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

GEOLOGIC ATLAS
OF THE
UNITED STATES

MURPHYSBORO-HERRIN FOLIO
ILLINOIS

BY

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SURVEYED IN COOPERATION WITH
THE GEOLOGICAL SURVEY OF ILLINOIS

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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.

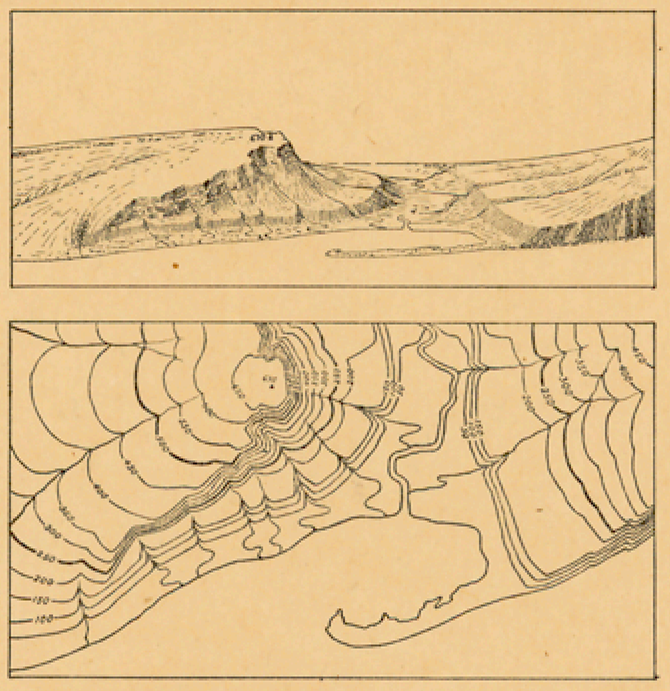


FIGURE 1.—Ideal view and corresponding contour map.

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 MURPHYSBORO AND HERRIN QUADRANGLES.[a]

By E. W. Shaw and T. E. Savage.

INTRODUCTION.

LOCATION AND AREA.

The Murphysboro and Herrin quadrangles cover about 471 square miles in southwestern Illinois. (See fig. 1.) They are bounded by parallels 37° 45' and 38° and meridians 89° and 89° 30', comprising parts of Williamson, Jackson, Franklin, and Perry counties. Duquoin and Carbondale lie not far beyond the boundaries of the quadrangles.

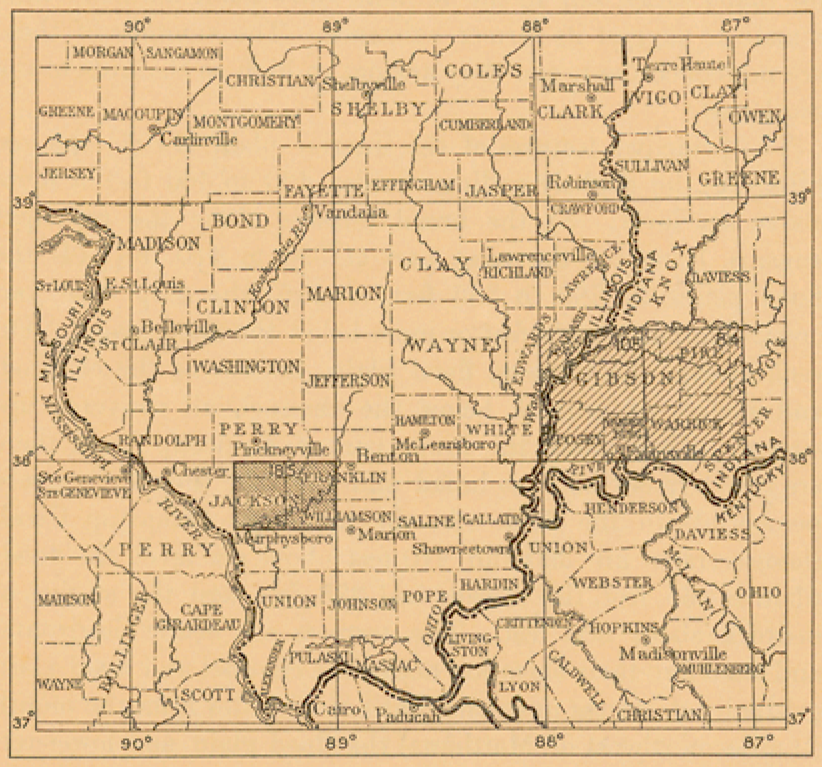


FIGURE 1.—Index map of southern Illinois and portions of adjacent States.
The location of the Murphysboro and Herrin quadrangles (No. 185) is shown by the darker ruling. Published folios describing other quadrangles, indicated by lighter ruling, are the following: No. 84, Ditney; No. 105, Patoka.

GEOGRAPHY AND GEOLOGY OF THE REGION.

PHYSIOGRAPHIC PROVINCES.

The greater part of southern Illinois, in which these quadrangles are situated, forms a portion of the Glaciated Plains, which occupy most of the upper Mississippi basin. Near the southern end of the State, along the Mississippi and Ohio, is a more elevated area, which is a part of the Ozark province, and at the extreme southern end is the margin of the Gulf Coastal Plain. Not far away to the southeast is the Appalachian province. (See fig. 2.) Each of these provinces has its own peculiar characteristics, and the events and conditions in each have had an important relation to events and conditions in the Murphysboro-Herrin area.

GLACIATED PLAINS.

Definition.—The lowland of southern Illinois is part of a great region of rolling plains which was subdivided by Powell into two provinces, to which he gave the names Lake Plains and Prairie Plains. These names, however, have no genetic significance, and as the history of the two regions has been very similar it seems better to regard them as constituting together a single physiographic province. As this province has been extensively modeled by glaciation and as there are no other extensive glaciated plains in the United States, it may be called the Glaciated Plains. (See fig. 2.)

The Glaciated Plains include most of the Mississippi Valley north of Ohio and Missouri rivers. They are bordered on the east and southeast by the Appalachian province, the northern part of which was also glaciated, and on the south by the Gulf Plain and the Ozark Plateau. On the west they merge into the Great Plains.

Relief.—The Glaciated Plains from a region of low relief. In southern Illinois the surface is low and smooth, much of it lying from 350 to 450 feet above sea level. The general altitude rises toward the north, reaching about 600 feet in the central part and 1000 feet in the northern part of the State. In northern Wisconsin the upland reaches 2000 feet above sea. Toward the northwest also the altitude increases considerably.

Although it is generally level the province presents a varied topography. In large part it consists of an old plain of erosion, which was reduced nearly to base-level in Tertiary time, but it includes also remnants of still older surfaces, which form the tops of the high hills in northwestern and southern Illinois.

During the Pleistocene epoch extensive ice sheets moved southward over the region, grinding down the more abrupt elevations and filling up the valleys. Except the Driftless Area, in northeastern Iowa, southeastern Minnesota, and southwestern Wisconsin, the entire province was glaciated, and the larger part of it became a great drift plain. Parts of it were not covered by the later ice sheets and such parts have been much more dissected than those more recently glaciated. On the whole, the areas that were covered by the later ice sheets are gently rolling, whereas those covered by the older drift sheets, especially the parts adjacent to the larger streams, are much dissected.

Drainage.—The Glaciated Plains lie within and include most of the upper Mississippi and Great Lakes or St. Lawrence basins, though the western tributaries of the Missouri, the southern tributaries of the Ohio, and the streams flowing into Lake Ontario and the lower St. Lawrence drain parts of adjacent provinces. The western, central, and southern parts of the province are drained by the Mississippi and its tributaries, the northern and eastern parts by streams of the St. Lawrence system. The divide between these drainage basins is very irregular and indefinite and is so low as to be scarcely perceptible.

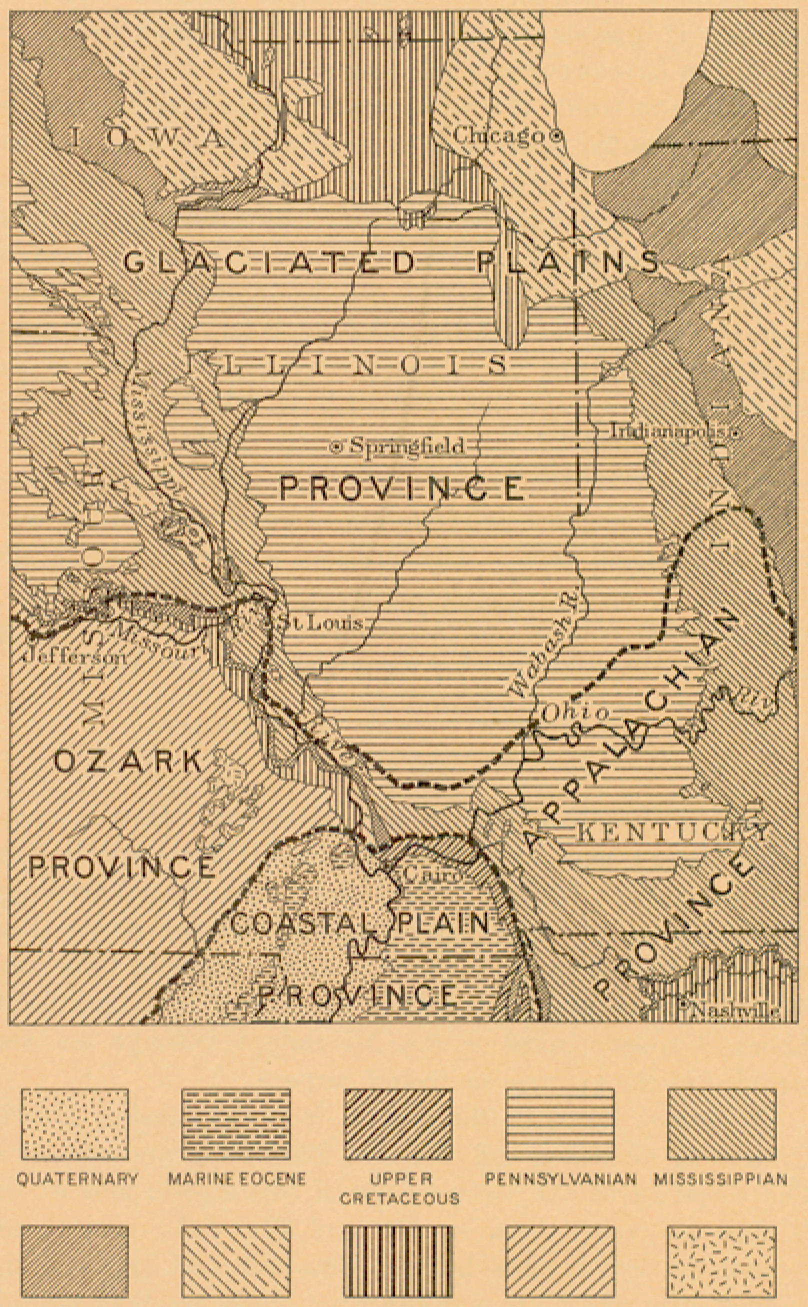


FIGURE 2.—Geologic sketch map of Illinois and surrounding region.
Shows also physiographic provinces of the region. The indefinite boundary between the Ozark and Appalachian provinces coincides approximately with the southeast boundary of Illinois. Map copied from Geologic Map of North America, U. S. Geol. Survey, 1911.

That part of the province which was not covered by the later ice sheets is fairly well drained, but it contains swampy tracts, some of which are extensive. The streams have irregular courses and lakes are numerous. The poor drainage is due to the successive invasions of ice, which during its presence blocked many drainage lines and on melting left superposed sheets of débris that in places are several hundred feet thick and that fill many of the old valleys. In the areas over which the greater thicknesses were deposited the drainage was considerably changed and the streams are only slowly regaining a more normal condition. In the belt at the west and south, which was covered by the earlier but not by the later glaciers, the streams have become almost readjusted, but throughout most of the province they have irregular courses and profiles, and the drainage systems have little symmetry.

Vegetation.—The Glaciated Plains include most of the great prairie region of the United States, in which the annual precipitation ranges from 20 to 40 inches. This abundant rainfall and a fertile soil furnish conditions favorable for luxuriant vegetation. Before the advent of the white settler the interstream areas were each year covered with a rank growth of grasses and other herbaceous plants, which were burned off from time to time. The slopes bordering the streams were covered by a thin and stony clay soil and were generally forested. In the northern part of the province the original forest covered most of the surface.

Resources.—The Glaciated Plains are preeminently agricultural, for they include the great corn belt, which furnishes the larger part of the corn raised in the United States. They also contain, however, important oil, coal, lead, and zinc producing areas.

OZARK PROVINCE.

The Ozark province lies south of the Glaciated Plains. It embraces most of the southern half of Missouri (except a belt of lowland bordering the Mississippi south of Cape Girardeau), the northwestern half of Arkansas, a small area in southeastern Kansas, and the eastern fourth of Oklahoma, a total area of about 100,000 square miles. In southern Illinois the uplift of the Ozark Plateau involved a considerable area lying between Chester and Cairo and having an eastward extension in the belt of hills known as Karbers Ridge or Shawneetown Hills.

Topographically and geologically the Ozark province is divided by Arkansas River into two parts—the Ozark Plateau and the Ouachita Mountains, and these parts are similar to the western and central parts of the Appalachian province. The Ozark Plateau comprises in reality at least two plateaus of different altitudes and extent. The northern and more extensive plateau ranges from 1000 to 1700 feet above sea level; the southern, known as the Boston Mountains, reaches a maximum altitude of 2200 feet. Toward the north and west the surface falls away in long and gentle slopes, but toward the south both the surface and underlying strata slope rather steeply.

The St. Francis Mountains, near the east side of the plateau, about 45 miles from the Mississippi, form the structural center of the Ozark Plateau. These mountains consist of Pilot Knob, Iron Mountain, Shepard Mountain, and a number of other peaks of crystalline rock rising 500 to 800 feet above the surrounding valleys and 1200 to 1700 feet above sea level. The highest part of the lower plateau forms the divide between Missouri and White rivers, extending from the St. Francis Mountains westward to Springfield, Mo., and thence southwestward to Fayetteville, Ark. Around the borders of the uplift the strata incline outward with dips somewhat greater than those of the surface slopes. In places the divides between the streams rise to a uniform elevation and their tops appear to represent a peneplain.

GULF PLAIN.

The Gulf Plain is continuous with the Atlantic Coastal Plain and forms part of the Coastal Plain province. It comprises a great area of lowland bordering the Gulf of Mexico from the Florida peninsula west and south into Mexico and extending inland to the uplands of the Appalachian, Ozark, and Great Plains provinces. Its northern limit in the Mississippi Valley is approximately the southern boundary of the Glaciated Plains.

The Gulf Plain on the whole slopes regularly toward the Gulf from an altitude of about 500 feet at its inner margin to sea level along the coast. It is dissected by shallow valleys having broad flood plains and commonly one or more low terraces. The slope continues beneath the Gulf to the edge of the continental shelf, about 100 miles distant and 200 to 400 feet below sea level.

The deposits underlying the Gulf Plain are gravel, sand, and clay of Cretaceous, Tertiary, and Quaternary age, deposited upon a submerged floor of Paleozoic rocks which had been deformed, uplifted, and rather uniformly reduced to a gentle slope by early Mesozoic erosion. They are chiefly of marine origin and show that in comparatively late geologic time the Gulf extended almost if not quite into southern Illinois. The post-Paleozoic strata now lie nearly parallel to the general surface but have a somewhat greater slope Gulfward, so that the

[a] Surveyed in cooperation with Illinois State Geological Survey.

older formations outcrop nearer the inner margin and progressively younger ones appear in concentric bands nearer the coast. Around the Mississippi embayment the post-Paleozoic strata dip from the marginal uplands toward the river, thus giving to this part of the province a spoon-shaped structure.

The Gulf Plain comprises four subdivisions, of which only one, the Mississippi flood plain, bears any close relationship to the Murphysboro-Herrin district. The flood plain is underlain by sand and silt of Quaternary age and is continuous with the narrow bottom lands of the Mississippi above Cairo. Along the western side of Illinois it is generally from 3 to 5 miles wide, but near the southern end of the State it widens and from Cairo to the Gulf has an average width of about 20 miles. Its nearly smooth surface is from 30 to 50 feet above low water, and it is bordered by one or more terraces a few feet higher.

APPALACHIAN PROVINCE.

Southeast of the Glaciated Plains is the Appalachian province, many of the topographic and geologic features of which are similar to those of the Ozark province, though others are quite different. Topographically and geologically the province is divided into two nearly equal parts by the Allegheny Front Range and by the eastern scarp of the Cumberland Plateau. The western part is the more or less dissected Appalachian Plateau; the eastern part comprises a wide belt of valleys and ridges called the Appalachian Valley, bordered on the east by the Appalachian Mountains. The rocks range in age from Archean to Permian. Immediately west of the Allegheny Front the strata are only slightly folded and still farther west they are nearly horizontal, whereas eastward from the Allegheny Front they are progressively more and more folded and metamorphosed.

STRATIGRAPHY AND STRUCTURE.

The indurated rocks of the central Mississippi basin range in age from Archean to Permian and are almost wholly sedimentary (see fig. 2, p. 1), though a small area of pre-Cambrian granite and porphyry forms the St. Francis Mountains of southeastern Missouri.

In the northern part of the Mississippi basin the oldest Paleozoic rocks outcrop around the southern border of the pre-Cambrian highland and dip southward with an inclination greater than the slope of the surface, successively younger formations outcropping in rudely concentric bands. In the Ozark region also the older Paleozoic formations outcrop in concentric bands about the Archean area of the St. Francis Mountains, each formation being exposed in a much wider belt on the west side of the mountains than on the east.

Throughout most of the central Mississippi basin the strata lie nearly horizontal. Where not affected by local deformation the Paleozoic strata in northern Illinois dip gently southward and in Iowa and southeastern Minnesota they slope gradually southwestward. In many places they have been more or less disturbed, so that they dip in different directions and at different angles in different parts of the region.

In the eastern part of the region a broad, low arch in the strata extends southeastward across Indiana, from Chicago to Cincinnati. This is the northern end of the Cincinnati anticline, which has been an important factor in the geologic history of the region since late Ordovician time. Beyond Cincinnati this arch extends uninterruptedly southwestward past Nashville and merges into the Appalachian uplift.

Another important structural feature of the region is the La Salle anticline, which crosses eastern Illinois essentially parallel to the Cincinnati arch. It is most prominent at the north, in the vicinity of Oregon and La Salle, where Ordovician strata are exposed at the surface, and it becomes less conspicuous toward the southeast, where the drift cover is deeper. Southeast of Princeton, Ind., it fades out or is connected with the anticline forming the Shawneetown Hills, which, as a spur of the Ozark uplift, extend east and west across the southern end of Illinois. For 50 miles north from this ridge the strata dip northward, at 30 to 40 feet to the mile, to the center of the basin, beyond which they rise gradually and almost continuously for 400 miles to central Wisconsin.

Besides these main structural features, the strata are everywhere bent into low folds, here and there broken by small faults, the latter being more common in the southern part of the region, especially near the borders of the Ozark uplift. Many of the folds and faults are probably of late Carboniferous age, but some of the deformation took place earlier in the Paleozoic and some no doubt at later times.

GEOLOGIC HISTORY.

Near the beginning of the Paleozoic era the whole central Mississippi basin outside of the Archean land areas was occupied by the interior Paleozoic sea, and the earlier Paleozoic strata were widely spread over the sea bottom. This sea may have continued to occupy some part of the region throughout the era, but owing to local warping and to oscillations of the relative level of the sea and land, its shape and size varied considerably. At times it was contracted into several basins; at other times, owing to general subsidence, one large sea again overspread the greater part of the region. Early in the era the central part of the dome now forming the Cincinnati anticline was sufficiently elevated to bring it in large part above water, where it probably remained continuously as an island until the final withdrawal of the sea. As the Paleozoic sea did not continuously cover any portion of this region, the Paleozoic sediments are not found in their total thickness in any one place and the successive formations, series, and systems show local differences. Numerous more or less extensive unconformities occur, and some formations locally far overlap those underlying them; hence in some sections a considerable thickness of strata is not represented.

In the Pennsylvanian epoch the sea was very shallow and at times it withdrew almost entirely from the region, and land or estuarine and tide marsh conditions prevailed. Small oscillations of coast line were frequent, resulting in the formation of alternating marine and fluviatile deposits, with numerous local unconformities.

During the Permian epoch an arm of the sea which lay west of the Ozark province may have extended into central Iowa. An old stream deposit exposed in the bank of Vermilion River near Oakwood, Ill., contains remains of some of the oldest Permian land reptiles so far found in this country and is thought to have been formed at that time.

These conditions were brought to a close by a widespread uplift, extending over eastern North America, which resulted in the permanent withdrawal of the sea from nearly the whole region. Only an area in the southwestern part remained submerged until the close of the Permian epoch, and was in part again occupied in Cretaceous time. The uplift was accompanied by intense folding and faulting in the Appalachian Mountains, by the principal uplift of the Ozark dome, and by folding and faulting around the margins of the smaller disturbed areas. The jointing and faulting in the fluorspar district of southern Illinois and northwestern Kentucky, and the intrusion of igneous dikes there and in the Ozark region are believed to have occurred at that time.

During the whole of the Mesozoic and Cenozoic eras the central Mississippi basin has remained above sea level and has been subjected to erosion. It is believed that the entire region was a peneplain during the Mesozoic. As a result of the slight but general uplift which closed that era, erosion was revived and a large part of the surface was again reduced to a peneplain in Tertiary time. After this peneplanation another uplift enabled the streams to entrench themselves in valleys cut 100 feet or more below their present level. During Pleistocene time a succession of ice sheets moved southward over the northern part of the region, grinding down elevations and filling up depressions and tending to bring the surface once more to a general level. The presence of the ice sheets and the great quantities of material transported by them greatly disturbed the courses and adjustment of the streams of the region, and they have not yet recovered from the effects.

TOPOGRAPHY OF THE QUADRANGLES.

RELIEF.

General features.—The Murphysboro and Herrin quadrangles lie in part within the Glaciated Plains and in part within the Ozark Plateau. The line between the two provinces is rather sharply marked in the quadrangles, separating them into two principal parts—a belt of maturely dissected hills lying to the southwest and a low rolling plain lying to the northeast. About 3 square miles of the Mississippi bottoms are also included in the extreme southwest corner.

The lowest point in the area is in the channel of Muddy River near Grimsby, and is about 330 feet above sea level. The elevation of the bottom land of this stream and of the Mississippi ranges between 350 and 380 feet; most of the interior flat country lies between 380 and 420 feet; and the highest hills, which are near the river bluffs, reach an altitude of about 750 feet. The topography is peculiar in that the upland surface has a general slope away from the master stream, the Mississippi.

Hilly country.—The hills are known locally as the Ozarks, a term that seems appropriate, as they were formed primarily by the Ozark uplift. Their summits are rounded or flat, are roughly concordant in elevation, and become lower toward the east. The hilly country thus appears to be an eastward-sloping, uplifted, and maturely dissected plain. The part that geologic structure has played in controlling this slope has probably been considerable, for much of the underlying rock is resistant sandstone, and the present surface slopes in the same direction and at about the same rate as the rock strata. The hilly area also coincides closely with the area in which part or all of the resistant Pottsville sandstone is above drainage level.

Much soft shale is interbedded with the sandstone, and the shapes of the hills and valleys show a notable relation to the resistance of the various rocks composing them. Hills composed of sandstone overlying shale have broad, flat or conical tops, with steep or vertical upper slopes, and with gentle lower slopes, which are commonly strewn with sandstone blocks that have rolled down from above. Hills of shale overlying sandstone have rounded summits, with more or less cliff-like basal slopes. Hills of alternating soft and hard rock have a less clear but commonly perceptible expression. All the hilltops except a few in the southwest corner of the area and many hillsides are covered with a deposit of glacial till and loess, which tends to make all the summits rounded and smooth.

Interior lowlands.—The interior lowland is more or less deeply covered with unconsolidated material, which attains in some places a thickness of 100 feet or more and obscures the slight irregularities of the underlying rock. Several rock hills, however, rise a few score of feet above the general flat surface. One of these is 2 miles north of Vergennes and another bears the village of Old Duquoin; others are in the southern part of the Herrin quadrangle. These low hills are composed of sandstone, which is more resistant than the soft shale underlying the other parts of the lowland though much less resistant than the Pottsville sandstone of the higher hills.

Presumably, the elevated plain indicated by the hilltops in the southwest part of the area once extended east and north for many miles, but in the lowland only small scattered hills remain to suggest its former existence. The summits of these are not concordant, and they are not so high as the hills to the southwest.

The principal features of the interior plain are (1) the low hills; (2) the slightly rolling divides, 420 to 460 feet or more above sea level; (3) the broad terraces along the principal streams, lying for the most part at 390 to 410 feet; (4) the flood plains, at 360 to 385 feet; and (5) the deep river and creek channels cut 20 feet or more below the flood plains. On each stream the terraces, flood plain, bottom of the channel, and surface of bedrock below the channel, all converge upstream. Thus along the lower part of Beaucoup Creek there are two terraces both so broad and low that they are scarcely perceptible in the field. At the mouth of Beaucoup Creek these terraces are 390 and 410 feet above sea level, the flood-plain is 365 feet, the stream bed 338 feet, and the surface of bedrock about 300 feet. The terraces are nearly horizontal and therefore their elevation above the channel and flood plain gradually decreases upstream, until at 23 miles from the mouth (2 miles northeast of Matthews) the flood plain and lower terrace merge into a surface about 395 feet above sea level and bedrock outcrops in the shallow channel. The valleys of Muddy and Little Muddy rivers and their principal tributaries are similar to Beaucoup Valley.

The terraces are the upper surfaces of valley fills which attain a maximum thickness of about 110 feet along the lower courses of the rivers. The material forming the upper terrace is generally sandy and loose, whereas that forming the lower is for the most part a greenish or purplish gray calcareous clay. Murphysboro is situated on the upper terrace, on a fill fully 110 feet thick. Herrin also stands on this sandy and well-drained material.

The terraces seem to have been formed by the deposition of material by temporarily obstructed streams, that once emptied into the Mississippi at a level considerably below that of their present channels. When the Mississippi, overloaded with glacial débris, began to build up its bed, it dammed the mouths of the tributary streams and caused them to silt up the lower ends of their valleys with more or less sandy clay. After the deposit had attained a thickness of more than 100 feet, and perhaps after an intermediate time of cutting and refilling, the streams were again able to carry their loads and to deepen their valleys, leaving terraces above the reach of high water. (See also pp. 12 and 13.)

Mississippi Valley.—In this region the Mississippi bottom is 5 to 7 miles wide and is generally flat but is seamed by numerous long, shallow, abandoned river channels, which trend more or less parallel to the river and give the surface a somewhat fluted appearance. Most of the bottom land lies from 350 to 365 feet above sea level, but toward the valley side the surface gradually rises to 380 to 390 feet. Though there is no perceptible terrace the higher part of the bottom land may correspond to one of the terraces on the Muddy and its tributaries. The depressions formerly contained water for at least a part of the year, and many of them were perennial lakes, but they have now been drained artificially and converted into fertile farms.

The sides of the valley are high bluffs and are almost continuous, being only here and there cut by a tributary valley.

Minor topographic features.—Almost all the area was covered at least once by a great ice sheet which left a continuous mantle of débris but did not greatly modify the surface configuration. Here and there throughout both quadrangles slight irregularities in the thickness and in the configuration of the upper surface of the till are apparent, but on the whole the mantle of partly ground rock left by the glacier was nearly uniform in thickness over hill and lowland. The ice, which in this region reached its southernmost limit, seems soon to have melted. This region thus differs from the central and northern parts of the State, which were subjected to the erosion of moving ice for a much longer time and which received thick deposits from an oscillating ice front.

Loess flats, so called, are most striking in the rough country, where they form the tops of the hills. The loess tends to smooth over the irregularities of the surface upon which it was deposited, and though it has been subjected to much erosion it remains in considerable amounts on the divides, giving them a smooth or gently undulating surface.

Rainwash aprons border the hills rising from the level country. The surfaces of the aprons are slightly concave and are smooth except where they have been eroded.

Several small areas of prairie, with low, flat, but comparatively well-drained surfaces, are found in the region. Although their outlines do not conform either to surface contours or to geologic boundaries, geologic conditions seem to have had some bearing on their development. No prairies exist in the dissected rough country, on poorly drained parts of the terraces, or in the bottom lands. Even the lowest hills are wooded.

