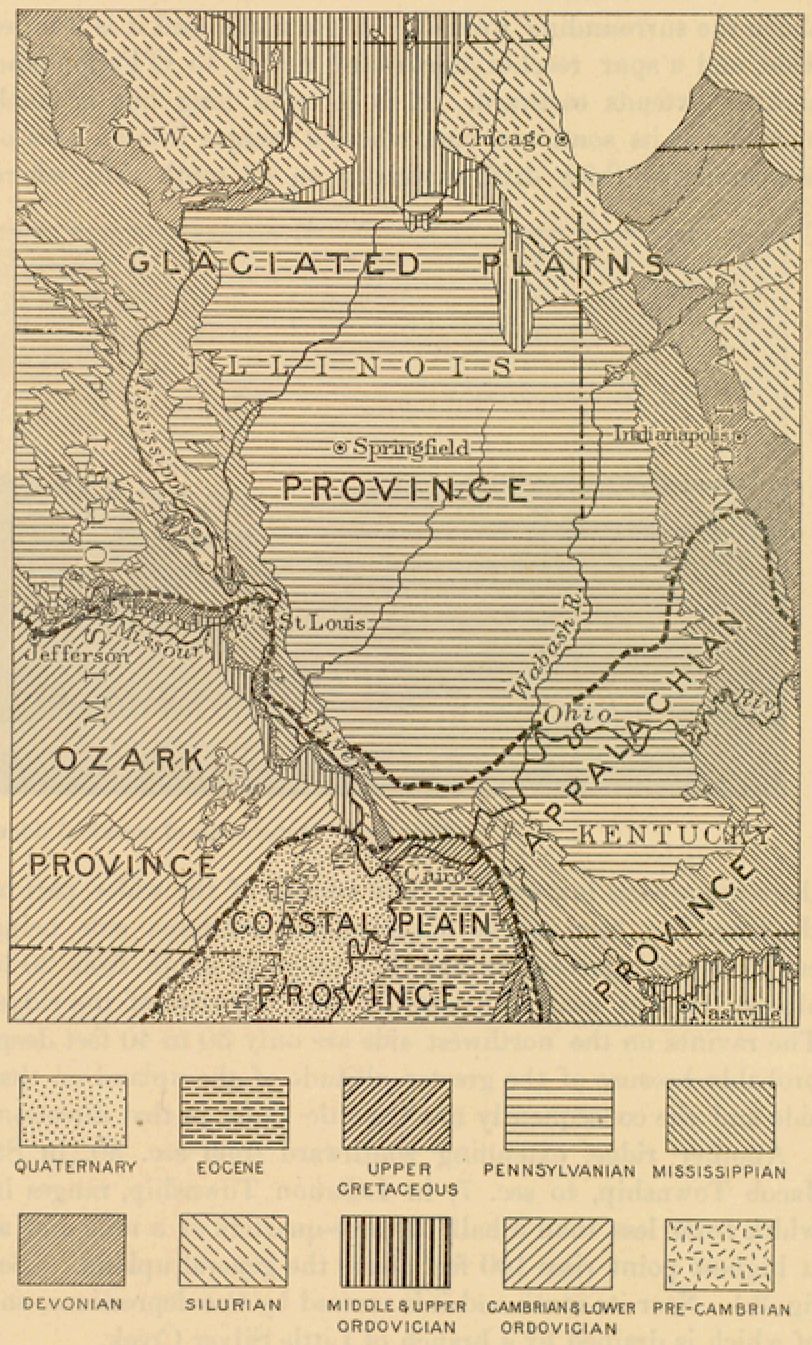

FIGURE 2.—Geologic sketch map of Illinois and surrounding region.

Shows also physiographic provinces of the region. The indefinite boundary between the Ozark and Appalachian provinces coincides approximately with the southeast boundary of Illinois. Map copied from geologic map of North America, U. S. Geol. Survey, 1911.

blocked many drainage lines and on melting left a sheet of débris reaching in places a thickness of several hundred feet and filling many of the old valleys. The reestablished drainage systems are only slowly approaching a normal condition. In the belt that was covered by the earlier glaciers but not by the later ones the streams have had time to become almost readjusted.

The average discharge of the Mississippi at Menard, near Chester, about 70 miles below St. Louis, is estimated to be 178,230 second-feet. The drainage basin above that point covers 711,900 square miles, and the run-off per square mile is thus 0.263 second-foot. Careful measurements indicate that the Mississippi annually carries past Menard 195,052,000 tons of mineral matter in solution and suspension. The surface of the basin above Chester is thus being lowered at an average rate of about 1 inch in 700 years.

Climate and vegetation.—The Belleville and Breese quadrangles receive about 40 inches of precipitation a year, somewhat more than half of which falls in the six months between the end of March and the beginning of October. The supply is thus bountiful and fairly well distributed though in many years droughts are troublesome in August. The mean temperature and the variations are similar to those of the large surrounding well-known territory of the North Central States.

A considerable part of the Glaciated Plains was once forested with deciduous trees and the remainder was prairie. In general, the rougher parts—the valley sides and the morainic hills—were forested and the flatter areas were prairie. Many small tracts of woodland still exist and some areas are reforesting, but the bulk of the land is under cultivation.

Stratigraphy and history.—The rocks underlying the Glaciated Plains include igneous, sedimentary, and metamorphic varieties and range in age from pre-Cambrian to Recent, or from the oldest known rocks to the youngest, but many epochs are unrepresented by beds of rock, and no epoch is represented by a formation that underlies the whole province, for there have been many shifts from deposition to erosion, some of which have involved the whole province.

In earlier geologic time, sea water frequently covered a large part of the province and remained long enough to permit extensive marine deposits to be formed. The surface was rarely, if ever, depressed far below sea level or elevated much above it but was affected throughout by gentle and more or less continuous warping, which allowed the sea to advance and retreat irregularly and brought about, from time to time and place to place, not only sea deposition and land erosion but sometimes, especially in the Pennsylvanian epoch, land deposition. Since the close of the Paleozoic era the entire province seems to have lain above sea level and to have been subjected to continuous erosion except in Quaternary time, when it received extensive deposits of glacial drift.

The pre-Cambrian formations are made up of igneous and metamorphic rocks having a complex structure. Upon their deeply eroded and planed surface rest all the later strata—the shales, sandstones, limestones, and unconsolidated rocks that outcrop throughout the province except in that part where the pre-Cambrian rocks themselves lie at or near the surface.

Lower and Middle Cambrian time seem to be unrepresented by deposits in the Glaciated Plains province, but in Upper Cambrian time most of its middle and southern parts received deposits. In the upper Mississippi Valley the Cambrian strata are from 400 to more than 1,000 feet thick and consist principally of sandstone and shale, limestone seeming to have been but slightly developed here or elsewhere in the province in Cambrian time. To the south and west, however, in southeastern Missouri, Oklahoma, and central Texas, the Upper Cambrian rocks consist largely of limestone. The rocks of Ordovician age consist mainly of dolomite and limestone but include also two or more sandstone formations, of which the St. Peter is the most important. The seashore migrated widely during this period and the deposits laid down are now divisible into numerous formations.

The Silurian system is made up of dolomite and limestone and a minor amount of shale. The numerous layers, or most of them, were formed in shallow seas, none of which covered the whole province, and all were surrounded by low-lying land. The Devonian system is best represented in the eastern, southern, and western parts of the province, where its greatest thickness is generally 700 or 800 feet, though in a few places it is somewhat thicker. In the central part of the province the Devonian is thin, and toward the north it thins out entirely. In western Illinois it consists chiefly of blue fossiliferous limestone overlain by black carbonaceous and commonly fossiliferous shale. The limestone was deposited in open sea water and the shale perhaps in shallow sea water and perhaps on low-lying swampy land. The sea was especially restricted in the early part of the period.

The Mississippian series consists, in the eastern part of the province, of clastic rocks having a thickness of 1,000 feet or more, but in the central and western parts it is made up largely of thick limestone and interbedded lenses of shale and sandstone, having a total thickness of 300 to 800 feet. As in the preceding periods, the extent and depth of the sea varied considerably and, especially near the close of the epoch, the earth's crust was extensively warped and large bodies of sand were deposited. The Pennsylvanian series is made up largely of rather sandy shale but includes much sandstone and some limestone and coal. Its area of outcrop is greater than that of any other series of rocks in the province. Many of the beds

[1] Surveyed in cooperation with the Illinois Geological Survey. The greater part of the material comprised in this report was prepared by J. A. Udden and transmitted by the Illinois Geological Survey in the form of a geologic report. Additional field studies, concerning principally the Quaternary formations, were made by E. W. Shaw, who has rewritten and supplemented the original matter for publication in folio form.

are lenticular, but some of the beds of coal and limestone can be traced continuously over hundreds of square miles. The conditions in Pennsylvanian time were markedly different from those that prevailed in the preceding epochs, for between periods of sea occupation extensive marsh deposits were formed, which have been more or less completely preserved in the form of carbonaceous shale and coal. Traces of the Permian series have been found near Danville, Ill., and large Permian deposits occur also to the southeast, in West Virginia and Ohio, and to the southwest, in Kansas. During this epoch most of the Glaciated Plains province seems to have stood above sea level and much material was carried from it into other areas.

With the exception of those of the Quaternary system, rocks of post-Carboniferous age are rare in the Glaciated Plains. Throughout Mesozoic and Cenozoic time the region stood considerably above sea level, and the land had sufficient slope to permit practically all the earthy material in the area that was moved at all to be carried out into other areas. The surface of the province has apparently been brought to its present level by several minor uplifts, and there may have been also some subsidence. The record, however, is obscure, because the movements were not great and because the strata are nearly horizontal and of uniform hardness over wide areas, so that it is difficult to distinguish low plateaus due to hard rock from those due to interrupted elevation. Furthermore, the age of features that appear to mark stages of elevation and erosion is uncertain, owing to difficulties in correlating them with deposits of known age. At the times of principal uplift of the Appalachian and Ozark mountains, however, the borders at least of the Glaciated Plains were also uplifted.

The older rocks almost throughout the province are covered with Quaternary deposits, which consist principally of glacial drift—material very different from any previously deposited within the area. Several times continental glaciers spread out from the north, bringing great loads of gravel, clay, and sand and remodeling drainage systems.

Structure.—The structure of most of the consolidated rocks underlying the Glaciated Plains is comparatively simple. The strata in most of the province lie nearly flat, their regularity being broken only by small faults and low, broad folds. The principal exceptions are the pre-Cambrian rocks that outcrop in Wisconsin, Minnesota, and northern Michigan, which are in some places so complexly folded, contorted, and faulted that their structure can be worked out only with difficulty. Aside from the complex structure of the pre-Cambrian rocks and local more or less pronounced irregularities, the major structural features are the following:

1. A low, broad arch on the southeast, known as the Cincinnati anticline, which lies in part within the Appalachian Plateau. North of Cincinnati, where it is highest, this arch divides, one branch running toward Lake Erie and the other toward Lake Michigan.
2. A shallow basin that is practically coextensive with the Lower Peninsula of Michigan.
3. Another basin that occupies most of Illinois and southwestern Indiana.
4. A still broader basin that extends westward from the Mississippi across Iowa and Missouri into the Great Plains.
5. A broad arch that affects Wisconsin and Minnesota.

The basins contain great coal fields, known as the northern interior, eastern interior, and western interior coal fields, and east of the province lies another basin containing the Appalachian coal field. Around each basin the strata crop out in concentric belts, the youngest being found in the middle and the oldest around the outer border. Thus, for example, 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 the State, and if all the beds found in Illinois were extended northward the uppermost would be several thousand feet above the present surface in central Wisconsin. The formation of the domes, basins, and other structural features seems to have begun early in the Paleozoic era, if not before, but the greatest movement seems to have occurred near the close of the Carboniferous period.

TOPOGRAPHY.

RELIEF.

General features.—The Belleville-Breese district is characterized by comparatively slight relief and gentle slopes. Its altitude is low in view of its great distance from the sea. From a height of 560 feet above sea level in the western part the land slopes in general eastward, away from the Mississippi, at a rate a little more than 3 feet to the mile, so that in the eastern part it lies only 475 feet above sea level. The surface is that of a drift-formed plain above which rise scattered ridges and into which streams have cut, forming valleys a quarter of a mile to 2 miles wide and 10 to 100 feet deep.

The area contains four varieties of topographic forms—upland prairies, morainic hills, valleys, and flood plains.

Upland prairies.—The uplands occupy more than half the area, are generally flat, and differ from the remaining portion in being largely prairie. They are the remnants of a plain formed by the deposition of a nearly flat-surfaced body of glacial till, over which a mantle of loess of comparatively uniform thickness was later spread.

The Breese quadrangle includes the larger part of the flat upland, which there has a general slope from 530 feet above sea level in the northern part to 460 feet in the southwestern and 430 feet in the southeastern part. It is broken by valleys that are gradually being broadened and lengthened and are developing new branches, so that the area of upland is slowly being reduced. The upland of the Belleville quadrangle is more irregular in outline and more diverse in topographic form, but it also is generally flat and slopes from 560 feet above sea level in the northwestern part of the quadrangle to 460 feet in the southeastern part. West of Troy the surface is very flat and lies at an altitude of 570 to 580 feet. This upland extends southwestward nearly to Belleville and in some places reaches an altitude of 600 feet. St. Jacob, in the northeastern part of the quadrangle, lies on an upland having an altitude of 490 to 530 feet. In the southeastern part of the quadrangle the uplands are very smooth and slope gently toward the ill-defined valley of Silver Creek.

Morainic hills.—Above the general upland surface rise several ridges having a north-northeasterly trend and forming part of a group of ridges which has been traced from Tower Hill, in Shelby County, southwestward beyond Belleville. These ridges are not remnants left by erosion, as they rise sharply from the surrounding flat upland, are formed of glacial drift, and are without rock cores. They appear to be some variety of moraine.

The most conspicuous ridge is the one on the summit of which the village of Shiloh is situated. It rises to a height of 660 feet above sea level and somewhat more than 100 feet above the surrounding upland. At its north end it is 2 miles wide, and a spur reaches northward nearly to O'Fallon and another extends eastward. It is 4 miles long but is much narrower at its southwest end, where it merges into an area of comparatively thick drift, especially on its south side, where there are several low swells. The surface of the wider part of the ridge has been much dissected, the southeast side being cut by several narrow ravines that range in depth from 20 to almost 100 feet, nearly all heading near the crest of the ridge. The ravines on the northwest side are only 30 to 40 feet deep, probably because of the greater altitude of the upland on that side and the consequently more gentle slope in that direction.

Another ridge, extending southward from sec. 30, in St. Jacob Township, to sec. 7, in Lebanon Township, ranges in width from less than a half to three-quarters of a mile and at it highest point rises 100 feet above the general upland. (See fig. 3.) Near its south end it is crossed by two depressions, one of which is drained by a branch of Little Silver Creek.

A less conspicuous but well-marked ridge, rising about 50 feet above the general surface, extends 3 miles southward from Highland. Another chain of hills, west of those just described, extends northeastward a mile west of Highland, the southernmost hill being just north of the Frey schoolhouse in sec. 14, St. Jacob Township. The next hill to the north is in the northeastern part of sec. 12 of the same township, and still farther north several hills merge into a continuous chain extending northeastward beyond the Breese quadrangle.

A broken ridge extends southward from Breese and a similar one extends southward and westward from Shoal Creek, in Germantown Township. Scattered throughout the area are isolated ridgelike hills, one standing on the east bluff of Sugar Creek a mile southwest of Damiansville and another on the opposite side of the same creek $1\frac{1}{2}$ miles west of Albers. Still another stands on the east bluff of Silver Creek in sec. 12, Shiloh Valley Township. A ridge northwest of Summerfield and a small hill immediately southeast of that place also appear to be without structural relations to other topographic features.

Valleys.—The surface of the quadrangles is fairly well dissected but none of the valleys is large. That of Shoal Creek, in the southeastern corner, is the widest, the valley bottom being a mile wide. Owing largely to irregularities of the surface into which they are cut, the valleys are irregular in shape, depth, and width. Most of them have not been cut down to bedrock and hence have the form of valleys carved in unconsolidated material. In places, as near Collinsville, the streams are cutting into hard rock and have considerable fall and the valleys are narrow and steep sided. Elsewhere they are broad and shallow and not sharply defined from the flat upland. This is especially true in the southern part of the area, where the valleys of Shoal, Sugar, and Silver creeks are poorly defined. In some places broad, shallow swales connect the heads of valleys across intervening uplands. One such swale, one-quarter to one-half mile wide, extends from sec. 18 to sec. 21 in St. Rose Township; another has a sinuous course in the uplands between the upper part of Spanker Branch and Sugar Creek, north and west of Sebastopol.

Along the upper part of Shoal Creek, from the northeast corner of the Breese quadrangle to sec. 2 in Breese Township, there are remnants of loess-covered terraces at a height of 30 feet above the creek bottoms. In the northern half of St. Rose Township the western limit of such a terrace is marked by a low bluff. The terrace probably represents a former alluvial plain caused by the presence of a ledge of limestone. In the southern part of the area, particularly along Shoal Creek, there are indistinct, low, broad terraces, which appear to have been caused by a silting up of the Kaskaskia Valley in Wisconsin time or soon afterward and a later downward cutting.

DRAINAGE.

The greater part of the quadrangles is well drained, but somewhat extensive flood-plain areas are subject to frequent overflow and part of the upland is so flat that the water from heavy rains disappears slowly. The western part of the area is better drained than the eastern, not only because of the generally greater altitude and slope of the surface and the steeper gradient of the streams but because the material immediately underlying the surface, though loess in both districts, is more porous in the western part, so that the water passes into the ground more readily there than in the eastern part.

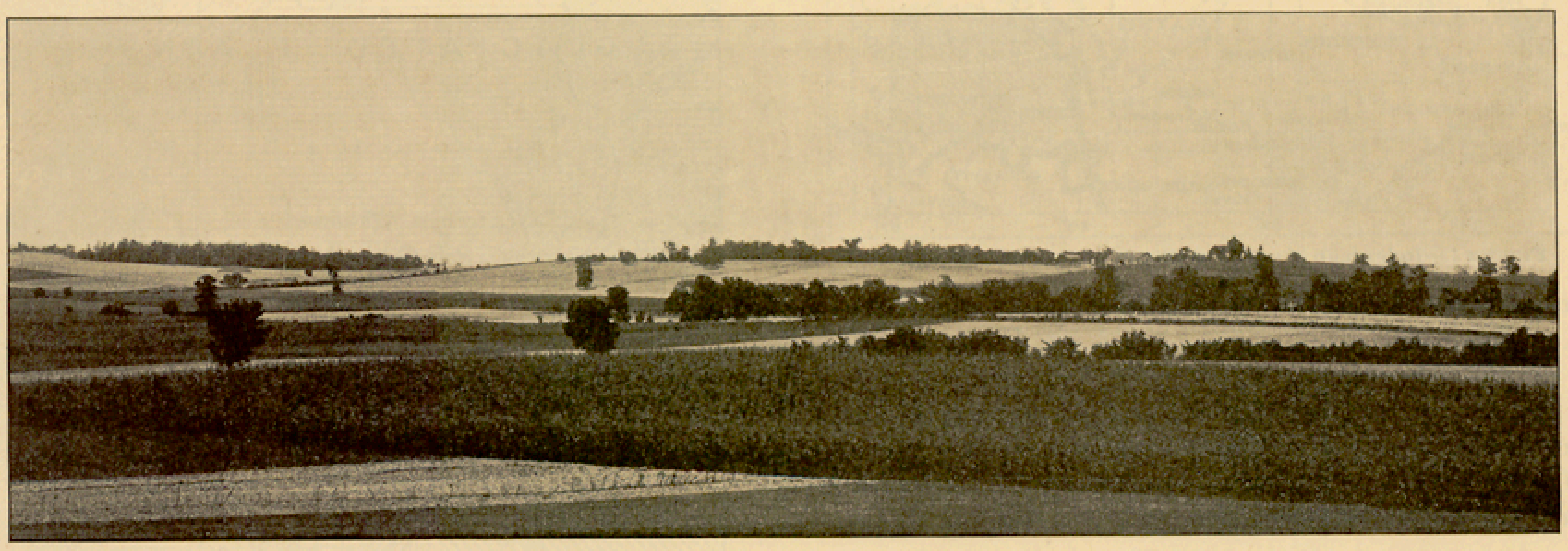

FIGURE 3.—Outer slope of morainal ridge 3 miles north of Lebanon, looking northeastward.

The run-off of the area passes by way of many small intermittent streams to Richland, Silver, Sugar, and Shoal creeks, which discharge into Kaskaskia or Okaw River a few miles south of the area. The Kaskaskia joins the Mississippi near Chester, Ill., nearly 100 miles south of Belleville as the stream flows, at a low-water altitude of 350 feet and a high-water altitude of 390 feet. The principal streams of the Belleville and Breese quadrangles leave the area at altitudes of about 400 feet and, the fall being slight, the water passes off slowly, particularly at times of high water. Some of the small streams, however, especially those in the northern and western parts of the area, have considerable fall and from these the water from heavy rains passes off rapidly. The Kaskaskia, like many other streams in the central Mississippi basin, falls very little in the lower part of its course and therefore, as the water moves slowly, it often backs up into tributary valleys in times of flood. As a result certain areas in the Belleville and Breese quadrangles are sometimes flooded by water which fell on areas not within the drainage basins of its streams.

The northwestern part of the area is drained by Canteen Creek and Schoolhouse and Judys branches and their numerous small intermittent tributaries. The southwestern part is drained by the headwaters of Richland Creek.

Silver Creek flows from north to south across the west-central part of the area, with a fall, measured by stream length, of a little more than a foot to the mile, or, measured by flood-plain length, of nearly 2 feet to the mile. Its principal tributaries in the area, named from north to south, are Wendel Branch, East and Lake forks, Mill and Ogles creeks, Rock Spring Branch, and Little Silver Creek.

Sugar Creek flows from north to south across the middle of the Breese quadrangle with a fall, measured by flood-plain length, of about 3 feet to the mile. It is a considerably smaller stream than Silver Creek. Within the quadrangle it receives the waters of Spanker and Lake branches and numerous smaller unnamed runs.

The course of Shoal Creek lies along the eastern border of the area, parallel to Sugar and Silver creeks, and its fall, measured by the length of the flood plain, is about 18 inches to the mile. Its drainage basin is narrow and its tributaries in the Breese quadrangle are intermittent and are only 2 or 3 miles long.

In the upland part of the area erosion channels are not well developed and the surface drainage is imperfect. The streams rise in ill-defined depressions and here and there throughout their courses are fed by small springs that issue from the contact between the porous loess and the underlying bowlder clay and form sandy lenses in the bowlder clay.

CULTURE.

The quadrangles are rather thickly, though not densely, populated. The city of Belleville, in the extreme southwest corner of the area, had a population in 1910 of 21,122. The other principal towns, named from west to east, are Collinsville, Glen Carbon, Troy, O'Fallon, Lebanon, Summerfield, St. Jacob, Highland, Trenton, New Baden, Aviston, Breese, and Germantown. The population of Collinsville is more than 7,000 and the other places contain several hundred people each. The area outside the towns is well settled, dwelling-houses along the principal roads averaging less than one-fourth mile apart, and schoolhouses and churches are numerous.

Most of the surface is under cultivation and agriculture and coal mining are the principal industries, the mines, which are most numerous near Belleville, giving employment to several thousand men. Manufacturing industries are not numerous or extensive, though some manufacturing is carried on, especially in Belleville. The men employed on the railroads live, for the most part, outside the area.

The quadrangles are well provided with transportation facilities. The Southern, Louisville & Nashville, and Illinois Central railroads radiate from Belleville; the Baltimore & Ohio Southwestern Railroad crosses the central part of the area from east to west; and the Pennsylvania, St. Louis, Troy & Eastern, and Illinois Central railroads cross the northwestern corner of the area. Electric lines from St. Louis reach Belleville, Lebanon, and Collinsville. Wagon roads are of ordinary abundance, and many of them follow land-survey lines. Hardly any point in the area is more than half a mile from a public road. Few of the roads are macadamized.

DESCRIPTIVE GEOLOGY.

STRATIGRAPHY.

