INTRODUCTION.
POSTION AND GENERAL RELATIONS.

The Carlyle and Centralia quadrangles, which comprise the area described in this folio as the Carlyle-Centralia district, are bounded by parallels 38° 30' and 38° 45' and meridians 89° and 89° 30'. They cover an area of 466.56 square miles in south-central Illinois, with which it includes small parts of Bond, Fayette, and Washington counties, though it includes small parts of Bond, Fayette, and Washington counties. The principal towns in the area are Carlyle, Centralia, and Beem. The quadrangles were surveyed under an agreement for cooperation between the United States Geological Survey and the Geological Survey of Illinois. Certain quadrangles in Illinois are being surveyed exclusively by the State Survey, others by the Federal Survey, and still others by both surveys in cooperation. Both the field and the office work for this folio were done entirely by the United States Geological Survey, but the results of the analysis and some additional analytical data were furnished by the State Survey.

The rocks underlying the Central Lowland include igneous, sedimentary, and metamorphic varieties that range in age from pre-Cambrian to Recent, or from the oldest known rocks to the youngest, though represented by younger, more continuous, and higher strata. The pre-Cambrian rocks are represented by gneiss, and in one formation underlie the whole province, for the shifts from deposition to erosion, have been numerous, and some of them have involved the whole province.

In earlier geologic time the sea at several times covered a large part of the province and remained long enough to permit extensive marine deposits to be formed. The surface was rarely, if ever, exposed for below sea level or elevated much above it but was modified throughout by gentle slopes and less continuous warping, which allowed the sea to advance and retreat irregularly and brought about from time to time and place to place not only the deposition of marine sediments and the erosion of the surface of the land but sometimes, especially in the Pennsylvania epoch, the deposition of material upon the land. Since the close of the Paleozoic era the entire province seems to have stood above sea level and to have been subjected to land formation except in Quaternary time, when it received extensive deposits of glacial drift.

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

The Central Lowland seems to contain no deposits of Lower and Middle Cambrian age, but deposits of Upper Cambrian age occur in most of its middle and southern parts. In the upper Mississippi Valley the Cambrian strata are from 400 to more than 1,000 feet thick and consist principally of sandstones and shales. Limestones seem to have been but slightly developed here or elsewhere in this province in Cambrian time, but to the south and west, in southeastern Missouri, Oklahoma, and central Texas, the Upper Cambrian rocks include considerable limestones. The rocks of Ordovician age consist mainly of dolomite and limestones but include also two or more sandstone formations, of which the St. Peter is the most extensive. The seashore migrated widely during this period, and the deposits laid down are now divisible into many formations.

The Illinoian system is made up of dolomite and limestones and some shales. The Illinoian system is made up of dolomite and limestones and some shales. The Illinoian system is made up of dolomite and limestones and some shales. The Illinoian system is made up of dolomite and limestones and some shales.
The record, however, is obscure, because the movements were not great and because the strata are nearly horizontal and of uniform hardness over wide areas, so that it is hard to distinguish low plateaus due to hard rock from those due to deposits of the same age of features that appear to mark stages of elevation and subsidence. In the central and western parts of this quadrangle the uplift is still extensive, though it is cut by half a dozen or more, small, irregular, and shallow valleys. In the southeastern and southeastern parts the uplift is more intimately dissected, but most of the positions that occupy the divides are from a mile to several miles broad.

The remarkable smoothness of the upland province is due in part to the fact that a mantle of glacial drift was so spread over the preglacial surface as to form a plain and in part to the fact that the preglacial surface was itself a plain of slight relief.

Mounds and drift ridges.—The general smoothness of the upland is relieved at many places, especially in the Carlisle quadrangle, by hills that rise abruptly from the plain and form impressive features of the landscape. The hills are at three distinct levels—nearly round, elongated, and irregular. A typical round hill stands in the northwest part of the Wheatfield Township. It has an altitude of more than 40 feet and a width of nearly half a mile. Other round hills are in the northeastern part of the Wheatfield Township, on the northwest side of the Wheatfield Township, and in the southeast part of the Wheatfield Township.

The driftless area is being slowly but continuously reduced by the wind-deposited loess and stream deposits. In certain areas the older rocks crop out at many places, but in others, some of which cover whole counties and even groups of counties, they are completely concealed by a mantle of unconsolidated drift rock, which in places reaches a thickness of several hundred feet. Even in the Driftless Area most of the surface is covered either with wind-deposited loess or stream deposits.