DRAINAGE.

Streams.—The run-off of the Murphysboro and Herrin quadrangles reaches the Mississippi through Muddy River, which enters the area near the northeast corner and follows a very irregular course southwest and west. Its average discharge at Murphysboro is about 1500 second-feet from a drainage basin comprising about 2250 square miles, the run-off per square mile being therefore 0.06 to 0.07 second-foot.

The water of the Muddy accords with the name of the stream. The amount of sediment and dissolved mineral matter which it annually carries has been estimated at 630,000 tons, or 268 tons for each square mile of its drainage basin. This estimate indicates that the surface of the basin as a whole is being lowered by erosion at a rate of an inch in 720 years. For comparison it may be stated that the Mississippi carries to the Gulf annually about 476,500,000 tons of material in solution and suspension, or 377 tons from each square mile of its drainage basin, and that its drainage basin is being lowered by erosion at the rate of an inch in about 500 years.

In the Murphysboro quadrangle Muddy River has only two important tributaries, Beaucoup and Kinkaid creeks. The former receives Galum, Rattlesnake, Camp, and Pond creeks. In the Herrin quadrangle Muddy River receives three streams from the north—Little Muddy River (a large southward-flowing stream that collects the waters of Reese and Sixmile creeks) Prairie Creek, and Andy Creek—and three from the south—Craborchard, Hurricane, and Pond creeks. Of these streams Little Muddy River is considerably the largest.

The principal streams are similar in profile and in certain other significant characters. Each is naturally separable into three longitudinal divisions. Beaucoup Creek, for example, rises in Washington County at an altitude of 535 feet, flows southward through Perry County, and discharges into Muddy River near the middle of Jackson County at an altitude of 338 feet. Its total length is thus about 58 miles. In the first 25 miles it falls 135 feet or at an average rate of nearly 5½ feet per mile; in the next 15 miles it falls 46 feet, or about 3 feet per mile; and in the last 18 miles it falls 16 feet, or less than 1 foot per mile, a gradient almost as low as that of the Mississippi, which flows parallel to it and which discharges a volume 500 times as great. In the first division of 25 miles the valley seems normal in all respects and rock outcrops are numerous. In the second division the valley is broader, the bottom is swampy, and the stream flows over an unconsolidated sandy deposit which widens and thickens downstream and is overflowed and built up a little at every time of high water. This deposit forms a flood plain which downstream gradually rises above the reach of high water and forms the broad terraces before described (p. 2). In the third division rock outcrops are absent except where the stream swings to one side of the valley, leaving the terraces on the opposite side. The gradient is very low, the banks are of mud or fine sand, the channel is deep, and the flood plain narrow.

Muddy River rises on the county line between Jefferson and Marion counties at an altitude of about 500 feet, flows southward through Jefferson, Franklin, Williamson, and Jackson counties, and discharges into the Mississippi in the northwest corner of Union County, at a low-water altitude of 325 feet. Its features are similar to those of Beaucoup Creek, except that it has a fourth division lying within the Mississippi bottoms. Its total fall is about 270 feet and its midstream length about 135 miles. In the first 20 miles it falls about 100 feet, or 5 feet per mile; in the next 28 miles it falls 40 feet, or less than 1½ feet per mile; in the third division, extending from the point where the stream crosses the 360-foot contour, near the northeast corner of the Herrin quadrangle, to the point where it enters the Mississippi flood plain, it falls 28 feet in 59 miles, or a little more than 6 inches to the mile; and in the last 28 miles of its course it falls only 7 feet, or 3 inches to the mile. (See fig. 3.) The very low gradient in the lower part of the course is in strong contrast to the gradient of the Mississippi, which flows near by with a fall of fully 7 inches to the mile.

Another striking feature of the streams of this region is the depth of their channels. The large channel of Beaucoup Creek is filled to overflowing several times a year. Measurements were made of the depth and breadth of the stream before and after flood time. At one time the enlargement was from a cross-section area of 9 square feet to one of 2000; at another it was from 7 square feet to 5000. Three miles west of Matthews Galum Creek, a tributary of Beaucoup Creek, is at ordinary stages a sluggish, muddy stream 6 to 8 feet wide and perhaps 6 inches deep, but at high water it rises until it is 10 or even 15 feet deep and spreads over a territory 1½ to 2 miles wide, covering it to an average depth of 6 inches. This great accumulation is due to the low gradients, which are commonly less than 2 feet per mile. When the Mississippi is also swollen the water on the tributaries passes off very slowly, the low gradients causing the high water on the big streams to affect the tributaries a long way from their mouths. The channels are of a size sufficient to accommodate the water to be handled.

Swamps and lakes.—The middle section of each of the principal stream courses is bordered for 2 to 3 miles on each side by more or less swampy land and contains several natural bodies of standing water. One of these, Buster Pond, is 5 miles north of Herrin; the Campbell Lakes are 5 miles northeast of Elkville; and another pond is 4½ miles west of Matthews. Swamps are thus formed where the streams flow at or only a short distance below the surfaces of the terraces or stream deposits. They either submerge these at every recurrence of high water or have so recently ceased doing so that drainage lines have not yet been developed across them. Along the lower parts of the streams the terrace surfaces were formerly swampy, but these have been redissected and the process has been gradually proceeding upstream. The swamps near the mouth of Muddy River were drained before those farther upstream, and those having the shortest outlet were drained first of all. A few swamps, such as that immediately north of Murphysboro, which are not far from the river and which were long ago left above the reach of flood water, have not yet been drained because their line of outlet is so long. The swamp at Murphysboro is 60 feet above low water and within 1½ miles of Muddy River, yet water from it, in order to reach that near-by point in the river, must flow 5 miles north by way of Pond Creek, thence 10 miles southeast by the winding course of Beaucoup Creek, and thence 5 miles down the Muddy, a total of 20 miles. This peculiar course is due to the fact that the swamp was formed on a newly exposed delta whose surface sloped in a direction opposite to that in which Muddy River flowed. The rejuvenated drainage, however, is gradually drawing near the utmost corners of the swamp. All the 20 miles was once swampy but now only the last 1½ miles is unreclaimed.

Former arrangement of drainage.—The waters of the hills first flow away from the Mississippi to the interior lowland, unite in larger streams near the middle of the broad shallow trough, and thence flow out radially through breaks in the rim to the Ohio and Mississippi. This peculiar arrangement of drainage lines seems to suggest either that formerly there was no Mississippi, the streams of the region discharging into some river to the northeast, or else that the course of the Mississippi is inherited from its position on the old plain represented by the hilltops, whereas the tributaries are in large part adjusted to the dip of the strata, to which is probably due the newly developed general northeast slope of the surface.

CULTURE.

The principal towns of the Murphysboro and Herrin quadrangles are Murphysboro, Herrin, and Carterville, each having several thousand inhabitants. The area contains many smaller towns, most of which depend for their prosperity on coal mining, and also numerous farmhouses. Agriculture and mining are the principal industries. Except for the hilly southwestern part of the area, which is largely wooded, most of the surface is under cultivation. About fifty coal mines are in operation, employing several thousand men. Coal mines are especially numerous in the Herrin quadrangle and in the vicinity of Murphysboro. The manufacturing plants are comparatively few, but there are several at Murphysboro and some at the other principal towns of the area.

The coal mines have required the building of several lines of railroad which employ a large number of men. Several trunk lines cross the region and a great many branches and spurs run out to coal mines. Wagon roads are of ordinary abundance; few are macadamized.

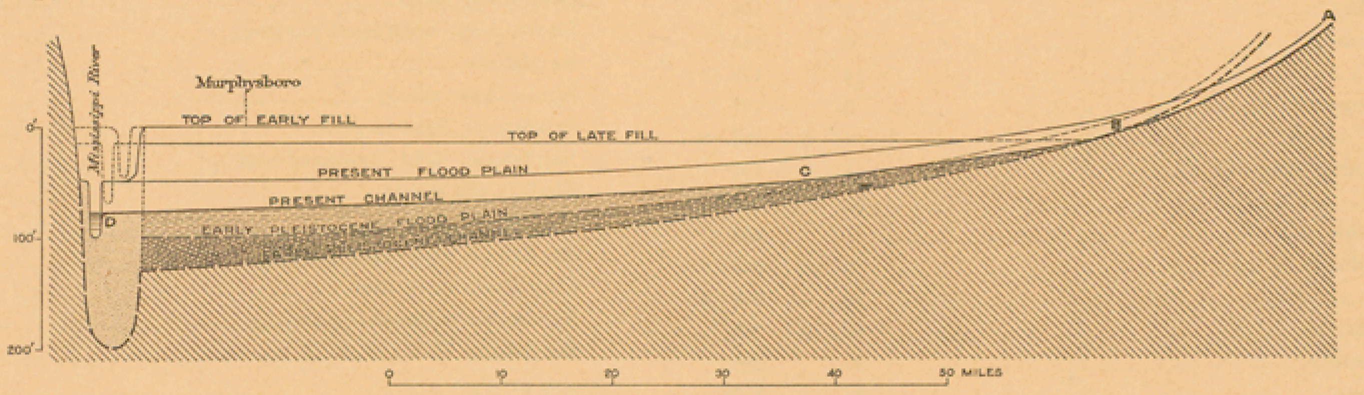


FIGURE 3.—Longitudinal section along Muddy River.

Shows the sediments below the bed of the river, the present flood plain, and terrace levels in the valley sides which represent former levels of valley fills. Bedrock is indicated by the diagonally ruled pattern. The present stream profile reflects the history of the river, the fall from A to B being moderate, from B to C low, and from C to D extremely low.

DESCRIPTIVE GEOLOGY.

STRATIGRAPHY.

GENERAL FEATURES.

The consolidated rocks lying near the surface in the Murphysboro and Herrin quadrangles are of sedimentary origin and consist of shale, sandstone, limestone, and coal belonging to the Carboniferous system. They are almost everywhere mantled by a complex of eolian, glacial, fluvial, and lacustrine deposits, most if not all of which are of Quaternary age. At many points in the hills but at only a few in the lowland this unconsolidated Quaternary material, which in places attains a thickness of 100 feet or more, is absent and bedrock is laid bare. The rocks appearing at the surface are the Birdsville formation, the uppermost formation of the Chester group of the Mississippian series, and the Pottsville, Carbondale, and McLeansboro formations of the Pennsylvanian series. Besides these rocks that are exposed at the surface earlier Mississippian strata underlie the region, as is known from the logs of deep wells, and these are in turn underlain by older rocks—Devonian, Silurian, and Ordovician shales, limestones, and sandstones, which outcrop in places along the river bluffs, outside the quadrangles. The oldest rocks in southern Illinois are exposed in Alexander County, 40 miles south of Murphysboro, where a limestone of Trenton age appears at the surface. This limestone lies 2500 to 3000 feet below the coal worked at Murphysboro. Still lower, probably Cambrian limestone and sandstone rest on pre-Cambrian metamorphic or igneous formations that outcrop in Missouri 50 miles west of Murphysboro.

System.	Series.	Formation and group.	Section.	Thickness (feet).	Character of rocks.
Carboniferous.	Pennsylvanian.	McLeansboro formation.		550+	Largely bluish clay shale and loosely cemented reddish or buff sandstone, with a few thin lenticular beds of coal and limestone.
		Carbondale formation. (Vergennes sandstone member).		250-300	Dark to light bluish-gray shale and loosely cemented micaceous sandstone, with several beds of limestone and coal.
		Pottsville sandstone.		420-510	Chiefly resistant, somewhat conglomeratic and saccharoidal sandstone in thick layers, separated by lenticular layers of soft shale and thin coal.
		UNCONFORMITY			
	Mississippian.	Chester group. Birdsville formation.		700-800	Limestone ranging from thick-bedded and compact to thin-bedded and soft: shale, generally greenish and soft; and clean sandstone, largely saccharoidal.
		Chester group. Tribune limestone.			
		Chester group. Cypress sandstone.			
		Ste. Genevieve limestone.[a]			
		Meramec group. St. Louis limestone, Spergen limestone, and Warsaw shale.		400-450	Largely hard gray limestone with some shale in lower part.
		Osage group and Kinderhook formation.		250	Cherty limestone with a little shale.
Devonian.					Chiefly limestone, in part dark, argillaceous, and cherty, with some dark shales. (About 1300 feet of limestone encountered in the deepest drill hole represents the Devonian, Silurian, and Ordovician systems.)

FIGURE 4.—Generalized columnar section of the rocks encountered in drilling in the Murphysboro and Herrin quadrangles.

Scale: 1 inch = 500 feet.

[a] Whether the Ste. Genevieve limestone should be included in the Chester group has not been finally determined. (See footnote, p. 5.)

The rocks penetrated by the drill in or near the Murphysboro and Herrin quadrangles are shown in the columnar section (fig. 4) and in the well records given on pages 4 and 5.

Drill record in western part of Herrin quadrangle.

	Thickness. Ft.	in.	Depth. Ft.	in.
Recent and Pleistocene series	26		26	
Pennsylvanian series:				
McLeansboro formation:				
Sandstone	14		40	
Clay shale	16		56	
Coal		2	56	2
Underclay	2	10	59	
Limestone	6		65	
"Slate," blue	6		71	
Coal	2	3	73	3
Underclay	5	9	79	
Shale	9		88	
Coal	1		89	
Underclay	8		97	
Limestone	14	6	111	6
Shale, sandy	22		133	6
Limestone	7	6	141	
Shale	8	6	149	6
Carbondale formation:				
Coal, Herrin (No. 6)	8	6	158	
Underclay	1		159	
Limestone	6		165	
Shale	14		179	
Limestone	3		182	
"Slate," black	4	6	186	6
Coal, Harrisburg (No. 5)	4	6	191	
Shale	58		249	
Limestone	1		250	
Shale, black	3	6	253	6
Coal	2		255	6
Underclay	10	6	266	
Shale, sandy	22		288	
Sandstone	25		313	
Shale	10		323	
Limestone	1		324	
"Slate," black	3		327	
Coal		6	327	6
Underclay	2	6	330	
Shale, sandy	5		335	
Sandstone	23		358	
Shale	24	6	382	6
Coal, Murphysboro (No. 2)?	1	10	384	4
Shale	20	2	404	6
Coal, Murphysboro (No. 2)?	2	3	406	9
Pottsville sandstone:				
Shale, sandy	33	3	440	
Sandstone (No. 7)	34	6	474	6
Coal		6	475	
Shale, sandy	8		483	
Limestone	1	6	484	6
Shale	16	6	501	
Limestone	1		502	
Shale, sandy (No. 6)	37	6	539	6
Coal		6	540	
Underclay	2		542	
Shale	85		627	
Sandstone	17		644	
Shale, sandy	37		681	
Sandstone (No. 5)	99		780	
Shale, sandy	31		811	
Sandstone (Nos. 3 and 4)	14		825	
Sandstone with shale partings	151		976	
Coal		3	976	3
Shale, sandy	8	9	985	
Sandstone (No. 2)	58		1043	
Clay shale	17		1060	
Coal		2	1060	2
Shale	9	10	1070	
Sandstone (No. 1)	13		1083	
Mississippian series:				
Chester group:				
Limestone	17		1100	
Clay shale	15		1115	
Limestone	30	6	1145	6
Shale	9	6	1155	
Shale, red	2		1157	
Shale	52		1209	
Sandstone	14		1223	
Clay shale	10		1233	
Limestone	7		1240	
Sandstone	33		1273	
Limestone, bastard	10		1283	
Shale	15		1298	
Limestone	3		1301	
Sandstone	37		1338	
Clay shale	27	6	1365	6
Limestone	2	6	1368	
Shale	11		1379	

The oldest strata so far penetrated by the drill in the Murphysboro quadrangle are probably Devonian in age and were reached by an 1800-foot well drilled at Murphysboro many years ago. No record is available. Two other deep wells were drilled at Murphysboro and two at Ava, but none of them extend below the base of the Chester group. No detailed record of the wells at Ava was kept, but records of those at Murphysboro are as follows:

Boring made with diamond drill in 1892, on the northwest corner of the SW. ¼ sec. 34, T. 8 S., R. 2 W., near Murphysboro.

[Surface about 445 feet above sea level.]

	Thickness. Ft.	in.	Depth. Ft.	in.
Valley filling:				
Clay and sand	86		86	
Carbondale formation:				
Shale	30	6	116	6
Shale, dark blue, with concretions	33	5	149	11
Coal, Murphysboro	6	4	156	3
Pottsville sandstone:				
Shale, dark blue	15		171	3
Sandstone, gray	20		191	3
Shale, blue, sandy, with black partings	3		194	3
Shale, gray, sandy, with black partings	13		207	3
Shale, dark, sandy, with black partings	30		237	3
Shale, bituminous	9		246	3
Shale, gray, sandy, with black partings	7		253	3
Sandstone, brown	69		322	3
Shale, dark, with sand partings	35		357	3
Sandstone, light	5		362	3
Shale, dark, with sand partings	21		383	3
Sandstone, light	46		429	3
Shale, dark, with sand partings	3		432	3
Sandstone	6		438	3
Shale, light, sandy	5		443	3
Sandstone, light	51		494	3
Sandstone, light; traces of coal	35		529	3
Shale, dark sandy	3		532	3
Clay shale, dark blue	67	6	599	9
Sandstone with shale partings	1	6	601	3
Clay shale, dark blue	3		604	3
Sandstone with shale partings	45		649	3
Sandstone	9		658	3
Chester group:				
Limestone	1		659	3
Clay shale, blue, with sand partings	5		664	3
Limestone	33		697	3
Clay shale, dark blue	10		707	3
Limestone	26		733	3
Clay shale	9		742	3
Shale, light, sandy	23	6	765	9
Coal, soft, and shale	1	6	767	3
Sandstone		6	767	9
Coal, soft, and shale	1	6	769	3
Shale, light, sandy	15		784	3
Sandstone with streaks of coal	42		826	3
Limestone	1		827	3
Clay shale, dark	5		832	3
Limestone	2		834	3
Clay shale, dark	5		839	3
Limestone	1		840	3
Clay shale, dark	3		843	3
Limestone, light	11		854	3
Clay shale, dark	5		859	3
Shale, light, sandy	2		861	3
Limestone	5		866	3
Clay shale, dark	14		880	3

Record of deep well in sec. 4, T. 9 S., R. 2 W.

	Thickness. Feet.	Depth. Feet.
Soil and drift	98	98
Carbondale formation:		
Shale, black	27	125
Coal (Murphysboro)	6	131
Pottsville sandstone:		
Shale, blue	20	151
Sandstone, gray	48	199
Shale, gray, sandy	67	266
Sandstone, white	163	429
Shale, blue	118	547
Sandstone (?)	30	577
Shale, light blue	20	597
Shale, dark	25	622
Chester group:		
Limestone	3	625
Shale, dark blue	10	635
Limestone, gray	18	653
Shale, dark blue	13	666
Limestone	54	720
Shale, bituminous	2	722
Shale, light blue	20	742
Shale, gray sandy	16	758
Shale, dark blue	4	762
Shale, dark, sandy	23	785
Limestone, gray	5	790
Limestone, dark	10	800
Shale, dark blue	25	825
Limestone	14	839
Shale, dark blue	11	850
Shale, dark, sandy	13	863
Sandstone, gray	15	878
Limestone, dark	12	890
Shale, dark blue	44	934
Limestone, dark	4	938
Limestone, gray	30	968
Limestone, dark	22	990
Shale, blue	15	1005

A deep boring made by the Illinois Central Coal & Coke Co. at St. Johns, about 3 miles north of the quadrangles, shows that the character of the deeper strata, as far down as the limestone of Trenton age, is as follows:

Record of a deep boring at St. Johns, Ill.

[Surface altitude about 466 feet.]

	Thickness. Feet.	Depth. Feet.
Recent and Pleistocene series:		
Glacial drift	42	42
Pennsylvanian series:		
Limestone	3	45
Shale, sandy	16	61
Shale and coal	10	71
Shale, sandy	25	96
Clay shale	30	126
Shale, sandy	80	206
Sandstone	15	221
Shale, sandy	23	244
Fire clay and shale	12	256
Shale with partings	55	311
Sandstone, fresh water	178	489
Mississippian series:		
Birdsville formation to Ste. Genevieve limestone, inclusive:		
Limestone[a]	31	520
Sandstone	15	535
Shale, sandy	28	563
Sandstone	15	578
Shale, sandy	32	610
Limestone	8	618
Sandstone	25	643
Shale	13	656
Sandstone	10	666
Limestone	3	669
Sandstone	10	679
Clay shale	30	709
Shale, sandy	35	744
Mixed shale	35	779
Limestone	16	795
Shale	20	815
Limestone	25	840
Clay shale	15	855
Limestone	5	860
Shale, sandy	15	875
Clay shale	40	915
Shale, sandy	67	982
Limestone	20	1002
Sandstone	20	1022
Limestone	10	1032
Shale, sandy	22	1054
Sandstone	13	1067
Shale, sandy	20	1087
Limestone	20	1107
Marl, red	4	1111
Sandstone	39	1150
Shale, sandy	40	1190
Sandstone	90	1280
Shale, soft	10	1290
Sandstone	10	1300
Limestone, blue	5	1305
Sandstone	5	1310
Shale	10	1320
Sandstone	10	1330
Shale	14	1344
Marl, red	4	1348
Shale	4	1352
Limestone	16	1368
Shale	7	1375
Sandstone	14	1389
Limestone	10	1399
Sandstone	15	1414
Limestone	6	1420
Shale with partings	20	1440
Limestone	35	1475
Shale	23	1498
Sandstone	20	1518
Shale, mixed	19	1537
Limestone	4	1541
Shale, sandy	8	1549
Limestone	40	1589
Shale	15	1604
St. Louis, Spergen, and Warsaw formations:		
Limestone	92	1696
Shale	3	1699
Limestone	250	1949
Fire clay or shale	20	1969
Limestone with partings	57	2026
Shale	10	2036
Osage group and Kinderhook formation:		
Limestone with partings	112	2148
Limestone, sandy	60	2208
Limestone, light gray	63	2271
"Spar" (fragments of calcite crystals)	4	2275
Devonian system:		
Limestone, light gray, hard	498	2773
Limestone, light gray, soft	227	3000
Silurian and Ordovician systems:		
Mainly limestone	600	3600

[a] The top of the Mississippian series may possibly be somewhat lower than is indicated in the section.

A test boring for oil, drilled by the Midvalley Oil Co., of Willisville, Ill., just beyond the north border of the Murphysboro quadrangle, showed the following section:

Driller's record of well on the L. Collier farm (NW. ¼ SW. ¼ sec. 17, T. 6 S., R. 3 W.), Perry County, with geologic interpretation.

[Altitude of curb about 400 feet.]

	Thickness.	Depth.
	Feet.	*Feet.*
Drift:		
Clay soil, yellow	6	6
Soil, yellow-brown	9	15
Loam yellowish	9	24
Sand, fine, gray; some quartz pebbles	8	32
Carbondale formation:		
Clay, gritty, yellowish; some lime	8	40
Sand, gray, pure; some particles of coal	8	48
Sand, gray; some hard lime	10	58
Sand, gray, cemented with shale	9	67
Sand, gray	7	74
Shale and lime	10	84
Slate, black	3	87
Slate, black; coal particles	5	92
Lime and black shale	6	98
Limestone	7	105
Shale, light gray, and slate	9	114
Shale, light gray	13	127
Slate, black, bituminous	8	135
Limestone; some coal	18	153
Sandstone, white; some lime	7	160
Sand and limestone	6	166
Limestone and sand in equal amounts	6	172
Shale and lime	6	178
Shale and some lime	6	184
Shale, dark, and lime	6	190
Shale, dark, and some lime	6	196
Shale, dark	6	202
Shale, light	4	206
Slate, light	12	218
Slate, dark, and some lime	6	224
Sand, gray, and lime	12	236
Shale, white	12	248
Slate, white	24	272
Coal; some slate	6	278
Shale, light; some lime	6	284
Coal	6	290
Pottsville sandstone:		
Limestone, hard	5	295
Shale and lime	6	301
Slate, light	5	306
Shale and sand	6	312
Sandstone, hard, granular	6	318
Sandstone, white, hard, granular	10	328
Sandstone, fine, white	6	334
Sand, white, and some shale	6	340
Sand, fine, white, and some shale	6	346
Sugar-sand, very white, clean, fine	30	376
Sand, white, very fine, almost flour	20	396
Sand, very fine, somewhat gray	5	401
Sand, coarse, gray; some slate	3	404
Shale, gray, and sand, white	3	407
Sand, white, very fine	3	410
Sand, gray, very fine	5	415
Sand, gray, very coarse	5	420
Sand, white, fine, clean	5	425
Sand, fine, gray	5	430
Sand, gray, fine to coarse	5	435
Sand, white	5	440
Sand, coarse, brown and white; some quartz crystals	5	445
Sand, white, in abundance; and sand, brown, coarse	5	450
Sand, coarse, gray white; sand-slate particles	5	455
Sand, white	6	461
Sand, white; coarser than next sample	5	466
Sand, white, very fine, pure, clean	6	472
Sand, purplish white, very fine, pure, clean	18	490
Sand, pinkish white, very fine, clean	6	496
Sand, white, pure, very fine	24	520
Sand, white, fine	5	525
Sand, dark gray	5	530
Sand, dark gray, some shale	5	535
Shale, and sand, loose, dark	5	540
Sand, cemented; shale, dark	6	546
Sand, dark gray, cemented with shale	6	552
Sand, gray white	12	564
Sand, pink, fine	5	569
Sand, gray, fine; some pink sand	5	574
Sand, pink; some gray	6	580
Sand, mixed pink and gray, fine	5	585
Sand, light gray, coarse	5	590
Sand, pinkish white	6	596
Sand, white, clean, fine	29	625
Chester group:		
Lime and sand, fine, white	5	630
Lime and sand, very fine, pink-white	5	635
Sand-lime, dark gray	5	640
Limestone and sand	5	645
Limestone and sand, fine, dark	5	650
Limestone, fine, dark gray, and sand, dark, fine	5	655
Sand, fine, dark gray, and lime; in equal amounts	5	660
Sand, powdery, white-gray, and lime	5	665
Lime, powdered, and sand, dark gray	5	670
Sandstone, dark gray, small bits of lime, and particles of red sandstone	5	675

Driller's record of well on the L. Collier farm (NW. ¼ SW. ¼ sec. 17, T. 6 S., R. 3 W.), Perry County, with geologic interpretation—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
Chester group—Continued:		
Sandstone, coarse, dark gray; small bits of lime	5	680
Lime and sand	5	685
Shale and lime, dark	15	700
Shale and lime; some red shale	5	705
Shale; some lime and some red shale	5	710
Lime and shale	5	715
Sandstone, white; some coarse, dark shale	5	720
Sandstone, white, some lime	3	723
Sand mostly; some shale and lime, dark gray	4	727
Sand, dark gray	11	738
Slate, gray	6	744
Slate, gray; a few pieces of red shale	13	757
Lime; some gray slate	6	763
Limestone, light gray	7	770
Shale and lime; some particles of red shale	6	776
Shale and lime	8	784
Limestone	2	786
Limestone; some dark shale	6	792
Shale, red	6	798
Lime, pure, white	6	804
Lime, pure, white; some light shale	5	809
Limestone and slate	3	812
Limestone, fine; some slate	3	815
Lime, mixed with black slate	6	821
Lime; some slate	6	827
Mostly lime; dark shale	5	832
Slate, dark gray; some limestone	6	838
Lime, fine stuff; dark-gray shale	6	844
Shale, dark; some coarse lime	6	850
Shale, dark, and dirt	6	856
Lime, dark gray, and shale, dark gray; equal amounts	6	862
Shale, dark gray (two-thirds), and lime (one-third)	6	868
Lime, dark gray (one-third), and shale, dark gray (two-thirds)	6	874
Shale, gray	6	880
Shale, red and gray	5	885
Shale, gray	5	890
Shale, gray, coarse; some lime	5	895
Shale, gray, coarse	5	900
Slate, coarse, dark gray	12	912
Slate, hard, black	6	918
Sand and slate, fine and dark	6	924
Sand, fine, white; slate, fine, black (salt water)	3	927
Slate, hard, dark gray	3	930
Sand, gray-white, fine (salt water)	5	935
Sandstone, fine, white (salt water)	5	940
Sandstone, grayish white, salty	5	945
Sandstone, reddish brown; some lime	5	950
Shale, very fine, black; some lime	7½	957½
Shale, very fine, black	2½	960
Shale, dark gray to black, coarse	5	965
Limestone; some shale and sand	5	970
Limestone, dark; some black slate	5	975
Lime, dark, and sand	10	985
Lime, fine, sandy, dark gray	5	990
Slate, gray, and some lime	5	995
Lime, fine, and shale, dark gray	5	1000
Lime, fine, dark gray	3	1003
Lime, fine, and shale	3	1006
Lime and some shale	3	1009
Lime, fine, and shale, dark gray; mostly lime	3	1012
Lime, fine, dark gray	3	1015
Lime, fine	5	1020
Slate, fine, and lime	5	1025
Slate, fine, and lime, dark gray	5	1030
Limestone, dark, fine; some shale	5	1035
Shale and limestone, gray	2	1037
Shale, red	17	1054
Shale, red and gray	11	1065

ROCKS NOT EXPOSED.