GENERAL CHARACTER OF THE ROCKS.

The rocks of the Belleville and Breese quadrangles are wholly sedimentary and consist in part of nearly horizontal indurated strata, Carboniferous or older, and in part of unconsolidated surficial deposits of Quaternary age, which nearly everywhere overlie the hard rocks. (See fig. 4.) The hard

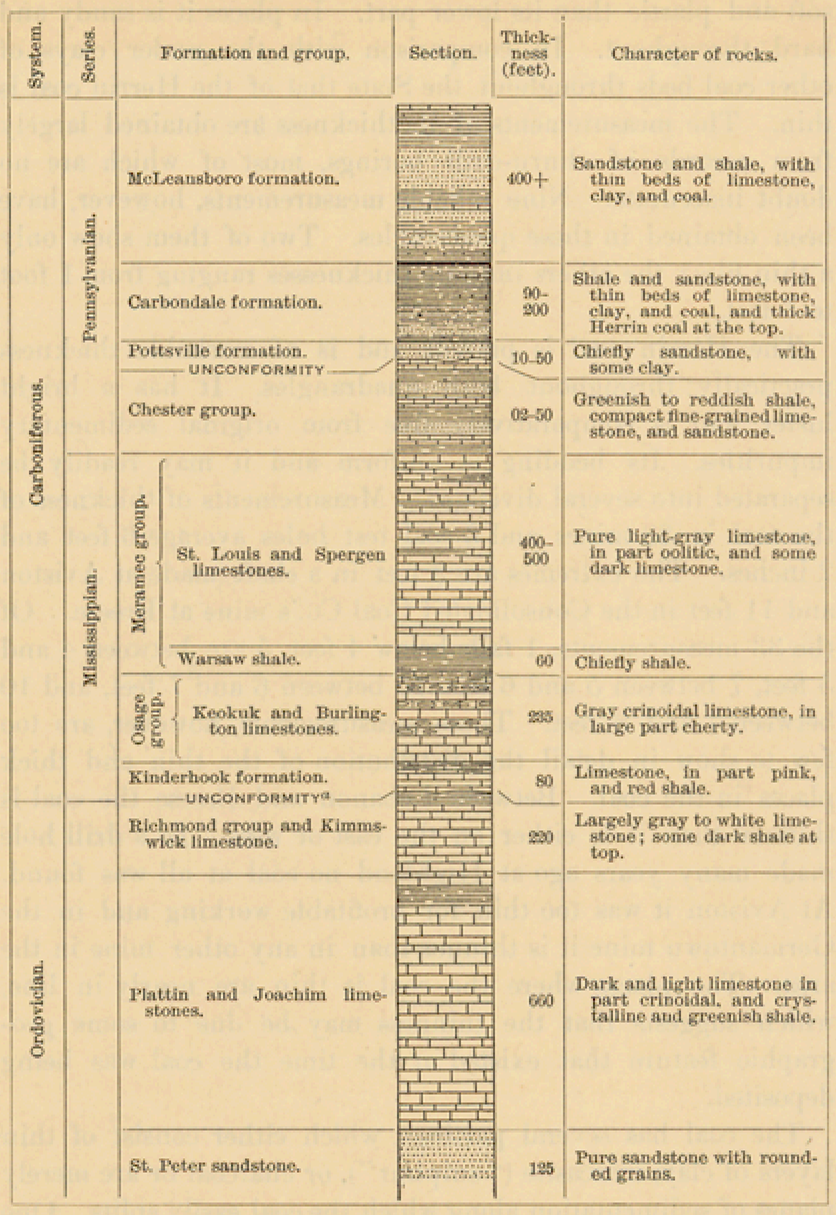

FIGURE 4.—Generalized columnar section of rocks underlying the Belleville and Breese quadrangles.

Scale: 1 inch=500 feet.

[a] Devonian and Silurian probably represented by deposits in some localities.

rocks are known from scattered exposures at the surface and from records of borings for coal, water, and oil, many of which are more than a thousand feet deep. One boring just outside the area is about 2,000 feet and another is about 3,000 feet deep.

Strata of ages ranging from Cambrian to Ordovician, resting on a pre-Cambrian floor of metamorphic rocks such as outcrop in the St. Francis Mountains in Missouri, probably underlie the Belleville-Breese district, for such strata have been penetrated by deep borings at many places in Illinois and outcrop in neighboring States. The deepest borings in this region are just outside the quadrangles, at Monks Mound and Mascoutah. They pass through all the thick Pennsylvanian and Mississippian formations and appear to have reached also through the Devonian and Silurian systems, if present, to the St. Peter sandstone of the Ordovician system. Samples from many of the strata encountered in these wells have been preserved and have been carefully examined by the authors and by several others. Sections made up from logs of wells are given on the columnar-section sheet. A few others are described below.

A well was drilled by Julius Postel in Mascoutah, about a mile from the southeast corner of the Belleville quadrangle, to a depth of 3,050 feet. Few samples of the drillings have been preserved, but some were examined and described by J. H. Southwell, who has studied many drill cuttings and well records.

Log of Postel Mill well, Mascoutah, Ill.

[Altitude of surface, 425 feet.]

System, formation, and bed.	Thickness.	Depth.
Quaternary system:		
Loess and till (104 feet):	*Feet.*	*Feet.*
Clay	30	30
Quicksand	5	35
Sand, white, compact	5	40
Bowlder clay, with gravel 7 feet above base	64	104
Carboniferous system:		
Pennsylvanian series (237 feet):		
McLeansboro formation (41 feet):		
Limestone	8	112
"Lime," hard, coaly	30	142
Limestone	3	145
Carbondale and Pottsville formations (196 feet):		
Coal, Herrin (Belleville, or No. 6)	6	151
Shale	15	166
"Soapstone"	10	176
Shale	25	201
Coal (probably equivalent to Springfield or No. 5)	5	206
Shale, light gray	50	256
Shale, blue	40	296
Shale, light gray	45	341
Mississippian series (1,739 feet):		
Chester group (?) (399 feet):		
Shale, red, sandy ("red rock")	45	386
Shale (?)	154	540
Limestone	5	545
Sandstone	45	590
Shale	25	615
Limestone	20	635
Shale, red, sandy ("red rock")	55	690
Shale, light colored, calcareous, with some sandstone	50	740
St. Louis and Spergen limestones (460 feet):		
Limestone	460	1,200
Warsaw shale, Osage group, and Kinderhook formation (880 feet):		
Shale (?)	420	1,620
Limestone, shaly	390	2,010
Marl, red (Fern Glen limestone member of Kinderhook formation?)	70	2,080
Ordovician and possibly Silurian and Devonian systems (989 feet):		
Limestone	126	2,206
Shale (Maquoketa?)	127	2,333
Limestone	449	2,782
Shale	58	2,840
Limestone	10	2,850
Shale and limestone	48	2,898
Sandstone, clean grains, well rounded, probably St. Peter	171	3,069

A well was drilled for oil about the year 1903 on a small mound 1,000 feet southwest of the village of Monks Mound and 5 miles west of Collinsville. At least 100 samples of the rocks penetrated were carefully collected by S. L. Shellenberger, of East St. Louis, and presented to the St. Louis Academy of Science. The following log is made up from a study of the samples, the interpretation being in part the work of the authors and in part that of E. O. Ulrich and others. The identification of one or two formations and the exact boundaries of several others are in doubt, as will appear from the log.

Log of well near Monks Mound, Ill.

[Altitude of curb, about 430 feet.]

System, formation, and bed.	Thickness.	Depth.
Quaternary system:		
Alluvium (150 feet):	*Feet.*	*Feet.*
Soil, sand, and gravel	40	40
Sand, fine grained	20	60
Sand, coarse	10	70
Gravel; one worn Unio shell	80	150
Carboniferous system:		
Pennsylvanian series ("Coal Measures") (75 feet):	*Feet.*	*Feet.*
Shale, gray, slightly calcareous	55	205
Shale, light blue, noncalcareous, in places laminated; a little limestone near top and base	20	225
Mississippian series (790 feet):		
Chester group (?) (90 feet):		
Sandstone, calcareous	5	230
Sandstone, white, compact	5	235
Sandstone, moderately fine grained, friable	65	300
Limestone, shaly, light colored	5	305
Sandstone, gray, fine, light-colored	10	315
St. Louis and Spergen limestones (403 feet):		
Limestone, fine grained, compact, white	45	360
Limestone, white, with a little sandstone and shale	20	380
Limestone, grayish white, with a little thinly laminated shale	30	410
Gravel and sand, cemented by laminated iron, with some dark chert in dolomitic limestone	30	440
Limestone, gray, with some bluish coarse sand	50	490
Limestone, white, fossiliferous	15	505
Limestone, gray, crinoidal, somewhat bituminous	10	515
Limestone, gray, brecciated	10	525
Limestone, nearly pure, with some chert	65	590
Limestone, fossiliferous	35	625
Limestone, brecciated, fossiliferous, without chert	45	670
Limestone, cherty, fossiliferous	10	680
Limestone, gray, not cherty, fossiliferous, containing some clay. (This bed and probably several overlying are Spergen)	38	718
Warsaw shale (62 feet):		
Shale, calcareous, gray	62	780
Osage group (Keokuk and Burlington limestones) (235 feet):		
Limestone, gray, crinoidal, fossiliferous, cherty	10	790
Limestone, cherty, light colored	20	810
Chert, white, and limestone	140	950
Limestone and chert, some having a greenish tinge and some containing organic fragments	15	965
Limestone, dull greenish with crinoid stem	30	995
Limestone, greenish gray, cherty; some dull purple and pinkish[a]	20	1,015
Kinderhook formation, with possibly some Devonian at base (80 feet):		
Marl, pink	30	1,045
Limestone, brecciated, crinoidal	5	1,050
Limestone, green	5	1,055
Limestone, grayish white	15	1,070
Limestone, gray, fossiliferous, with some gray and pink fragments	11	1,081
Limestone, gray	14	1,095
Ordovician system:		
Richmond group and Kimmswick limestone (220 feet):		
Marl, gray, with some marcasite	10	1,105
Shale, dark bluish gray, calcareous, very hard	20	1,125
Limestone, dark gray, shaly, with many grains of marcasite. (This and the two preceding beds probably constitute the Maquoketa shale of the Richmond group)	10	1,135
Limestone, gray, in thick flakes	35	1,170
Limestone, purplish and greenish pink, gritty, crinoidal	25	1,195
Limestone, pinkish, greenish gray, and white	18	1,213
Limestone, dull pink, with some chert	12	1,225
Limestone, magnesian, dull greenish, with pinkish blotches of indistinct outline and many poorly preserved crinoid stems and other fossils	5	1,230
Limestone, red, reddish and greenish gray, with some white limestone having a resinous luster	20	1,250
Limestone, dull pinkish gray	5	1,255
Limestone, white, compact, with crinoid stems, in places coarsely crystalline	20	1,275
Limestone, slightly fossiliferous, marcasitic	5	1,280
Limestone, nearly white	5	1,285
Limestone, white, crystalline, granular	15	1,300
Limestone, white with greenish and black specks and a little marcasite	15	1,315
Plattin and Joachim limestones (660 feet):		
Limestone, magnesian, faintly yellowish gray, slightly porous and siliceous	20	1,335
Shale, greenish gray, noncalcareous	55	1,390
Limestone, gray, bituminous, somewhat crinoidal and pyritic	100	1,490
Limestone, white, coarsely crystalline	90	1,580
Limestone, light gray, slightly bituminous	100	1,680
Limestone, dark gray	20	1,700
Limestone, light straw-colored	75	1,775
Limestone, gray, with some pyrite	5	1,780
Limestone, gray to brownish straw-colored	35	1,815
Limestone, brownish gray	160	1,975
St. Peter sandstone:		
Sandstone, pure, some of the grains with facets of secondary crystallization, but most grains rounded, uniform grained	125	2,100

[a] It is possible that the basal portion of this stratum should be classed with the Kinderhook.

PRE-CARBONIFEROUS ROCKS.

In the well near Monks Mound a sandstone found at a depth of 1,975 feet and penetrated for 125 feet, closely resembles the St. Peter sandstone and has approximately the same stratigraphic position and was therefore correlated with that formation. There appears to be little doubt about the correctness of the correlation, for the St. Peter sandstone is peculiar in that it is composed of well-rounded, poorly cemented grains of clean quartz sand having surfaces like frosted glass.

The strata lying between the St. Peter sandstone and the Mississippian series and the probable identity of the beds are indicated in the foregoing sections. The log of the Monks Mound well is unusually complete and satisfactory, for the samples of the drillings were carefully collected and preserved.

CARBONIFEROUS SYSTEM.

MISSISSIPPIAN SERIES.

LOWER BEDS.

Concerning the lower part of the Mississippian series in the Belleville and Breese quadrangles not much more is known than of the underlying formations. The Fern Glen limestone member of the Kinderhook formation is usually noted in well records on account of its red color and therefore serves as a valuable index rock. It also contains an organic fragmental limestone of somewhat characteristic appearance. Red shale, probably belonging to this member, was noted in the Trenton Oil & Gas Prospecting Co.'s well at a depth of 1,900 to 2,000 feet and in the Postel Mill well at 2,010 to 2,080 feet. However, the correlation is not regarded as certainly correct.

Above the Fern Glen limestone member lie the limestones of the Osage group which are generally identifiable from their stratigraphic position and their cherty character. The three well records which have reached the Osage group are not closely concordant for this part of the section, and it is not known whether the apparent discrepancies are due to faulty records or whether there is an unconformity or overlap in the section. Apparently the basal part of the Mississippian series has a greater dip to the south and east than that of the overlying Pennsylvanian beds.

What is definitely known of the character of the other Mississippian rocks beneath the quadrangles is shown in the well sections, but much more may be reasonably inferred from the character of the rocks in the area of their outcrop a short distance to the south and west. The Meramec group includes the Warsaw shale and the Spergen and St. Louis limestones, the three formations having a combined thickness in the region of 400 to 500 feet. The Warsaw is composed chiefly of shale and is not readily separable from the upper formation of the Osage group, the shaly Keokuk limestone. The succeeding Spergen limestone is a nearly pure light-gray limestone, which is locally oolitic and in places very fossiliferous. The St. Louis limestone is composed of light to dark gray, commonly fine-grained limestone including local beds of shale and shaly limestone. It is better known than the underlying formations because of its extensive outcrop in the region and the fact that on account of its thick resistant cherty nature it is usually noted in well drilling. In fact the well drillers use it extensively as an index stratum and have the habit of referring to it as the "Mississippi lime."

CHESTER GROUP.

The Chester group, which constitutes the uppermost part of the Mississippian series of the region, includes the rocks which in southern Illinois and western Kentucky have heretofore been classified by Ulrich as Cypress sandstone, Tribune limestone, and Birdsville formation. Whether it also includes the Ste. Genevieve limestone is undecided. As a result of recent detailed stratigraphic and paleontologic work in Monroe and Randolph counties, Ill., a few miles south of the Belleville and Breese quadrangles, Weller[1] has recently subdivided the Chester group of this immediate region into the following formations, from the top downward: Clore limestone, Palestine sandstone, Menard limestone, Okaw formation, Ruma formation, Paint Creek formation, Yankeetown chert, Renault formation, and Brewerville sandstone.

The rocks of the Chester group consist of about equal amounts of shale, limestone, and sandstone. The shale is gray, greenish, bluish, and reddish. The limestone is compact, fine grained, and in places magnesian, as was noted in samples obtained from a well at the vinegar factory west of Belleville. Some specimens of limestone are nearly white but contain scattered dark-green grains; others are dark and some contain embedded fine sand. The sandstones of the Chester are not uniform in composition or in texture. In some places the grains are coarse and rounded; elsewhere they are fine and angular. The sandstones are also locally calcareous.

From the type locality, which is about 40 miles south of Belleville, the Chester group dips and thins to the northeast. In the Belleville and Breese quadrangles only a small part of the Chester is present, and possibly in some districts none of the group remains. The thinning is largely the result of the removal of the upper part of the group by erosion before the deposition of the succeeding Pennsylvanian series. Almost everywhere beneath the quadrangles the Chester includes conspicuously red shale and marl, easily noted and almost always reported by careful drillers.

[1] Weller, Stuart, The Mississippian Brachiopoda of the Mississippi Valley basin: Illinois Geol. Survey Mon. 1, pp. 23-29, 1914.

In the Collinsville well and in the old smelter well at Collinsville, red shale and red rock were noted at two horizons 90 feet apart. In the Hoblitzell well, near Aviston, two strata of red rock are 170 feet apart, and in the Postel Mill well, at Mascoutah, similar strata are 250 feet apart. The "red rock" strata seem to be rather persistent, though the stratigraphy of the Chester is, on the whole, somewhat irregular, shale, limestone, and sandstone giving place to each other within comparatively short horizontal distances. The unconformity at the top of the Mississippian series is well known from outcrops outside the quadrangles and from the records of many borings throughout southwestern Illinois. The truncation of the Chester group in the quadrangles is also indicated by the following table compiled from well borings:

Increase in distance of red shale of Chester group from the Herrin coal (Belleville, or No. 6) toward the southeast across the Belleville and Breese quadrangles.

Location of well.	Description of beds in records.	Depth of "red rock" under the Herrin coal, in feet.	Approximate distances from Collinsville, in miles.
Collinsville	Red shale, red and black shale	135-225	0
Do	Red shale	290-380	0
Cantine	Red fire clay, red shale with lime	175	1
Belleville	Red shale	250	6
Do	Red shale rock	300	7
Highland	Brown limestone, red sandstone, red shale, brown sandstone, red stone	575	9
Trenton	Red shaly rock	500	13
Mascoutah	Red rock	485	14
Aviston	do	425-595	16

This table indicates that the Pennsylvanian series is thicker in the southern and eastern parts of the area than in the northern and western parts. The irregularity of the change, however, suggests that there may be more than two strata of red rock.

The sandstones of the Chester group contain water almost everywhere except where they are very compact, though generally the water is salty, particularly at a distance of several miles from their outcrop. Near Carlyle and Sandoval, a few miles to the east, these sandstones contain valuable pools of oil and gas.

PENNSYLVANIAN SERIES.

POTTSVILLE FORMATION.

The Pottsville formation comprises the strata from the base of the Pennsylvanian series to the base of the underclay of the Murphysboro coal. It consists largely of sandstone and, like the underlying Chester group, it thins northward, so that although many hundred feet thick in southernmost Illinois it is generally only 10 to 50 feet thick in the Belleville-Breese area. In places it is represented only by clay, but the clay contains, here and there, remnants of plants by which the beds are correlated with the Pottsville formation of Pennsylvania. Generally the formation in this region includes some shale and a little thin, irregularly bedded coal, but no limestone. It is thus sharply differentiated from the underlying Chester group the uppermost part of which is limestone. It is more difficult, however, to distinguish the Pottsville from the overlying Carbondale formation in borings, because in this area these two formations are much alike in character and thickness.

CARBONDALE FORMATION.

General features.—The Carbondale formation is named from the town of Carbondale, in southern Illinois, near which it is well exposed. It embraces the strata from the base of the underclay of the Murphysboro coal, which is somewhat irregular in development, to the top of the Herrin coal, which underlies most, if not all, of the area.

Like the Pottsville formation, the Carbondale is known in the quadrangles only from borings, though in the western part of the area it lies near the surface. It consists mainly of sandstone and shale, a few somewhat lenticular beds of limestone and fire clay, and one to three coal beds, all but the Herrin coal being thin. In many places the shale is sandy and in some places it includes thin beds of sandstone. The formation ranges in thickness from about 90 feet at Belleville, where the Mississippian series reaches the highest altitude, to about 200 feet in the northeastern part of the area. From Belleville it thickens northward and eastward, as is shown in the following table, made up from such well records as indicate most definitely the position of the Mississippian-Pennsylvanian contact.

Increase of the combined thicknesses of the Pottsville and Carbondale formations in the Belleville and Breese quadrangles.

	Feet.
Belleville, Reinecke mine shaft	100
Collinsville Water Co.'s well	140
Collinsville old smelter well	140
Sec. 32, Jarvis Township, Lumaghi Coal Co.'s test hole No. 2	190
Lebanon, Lebanon City Coal Co.'s boring	190
Highland, Highland Prospecting Co.'s boring	240
Trenton, Trenton Oil & Gas Prospecting Co.'s boring	200?
Aviston, Hoblitzell oil prospect well	200?
Albers, boring for coal	220

This table bears out the inference of an overlap of the basal part of the Pennsylvanian series and this inference is further strengthened by changes in the number and position of the coal beds and by the fact that the thickness continues to increase southeastward from the quadrangles. There appear to be three coal beds, one in the Pottsville formation, another about 50 feet higher, at the base of the Carbondale formation, and another about 40 feet below the Herrin coal. Where the Mississippian series rises highest the lowest of the three coals, which is probably the stratigraphic equivalent of that described by Worthen as coal No. 1, is absent. The second coal bed, which is probably the Murphysboro coal (No. 2), overlies the clay in the mine near Collinsville and serves as a roof in the entries. At this place the coal is cut by numerous "clay veins," 1 inch to 5 inches thick and 1 foot to 3 feet apart, which follow sinuous courses in haphazard fashion and are not influenced by any system of parallel joining. The highest of the three minor coals is probably equivalent to the Springfield coal (No. 5 of Worthen). It ranges in thickness from 2 to 6 feet and in position from 32 to 58 feet below the Herrin coal. The distance between any two of the coal beds increases, however, somewhat irregularly from west to east, most if not all of the beds showing a thickening in that direction.

Herrin coal (Belleville, or No. 6) and immediately underlying strata.—The Herrin coal is the most persistent stratum underlying the quadrangles. It is commonly underlain by clay, beneath which is a bed of limestone that is almost as persistent as the coal. Where the clay is absent the coal lies directly upon the limestone. These beds and those just above the coal are better known than any other parts of the Carbondale and McLeansboro formations on account of the extensive mining operations on the Herrin coal.

The thickness of the limestone ranges generally from 2 to 6 feet. In some places the amount of calcareous material is just sufficient to give a marly character to sandstone and shale. Elsewhere the bed has the form of scattered limy concretions. In some places the limestone is much thicker, as in the Lumaghi Coal Co.'s test hole No. 2, where the material from 1 foot to 29 feet below the coal is reported as limestone. Near Breese the limestone immediately underlies the coal. In the Summit Coal & Mining Co.'s shaft, north of Belleville, the upper part of the limestone is nodular, and elsewhere around Belleville the limestone and overlying coal are each about 5 feet thick. In many places the limestone includes partings of clay. In the records of many borings and coal shafts the limestone is described as concretionary. The upper part of the bed commonly contains dark nodules of bituminous material, and although the upper surface is as a general rule sharply defined, in some places the limestone grades into the overlying clay.

The under clay of the Herrin coal averages about 2 feet in thickness and is generally light gray, although in some places it has a greenish tinge. When wet its upper part is usually more soft and plastic than its lower part. In places it is sandy and hard throughout. In comparison with the under clays of other coal beds throughout the State that of the Herrin coal is thin. The measurements of its thickness are obtained largely from records of churn-drill borings, most of which are no doubt inaccurate. Nine reliable measurements, however, have been obtained in these quadrangles. Two of them show only a thin film; the others indicate thicknesses ranging from 1 foot to 5 feet.

The Herrin coal is present and is of workable thickness practically throughout both quadrangles. It has a bright luster and is comparatively free from original sedimentary impurities. Its bedding is uniform and it may readily be separated into several divisions. Measurements of thickness of the coal in 33 mines and 6 coal test holes average 6 feet and 2 inches. The extremes are 3 feet in a shaft made at Aviston and 11 feet in the Consolidated Coal Co.'s mine at Breese. Of the 33 measurements, 1 falls below 4 feet, 5 are between 4 and 5 feet, 7 between 5 and 6 feet, 15 between 6 and 7 feet, and 10 between 7 and 8 feet. These measurements, however, are too few to show in detail the distribution of the thin and thick places in the coal. Between Lebanon and Breese the coal is thinner than it is either on the east or west. In a drill hole made many years ago at Highland no coal at all was found. At Aviston it was too thin for profitable working and in the Germantown mine it is thinner than in any other mine in the area. The places where the coal is thin are nearly in line, which suggests that the thinness may be due to some geographic feature that existed at the time the coal was being deposited.