The structure of most of the hard rocks that underlie the surficial deposits in the Central Lowland is comparatively simple. In the greater part of the province the beds lie nearly flat, their regularity being broken only by small faults and bed-ends. The pre-Cambrian rocks that outcrop in Wisconsin, Minnesota, and Michigan, however, are in some places so much folded, contorted, and faulted that their structure can be worked out only with difficulty. The structure of the Paleozoic rocks includes local or less pronounced irregularities, but the larger structural features of the province are a low, broad arch on the southeast, known as the Cincinnati anticline, which lies in part within the Appalachian Plateau and which is divided north of Cincinnati, where it is highest, one branch running toward Lake Erie and the other toward Lake Michigan; a shallow basin that is practically coextensive with the Lower Peninsula of Michigan; another basin that occupies most of Illinois and southern Indiana; and another basin that extends westward from the Mississippi across Iowa and Missouri into the Great Plains; and a broad belt that lies in Wisconsin and Minnesota.

The basin contains the great coal fields known as the northern interior, eastern interior, and western interior coal fields. East of the province lies another basin which contains the Appalachian coal field. Around each basin the strata crop out in concentric belts, the youngest in the middle and the oldest against the outer border. Thus, for example, beds that are 1,000 feet above sea level in northern Illinois are more than 2,000 feet below sea level in the central part of the State, and if all the beds of Illinois that were in theIllinois Basin were extended northward the upthrow would stand several thousand feet above the present surface in central Wisconsin. The movement that formed the Illinois Basin, and other structural features of the province seems to have begun early in the Paleozoic era, but the greatest movement seems to have occurred near the end of the Carboniferous period.

The surface in the Carlin-Centralia district is one of comparatively slight relief and gentle slopes. In view of the great distances of the district from the sea its altitude is low. In its highest point, which stands more than 460 feet above sea-level, is the summit of Pelican Pouch Hill, about 4 miles southeast of Carlyle, and its lowest point, about 400 feet, is in a point in the valley of Kaskaskia River where that stream crosses the southern border of the Carlyle quadrangle. The surface features are due in part to the character of the original surface left by the ice and in part to stream erosion. Much of the area forms a comparatively flat upland that stands 400 to 500 feet above sea level. Above the level of this generally smooth surface rise morainic hills, particularly in the north and southern parts of the Carlyle quadrangle and along the eastern border of the Carlisle quadrangle, and below it the streams have carved valleys that are at some places 1 to 2 miles wide and 200 to 400 feet deep.

The area consists of four rather distinct varieties of topographic forms—morainic hills and drift ridges, upland prairies, erosion slopes, and flat plains.

Upland prairies.—The uplands comprise more than half of the area and are generally smooth and gentle in form. The meadows are not so broad nor so irregular in width. Most of the uplands is being slowly but continuously reduced by the wind-deposited loess and stream deposits. In certain areas the older rocks crop out at many places, but in others, some of which cover whole counties and even groups of counties, they are completely concealed by a mantle of unconsolidated drift rock, which in places reaches a thickness of several hundred feet. Even in the Driftless Area most of the surface is covered either with wind-deposited loess or stream deposits. In certain areas the older rocks crop out at many places, but in others, some of which cover whole counties and even groups of counties, they are completely concealed by a mantle of unconsolidated drift rock, which in places reaches a thickness of several hundred feet. Even in the Driftless Area most of the surface is covered either with wind-deposited loess or stream deposits.

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The river is generally muddy, doubtless on at times of high water, when it carries large quantities of sediment to the Mississippi. It carries an even larger amount of mineral matter in solution than in suspension, and by the loss of material that supplies matter thus carried the surface of the region is being continually lowered.

The gradient of the streams range from that of the Kaskaskia, which is less than a foot to the mile, to that of its intermediate tributaries, which is commonly 5 and at a few places 20 feet to the mile. The fall of Crooked Creek and East Fork at Kaskaskia are very steep, though they are not broad nor so irregular in width. Most of the flood plains of the river are covered by a layer of loess and extended backward or toward the place where the stream becomes intermittent.

DRAINAGE.

The Kaskaskia-Centralia district is drained into Kaskaskia River, which flows in general southwest across the Carlyle quadrangle. The drainage of the Kaskaskia is a whole in long, narrow, and shallow. Its width ranges from 30 to 60 miles, and its area above Kaskaskia is about 3,720 square miles.

The river is very crooked, its length being twice the length of its valley. At ordinary stages it is about 250 feet wide, and it ranges in depth in from 1 foot to 29 feet. The surface near it is low and only slightly undulating. The average fall of the river is about one foot to the mile. Its range between high and low water amounts to 30 to 90 feet, and its discharge ranges from about 250 to about 2,500 cubic feet per second, but at times in the same parts of its course it runs nearly dry. Its average discharge is estimated at 0.74 second-foot per square mile of its drainage basin.

The construction of drainage ditches has not doubt increased the range between high and low water, and the draining of the bottom of the river will probably increase still further the height of floods. Most of the bottom land is flooded so frequently that it can be cultivated only with utmost difficulty for agriculture, and therefore certain areas, such, for example, as one including 3 or 3.5 square miles southeast of Bartelso, have been protected by levees.