ORDOVICIAN SYSTEM.

The strata underlying the Murphysboro and Herrin quadrangles down as far as the Ordovician are known from the well records and from outcrops in Union and Alexander counties, Ill., and in adjacent parts of Missouri within 40 miles of the area.

The lowermost 200 feet of strata penetrated in the St. Johns well (p. 4), the deepest well near the quadrangles of which a record is extant, probably belongs to an older group of rocks than any outcropping in southern Illinois. The succeeding 170 feet doubtless corresponds with the Plattin and Kimmswick limestones of the Mohawkian or Middle Ordovician series, which are well exposed at Cape Girardeau, Mo.

The Cincinnatian or Upper Ordovician rocks were not identified with certainty in the St. Johns well record, but their presence is inferred because they are persistent in outcrops in southern Illinois. They belong to the Richmond group and correspond in part to the Maquoketa shale of the upper Mississippi Valley. In their southern Illinois outcrop they have a total thickness of about 145 feet and include limestone, sandstone, and shale, to which several formation names have been applied.

SILURIAN SYSTEM.

Rocks of early Niagaran (Clinton) age are generally present in southern Illinois and southeastern Missouri. They consist for the most part of hard gray thin-bedded impure limestones with bands of chert alternating with the limestone layers. At the top are 12 to 18 feet of pink or mottled fine-grained limestone in layers 1 to 4 feet thick, containing many small fossils. Their total maximum thickness is about 70 feet. No Silurian strata of the age of the Niagara dolomite farther north in the Mississippi Valley occur in this part of the State, the Devonian rocks overlying strata of early Niagaran age.

DEVONIAN SYSTEM.

The thickness of the rocks interpreted as Devonian in the log of the boring at St. Johns is about 725 feet, which corresponds closely to the thickness of the Devonian strata known from outcrops in southern Illinois and southeastern Missouri, where formations of New Scotland, Oriskany, Onondaga, Hamilton, and later Devonian age have been recognized.

CARBONIFEROUS SYSTEM.

SUBDIVISIONS.

The Carboniferous, which is the thickest and economically the most important system of rocks in southern Illinois, falls naturally into two series of markedly different character. The lower or Mississippian is composed of limestone with interbedded shale and sandstone in the upper part, and the upper or Pennsylvanian is made up of soft shale and sandstone with numerous thin beds of limestone and several more or less lenticular beds of coal. The Permian, which elsewhere forms the uppermost series of the Carboniferous, is not known to be present in southern Illinois. The individual beds vary somewhat in character from place to place, but the Carboniferous system as a whole is uniform throughout thousands of square miles in the central part of the Mississippi basin. It differs, however, from the same system in the eastern part of the United States; in the Mississippi basin much of the shale is greenish gray, very soft, and poorly laminated, whereas in the east it is darker and harder and contains many beds of whitish clay; in the west also the system contains little but limestone, whereas in the east the Mississippian series is composed largely of sandstone.

MISSISSIPPIAN SERIES.

In southern Illinois the Mississippian series has been subdivided into the following groups and formations:

- Chester group:
  - Birdsville formation.
  - Tribune limestone.
  - Cypress sandstone.
  - Ste. Genevieve limestone.[a]
- Meramec group:
  - St. Louis limestone.
  - Spergen limestone.
  - Warsaw shale.
- Osage group.
  - Keokuk limestone.
  - Burlington limestone.
- Kinderhook formation.

KINDERHOOK FORMATION.

Upon the Devonian, as shown in well sections, lies the Kinderhook formation, a series of variable strata 70 feet or more in thickness, consisting of limestone and shale with some chert and containing very few fossils.

OSAGE GROUP.

Upon the Kinderhook lies the Osage group, which is dominantly limestone. Its lower part, the Burlington limestone, is coarsely crystalline, crinoidal, and light gray and contains many beds of chert, especially near the top. It is overlain by impure limestone and shale representing the Keokuk limestone. The combined thickness of the two formations is about 250 feet.

MERAMEC GROUP.

The Meramec group includes the Warsaw shale and the Spergen and St. Louis limestones, the three having a combined thickness in the region of 400 to 450 feet. The Warsaw is composed chiefly of shale and is not readily separable from the shaly Keokuk limestone of the region. 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 dark-gray, commonly fine-grained limestone and local beds of shale and shaly limestone.

CHESTER GROUP.

The Chester group, composed largely of limestone, extends to the top of the uppermost Mississippian rocks in southern Illinois, and includes the Cypress sandstone, Tribune limestone, and Birdsville formation. Whether it also includes the Ste. Genevieve limestone is undecided.

[a] Some geologists include the Ste. Genevieve limestone in the Chester group; others refer it to the Meramec group; and still others suggest that it should be considered an independent group lying between these two. Decision as to its proper classification is postponed pending the collection and full discussion of additional evidence

The type locality of the group is near Chester, northwest of Murphysboro, where the limestone in the central part of the section is quarried extensively for road metal. Stuart Weller, who has made a study of the exposures, furnishes the following section, made up from careful measurements in the river bluff between Modoc and Rockwood:

Section of Chester group near Chester, Ill.

	Thickness.	Depth.
	Feet.	*Feet.*
Birdsville formation:		
Sandstone	100	100
Limestone ("No. 3")	20	120
Shale or shaly sandstone, arenaceous	47	167
Sandstone	10	177
Shale, arenaceous or shaly sandstone	33	210
Limestone ("No. 2")	54	264
Shale	42	306
Limestone, persistent bed	8	314
Shale	26	340
Sandstone	0–20	350
Limestone	4	354
Shale	4	358
Tribune limestone:		
Limestone ("No. 1"); the layer worked at the penitentiary	80	438
Shale and limestone	30	468
Limestone	49	517
Shale ?	38	555
Shales, variegated red and green	15	570
Concealed	5	575
Limestone (fossils)	10	585
Shale (fossils)	10	595
Limestone (fossils abundant)	8	603
Shale	7	610
Concealed	25	635
Cypress sandstone	134	769
Ste. Genevieve limestone, partly oolitic.		

From Chester the strata dip eastward and disappear beneath younger rocks.

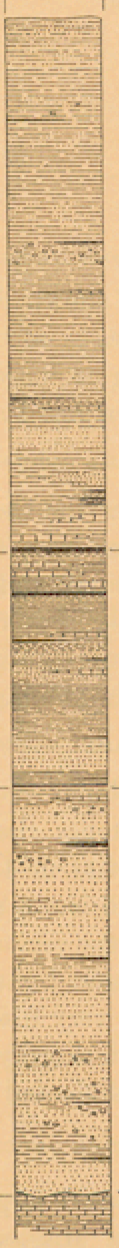
ROCKS EXPOSED.

CARBONIFEROUS SYSTEM.

MISSISSIPPIAN SERIES.

CHESTER GROUP.

Birdsville formation.—The Birdsville formation of the Chester group appears at the surface in the Murphysboro and Herrin quadrangles in only a few small exposures. At one of



System.	Series.	Formation.	Section.	Thickness (feet).	Minor divisions.	Character of rocks.	Character of topography (somewhat obscured by drift).
Carboniferous.	Pennsylvanian.	McLeansboro formation.		550+	Coal. Coal. Coal. Coal.	Largely bluish shale and loosely cemented reddish or buff sandstone with a few thin lenticular beds of coal and limestone.	Smooth plains with low irregular hills marking the outcrops of the principal sandstone layers.
		Carbondale formation.		250–300	Herrin (No. 6) coal. Harrisburg (No. 5) coal. Coal. Coal. Coal. Vergennes sandstone member. Murphysboro (No. 2) coal.	Dark to light bluish-gray shale and loosely cemented micaceous sandstone with several beds of limestone and coal. Vergennes sandstone member near base.	Smooth plains with sandstone hills, generally low and irregular, but the Vergennes sandstone hills are 20 to 200 feet high.
		Pottsville sandstone.		420–510	Coal. Coal. Coal. Coal.	Chiefly resistant, somewhat conglomeratic and saccharoidal sandstone in thick layers, separated by lenticular layers of soft shale and thin coal.	Rough rocky country with relief of several hundred feet.
		UNCONFORMITY					
	Mississippian.	Birdsville formation (of Chester group).		100+		Thick-bedded limestone separated by beds of thin limestone and soft shale.	Nearly smooth steep slopes with large blocks of limestone on the surface in places.

FIGURE 5.—Generalized columnar section of the rocks exposed in the Murphysboro and Herrin quadrangles.
Scale: 1 inch = 200 feet.

these, at the foot of the Mississippi bluffs near the western edge of the area, the fossils collected, as identified by Weller, include *Diaphragmus fasciculatus, Spirifer increbescens, Composita subquadrata, Straparollus* sp., and several species of fenestelloid bryozoans, indicating that the rock belongs in the central part of the Chester group. Another exposure is on a branch of Kinkaid Creek near the middle of sec. 24, T. 8 S., R. 3 W. A third is in the NE. ¼ sec. 31, T. 8 S., R. 3 W., where *Derbya kaskaskiensis* McChesney, *Diaphragmus fasciculatus* McChesney, *Martinia* sp., *Composita subquadrata* Hall, and *Bellerophon* sp. were collected. At the last-named place the limestone exposed is nearly 100 feet higher, both actually and stratigraphically than it is at the other places. This accords with numerous observations in other districts in indicating that the upper surface of the Chester is very uneven. In other words there is an erosional unconformity between the Chester group and the overlying strata. The name Birdsville is applied to these rocks because their fossils and lithologic character correlate them with the Birdsville formation, the type locality of which is in western Kentucky.

PENNSYLVANIAN SERIES.

CORRELATION.

Through the work of David White on the fossil plants it is known that the Pottsville, Allegheny, and Conemaugh formations of Pennsylvania and other eastern States are represented in southern Illinois, though their exact correlation and limits have not yet been determined. The upper limit of the Pottsville, which is known with fair accuracy, lies a very short distance below the Murphysboro (No. 2) coal, and for convenience the base of the underclay of that coal will be used as the formation boundary. The division plane between the strata of Allegheny and overlying Conemaugh age is much more difficult to determine; it probably lies near the Herrin (No. 6) or the No. 7 coal, but its exact place is doubtful. For this reason local formation names will be applied and the top of the Herrin coal will be used as the formation boundary.

POTTSVILLE SANDSTONE.

Character and thickness.—The Pottsville formation is composed principally of sandstone. In the southwestern portion of the area it crops out extensively with a thickness ranging from 420 to 510 feet, and owing to its resistant nature and its uplift it forms very rugged hills.

In the northern and eastern parts of the area the Pottsville generally extends from near the base of the coal No. 2 down to the first limestone and may thus be identified in drill holes by its position. But in some places a sandstone overlying this limestone belongs below the Pottsville, and in such places the base of the Pottsville is very difficult to determine, even in outcrops. The formation is generally made up of seven sandstone members separated by layers of shale, though in many places one or more shale members are absent or are represented by sandstone. In such places there appear to be fewer sandstone members. The shale generally contains some thin-bedded or lenticular sandstones and one or more carbonaceous beds or coal seams. All the strata are very irregular; beds of sandstone grade laterally into shale, and hardly any bed holds its physical character throughout any considerable area. The seven main sandstones are not very persistent and are of irregular thickness.

The lowest sandstone, which, in general, is fine grained, creamy white, and relatively soft, has a maximum thickness of 60 feet though locally it seems to be absent. Above it lies 5 to 75 feet of sandy shale locally containing traces of coal.

The second sandstone is 35 to 60 feet thick and the third 50 to 85 feet thick. These two sandstones are considerably more resistant than the first and contain pebbles, especially in their lowermost parts. Throughout most of the area they are separated by a bed of soft shale, ranging in thickness up to about 20 feet, with lenses of sandstone and traces of coal. The upper of the two is overlain by a more or less sandy shale, 1 to 20 feet thick, containing beds of pure sandstone.

The fourth sandstone measures 45 to 85 feet and the fifth 70 to 100 feet. Both are gray, clean, and hard, and contain a few lenses of shale, and toward the top scattered pebbles. They are separated by an irregular mass of shaly sandstone, from 30 to 90 feet thick, containing lenses of soft shale, and having at the top a fairly persistent coal bed, 2 to 25 inches thick. The fifth sandstone is overlain by 1 to 40 feet of shale and shaly sandstone.

The sixth sandstone is 40 to 80 feet thick and the seventh 20 to 35 feet. Both are conglomeratic, particularly northeast of Ava. The pebbles seem to be concentrated along bedding planes and not scattered irregularly through the mass. The shale with shaly sandstone, between these uppermost sandstones is irregular in thickness, ranging from 3 to 30 feet, and contains one or more lenticular coal beds and commonly masses of iron oxide. At least a part of this shale member is of Mercer age. Near Oraville and on the Mississippi bluffs little conglomerate appears in any layer of the Pottsville, but in other places, as near Sugar Hill school, quartz pebbles are scattered through much of the formation. Between the uppermost sandstone and coal No. 2 there is a 10 to 30 foot shale member with local sandstone layers.

Fossils and age.—Fossil plants were collected from shale between the fifth and sixth sandstones in the bottom of a ravine one-half mile east of Union school (SE. ¼ SW. ¼ sec. 34, T. 7 S., R. 3 W.). David White, who identified the flora, says that it is clearly of upper Pottsville age, though the collection is too meager to be adequate for close correlation. "However," he adds, "it is probably as young or younger than Sharon and older than Mercer." The following species were identified:

Mariopteris inflata (Newb.) D. W.	Neuropteris cf. gigantea Sternb.
Sphenopteris sp. indet.	Sphenophyllum cuneifolium (Sternb.) Zeill.
Alethopteris cf. grandifolia Newb.	Lepidodendron clypeatum Lx.
	Sigillaria sp. indet.

The shale between the sixth and seventh sandstones is exposed in a railway cut near the road crossing at the middle of the north side of sec. 33, T. 8 S., R. 3 W. Here fragments of *Stigmaria* rootlets and a *Lepidophyllum* were found. Through these and other fossils collected in the region David White is able to say that the rocks between the top of the Chester group and the Murphysboro (No. 2) coal are to be correlated with the Pottsville formation of Pennsylvania.

CARBONDALE FORMATION.

General character.—The Carbondale formation includes all the Pennsylvanian strata between the base of the underclay of the Murphysboro coal and the top of the Herrin coal. The name is taken from the town of Carbondale, Ill., in the vicinity of which this formation is well exposed. The formation in these quadrangles ranges in thickness from 250 to 300 feet and is made up of shale and sandstone with several thin layers of limestone and more or less lenticular beds of coal. The shale, which is poorly laminated and claylike, ranges in color from dark to light gray. The sandstone is generally loosely cemented and rather micaceous, though one or two of the thinner beds are firmly cemented by calcium carbonate. The limestone is hard, gray or bluish gray, and more or less fossiliferous. Some of it has a peculiar brecciated or conglomeratic appearance.

Coal beds.—In the early reports on the geology of Illinois the successive coal beds in the State were designated by numbers, beginning with No. 1 at the bottom. The correlation of beds in different parts of the State was in general correct, but most of the coal beds are lenticular, and for this and other reasons the use of numbers for the various coal beds has been found not so desirable as geographic names. Hence such names have been introduced in this report. The thick "Blue Band" (No. 6) coal, which is the principal bed worked in the Herrin quadrangle, will be designated the Herrin coal. In Worthen's reports on Williamson and Franklin counties this bed was called No. 7, but it has since been found to be the same as No. 6 in the Belleville district. This bed is also the equivalent of the Duquoin coal of the Perry County report.

The 4-foot coal lying 35 to 40 feet below the base of the Herrin coal is probably the Springfield (No. 5) coal, but as this is not certainly known it will be referred to in this folio as the Harrisburg coal. Another bed (No. 2, or Big Muddy) about 225 feet below the Harrisburg coal is designated the Murphysboro coal. The Murphysboro and Herrin coals are persistent and easily recognized, and hence they are used as the exact limits of the Carbondale formation.

Outcrops.—The Carbondale formation underlies the surface formations between the outcrops of coals No. 2 and No. 6. In a general way this area embraces the southern fourth of the Herrin quadrangle, the eastern half and northwestern fourth of the Murphysboro quadrangle, and a few square miles in the vicinity of Ava near the western border of the Murphysboro quadrangle. On the north side of a ravine $1\frac{3}{4}$ miles north of Ava an outcrop of limestone contains *Productus*, *Pugnax uta* Marcou, and other fossils; this rock belongs in the central part of the Carbondale formation.

Lithology.—The sequence of the beds composing the formation may be seen in the columnar section (fig. 5) and is shown below:

Section illustrating character of Carbondale and parts of adjacent formations between Vergennes and Elkville.

	Ft.	in.
Drift	19	
Coal (Herrin)	2	
Clay	8	
Sandstone	14	
Shale, sandy	20	
Clay shale	29	6
Limestone	1	6
Shale, black	3	
Coal (Harrisburg)	2	
Clay	8	
Shale, sandy	49	
Limestone	2	
Shale, black	5	
Coal		6
Clay	2	6
Sandstone	15	
Shale, sandy	17	3
Coal	1	9
Clay shale	1	
Sandstone	11	
Shale, sandy	7	
Clay shale	5	9
Coal	1	
Clay	1	
Coal	1	6
Clay	2	9
Shale, sandy	12	
Clay shale	5	
Shale, black		6
Coal		6
Clay	11	
"Fire clay," pink	4	
Clay	4	9
Coal		3
Clay	2	
Shale, sandy	14	
Limestone	1	
Clay	2	
Shale, sandy	11	
Shale, black	2	
Limestone	1	6
Shale, black		3
Coal (Murphysboro?)		9
Clay shale	6	6
Shale, sandy	10	6
Coal (Murphysboro?)		6
Shale, sandy	2	
Sandstone	4	
Shale, sandy	2	
Coal		6
Clay		6
Shale, sandy	3	
Clay	2	
Shale, sandy	64	
	399	

Correlation.—From a study of the fossil plants found in the coal seams and associated strata in the State David White concludes that the Murphysboro coal is the lowest coal bed in Illinois that falls within the time interval of the Allegheny formation of Pennsylvania. He also concludes that the Herrin coal may be of Freeport age, possibly as high in the stratigraphic column as the Upper Freeport coal, which is the uppermost layer of the Allegheny formation in the Appalachian region. From these correlations it will be seen that the Carbondale formation corresponds in a general way to the Allegheny formation of the Appalachian coal basin.

Murphysboro (No. 2) coal and associated beds.—The Murphysboro coal ranges in thickness from 1 to 6 feet or more and is commonly divided into two or more benches. In part of the SW. ¼ sec. 32, T. 8 S., R. 2 W., the coal is separated into two benches about 35 feet apart, but half a mile to the east the two benches are only 4 to 5 feet apart.

These relations are illustrated by the following sections:

Lower part of Carbondale formation at the east side of the SE. ¼ SW. ¼ sec 32, T. 8 S., R. 2 W.

		Ft.	in.
Loess and valley filling		30	7
Carbondale formation:			
Shale, yellow clay		10	9
Shale, hard, blue		37	6
Coal	Murphysboro coal	2	2
Shale	Murphysboro coal	8	4½
Coal	Murphysboro coal	3	5½
Coal, bony	Murphysboro coal		6
Clay			2½

Lower part of Carbondale formation at the west side of the SE. ¼ SW. ¼ sec. 32, T. 8 S., R. 2 W., less than one-eighth mile from place where preceding section was measured.

		Ft.	in.
Loess and valley filling		31	8
Carbondale formation:			
Shale, yellow, soft		5	
Shale, blue		11	4
Shale, black			7
Coal	Murphysboro coal	2	5
Coal, bony	Murphysboro coal		5
Shale, blue	Murphysboro coal	35	10
Coal	Murphysboro coal	3	2
Shale, blue		4	5
Shale, dark, calcareous		4	
Sandstone, hard		4	7

The coal seems to be the most regular in the vicinity of Murphysboro. Plant fossils are found in this coal and associated beds, the overlying shale being particularly fossiliferous. Among the species which were collected from these shales are the following:

Eremopteris solida D. W.	Odontopteris bradleyi Lx.
Mariopteris sphenopteroides (Lx.).	Odontopteris subcuneata Bunb.
Mariopteris callosa (Lx.) D. W.	Neuropteris rarinervis Bunb.
Cheilanthites (Pseudopecopteris) squamosa (Lx.) D. W.	Neuropteris ovata Hoffm.
Aloiopteris sp. cf. A. gracillima (Newb.) D. W.	Neuropteris scheuchzeri Hoffm.
Pecopteris villosa Brongn.	Neuropteris decipiens Lx.
Alethopteris serlii (Brongn.) Goepp.	Linopteris rubella (Lx.) D. W.
Callipteridium membranaceum Lx.	Calamites ramosus Artis.
	Annularia sphenophylloides (Zenk.) Gutb.
	Sphenophyllum emarginatum Brongn.
	Ulodendron sp.

Vergennes sandstone member.—The Murphysboro coal is generally overlain by a seam of clay ("sheepskin"), which is in turn overlain by 20 to 40 feet of shale or in a few places shaly sandstone, which where thickest locally contains a thin coal seam near the middle. This shale is in turn overlain by sandstone or in some places by sandy shale, which seems to be persistent though irregular in thickness, ranging from 15 to 45 feet. This sandy member is micaceous, loose, friable, and brownish. Although it is not nearly so resistant as the beds of the Pottsville sandstone, it forms low hills, and 4 miles northwest of Vergennes, in sec. 11, T. 7 S., R. 3 W., it is well exposed on a large hill. The persistent nature of this rock and its importance as a key stratum (as it forms low hills and crops out more extensively than other parts of the Carbondale formation) seems to warrant a special name, and the term Vergennes sandstone member is here proposed.

Strata between Vergennes sandstone member and Harrisburg (No. 5) coal.—Above the Vergennes sandstone member is a bed of clay 5 to 6 feet thick, and overlying the clay and about 55 feet above coal No. 2 there is a persistent coal bed, 6 to 28 inches thick. This coal, which is thin in the northern part of the area and thickens toward the south, is exposed at the surface in the east bank of Craborchard Creek, near the northwest corner of sec. 36, T. 8 S., R. 1 W., where it has been mined by drifting. The following section was made at this place:

Section exposed in sec. 36, T. 8 S., R. 1 W.

	Feet.
5. Sandstone, yellowish-brown, marked with numerous small brown spots	4½
4. Limestone, argillaceous, single bed	1½
3. Shale, black, fissile	2½
2. Coal	2
1. Underclay, gray	1½

Eight rods north of this exposure 12 feet of sandstone is laid bare in the bank of the creek. One-fourth mile up the creek from the latter point 10 feet of the sandstone overlain by 6 feet of gray sandy shale is exposed.

At the east end of the wagon bridge over Craborchard Creek, near the middle of the north half of sec. 2, T. 9 S., R. 1 W., the following succession of strata is exposed:

Section exposed in sec. 2, T. 9 S., R. 1 W.

	Feet.
8. Limestone, argillaceous, somewhat concretionary	1
7. Shale, black, fissile, containing *Orbiculoidea missouriensis* and dermal tubercles of *Petrodus occidentalis*	3
6. Coal	2½
5. Underclay, gray	2½
4. Shale, gray	5½
3. Shale, gray, sandy	7
2. Sandstone, yellowish gray	8
1. Sandstone, fine grained, shaly	10

In the above section the beds numbered 5 to 8 inclusive are the equivalents respectively of those numbered 1 to 4 in the preceding section. Corresponding beds outcrop about a mile southeast of the bridge over Craborchard Creek, in sec. 1 of the same township, where the coal has been stripped for local use. The sandstone bed at this last place, overlying the 1-foot limestone above the coal seam, is 16 feet thick. In a ravine about half a mile north of this point 14 feet of the sandstone, succeeded by 5 feet of shale, is exposed. In some records the sandstone is reported to be about 25 feet thick.

The strata described represent the beds associated with the coal lying about 55 feet above coal No. 2. The sandstone member above the coal is succeeded by a bed of shale 40 to 50 feet thick, commonly more or less sandy and locally a true sandstone. In some places, as 2 miles southeast of Denmark, the central part of this shale contains calcareous and fossiliferous layers of sandstone, from which the following shells have been identified by Weller:

Derbya crassa M. and H.	Productus nebraskensis Owen.
Chonetes mesolobus N. and P.	Marginifera muricata N. and P.
Productus costatus Sow.	Spirifer cameratus Morton.
Productus cora D'Orb.	Squamularia perplexa McChesney.
Productus punctatus Martin.	Composita argentea Shep.

Above the shale is a bed of clay 5 to 6 feet thick, which is in turn overlain by a 2-foot bed of coal. This coal lies about 80 feet above the coal referred to in the preceding paragraph and 135 feet above coal No. 2. It is overlain by a bed of black, finely laminated shale 3 to 5 feet thick, upon which rests a 1-foot layer of limestone. Above the limestone 40 feet or more of gray shale, locally fossiliferous in the lower part, grades upward into sandstone. In the NW. ¼ NE. ¼ sec. 19, T. 8 S., R. 2 W., $2\frac{1}{2}$ miles west of Grange Hall the following fossils were collected:

Derbya sp.	Productus sp.
Chonetes sp.	Fenestelloid bryozoan.

The sandstone which overlies the shale has lenses of shale and limestone containing *Productus cora* and other fossils. A bed of clay 1 to 5 feet thick overlies this shale and sandstone, and underlies coal No. 5.

Harrisburg (No. 5) coal and associated beds.—The Harrisburg coal is found in the Murphysboro and Herrin quadrangles wherever borings have penetrated to its horizon. It is remarkably uniform in thickness, averaging $4\frac{1}{3}$ feet in 40 records and generally departing not more than 6 inches from the average. The sequence of strata associated with the Harrisburg coal is well exposed in the south bank of a creek in the E. ½ sec. 1, T. 9 S., R. 1 E., where the following section was made:

Section near the middle of the E. ½ sec. 1, T. 9 S., R. 1 E.

	Feet.
5. Shale, gray, yellowish where weathered	4
4. Shale, soft, gray, calcareous; many fossils	1½
3. Limestone, single layer, hard, bluish gray, argillaceous	1
2. Shale, black, fissile, finely laminated; contains numerous more or less round "niggerheads" or iron-stone concretions 8 to 30 inches in diameter	6¾
1. Harrisburg coal (No. 5)	4

The black shale overlying the Harrisburg coal is locally as much as 15 feet thick, but generally its thickness is between 6 and 9 feet. The shale contains the fossils *Orbiculoidea missouriensis* and impressions of pelecypod shells.

A peculiar black laminated shale, such as that above the Springfield coal (No. 5), farther north, generally overlies the Harrisburg coal in this region. In the vicinity of Springfield and in other portions of the State there is, immediately above the Springfield coal seam and at the base of the black shale, a local pyritiferous band a few inches thick, with many fossils, in most places marine, showing the shales to be true marine deposits.

The limestone overlying the roof shale of the Harrisburg coal is 12 to 36 or more inches thick. It contains the fossils *Derbya crassa*, *Productus cora*, *P.* cf. *pertenuis*, *Marginifera splendens?*, *Spirifer cameratus*, *Squamularia perplexa*, *Spiriferina kentuckiensis*, *Composita argentea*, *Hustedia mormoni*, and *Leda bellistriata*. The limestone is comparatively resistant and if it were thicker no doubt it would form hills. In the Murphysboro quadrangle it outcrops more extensively than any other layer above the Pottsville, the principal exposures being along Beaucoup Creek 2 to 3 miles southeast of Finney and 1 to 2 miles southeast of Denmark. Above the limestone is a thin bed of rather soft gray calcareous shale, in which *Chonetes mesolobus*, *C. variolatus*, *Marginifera splendens*, *Ambocœlia planoconvexa*, and *Composita argentea* occur abundantly. This shale is succeeded by a bed of gray barren shale, 10 to 14 feet thick, which is generally overlain by a limestone bed 4 to 10 feet thick.