The coal has several partings, which either consist of thin layers of clay, marcasite ("sulphur"), or charcoal or are merely planes of sedimentation along which the coal easily splits. One of the partings, known as the "blue band," is thicker than any other and is persistent throughout the quadrangles and an adjacent much larger area.

The bottom coal has a somewhat duller luster than the overlying bench and is more sooty in its partings. It also contains more marcasite, which lies in irregular more or less horizontal streaks and generally contains impressions of wood. The thickness of the bottom coal averages about 18 inches and ranges from 8 inches at one place in the Germantown mine, where the coal bed is thin, to 4 feet in one of the mines at Breese, where the thickness of the entire bed is 11 feet. In general the thickness of the bottom coal differs from place to place with that of the whole bed, but in the thicker sections the bottom coal makes up a larger part of the whole than it does in the thinner sections.

The thickness of the clay seam known as the "blue band" ranges from one-fourth inch to 2 inches and increases with the thickness of the whole coal, although the increase is less regular than that of the bottom coal. The "blue band" is generally dull gray with a bluish or greenish tinge, but in some places it is reddish or yellowish, this color being due to the presence of ferric material. In places it is dark gray or almost black from carbonaceous material or marcasite. It consists for the most part of clay, although in places it contains iron and calcium carbonate. Here and there it contains so much calcareous material that the seam is almost a limestone. Where it is thinnest it generally contains marcasite in streaks and also "smutty" coal.

The thickness of the coal above the "blue band" ranges from 33 to 84 inches, the average being 55 inches, or a little more than three times that of the bottom coal. The maximum thickness is about two and a half times the minimum, and in this respect it is less irregular than the bottom coal, whose maximum thickness is six times its minimum. The upper coal is more or less distinctly divided into three benches, which are variously called by the miners bench coal, bulk coal, drift coal, 9-inch coal, top coal, and blacksmith coal. Owing to looseness of usage and to differences in the coal itself these names are used differently by different miners, but in general they apply from below up in the order given.

MCLEANSBORO FORMATION.

Stratigraphic position, character, and thickness.—The McLeansboro formation comprises all the Pennsylvanian strata above the top of the Herrin coal (Belleville, or No. 6). It is named from McLeansboro, Hamilton County, Ill., where its thickness is probably greater than elsewhere in the State. Stratigraphically it is the highest indurated formation of the quadrangles and it underlies the surficial deposits practically throughout the area. Its greatest thickness in the quadrangles is about 400 feet along the east side of the area, and it has been so truncated by erosion along the west side of the area that only a few feet of its lowermost part remains.

The formation, like the Conemaugh formation of the Appalachian region, to which it in large part corresponds in age, is barren of workable coal beds and consists chiefly of shale and sandstone. It contains also limestone, clay, and thin coal, the proportion of coal being considerably less than in the Carbondale formation. The succession of strata is shown in the columnar section forming figure 4, and their variations from place to place are indicated by the following selected records of borings:

Section at Consolidated Coal Co.'s Troy or Brookside mine, at center of south line of sec. 9, T. 3 N., R. 7 W.

[Altitude of surface, 550 feet.]

	Ft.	in.
Quaternary system:		
Surface deposits	28	
Carboniferous system:		
McLeansboro formation:		
Sandstone	4	
"Soapstone"	40	
Limestone	2	
"Soapstone"	16	
Sandstone	1	
Coal		3
Clay	3	
Clay, nodular	3	
Sandstone	6	
"Soapstone"	3	
Limestone	2	
Shale	4	
Sandstone	40	
Shale, sandy	35	
Limestone, white	6	
"Soapstone"	14	
Shale	1	
Clay	1	
Conglomerate	6	
Clay	8	
Limestone, white	4	
"Soapstone"	14	
Sandstone	12	
Shale, blue, hard	8	
"Soapstone"	8	
Carbondale formation:		
Coal, Herrin	5	6
Clay	3	
Limestone	4	
Clay	4	
	285	9

Section in Lumaghi Coal Co.'s test hole No. 4, in the NW. ¼ SE. ¼ sec. 17, T. 2 N., R. 7 W.

[Altitude of surface, 505 feet.]

	Ft.	in.
Quaternary system:		
Surface deposits	3	
Clay, yellow, and gravel, mixed	12	
Gravel	3	
Clay, yellow	10	
Clay, blue, and gravel	8	
Carboniferous system:		
McLeansboro formation:		
Shale, hard, light blue	25	
Clay and lime bowlders	15	
Limestone, gray	10	
Clay and bowlders	6	
Limestone, gray	22	
Shale, hard, dark blue	4	
Carbondale formation:		
Coal } Herrin coal	1	6
Coal and shale mixed } Herrin coal	2	6
Coal } Herrin coal	4	
Limestone, gray	2	
Clay	3	
Clay and lime bowlders	10	
Limestone, gray, with partings of fire clay	20	
Shale, hard, light blue	20	
Clay	10	
Shale, hard, light blue	9	
	200	

Section at Cooperative Coal Co.'s mine, near Breese, a little east of the center of the N. ½ sec. 23, T. 2 N., R. 4 W.

[Altitude of landing, 435 feet.]

	Ft.	in.
Quaternary system:		
Soil, black	1	
Subsoil	1	
"Hardpan"	2	
Clay, bluish sandy	17	
Clay, hard blue	5	
Carboniferous system:		
McLeansboro formation:		
Shoal Creek limestone member	11	6
"Slate," black, horizon of coal No. 9	2	8
Clay	3	2
Sandstone	24	
Shale, blue, sandy	16	
Shale, hard clay	21	
Limestone	1	8
Shale, black	3	9
Limestone		6
"Fire clay"	5	
Shale, hard, sandy	12	6
Shale, soft, sandy	7	3
Shale, blue	5	
Sandstone, hard	2	
Shale, sand	10	
Sandstone	7	
Shale, sand	20	
Sandstone, blue	6	
Shale, hard, blue	8	
Shale, soft, blue	32	
Shale, black	3	
Coal No. 8	1	2
Limestone	5	8
Shale, hard sand	28	
Shale, blue sand	10	
Limestone, hard, blue	5	
Shale, blue, and bowlders	27	
Shale, hard, blue	28	
Limerock	1	
Shale, black	3	
Shale, sand	4	
Limestone	2	
Shale, black	4	
Coal No. 7	1	
Shale, soft	1	
Clay	8	
Limestone, "marble"	6	
Shale, black	3	
Limestone	1	
Limestone, blue	1	
Limestone, hard	2	
Limestone, black	13	
Carbondale formation:		
Coal, Herrin	7	
"Fire clay"	10	
	399	10

Section in Cooperative Coal Co.'s test hole, one-half mile south of shaft of Consolidated Coal Co.'s mine, east of Breese, near center of the S. ½ sec. 23, T. 2 N., R. 4 W.

[Altitude of surface, 420 feet. Description furnished by Mr. Emil Ericson, drill foreman.]

	Ft.	in.
Quaternary system:		
Clay	8	
Sand	12	
Gravel and bowlders	10	
Carboniferous system:		
McLeansboro formation:		
Sandstone	16	
Shale, sandy	24	
Shale, blue	12	6
Shale, sand	2	6
Shale, black	3	
Shale, sand	1	
Shale, clay	8	
Shale, sand	11	
Shale, blue	15	
Shale, sand	18	
Shale, sandy, blue	61	
Shale, black	2	6
Limestone	1	
Shale, black		6
Coal		9
Shale sand	9	3
Shale, blue	13	
Sandstone with shale partings	7	
Shale, blue	9	
Shale, blue, sandy	3	
Shale, black	6	
Limestone	2	
Shale, black	10	
Shale, dark blue	7	
Shale, blue	30	
Shale, black		6
Shale, clay	1	
Shale, light blue	13	6
Shale, sand	1	
Shale, black	1	
Shale, clay	8	
Limestone	3	6
Shale, clay	1	6
Shale, blue	3	
Shale, clay	8	
Limestone	6	6
Shale, blue	6	
Limestone, blue	1	
Shale, blue	4	6
Limestone, dark		10
Limestone	1	6
Shale, black		4
Carbondale formation:		
Coal	6	11
Limestone, dark		8
	372	3

Section of Germantown coal-test boring, about one-fourth mile south of center of sec. 4, T. 1 N., R. 4 W., northwest side of Germantown, north of the Southern Railway.

[Altitude of land, 435 feet. Diamond drill test made in 1897. Log furnished by secretary of the local company.]

	Ft.	in.
Quaternary system:		
Soil, surface	5	
Clay	5	
Sand, yellow	7	
Sand and gravel	2	
Quicksand	2	
Sand, yellow	5	
Sand, gray	3	
Carboniferous system:		
McLeansboro formation:		
Shale, black	4	6
Shale, dark blue, soft	2	
Shale, light blue, soft	1	6
Coal	1	7
Clay		5
Shale, light blue, soft	73	
Sandstone	2	
Shale, gray, sandy	18	
Sandstone	2	6
Shale, gray, sandy	26	
Sandstone	68	6
Shale, dark blue	52	
Shale, light blue	17	
Shale, black	1	
Shale, light blue	8	6
Limestone	6	
Shale, light blue	11	
Shale, black, and coal		6
Shale, light blue	12	
Limestone, "flinty"	4	
Shale, light blue	6	4
Shale, black	2	
Carbondale formation:		
Coal (Herrin), with a parting	5	1
Shale, light blue	1	2
	355	7

Roof shale of the Herrin coal (Belleville, or No. 6).—The Herrin coal is overlain by shale, the lower part of which is commonly black from carbonaceous material. In the Trenton mines the coal is overlain by 8 inches of coaly shale consisting of many thin alternating laminæ of dark shale and pure bright coal. Above this is coal from 2 to 6 inches thick, overlain by 2 inches of dark shale. A similar succession has been noted in some places in the Breese mines and in the Bennett mine. The dark shale and thin coal contain a few fossils, such brackish-water shells as *Lingulidiscina missouriensis*, *Squamularia perplexa*, and *Leaia tricarinata*. Dermal fish tubercles and spines are also found in places and poorly preserved plant remains are abundant. Among the recognized plant fossils are *Pecopteris dentata* and *Sigillaria mamillans*. Megaspores and resin casts are common. The shale is well known, for many mines have made it accessible, and it is economically important because it forms the roof of the coal mines. The lower part, except in the Germantown mine, where it is typical miners' slate, is moderately tough, almost black, and contains flat bands of white fragmental material similar to that found in the Springfield coal in the mines near Peoria. In both the Breese and Germantown mines the black shale contains large concretions of calcium and iron carbonate. The upper part of the shale is light gray and in many places where the deposit is less than 2 feet thick the dark part is absent.

For some reason the shale was deposited very unevenly over the coal and in many places it is lacking. In the Shiloh mine and in several of the mines about Collinsville and Breese the roof limestone in some places lies directly upon the coal. In the Southern Coal Co.'s mine No. 6, in Belleville, the shale overlies only about half of the coal bed and occurs in patches from 50 to 100 feet wide and two or three times as long, their longest diameter extending east-west. In the Glendale mine in Belleville the conditions are similar, but the slate patches appear to run in winding courses, somewhat like the meanders of a stream.

Roof limestone of Herrin coal (Belleville, or No. 6).—Above the roof shale, or immediately above the coal where the shale is absent, lies a limestone that is probably continuous throughout both quadrangles and that ranges in thickness from 1 to 35 feet, though the greater thicknesses may include one or more local beds of limestone that are represented elsewhere by shale. In some of the mines east of O'Fallon and west of Aviston exploration has not been carried up through the roof shale to the limestone, but in all the other mines the limestone is present. In all mines where the shale is lacking or is not too thick the limestone is used for roof. The rock consists of a calcareous matrix in which are embedded minute organic fragments. In most places it is light gray, but in some, as in the mines at New Baden and at Germantown, it contains disseminated bituminous matter, which makes it dark gray or almost black. Where it is light gray the bituminous material takes the form of black nodules or blotches. In texture the rock is generally close grained and commonly it is made up of layers 8 to 12 inches thick.

Opportunities for observing the fauna of this limestone are not numerous as it is not exposed anywhere except in the mines. The fossil commonly known as *Fusulina secalica* is abundant and specimens may be found in every pound of rock, though it is usually not visible except on polished specimens. Crinoid stems are also abundant. The fossils evidently belong to a marine fauna and show a recurrence of the conditions that prevailed before the vegetal material which now forms the coal was deposited.

At only a few places has mining extended above the limestone and observations on its thickness have been made only in shafts and test holes. In twelve such artificial exposures the thickness ranges from 1 to 35 feet, and in more than half of them it is less than 5 feet.

The lower surface of the limestone may be seen at many places in the mines. Generally it appears flat and even, but in places it has wavelike undulations that resemble large ripple marks. In one of the mines at Breese these waves measure 10 inches from crest to crest. Here and there, as in the Consolidated Coal Co.'s mine at Glen Carbon and in the mine in Germantown, the undulations project downward as much as 8 or 10 inches, forming elongated cusps or combs which the miners call "cat claws."

Strata between the roof limestone of the Herrin coal (Belleville, or No. 6) and the Shoal Creek limestone member.—The lower 50 or more feet of the beds above the roof limestone are known from the exposures on Richland Creek in Belleville, from the excavation of the air shaft in the Glendale mine, and from a number of records of shafts and bore holes elsewhere. In the west half of the Belleville quadrangle these beds consist of soft limestone, containing more or less fine sand. At Aviston, Breese, and Highland, where this part of the section is thinner than at the west end of the area, they include some shale. In the east half of the Belleville quadrangle and at Summerfield the records show two thin limestones separated by a thick deposit of shale, the lower limestone being probably continuous with a heavier limestone to the east and to the west. This limestone can be found on the dump from every Herrin coal shaft in this part of the State and on dumps for more than a hundred miles to the southeast. It is characterized by rapid superficial oxidation on exposure to the air, giving it a reddish-yellow color on the surface, the interior remaining light bluish gray or almost white.

This limestone, together with some overlying shale and another higher limestone, is well exposed in the county quarry at Belleville, where the following section was measured:

Section in county quarry in Belleville.

	Ft.	in.
Limestone, hard, dark gray, of compact but partly fragmental texture, containing fragments of corals and some entire fossils	3	
Shale, greenish gray, containing a long, slender form of Fusulina and a tuberculated plate of a crinoid	4	
Clay, black, carbonaceous, with traces of fossil vegetation		2
Clay shale, dark, mottled in places with dark purplish-red blotches	5	
Limestone, very soft, fragmental and impure, with loaf-like soft concretions and small nodules of oolitic structure; contains gastropods and other fossils	1	
Limestone, bluish gray, sandy, and soft, rapidly weathering rusty yellow. The layers are not well marked and range in thickness from 2 to 4 feet. The lower part contains segregated nodules of purer limestone 2 to 3 inches in diameter. A fragment of a fish spine was noted in the lower 6 inches and gastropods higher up; fossils rare	12	
Clay shale, green		6
Limestone like the second bed above (reported by quarryman)	18	
	43	8

The upper limestone shown in this section appears in several places in the bed and banks of a ravine that comes from the west at this point, and it has been quarried extensively along the creek. The old quarries are now filled with water. The rock in these quarries is reported to have had an average thickness of 5 feet.

In the record of the shaft of the St. Ellen mine, west of O'Fallon, in that of the old Van Court mine in O'Fallon, and in the Lumaghi Coal Co.'s test hole No. 2, north of O'Fallon, more or less sandstone is reported from this part of the section. Whether this sandstone indicates extreme differences in the same bed of rock or whether it is caused by an intraformational unconformity can not be made out from the data at hand. This horizon is near that of Worthen's coal No. 7 in the Peoria quadrangle, and in both the Peoria and the Belleville-Breese areas there is more or less red shale or red rock at about this horizon. "Red rock" is reported from the shaft of the St. Ellen mine 74 feet above the Herrin coal, from the Van Court mine 78 feet above the coal, and from the Lebanon City Coal Co's. mine at about the same position.

In four explorations a conglomerate is recorded also at about this horizon. It is mentioned in the Consolidated Coal Co's. shaft at Troy, where it lies 50 feet above the Herrin coal, and in the Van Court shaft in O'Fallon, where it was noted at 80 feet above the coal; and perhaps it is represented by the "fire clay with lime bowlders" mentioned from nearly the same horizon in several of the Lumaghi Coal Co's. test holes. In the Aviston and Breese shafts and bore holes a thin coal lies at the same height above the main coal. All these materials, the sandstone, the oxidized red rock, the coal, and especially the conglomerate, may be regarded as indications of an unconformity. Specimens of what is believed to be this conglomerate were noted on the dumps of the shafts at Aviston, Breese, and Trenton, in material that could not have come from a horizon far above that of the lower limestone in the section. It consisted of well-rounded flat pebbles of limestone, ranging in diameter from less than an inch to 2 inches, embedded in a calcareous matrix and resembling what has been described as "desiccation conglomerate."[1]

Alternations of shale, sandy shale, clay, sandstone, and thin limestones make up the section from 60 to 120 feet above the Herrin coal. Sandy shale is predominant and is exposed at many places in the country about Collinsville and Glen Carbon. The limestones contain such fossils as *Composita subtilita, Chonetes mesolobus, Lophophyllum profundum, Trepospira sphærulata, Patellostium montfortianum, Leda bellistriata,* and *Euphemus nodicarinatus.*

From 100 to 130 feet above the Herrin coal many explorations have penetrated a limestone from 3 to 6 feet thick, which among some mining men has become known as the "top limestone." In the country from Glen Carbon to Belleville it is usually encountered in the upper part of the coal shafts located on the uplands, and, as shown in the local descriptions already given, outcrops of such ledges are found in many places along the watercourses in the Belleville quadrangle. Whether the limestone outcropping at these places belongs to the same bed or whether there are several small limestones can not be definitely determined, owing to insufficient exploration and to the drift cover. Possibly some of the uppermost limestones already noted in the shafts and borings may not be the same strata that are seen in some of the creeks. If they are not identical, they can not, at any rate, be far apart in the section. They range in thickness from 2 to 6 feet. In the main they contain abundant organic fragments, and in a few places some embedded quartz sand. In one place on Ogles Creek a quartz pebble an inch in diameter was found embedded in a ledge of pure limestone. In a few places the rock is brecciated. It seems probable that the limestone at this horizon is to be correlated with the limestone at the Lonsdale quarry near Peoria. Both contain, locally, in abundance, a shell which is probably *Campophyllum torquium,* and on the under surface of the rock at both Belleville and Peoria was found a long and slender form of *Fusulina cylindrica* (?), seen in no other part of the section at either place. The fossil is quite different from the form of Fusulina found in the roof limestone over the Herrin coal. In texture also, and in some features of structure not readily described, the two rocks are alike.

The vertical distance from the "top limestone" to the Shoal Creek limestone member in the general section is about 230 feet. Just above the "top limestone" there is some shale, which at one point in Ogles Creek shows red oxidized blotches. In some shafts this shale contains a fauna that is profuse in individuals, especially certain small gastropods.

Above this shale and sharply defined from it lies a typical coal-measure sandstone about 100 feet thick. This sandstone may be equivalent to the Merom sandstone of southwestern Indiana, though it appears to be somewhat older than that bed. In this part of the State it is an important horizon marker, and in the region southeast of these quadrangles it is sufficiently resistant to erosion to form a ridge along its outcrop. It is medium coarse, gray to brown, rough to the touch, and commonly cross-bedded. Its texture ranges within short distances from soft and friable to tough and hard, and here and there it contains imprints of the leaves and stems of plants. It underlies the drift in the country between Troy, Highland, and Lebanon, and in this area no doubt, as well as farther north, outside the quadrangles, it receives a copious supply of water from the drift. Explorations made in Tps. 3 and 4 N. show that this sandstone extends from Troy to the eastern boundary of the Breese quadrangle, and in Helvetia Township it is a water-bearing rock into which many wells have been bored. In most of the records of bore holes and shafts it is reported as sandstone. In some records it is given partly as sand and partly as shale, and in several localities the sand seems to have been sufficiently fine to be called sandy shale or shale. The upper part of this sandstone is generally nonresistant and is exposed at but few places, having been extensively removed by erosion where it has not been protected by an overlying more durable rock.

Above this sandstone is 100 feet of shale that includes a few thin beds of coal and limestone. One rather persistent bed of limestone lies near the middle of this shale.

Fossils in fragments of limestone or marly shale derived from beds between the "top limestone" and the Shoal Creek limestone member are found on mine dumps.

[1] Hyde, J. E., Am. Jour. Sci., vol. 25, p. 400, 1908.

Shoal Creek limestone member.—Except at a few localities, the top of the Pennsylvanian section in the Belleville and Breese quadrangles consists of the limestone described by Englemann in the early Illinois reports as the Shoal Creek limestone.[1] This rock appears in borings at Highland, Breese, and Trenton. Not taking into account the thickness reported in the Trenton boring, which appears doubtful, three measurements reported from deep explorations and ten measurements made in exposures give an average thickness of 6 feet. In five places it measures 4 feet; in three it measures 5 feet; in one place, 6 feet; in one, 7 feet; in one, 9 feet; in one, 10 feet; and in one, 11 feet.

This limestone is exposed around Trenton and Breese, along Shoal Creek north from Breese, in the creeks from 2 to 4 miles west of Highland, and in the tributaries to Sugar Creek coming in from the west between Highland and Trenton.

Near its outcrops the Shoal Creek limestone has evidently undergone extensive erosion and underground leaching. It is probably most continuous and intact in the east half and the north half of St. Rose Township, in the north half of Helvetia Township, and in those parts of Saline and Pocahontas townships that are included in the Breese quadrangle. About the center of the triangular area included between lines drawn through Highland, Breese, and Trenton it is probably largely absent. Well drillers report that it is lacking in about half the wells in the north third of the quadrangle. This rock, like other limestones in the coal measures, is mostly compact and hard, and contains many organic fragments embedded in a fine calcareous matrix. In Timmermann's quarry, north of Breese, it includes in some ledges a considerable admixture of fine sand. Two features distinguish it from most other Pennsylvanian limestones: (1) It exhibits on fractures, especially those that follow the bedding planes of the rock, faint bluish-gray irregular blotches; and (2) after much weathering it separates into flags from 2 to 3 inches thick. Even the more massive ledges exhibit faint partings 2 to 3 inches apart.

The Shoal Creek member rests in some places on soft shale and elsewhere on hard shale. The hard shale is nearly black (miner's "slate") and owing to certain unique markings is sometimes an aid in identifying the overlying limestone. These markings consist of white bands, which can everywhere be found in about 6 inches of the black shale and which run with its bedding planes. They are sinuous, half an inch or less wide, and at intervals they fork and cross. (See fig. 5.)

FIGURE 5.—Characteristic fucoid-like markings in black shale underlying Shoal Creek limestone member of McLeansboro formation.

Strata above the Shoal Creek limestone member.—Small outliers of a still higher limestone lie under the drift in St. Rose Township between St. Rose and Jamestown. This rock is separated from the Shoal Creek limestone by a sandy blue shale, and is almost a breccia of entire and broken fossils. The layers of this limestone are 3 or 4 feet thick and are the highest consolidated strata in the quadrangles.

QUATERNARY SYSTEM.

CHARACTER AND THICKNESS OF THE DEPOSITS.

The surficial deposits of the area, which are generally 40 to 60 feet thick, belong to the Quaternary system. They consist of till, loess, and terrace deposits of Pleistocene age and alluvium of Recent age. All the material has been derived from consolidated rocks, partly through normal processes of weathering, partly through the grinding and plucking action of glaciers, and in small part by wear effected by streams. It has been transported and deposited by ice, wind, and water.

The greatest thickness of the Quaternary deposits found in any of the wells or mine shafts is 148 feet, which is recorded in a well sunk on the ridge that runs north and south 3 miles north of Lebanon, but under the highest point of Shiloh Ridge the bedrock probably lies 200 feet below the surface. The surficial material reaches its maximum thickness in the ridges and in the wide preglacial valleys. Except in postglacial valleys it is thinnest on the preglacial uplands. In the low plains on each side of Silver Creek some excavations show that in places the thickness of the unconsolidated material exceeds 100 feet and that the average thickness is about 80 feet. On the uplands west of Sugar Creek and in St. Rose and Pocahontas townships the thickness is in many places less than 50 feet. It appears that in general the surficial material is thicker west

[1] Illinois Geol. Survey, vol. 3, pp. 148, 159-164, 175, 220, 1868.

of the drift ridges extending from St. Jacob through Lebanon and past Shiloh. The average of all measurements of the surficial material in the western part of the area is 61 feet. In the central part it is 81 feet and in the eastern part 38 feet. The average of the measurements in the northern part of the area is about the same as that in the southern part, and the average of all observations is 56 feet.