Herrin coal (No. 6) and underclay.—Above the limestone referred to in the preceding paragraph is the clay underlying coal No. 6. This clay, though generally only 1 to 3 feet thick, locally reaches 9 feet and generally contains impressions of the roots of a plant (*Stigmaria*). The overlying coal is $6\frac{1}{2}$ to 14 feet thick, the average thickness in 130 records being 9 feet 5 inches. The coal is characterized by a layer of dirt, bone, or shaly coal, known as the "blue band," which lies 18 to 30 inches above the base of the coal. Twenty-five measurements show that the average thickness of the "blue band" is $1\frac{3}{4}$ inches, but in places near the western outcrop of the coal it measures 6 to 11 inches. In the same 25 measurements the entire thickness of the coal, including the "blue band," is 9 feet 3 inches. The approximate outcrop of this coal in the Herrin quadrangle is indicated on the map by a broken line. The portion of the quadrangle lying south of this line represents the area in which the Carbondale formation immediately underlies the surficial materials.

McLEANSBORO FORMATION.

General character.—The McLeansboro formation in Illinois, like the Conemaugh formation of the Appalachian region, with which it in large part corresponds in age, is barren of workable coal beds and consists very largely of shale and sandstone. In the vicinity of Christopher, where the greatest thickness of this formation is present, the ratio of clastic sediments (shale and sandstone) to organic materials (coal and limestone) is about 25 to 1, and the aggregate thickness of the coal beds of the formation is between 4 and 5 feet.

The McLeansboro formation embraces all strata of Pennsylvanian age above the top of the Herrin coal. Its name is taken from the town of McLeansboro, the county seat of Hamilton County, Ill., near which place it has a thickness of about 1000 feet. The greatest known thickness in the area was found in a boring near the northeast border of the Herrin quadrangle, where 550 feet of Carboniferous strata were passed through before reaching the Herrin coal. The formation underlies the surficial materials in all of the Murphysboro and Herrin quadrangles north and east of the outcrop of the Herrin coal.

Shale and limestone immediately overlying the Herrin coal.—The Herrin coal of the Carbondale formation is generally overlain by a bed of gray shale or shaly sandstone 15 to 110 feet in thickness, the average of 120 records being 64 feet. Locally a few feet of black shale forms the roof of the coal and is overlain by 3 to 4 feet of limestone. In some of the mines the black shale is present in one part and absent in another. One-half mile south of Spillertown, a few miles east of the Herrin quadrangle, the Herrin coal is overlain by a few feet of black shale, above which is a bed of hard, bluish limestone, 3 to 4 feet thick. This limestone furnished the fossils *Derbya crassa*, *Chonetes mesolobus*, *Productus* cf. *pertenuis*, *P. semireticulatus*, *Marginifera splendens?*, and *Spirifer cameratus*, and a little fusulinoid shell which has been referred both to *Fusulina cylindrica* and to *F. secalica*. According to G. H. Girty it really belongs to neither but to a species which Meek identified as *F. ventricosa* but which is probably new. It seems to be characteristic of the limestone lying a few feet above the Herrin coal and hence is a valuable key to the stratigraphy and is being widely used as such by drillers and others seeking the coal.

A black roof shale underlying a limestone cap rock commonly overlies the Herrin coal in the east part of Williamson County and in Saline County. The presence of such a succession at some points in the Herrin quadrangle and its absence at others is thought to indicate an erosional unconformity, the black shale and limestone cap rock having been generally removed by erosion previous to the deposition of the gray shale that overlies the Herrin coal throughout most of this region.

Above the bed of gray shale is a bed of limestone with an average thickness in 115 records of 5¾ feet. This limestone is well exposed in the NE. ¼ SE. ¼ sec. 36, T. 6 S., R. 2 W., where the following fossils were collected:

Chætetes milleporaceus M.-E. and H	Marginifera splendens?
Crinoid stems.	Spirifer cameratus Morton.
Productus punctatus Mart.	Squamularia perplexa McChesney.
	Composita argentea Shep.

Strata 105 to 550 feet above the Herrin coal.—About 40 feet above the last-described limestone, and 105 to 110 feet above the Herrin coal, is a fairly persistent coal bed 1½ to 2 feet thick. The strata between the limestone and this coal consist of sandy shale or sandstone, in places with a thin band of bituminous shale or coal near the middle part and with a bed of gray underclay at the top.

A thickness of 25 feet of the upper portion of this sandstone outcrops along the east bank of Little Muddy River in sec. 35, T. 7 S., R. 1 W. Farther south, in sec. 2, T. 8 S., R. 1 W., 15 feet is exposed.

The coal seam is overlain by 2 to 5 feet of black shale, over which a bed of limestone 3 to 7 feet thick is generally present. Another clay, coal, black shale succession generally occurs above this limestone. Overlying the black shale in some places there is another bed of limestone, and in other places 22 feet or more of sandy shale or shaly sandstone. Upon these beds rests a thin seam of clay and commonly a 3 to 12 inch seam of coal, which lies about 45 feet above the 2-foot bed last described and 150 to 160 feet above the Herrin coal. A bed of black shale, 1½ to 5 feet thick, is generally reported above this coal. Overlying the black shale is a bed of more or less sandy shale 90 to 125 feet in thickness, and in the northeast portion of the area there is another thin and local coal bed 300 to 315 feet above the Herrin coal. This coal is overlain by a few feet of dark shale, above which is 90 to 100 feet of sandstone or sandy shale.

The lower part of this sandstone and sandy shale is exposed at the east end of the wagon bridge over Muddy River near the village of Plumfield in the SW. ¼ sec. 20, T. 7 S., R. 2 E., where the following section was measured:

Section at Muddy River near Plumfield, Ill.

	Feet.
3. Shale, yellowish brown, fissile, micaceous, sandy	8
2. Sandstone, massive, micaceous; marked with small brown spots	9
1. Conglomerate, yellowish gray, consisting of sandstone in which are embedded fragments of drab shale 1 to 4 inches thick	3

Strata corresponding with No. 3 of the above section outcrop again near the middle of the west side of sec. 29, in the same township. The sandy member is separated from another thick bed of sandy shale above by a coal seam 12 to 20 inches thick. The strata comprising the uppermost part of the McLeansboro formation in the Murphysboro and Herrin quadrangles consist of a succession of shales and shaly sandstones, with local thin bands of coal and black shale.

TERTIARY (?) SYSTEM.

Neither Cretaceous nor Tertiary rocks were found in place in the quadrangles, but the basal part of the glacial drift here and there contains a great many rounded pebbles of quartz; and at some localities small masses of conglomerate, which are cemented by iron oxide and resemble a Tertiary conglomerate, are found in place. Near the mouth of the Wabash such a deposit lies at an elevation of 540 feet above sea level, 200 feet above the river. The pebbles, some of which are 1½ inches in diameter, are firmly cemented by dark-brown iron oxide. Fragments of similar conglomerate are found in the drift as far north as northwestern Illinois, so that it is possible that this gravel deposit, which is probably of late Tertiary age, may at one time have extended over a considerable part of southern Illinois. If it did cover this larger region, however, most of it has been removed or has been so reworked by ice and water as to be unrecognizable.

QUATERNARY SYSTEM.

PLEISTOCENE SERIES.

Pre-Illinoian alluvium.—At several localities along the base of the high hills remnants of an old alluvium are preserved beneath the Illinoian glacial till. One good exposure is 1½ miles west of Oraville; another is 3 miles north of Grimsby, near the middle of the north side of sec. 33, T. 8 S., R. 3 W. This old alluvium, which is 2 to 5 feet thick and is cemented into hard conglomerate, consists chiefly of slightly rounded pebbles or blocks of sandstone with an interstitial filling of consolidated silt and sand. Presumably it may once have extended along all the streams of the region, but if it was generally present most of it has been removed from the lowland by the ice and from the hills by stream erosion. Along the border of the hills, however, the valleys were narrow and stream erosion was not severe. In the eastern part of the region the streams have on the whole built up, but in the western part they have almost continuously deepened their valleys. The cementation of the gravel has probably been in progress throughout a large part of Quaternary time.

Pre-Illinoian regolith.—In the hills the glacial deposits generally rest immediately upon consolidated rock, but in the lowland they overlie a dark blue or gray clay that well drillers and others call blue gumbo. This clay is 5 to 20 feet thick and in places contains numerous blocks of stone. Most of it seems to be of local origin and the small amount of foreign material it contains is largely in the upper part and is mixed with glacial material. However, it is possible that the clay was derived not only from the old soil near by but also from the soil of the central and northern parts of the State. It is probable also that some of the more silty parts that are free from stones are pre-Illinoian loess such as occurs in other places in southern Illinois. No good natural exposures of this material occur, and exact data concerning it are scarce. Its origin therefore remains in some doubt, but it is tentatively regarded as in part a pre-Illinoian mass derived from the decay of rock in place and in part as old loess.

Illinoian glacial till.—The Illinoian glacial till mantles almost the whole of the quadrangles except the comparatively small area of the stream valleys, from which it has been removed by erosion. It consists of an intimate mixture of clay and more or less decayed pebbles and bowlders of many kinds of rock. It is very gravelly and it would seem that either a considerable part of the fine material had been sorted out and carried away by water or wind, or that the till was derived from material more gravelly than deeply weathered Carboniferous rocks. Many of the pebbles are well rounded but most of them are subangular and some have sharp corners. A large proportion measure from half an inch to 1½ inches in diameter and only a few measure more than 1 foot. Among them, quartz and flint are present in relatively great amount, a fact probably at least partly due to their superior resistance to crushing.

The glacial till has a rather uniform thickness, which averages about 15 feet. Where weathered, it varies in color from light yellow to dull orange, the darkest shades appearing at the base of the weathered portion; but here and there, as in the railroad cuts near Buckner, its basal unweathered portion is bluish gray. In such places the line of demarcation between the yellowish weathered part and the fresher bluish material below is generally remarkably sharp.

Almost no terminal or recessional moraines border this drift sheet. In a small district extending southeastward from Ava the drift seems to show an irregular thickening, but exhibits little or no development of moraine topography; elsewhere it presents slight undulations, which are not produced by irregularities in the surface of the bedrock, but it forms nowhere a continuous and well-developed terminal moraine. The till of these quadrangles appears to consist of material deposited beneath the ice (ground moraine) and of englacial material left as the ice melted. The two are apparently indistinguishable.

Earlier valley deposit.—A deposit of clay and fine sand, in places as much as 120 feet thick, found in the principal valleys of the region, may in reality consist of two separate deposits having the relations indicated in figure 6.

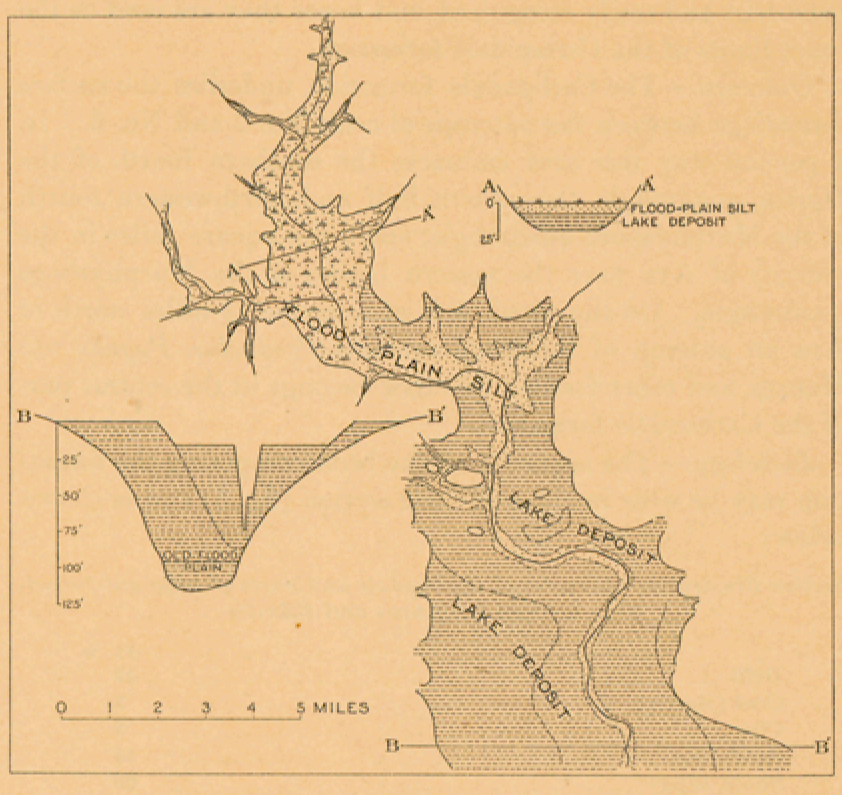


FIGURE 6.—Sketch map and cross sections of the deposits in the valley of Beaucoup Creek.

The lower part of this valley, once occupied by a lake which has been drained by the cutting down of the channel, is nearly filled with lake deposit. Two stages of valley cutting and valley filling are shown in the diagram. The present flood-plain silt of the stream occupies wide swampy belt at the upper end of the lake deposit, where the stream grade decreases abruptly, and is very narrow in the lower part, where the stream has cut below the top of the fill.

The evidence for two separate stages of valley filling is not conclusive and consists principally of the following facts: (1) An old soil occurs locally between the two deposits; (2) two extensive and fairly distinct terraces exist, the top of one being about 410 feet above sea level and the top of the other about 390 feet; (3) the materials forming these terraces are different, the higher terrace consisting for the most part of fine sand and the lower terrace of clay; (4) the upper terrace bears a fairly heavy deposit of loess, whereas the lower has little and in places none; this absence of loess is conspicuous in the vicinity of Bush, where an exposure shows loess beneath the lower terrace deposit. The deposits are most distinct along the lower stream courses, where the early filling consists of fine sand with lenses of dark clay, and the later filling is made up of clay with subordinate amounts of sand. None of the clay was found above an altitude of 395 feet, but the fine sand was found almost if not quite to the base of the deposit. These conditions exist for about 6 miles above Murphysboro; farther upstream the distinctive characters of the deposits are lost and the filling consists almost entirely of clay with a few lenses of sand about the border. The surface of the filling seems to have been not flat but somewhat concave, the deepest parts of the old valleys not having been filled up as high as the borders.

The streams have cut into the early valley filling and have removed part of it, but the full thickness seems to be preserved over a considerable area. At Murphysboro the upper surface of the sand is well preserved and the upper layers are exposed in numerous railroad cuts in the vicinity.

In places the early valley fill rests upon an old alluvium that is locally coarse; in other places it rests upon more or less deeply eroded glacial till; and in still other places it lies directly upon bedrock. No fossils or concretions were found in the sandy portion, but the clay is locally fossiliferous and generally contains irregular masses of lime.

Thick loess.—On the high hills near the Mississippi there is a heavy deposit of loess, a fine-grained, massive yellowish earth or loam or very fine sand. Its maximum thickness is 40 or 50 feet. It shows little plasticity when wet, and it is soft, powdery, and smooth to the feel when dry. It does not seem to be stratified and resembles and is no doubt to be correlated with the common loess of the Mississippi Valley farther north. It contains land shells and lime concretions, or "loess-kindchen," and, like most loess, is rather calcareous.

Its extent in the quadrangles is not great, for it is found for only about 2 miles from the Mississippi bluffs and thus covers a total area of only a few square miles. Its altitude is mostly 700 to 750 feet above sea level. A remarkable and characteristic feature of the loess here as elsewhere is its tendency to weather into steep, commonly vertical cliffs. Such cliffs 10 feet or more in height may be seen along the road 1 mile northeast of Grimsby.

The uppermost foot or two of the loess is very porous and is mixed with humus, having no doubt been modified by vegetation and other agencies of weathering. At a depth of 2 to 5 feet it is much more compact and indeed clayey, tending to be hard and to break into blocks when dry. The finest parts of the surface loess appear to have been carried down a few feet, leaving a comparatively coarse and loose layer at the surface and forming lower down a secondary compact layer, whose interstices are filled with the fine particles. Below 5 feet or so the loess is more typical and medium grained.

Samples of loess taken from a road cut a mile northeast of Grimsby have been subjected to mechanical analysis by the ceramics department of the University of Illinois and the results are given in the table below. In the second column the sizes of particles determined are shown, the numbers 20 to 120 signifying the number of wires to the inch in the sieves on which they are caught; the other sizes, left in cans numbered I, II, and III, though not known with exactness, become progressively finer. The apparatus for sorting these very fine particles makes use of a slow and uniform current of water. The figures in the third column indicate the percentage (by weight) of each size. The fourth column gives the surface area of the particles in millimeters for each one-thousandth of a gram; and the fifth gives the product of the surface factor into the percentage weight of each size. The total of the fifth column for each sample gives the total surface area of all particles in a unit amount of material. The sixth column gives the relative colloid value as determined from Ashley's standard curve. In the opinion of Ashley, the relative amount of colloid (jelly-like) matter in unit weight of clay may be found by determining the amount of malachite green adsorbed from a solution containing 3 grams of this substance per liter. By taking a very plastic clay (Tennessee ball clay) as the standard for comparison, the relative colloid value is made to express the colloid content compared with the standard.

Mechanical analyses of loess from road cut a mile northeast of Grimsby.[a]

	Size of particles (screen number).	Weight in per cent of whole.	Surface factor (surface area in mm. for each $\frac{1}{1000}$ gram).	Product (surface factor times weight in per cent).	Relative colloid value.	Dye adsorbed (grams).
	20	.08	.01	.0008		
	40	.14	.0153	.0021		
	60	.22	.0308	.0067		
	80	.12	.0472	.0057		
	100	.04	.0630	.0025		
Loess 1 foot below surface.	120	.20	.0805	.0016		
	Can I	16.08	.1732	2.7850		
	Can II	52.08	.2822	14.6969		
	Can III	5.86	.5985	3.5072		
	Fines	25.18	2.000	50.3600		
				71.3685	16	0.88
	20	.08	.01	.0008		
	40	.14	.0153	.0021		
	60	.10	.0308	.0031		
	80	.04	.0472	.0019		
	100	.04	.0630	.0025		
Loess 2 feet below surface.	120	.14	.0805	.0113		
	Can I	23.06	.1732	3.9939		
	Can II	39.24	.2822	10.0735		
	Can III	14.98	.5985	8.9655		
	Fines	22.18	2.000	44.3600		
				67.4146	28	1.85
	20	.28	.01	.0028		
	40	.24	.0153	.0037		
	60	.14	.0308	.0043		
	80	.06	.0472	.0028		
	100	.04	.0630	.0025		
Loess 3 feet below surface.	120	.12	.0805	.0097		
	Can I	22.08	.1732	3.8242		
	Can II	35.78	.2822	10.0971		
	Can III	12.74	.5985	7.6249		
	Fines	28.52	2.000	57.0400		
				78.6120	12	.66
	20	.10	.01	.0010		
	40	.06	.0153	.0009		
	60	.06	.0308	.0018		
	80	.02	.0472	.0009		
	100	.02	.0630	.0013		
Loess 4 feet below surface.	120	.12	.0805	.0096		
	Can I	26.10	.1732	4.5205		
	Can II	37.12	.2822	10.4752		
	Can III	1.10	.5985	.6583		
	Fines	35.30	2.0000	70.6000		
				86.2695	19	1.20
	20	.12	.01	.0012		
	40	.06	.0153	.0009		
	60	.08	.0308	.0002		
	80	.10	.0472	.0047		
	100	.06	.0630	.0004		
Loess 10 feet below surface.	120	.30	.0805	.0024		
	Can I	37.60	.1732	6.5110		
	Can II	44.62	.2822	12.5917		
	Can III	1.30	.5985	.7780		
	Fines	15.76	2.000	31.5200		
				51.4105	20	1.25

[a] Made by ceramics department, University of Illinois.

One of the most interesting facts shown by these analyses is the confirmation of the inference that fine particles are being carried down from the surface to a position a few feet below the surface. The materials taken in the order of their depth below the surface contain about 25, 22, 29, 35, and 16 per cent of extremely fine particles. It appears not only that fine particles are being carried down a few feet, but that many are formed near the surface. The distribution is such as would result, for example, if the original amount of fine particles had been 15 per cent, and if the fine material formed at and near the surface, perhaps by the work of plants and frost, had been in a continual process of being carried down a few feet, the maximum amount being dropped about 4 feet below the surface.

The carrying down of the finest particles to a position a few feet below the surface results, particularly in the thin loess, in the production of a hard, impervious subsoil, commonly known as hardpan though it is very different from the iron-cemented hardpan known elsewhere. In places where the hardpan is best developed the vegetation consists almost entirely of the oak *Quercus obtusiloba*, and such districts are commonly referred to as "post-oak flats." This tree is not found on the more porous loess.

Thin loess.—Extending many miles northeast from the narrow belt of deep loess bordering the Mississippi is a persistent deposit of fine, yellow, apparently wind-borne material covering hill and valley but differing from the deep loess in being plastic when wet and hard when dry. It resembles the compact portion of the loess above described. It generally rests upon the glacial till but is found also on and fingering in between other deposits.

Throughout a large part of the area of its occurrence the thin loess is about 10 feet thick, but in a belt about 20 miles wide parallel to the thick loess area it thickens to the southwest, and a few miles from the river it seems to grade laterally into the typical thick loess. The two are therefore thought to be phases of the same deposit. If both were derived from the flood plain of the Mississippi the differences may be due to a sorting process, the material dropped nearest the river being the coarsest. It seems also possible that the character of the two kinds of loess may have been due, in part at least, to the conditions under which each was deposited. The thick loess was deposited on high, rough, well-drained, and possibly forested country, whereas the thin loess was developed on low, flat, poorly drained, and possibly nonforested lands.

Origin of the loess.—The two phases of the loess appear to have had a common origin, the thinner, more clayey inland phase seeming to thicken and become more powdery and calcareous toward the rivers and to grade into the typical thick loess of the river bluffs. The mode of accumulation of the two, however, has for years been a problem for which no complete and satisfactory solution has ever been reached, opinion seeming to be about evenly divided in ascribing their origin to wind and to water.

In favor of a water origin is the fact that some loess or loesslike material is stratified and contains pebbles and aquatic fossils. In favor of a wind origin are the facts that nearly all the fossils are the remains of land animals and that the distribution of the material indicates deposition by wind rather than by water. It is thicker on the high hills that border the rivers than on the lowland 20 to 100 miles distant, and it is thickest on the east and north or windward sides of the river valleys. Furthermore, if it had been deposited by water the highest hills must have been submerged. At present the eolian hypothesis seems to be in better favor, but many observers still believe that at least a large part of the loess must have been deposited by water.

For the upland loess to be of aqueous origin, would require streams several hundred feet deep. Moreover, though most of southern Illinois lies below the altitude of the principal deposits of loess on the river bluffs, and though (for there seems to have been little or no post-Illinoian warping here) this region must also have been under water, yet throughout the southwestern part of the State the loess does not appear to be stratified or to show other evidence of aqueous origin.

In the Murphysboro and Herrin quadrangles neither the ordinary heavy loess on the river bluffs nor the thinner and more clayey variety in the lowland shows stratification or other characters that would indicate that it was deposited by water. Both cover hills and valleys alike except that, owing probably to erosion, each is now somewhat thicker on the hills than in the valleys. Neither is interbedded with sand or gravel and neither has a terrace form. All the fossils found were those of woodland snails, which are air-breathing animals. It therefore seems probable that the loess of this part of Illinois is wind deposited. Elsewhere the loess may include local water deposits, but its character and surface features throughout southern Illinois seem very different from those which would result from a general submergence. The difference, for example, between the loess and the valley filling is very marked. Moreover, the hypothesis of submergence involves important physical difficulties which can not be discussed in detail here.

Still another possible source of part of the loess is found in the work of earthworms. In making their borings these worms continually bring fine material to the surface, and the result of many thousands of years of such work may be a considerable layer. The process is opposed by erosion, which tends to carry away fine material from the surface, and it is limited by the depth to which worms penetrate. The presence of scattered quartz pebbles in the basal few feet of the loess may be reasonably explained as due to the burial of coarser material by worm work, though it may also be explained as the result of a combination of wind and water work. Presumably the loess is not solely or even in large part the work of worms. In many places along the river bluffs the uppermost part grades into sand dunes and these are certainly wind deposited.

Source of the loess.—The source of the loess is an even more difficult problem. Those who have worked most on it incline toward the belief that it was carried up as dust from the river flood plains. Supporting this view are the facts that the loess is not only thickest on the river bluffs but thicker on the side opposite the direction from which the prevailing winds blow, and that in this region dry river bars are today productive sources of dust. At the time of loess accumulation the river bluffs may have been, as they are now, forest covered, and the trees may have played an important part in catching and holding the dust.

The difference between the loess bordering the large rivers and that distant from them may be due either to differences in the conditions under which the two were deposited and to which they have since been subjected (such as the presence or absence of forests or other vegetation, and the amount of moisture) or it may be due to wind sorting. Under the hypothesis that most or all of the loess was derived from the large valley bottoms, the coarser dust would no doubt have been dropped first. Incidentally, if there were some chemical difference between the coarse particles as a whole and the fine particles as a whole, the resulting deposits would differ not only physically but chemically. As a matter of fact, as already indicated, such differences, both chemical and physical, do exist, but that they are due to wind sorting has not been demonstrated.

On the other hand, that all or nearly all the loess was derived from stream-deposited silt seems doubtful on account of the great volume of the loess. It now covers large parts of several States to a depth of a few feet and may have originally covered these areas to an average depth of 15 feet or even more. It seems hardly believable that such a mass could, in a small part of one period, have been blown up by wind from the river channels. A part of the loess may have come from the dry plains to the west and perhaps a part from glacial till before it became covered with vegetation.

Later valley deposit.—Upon the deeply eroded surface of the earlier valley filling lies, apparently, a later deposit, ranging in thickness from a few feet on the upper stream courses and tributaries to about 70 feet near the Mississippi. The base seems to be little above and the upper surface about 20 feet below the base and top respectively of the earlier and more sandy deposit.

On the bank of Muddy River, a mile southeast of Royalton, several Pleistocene formations are exposed, as indicated in the following section:

Section of Pleistocene materials exposed in the SW. ¼ SE. ¼ sec. 33, T. 7 S., R. 1 E.

	Feet.
5. Clay, greenish gray, lime concretions (later fill)	20
4. Clay, light, yellowish (loess)	6
3. Sand and gravel stratified (earlier fill)	7
2. Gravel and clay, unassorted, light-yellowish gray (Illinoian till)	5
1. Gravel and clay, unassorted, dark-bluish gray (Illinoian till?)	9

The late valley fill consists largely of a limy clay, greenish gray to purple in color, which along the middle stream courses, is not distinguishable from the early fill. The lower part, in which the purplish tints are developed, is commonly evenly stratified and in places finely laminated. The upper part is characterized by numerous irregular concretionary masses of lime. Lenses of fine sand lie around the border of the deposit and sand forms a large part of the deposit in the delta at Murphysboro, though it forms only a small part of the formation considered as a whole. With the exception of the concretionary lime, some particles of which are as small as sand grains, much of the deposit is without perceptible grit. The following sections show the character of the surficial material near Murphysboro:

Sections showing character of surficial material in the southwest corner of the SE. ¼ NE. ¼ sec. 4, T. 9 S., R. 2 W., near Murphysboro.

	Feet.
Clay, yellow, sandy	18
Clay, gray	10
Clay, gray, sandy	1
Sand, yellow	6
Clay, blue, sandy	15
Clay, red	16
Clay, gray, sandy	1
Clay, red	2
Clay, gray, sandy	15
Clay, brown, sandy	4
Clay, green, sandy	4
Sand, yellow, and gravel, mixed	5½
Shale, yellow, sandy	½
Shale, gray, sandy	13

Section in SE. ¼ sec. 3, 500 feet from center of SW. ¼ sec. 3, T. 9 S., R. 2 W.

	Feet.
Clay, gray	15
Clay, yellow, sandy	2
Clay, blue, sandy	23
Sand and clay mixed	10
Quicksand	5
Clay, blue, sandy	5
Quicksand and gravel mixed	5
Clay, red	11
Quicksand	2
Clay, red, and sand mixed	8
Shale, blue, sandy	½
Sand, clay, and coal mixed	5½
Shale, blue, sandy, with concretions	17

The late valley fill is found along all the principal streams in the region, extending from the Mississippi bottoms 20 miles or more up the valleys and finally merging into the flood-plain deposit. Its width is generally about 2 miles. Excellent exposures may be seen on Beaucoup Creek just west of Grubbs and 3 miles south of Vergennes, on Craborchard Creek 3 miles southeast of De Soto, and on Muddy River 1 mile southeast of Royalton.

The following fossil shells determined by Dall were collected on Beaucoup Creek at 30 to 40 feet below the top of the formation:

Shells from valley filling near Grubbs:
- Aquatic species:
  - Campeloma decisum Say.
  - Lioplex subcarinata Say.
  - Somatogyrus subglobosus Say.
  - Amnicola limosa Say.
  - Valvata tricarinata Say.
  - Pomatiopsis lapidaria Say.
  - Lymnæa desidiosa Say.
  - Planorbis bicarinatus Say.
  - Segmentina armigera Say.
  - Planorbis deflectus Say.
  - Sphærium stamineum Conrad.
  - Corneocyclas sp.

Shells from valley filling 3 miles south of Vergennes:
- Aquatic species:
  - Campeloma decisum Say.
  - Somatogyrus subglobosus.
  - Amnicola limosa Say.
  - Valvata tricarinata Say.
  - Pomatiopsis lapidaria Say.
  - Lymnæa desidiosa Say.
  - Planorbis bicarinatus Say.
  - Segmentina armigera Say.
  - Planorbis deflectus Say.
  - Sphærium stamineum Conrad.
  - Corneocyclas sp.
  - Ancylus tardus Say.
- Pulmonates:
  - Zonitoides minuscula Binney.
  - Pyramidula anthonyi Pillsbury.
  - Vertigo gouldii Morse.
  - Succinea sp.

Most of the aquatic species named inhabit lagoons and quiet parts of streams. One of them (*Campeloma*) is a scavenger living on decaying animal matter. Others, particularly *Amnicola* and *Valvata*, frequent lily ponds. Some, such as *Vertigo*, are northern forms, being found at present from Wisconsin northward. *Sphærium* is found to-day in southern Illinois on the mud bottoms of pools.

Sand dunes.—The upper part of the early valley fill has in some places been partly resorted by wind. Two to four miles northeast of Murphysboro the surface of the sand is undulating, as though sand dunes had started to develop but had failed to become large enough to be mappable.

RECENT SERIES.

Alluvium.—Flood plains or "first bottoms" are found along almost all the streams of the Murphysboro and Herrin quadrangles. In the hills the recent alluvium is made up of subangular pebbles of sandstone and shale interbedded with sand and silt, but in the lowland it is composed of silt, much of which is fine and more or less colloidal and hence is properly called a clay. The streams are muddy the year round, the sediment being gathered largely from the valley filling but also from the loess of the upland; much of it is so fine that it will pass through filter paper. Currents are not strong enough to move pebbles except those which are nearly round. Most stones therefore lie until they disintegrate before they are carried away.

Rainwash.—In favorable situations, particularly where one of the broad flat terraces is developed close to the base of a hill or group of hills, deposits have apparently been built by rainwash from the steeper surfaces above. The material consists principally of whitish silt or clay, but in places contains considerable sand and some gravel. The deposit is lenticular in shape, the hillward edge thinning out somewhat abruptly and the opposite edge being more attenuated. It resembles a glacial outwash apron on a small scale. The thickest part commonly measures 10 feet or more and the upper surface is gently sloping. The deposits just above the flood plain at the foot of the Mississippi bluff are probably in part of eolian origin; for winds blowing across the dry bars of the Mississippi now as in former times carry dust to the bluffs, where they are checked and drop a part of their dust. Part of the material, however, seems to be coarser and to have been washed from the steep slope above.

The rainwash, where best developed in the interior lowland, contains throughout its extent small concretions of both iron and manganese oxide which commonly contain some sand and are locally known as "buckshot." These concretions are found scattered over the surfaces above the rainwash even to flat summits of some of the lowest hills, and therefore were probably not developed in the rainwash. But whether they formed in the material before it began to be moved or while it was in transit has not been determined.

Recent lake deposits.—In the bottom land of the Mississippi are several lake beds which have been recently drained. The deposit in these lake beds, which consists of partly decomposed plant remains mingled with fine silt, is brown and is in places i15 feet or more in thickness. Its large organic content makes t the most fertile land in southern Illinois.

STRUCTURE.

REPRESENTATION OF STRUCTURE.

Methods employed.—Geologic structure is commonly represented in two ways—by cross sections and by structure 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 very low and faulting is almost or quite lacking they are of small value, the structural features shown on them being almost imperceptible. In such regions contour lines show the structure more clearly.

Delineation by structure contours.—For the delineation of structure by means of contours it is necessary to choose an easily recognizable reference stratum whose position is well known through outcrops or borings. The altitude and dip of the surface of this stratum are determined at as many points as possible, and points of equal altitude are connected by lines on the map drawn in the same manner as surface contour lines. The direction of dip is thus at right angles to the contour line. 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 as a rule 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 elevation may be determined and the elevation of the reference stratum calculated therefrom by subtracting 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 interval is added, thus giving the approximate elevation at which the reference layer would lie if it were present. An intersection of a surface contour with a structure contour of the same altitude marks a point of outcrop of the reference stratum.

Uses of structure contours.—The structure map is of use not only for the study of broad structural problems and for conveying an abstract knowledge of the structure of the region but also for the practical aid it gives in locating and recognizing valuable beds and for determining 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 elevation of the reference stratum, the approximate position of any bed at any point by adding or subtracting, according to whether the bed is above or below the key rock, the average distance between the two as given. The map may be used in this way for locating coal, clay, limestone, and oil-bearing and gas-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. It gives information that is useful in the selection of locations for mine shafts, for the dip of the coal bed affects very greatly the cost of drainage and haulage.

Reliability of structure contours.—The reliability of the structure contours is affected (1) by the accuracy of the surface elevations; (2) by the variability of the calculated intervals between the key rocks; and (3) by the number and distributions of the points whose altitudes are known.

In the Murphysboro and Herrin quadrangles the surface elevations are accurately known. The reference strata are coal beds which have been extensively worked and whose depth below the surface has been noted in numerous shafts, wells, and drill holes. At most such points the altitude of the surface was obtained by hand level or barometer from some of the numerous bench marks, and the determinations have involved short horizontal distances and small possibilities of error.

The variability of the intervals between the strata is more likely to lead to mistake. However, the interval between any two strata does not seem to vary more than about 20 feet and, curiously enough, does not seem to vary much more between strata that are far apart than between those that are close together.

On account of the scarcity of outcrops artificial excavations are the principal sources of information and these are not so numerous as might be desired. They are fairly evenly distributed, however, so that the error arising from the scarcity of determined altitudes of recognizable strata is probably not great.

The dip of the coal in mines also affords some information for working out the structure, though the assumption of a uniform dip between determined points may be a source of slight error. A few faults having a throw of 8 to 22 feet, local irregularities in dip, and low folds were found in some of the coal mines and in a few surface exposures. (See figs. 7 and 8.) Local irregularities such as these do not appear in the structure contours on the geologic map.

The probability of error in the map is greater where the test holes of which records were obtained are a considerable distance apart, as in the vicinity of Little Muddy River, in the northeast portion of each quadrangle, and in hilly country from which the reference strata have been eroded away. Such areas, where the data are so meager as to leave reasonable doubt as to the structure are mapped with broken contour lines. However, in general, the errors from the above-mentioned causes are not so great as to amount to one contour interval, or 25

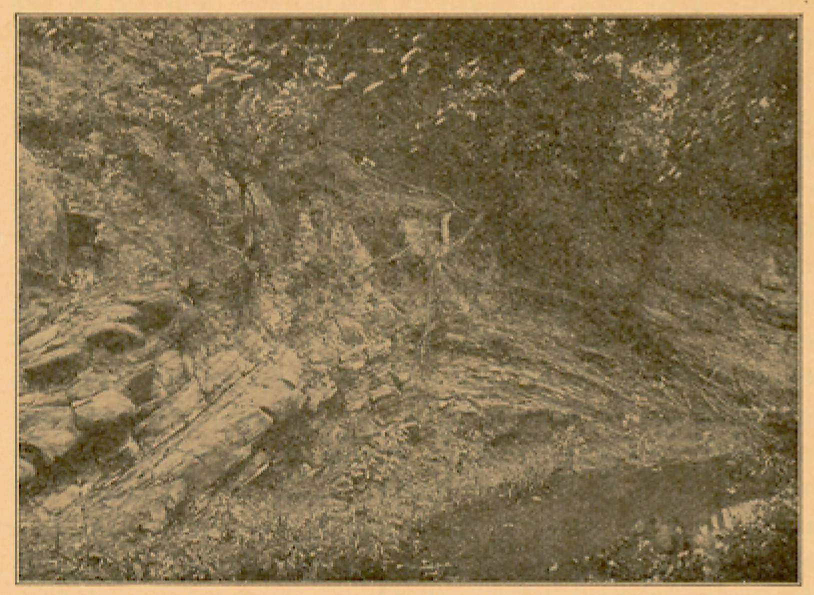


FIGURE 7.—Small anticlinal arch in shales of the Carbondale formation, exposed 2 miles south of Herrin.

feet, and it is assumed that the general attitude of the coal beds and thus the general structure of the Pennsylvanian strata in the area are essentially as shown on the map.

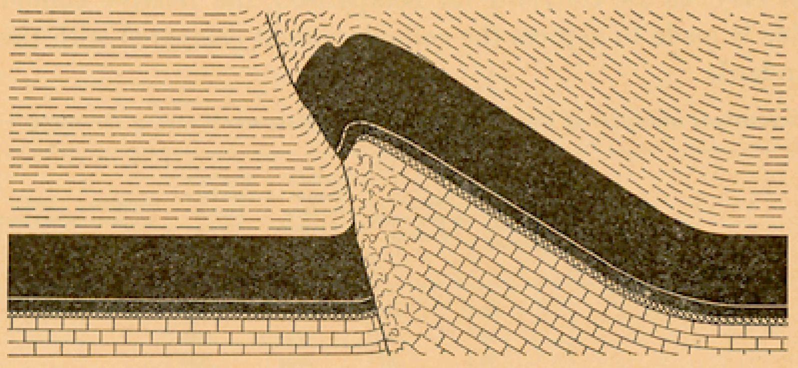


FIGURE 8.—Small thrust fault exposed in mine B of the Chicago & Carterville Coal Co., 2 miles northeast of Herrin.

STRUCTURE OF THE MURPHYSBORO AND HERRIN QUADRANGLES.

General features.—The structure of the Murphysboro and Herrin quadrangles is dominated by an uplift in their southwestern part which results in a general northeastern dip. The horizon of the top of the Pottsville sandstone, for instance, which is 850 feet above sea level near Grimsby, drops to nearly 400 feet below in the northeast corner of the Herrin quadrangle. The area of greatest uplift is flanked on the east by steeply dipping strata and is terminated on the north by a fault of 100 to 200 feet throw. The dips vary from a fraction of a degree to as much as 10°, or 1 foot in 6, the steepest dips being found along the eastern and northern borders of the hilly country. The average slope of the strata is 50 to 75 feet to the mile, or somewhat less than 1°.

Murphysboro quadrangle.—The structure of the Murphysboro quadrangle is shown by the use of contour lines drawn on the floor of the Murphysboro coal. The vertical interval between two adjacent contours is 25 feet. Widely spaced contours indicate a gentle dip of the strata, whereas crowded contours indicate a steep dip. The accuracy of the indicated elevations varies from place to place. In the vicinity of Murphysboro drill holes are numerous and the exact position of the coal is known. Along the base of the hills the coal is exposed at many points, at all of which careful measurements of its elevation and dip were made. But in the southwestern quarter of the quadrangle the coal has been eroded away from the tops of the hills, and in the eastern and northern parts considerable areas have no exposures of recognizable strata and no available drill records. In such places the contours may be in error 25 feet or more, vertically.

The general northeast dip of the strata is modified by many more or less pronounced irregularities. The most important of these are (1) an unsymmetrical broad anticline between Grimsby and Ava, whose western limb is low and gentle and whose eastern limb is high and steep, the strata in one place

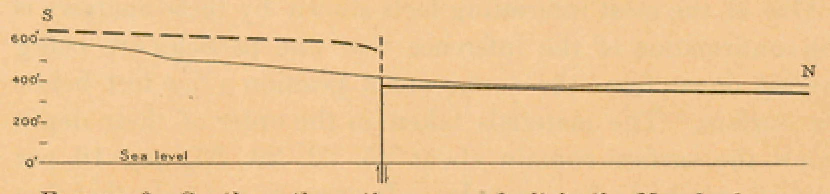


FIGURE 9.—South-north section across fault in the Murphysboro quadrangle.

Shows the offset in the Murphysboro coal (heavy black line) at the base of the Carbondale formation. South of the fault, where the coal has been removed by erosion, its former position is indicated by dashes.

Horizontal scale: 3 inches = approximately 1 mile.

descending over 300 feet in a mile; (2) a broad, somewhat irregular syncline, plunging northeastward and extending from Grimsby to the eastern side of the quadrangle; (3) an east-west syncline just north of Ava; (4) an anticline lying just north of the syncline last mentioned and extending east, curving somewhat to the north, to the northeast corner of the quadrangle; (5) an east-west fault of 100 to 200 feet throw, cutting the north limb of anticline No. 4 (see fig. 9); (6) a syncline just north of the fault, with a branch extending north to the quadrangle boundary.

Herrin quadrangle.—The structure of the strata in the Herrin quadrangle has been worked out from the study of about 200 records of test borings, coal shafts, and water wells in the area, the base of the Herrin coal being used for a reference stratum. This coal is easily recognized in the records, and it is found in nearly every test boring north of its line of outcrop.

In the southern part of the quadrangle the strata dip strongly toward the north, whereas near the western border, from De Soto north, they slope steeply toward the east. Notwithstanding this dominantly north and east slope of the strata, local changes in the direction and degree of dip are not rare. In one area near the northwest corner of the quadrangle the eastward dip of the coal exceeds 200 feet to the mile; in other areas it is less than 25 feet to the mile. The average dip per mile probably does not exceed 40 feet.

The most conspicuous irregularities of structure appear in the northwest quarter of the quadrangle. A marked change appears in the dip in sec. 26, T. 7 S., R. 1 W., where within 1 mile east from the border of sec. 27 coal No. 6 rises 150 feet. Still farther east the general dip of the strata is eastward. On the structure map this abrupt rise of the strata is represented as a short, domelike arch. About 7 miles farther north the records of borings in secs. 23, 24, and 25, T. 6 S., R. 1 W., indicate a corresponding arch 100 feet high. (See fig. 10.)

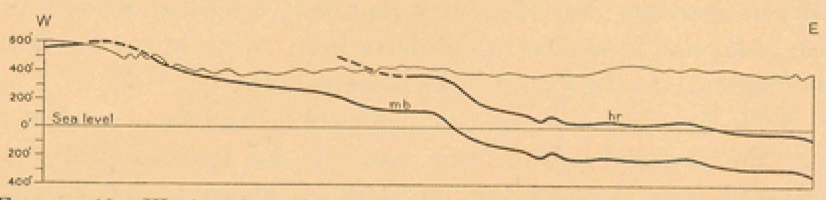


FIGURE 10.—West-east section across the Murphysboro and Herrin quadrangles through Christopher.

Shows position and structure of the Herrin coal, hr, and Murphysboro coal, mb, based on well records.

Horizontal scale: 3 inches = approximately 1 mile.

The absence of borings between the two localities leaves uncertain the true character and relation of these irregularities. It is probable, however, that they are parts of a single continuous anticline, the axis of which is parallel to the strike of the steeply dipping strata farther west.

GEOLOGIC HISTORY.

PALEOZOIC ERA.

GENERAL FEATURES.

The lower Paleozoic strata of the region were chiefly laid down in an arm of the sea extending northward from the Gulf of Mexico. The coast line oscillated with the uplifts and depressions of the land, sometimes lying farther north than the quadrangles under consideration and again moving southward beyond their limits. During the periods of submergence beds of more or less broken-up shells and layers of mud and sand accumulated and became limestone, shale, and sandstone through consolidation by the pressure of overlying beds and through cementation by calcium carbonate or iron oxide deposited from percolating water. During the intervals of emergence the surface was subjected to erosion and as a consequence the geologic sequence shows numerous erosional unconformities.

The basin lay immediately east of the Ozarkian land mass, which during much of the time formed its western margin. Movements of the strand line were registered clearly, even minor oscillations being recorded. The frequent oscillations are especially well recorded in the Pennsylvanian deposits, which contain numerous coal beds separated by marine sediments, but the many movements of the strand line indicated during late Ordovician and early Silurian time show that oscillations were not peculiar to the Pennsylvanian epoch, and it seems probable that they occurred frequently throughout the Paleozoic era. The general scarcity of records of such oscillations may be largely due to the facts that deposits in shallow water near shore are not formed over large areas and that such deposits, if formed, are most likely to be removed by subsequent erosion.

ORDOVICIAN PERIOD.

The oldest strata exposed in the vicinity of the Murphysboro and Herrin quadrangles were formed during a period of widespread submergence. The sea water was clear and the conditions were favorable for the luxuriant growth of marine organisms secreting calcareous shells. As a result the thick beds of limestone which constitute the Plattin and Kimmswick limestones of the Mohawkian (Middle Ordovician) series were laid down. This deposition was closed by an extensive emergence which lasted throughout the Mohawkian and much of the Cincinnatian epochs.

In early Richmond time a clear sea, peopled with abundant shell-bearing life, again advanced over the region, and a limestone bed, the Fernvale limestone, a few feet thick but widely distributed, was deposited upon the eroded surface of the Kimmswick. The deposition of this limestone was likewise

terminated by emergence, but the elevation was not sufficient to permit much denudation of the surface.

Subsequent warping resulted in the uplift and accelerated erosion of an area in the Ozark region, to the west, and an accompanying depression in the Mississippi embayment that permitted the sea again to advance over southern Illinois. The streams draining the bordering lands carried into the basin much coarse detritus, which now forms the Thebes sandstone. The deposition of this sand was followed by another emergence and then by another subsidence that permitted the laying down of the mud which now forms the Orchard Creek shale of Savage. The Girardeau limestone, which overlies this shale, is thought to have been laid down upon an eroded surface of that formation.

After a relatively short emergence, succeeding the deposition of the Girardeau limestone, another incursion of the sea spread a series of argillaceous and calcareous layers, constituting the Edgewood formation of Savage, over a narrow belt. These two formations are regarded by Savage and others as Silurian.

SILURIAN PERIOD.

Land conditions prevailed for a considerable time and in some places erosion had extended down almost to the Thebes sandstone before the deposition of the next sediments. The sea that next advanced northward over the area extended well to the north, spreading from southern Indiana and Ohio to Oklahoma. The water was relatively clear and the calcareous deposits are of early Niagaran (Clinton) age.

After the deposition of these strata the sea withdrew from the region for the remainder of the Silurian period. The southern shore of the Niagaran sea, in which the Niagara dolomite or limestone of the upper Mississippi Valley was laid down, was at about the latitude of St. Louis. No Silurian deposits later than those of early Niagaran (Clinton) time are found in southwestern Illinois.

DEVONIAN PERIOD.

In early Devonian time the sea again advanced from the south beyond Jackson County, Ill., and deposits of New Scotland (early Helderbergian) age were laid down. This deposition was closed by the withdrawal of the sea southward, the region being a land surface during the remaining Helderbergian and early Oriskany time. Near the middle of Oriskany time the sea again covered the region, and a thick bed of calcareous mud, later almost entirely replaced by chert (the Clear Creek limestone of the Illinois State Survey) was deposited. Evidence that the formation was at first calcareous is found in the numerous casts of shells in the chert layers and in the fact that in places the replacement is not complete, the strata merging along the strike from chert into siliceous limestone.

Deposition in Oriskany time was brought to a close by oscillatory movements that increased the elevation of the bordering land but did not banish the sea from the basin. Such movements are indicated by the interwedging of the upper layers of the deposits of this epoch with sandstone like that of the overlying strata of Onondaga age. Subsequently more stable conditions prevailed and the basal sandstone of Onondaga time was spread over the region. After its deposition further warping resulted in local changes of the shore line, but sedimentation continued over the greater part of the basin, and the sandy sediments were succeeded by almost pure limestone.

In some places a stratigraphic break occurs between the strata of Onondaga age and those of the succeeding Hamilton time, but in others deposition appears to have been continuous from late Onondaga until early Upper Devonian time. A land period intervened between the deposition of the earlier, restricted, and more calcareous Upper Devonian and the more widespread, barren, fissile shale overlying it.

CARBONIFEROUS PERIOD.

MISSISSIPPIAN TIME.

The land conditions that prevailed between the deposition of the uppermost Devonian and the lowest Mississippian strata in the region were followed by extensive submergence during the Mississippian epoch. During Kinderhook time some of the bordering land was sufficiently high to cause the streams to carry a considerable quantity of sand and clay. At the close of Kinderhook and during Osage time the water was receding and becoming clearer, so that the deposits of that time consist largely of limestone. At the close of the Osage the sea withdrew from the region. When the embayment was again submerged the bordering land was low and the Warsaw shale was laid down, after which the water cleared and pure calcareous sediment (the Spergen limestone, parts of which consist mainly of oolite) accumulated. During the succeeding St. Louis epoch the sea continued to deepen and to encroach northward, reaching as far as central Iowa. At the close of St. Louis time the water withdrew by a series of oscillations accompanied by the accumulation of a succession of oolite beds similar to the Spergen, with a sandy member near the middle. These make up the Ste. Genevieve limestone. After a considerable land interval further warping raised the bordering land but permitted the sea again to advance nearly as far north as St. Louis. The Cypress sandstone, Tribune limestone, and Birdsville formation were deposited during this submergence.

PENNSYLVANIAN TIME.

Pottsville epoch.—For a long period after the Chester submergence the region was land, and the surface, though it did not stand at a high altitude, was much trenched by stream valleys. Warping was followed by the beginning of Pennsylvanian deposition, which later covered extensive areas in the northern part of the basin. Early in Pennsylvanian time the sedimentation in this region was confined to a rather narrow area in the eastern interior coal field in Illinois and western Kentucky, but later it slowly spread northward and eastward. Most of the sediments laid down in the Pottsville epoch are terrigenous and their deposition was probably due to unusually extensive and rapid warping. The sand and mud thus deposited constitute the Pottsville sandstone. The source of these comparatively coarse sediments was doubtless in part rocks of the Chester group a short distance to the west, where erosion had not ceased. Some marshes developed, and in these enough vegetal material accumulated to form coal seams.

Carbondale epoch.—During the Carbondale epoch the sea alternately submerged the region, depositing shale, limestone, and perhaps sandstone, and retreated for longer or shorter periods, during which the surface was either so low and flat or bore such relation to the surrounding land that fresh-water swamps covered extensive areas and sand and mud were laid down above sea level. In these swamps beds of vegetal matter, since transformed into coal, accumulated.

At the beginning of the Carbondale epoch the area was a general peat marsh, though parts of it were apparently drained. The peat, after attaining a thickness of 10 to 20 feet or more, was buried beneath the layers of mud, which compressed it and began its transformation into coal. Next, a warping of the earth's surface, or some other change, caused a great body of sand to be spread over much of the area. This sand, now forming the Vergennes sandstone member, was thickest in the central part of the Murphysboro quadrangle. Sedimentation continued, at one time a little above sea level and at another time a little below it, and small peat marshes developed here and there until late in the epoch, when the material now forming the Harrisburg coal accumulated.

It is probable that the vegetal accumulation that now forms the Harrisburg coal was stopped by a slight general subsidence which permitted a broad but shallow sea to advance over the region from the south. Owing to the slight relief of the bordering lands, but little sediment was discharged into the basin, and this little was fine material. As the waters advanced over the old swamp deposit they worked over the upper surface of the vegetal accumulation, comminuting the material and mixing it thoroughly with the fine land-derived sediment and finally laying it down in thin laminated bands of black carbonaceous clay. As the deposit of this clay became thicker, the amount of vegetal material reached by the waves decreased, and conditions became more favorable for the growth of organisms and for the preservation of calcareous shells that become buried in the sediments. As a consequence a bed of argillaceous limestone generally accumulated above the black shale. More mud and sand layers were then formed, and at the close of the epoch the region again became a continuous peat swamp, in which the material now forming the Herrin coal accumulated.

McLeansboro epoch.—Conditions such as prevailed in the Carbondale epoch continued in the McLeansboro without much change, except that peat formation was less widespread and of shorter duration. The strata laid down consisted mainly of more or less sandy mud and interbedded sand with subordinate but considerable amounts of limestone.

Peat forms today only in quiet shallow water in climates that are neither very dry nor very warm, for in both such climates plant material generally decays. Presumably in the large marshes of Carboniferous time the water was kept quiet by the growing vegetation, but perhaps at times and places peat did not form because the water was a little too deep for the growth of peat-yielding plants.

At the opening of the epoch the area was part of a great almost unbroken peat swamp in which the material for the Herrin coal had just been formed. This was buried under mud, which was covered by a bed of lime secreted by marine organisms. There is some indication of emergence and erosion at this time, and no doubt there was at least local emergence later, in the McLeansboro epoch. The kind of material deposited at any place changed from time to time, the most widespread material forming a thick, predominantly sandy bed, and a relatively thin bed of lime—now the Shoal Creek limestone member. How long sedimentation continued after the close of the Shoal Creek deposition is not known, for all of the record except that preserved in the few feet of overlying strata has been destroyed.

PERMIAN TIME.

Events in the later part of Pennsylvanian and in Permian time are unknown, but probably no thick deposits were made, for no traces of such deposits are found in surrounding territory. Very likely the area was low and stood in such relations to surrounding territory that no sediments were laid down.

POST-CARBONIFEROUS DEFORMATION.

Carboniferous deposition in the region was closed by widespread movements which resulted in the uplift of the Appalachian Mountains on the east and the Ouachita Mountains and the Ozark dome on the west, the further uplift of the La Salle anticline in eastern Illinois, and the permanent withdrawal of the sea. The effect of these movements was to tilt the strata in the Murphysboro and Herrin quadrangles gently to the northeast, causing them to decline in that direction about 1000 feet. Before this uplifting the region had stood most of the time so near sea level that slight movements up or down were recorded by the erosion or deposition of sediments. But since Carboniferous time the region has stood so high that the moderate vertical movements, although affecting stream erosion to some extent, did not admit the sea and left a comparatively obscure record.

MESOZOIC ERA.

GENERAL FEATURES.

The deformation at the close of Carboniferous time greatly increased the general altitude of central and eastern United States and elevated the surface of the Murphysboro and Herrin quadrangles from approximately sea level to a position a few hundred feet above it. New processes began to act and areas which before had almost continuously received rock material began to lose it. Erosion has continued practically without interruption to the present time, though at several epochs it has probably been accelerated by uplifts. No reliable evidence of any general subsidence has been found.

In the Appalachian Mountains and in the Ozarks great uplifts at times took place, many or all of which may have affected southern Illinois, though to a much less extent. Between and during these uplifts the surface was reduced many hundreds of feet by erosion, hills being carved and later reduced nearly to a plain. 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 cycle. Moreover, all possible stages in reduction occurred, and the less complete the cycle the more easily was its record obliterated. The facts that in most of Illinois the uplifts were not great and that most of the rocks are nonresistant account for the poor preservation of the records. In the Appalachian and Ozark provinces the record is better preserved by harder rocks but has not yet been thoroughly worked out.

In the Appalachian province the largest and most perfect of the peneplains of which there is good evidence seems to pass beneath the Cretaceous rocks of the Coastal Plain and hence must have been developed before the Cretaceous sediments were laid down.

CRETACEOUS PERIOD.

Near the beginning of the Cretaceous period a crustal movement is thought to have again raised the Appalachian Mountains and the Ozark dome and, presumbly, at least the borders of the Glaciated Plains. After this movement erosion of the surface proceeded with renewed vigor until a lower more or less planed surface was formed. This surface seems to pass beneath the Tertiary sediments of the Coastal Plain and, with remnants of an earlier peneplain, to cap some hills in southern and northern Illinois. It seems to be older than the lowland that occupies most of the Murphysboro and Herrin quadrangles, indicating that a third cycle of uplift and erosion preceded the formation of the lowland surface.

CENOZOIC ERA.

TERTIARY PERIOD.