PLEISTOCENE SERIES.

PRE-ILLINOIAN DEPOSITS.

Preglacial (?) silt.—Below the glacial till and immediately overlying the bedrock a bluish silt has been found in several localities. It is exposed in the ravine running north near the center of the SW. $\frac{1}{4}$ sec. 33, Caseyville Township, where it is 8 feet thick, shows traces of cross-bedding in the upper part, and is somewhat indurated. In the lower part it is dark colored. The silt also appears in the south bank of Ogles Creek, at the bend a quarter of a mile west of the center of the east line of sec. 3 in McClellen Township, where it is about 8 feet thick and is traversed by irregular cylindrical masses of yellow gravel and sand and lentils of glacial till in which are included some coniferous wood and some pieces of coal. The lower part of the silt is almost black. What is believed to be preglacial silt is also reported to occur in Collinsville Township.

Pre-Illinoian (?) till.—A till that has some of the characteristics of the Nebraskan and Kansan tills found elsewhere in Illinois and adjacent States is exposed at a few places in the quadrangles, as in the south bank of Ogles Creek about a quarter of a mile east of the center of sec. 3 in O'Fallon Township, in the south bank of Sugar Creek, sec. 27, Helvetia Township, and in the east bank of that creek in sec. 18 of the same township. This material, however, though it differs in appearance from the overlying Illinoian till, may be a part of that deposit, for the features that elsewhere characterize the older deposit may be merely local. These features consist of a comparatively high percentage of limestone among the smaller pebbles, the presence of considerable coniferous wood among pebbles of coal, and of a dark and in places a greenish color of the till itself. In a well made on the Lebanon ridge of the campus of McHenry College a blue tough clay containing shells was found about 40 feet from the surface and apparently beneath the Illinoian till. A similar shell bed was found near the corner of Herald and First South streets, Belleville.

Yarmouth (?) soil.—In the McHenry College well an old black soil containing some sand and blue clay was noted 30 or 40 feet below the surface. "Brush and rocks" were reported at a depth of 75 feet in an unfinished coal shaft sunk many years ago on the low plains south of Lebanon. In the shaft of the east mine at Trenton a buried soil is reported at a depth of 30 feet, and from the description given by the workmen it appears to be a distinctly marked soil. It lies near the middle of the glacial deposits. The data, however, are not regarded as sufficient to determine the presence of pre-Illinoian glacial till in the area, much less the exact age of such a till if it is present.

Pre-Illinoian loess.—In some places the Illinoian till rests upon material that somewhat closely resembles the overlying loess, and as a pre-Illinoian loess is known in other parts of southwestern Illinois it seems probable that this material is loess that was deposited between the Kansan and Illinoian stages. The exposures are too few and too poor to form a basis for a definite conclusion.

ILLINOIAN TILL.

Distribution and character.—With the exception of the comparatively small areas from which it has been removed by erosion the Illinoian till is present throughout both the Belleville and Breese quadrangles. Its upper surface, upon which the main deposit of loess rests, is for the most part even, the principal irregularities being in the drift ridges, but as it was deposited on an uneven surface its thickness is somewhat irregular. It is probably 20 feet thicker on the old uplands of the Belleville quadrangle than on the old divides in the Breese quadrangle, although the altitude of the preglacial uplands in the western part of the area exceeds that in the eastern part. The western part of the area is near the border of the Illinoian drift and appears to lie in a belt of marginal thickening. The difference, however, is slight and the configuration of the surface gives no indication of a terminal moraine parallel to the ice front. The average thickness of the till is probably not far from 40 feet.

In general the Illinoian drift in this region is a dark bluish-gray till, which weathers yellowish-gray and in some places becomes incrusted with iron. It consists of sandy clay containing pebbles and a few bowlders. The clay and sand that make up the main body of the till were probably derived for the most part from beds of shale and sandstone that lay farther north in Illinois and that were more or less deeply weathered when they were overridden by the glacier. In texture the till is probably slightly finer than that in the northern part of the State and the clay matrix is tougher, especially in the lower and darker part.

The coarser constituents of the till are of two sorts, one consisting of pebbles and bowlders of crystalline rock brought from areas far north and northeast of the quadrangles, the other of fragments of chert and masses of limestone transported from regions less remote. The rock fragments appear equally distributed throughout the till. Bowlders 3 feet in diameter are rare and not one exceeding 5 feet was found. Among the larger bowlders such rocks as limestone, dolomite, and sandstone, derived from the higher Paleozoic terranes, are more abundant than in the central and northern parts of the State, whereas such rocks as granite, eruptive rocks, and quartzite, which are of Canadian derivation, are probably less abundant than they are farther north. Igneous rocks have supplied a larger proportion of the pebbles near the surface than in the unweathered parts of the till, partly, at least, because the sedimentary rocks are more easily weathered. Fragments of coal are fairly common. Below is a table giving the percentages of the more common rocks among the different sizes of erratics. It gives the averages of several lots of 100 erratics for each of the sizes indicated.

Percentages of different kinds of rock among glacial bowlders of different sizes in Illinoian till in the Belleville and Breese quadrangles.

Kind of rock.	Average diameter of bowlders in inches.				
	9	3	1	$\frac{1}{3}$	$\frac{1}{9}$
Granite	30	10	6	4	3
Diabase and gabbro	18	7	4	5	4
Greenstone	5	5	-----	Trace.	Trace.
Schist	-----	1	3	1	Trace.
Quartz	-----	-----	2	4	11
Chert	-----	3	19	14	22
Quartzite	4	2	1	2	Trace.
Dolomite	1	10	10	40	43
Limestone	25	40	25	20	11
Sandstone, shale, coal, clay ironstone	17	22	30	10	6

Drift ridges.—The Illinoian till of the drift ridges is similar to that of the till plain except that it is thicker and contains considerably more sand and gravel. In a well about a quarter of a mile southwest of Shiloh coarse yellow sand underlain by quicksand appears to form the upper part of the ridge till. A reddish sandy till lies immediately beneath the loess in many wells, in some of which it is as much as 20 feet thick. Sand lenses are somewhat common throughout the till of the drift ridges.

A well 90 feet deep near the northeast corner of sec. 9 in Shiloh Valley Township shows the general character of the drift of the ridges. The first 16 feet penetrated was loess. Below that was 18 feet of pebbly red clay in which no bowlders were encountered, and beneath that, on one side of the well, there was a little more than 20 feet of clean fine red sand, but on the other side of the well there was coarse white sand. Below that point to the bottom of the well coarse white sand was found the lowermost 3 feet of which was quicksand. It appears that the plane separating the fine red sand from the coarse white sand is inclined at a high angle, and the descriptions by the well diggers indicate that the bedding planes in each body of sand were parallel to this plane. Whether the beds were deformed by the ice or are only cross-bedded is not known.

POST-ILLINOIAN LOESS.

Loess is practically continuous over all the uplands. With the exception of the valley bottoms, their steepest sides, and the narrow ravines which have most recently been cut back in the uplands, it forms a blanket which everywhere overlies the Illinoian till. It reaches its greatest thickness in the northwest corner of the area, where in some places it is as much as 30 feet thick. The average of several measurements in the west tier of townships is 27 feet. Toward the east it gradually thins, averaging 20, 18, 11, and 7 feet successively in the several tiers of townships, this thinning from west to east being most rapid between Silver and Sugar creeks.

There appear to be three main types of the deposit. One is characteristic of the uplands nearest the Mississippi bluffs and is especially extensive in Collinsville and Caseyville townships. It is uniformly yellowish gray in color and is markedly homogeneous in structure and texture. In places it contains shells of small land snails, such as *Succinea avera* and *Helicina occulta*. In the cut recently made for the railroad in the west part of sec. 33, in Caseyville Township, loess of this type forms the upper part of the section, and loess of another type, which has a purplish tint, forms the lower part. The two phases are separated by a layer of indistinctly and irregularly bedded loess. The total thickness of loess exposed at this place is 22 feet, and at the base there is a sticky gumbo containing a few cherty pebbles.

The second variety of loess covers most of the uplands that lie east of the townships mentioned and assumes a multitude of shades of color and many slight variations of appearance. In general it is freer from calcareous material than the other loess, and here and there it contains some ferruginous material. In some places leaching by surface waters has produced an ashen-gray subsoil. Below what appears to have been the old level of the water table before white men came to the country it is bluish gray, and well markers report that just above this level it has a mottled yellow and bluish appearance. At a few places, as in the west bluff of Sugar Creek east of Kalmar schoolhouse, in Looking Glass Township, it has a warm red color, and in places the base of the loess, which rests immediately on the till, has a faint appearance of an old soil, representing, perhaps, the soil of the Sangamon stage in eastern Iowa. The best development of this soil was noted in the bottom of some road ditches about three-fourths of a mile west of Highland.

The third type of the loess was noted on and near the drift ridges that have already been described. It is a trifle more sandy than the loess of the flat upland, though the difference in this respect is very small. In places it appears also to be faintly stratified.

WISCONSIN DEPOSITS.

Along the lower course of Shoal Creek the Recent alluvium rests upon a different water-laid deposit, the existence of which is shown by the broad, low terrace remnants and by the character of the material found in borings and in a few exposures. The terrace deposit contains more clay and is better stratified than the alluvium. A small amount of it appears to underlie the bottom of Sugar Creek valley near Damiansville and possibly a similar deposit lies along Silver Creek near the south boundary of the area. These deposits appear to be the somewhat ill-defined upstream ends of a valley filling which was formed in or very soon after Wisconsin time along the Kaskaskia and its tributaries. There is little definite information concerning the valley filling deposited within the area under discussion, and indeed it is nowhere extensively exposed, for the reason that it underlies the lowest and least dissected parts of the region. Along tributaries of the Kaskaskia the deposit consists generally of varicolored limy clay and sandy clay, nearly everywhere finely laminated and in places containing shells of animals that inhabit quiet fresh water.

RECENT SERIES.

ALLUVIUM.

The alluvial deposits that underlie the flood plains of the streams consist of silt and sand with some gravel. The silt and finest sand have been derived largely from the loess of the uplands, and much of the alluvium of this region has the same texture as that deposit. The thickness of the alluvium generally exceeds the vertical distance between the bottom lands and the stream beds. On the borders of the valleys the alluvial deposits have been more or less augmented by wash from the hills, forming a low talus slope and alluvial fans.

STRUCTURE.

In the Belleville and Breese quadrangles the layers of hard rock are not quite horizontal, having a general slope to the east of a few feet to the mile. This slope is not regular but is interrupted by low anticlines, synclines, and terraces and minor irregularities.

REPRESENTATION OF STRUCTURE.

Methods employed.—Structure is commonly represented in two ways, by cross sections and by contour lines. Cross sections are best for a region in which the rocks are sharply folded and faulted, but for one where the folds are low and there are few if any faults they are of small value, for in them the structural features are almost imperceptible. In such a region contour lines show the structure more clearly. The structure contours for the Belleville-Breese region are shown on the areal-geology maps.

Delineation of structure by contours.—For the delineation of structure by means of contours an easily recognizable reference stratum is chosen, whose position can be determined at many points by means of outcrops or borings. The altitude and dip of its surface are determined at as many points as possible, and points of equal altitude are connected by lines on the map just as topographic contour lines are drawn. In some places the altitude of the reference stratum is observed directly in outcrops, mines, or wells, and in other places it is calculated from observations on some other recognizable stratum, for generally the layers of stratified rock are approximately parallel and the average interval between any two may be determined. Thus, if a stratum above the reference layer is found its altitude above sea level at the point of discovery may be determined and the altitude of the reference stratum or key rock at that point may be calculated by subtracting from the altitude of the stratum discovered the average distance (or the nearest measured distance) between the two. If the outcrop of a bed below the reference stratum is found the average distance is added, thus giving the approximate altitude at which the reference layer would lie if it were present.

Use of structure contours.—The structure map is useful not only for the study of broad structural problems and for conveying an abstract knowledge of the structure of the region, but it is also of practical value for the aid it gives in locating and recognizing valuable beds and for the data it gives concerning their "lay." As the strata are approximately parallel and the average spacing of valuable beds is known, it is not difficult to calculate from the altitude of the reference stratum the approximate position of any bed at any point by adding or subtracting, according as the bed is above or below the key rock, the average distance between the two as indicated on the map. The map may be used in this way for locating coal, limestone, and oil-bearing rocks.

The structure map also serves to show the direction and amount of dip of the beds, a knowledge of which is most essential in all mining operations.

Accuracy of structure contours.—The accuracy of the structure contours depends upon three factors—first, the accuracy of the altitudes obtained directly; second, the difference between the actual and the assumed distance to the key rock, as calculated; third, the number and distribution of the points whose altitudes have been determined.

In the Belleville and Breese quadrangles the reference stratum used is the Herrin coal, which is the most extensively worked coal bed in the area. It has few natural exposures but has been penetrated in many mine shafts and borings, and the altitude of the surface at such places was determined by hand level and barometer. Bench marks are numerous in this area, and consequently the hand-level and barometer determinations involved only short horizontal distances and small possibilities of error.

The second factor is more likely to lead to error because the strata are not absolutely parallel. However, the distances between the Herrin coal and other known strata do not generally range through more than 20 feet.

On account of the scarcity of outcrops and the fact that artificial excavations are almost the only source of information, the determined altitudes of recognizable strata are not so numerous as might be desired, but they are comparatively evenly distributed, so that any error arising from this factor is probably not great. The dip of the coal bed in mines also afforded information for working out the structure. After allowance is made for all possible error it is believed that the structure lines are correct within a contour interval, or 50 feet, and that the average error is not more than 10 or 15 feet.

STRUCTURE OF THE QUADRANGLES.

In the Belleville and Breese quadrangles, or close to their boundaries, the altitude of the Herrin coal has been ascertained at 110 places. Most of the data are derived from mines and coal tests, but some have been obtained from well borings. Several determinations are calculated from outcrops of limestones, the distance of which above the coal is known. The contour lines on the structure map are based on these figures, and they show the elevation of the coal in feet above sea level, being drawn at intervals of 50 feet, vertically.

The dip is most regular along the north side of the area, where it is nearly uniform. The average dip is a trifle less than 11 feet to the mile in the northern part of the area, but in the southern part it amounts to fully 14 feet. The rocks in the southwest corner of the area lie a little higher than those in the northwest corner. The general eastward dip is greatest in a district southwest of New Baden, where it exceeds 20 feet to the mile, and least between New Baden and Germantown, where it is only a trifle more than 6 feet to the mile.

The general monoclinal structure is affected by some minor deformations, the most important of which is an anticlinal fold whose crest extends from a point about a mile east of Belleville to a point about half a mile west of O'Fallon and the fold pitches in the same direction. It is a very flat anticline, its average height being not much more than 20 feet, although it is 4 or 5 miles wide. This anticline causes an irregular bend in the 400-foot contour line and produces a loop 6 miles long in the 350-foot contour line north of O'Fallon. In the 300-foot contour line its effect is still evident but less marked, perhaps for lack of data. The coal in Caseyville Township lies level, having no persistent dip in any direction.

Another local irregularity in the contours occurs at Highland. If it is correctly identified, the coal lies 30 or 40 feet higher here than in the surrounding country. It is not clear whether this is due to a flexing of the strata or to inequalities in the surface upon which the coal-forming material was deposited.

Deformations of another class, which are much smaller, are seen in the mines. They consist of "swamps" from a few rods to a mile across, the sides of which have dips ranging up to a degree. These "swamps" are probably not folds with definite trend or basins with regular arrangement. They seem to be more common in the mines near Belleville than elsewhere.

Small faults cut the coal in the New Baden mine and in the mine west of Trenton. (See figs. 6, 7, and 8.) In the New Baden mine some faults have been followed for nearly a mile. On the map of the mine they appear as gently bending lines trending variously from east to almost southeast, and in some places they branch and elsewhere join again. In the Breese-Trenton Mining Co.'s mine, west of Trenton, the trend of the faults is from northeast to southwest. (See fig. 6.) The downthrow is to the southeast and measures from 2 to 6 feet. In the New Baden mine the downthrow has the same range but is to the north. The hade of the fault planes in both

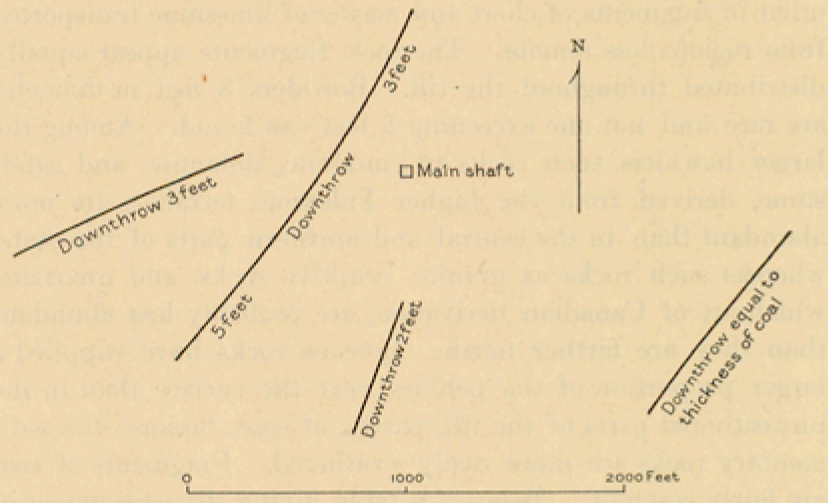

FIGURE 6.—Sketch plan of Breese-Trenton Mining Co.'s mine west of Trenton, showing courses of principal faults and direction and amount of their throw.

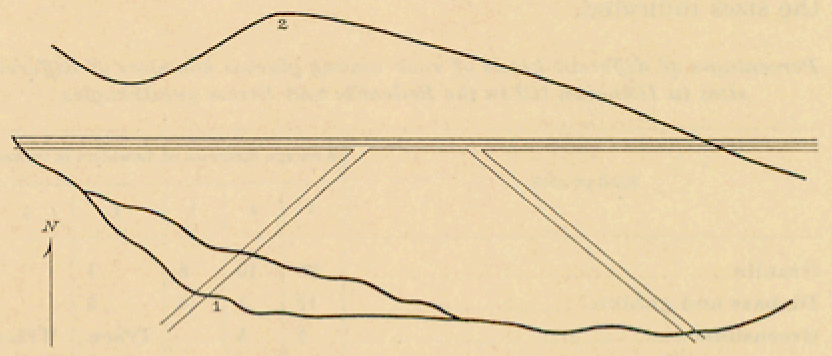

FIGURE 7.—Sketch plan of Southern Coal & Mining Co.'s mine at New Baden, showing course of the two principal faults.

Length of plat about 1 mile. Sections of coal beds at 1 and 2 are shown in figure 8.

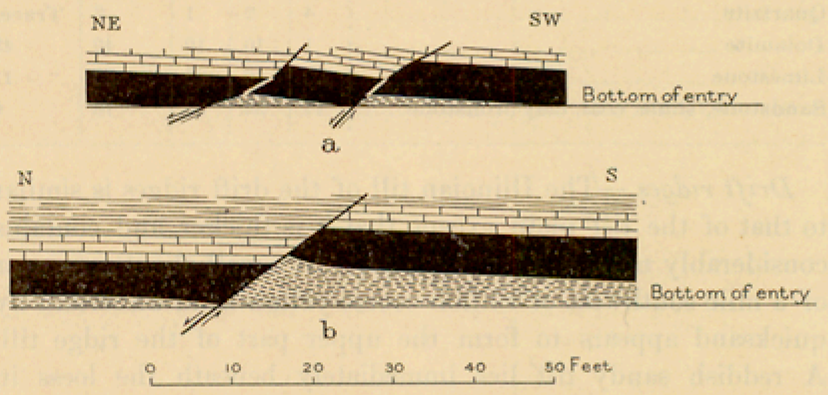

FIGURE 8.—Sections in entry of Southern Coal & Mining Co.'s mine at New Baden, showing faults offsetting the coal beds.

a, East rib of entry at point 1, figure 7; b, point 2, figure 7.

mines ranges from 40° to 60° and is in the same direction as the downthrow, so that the faults are of the normal type. (See fig. 8.)

A dislocation related to these faults is exposed in the bottom of the creek running through the south half of sec. 28, in O'Fallon Township. It consists of three east-west fault planes, from 2 to 4 feet apart, with tilted blocks between them. These faults appear to be the result of a thrust. One block, which lies between two of the fault planes, has been tilted or rotated until its bedding planes are nearly parallel with the fault planes themselves. The whole displacement can not be more than a few feet. In mines where the dislocations are close together they may break up the roof of the coal so much as to interfere with safe mining, but difficulties of this sort have not yet been encountered in the mines in this area.

GEOLOGIC HISTORY.

IMPERFECTION OF THE RECORD.

Only a small part of the geologic history of the quadrangles can now be deciphered from rocks exposed at the surface or encountered in borings. The record of many of the principal and some of the minor events of the Carboniferous and Quaternary periods is preserved and is legible, but the record of pre-Carboniferous time lies so far below the surface that only the rocks showing its later part have been reached by drill holes. That of the periods between the Carboniferous and Quaternary has been erased, though there is an indistinct record of the progress of erosion. However, many facts in the history of the quadrangles may be inferred from the results of studies in other areas in the general region, for the processes that operated in the quadrangles affected also an extensive province around them. Much of the history of the smaller area is therefore contained in the more complete record of the larger area.

During the Paleozoic era Illinois was intermittently submerged in an epicontinental sea, the shores of which migrated widely and almost continuously, though the rate at which they shifted varied greatly. Since Paleozoic time the surface of the State has, so far as known, been continuously above sea level and has been subjected to the wear of streams.

PALEOZOIC ERA.

EARLY PERIODS.

At the opening of the Paleozoic era the surface of Illinois had probably been above the sea for a long time and had been eroded until it was nearly flat. Early in the era the region was gradually submerged and sandy deposits were laid down in the encroaching sea. The submergence probably took place in Middle Cambrian time and lasted at least until the close of Cambrian time.

The sediments deposited during Ordovician time consisted mainly of calcium carbonate and perhaps magnesium carbonate but included some argillaceous or muddy material. Numerous forms of life inhabited the sea and their remains have been preserved in the beds. In Silurian time much of what is now the Mississippi Basin was covered by a clear sea and received extensive calcareous deposits. During a part of the Devonian period also calcareous deposits were formed but for some of the time the water was shallow and muddy and occasionally it retreated from large parts if not all of the region.

CARBONIFEROUS PERIOD.

MISSISSIPPIAN EPOCH.

The region was a land surface between the deposition of the Upper Devonian strata and the lowermost Mississippian. During the Mississippian epoch the Mississippi Valley was extensively submerged. In Kinderhook time a considerable quantity of fine sand and clay was carried to the sea by the streams. At the end of the Kinderhook epoch and during the Burlington epoch the sea expanded farther and became clearer, so that the deposits which accumulated during that epoch consist largely of limestone. In the Keokuk and Warsaw epochs conditions varied, both sand and calcareous mud being deposited. At the close of the Warsaw epoch the sea withdrew to the southern part of the region. When it next advanced it was bordered by lands so low that they yielded little sediment. The waters were therefore clear and the deposit formed pure limestone, which in some places consists mainly of oolite. The strata formed at this time are now known as the Spergen limestone. During the succeeding St. Louis epoch the sea grew deeper and extended at least to central Iowa. At the close of the St. Louis epoch the water withdrew by a series of oscillations which furnished conditions for the accumulation of oolite beds similar to the Spergen, containing a sandy member in the middle part and forming the Ste. Genevieve limestone. After a considerable interval in which the area was dry land further warping elevated much of the bordering region but permitted the sea again to advance as far north as St. Louis. The thick beds of sandstone, limestone, and shale deposited during this period of submergence constitute the formations of the Chester group.