The third cycle of erosion began with an uplift, probably early in the Tertiary period. During this cycle the surface features of Illinois acquired almost their present form. No doubt other Tertiary movements and other substages of erosion took place, but their record, if preserved at all, is so obscure that it has not yet been deciphered. Before the end of Tertiary time the lowland lying northeast of the hills was developed, though by what method is not yet known. The shales of the region yield readily to erosion but are interspersed with rather resistant layers of limestone and sandstone. Thus, though the rocks of the lowland are as a whole less resistant than those of the hills, the contrast seems scarcely great enough to account for the difference in amount of erosion, especially as the higher hill country lies nearer the great river. Hence the general topography of the region suggests that there has either been deformation or, more probably, a change in the direction of the drainage since the lowland was developed. It may be that not far back in Tertiary time there was no large river in this region but that southern Illinois was drained northeastward by many small streams and rivers.

That the Mississippi Valley is youthful and unadjusted to rock structure is indicated—

1. By the position of the valley with reference to the general topography and the hard and soft rocks of the region. Southern Illinois is shaped like a shallow basin or trough with an interior lowland bordered by a rugged rim of hills. The strata are in a broad way nearly parallel to the surface. The natural place for the master drainage line is in the lower part of the area, but the trough of the Mississippi is developed on the side of the structural and topographic trough and its floor is barely as low as much of the interior country from which tributaries flow to it. From the topographic maps it may be seen that though much of the area lies between 350 and 410 feet above sea level, yet most of the Mississippi Valley bottom is more than 350 feet above the sea.

2. By the shape of the Mississippi Valley. The flood plain is only 5 to 6 miles broad, too narrow for so large a stream except in a youthful stage. The valley sides are high and almost continuous bluffs; and the floor slopes downstream at a rate greater than that of many smaller streams and much greater than that of the Nile or Amazon.

3. By the arrangement of the tributary valleys. Many of the smaller tributary streams near the Mississippi flow directly away from that stream into valleys in the interior lowland, as if the natural place of their master stream were to the northeast instead of to the southwest.

4. By the distribution and development of the mollusks, both terrestrial and aquatic, of the central United States. Studies of these made by A. E. Ortmann and others seem to indicate that in Tertiary time no large river flowed from the vicinity of Cairo to the Gulf. That the preglacial basin draining into the Gulf was not quite so large as the present one is certain, for the glacier blocked at least a few large northward-flowing streams and held them until southward outlets were formed.

Near the close of Tertiary time the border at least of the continent seems to have been depressed, though no certain evidence of subsidence has been found in Illinois. On the other hand, elevation seems to have taken place in the northern part of the valley in the later part of Tertiary time, causing deep valley cutting.

QUATERNARY PERIOD.

GENERAL FEATURES.

At the beginning of the Quaternary period the physical features of southern Illinois had the same general form as at present. Certain details, however, particularly of the valleys, were different. The surface at that time was the result solely of erosion, whereas the present surface has been modified (1) by a heavy deposit of unconsolidated material, some of which has been brought to its present position by ice, some by wind, and some by water; and (2) by the erosion of stream valleys. The deposition tended on the whole to make the surface more even and the valley erosion to make it more irregular. Near the beginning of the Quaternary period a general uplift of the interior of the continent, perhaps in part at least contemporaneous with a movement in the opposite direction which affected the continental border late in the Tertiary period, allowed the streams to deepen their valleys. The great changes of climate which began early in the Quaternary if not late in the Tertiary period may also have had an important effect on the deposits and topographic features which date from about that time.

PLEISTOCENE EPOCH.

ILLINOIAN STAGE.

So far as is now known the first recorded event of the Pleistocene epoch was the advent of the Illinoian ice sheet. Older ice sheets—the Kansan and Nebraskan (or pre-Kansan)—covered much of the northern United States, but have not, as yet, been certainly shown to have reached the Murphysboro and Herrin quadrangles. The till seems to be uniform in composition and for the most part is yellowish from top to base, though in some places the lower part is bluish and is separated from the yellowish by a generally sharp line of demarcation. It is quite possible, however, that weathering has affected the till down to a very definite plane, and as no other evidence of an older till was found, it is assumed that the Illinoian is the oldest till in the district. It is possible that part of the Illinoian till was derived from a thin older till which was so completely reworked and mixed with other material as to be no longer recognizable as a distinct deposit. The continental glaciers seem generally to have removed the upper few feet of loose material, in many places taking all of it and even abrading the bedrock, so that a mantle of till only a few feet thick may consist entirely of reworked materials. In places, however, the glacier overrode the surface without greatly disturbing the surficial material and in some places even left old soils. In the Murphysboro and Herrin quadrangles fragments of wood are reported in several drill records, but they do not seem to lie at any definite horizon and it is not even certain that any of them lie above the base of the till, though scattered pieces may be incorporated and preserved along with other ingredients of the drift.

At but few of the exposures seen in the area does the loose material mantling the surface of the hard rock seem to have been so far removed as to allow the undecomposed rock to be abraded by the glacier. One of the best exposures of striæ on bedrock is in a railway cut one-fourth mile east of Bush, where the marks trend approximately north and south. In another exposure, observed by Leverett in sec. 10, T. 8 N., R. 3 W., they trend S. 30° W.

The great Illinoian glacier reached in southern Illinois the most southerly point attained by any Pleistocene ice sheet and covered more than a thousand square miles south of the 38th parallel. Except for a small area in the southwest it occupied all of the Murphysboro and Herrin quadrangles, and on melting left a load of rock fragments, rock flour, and clay gathered on its journey from Canada. Thus to-day, wherever it has not been removed by erosion, it covers the area with a mantle of gravelly clay in which many kinds of rock are represented—coarse-grained igneous rocks from Canada, jaspilite, conglomerate, and quartzite from the eastern end of Lake Superior, and flint and silicified limestone from Illinois. Quartz pebbles are conspicuous, and are surprisingly numerous, when it is considered that very few of the rocks of Illinois contain any considerable amount of quartz in particles larger than sand grains. The occurrence of such pebbles at widely separated places in Illinois suggests that they may represent extensive deposits of the Lafayette formation which have been so disintegrated that they survive as little more than loose pebbles.

Aside from some of the rounded pebbles and some sand and silt, the material left in this area by the ice was probably gathered from deposits left by older ice sheets and from the still older regolith, including both the residuum of rock decay and blocks which had been loosened by weathering. Not all the old residual material was removed, and in places none of it was moved far; but elsewhere its whole thickness and some of the underlying hard rock was displaced, for the ice was very thick and the friction at its base was very great. As the ice melted at the margin this glacial débris, consisting of clay, sand, pebbles, and bowlders, was spread somewhat evenly over the surface. Some of the material doubtless lodged under the moving ice; a small part was pushed along in front of it; some was dropped at the melting front of the still advancing ice; and the remainder of the load was let down when the glacier finally melted.

POST-ILLINOIAN TIME.

First epoch of valley fill.—When the ice sheet melted it left a mantle of drift which covered the previously developed hills and valleys and made the surface somewhat more even than it had been.

At some time between the Illinoian and Wisconsin stages of glaciation the large rivers began to fill their valleys so rapidly that the waters in the tributary valleys were ponded, forming lakes. When this process began the main rivers were flowing about 100 feet below their present beds, this depth of channel having perhaps been attained in a preglacial or possibly an interglacial stage in consequence of regional uplift, or through the deep scouring of glacial floods, or simply through an enlargement of the drainage basin. The tributaries entered the flood plains of the Mississippi and Kaskaskia on beds only about 40 feet lower than those of to-day, and their flood plains were near the position of their present beds, these positions being controlled by the low-water and high-water stages on the master streams. At the low-water stage there was no standing water in the tributaries, but at high water the 30 to 50 foot deep channels were filled by backwater from the rivers, thus intermittently forming long, narrow, winding lakes. When aggradation began on the Mississippi and Kaskaskia both low-water and high-water marks on them and on the tributaries rose. At low water embryo perennial lakes formed in the channels of the tributaries at their mouths, and at high water the flood plains were covered more deeply than before. The area covered at both stages gradually extended until low-water stage reached the altitude of the former flood plain. From this time on perennial bodies of quiet water of considerable size persisted on each tributary, and a lake deposit nearly 100 feet thick at the lower end and thinning gradually to a feather edge upstream accumulated on the old flood plain.

Nearly all the material deposited in the lakes was fine sediment such as would be carried in suspension, and the lakes seem to have been filled with this material up to certain concordant positions, which were probably the natural positions of flood plains, or just below the high-water marks of the time.

When the Mississippi and Kaskaskia finally became able to carry not only the load delivered to them but a little more, they began to cut down again. Perhaps even before this time the lakes had become intermittent, their beds being dry except at times of high water, for they were almost filled with sediment.

The great flat lake bottoms became swamps and channels began to deepen again at the former outlets.

Soil development and loess deposition.—On the more level portions of the upland drift enough organic matter from successive generations of plants accumulated to form a carbonaceous soil layer that was peaty in places, and on the slopes in the vicinity of the streams the surface material was leached and oxidized to a considerable depth by weathering. To the stage of deglaciation during which this soil was developed the name Sangamon has been given. It is possible that this time of exposure may have also included much if not all of the stage of deglaciation to which the name Peorian has been given, for there is within this area no evidence of a post-Illinoian incursion of the continental ice sheet.

After the conditions above described had continued undisturbed for a long cycle, extensive deposits of dust accumulated. This dust, or loess, was spread over the soil developed upon the Illinoian till and over the leached and eroded surface of the Illinoian till where the soil was thin or absent.

Second epoch of valley filling.—At about the time the latest or Wisconsin ice sheet was advancing over the northern half of Illinois, conditions seem to have once more become favorable for the development of lakes. The data thus far collected do not show the exact time of the second development; they do not even show with certainty that there were two distinct times; they seem to indicate it, however, and for the present it will be assumed that a first extensive series of lakes formed early in the interval between Illinoian and Wisconsin time, and that a second series developed in or soon after Wisconsin time. The lakes may have existed in the early part of Recent time, for, though it is customary to think of glacial outwash deposits such as caused these lakes as having developed directly in front of the ice, it is quite possible that they might at least have continued to grow after the ice melted. Indeed it appears possible that their entire growth may have taken place after the ice retreated. Glacial streams are generally aggrading streams, but it would seem that a great mantle of gravelly rock flour, without plant roots to hold it in place, would be as likely to lead to the overloading of streams having gradients adjusted to other conditions as would the material delivered directly to streams at the ice front. A large stream, such as the Mississippi, flowing away from the ice, might become overloaded by material fed to it more or less directly by the glacier or possibly by a decrease in the velocity and carrying power of the streams, produced by crustal deformation due to the weight of the ice. But it seems possible if not probable that, after the melting of the ice, tributaries rapidly cutting new valleys in the drift would deliver material to the Mississippi at such a rate as to overload it, and it is even possible that the débris would be delivered at a more rapid rate than when it was fed directly by the ice to the rivers. The location and extent of the lake in Muddy River valley are shown in figure 11.

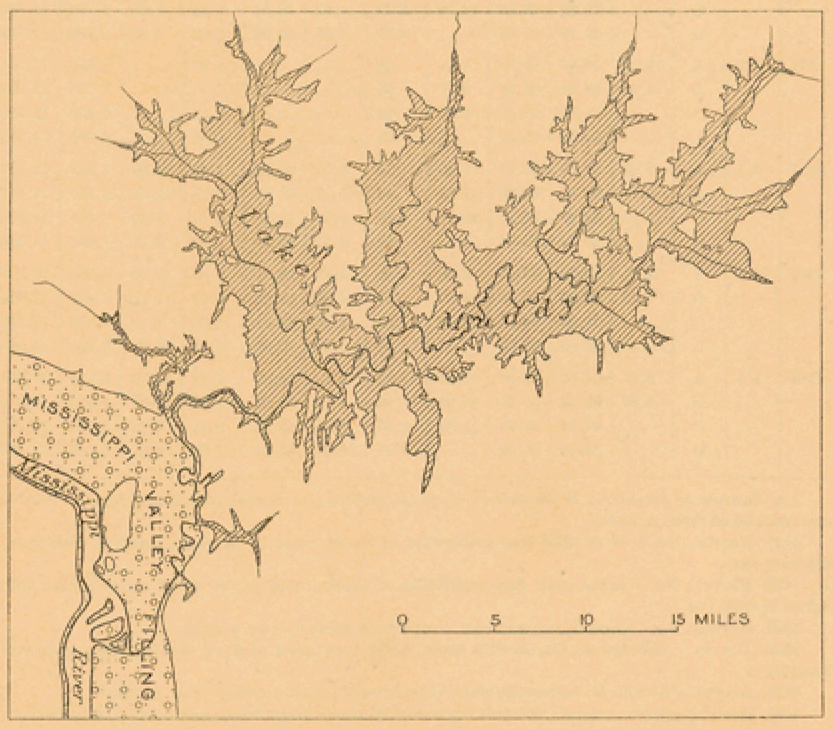


FIGURE 11.—Sketch map of the extinct lake in the Muddy River valley.
The lake was caused by the silting up of the Mississippi Valley in Pleistocene time, the outlet of Muddy River being thus temporarily dammed. The channel of the Mississippi has since been cut down, and the lake drained.

The Murphysboro and Herrin quadrangles include a large part of the bed of the extinct Lake Muddy, named from Muddy River, which now drains the lake bed. The depth of this lake varied greatly every year, for it was controlled by the stage of the rivers. If the range between high and low water had been the same as it now is the water level of the lake would have fluctuated about 40 feet, and the shore line would have oscillated annually over an average distance of a mile or more. But this lake with others formed a huge reservoir, so that with the same discharge as at present the rivers would not have risen nearly so much in time of flood.

Owing to difference in rock resistance to erosion, to drainage modification, or to uplift of the area bordering the river, the middle and upper part of the valley of Muddy River is broad and shallow and the lower part near the Mississippi is narrow and high walled. While Lake Muddy existed a rise of water on the Mississippi would cause a rush of water through the narrow part of the lake near the river to the broader part beyond, and this water would carry much sediment in a direction opposite to that in which Muddy River now flows and would thus build the delta which was formed at the lower end of the lake, fronting toward the upper end.

RECENT EPOCH.

Some time in the early part of the Recent epoch the Mississippi began to cut down again, and as the lakes were almost filled with sediment they soon became great swamps. At the same time the swamps themselves began to be drained at their lower ends. The process of swamp draining still continues, and on medium-sized streams there now remain only 10 to 20 miles of swamp, the lower 20 to 50 miles having been drained.

The erosion of the deposit on the Mississippi has almost completely removed the upper 50 feet of the material. Indeed, the terrace remnants make up much less than 1 per cent of the original surface of the deposit. On the other hand, less than one-tenth of the surface of the fill on the tributary streams has been cut away. This is undoubtedly due to the greater erosive power of the Mississippi and the relative narrowness of the fill on that stream, for the trough of the Mississippi is little wider than that of some of its smaller tributaries. All the streams, whether on the whole building up or cutting down, have made deposits continuously, and these deposits are found 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 in time 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 an average section of flood-plain deposit is progressively finer from base to top and seems to change rather abruptly from coarse to fine somewhat above the middle of the deposit.

Besides the above-described work of streams, several other processes of grading have been in operation throughout Recent time. Among the most important of these is the work of surface water from the time it falls as rain until it is gathered into streams with comparatively fixed courses. Much fine material, for which the term rainwash seems appropriate, is started by the rain water from gentle slopes surrounding the lake deposits and on reaching the flat surface is dropped, forming peculiar lenticular masses which may be spoken of as rainwash aprons. This process seems to favor the development of the rounded pellets known as "buckshot," but it is not essential to their formation, for they are also found on flat upland areas.

In the flood plain of the Mississippi many abandoned parts of the river channel form long depressions, generally closed at both ends by river deposits. A few hundred years ago most of these depressions were occupied by perennial lakes containing a more or less rank growth of swamp vegetation. At times of extreme high water, when the flood plain was covered, these lakes received silt from the muddy river water and deposited a peculiar mixture of vegetable remains and silt. Many of these lake beds have now been drained and converted into fertile farms by ditches whose outlets to the river are kept open at low water and closed at high water. The lake beds are thus only rarely submerged.

MINERAL RESOURCES.

Aside from soil and water the most important mineral resource of the Murphysboro and Herrin quadrangles is coal. Most of the area is underlain by at least one bed of workable coal and the eastern part by two or three such beds. Next in importance are clay and shale, of which the supply is almost unlimited. Sandstone for building stone, glass sand, and ganister is abundant in the southwestern part of the area.

COAL.

MURPHYSBORO QUADRANGLE.

Coal production.—In the year ended July 1, 1911, the Murphysboro quadrangle produced 381,666 tons of coal, all of which was mined from the Murphysboro coal in Jackson County. In the vicinity of Murphysboro this coal is in two divisions, separated by an interval ranging from less than 1 foot to 36 feet. Where this interval is greatest the lower bench has sometimes erroneously been called No. 1, but it is really a division of No. 2.

Pottsville coals.—A short distance above the middle of the Pottsville sandstone is a lenticular bed of coal, which locally attains a thickness of 2 feet but which is absent from a considerable part of the area. One of the best exposures of this bed is in the bank of a small stream in the SE. ¼ sec. 8, T. 8 S., R. 3 W., where 20 inches of good short-grained coal may be seen. The next coal is about 75 feet higher and is nowhere more than 1 foot thick.

The only Pottsville coal so far worked, locally known as the Pocket coal, lies 50 to 70 feet below the top of the formation. It is of Mercer age and is probably contemporaneous with the variable and lenticular beds that in other portions of the State have been called coal No. 1. This bed has been opened near the middle of the SW. ¼ sec. 7, T. 9 S., R. 2 W., where it is of excellent quality and is about 3 feet thick. The bed is also found in the NW. ¼ sec. 18, T. 8 S., R. 3 W., but is there pockety and scarcely workable at present.

Carbondale coals.—The lowest coal bed of the Carbondale formation is the Murphysboro (No. 2). The coal taken from it is of a quality scarcely surpassed in the State. The Murphysboro coal is probably identical with the bed mined at Colchester, with the "third vein" near La Salle, and with the coal No. 2 in the vicinity of Morris and Braidwood in the northeastern part of the basin. It is somewhat irregular in thickness, averaging about 5 feet where mined, and seems to be absent from a considerable area in the northern and eastern parts of the quadrangle. It is also absent throughout most of the hills, whence it has been removed by erosion, but is workable almost continuously along their base. In the vicinity of Murphysboro it is divided into two beds, each of which has been mined extensively.

It has also been mined 1½ miles northwest of Oraville, at Bryden, at Sato, 1½ miles south of Ava, and 2½ miles southwest of Matthews. At these places the bed is somewhat variable but generally contains 3 to 4 feet of excellent coal. (See fig. 12.)

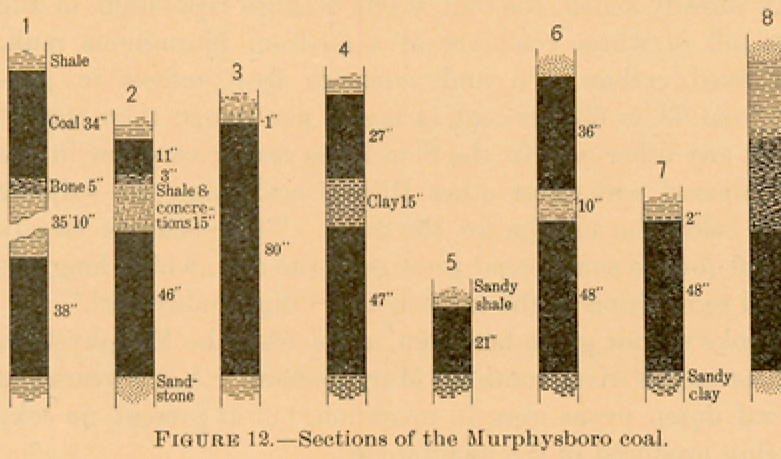


FIGURE 12.—Sections of the Murphysboro coal.

1. Drill hole in SW. ¼ sec. 32, T. 8 S., R. 2 W.
2. Gus Blair mine No. 1, Murphysboro.
3. Drill hole in SW. ¼ sec. 3, T. 9 S., R. 2 W.
4. Drill hole in SW. ¼ sec. 28, T. 8 S., R. 2 W.
5. Drill hole in NE. ¼ sec. 16, T. 8 S., R. 2 W.
6. Cairo Ice & Coal Co. mine, Bryden.
7. J. B. Schimpf mine, NE. ¼ sec. 11, T. 7 S., R. 3 W.
8. Nesbit & Wilson mine, Sato, SE. ¼ NW. ¼ sec. 22, T. 7 S., R. 3 W.

Scale: 1 inch = 5 feet.

The following is a list of the coal mines of the Murphysboro quadrangle.

Coal mines of the Murphysboro quadrangle.

[All mines operate on Murphysboro coal except that of Alfred Phillips, which is on Herrin coal.]

Company.	Mine or town.	Location.				Depth to base.	Thickness.	Remarks.
		Quarter.	Section.	T. S.	R. W.			
SHIPPING MINES.						*Ft.*	*In.*	
Big Muddy Coal & Iron Co	Harrison	NE. ¼ NW	33	8	2	160	68	
Do	6	SE	3	9	2	131	60	Abandoned.
Do	9	SW. ¼ SE	34	8	2	108	72	
Cairo Ice & Coal Co., V. L. Church, operator.	Simpson	NE. ¼ SE	27	7	3	Drift	84	Coal in 2 beds; 10 feet of shale between.
Gartside Coal Co	4	SE. ¼ SE	29	8	2	145	60	
Do	3	SW. ¼ SW	33	8	2	145	47	
Gus Blair Big Muddy Coal Co.	1	SW. ¼ NE	29	8	2	138	60	Coal in 2 beds separated by 21 feet of shale and bone.
Do	2	NW. ¼ SE	32	8	2		60	
Schmidtgall Coal Co	1	SE. ¼ SW	32	8	2	98	60	
NON-SHIPPING MINES.								
Campbell, W. R	Vergennes	SE	2	7	3	Slope	50	
Johnson, W. F	Do	SE. ¼ SW	11	7	3	34	47	
Nisbet & Wilson	Ava	SE. ¼ NW	22	7	3	Drift	74	
Nisbet & Le Pere	Do							Abandoned.
Phillips, Alfred[a]	Pinckneyville	NW. ¼ SW	16	6	2	Slope	86	
Schaffer, Michael	Ava							Abandoned.
Schimpf, J. B	Vergennes	NW. ¼ NE	11	7	3	Slope	50	
Sherman, John	Oraville							Abandoned.

[a] The opening is in Perry County, just outside the Murphysboro quadrangle, but part of the mine workings are inside.

Quality of the coal.—Several samples of the Murphysboro coal for analytical tests were collected, the method of sampling being that used by both the United States and the Illinois geological surveys in taking samples. This method, which has been worked out with a view to getting an average analysis of the coal, has been in use several years and from time to time has been slightly modified. It has now been carefully and extensively tested and the results are very satisfactory. It is in brief, as follows: At a freshly cut and cleaned face a groove is cut across the full thickness of the bed, all partings more than three-eighths of an inch thick being rejected. The material thus obtained is crushed so that it will pass through a half-inch mesh, and it is quartered until a quart sample is obtained, which is sealed air tight in a galvanized-iron can and sent to the chemical laboratory.

Proximate analyses of five face samples of the Murphysboro (No. 2) coal from the Murphysboro region, made by W. F. Wheeler and J. M. Lindgren under the direction of S. W. Parr for the Illinois State Geological Survey, are shown in the following table. In accordance with the present usage in the State the locality data relating to the samples are not communicated by the State Geological Survey.

Proximate analyses of face samples of Murphysboro (No. 2) coal from Murphysboro quadrangle, Ill.

Lab. No.	Form of analysis.[a]	Total moisture.	Fixed carbon.	Volatile matter.	Ash.	Sulphur.	British thermal units.	Fuel ratio.
1875	As received	14.25	50.70	30.77	4.28	0.67	12,102	1.65
	Dry coal		59.13	35.88	4.99	.79	14,113	
	Pure coal		62.23	37.77			14,854	
1876	As received	9.00	50.28	34.46	6.26	1.84	12,558	1.46
	Dry coal		55.25	37.88	6.87	2.02	13,799	
	Pure coal		59.34	40.67			14,819	
1878	As received	12.73	51.17	31.96	4.14	.62	12,319	1.60
	Dry coal		58.63	36.62	4.75	.71	14,115	
	Pure coal		61.55	38.45			14,818	
2737	As received	9.32	52.32	33.12	5.24	.90	12,480	1.58
	Dry coal		57.70	36.52	5.78	.99	13,762	
	Pure coal		61.24	38.76			14,606	
2738	As received	9.10	49.54	35.54	5.82	1.68	12,466	1.39
	Dry coal		54.49	39.10	6.41	1.85	13,713	
	Pure coal		58.23	41.77			14,652	
Average:								
	As received	10.88	50.80	33.17	5.15	1.14	12,385	1.54
	Pure coal		60.52	39.48			14,749	

[a] In addition to the analysis of the sample as received two theoretical forms are given as follows: "Dry coal" represents the sample free from moisture; "Pure coal" represents the sample free from moisture and ash.

As already stated, the coal is one of high reputation in the State, all of whose coals are of a medium bituminous rank. The fixed carbon (ash and moisture free) ranges in general from 53 to 63 per cent (a larger percentage than that of almost any other coal in the State), the coal is very low in ash as compared with most other Illinois coals, and the sulphur is far below the average for the State. These features largely account for the commercial prestige of the coal, which long ago gained recognition in the trade as the "Big Muddy coal."

A coke of fair grade has been made from the Murphysboro coal across the river south of Murphysboro. A few years ago several dozen ovens were in operation, but at present no coke is being produced in the quadrangle.

The Murphysboro coal has a bright luster and bears considerable exposure without slacking. Most of it is shipped for domestic use to towns south and southeast of Cairo. In parts of the territory it competes with Alabama coal, which sells for a higher price.

Mining methods.—Most of the coal produced in the Murphysboro quadrangle is mined from shafts but some from slopes and drifts. The room and pillar system is used in all mines.

In the larger mines the coal is either undercut with electric chain machines and shot down, or it is cut with compressed-air punchers. The coal is hauled by mule or electric power to the shaft bottom, whence it is hoisted to 40 to 60 feet above the surface by steam and dumped on inclined stationary or shaker screens, which size it as it slides down into the railroad cars. The sizes produced are generally mine run (unscreened), lump, nut, pea, and slack. The full capacity output per mine ranges from 20 to 500 tons a day, but as the coal gradually deteriorates on exposure to the air, it is mined according to the demand, some of the mines being shut down for a few months every summer and others being run for two or three days a week. Grain threshing in the later part of the summer perceptibly increases the demand.

In the smaller mines or country banks the coal is shot from the solid and is loaded on small cars, which are pushed by hand, in the drift mines to the tipple and in the shaft mines to the base of the shaft, whence the coal is hoisted to the surface by horse or steam power.

The amount of slack or waste coal is about 2.25 per cent; the percentage is gradually decreasing and in 1911 was about half what it was in 1900.

HERRIN QUADRANGLE.

Coal production.—In the year ended July 1, 1908, 4,931,624 tons of coal was mined in the Herrin quadrangle,[a] this quantity being an increase of 1,822,392 tons over the output of the quadrangle for the year 1905, a gain of 59 per cent. Five new mines have been opened since 1908, and in 1911 there were in operation within the quadrangle 32 commercial mines and 7 mines that were worked intermittently to supply local trade. The output for the year ended July 1, 1911, was 5,128,889 tons.

Coal occurs at several horizons in both the Carbondale and the McLeansboro formations. (See fig. 5, p. 6.) In the Herrin quadrangle only two of the coal beds, Harrisburg (No. 5) and Herrin (No. 6), are of sufficient thickness to warrant development under present commercial conditions, but it is possible that in the future some of the other coals, which in places are of workable thickness, may become of economic importance. (See fig. 13.)

Herrin (No. 6) coal.—The Herrin coal, also known as coal No. 6, underlies practically the entire surface of the quadrangle except about 45 square miles in the southern and southwestern portions. North of its outcrop test borings put down to the proper depth seldom fail to find it. The line of outcrop, which is indicated on the map by a broken line, is generally regular except where it crosses the large Pleistocene valleys of Little Muddy and Muddy rivers.

[a] Twenty-seventh Ann. Coal Rept. Ill. Bur. Statistics, 1908.