PENNSYLVANIAN EPOCH.

POTTSVILLE EROSION AND DEPOSITION.

For a long period after the Chester submergence the region was a land area, and during this time the surface became much dissected. This old surface is now exposed at many places in Illinois and has been reached by thousands of borings. It is nowhere smooth and in places it has considerable relief. Slight warping seems to have preceded the resumption of extensive deposition. At first sedimentation was restricted to a rather narrow area in the eastern interior coal field of Illinois and western Kentucky, and this area slowly enlarged toward the north and east. Further warping elevated the surrounding country so that the area of sedimentation gradually advanced northward and spread eastward and westward. Most of the sediments laid down at this time were continental sand and mud, which now make up the Pottsville formation. The sand was doubtless in part derived from the Chester group, which formed the western border of this portion of the Pottsville area of deposition, though since much of the sand of the Pottsville is coarser and more micaceous than any in the Chester, a large part must have come from elsewhere. The coarseness and the great volume of the material show that the territory from which it was derived must have stood considerably above sea level.

Early in the Pennsylvanian epoch great temporary peat marshes began to develop in Illinois and parts of adjacent States, and some of them persisted for a long time. Now and then conditions so changed that mud or sand was washed in upon the peat, sometimes in thin films and at other times in deposits reaching many feet in thickness. Most of such bodies of sediment were of lenticular form, but groups of them so fit together as to make a stratum of fairly uniform thickness. In the Pottsville epoch the accumulations of peat were not so extensive as in later epochs, but occasionally local marshes were here and there developed in which layers of vegetal material were accumulated in quantities large enough to form seams of coal.

CARBONDALE DEPOSITION.

During the deposition of the Carbondale sediments the region was at times covered by the sea and received deposits of mud, both aluminous and calcareous, and of sand, and at other times the sea was essentially banished for longer or shorter periods, when the surface commonly stayed so low and so level that brackish or fresh water marshes covered large areas, in which were accumulated beds of vegetal matter that were afterward transformed into coal. A large part of the sand may have been deposited on land, but the limestone and some of the shale formed during that time contain well-preserved remains of marine animals, showing conclusively that the rocks in which they are found were deposited in the sea.

There appear to have been also times of both local and general emergence and erosion, though the erosion was not nearly so extensive as that at the beginning of the preceding Pottsville epoch. Conditions generally were more quiet than in that epoch. Sand beds, though in some places coarse and thick, were not so extensive, and clay was the predominant material laid down. Peat made up a larger part of the deposits formed in this epoch than in any other.

The time of greatest peat development was at the close of the Carbondale epoch, when the Herrin coal was formed. The accumulation of this peat was interrupted from time to time by the spreading out of films of sediment and by the development temporarily of conditions favorable to decomposition, resulting in the division of the deposit into several layers.

That certain areas were more favorable than others for further development of peat is shown not only by the fact that the resulting coal is considerably thicker in some places than in others, but also by the fact that the thickness of each division of the coal is greatest where the whole bed is thickest. Where the coal is thinnest the lowermost division averages 19 per cent of the whole, where it is of medium thickness nearly 25 per cent, and where it is thickest 36 per cent.

McLEANSBORO DEPOSITION.

Conditions similar to those of the Carbondale epoch continued throughout McLeansboro time with the difference that the proportion of marine sediments was greater and that of vegetal material was less. Gradual subsidence such as seems to have affected the region throughout most of Pennsylvanian time continued, as is proved by the fact that although the rocks and their fossils show that each layer must have been deposited near sea level, the layers aggregate many hundreds of feet in thickness and when the latest were laid down the earliest must have been far below sea level. On the whole, shallow water or marshes prevailed, but owing to the fact that the region lay very near sea level there was much variation in conditions. At many times the region was flooded by the sea; at others it rose slightly above sea level.

The accumulation of the material now forming the Herrin coal was followed by a time during which the greater part of the peat bed was covered by a fine clayey silt, now hardened into shale. In interpreting the physical conditions under which the shale was deposited the significance of its unequal distribution is not perfectly clear. On the surface of sinking marshes gentle currents might keep some channels open while fine silt might be settling in the more quiet water between them. That such currents existed is shown conclusively by the nature of the shale in at least two places. One of these places is in the Breese-Trenton Mining Co.'s mine, in Breese, where the roof consists of sandy and micaceous silt in which there are angular and rounded lumps of shale and coal mingled with kidney-shaped masses of clay ironstone. There are also imprints of flattened trunks of small trees and fragments of smaller branches and leaves. All these except the concretions were evidently left on the border of some current which once flowed over the surface of the peaty deposit that now forms the coal. In fact, the bed of this current has been traced for nearly a mile in a number of entries and rooms of the mine, and it has been found to have a general northeasterly course. Erosion that was contemporaneous with deposition is recorded in the Madison Coal Co.'s mine at Glen Carbon, just outside the Belleville quadrangle, as shown in figure 9. At a point about 1,000 feet north of the shaft in the main entry in this mine lies a mass of shale or "clod" 3 feet thick and 30 feet long with its horizontal layers beveled off at both ends. It has the relation of an outlier and is overlain by shale whose sedimentation planes follow the beveled edges of the older deposit. In this mine the areas of thick roof shale are said to run northwestward.

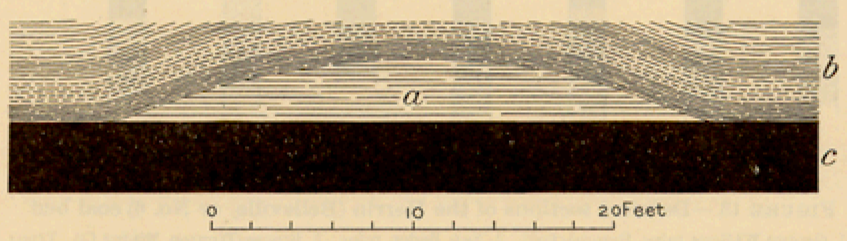

Figure 9.—Unconformity due to erosion contemporaneous with sedimentation, exposed in the roof shale of the Madison Coal Co.'s mine at Glen Carbon in the north entry, 1,000 feet from the main shaft.

a, "Clod"; *b*, roof shale; *c*, coal.

The fact that the thickness of the roof shale, which was measured at 32 places, seems to have a relation to the thickness of the coal, throws further light on the conditions existing at the time of its development. The shale ranges in thickness from a thin film to 46 feet and it is thickest where the coal is thinnest, but whether this relation is due to erosion immediately following the deposition of the shale or to irregularities in the original deposit is not known.

POST-CARBONIFEROUS DEFORMATION.

Carboniferous deposition was closed by widespread movements which resulted in the uplift of the Appalachian Mountains on the east and the Ouachita and Ozark mountains on the southwest and the further uplift of the La Salle anticline in Illinois. These movements permanently banished the sea from the region.

The attitude of the rocks of the Belleville and Breese quadrangles was not greatly modified by the widespread deformation at about the close of Carboniferous time. The folds produced at that time are so broad and low that they are almost indistinguishable from original irregularities of deposition and no large faults have been found, but the general altitude of the surface was probably considerably increased, the district being raised from approximately sea level to a position a few hundred feet above it. Whether the general eastward dip of the strata was produced altogether at that time or is in part a result of subsequent movements is not known.

In some parts of southern Illinois and elsewhere molten rock was forced from places far down in the earth up to levels so near the surface that it has since been laid bare by erosion, but no igneous rock has been found in these quadrangles and probably no such rock lies within several thousand feet of the surface in this part of Illinois.

MESOZOIC ERA.

After the elevation and deformation near the close of the Carboniferous period new processes began to act in the region, and areas which before had almost continuously received rock material began to lose it by erosion. Erosion has continued practically without interruption to the present time, though at several epochs it has probably been accelerated by uplifts. There is no reliable evidence of any general subsidence.

Several great uplifts affected the Appalachian Mountains and the Ozarks and between and during these epochs of uplift extensive erosion reduced the surface by many hundreds of feet. Perhaps at each of the epochs of mountain uplift southern Illinois suffered some deformation, but presumably it was slight. In each cycle of uplift and long-continued erosion valleys were carved and the intervening hills were afterward reduced nearly to a plain, and this process may have been repeated several times, for each planed surface—the record of one cycle—was more or less completely destroyed by erosion during the next. Moreover, all possible stages occur in the process of reduction, and the less complete the cycle the more easily is its record destroyed. In southern Illinois the uplifts were slight and the rocks are almost uniformly soft, so the records of uplift and erosion are not well preserved. In the southernmost and northernmost extremities of the State the tops of certain hills of resistant rock apparently constitute remnants of two peneplains older than any recorded in the Belleville and Breese quadrangles; hence another cycle of uplift and erosion seems to have taken place before the oldest surface in the quadrangles was formed.

CENOZOIC ERA.

TERTIARY PERIOD.

Development of relief.—If the third cycle of erosion just referred to took place, it was probably begun by an uplift, perhaps near the beginning of the Tertiary period. In any event some time before the close of the Tertiary the surface of most of Illinois and of much adjacent territory had been reduced to a nearly level plain, for the surface beneath the Quaternary deposits is very even except where narrow valleys were cut, in late Tertiary or early Quaternary time.

The surface of hard rock underlying the drift, which is approximately the same as the surface at the close of the Tertiary, has wide, shallow valleys, which seem to have a relation to the softer beds of rock, and wide, low table-lands of irregular outline, which are underlain by harder layers. The old surface shown in figure 10, sloped from northwest to southeast at about 2 feet to the mile, being in that respect closely similar to the present surface. The lowest point at which bedrock has been encountered in the quadrangles is in the Wiersberger mine shaft at Lebanon, at an elevation of 345 feet above sea level. South of the quadrangles the bedrock surface is still lower and it thus appears probable that at the close of the Tertiary the general slope of the surface was, as it is to-day, southeastward.

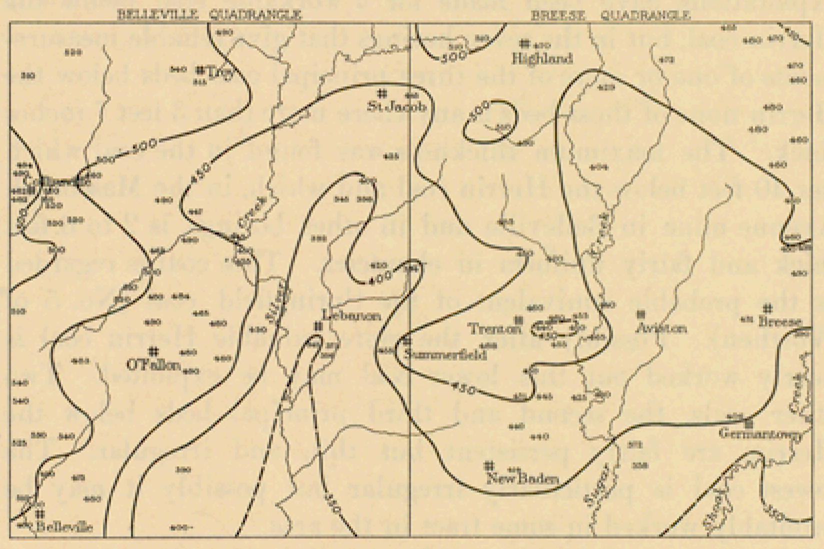

Figure 10.—Outline map of the Belleville and Breese quadrangles showing the elevation and configuration of the bedrock surface by contour lines.

Figures show elevation in feet above sea level. Contour interval, 50 feet.

The arrangement of drainage lines at the close of the Tertiary was also similar to that of the present, as would be supposed in view of the fact that the thickness of the drift averages only about 60 feet and, except in the drift ridges, which have had only local influence on stream alignment, is rather uniform. The old floor of the valley now occupied by Silver Creek seems to have been 100 feet below the ancient highlands on either side. Other preglacial depressions lie beneath the lower course of Sugar and Shoal creeks. An ancient upland divide lies west of Silver Creek, extending from Troy and Edwardsville on the north to Belleville on the south. It has a general altitude of 516 feet above sea level and marks the outcrop, beneath the drift, of the limestone known in the region as the "top limestone," which stands 125 to 150 feet above the Herrin coal. Another upland divide in the preglacial topography is capped by the Shoal Creek limestone and extends southward from Highland to Shoal Creek, in the northeastern part of the area, and thence southward, disappearing in that direction because of the general dip of the limestone. In the regions between Breese and Highland and between Breese and Aviston, Albers, and Germantown few data are available to show the height of the old land surface, but the indications are that in most of that country the Shoal Creek limestone has been cut away and that the general land erosion preceding the deposition of the drift had extended below the limestone into the underlying shale to a depth of probably 50 to 100 feet. Data are also lacking in the region around upper Silver Creek, in the western part of St. Jacob and Marine townships and in the eastern part of Jarvis and Pinoak townships. The absence of outcrops of bedrock in both these regions indicates that it lies at some distance below the present channels of the streams. In one well in the southwest corner of St. Jacob Township bedrock lies 345 feet and in another 398 feet above sea level. This considerable depth of the preglacial valley so far north suggests that the valley extends still farther north and probably lies somewhere near the west boundary of St. Jacob Township.

QUATERNARY PERIOD.

PLEISTOCENE EPOCH.

At the beginning of the Quaternary period the surface of the quadrangles, though in general much like the present surface, differed from it in one important respect. The configuration of the surface at that time was the result solely of erosion, whereas that of the present surface is the product in part of deposition of drift and in part of subsequent erosion of these deposits by the present streams.

PRE-ILLINOIAN TIME.

In the early part of the Pleistocene epoch, probably during Kansan time, an ice sheet formed farther north spread broadly over the northern interior region, covering part of Illinois and possibly the Belleville and Breese quadrangles. After occupying this region for a considerable period the ice melted away, leaving in its place a thick mantle of clay, sand, pebbles, and bowlders, which it had brought down with it.

The melting of the glacier and the accompanying change of climate were followed by a long interval during which the climate probably did not differ greatly from that prevailing in the region to-day. During this interglacial time, probably the time known as the Yarmouth stage, the surface of the drift was covered with vegetation and the glacial deposits were subjected to considerable erosion.

ILLINOIAN TIME.

The next important event was the invasion of the region by the Illinoian ice sheet, which came from the northeast, originating in Labrador. As it advanced it gathered up much of the material left by the Kansan glacier and mixed it with other débris that had been brought from the north. In some places, however, it did not greatly disturb the other drift or even the soil which had formed upon it, but buried it just as it was.

This glacier reached in southern Illinois the most southern point attained by any Pleistocene ice sheet and spread over 1,000 square miles south of the thirty-eighth parallel. It covered the Belleville and Breese quadrangles and left upon them a mantle of gravelly clay in which many kinds of rock were represented, including coarse-grained igneous rocks which do not outcrop south of Canada along the route traversed by the ice reaching this area, as well as flint, silicified limestone, and other rocks from Illinois. Quartz and flint occur in this deposit in much larger proportion than in the rocks from which they were derived, partly, no doubt, because these materials are very resistant to erosion, though some of the pebbles may have been taken from remnants of Tertiary or Cretaceous gravel that were so much disintegrated that little remained but loose pebbles.

The conditions and events that led to the formation of the drift ridges which cross the Belleville and Breese quadrangles are not known. This system of ridges is the middle one of three which are approximately parallel. The ridges may be interlobate morainic material deposited between two ice fields, terminal or recessional moraines marking the west border of an ice lobe which persisted in southern Illinois after the ice had retreated from the western part of the State, accumulations under the ice, or material collected in or on the ice. The facts that there is no other evidence of ice lobes on either side of the belt of drift ridges and that no immediate cause is known for such accumulations beneath the ice seem to militate against the first three possibilities; whereas the facts that the bedding planes of the water-laid parts of the drift in the ridges have been disturbed and that the proportion of rocks from Canada seems larger than in the drift elsewhere seem to favor the idea that the bodies of till that form the ridges were gathered together in or near the top of the ice.

SANGAMON TO PEORIAN TIME.

Upon the surface of the Illinoian till, which with the exception of the drift ridges was somewhat more smooth than the preglacial surface, new lines of drainage were developed and in the flattest parts of the interstream areas organic material from successive generations of plants accumulated to such an extent as to form a carbonaceous soil (the Sangamon soil) which was in places peaty, particularly in central Illinois where it is dark though it is elsewhere reddish or whitish. In the Belleville and Breese quadrangles this soil seems to be represented in places at the top of the till, where it appears as a grayish or reddish layer a foot or less thick. On slopes where erosion was more active the Sangamon soil was not allowed to accumulate and hence in many exposures the upper limit of the till is not sharply defined, and indeed the till, probably as a result of creeping and of original scarcity and later solution and decomposition of pebbles near the top, appears generally to grade upward into the loess.

After these conditions had continued undisturbed for some time and the present valleys were fairly well developed the conditions became favorable for the accumulation of extensive deposits of silty material, probably dust. This dust, or loess, was spread over the Sangamon soil and over the leached and eroded Illinoian till in places where the Sangamon soil was absent. Later dust deposition diminished and became overbalanced by erosion, and the carving of valleys continued up to Wisconsin time, when they had reached almost their present form.

A feature of the loess which appears to have some bearing on its origin is the fact that its texture and thickness are noticeably less uniform in the vicinity of the drift ridges, where on the whole it seems to be thicker and coarser. In the great drift ridge at Shiloh its thickness increases from 18 to 30 feet in less than 2 miles. On the crest of the ridges north of Highland it thins out and disappears. Similar variations were noted in the hills south of Breese. The reason for these peculiarities is not known. Perhaps they have a relation to the fact that ridges are commonly forested, whereas the flat upland is in general a prairie.

The writers believe that the loess in this region was deposited by the wind. Their opinion is based largely on the facts that the deposit differs from ordinary water-laid clay in being very homogeneous and in showing little evidence of stratification, in containing shells of air-breathing snails, which, though exceedingly fragile, are commonly unbroken, and in being thickest on the highest parts of the surface.

WISCONSIN TIME.

Sometime after the deposition of dust had practically ceased ice of the Wisconsin stage invaded northern and eastern Illinois and spread southwestward to a position within 65 miles of the area under discussion. Water overloaded with glacial débris was discharged westward from the ice, depositing large quantities of sand and gravel in the valley of Kaskaskia River. Such deposition may have continued after the ice front receded, while new valleys were being established on the newly deposited till. Inasmuch, however, as none of the valleys traversing this area were invaded by the Wisconsin ice, no deposits of Wisconsin age can be discriminated except a little back-water sediment laid down by Shoal Creek on low terraces in the southeast corner of the area, on account of conditions on the Kaskaskia.

RECENT EPOCH.

In the Recent epoch there has been, so far as known, no change in the altitude of the district. The principal event has been the removal of part of the material deposited during the Pleistocene epoch. The streams have been widening their valleys and forming flood plains.

The effectiveness of postglacial erosion in dissecting the drift plain differs greatly from place to place. The general slope of the drift plain being very slight, the headward cutting of the ravines has in most places been exceedingly slow, owing, no doubt, to the fact that rain and snow water soak slowly into the ground instead of being at once drained away. Thus the uplands drained by Shoal and Sugar creeks and by the east tributaries of Silver Creek are much less dissected than the uplands west of Silver Creek. The west tributaries of Silver Creek, in Jarvis and O'Fallon townships, have dissected the uplands in their basins more rapidly on account of the greater general eastward slope in that area. The difference in the rate of dissection of the uplands is due in part also to difference in the gradient of the streams themselves. Thus in the west part of Collinsville and Caseyville townships the uplands are much dissected owing to the comparatively rapid headward cutting of the streams, which flow directly to the Mississippi.

All the streams, whether on the whole building up or cutting down, have made deposits continuously, and some of these deposits lie along their banks to-day. Each stream swings back and forth across its valley depositing on one bank and cutting on the other. Most of the work is done at times of high water, when the streams spread over their flood plains, dropping the finer material where the water is shallower and the coarser where it is deeper. In consequence the average section of flood-plain deposit is progressively finer from base to top.

ECONOMIC GEOLOGY.

The mineral resources of the Belleville and Breese quadrangles, named in approximate order of importance, are coal, soils, water, clay, building stone, oil, and gas.

COAL.

The quadrangles lie in the southwestern part of the eastern interior coal basin. (See fig. 11.) Coal occurs at several hori-

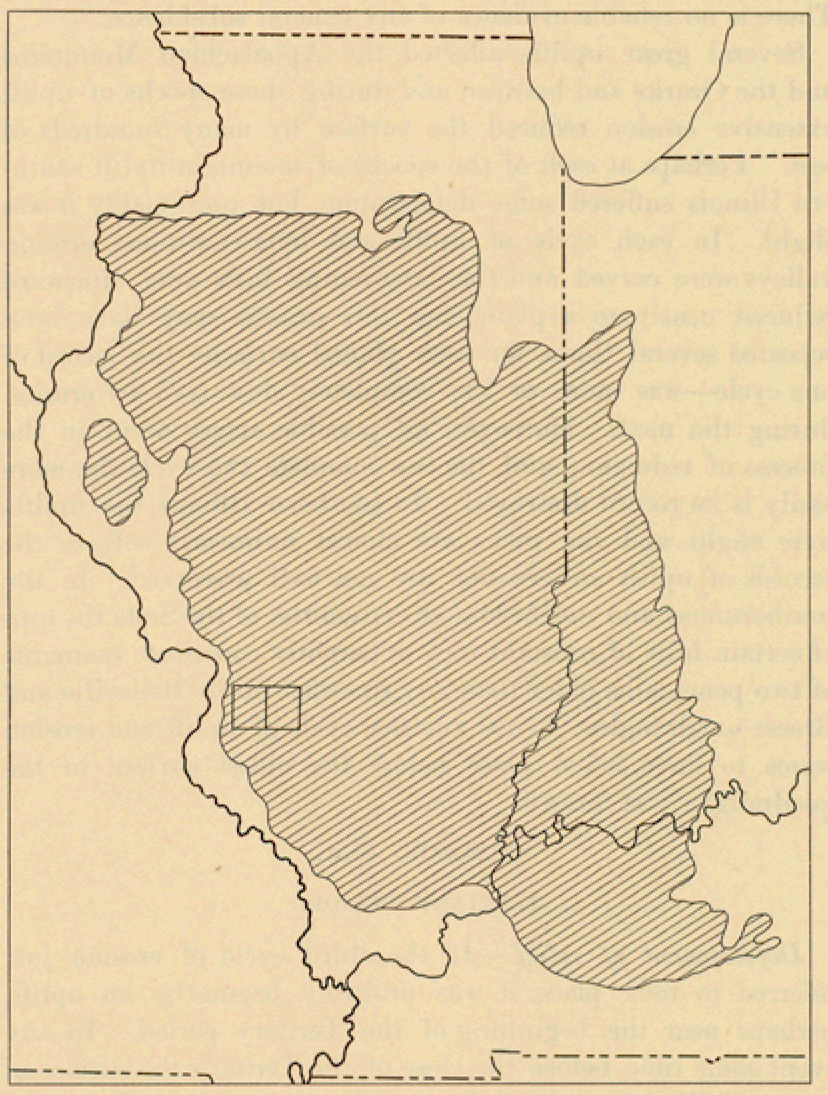

FIGURE 11.—Outline map showing the location of the Belleville and Breese quadrangles (the small rectangles) in the eastern interior coal basin of Illinois, Indiana, and Kentucky, represented by the ruled area.

zons in the Carbondale and McLeansboro formations, but the Herrin coal is of much greater value than any other and is the only one now worked. The coal production of St. Clair County in 1913 was 4,383,459 short tons.

Coals below the Herrin coal (Belleville, or No. 6).—Extensive explorations have been made for a workable coal below the Herrin coal, but in the seven borings that give reliable measurements of one or more of the three principal coal beds below the Herrin none of those beds is anywhere more than 3 feet 7 inches thick. The maximum thickness was found in the coal which lies 40 feet below the Herrin coal and which, in the Mascoutah Avenue mine in Belleville and in other borings, is 2 to 6 feet thick and fairly uniform in character. This coal is regarded as the probable equivalent of the Springfield coal (No. 5 of Worthen). Possibly after the more valuable Herrin coal is nearly worked out this lower coal may be exploited. Two other coals, the second and third principal beds below the Herrin, are fairly persistent but thin and irregular. The lowest coal is particularly irregular but possibly it may be profitably worked in some tract in the area.

Herrin coal (Belleville, or No. 6).—The Herrin coal underlies practically all of both quadrangles and except in a few small tracts appears to be uniform and everywhere workable. At Highland it is reported as not found in a boring made many years ago, but its absence must be considered a local peculiarity, for the coal is found on all sides of Highland. At Aviston it is too thin for profitable working. Entries were driven 50 feet north, south, east, and west from the bottom of the shaft, but in no direction did the coal increase in thickness from 26 inches. In the light of present knowledge there is not a section of land in the whole area on which it would seem out of place to explore for coal, but there are probably small areas where the coal was either thin when originally laid down or where it underwent erosion and concomitant small faulting which reduced and broke up the bed so much as to render mining unprofitable under present economic conditions. The thin part of the bed will probably be found in an irregular belt between Highland, Aviston, and Germantown, but this probability should deter no one from making tests even in that belt.

Another condition limiting profitable mining may be found in the amount of water locally contained in some of the overlying sandstones, for in some places the quantity of such water is probably large enough to require so much pumping that mining will be unprofitable.

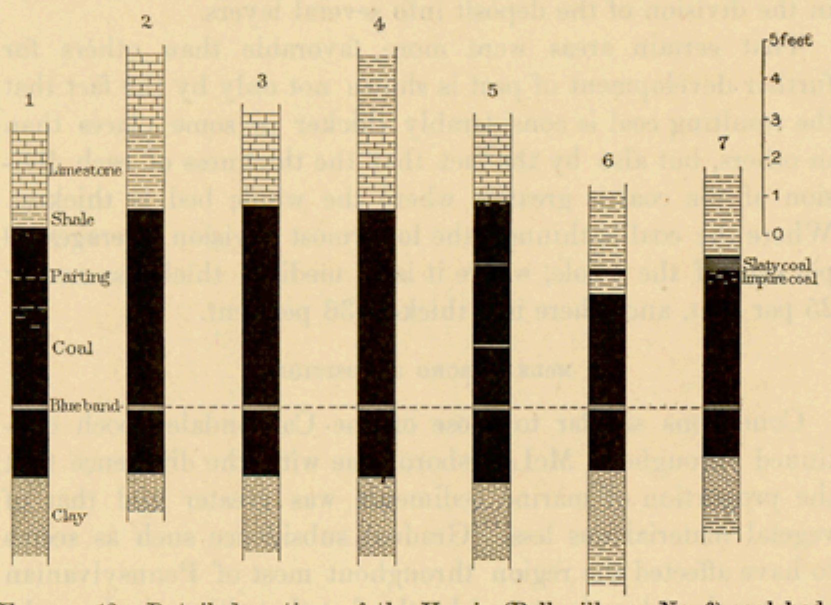

FIGURE 12.—Detailed sections of the Herrin (Belleville, or No. 6) coal bed.

1, Summit Coal & Mining Co.; 2, Southern Coal & Mining Co., mine No. 6; 3, Southern Coal & Mining Co., mine No. 8; 4, Glendale mine, air shaft; 5, Missouri & Illinois Coal Co., Reutchler mine; 6, International Coal & Mining Co., Bennett mine; 7, Lebanon City Coal Co.

The physical character of the Herrin coal, including its thickness, its roof, its floor, and its subdivisions, is described under the heading "Stratigraphy" (p. 5). The following sections show in greater detail the character of that group of beds in the Pennsylvanian which is by far the most fully explored and best known in the area and which for that reason has been used as a datum horizon in the stratigraphic work. Among some miners the Herrin coal is known also as the "bench coal," owing to the development of seams in its upper part which make it possible to mine the coal in benches of coal of different quality. Not only has the coal itself been extensively explored, but, incidentally to the mining operations, excavations have been made into the underlying fire clay and into the roof above, as the nature of these is of much importance to the miners. In some mines excavations have been carried 30 feet above the coal and 15 feet below it.

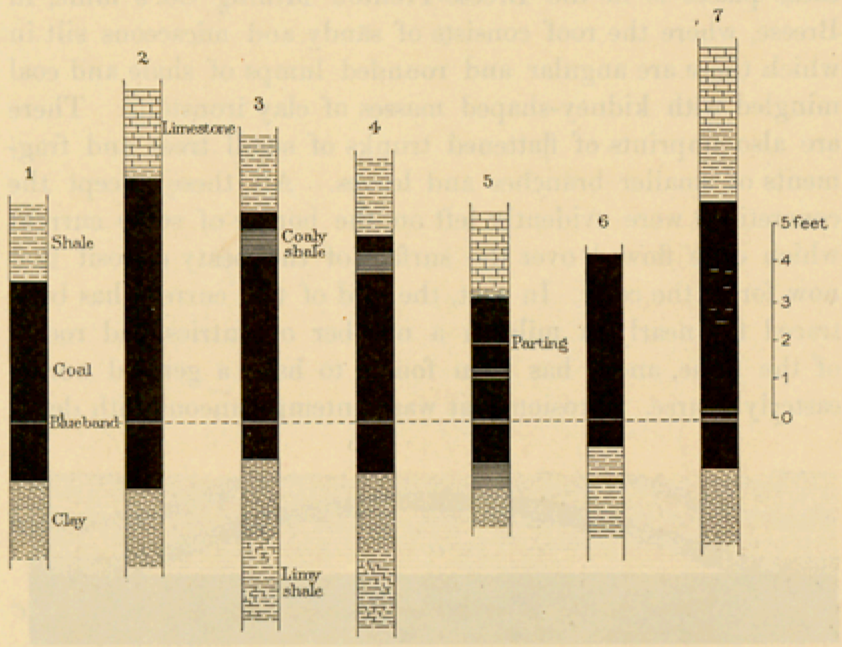

FIGURE 13.—Detailed sections of the Herrin (Belleville, or No. 6) coal bed.

1, George Widicus mine, Summerfield; 2, New Baden mine; 3, Breese-Trenton Mining Co., Trenton mine; 4, Trenton Coal Co.; 5, Southern Coal & Mining Co., Germantown mine; 6, Southern Coal & Mining Co., Germantown mine; 7, Consolidated Coal Co., Breese mine.

Fourteen typical sections of the coal and associated beds in this area are presented in graphic form in figures 12 and 13, and the details of the sections are as follows:

Section in Summit Coal & Mining Co.'s mine, north of Belleville.

	Ft.	in.
Limestone	4	
"Miner's slate," black, wanting in half of the mine; where present it ranges from 1 inch to 2 feet		6
Herrin coal:		
Coal, with bright luster; upper 4 inches known as "blacksmith coal," transparent in thin splinters, lustrous dark amber in color, and free from impurities; in the lower part are a few balls of pyrite; this bench is from 8 to 20 inches thick	1	3
Parting of clay and pyrite, interrupted		$\frac{1}{2}$
Coal, known as the "9-inch seam," clean, bright, free from pyrite, except a few spherical concretions		9
Parting of fire clay, interrupted		$\frac{1}{8}$
Coal, known as the "drift seam," with two interrupted bands of pyrite, one-eighth and one-half inch thick, and with scattered pockets and streaks of mineral charcoal		10

	Ft.	in.
Coal, known as "block coal," breaking into larger blocks than the other benches	1	8
Clay parting, known in the Illinois coal field as the "blue band"		2
Coal, duller in luster than the coal above, known as the "bottom coal," with some pyrite and some mineral charcoal ("smut") in partings	1	8
Fire clay	2	
	12	10½

Section in Southern Coal Co.'s mine No. 6, at Belleville.

	Ft.	in.
Limestone	3	
Shale, absent over half the mine, greatest thickness 5 feet, in elongated patches, 50 to 200 feet wide, with greatest length extending from west to east	2	
Herrin coal:		
Coal	5	
Clay seam, "blue band"		2
Coal	1	7
Fire clay	1	
	12	9

Section in Southern Coal Mining Co.'s mine No. 8, at Shiloh.

	Ft.	in.
Limestone		3
Shale, absent in many places, nowhere more than 3 feet thick		4
Coal (Herrin), from 6 to 7 feet thick	6	6
Fire clay	2	
	11	10

Section in air shaft of Glendale mine, at Belleville.

	Ft.	in.
Shale	1	6
Coal, impure		1½
Shale	4	6
Limestone	2	
Herrin coal:		
Coal	5	
Clay seam, "blue band"		2
Coal	1	8
Fire clay	2	
	16	11½

Section in International Coal & Mining Co.'s Bennett mine, east of O'Fallon.

	Ft.	in.*
Shale, hardest next to the coal, softer higher up	15	
Herrin coal:		
Coal		2
Shale, black		6
Coal	2	9
Clay parting		2
Coal	1	6
Fire clay	2	
Shale	1	
	23	1

Section in Lebanon City Coal Co.'s mine, at Lebanon.

	Ft.	in.
Shale	20	
Shale, in alternate thin black and gray layers	1	
Shale, black, containing some impressions of leaves, a Discina, and *Leaia tricarinata*		4
Herrin coal:		
Coal, impure		6
Coal, pure	3	
Clay parting, "blue band"		1
Coal	1	3
Fire clay, passing into shale below	2	
	28	2

Section in George Widicus's mine, at Summerfield (abandoned).

	Ft.	in.
Shale	10	
Herrin coal:		
Coal with bright luster, known as "blacksmith coal"		4
Coal	3	4
Partings of impure coal with some pyrite, discontinuous		¼
Coal	1	6
Fire clay	2	
	17	2¼

Section in New Baden mine, at New Baden.

	Ft.	in.
Limestone, in which were noted *Fusulina cylindrica*, *Productus longispinus*, and a Seminula	4	
Shale, containing Discina; lenticular		6
Herrin coal:		
Coal, with several thin, flat, smooth partings in the upper 2 feet of the bed, 4 to 9 inches apart. These partings contain a powdery graphitic mineral charcoal which is greasy to the touch	6	4
Clay		2
Coal	1	6
Fire clay	2	
Limestone	?	?
	14	6

Section in West mine of Breese-Trenton Mining Co., at Trenton.

	Ft.	in.
Shale, light gray	4	
Shale, black, stiff, with some impressions of fern leaves and other vegetation; also *Leaia tricarinata*, *Discina nitida*, the latter abundant, also minute denticles of unknown relationship		2
Herrin coal:		
Coal, pure, known as "top coal"		5
Shale, black, and coal, in alternate thin layers, from 10 to 15 in a thickness of 1 millimeter, and with some layers of coal about one-tenth millimeter thick; in some seams were noted faint impressions of leaves (?)		8
Coal, bright luster		5
Coal, less bright luster	3	10
Clay "blue band"		1½
Coal		11
Fire clay	2	
Shale with irregular concretions, or lumps, of gray limestone containing a species usually identified as *Fusulina cylindrica* and Myalina sp	8	
	20	6½

Section in South Rutledge & Taylor (South) mine of Trenton Coal Co., at Trenton.

	Ft.	in.
Shale, gray	30	
Shale, black with *Leaia tricarinata*	1	
Herrin coal:		
Coal		5
Shale, black, with thin alternate layers of coal		6
Coal with thin seams of mineral charcoal	2	5
Coal with somewhat distant joints; known as "block coal"	1	5
Clay, "blue band"		1
Coal	1	4
Fire clay	2	
Marly clay and lumps of limestone	5	
	44	2

Section near main shaft in Germantown mine, at Germantown.

	Ft.	in.
Limestone, dark, containing Fusulina	2	
Shale, gray, with large concretions and with small flat bands of light-gray color; containing a few specimens of Discina		2
Herrin coal:		
Coal with bright luster	1	2
Parting with mineral charcoal, "sooty."		
Coal of somewhat dull luster, with two half-inch seams of impure coal		9
Parting of dark shale, with some pyrite		½
Coal		2
Clay, interrupted		½
Coal, known in this mine as "bench coal"	1	
Clay		2
Coal	1	
Shale, black, with thin layers of coal		6½
Fire clay		½
Coal		½
Fire clay, gray	1	
	8	1½

Section at face of north entry of Germantown mine, at Germantown, in August, 1907.

	Ft.	in.
Shale		
Herrin coal:		
Coal, with several thin partings about 4 inches apart	4	3
Clay parting (blue band ?)		½
Coal		8
	4	11½

NOTE.—Not far from this point an exploration was once made extending 9 feet below the coal. The first 7 feet is reported as consisting of gray clay with some thin streaks of coal, and below this was a coal 2 feet thick. The floor is variable in this mine, but the upper part of the fire clay commonly contains some laminæ of coal.

Section in room 14, south side of mine of Consolidated Coal Co. at Breese.

	Ft.	in.
Limestone, gray, with a Fusulina usually identified as *F. cylindrica*	2	
Shale, black, with *Discina nitida*	2	
Herrin coal:		
Coal, known as "top coal," pure and bright, with two persistent straight seams of mineral charcoal, or "smut," consisting of a fine powder of graphitic luster	1	4
Coal with comparatively distant joints, "block coal," with thin pyritiferous seams from 2½ to 4 inches apart and from one-eighth to one-half inch thick	2	
Coal with comparatively distant joints free from seams of pyrite	2	
Parting of compact pyrite, with some clay, discontinuous		½
Coal		2½
Clay seam, "blue band"		1½
Coal, with some streaks of pyrite	1	2
Fire clay	2	
	13	10½

The coals mined in the Belleville and Breese quadrangles are well known to the trade, and rank among the best coals of the State.

Chemical character.—The chemical character of the coal, like the physical character, differs greatly from place to place, though all the coal comes from the same bed. In the following tables the analyses of coal "as received" must represent approximately the actual commercial product of the area, though there is doubtless some difference as regards moisture and ash. Certain variations in the analyses seem related to differences in the roof materials. About one-third of the mines have a shale roof; the others are overlain by a hard limestone, which lies a few inches or a few feet above the coal. The moisture in coal "as received" from the mines having a shale roof generally runs higher and the heat value lower than in coals having a limestone roof, though some exceptions to this rule have been noted. The heating value of the samples of coal taken beneath the shale roof, as shown by its content of ash, moisture, and sulphur, averages 14,275 British thermal units per pound; whereas the heating value of the other samples averages 14,570 British thermal units per pound, and this general difference in heating value has no exception, although the cause of the difference has not yet been satisfactorily explained.

The chemical composition of the Herrin coal in this region is illustrated by the accompanying tables of analyses, most of which give the determined classified values. The character of the beds at the points at which the samples were taken by the United States Geological Survey is described in Bureau of Mines Bulletin 22. The analyses contained in the first table were made in the laboratory of the United States Geological Survey, where, also, ultimate analyses were made of several of the samples, as shown in the table. The analyses contained in the second table were made under the direction of Prof. S. W. Parr, in the laboratories of the University of Illinois.

Analyses of samples of the Herrin coal (Belleville, or No. 6) including determinations of the ultimate fuel constituents.

[Analyzed in the laboratory of the United States Geological Survey.]

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
2854	10.1	A	13.43	33.02	44.37	9.18	3.35					6,076	10,937
		B	3.70	36.73	49.36	10.21	3.73					6,759	12,166
		C		38.14	51.26	10.60	3.87					7,019	12,634
		D		42.66	57.34		4.33					7,851	14,132
2855	9.6	A	12.73	33.35	44.32	9.60	3.60						
		B	3.46	36.89	49.03	10.62	3.98						
		C		38.21	50.79	11.00	4.13						
		D		42.93	57.07		4.64						
2972	7.4	A	11.44	33.93	43.92	10.71	4.94	5.39	60.06	1.02	17.88	6,088	10,958
		B	4.36	36.64	47.43	11.57	5.33	4.94	64.86	1.10	12.20	6,575	11,835
		C		38.31	49.60	12.09	5.58	4.65	67.82	1.15	8.71	6,874	12,373
		D		43.58	56.42		6.35	5.29	77.15	1.31	9.90	7,820	14,076
2856	6.7	A	11.64	35.41	44.29	8.66	3.41					6,272	11,290
		B	5.30	37.95	47.47	9.28	3.65					6,722	12,100
		C		40.07	50.13	9.80	3.86					7,098	12,776
		D		44.42	55.58		4.28					7,870	14,166
2857	7.6	A	12.15	35.60	42.97	9.28	4.01						
		B	4.92	38.53	46.51	10.04	4.34						
		C		40.52	48.92	10.56	4.56						
		D		45.31	54.69		5.10						
2991	5.9	A	11.35	34.62	40.63	13.40	4.76	5.41	57.36	1.05	18.02	5,963	10,733
		B	5.79	36.79	43.18	14.24	5.06	5.05	60.96	1.12	13.57	6,337	11,407
		C		39.05	45.83	15.12	5.37	4.68	64.70	1.18	8.95	6,726	12,107
		D		46.00	54.00		6.33	5.51	76.23	1.40	10.53	7,924	14,263
1341	3.2	A	15.09	31.00	46.49	7.42	.83					6,195	11,151
		B	12.28	32.02	48.03	7.67	.86					6,400	11,520
		C		36.51	54.75	8.74	.98					7,296	13,133
		D		40.01	59.99		1.15					7,994	14,389
1342	3.0	A	14.42	32.18	44.59	8.81	1.52						
		B	11.77	33.18	45.97	9.08	1.57						
		C		37.60	52.11	10.29	1.78						
		D		41.91	58.09		1.98						
1417	1.7	A	12.91	31.90	43.55	11.64	1.32	5.43	60.74	1.15	19.72	6,002	10,804
		B	11.40	32.45	44.30	11.85	1.34	5.33	61.79	1.17	18.52	6,106	10,991
		C		36.63	50.00	13.37	1.52	4.59	69.74	1.32	9.46	6,892	12,406
		D		42.28	57.72		1.75	5.30	80.50	1.52	10.93	7,955	14,319
2770	10.5	A	15.23	31.42	44.32	9.03	1.59					6,056	10,901
		B	5.28	35.11	49.52	10.09	1.78					6,767	12,181
		C		37.06	52.29	10.65	1.88					7,144	12,859
		D		41.48	58.52		2.10					7,998	14,396
2771	13.3	A	17.79	28.78	42.34	11.09	1.40						
		B	5.18	33.20	48.83	12.79	1.62						
		C		35.01	51.50	13.49	1.70						
		D		40.47	59.53		1.97						
2852	10.4	A	15.54	31.26	42.27	10.93	1.38	5.59	58.02	1.09	22.99	5,837	10,507
		B	5.74	34.89	47.17	12.20	1.54	4.94	64.76	1.22	15.34	6,514	11,725
		C		37.01	50.05	12.94	1.63	4.57	68.69	1.29	10.88	6,910	12,438
		D		42.51	57.49		1.88	5.25	78.91	1.48	12.48	7,938	14,288
2920	8.2	A	15.30	30.59	43.40	10.71	1.43						
		B	7.73	33.32	47.28	11.67	1.56						
		C		36.12	51.24	12.64	1.69						
		D		41.35	58.65		1.93						
1556	12.5	A	17.02	30.60	35.59	16.79	3.29	5.50	50.77			5,177	9,319
		B	5.16	34.98	40.67	19.19	3.76	4.69	58.02			5,917	10,651
		C		36.88	42.89	20.23	3.96	4.35	61.18			6,239	11,230
		D		46.23	53.77		4.97	5.30	76.70			7,821	14,078
2896	11.2	A	13.03	32.65	39.79	14.53	4.35	5.25	55.94	.89	19.04	5,662	10,192
		B	2.06	36.77	44.81	16.36	4.90	4.52	62.99	1.00	10.23	6,376	11,477
		C		37.54	45.75	16.71	5.00	4.37	64.32	1.02	8.58	6,510	11,718
		D		45.07	54.93		6.01	5.25	77.23	1.23	10.28	7,816	14,069
3910	2.3	A	10.73	39.60	40.41	9.26	4.12						
		B	8.63	40.53	41.36	9.48	4.22						
		C		44.36	45.27	10.37	4.62						
		D		49.49	50.51		5.15						
3912	2.2	A	9.88	42.26	37.05	10.81	3.83					6,355	11,439
		B	7.85	43.21	37.89	11.05	3.92					6,498	11,696
		C		46.89	41.12	11.99	4.25					7,052	12,694
		D		53.28	46.72		4.83					8,013	14,423
4364	8.7	A	11.69	35.70	39.42	13.19	4.38	5.46	57.15	.94	18.88	5,944	10,699
		B	3.27	39.10	43.18	14.45	4.80	4.92	62.60	1.03	12.20	6,510	11,718
		C		40.43	44.63	14.94	4.96	4.71	64.72	1.06	9.61	6,731	12,116
		D		47.52	52.48		5.83	5.54	76.08	1.25	11.30	7,913	14,243

A, Sample as received; B, air dried; C, moisture free; D, moisture and ash free. C and D are calculated from A and B.

Clinton County.

2854. New Baden; Southern No. 9 mine; 400 feet northwest of shaft, north entry 1 off west entry 1, 7-foot 5⅝-inch cut.

2855. New Baden; Southern No. 9 mine; 600 feet northeast of shaft, room 4, east entry 1 off north entry 1, 6-foot 7⅞-inch cut.

2972. New Baden; Southern No. 9 mine; lump, over 5¼-inch bar screen.

2856. Germantown, half mile east of; Southern No. 10 mine; 2,100 feet north of shaft, back north entry, 4-foot 7⅞-inch cut.

2857. Germantown, half mile east of; Southern No. 10 mine; 2,200 feet northwest of shaft, west entry 6, 4-foot 5⅝-inch cut.

2991. Germantown, half mile east of; Southern No. 10 mine; lump, over 1¾-inch screen.

Madison County.

1341. Troy, 1 mile west of; No. 3 mine; room 15 off west entry 5, north side of shaft, 5-foot 2-inch cut.

1342. Troy, 1 mile west of; No. 3 mine; room 16 off east entry 5, south side of shaft, 5-foot ½-inch cut.

1417. Troy, 1 mile west of; No. 3 mine; lump, over 2-inch screen; car sample.

2770. Troy; No. 3 mine; 1,500 feet southeast of shaft, room 22 off east entry 5, south side, 4-foot 6-inch cut.

2771. Troy; No. 3 mine; 800 feet northwest of shaft, room 26 off west entry 3, north side, 5-foot 3-inch cut.

2852. Troy; No. 3 mine; lump, over 2¼-inch screen, sample 1; car sample.

2920. Troy; No. 3 mine; lump, over 2¼-inch screen, sample 2; car sample.

1556. Collinsville; No. 1 mine, No. 5 washed coal; car sample.

2896. Maryville; No. 2 mine; nut, pea, and slack, through 2-inch screen; car sample.

St. Clair County.

3910. Shiloh; Southern No. 8 mine; 900 feet southwest of shaft, crosscut off west entry 1, south side, 6-foot 7¼-inch cut.

3912. Shiloh; Southern No. 8 mine; 800 feet northeast of shaft, east entry 3, 5-foot 5$\frac{3}{16}$-inch cut.

4364. Shiloh; Southern No. 8 mine; nut coal, through 3-inch and over 2-inch shaking screen; car sample.

Proximate analyses of face samples of Herrin coal (Belleville, or No. 6) from Belleville and Breese quadrangles.

[Made under the direction of Prof. S. W. Parr for the Illinois State Geological Survey.]