The Herrin coal, from which practically all the coal mined in the Herrin quadrangle is obtained, is mined extensively in the vicinity of Herrin, Carterville, Christopher, Royalton, Zeigler, Hallidayboro, Bush, De Soto, and other places. The bed is uniformly thick, ranging from 7½ to 14 feet and averaging 9 feet 5 inches in 130 borings. The coal is shining black, commonly banded, and on close inspection appears laminated with alternating bright and dull lines. A "blue band," or dirt band, found almost everywhere 18 to 30 inches above the floor, generally consists of bone or shaly coal or of gray shale. Its thickness varies from one-half to 2½ inches, with an average of about 1⅔ inches. In the mines along the western border of the quadrangle the horizon of this "blue band" is marked by 5 to 11 inches of gray shale and bone.

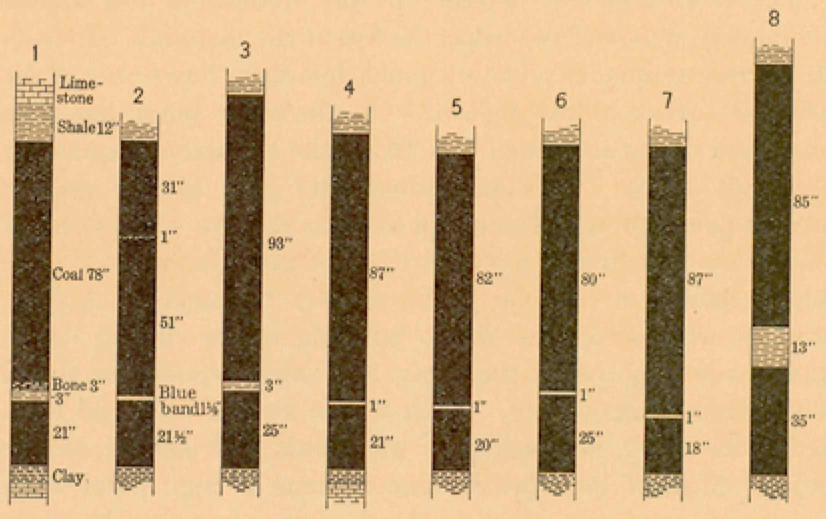


FIGURE 13.—Sections of the Herrin coal.

1. Chicago & Carbondale Coal Co. mine No. 1, NE. ¼ sec. 8, T. 8 S., R. 1 W.
2. Madison Coal Corporation mine No. 9, SE. ¼ sec. 22, T. 8 S., R. 1 E.
3. Zeigler District Colliery Co. north mine, SW. ¼ sec. 24, T. 6 S., R. 1 E.
4. Chicago & Carterville Coal Co. mine B, NE. ¼ sec. 17, T. 8 S., R. 2 E.
5. Big Muddy Coal & Iron Co. mine No. 7, SE. ¼ sec. 20, T. 8 S., R. 2 E.
6. Hafer Washed Coal Co. mine No. 3, NE. ¼ sec. 36, T. 8 S., R. 1 E.
7. Davis Coal & Iron Co. Queen mine, NW. ¼ sec. 15, T. 6 S., R. 1 W.
8. Peacock Coal Co., NE. ¼ sec. 17, T. 8 S., R. 1 W.

Scale: 1 inch = 5 feet.

A clean persistent parting of mother coal lies 14 to 24 inches below the top of the bed, and a second parting generally appears 5 to 8 inches lower down. Above the upper parting the coal is in layers 3 to 6 inches thick, with partings of mother coal between them. Local lenses of mother coal, 6 inches to 5 feet in length and 1 inch to 4 inches thick, are common in the upper third of the bed. Small pyrite lenses and streaks of bone, a few inches to a foot or more in length and one-fourth inch to 1 inch in thickness are found here and there in the middle portion of the bed, a short distance above the "blue band." In the middle and lower parts of the bed the lamination is less distinct but the bedding is still evident.

Above the coal there is a bed of gray, impure shale, 15 to 110 feet thick, the lower part of which generally contains a great number of plant impressions. This shale does not stand well when the coal is removed, and for this reason the 18 to 30 inch zone of coal above the charcoal parting is usually left for a roof until the rooms are mined out, after which it may be taken down. The clay beneath the coal is hard and generally thin, ranging from 4 to 50 inches. It is generally underlain by a limestone and in but few places squeezes enough to cause trouble. Some rock rolls occur at the top, the larger ones extending down into the coal 2 to 3 feet. A distinct cleat is generally present but is not so strong as to prevent the cutting of the coal in any direction desired. The composition and fuel value of this coal are given in the table of analyses.

Harrisburg (No. 5) coal.—The records of borings that have penetrated to the Harrisburg coal show it to be persistent in its distribution and thickness at an average distance of 37 to 40 feet below the bottom of the Herrin coal. It outcrops about three-fourths mile south of the border of the higher coal.

The excellent quality of the coal is shown in the table of analyses. Locally it is reputed to be superior to the Herrin coal, and, though lying about 45 feet deeper and averaging somewhat less than half the thickness of the higher bed, it is easily workable and is sure to become of considerable commercial importance. The thickness of the Harrisburg coal is remarkably uniform wherever known; it averages 4 feet 4 inches in 40 exposures and records. It contains no "blue band" and appears to be freer from pyrite lenses, bone, and other impurities than the Herrin coal.

The conditions for mining are favorable. The underclay is hard and does not creep readily. Above the coal is a bed of hard black shale that stands well as a roof with little or no timbering. In many places in the lower part of the roof shale pyritic concretions or "niggerheads" are abundant.

The Harrisburg coal could generally be mined in connection with the Herrin coal, below, without sinking separate shafts.

Chemical analyses of the coals.—Samples of coal were collected from the face of the bed in 17 of the mines listed in the table on page 15, and subjected to chemical analysis.

In these 17 analyses the moisture content of the coal as received ranges from 6.47 to 11.03; the ash from 6.77 to 12.17, and the sulphur from .62 to 3.56. In efficiency these face samples were found to range from 11,079 British thermal units (the calorific value of the sample containing the maximum moisture content and very nearly the maximum ash) to 12,144 British thermal units.

The following table gives the average of these 17 analyses:

Average of 17 proximate analyses of Herrin (No. 6) coal from Herrin quadrangle and vicinity.

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

Form of analysis.[a]	Total moisture.	Fixed carbon.	Volatile matter.	Ash.	Sulphur.	British thermal units.	Fuel ratio.
As received	9.11	48.79	32.65	9.43	1.65	11,799	1.47
Dry coal		53.02	36.18	10.39	1.86	13,004	
Pure coal		59.39	40.60			14,507	

[a] See note to table in first column.

The following detailed analyses of samples of the Herrin coal from localities in or near the Herrin quadrangle were made in the laboratory of the United States Geological Survey. Several of the samples were also subjected to ultimate analysis as shown in the following table:

Analyses, including determinations of the ultimate fuel constituents, of samples of the Herrin coal.

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

Laboratory No.	Air-drying loss.	Form of analysis.[a]	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
1731	5.7	A	9.37	30.69	52.57	7.37	1.25					6,699	12,058
		B	3.89	32.55	55.75	7.81	1.33					7,104	12,787
		C		33.86	58.01	8.13	1.38					7,392	13,306
		D		36.86	63.14		1.50					8,046	14,483
3636		A	8.80	29.85	53.83	7.52	1.13	5.08	68.70	1.33	16.24	6,790	12,222
		C		32.73	59.02	8.25	1.24	4.50	75.33	1.46	9.22	7,445	13,401
		D		35.67	64.33		1.35	4.90	82.10	1.59	10.06	8,114	14,605
1732	4.8	A	8.59	31.07	53.37	6.97	1.78						
		B	3.98	32.64	56.06	7.32	1.87						
		C		33.99	58.38	7.63	1.95						
		D		36.80	63.20		2.11						
3789	3.0	A	7.78	29.85	52.39	9.98	1.32	5.06	67.45	1.21	14.98	6,644	11,959
		B	4.93	30.77	54.01	10.29	1.36	4.88	69.54	1.25	12.68	6,849	12,328
		C		32.37	56.81	10.82	1.43	4.55	73.14	1.31	8.75	7,205	12,969
		D		36.30	63.70		1.61	5.11	82.01	1.47	9.80	8,079	14,542
1820	4.0	A	8.43	30.08	51.89	9.60	1.14	5.18	67.33	1.50	15.25	6,644	11,959
		B	4.62	31.33	54.05	10.00	1.19	4.94	70.13	1.56	12.18	6,921	12,457
		C		32.85	56.67	10.48	1.24	4.63	73.53	1.64	8.48	7,256	13,061
		D		36.70	63.30		1.39	5.17	82.14	1.83	9.47	8,106	14,591
1683	5.2	A	8.29	31.19	49.69	10.83	2.81			1.16		6,576	11,837
		B	3.26	32.90	52.42	11.42	2.96					6,937	12,486
		C		34.01	54.18	11.81	3.06			1.26		7,170	12,906
		D		38.56	61.44		3.47			1.43		8,131	14,636
1762	3.6	A	8.20	32.26	46.59	12.95	3.48	5.09	62.52	1.10	14.86	6,312	11,362
		B	4.77	33.47	48.33	13.43	3.61	4.86	64.86	1.14	12.10	6,548	11,786
		C		35.14	50.75	14.11	3.79	4.55	68.10	1.20	8.25	6,876	12,377
		D		40.91	59.09		4.41	5.30	79.29	1.40	9.60	8,005	14,409
1634	4.9	A	8.30	33.75	48.69	9.26	2.82					6,666	11,999
		B	3.57	35.49	51.20	9.74	2.97					7,010	12,617
		C		36.80	53.10	10.10	3.08					7,269	13,084
		D		40.93	59.07		3.43					8,086	14,555
1660	5.8	A	8.86	31.25	48.23	11.66	2.46	5.24	64.29	1.29	15.06	6,501	11,702
		B	3.25	33.17	51.20	12.38	2.62	4.88	68.24	1.37	10.51	6,901	12,422
		C		34.29	52.92	12.79	2.70	4.67	70.54	1.42	7.88	7,133	12,839
		D		39.32	60.68		3.10	5.36	80.89	1.62	9.03	8,180	14,724
1871	5.2	A	9.90	28.67	53.69	7.74	.48			1.47		6,667	12,001
		B	4.96	30.24	56.63	8.17	.51					7,033	12,659
		C		31.82	59.59	8.59	.53			1.55		7,400	13,320
		D		34.81	65.19		.58			1.69		8,095	14,571
3447	3.8	A	9.58	29.18	50.24	11.00	.52	5.33	65.33	1.43	16.39	6,345	11,428
		B	6.01	30.33	52.23	11.43	.54	5.10	67.91	1.49	13.53	6,596	11,873
		C		32.27	55.56	12.17	.58	4.72	72.25	1.58	8.70	7,018	12,632
		D		36.74	63.26		.66	5.37	82.26	1.80	9.91	7,991	14,384
1926	9.1	A	14.91	26.66	49.50	8.93	.52	5.42	62.76	1.35	21.02	6,088	10,958
		B	6.39	29.33	54.46	9.82	.57	4.85	69.04	1.49	14.23	6,697	12,055
		C		31.33	58.18	10.49	.61	4.42	73.76	1.59	9.13	7,155	12,879
		D		35.00	65.00		.68	4.94	82.40	1.77	10.21	7,994	14,389
1786	4.6	A	8.31	31.65	49.56	10.48	1.55	5.18	65.83	1.48	15.48	6,515	11,727
		B	3.89	33.18	51.95	10.98	1.62	4.90	69.01	1.55	11.94	6,829	12,292
		C		34.52	54.05	11.43	1.69	4.65	71.80	1.61	8.82	7,105	12,789
		D		38.98	61.02		1.91	5.24	81.12	1.82	9.91	8,028	14,450

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

1731. Herrin; No. 7 mine (2300 feet southwest of shaft, room 17 off south entry 6, west side, 85⅜-inch cut).

1732. Herrin; No. 7 mine (2400 feet northeast of shaft, room 14 off north entry 5, east side 8-foot 7½-inch cut).

1820. Herrin; No. 7 mine (lump and egg, over 3-inch mesh). Car sample.

3636. Herrin; Chicago & Carterville mine (2000 feet northwest of shaft). Experimental sample.

3789. Herrin; Chicago & Carterville mine (lump, over 3-inch screen). Car sample.

1683. Bush; Bush No. 1 mine (1000 feet northeast of shaft, room 10 off east entry 1, 70-inch cut).

1762. Bush; Bush No. 1 mine (run of mine). Car sample.

1634. Carterville, near; Daw's shaft (north entry off straight west heading, 8-foot 10¾-inch cut).

1660. Carterville, near; Daw's shaft (mixed run of mine and lump coal). Car sample.

1871. Zeigler; Zeigler mine (680 feet northwest of shaft, room 5, west entry 1, north side, 94$\frac{7}{8}$-inch cut).

3447. Zeigler; Zeigler mine (run of mine). Car sample.

1926. Zeigler; Zeigler mine (over ¾-inch perforated screen). Car sample.

1786. Benton; Benton mine (egg coal, through 6-inch and over 1¼-inch screens). Car sample.

Mines and mining methods.—Some of the mines in the area have been worked for many years. The larger and newer mines are generally provided with modern equipment and conveniences, but the smaller ones still employ primitive methods. Pick mining is not usually practiced, but the coal is shot from the solid, and hauled by mules on wooden cars of 1 to 3 tons capacity. No effort is made to prevent the shattering of the coal. About one-third of the mines are furnished with mining machines for undercutting. Compressed air is commonly used for working the drills, and electricity is, in places, supplied for lighting the mines. Electric motors or tail ropes are used for the main haulage in a number of the larger mines. Most of the deeper mines are dry, but the more shallow ones are sometimes troubled with water seeping in from above. In most mines neither the necessary pumping nor sprinkling entails very great expense.

A modification of the room and pillar system of mining is in general practice, but in a very few mines the panel system is employed. In the greater number of the mines few of the pillars are pulled, and in some, where the shale drops easily, the roof coal is not taken out. The amount of coal left in the ground ranges from 33⅓ to 50 per cent, which in a seam averaging 9 feet in thickness, amounts to a loss of 5300 to 7800 tons per acre, or more than 4,000,000 tons per square mile. In other words, under the present method of mining, the amount of coal left in the ground on every square mile mined is nearly equal to the total number of tons produced in this area in 1908. This very large amount of coal is permanently lost, for it is left in such condition that it can not later be recovered. With the price of coal land at $150 per acre, as at present, the cost (land value) of coal per ton to the company is so trifling—about 1 cent per ton—that the operators can make more money by leaving the pillars and less accessible coal in the ground, and taking out only what can be mined most cheaply. It is probable that more than 95 per cent of the coal could be taken out, if mines were laid out and developed in a systematic manner with this end in view.

The following coal mines were operated in the Herrin quadrangle and marginal area during 1909:

Table showing mines of the Herrin quadrangle.

[All except mine of A. J. Young operate on Herrin coal.]

Company.	Mine.	Location.				Herrin coal (No. 6).		
		Quarter.	Section.	T. S.	Range.	Depth to base—feet.	Thickness—inches.	Source of information.[a]
SHIPPING MINES.								
Bell & Zoller Mining Co		SE	13	7	1 E	429	120	S
Big Muddy-Carterville Mining Co	1	SW	33	7	1 E	212	107	M
Do	2	NW	28	7	1 E	315	118	S
Big Muddy Coal & Iron Co	7	S	20	8	2 E	146	103	M
Do	8	SW	14	8	1 E	169	108	S
Big Muddy River Con. Coal Co		SW. ¼ SW	33	7	2 E	325	108	S
Do	Hemlock	S	30	8	2 E	150	108	M
Carterville & Big Muddy Coal Co	1	NE. ¼ NW	33	8	1 E	80	114	M
Carterville Coal Co	Burr C	S	34	8	1 E	100	112	M
Carterville Mining Co	1	SE. ¼ NW	32	8	2 E	56	112	M
Do	2	N	31	8	2 E	140	117	M
Do	3	SW. ¼ NW	33	8	1 E	69	107	M
Chicago & Carbondale Coal Co	1	NE	8	8	1 W	79	105	M
Chicago & Carterville Coal Co	A	NW	19	8	2 E	186	114	M
Do	B	N	17	8	2 E	247	108	M
Chicago-Herrin Coal Co	1	NW	30	8	2 E	175	131	M
Donally & Koennecke Coal Co	1	NW	26	8	1 E	130	114	S
Duquoin & Pittsburgh Coal Co. (Brilliant Coal & Coke Co.)	Horn	NW	19	6	1 W	80	72	S
Hafer Washed Coal Co	1	NE	36	8	1 E	120	107	M
Madison Coal Corporation	8	NW. ¼ NW	35	8	1 E	100	108	S
Do	9	SE	22	8	1 E	125	106	M
Majestic Coal & Coke Co		NW	23	6	1 W	412	106	M
Muddy Valley Mining & Mfg. Co	1	NW	29	7	1 W	169	90	M
Paradise Coal & Coke Co		NE	15	6	1 W	374	96	M
Peacock Coal Co		NE	17	8	1 W	50	120	M
Pond Creek Coal Co		W	5	8	2 E	246	108	M
Bend, W. P., Coal Co	2	NW	1	8	1 E	200	118	S
Robert Dick Coal Co		SE	28	8	1 E	121	104	S
St. Louis-Carterville Coal Co	Dale	S	29	8	2 E	100	103	M
Sunnyside Coal Co		N	25	8	1 E	159	96	M
United Coal Mining Co		NW	30	6	2 E	500	114	M
Western Coal & Mining Co		NW	7	8	1 E	118	102	M
Zeigler District Colliery Co		SW	24	6	1 E	517	121	M
NON-SHIPPING MINES.								
Beltz, George	Slope	S	2	9	1 E	35	108	S
Odum, E. D	Stripping	E	5	9	2 E		78	M
Phillips, George	Drift	NW	32	8	1 E		114	M
Porritt, T. B., & Son	Slope	SE	2	9	1 E	21	107	M
Spiller & Whitecotton	Drift	NE	5	9	2 E		108	S
Young, A. J.[b]	Shaft	NW	11	9	1 E	50	46	M

[a] M, Measured by representative of Illinois Geological Survey; S, information from superintendent of mine.

[b] Harrisburg (No. 5) coal at this mine only.

CLAY AND SHALE.

Clay and shale suitable for the manufacture of common brick and tile are abundant in all parts of the Murphysboro and Herrin quadrangles.

CARBONIFEROUS CLAY AND SHALE.

The Pottsville sandstone contains several more or less lenticular beds of shale and clay and no doubt most of this material is usable for at least the commoner grades of brick, though so far it has not been worked. In general this shale and clay are overlain by sandstone, so that they can not be stripped profitably. Possibly, however, some of the beds of clay may be valuable enough to mine. The important clay mined at St. Louis and known by the trade name "Cheltenham" belongs near the top of the Pottsville, and pockets of valuable clay may be found at the same horizon in the Murphysboro quadrangle.

Plastic clay underlies the Murphysboro coal in a few places, but it is thin and does not appear valuable enough to warrant exploitation. The underclays of other coals seem likewise to be of no great value, though locally they may be worth mining. No tests on them have been made.

Apparently the most valuable and accessible shale in the quadrangles is that overlying the Murphysboro coal (No. 2). This shale is persistent and appears to be fairly uniform. It is light gray in color, is fairly firm though it readily becomes soft and plastic on wetting and grinding, and contains scattered iron concretions commonly 3 to 6 inches in diameter. As a rule it contains little quartz sand though commonly abundant mica flakes. Its thickness varies not only through variation in the thickness of the bed as a whole but also through variation in the character of its upper part. Thus, the shale overlying the Murphysboro coal west of Vergennes is only 20 feet thick and is overlain by a soft massive sandstone, which south of this point grades into the shale. Near Murphysboro the shale forms an almost unbroken mass nearly 100 feet thick, with a thin coal near the top which 10 miles to the north is underlain by the heavy sandstone mentioned above.

The value of this shale lies principally in the facts that (1) it readily becomes fairly plastic, so that it can be molded by the stiff-mud process; (2) it does not shrink greatly on drying and firing; (3) there is a considerable range in temperature between the point at which it begins to fuse and the point at which it becomes viscous, and (4) the burned product has good tensile strength. These characters make it a desirable material for paving brick as well as for common brick and tile. For paving brick and some other products the shale is scarcely as plastic as is desirable, but this can be remedied by the addition of the more plastic loess clay, which is present almost everywhere in the region. Fireproof tiling requires a very plastic clay, in order that it may pass readily through the peculiar-shaped molds which are used, and for this purpose it would probably be desirable to add 75 per cent or more of surface clay; but for paving brick 25 per cent of surface clay is found sufficient.

The part of this shale which overlies the thin coal at Murphysboro (and lies about 100 feet above the Murphysboro coal) is being worked extensively by the Murphysboro Paving Brick Co. at Murphysboro. The same beds outcrop in the southern part of the Herrin quadrangle and might be successfully worked at De Soto and elsewhere, with or without mixing with valley filling or loess clay. The shale is not valuable enough to warrant underground working and its exploitation is confined to the area in which it outcrops or lies under thin cover, so that it can be worked by the common pit and quarry method. It outcrops in a strip varying in width from a few feet to 2 miles, extending east from Murphysboro beyond the boundary of the quadrangle and north from Murphysboro nearly to the northwest corner of Vergennes Township, where it is faulted down to some distance below the surface. Most of the outcrop lies near a railroad.

The upper part of the Carbondale formation includes several fairly continuous beds of shale which are no doubt usable for the common clay products. In some places the underclay of the Herrin coal may be workable at a profit.

The shale overlying the Herrin coal outcrops at many places, particularly in the vicinity of Carterville, where it could be worked without a great amount of stripping. No tests have been made as to its quality, but it is doubtless adapted for making the more common grades of brick and drain tile.

QUATERNARY CLAYS.

The sandy portion of the earlier valley deposit has been worked at several small pits, such as that in the northeastern part of Murphysboro, where it is overlain by a few feet of loess clay, with which it is mixed to make brick. The less sandy portion has, so far as known, not been tested, and the material is not looked upon by practical clay men as very promising. However, it may be a useful material to mix with other clays for particular purposes.

The later valley deposit is worked at only a few small pits by the ordinary methods of brick manufacture. It would seem, however, that the extensive deposits of clay in the region and the considerable demand for clay products might warrant more extensive utilization.

With the possible exception of the glacial till the loess is the most widespread of all the surficial formations, and on account of its great extent and its position immediately below the surface, together with its general availability for commercial use, it is the most universally acceptable source of clay.

Loess clay has been used at Carterville by the Carterville Brick & Tile Co. in the manufacture of common construction brick, of which about 700,000 per year are burned to supply local demand.

The recent alluvium is not of great importance as a source of clay. It is of minor extent, is commonly gravelly, and is subject to overflow several times a year. Along the larger streams, however, there are considerable bodies of clay in the first bottoms.

SANDSTONE.

Good building stone is not abundant in the quadrangles. Indeed, throughout the lowland there is little stone that is at all usable for masonry, but in the hilly part of the area, where the Pottsville sandstone outcrops, there is some rock which can be worked into good dimension stone and an abundance of medium and low grade rock. At present active quarries are few. At one, in sec. 7, T. 7 S., R. 3 W., a layer about 70 feet below the top of the Pottsville is quarried, and the product has been hauled 10 to 15 miles for use in foundations and bridge abutments.

The Vergennes sandstone, a member of the Carbondale formation, is usable for rough masonry and in places may yield dimension stone. It has been worked at a few places. A small quarry has been operated for local use in the east bank of Craborchard Creek, in the NW. ¼ sec. 35, T. 8 S., R. 1 W. The rock is a rather firm sandstone, in two or three massive layers, and belongs to a horizon about 70 feet above coal No. 2. A thickness of 10 feet has been worked at this place. The rock is rather firmly cemented with iron oxide and can be used for foundation work and cellar walls, but would not prove durable as a building stone.

Parts of the Pottsville sandstone are very hard and appear to consist of almost pure silica. This rock may be worth working for ganister and other materials made from very hard siliceous rock.

LIMESTONE.

The limestones of the Carbondale and McLeansboro formations are not thick but yield local supplies of rough building stone.

At a few points in the southern portion of the Herrin quadrangle two limestone beds are exposed; one, which is 1 to 3 feet thick, overlies the roof shale of coal No. 5; the other, which is thin, lies about 150 feet lower. Both are more or less nodular or concretionary, carry considerable iron in the form of pyrite, and contain a large admixture of shale.

WATER RESOURCES.

Muddy River and its large tributaries, Little Muddy River and Craborchard Creek, furnish an abundant and permanent supply of water to the regions through which they flow. The water of these streams carries considerable sediment and like that of other streams its content of dissolved solids is variable.

Away from the streams the water supply is largely drawn from shallow open wells. The water-bearing bed is generally a bed of sand or sandy clay associated with the drift and commonly lying immediately beneath the bowlder clay. Water is found at depths of 15 to 40 feet but commonly at less than 25 feet. Over the 2 to 4 miles width of the preglacial channels of Muddy and Little Muddy rivers a bed of sand 6 to 18 feet thick lies in many places beneath the drift and the fluvial materials and is a permanent source of water in this immediate area. Several of the larger towns of the region, Herrin, Carterville, and De Soto for instance, have no general water supply but depend on shallow wells, most of which are dug. The general water supply at Carbondale is obtained from two wells, 411 and 417 feet deep, which tap a sandstone in the lower part of the Pottsville formation. A well at the Egyptian Powder Co.'s plant, near the middle of the north line of sec. 5, T. 9 S., R. 2 E., also obtains water from a bed in the Pottsville at a depth of about 900 feet.

In a well 2271 feet deep at St. Johns, north of Duquoin, fresh water was found at 311 feet and salt water in various beds between 520 and 980 feet; also at 1604, 1969, and 2271 feet.

The character of the water found in this well indicates that potable supplies must be sought in the rivers of the region, in porous beds buried beneath the drift, or in some water-bearing bed of the Pottsville sandstone. The lower water horizons, which furnish permanent supplies of excellent water farther north in the State, appear to be too highly mineralized in this region to be of general use.

June, 1912.