Laboratory No.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	British thermal units.
996	A	10.97	38.08	41.62	9.33	4.27	11,409
	B	5.91	40.25	43.99	9.85	4.52	12,058
	C		42.78	46.75	10.47	4.80	12,815
1175	A	11.83	34.42	44.25	9.50	3.49	11,162
	B	4.08	37.44	48.14	10.34	3.80	12,143
	C		39.03	50.19	10.78	3.96	12,659
1176	A	12.86	35.68	39.62	11.84	3.93	10,672
	B	3.98	39.82	43.65	13.05	4.33	11,759
	C		40.95	45.46	13.59	4.52	12,246
1177	A	15.19	31.79	43.57	9.45	1.39	10,660
	B	4.00	36.00	49.30	10.70	1.58	12,067
	C		37.50	51.35	11.15	1.65	12,569
1178	A	1.81	30.87	40.21	14.11	2.55	9,916
	B	34.41	35.00	45.59	16.00	2.89	11,243
	C		36.24	47.20	16.56	2.99	11,639
723	A	12.11			10.75	3.84	11,097
	B	9.13			11.12	3.97	11,473
	C				12.23	4.37	12,604
724	A	12.23			8.50	2.92	11,395
	B	9.34			8.79	3.02	11,770
	C				9.69	3.33	12,982
991	A	9.76	37.26	38.72	14.26	4.29	11,011
	B	3.19	39.97	41.54	15.30	4.61	11,813
	C		41.29	42.91	15.80	4.76	12,202
992	A	10.18	34.37	40.89	14.56	4.50	10,596
	B	3.75	36.83	43.82	15.60	4.82	11,354
	C		38.26	45.53	16.21	5.01	11,797
993	A	9.44	40.80	39.59	10.17	3.96	11,523
	B	4.82	42.88	41.61	10.69	4.16	12,110
	C		45.05	43.72	11.23	4.37	12,723
995	A	10.05	39.00	39.73	11.22	3.77	11,311
	B	5.27	41.07	41.84	11.82	3.97	11,913
	C		43.36	44.17	12.47	4.19	12,587
1001	A	13.75	29.95	45.50	10.80	1.84	10,769
	B	6.60	32.43	49.27	11.70	1.99	11,662
	C		34.72	52.75	12.53	2.13	12,486
1002	A	13.15	31.15	44.04	11.66	2.90	10,674
	B	5.37	33.94	47.98	12.71	3.16	11,630
	C		35.87	50.70	13.43	3.23	12,290
1129	A	15.91	37.33	37.43	9.33	3.95	10,685
	B	2.38	43.33	43.48	10.81	4.58	12,404
	C		44.39	44.54	11.07	4.70	12,706
1130	A	11.11	38.00	40.22	10.67	4.20	11,191
	B	2.38	41.73	44.17	11.72	4.61	12,289
	C		42.75	45.25	12.00	4.72	12,587
1650	A						
	B	6.27			10.51	3.98	11,830
	C				11.21	4.25	12,621
2632	A	10.43	37.62	40.35	11.60	4.21	11,060
	B	6.10	39.44	42.30	12.16	4.41	11,595
	C		42.00	45.05	12.95	4.70	12,348
2633	A	11.43	37.31	39.93	11.33	4.26	10,940
	B	7.14	39.12	41.86	11.88	4.47	11,741
	C		42.13	45.08	12.79	4.81	12,352
4386	A	10.62	39.88	38.33	11.17	4.89	10,921
	B	6.42	41.76	40.12	11.70	5.12	11,435
	C		44.62	42.87	12.51	5.47	12,218
1118	A	14.16	31.78	42.34	11.72	2.41	10,399
	B	4.29	35.43	47.21	13.07	2.69	11,594
	C		37.02	49.33	13.65	2.81	12,114

A, Sample as received; B, air dried; C, moisture free.

Samples 996, 1175, 1176, 1177, and 1178 from Clinton County; samples 723, 724, 991, 992, 993, 995, 1001, 1002, 1129, 1130, 1650, 2632, 2633, and 4386 from St. Clair County; sample 1118 from Madison County.

Most of the coal from the quadrangles is used for miscellaneous heating and for making steam. For such use this coal is not inherently so valuable as that of the first coals of the Appalachian field, owing to its relatively high content of oxygen, sulphur, ash, and moisture, but in spite of these facts it has a high average value, being as good as most of the coal in the eastern interior and western interior basins. It is essentially a noncoking coal, as attempts to produce a good blast-furnace coke from it have not been successful. Steaming and coking tests were made of coal from these quadrangles at the fuel-testing plant of the United States Geological Survey at St. Louis and the results published.[1]

Successful briquetting and gas-producer tests[2] of this coal were made at St. Louis, which show that it is also well adapted to use in gas producers and for briquetting, and that, with the development of these industries, the demand for the coal should increase.

OIL AND GAS.

Several deep borings have been made in the quadrangles in search of oil and gas. The first, made by the Belleville Natural Gas Co. in 1899, 2 miles north of the city square in Belleville, reached a depth of 1,500 feet. Later in the same year the Highland Prospecting Co. sunk a well to a depth of 1,089 feet at Highland. In 1907 two borings were made for oil near the village of Aviston, one near Sugar Creek, 1½ miles southwest of the village, the other 2 miles south of it. Concerning the well last mentioned no data are at hand. In the other a calcareous sandstone 940 feet below the surface emitted a bituminous odor. The same year the Trenton Oil & Gas Co. began a deep boring for oil 2 miles north of Trenton, which was deepened to 2,000 feet the following year. This well is the deepest yet bored in the quadrangles. At a depth of 1,320 to 1,340 feet a sandstone containing considerable calcareous material was penetrated, which gave a strong bituminous odor when heated in a closed tube. The oil show in these two wells was found in the upper part of the Mississippian series, in rock which is approximately equivalent to that producing oil in the eastern part of the State. Near Aviston several wells about 1,000 feet deep were sunk in 1912, but oil in paying quantities was not found.

Although all these tests proved failures, there is one well in the Belleville quadrangle that is reported to have actually produced some oil, and one just outside the southern boundary that now yields a small quantity of oil. The well within the quadrangles is No. 27 of the Belleville Deep Well Water Co. According to the superintendent of the company, this well at one time yielded nearly a barrel of oil a day, which is the more significant in view of the fact that Belleville is on the axis of a small anticline that extends northward beyond O'Fallon, where it is even more sharply marked than farther south. The well outside the quadrangles is the deep well at Mascoutah, which during the last few years has produced more than a gallon of oil a day. The oil comes in drops in the strong flow of salt water which the well yields and is caught in a trap and used for lubricating the machinery of the mill. The fact that the well was originally cased to a depth of about 800 feet and that it has shown oil only during the last few years, since the casing has become leaky, seems to indicate that the oil, like that in Belleville, comes from the upper part of the Mississippian rocks. The significant structural feature with which the oil is associated is the upper part of a steep slope in the general easterly dip.

CLAY AND SHALE.

Clay and shale suitable for the manufacture of common brick and tile occur throughout the quadrangles, different varieties being found in different geologic formations. The shale, however, is for the most part deeply buried and probably it is not valuable enough to warrant the unusual expense of obtaining it.

The Carboniferous rocks of the area contain some clay, one bed of which, although deeply covered, appears in some places to be valuable enough for underground working. It lies near the contact between the Pennsylvanian and Mississippian series and is probably of Pottsville age. It is worked by the Hydraulic Pressed Brick Co., on Canteen Creek about half a mile east of Collinsville. An overlying coal bed is used for the roof in the entries from which the clay is taken. The excellent quality of the pressed brick made is presumably due partly to a more or less local leaching of the clay before the overlying coal was formed. The thickness of the clay ranges from 10 to 16 feet. In places the bed contains ill-defined lentils of concretionary calcareous material. The ornamental qualities of the brick are heightened by varied coloring.

The most extensive clay in the area is the loess which covers almost the entire surface and is universally accessible. It is fairly uniform in physical and chemical character and has been successfully used for making common brick at many places. The Troy Pressed Brick Co. has its works on the north side of the Vandalia Railroad, where the loess is 20 feet thick. In the plant of the Ittner Brick Co., on the east side of the Louisville & Nashville Railroad, in the NE. ¼ sec. 16, T. 1 N., R. 8 W., bricks are made from a thin and well-leached loess, though it is mixed with some of the underlying weathered bowlder clay. The Kloess, Belleville, and Gansmann & Miller brickyards, in or near Belleville, also use the loess, generally its upper, weathered part.

BUILDING STONE.

The building stone of the quadrangles is taken from the limestones which outcrop in the area. The stone is of fair quality but quarries are not numerous and are worked only part of the time.

The Shoal Creek limestone member of the McLeansboro formation has been worked extensively in Timmermann's quarry, 4 miles north of Breese, where the thickest layers of the member lie near the surface and average about a foot in thickness. Another small country quarry on this limestone is on the east bank of Sugar Creek, 1½ miles southwest of Aviston, where the lower layers are best preserved and consist of hard, tough, blue limestone, in blocks about 10 inches thick. The same layers have been quarried extensively on the west side of Sugar Creek east of Trenton, at one or two places on the east side of the creek, and at some of the outcrops along the tributaries of Shoal Creek between Timmermann's quarry and Jamestown.

A soft sandy limestone, belonging in the beds overlying the roof limestone of the Herrin coal, has for many years been worked in a quarry on Richland Creek in the northern part of Belleville. The rock is crushed and used for road metal.

The limestone which has been spoken of as the "top limestone" was formerly worked extensively along Cantine Creek in Collinsville. The same stratum yielded some building stone in other places, as on the south fork of Spring Creek, from 2 to 3 miles east of O'Fallon, and in a few places on Ogles Creek. On this creek some sandstone also has been quarried and used for foundation work.

Everywhere the rock requiring the least stripping has been taken first, and at the present time the product of the local industry does not compete successfully with imported stone and brick.

WATER RESOURCES.

Deep wells.—The deepest water wells in the quadrangles, which are at Belleville, Collinsville, Highland, and Trenton and which range in depth from 300 to 800 feet, draw from the sandy strata in the upper part of the Mississippian series. The water-bearing strata are fine grained and contain more or less calcium carbonate; some of them might more properly be called limestone, though they are generally recorded as sandstones. The quantity of water obtained is not great, and some borings are dry.

The Belleville Deep Water Co., which furnishes the public supply of Belleville, relied for many years on deep wells, but has recently been obliged to add impounded water from small tributaries of Richland Creek, north of Belleville. Mains have been laid also to wells in the American Bottoms, half a mile northwest of Edgemont, where an abundant supply of water has been obtained in alluvial gravel and sand. Before these changes were made it was evident that the deep wells would be inadequate, as the water level in them had been lowered to 300 feet. The company had at one time 30 wells in the southern part of Belleville, which were pumped by separate electrically operated pumps. The average daily yield was about 900,000 gallons, but the yield of individual wells ranged from 75,000 to less than 5,000 gallons. The daily yield of some other wells in Belleville is given in the following table:

Daily yield of deep wells in Belleville, in gallons.

Belleville Distilling Co., two wells, 15 feet apart	140,000
Star Brewery, three wells, now abandoned	5,000
Western Nail Mill	50,000
Crown Milling Co	20,000
Belleville Gas Co	30,000
Waugh Steel Co., two wells, abandoned	150,000
Harrison Switzer Mill	40,000
Western Brewing Co	150,000

As the wells, even those close together, differ greatly in production, the yield is probably controlled by the texture of the rock. In general the texture is close and the yield of water is slow but continuous. Two or three wells have never been pumped dry.

Collinsville was supplied for several years by deep wells, but now obtains water from wells in the American Bottoms. The Collinsville smelter has a deep well drawing from a calcareous sandstone in the upper part of the Mississippian series. The same stratum supplies one of the wells of the Helvetia Milk Condensing Co., in Highland, and two wells of the Grafeman Dairy Co., at Trenton. These wells are about 550 feet deep and yield about 140,000 gallons a day, but this large production was obtained only by shooting the wells.

Wells of medium depth.—The sandy shale and the sandstone 120 to 220 feet above the Herrin coal generally carry good supplies of water. Many farm wells in the northern part of the Breese quadrangle have been sunk to these rocks and failures to get water from them have been rare; the aquifer is entered at a depth of 130 to 180 feet and is 60 to 100 feet thick. One of the two wells of the Helvetia Milk Condensing Co., in Highland, the well at the Trenton flour mills, and the well of the Bassler Brewing Co., in Trenton, obtain water from this rock. The intake area of the strata is doubtless in the basin of Silver Creek.

Shallow wells.—Most private wells draw water from the drift. Open wells on many farms along the western border of the Belleville quadrangle, where the loess is 30 feet or more thick, are supplied from the base of the loess, where water is held on the less pervious bowlder clay, into which the wells are sunk 5 to 15 feet. On the uplands farther east the loess is thin and holds little water, and supplies are therefore commonly obtained from layers or lenses at the base of the bowlder clay, where it overlies Pennsylvanian shale. On the uplands, where the drift is thin and underlain by Pennsylvanian limestone, some wells are amply supplied from that rock. Springs exist in some places where limestone outcrops, as along Sugar Creek, the two branches of Spring Creek, and some of the small tributaries of Shoal Creek north of Breese. Plenty of water may be found at moderate depths in the stream sands that are buried under fine silt almost everywhere in the flat alluvial bottoms of Silver, Sugar, and Shoal creeks. The public supply of Breese is taken from Shoal Creek. The pumping station is 2 miles east of the town, and the creek water has so far proved sufficient in quantity.

Surface waters.—The supply of surface water for all ordinary purposes is abundant, but the water contains so much sediment and more important impurities that filtering is necessary to make it fit for domestic use, and as good well water is plentiful stream water has not been much utilized. Although the stream waters are muddy, especially at times of flood, they can be more economically purified for locomotives and for industrial use than can the ground waters.

[1] U. S. Geol. Survey Bulls. 290, 332, 447, and Prof. Paper 48; Bureau of Mines Bull. 23.

[2] U. S. Geol. Survey Bulls. 290, 332, 447, and Prof. Paper 48; Bureau of Mines Bulls. 13, 24, and 58.

Quality of waters.—Six analyses of ground waters within the area are given in the following table. They were made by the Illinois State Water Survey.[1]

Analyses of water from springs and wells in the Belleville-Breese area.

[Parts per million.]

	A	B	C	D	E	F
Silica (SiO_2)	10	4.2	24	3.3	9.5	13
Iron (Fe)	.9		2.5	1.5	1.2	1.1
Aluminum (Al)	3.6		4.3	.6	1.0	2.3
Calcium (Ca)	111	3.8	39	32	74	27
Magnesium (Mg)	40	3.5	18	20	28	13
Sodium (Na)	28	139	830	884	38	625
Potassium (K)	4.0		28	19	2.2	8.7
Ammonium radicle (NH_4)	3.6			1.3	.1	
Bicarbonate radicle (HCO_3)[a]	616	281	394	761	433	594
Sulphate radicle (SO_4)	7.4	5.5	450	505	17	64
Nitrate radicle (NO_3)	.3	.3	1.7	.6	.7	.9
Chlorine (Cl)	3.2	9.0	865	680	10	665
Total solids	704	384	2,609	2,545	329	1,679

[a] All combined carbonic acid computed as the bicarbonate radicle.

A. Spring of F. Voellinger, Belleville; collected Apr. 4, 1903.

B. Well of H. Kircher, Belleville; 425 feet deep: water from rock; collected Feb. 8, 1902.

C. Well of J. R. Wadsworth, Collinsville; water from rock at depth of 601 feet; collected Oct. 26, 1898.

D. Same as C; water from a depth of 706 feet.

E. Well of S. E. Simpson, Collinsville; 90 feet deep in sand; collected Nov. 10, 1902.

F. Well of Highland Brewing Co., Highland; water from rock at 246 feet; collected Oct. 18, 1905.

[1] The mineral content of Illinois waters: Illinois State Water Survey Bull. 4, 1908.

The waters represented by analyses C, D, and F are too salty to be entirely acceptable for domestic use. Analysis B represents a very soft sodium carbonate water of moderate mineral content; analysis E, however, shows a hard calcium carbonate water, which is more or less typical of this section of the Mississippi Valley, where limestones and unconsolidated deposits derived from the disintegration of that rock abound. These figures indicate the range of mineral content of the water and the different kinds of ground water found in these quadrangles.

SOILS.

The soil of the quadrangles has for the most part been derived from the loess. In places it is derived chiefly from the glacial till and in a few small tracts it is made up largely of detritus of the underlying bedrock. The streams of the district are bordered by alluvium transported from the interstream areas, and as those areas are mantled almost continuously by loess the alluvial soil is largely derived therefrom, but it contains considerable gravel and sand derived from the till.

The fertility of a soil depends on many factors, all of which are controlled rather closely by geologic processes, for the texture and the physical and chemical composition of a soil at any place are determined by the character of the rock or rocks from which it has been derived and the conditions and forces that have affected it.

The soil of the quadrangles consists of a great variety of more or less decomposed minerals. In its formation there seems to have been a general leaching of lime, compensated in places by the addition of lime by lime-secreting plants and animals. The loess soil has a consistency such as would be expected of a soil made of dust particles somewhat modified by weathering. It is comparatively open and porous and consists of extremely fine sand and more or less clay. In general the proportion of clay seems to increase with distance from the Mississippi, so that the soil in the eastern part of the area is rather heavier and less porous than that in the western part. The porous soil is yellowish gray and the more compact soil is light gray. In some places, especially on the alluvial bottoms, the soil is dark gray or black.

The organic content of the soil differs from place to place both in kind and amount. The general light color of the loess soil is due to the character and amount of the organic material it contains, which is controlled in large part by the warm climate and good drainage of the region, though there are no doubt other important factors, such as the original content of of lime.

April, 1914.

TOPOGRAPHY

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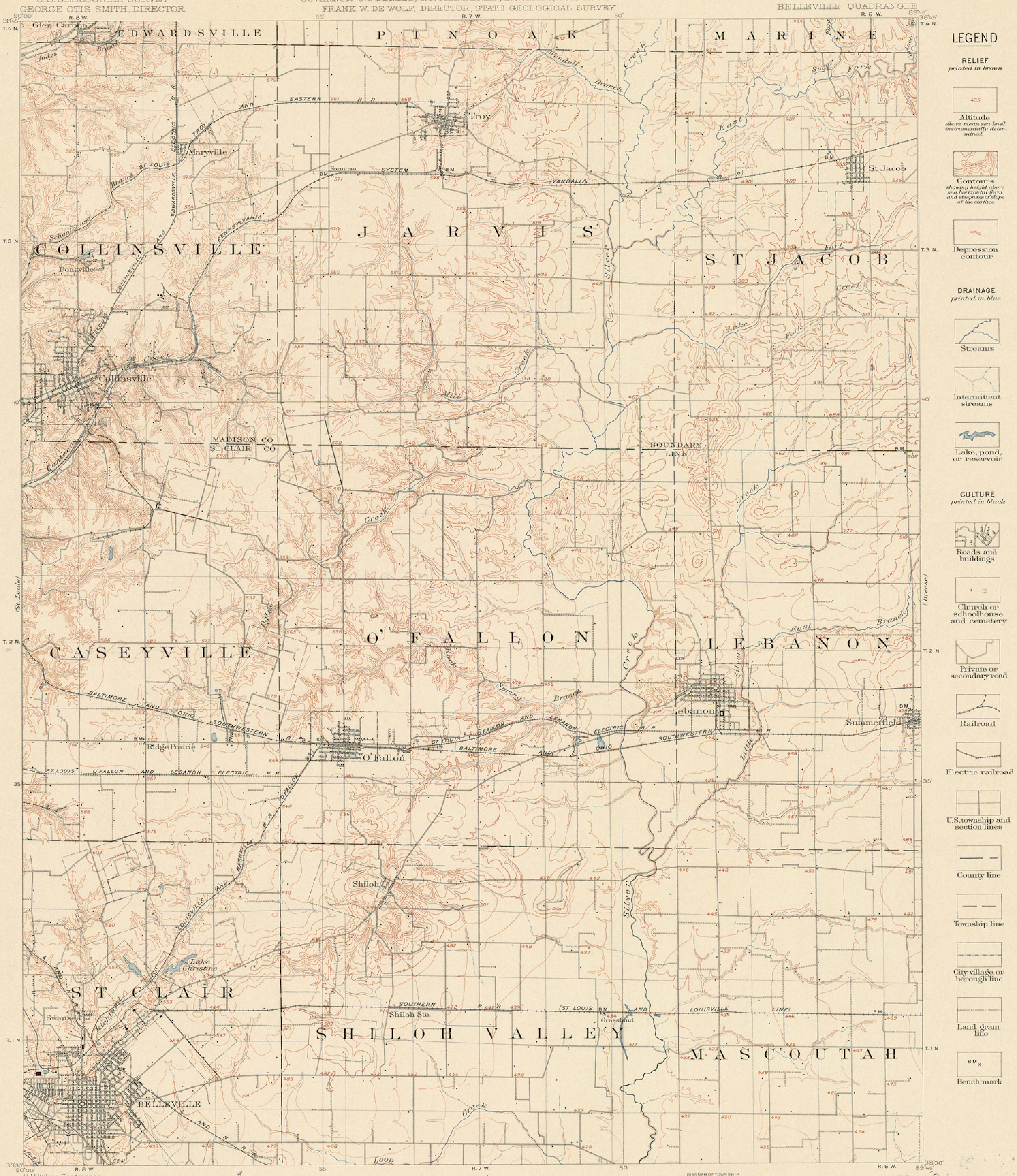
ILLINOIS
BELLEVILLE QUADRANGLE



H. M. Wilson, Geographer.
Chas. E. Cooke, in charge of section.
Topography by W. J. Lloyd and L. Scott Smith.
Control by J. R. Ellis.
Surveyed in 1905.

SURVEYED IN COOPERATION WITH THE STATE OF ILLINOIS.

APPROXIMATE MEAN DECLINATION 1905.

Scale $\frac{1}{62500}$

Contour interval 20 feet.
Datum is mean sea level.

DIAGRAM OF TOWNSHIP

Edition of April 1907, reprinted Jan. 1913.

TOPOGRAPHY

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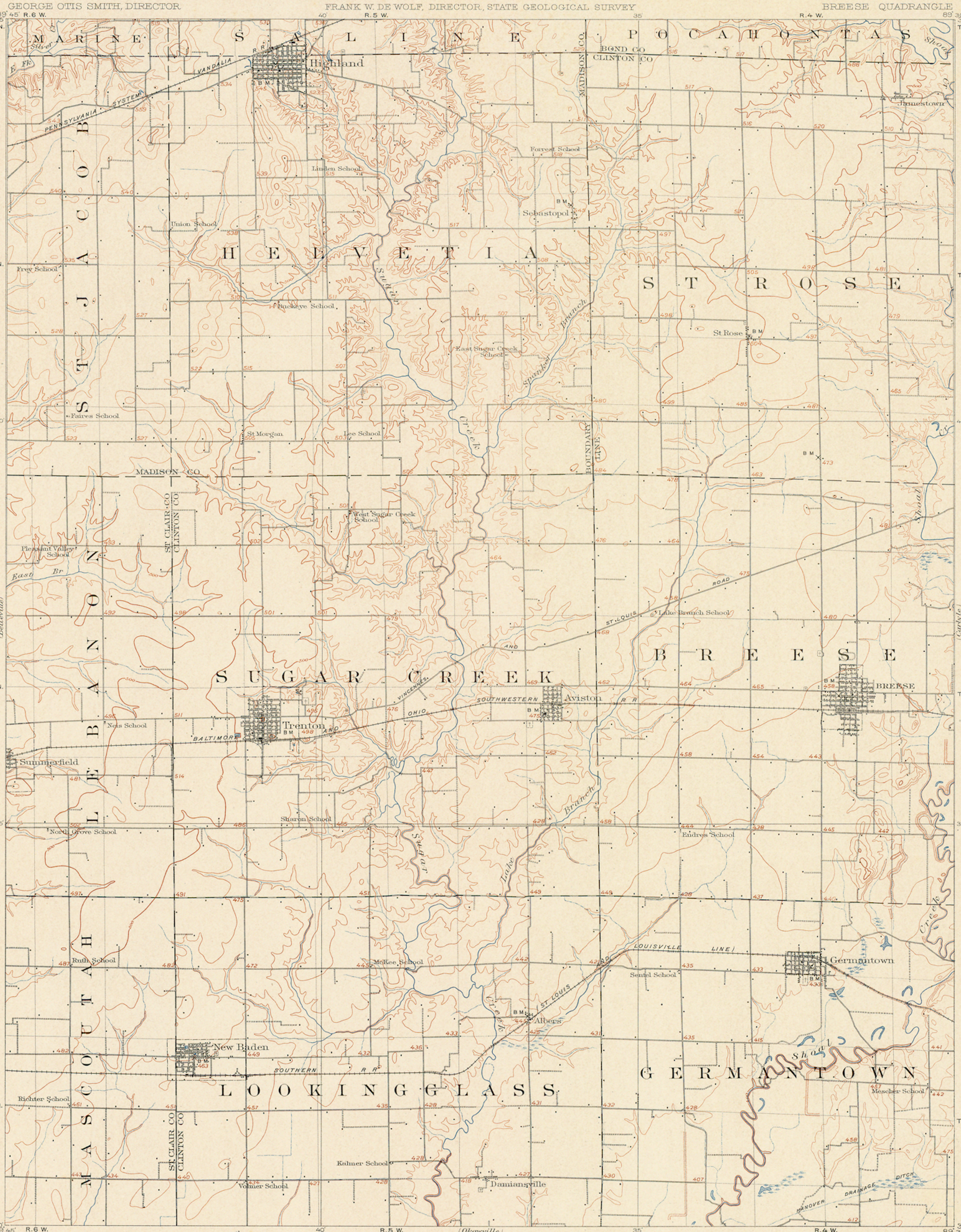
ILLINOIS
BREESE QUADRANGLE



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

Levee

DRAINAGE
printed in blue

Streams

Intermittent streams

Lake or pond

Marsh

CULTURE
printed in black

Roads and buildings

Church or schoolhouse and cemetery

Private or secondary road

Railroad

Bridges

U.S. section lines

County line

Township line

City, village or borough line

Bench mark

Triangulation stations

H. M. Wilson, Geographer.
W. H. Herron, in charge of section.
Topography by C. L. Sadler.
Control by J. R. Ellis.
Surveyed in 1906.

SURVEYED IN COOPERATION WITH THE STATE OF ILLINOIS.

APPROXIMATE MEAN DECLINATION 1906.

Scale 1/62500

Contour interval 20 feet.
Datum is mean sea level.

Edition of Nov. 1907, reprinted with corrections Jan. 1913.

AREAL GEOLOGY

U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

STATE OF ILLINOIS
GOVERNOR C.S. DENEEN, T.C. CHAMBERLIN, E.J. JAMES, COMMISSIONERS
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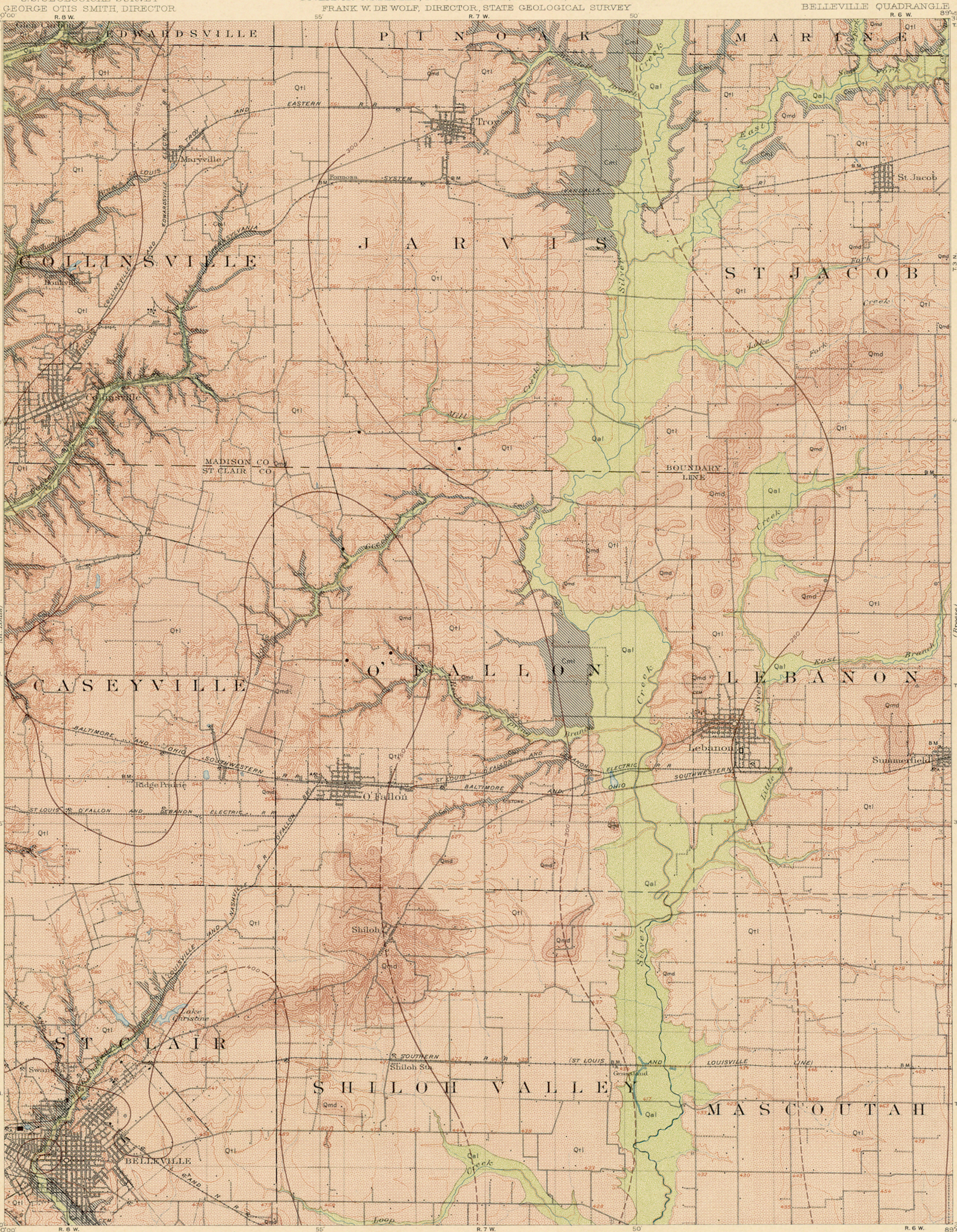
ILLINOIS
BELLEVILLE QUADRANGLE



LEGEND

SEDIMENTARY ROCKS

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

QUATERNARY

Pleistocene — Recent

Qal — **Alluvium** *(in flood plains of present streams; upper part generally fine silt, lower part sandy or gravelly)*

Pleistocene — Illinoian stage

Qtl — **Glacial till overlain by loess** *(gravelly and sandy clay generally overlain by buff to gray loess; near the larger streams the material is partly sorted by water)*

Qmd — **Morainal drift** *(hills of gravelly and sandy clay with some lenses of clean sand and gravel, mantled with loess)*

CARBONIFEROUS

Pennsylvanian

Cml — **McLeansboro formation** *(generally soft shale and sandstone with some limestone and thin beds of coal; underlies all Quaternary deposits in the quadrangle)*

ECONOMIC AND STRUCTURE DATA

Structure contours on the base of Herrin (No.6) coal *(doubtful position of coal indicated by dashed lines; contour interval, 50 feet; datum, mean sea level)*

Coal mines
Abandoned coal mines
Coal test borings
Deep wells
Clay pits
STONE *Quarries*

Note: *The most valuable coal, Herrin (No.6) at the top of the Carbondale formation, lies 50 to 200 feet below the surface; other coals occur in the Carbondale and McLeansboro formations; shale for brick and tile, and limestone for cement materials and building stone occur in the McLeansboro formation; loess and glacial till yield clay for brick and tile; alluvium and morainal drift locally carry sand and gravel. The Herrin coal is known in the region of the Belleville and Breese quadrangles as the Belleville bed.*

H.M. Wilson, Geographer.
Chas. E. Cooke, in charge of section.
Topography by W.J. Lloyd and L. Scott Smith.
Control by J.R. Ellis.
Surveyed in 1905.

SURVEYED IN COOPERATION WITH THE STATE OF ILLINOIS.

TRUE NORTH — MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1905.

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 May 1913.

DIAGRAM OF TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Geology by J.A. Udden,
assisted by I.J. Broman.
Surveyed in 1907.

SURVEYED BY THE STATE OF ILLINOIS.

AREAL GEOLOGY

U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR.

STATE OF ILLINOIS
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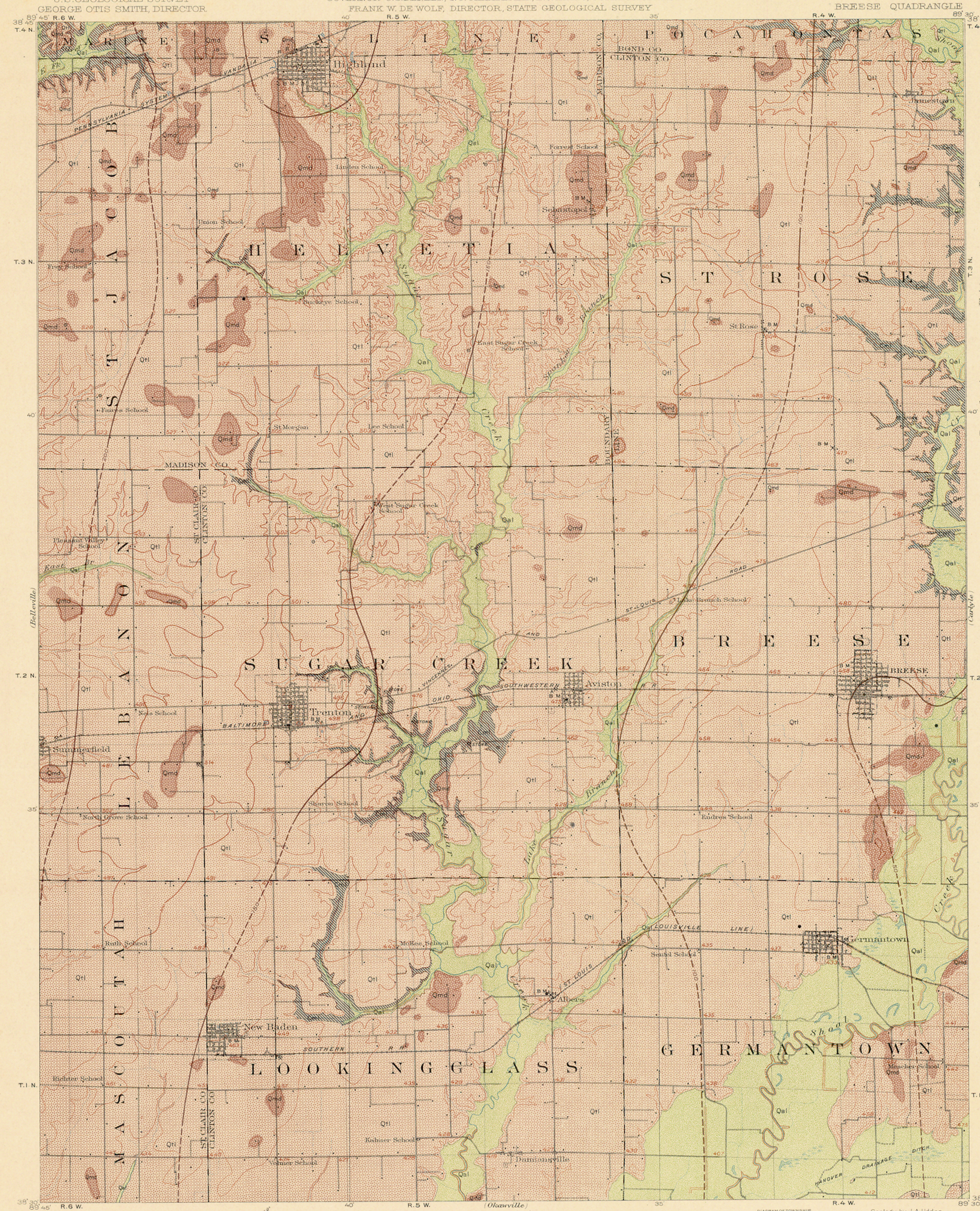
ILLINOIS
BREESE QUADRANGLE



LEGEND

SEDIMENTARY ROCKS

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

QUATERNARY

Recent

Qal — Alluvium *(in flood plains of present streams; upper part generally fine silt, lower part sandy or gravelly; in lower Sugar Creek and Shoal Creek valleys includes lake and sluggish stream deposits)*

Pleistocene — Illinoian stage

Qtl — Glacial till overlain by loess *(gravelly and sandy clay generally overlain by buff to gray loess; near the larger streams the material is partly sorted by water)*

Qmd — Morainal drift *(hills of gravelly and sandy clay with some lenses of clean sand and gravel, mantled with loess)*

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Cml — McLeansboro formation *(generally soft shale and sandstone with some limestone and thin beds of coal; underlies all Quaternary deposits in the quadrangle)*

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Structure contours on the base of Herrin (No.6) coal (doubtful position of coal indicated by dashed lines; contour interval, 50 feet; datum, mean sea level)

Coal mines
Abandoned coal mines
Coal test borings
Deep wells
STONE *Quarries*

Note: *The most valuable coal, Herrin (No.6) at the top of the Carbondale formation, lies 50 to 400 feet below the surface; other coals occur in the Carbondale and McLeansboro formations; shale for brick and tile, and limestone for cement materials and building stone occur in the McLeansboro formation; loess and glacial till yield clay for brick and tile; alluvium and morainal drift locally carry sand and gravel. The Herrin coal is known in the region of the Belleville and Breese quadrangles as the Belleville bed.*

H.M.Wilson, Geographer.
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Surveyed in 1906.

SURVEYED IN COOPERATION WITH THE STATE OF ILLINOIS.

APPROXIMATE MEAN DECLINATION 1906.

Scale $\frac{1}{62500}$

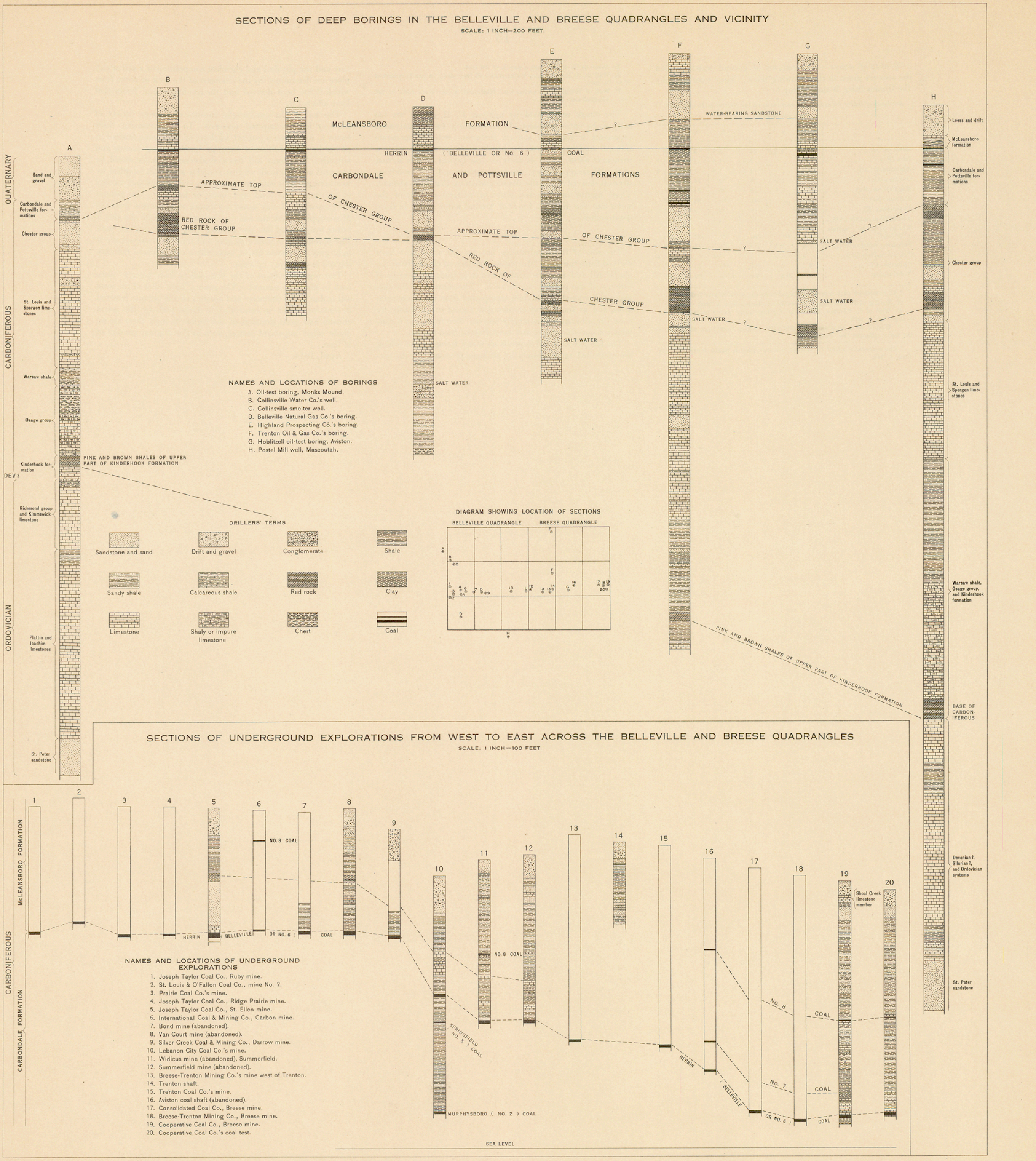
Contour interval 20 feet.
Datum is mean sea level.

Edition of May 1913.

Geology by J.A.Udden,
assisted by I.J.Broman.
Surveyed in 1907.

SURVEYED BY THE STATE OF ILLINOIS.

COLUMNAR SECTIONS



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.

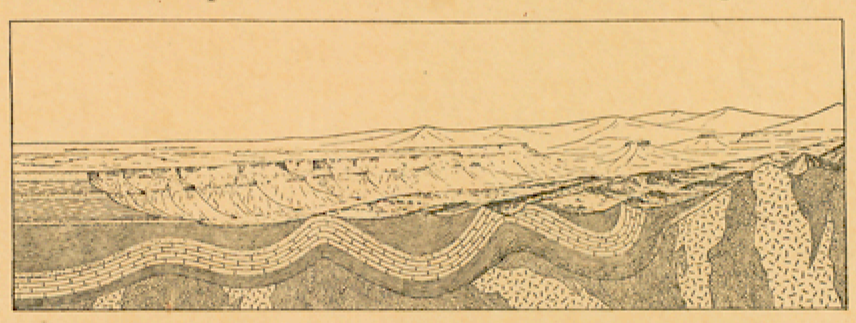


FIGURE 2.—Sketch showing a vertical section at the front and a landscape beyond.

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.

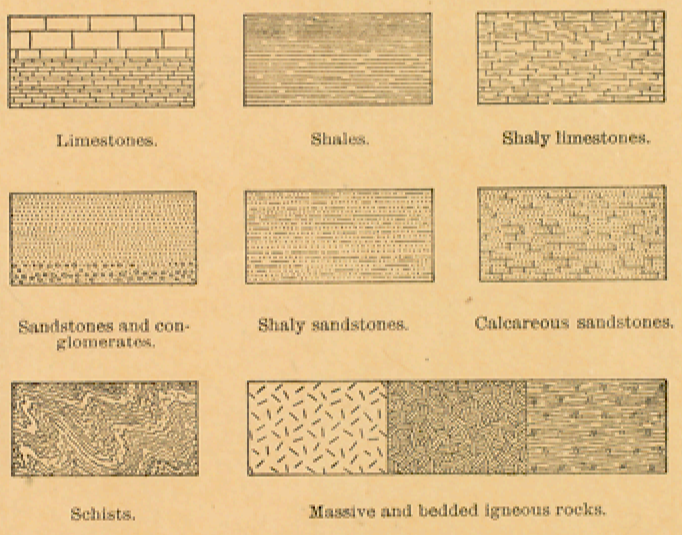


FIGURE 3.—Symbols used in sections to represent different kinds of rocks.

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.

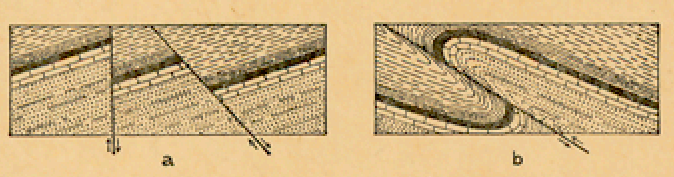


FIGURE 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* or *reverse* fault.

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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‡19	Stevenson	Ala.-Ga.-Tenn		117	Casselton-Fargo	North Dakota-Minnesota	5
20	Cleveland	Tennessee	5	118	Greeneville	Tennessee-North Carolina	5
‡21	Pikeville	Tennessee		119	Fayetteville	Arkansas-Missouri	5
‡22	McMinnville	Tennessee		120	Silverton	Colorado	5
23	Nomini	Maryland-Virginia	5	121	Waynesburg	Pennsylvania	5
24	Three Forks	Montana	5	122	Tahlequah	Oklahoma (Ind. T.)	5
‡25	Loudon	Tennessee		123	Elders Ridge	Pennsylvania	5
‡26	Pocahontas	Virginia-West Virginia		124	Mount Mitchell	North Carolina-Tennessee	5
‡27	Morristown	Tennessee		‡125	Rural Valley	Pennsylvania	
‡28	Piedmont	West Virginia-Maryland		126	Bradshaw Mountains	Arizona	5
‡29	Nevada City Special	California		‡127	Sundance	Wyoming-South Dakota	
‡30	Yellowstone National Park	Wyoming		128	Aladdin	Wyo.-S. Dak.-Mont	5
‡31	Pyramid Peak	California		‡129	Clifton	Arizona	
‡32	Franklin	West Virginia-Virginia		‡130	Rico	Colorado	5
‡33	Briceville	Tennessee		131	Needle Mountains	Colorado	5
‡34	Buckhannon	West Virginia		132	Muscogee	Oklahoma (Ind. T.)	5
‡35	Gadsden	Alabama		133	Ebensburg	Pennsylvania	5
36	Pueblo	Colorado	5	134	Beaver	Pennsylvania	5
‡37	Downieville	California		135	Nepesta	Colorado	5
‡38	Butte Special	Montana		136	St. Marys	Maryland-Virginia	5
‡39	Truckee	California		137	Dover	Del.-Md.-N. J	5
‡40	Wartburg	Tennessee		‡138	Redding	California	
‡41	Sonora	California		139	Snoqualmie	Washington	5
42	Nueces	Texas	5	140	Milwaukee Special	Wisconsin	5
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‡44	Tazewell	Virginia-West Virginia		‡142	Cloud Peak-Fort McKinney	Wyoming	
‡45	Boise	Idaho		143	Nantahala	North Carolina-Tennessee	5
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47	London	Kentucky	5	‡145	Lancaster-Mineral Point	Wisconsin-Iowa-Illinois	
‡48	Tenmile District Special	Colorado		146	Rogersville	Pennsylvania	5
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53	Standingstone	Tennessee	5	‡151	Roan Mountain	Tennessee-North Carolina	
‡54	Tacoma	Washington		152	Patuxent	Md.-D. C	5
‡55	Fort Benton	Montana		153	Ouray	Colorado	5
‡56	Little Belt Mountains	Montana		‡154	Winslow	Ark.-Okla. (Ind. T.)	
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58	Elmoro	Colorado	5	156	Elk Point	S. Dak.-Nebr.-Iowa	5
‡59	Bristol	Virginia-Tennessee		‡157	Passaic	New Jersey-New York	
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61	Monterey	Virginia-West Virginia	5	159	Independence	Kansas	5
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‡63	Mother Lode District	California		161	Franklin Furnace	New Jersey	5
64	Uvalde	Texas	5	‡162	Philadelphia	Pa.-N. J.-Del	
65	Tintic Special	Utah	5	‡163	Santa Cruz	California	
‡66	Colfax	California		164	Belle Fourche	South Dakota	5
67	Danville	Illinois-Indiana	5	165	Aberdeen-Redfield	South Dakota	5
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69	Huntington	West Virginia-Ohio	5	167	Trenton	New Jersey-Pennsylvania	5
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76	Austin	Texas	5	174	Johnstown	Pennsylvania	5
77	Raleigh	West Virginia	5	175	Birmingham	Alabama	5
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* Order by number.
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‡ These folios are out of stock.
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§ These folios are also published in octavo form at 50 cents each, except No. 193 which is 75 cents.

Owing to a fire in the Geological Survey building the folios in stock were slightly damaged, but those that were saved are usable and will be sold at 5 cents each. They are priced accordingly in the list above. Circulars showing the location of the area covered by any of the above folios, as well as information concerning topographic maps and other publications of the Geological Survey, may be had on application to the Director, United States Geological Survey, Washington, D. C.