TOPOGRAPHY

STATE OF ILLINOIS

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FRANK W. DE WOLF, DIRECTOR, STATE GEOLOGICAL SURVEY

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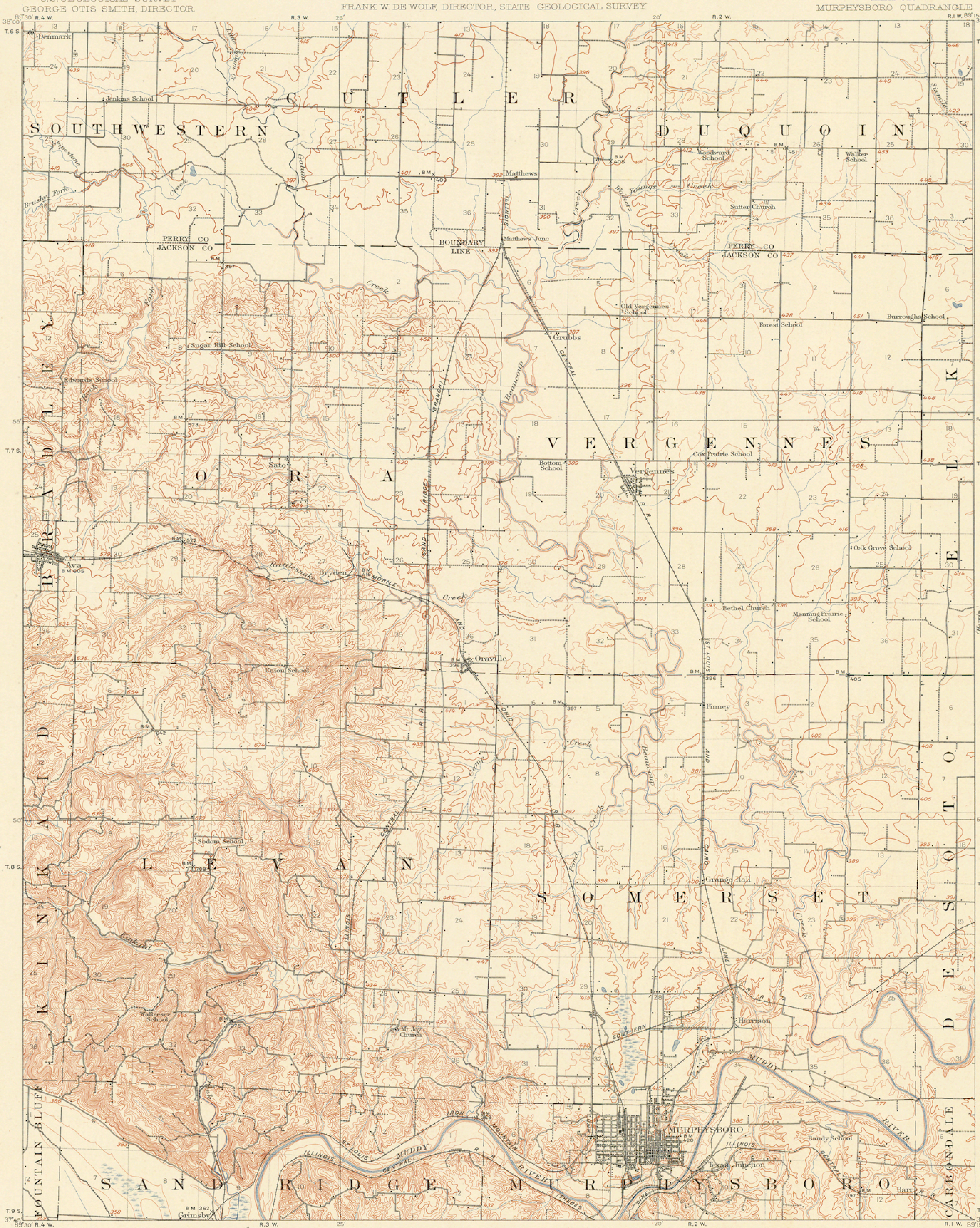
ILLINOIS
MURPHYSBORO QUADRANGLE



LEGEND

RELIEF
printed in brown

Figures
showing heights above mean sea level instrumentally determined

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

Depression contours

DRAINAGE
printed in blue

Streams

Intermittent streams

Ponds

Marshes

CULTURE
printed in black

Roads and buildings

Churches, school houses, and cemeteries

Private and secondary roads

Railroads

Bridges

Trails

U.S. township and section lines

County lines

Township lines

City, village, and borough lines

Triangulation stations

Bench marks
giving elevation above sea

R.B. Marshall, Chief Geographer.
W.H. Herron, Geographer in charge.
Topography by W.J. Lloyd.
Control by L.E. Tucker and Henry Bucher.
Surveyed in 1908.

SURVEYED IN COOPERATION WITH THE STATE OF ILLINOIS.

TRUE NORTH / MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1908.

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 July 1910. reprinted Jan. 1912.

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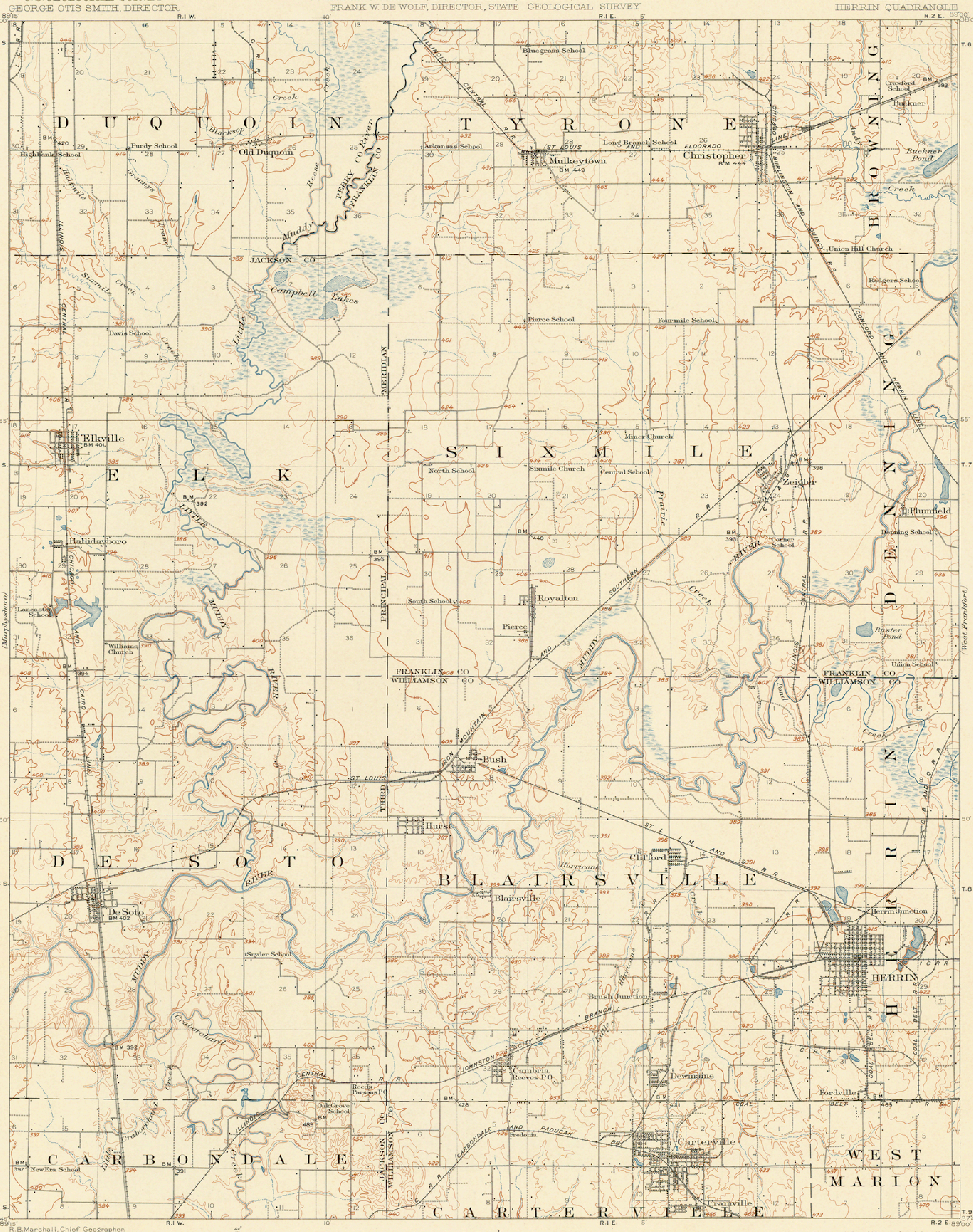
ILLINOIS

HERRIN QUADRANGLE



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Bench marks *giving elevation above sea*

AREAL GEOLOGY

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ILLINOIS
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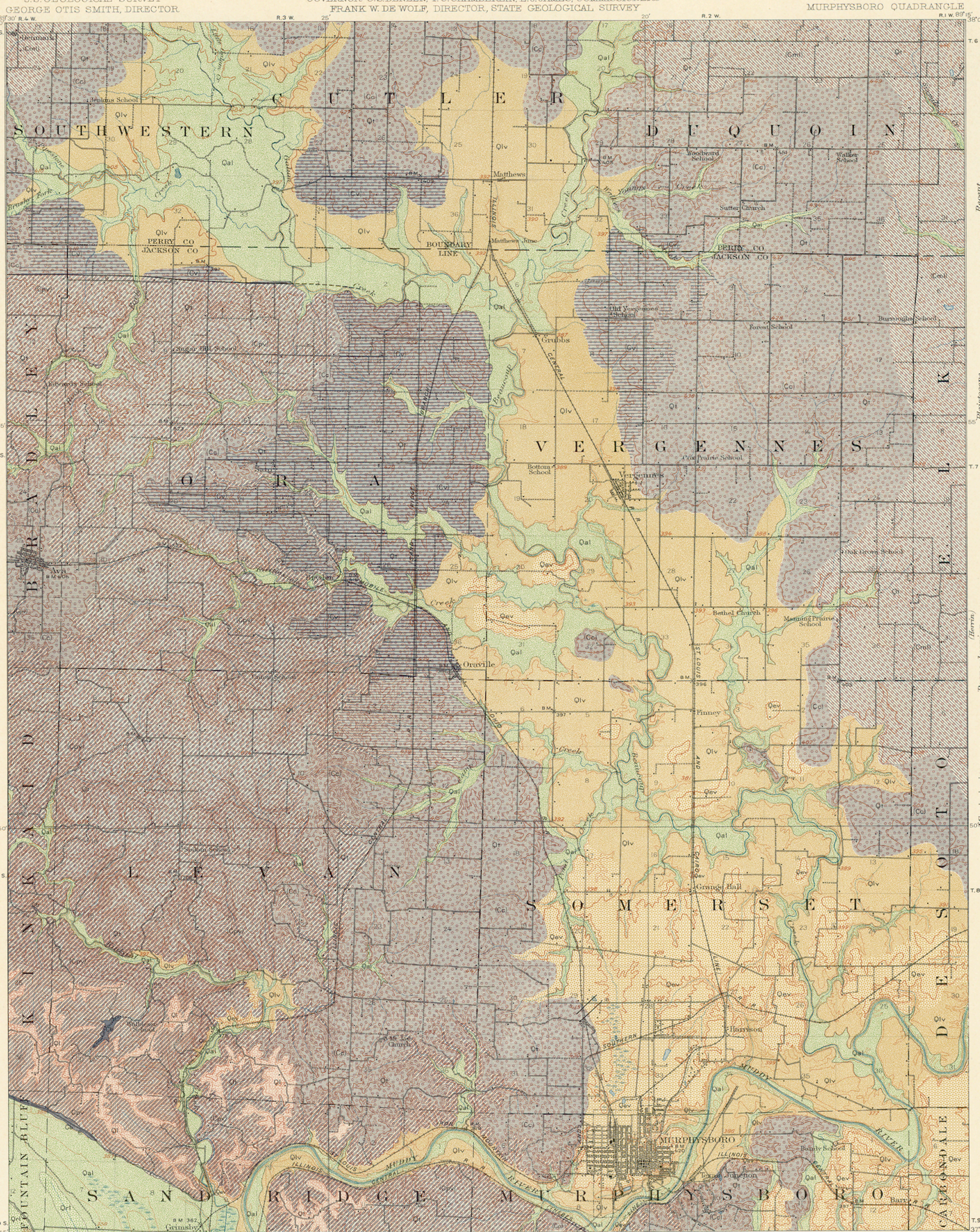

LEGEND

SEDIMENTARY ROCKS

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

QUATERNARY

Recent

Qrl — **Recent lake deposits**
(peat and silt in beds of drained lakes in flood plain of Mississippi River)

Qal — **Alluvium**
(in flood plains of present streams)

Pleistocene

Qlv — **Later valley fill**
(fluvio-lacustrine clay and silt on tributaries of Mississippi River; includes fine delta sand near Murphysboro and other small delta deposits)

Ql — **Thick loess**
(buff calcareous very fine sand and clay containing shells and concretions; thin non-calcareous non-fossiliferous clay, remote from Mississippi River, mapped with glacial till)

Qev — **Earlier valley fill**
(fluvio-lacustrine sand, clay, and silt, apparently older than Qlv, on tributaries of Mississippi River; includes fine delta sand at Murphysboro and other small delta deposits)

Illinoian stage

Qt — **Glacial till**
(drift overlain by thin loess and locally by fine wash, with numerous bedrock exposures in the western part of the quadrangle)

CARBONIFEROUS

Pennsylvanian — *Deeply covered by drift and loess in most places except in southwest corner of quadrangle*

(Herrin)

(Cml) — **McLeansboro formation**
(shale, limestone, and sandstone with several thin coal beds)

(Cc) — **Carbondale formation**
(shale, sandstone, and limestone with two or more workable coal beds; Herrin (No.6) coal at top, Murphysboro (No.2) coal at base. Vergennes sandstone member Cv, mapped only where prominently developed)

(Cpv) — **Pottsville sandstone**
(massive resistant sandstone, locally conglomeratic, with interbedded shale and some coal)

Mississippian — *Chester group*

Cb — **Birdsville formation**
(gray limestone, shale, and sandstone)

Faults

R.B.Marshall, Chief Geographer.
W.H.Herron, Geographer in charge.
Topography by W.J.Lloyd.
Control by L.E.Tucker and Henry Bucher.
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Geology by E.W.Shaw.
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AREAL GEOLOGY

STATE OF ILLINOIS
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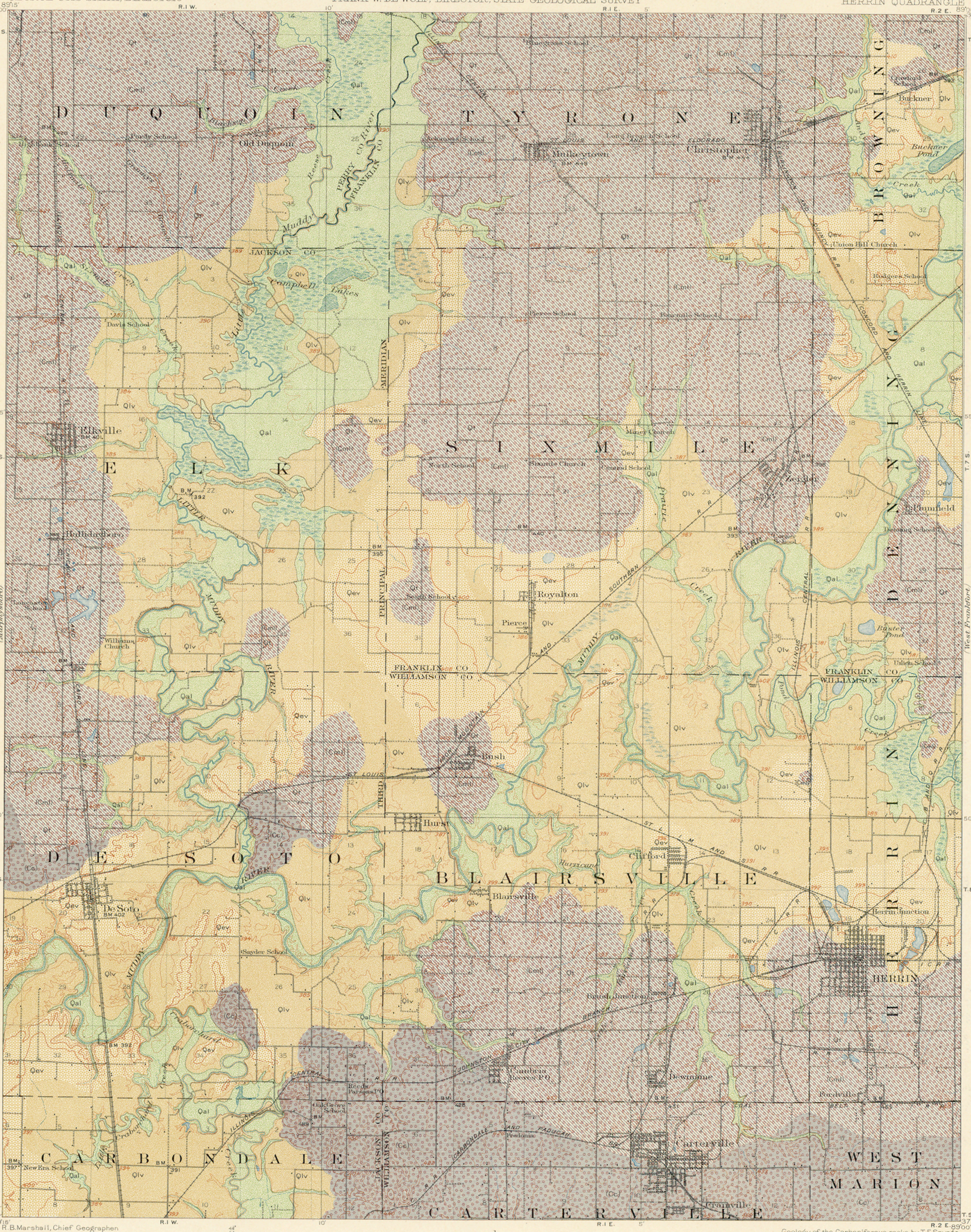

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Geology of the Carboniferous rocks by T. E. Savage,
Quaternary by E. W. Shaw.
Surveyed in 1908 and 1909.

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STRUCTURE AND ECONOMIC GEOLOGY

U.S. GEOLOGICAL SURVEY
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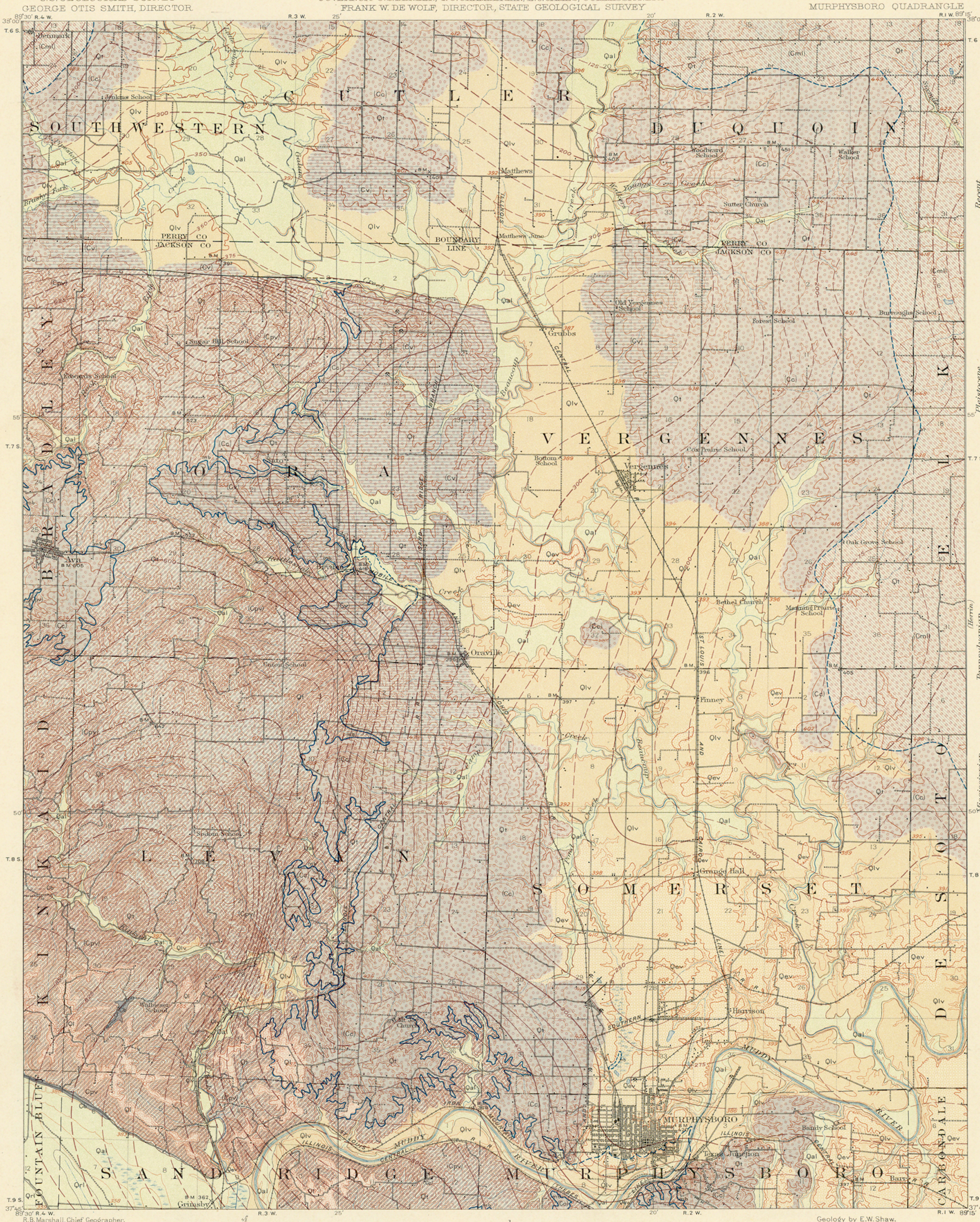

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Faults

ECONOMIC AND STRUCTURE DATA

hr, mb — *Outcrops of workable coals* *(Murphysboro (No.2) coal, mb, and Herrin (No.6) coal, hr, in Carbondale formation, generally overlain by drift and loess; where deeply covered and position is doubtful, approximate outcrop is shown by dashed lines)*

200 — *Structure contours on the base of Murphysboro (No.2) coal* *(doubtful position of coal indicated by dashed lines; contour interval, 25 feet)*

⚒ *Coal mines*

Note: The most valuable coal is the Murphysboro (No. 2) at the base of the Carbondale formation; other coals and clay and shale, for brick and tile, occur throughout the consolidated formations; limestone for cement material and building stone in McLeansboro, Carbondale, and Birdsville formations. The Pottsville formation contains hard pure quartz sandstone which may be valuable for glass sand and ganister. Quaternary deposits yield sand and clay.

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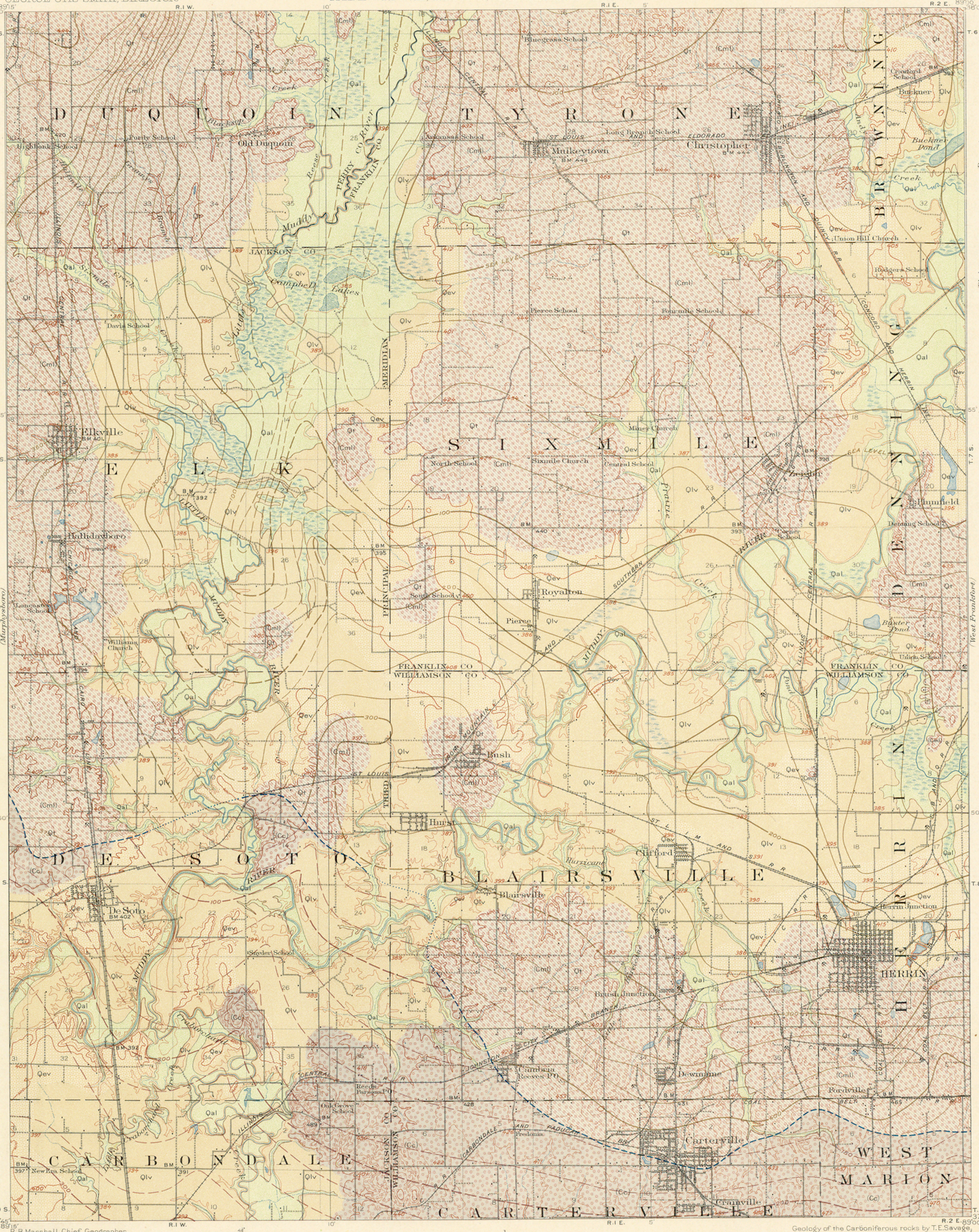

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ECONOMIC AND STRUCTURE DATA

Outcrop of workable coal *(Herrin (No.6) coal in Carbondale formation, generally overlain by surficial deposits; dashed line shows approximate and dotted line very doubtful location of outcrop)*

Structure contours on the base of Herrin (No.6) coal *(doubtful position of coal indicated by dashed lines; contour interval, 25 feet)*

Structure contours on the base of Murphysboro (No.2) coal *(Murphysboro coal about 250 feet below Herrin coal; doubtful position of coal indicated by dashed lines; contour interval, 25 feet)*

⚒ *Coal mines*

Note: The most valuable coal is the Herrin (No.6) at the top of the Carbondale formation. Other coals, more deeply buried, occur throughout the quadrangle; clay and shale, for brick and tile, and limestone, for cement material and building stone, occur in McLeansboro and Carbondale formations. Quaternary deposits yield sand and clay.

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APPROXIMATE MEAN DECLINATION 1908.

Scale $\frac{1}{62500}$

Contour interval 20 feet.
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Edition of Mar. 1912.

Geology of the Carboniferous rocks by T.E.Savage;
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SURVEYED IN COOPERATION WITH THE STATE OF ILLINOIS.

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

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

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

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

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

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

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

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

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

Symbols and colors assigned to the rock systems.

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

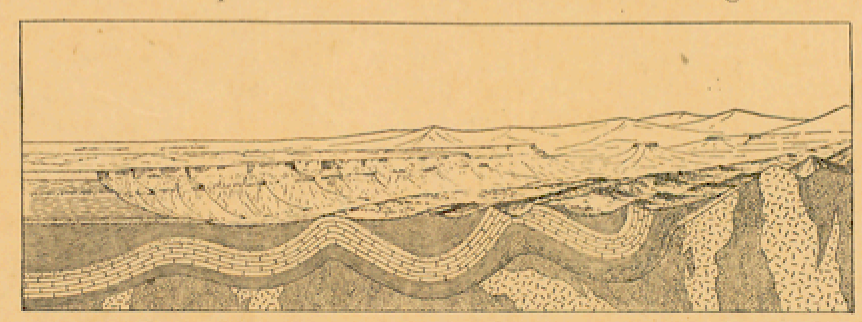

FIGURE 2.—Sketch showing a vertical section at the front and a landscape beyond.

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.

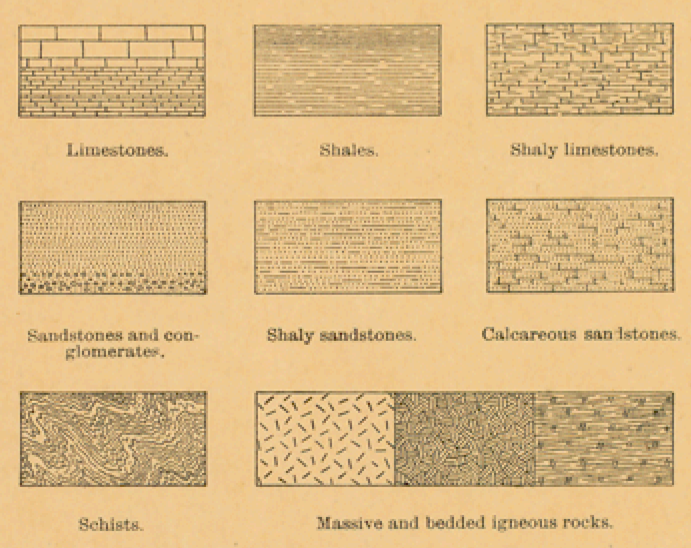

FIGURE 3.—Symbols used in sections to represent different kinds of rocks.

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.

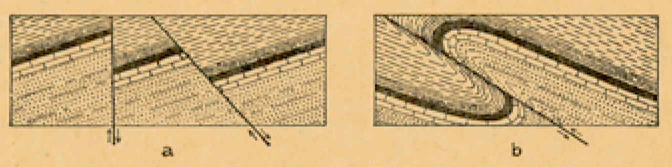

FIGURE 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* or *reverse* fault.

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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