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A considerable area is without definite stream channels, though it has been in process of reduction since Illinois time. When many of the valleys of the southern Illinois were obliterated by glacial action. The principal tracts of flat upland with ill-defined drainage lines lie between the Kaskaskia and Mississippi River and around the eastern part of the Carlyle quadrangle. The depth of these uplands is very considerable, and in the highly undulating the border these areas small streams rise in ill-defined depressions in the prairie, where they are fed here and there by springs, while commonly reach the contact of the prairie surface and the underlying bedrock clay, they are perennial in parts of their courses and intermittent in other parts where there are no springs near by.
The Carboniferous, the thickly and economically the most important system of rocks in southern Illinois, falls naturally into two markedly different series. The lower series, the Mississippian, is composed of limestones that includes interbedded shale and sandstone in the upper part, and the upper series, the Pennsylvanian, is composed of soft shales and sandstones together with numerous thin beds of limestones and several more or less lenticular beds of coal. The Formation, which is in some respects forms an uppermost series of the Carboniferous, is not found in southern Illinois. The individual beds differ 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 Appalachian basin. In the Pennsylvania series of the Mississippi basin much of the shale is greenish gray, very soft, and poorly laminated, whereas in the Appalachian basin it is darker and harder and contains many beds of whitish clay. In the western area also the Mississippian series contains chiefly limestones, whereas in the eastern area it is composed largely of sandstone.

MISSISSIPPIAN SERIES

LOWER FORMATIONS.

The rocks of the lower part of the Mississippian series in the Carleyle-Centralia district are not much better known than the underlying formations. They are extensively exposed, however, in the Wabash and other areas to the east, where they have been studied in detail by Welles.4 The lowest bed constitutes the Kinderhook group, which consists of lime, sandstone, and shale, the proportions ranging through wide limits. Informally, the Kinderhook in this region is a reddish stratum known as the Fern Glen limestone member, which affords a means of correlative wall records, for it is usually noted by drillers on account of its red color. It also contains organic fragmental limestones of somewhat characteristic appearance.

Above the Fern Glen limestone member lies in ascending order the Burlington and Keokuk limestones, of the Omeg group, which are commonly identifiable in wells from their strigraphic position and their chalky character. They are much more uniform than the Kinderhook and consist largely of crinoidal cherty limestones.

Above the Keokuk limestones lies the Morrowan group, consisting, in ascending order, of the Waverly shale, the Sperry limestones, and the St. Louis limestone, the three formations having a combined thickness in the region of 400 to 500 feet. The Waverly is usually composed chiefly of thin shale, and in most places is readily separable from the upper formation of the Omeg group, the cherty Keokuk limestones. Northeast of the district it is extensively developed, but within the district it is commonly wanting and the Keokuk is shale, so that in well records the strata are difficult to identify. The succeeding Keokuk limestone is a largely pure light-gray limestone which is at some places oilitic or very fusiliniferous, containing many boscopids and fusuliferous Bryozoa. Some of the beds are flinty in character. The St. Louis limestone is composed of light to dark gray generally fine-grained limestone, including local beds of shale and cherty limestones. It is better known than the underlying formations, for it crops out extensively in the bluffs along the Mississippi, and it is usually noted in drilling.
wells because it is thick, resistant, and cherty. In fact, well drillers generally use it as an index stratum and refer to it as the "Mississippi line." It is about 300 feet thick and is not very fissile. Some of its beds are brittle and resemble lithographic stone. Very little dolomite has been found in the formation in this region.

The Ste. Genevieve is overlain by an olitic limestone, the Ste. Genevieve, which generally consists of fine to coarse sandstone and limestone. In southern Illinois this limestone is composed principally of alternating beds of limestone and sandstone. It is thinly banded or planar, and its bedding is generally more angular than in most other parts of the area. It is characterized by its high porosity and permeability, which make it an important aquifer in the region.

Above the Ste. Genevieve is the Kinkaid limestone, consisting of 140 feet of regularly bedded sandstone, which is overlain by calcareous beds beneath the underclays of the other coal beds of Illinois. Generally there are one or more beds of pure limestone.

The Devonian of Pennsylvania includes the following formations of the Chester group and extends up to the base of the underlying Pottsville series. It ranges in thickness from 10 feet or perhaps less to about 200 feet. So far as known it is thinnest in the vicinity of the Carlyle-Centralia district, but it has been encountered in many drill holes and mine shafts. Its thickness, which seems to increase toward the east, is at most places from 180 to 225 feet. It consists chiefly of shale and sandstone but includes several thin layers of limonite and more or less limonitic beds of coal. The shale at many places forms a soft light-gray clay, which is not at all shaly. The sandstone is generally loosely cemented and rather micaceous, though one or two of the beds in the central part are commonly cemented by calcite carbonate. The limestone is hard, gray or bluish gray, and more or less fissile. At some places it has a peculiar reddish or blackish cast. The uppermost part is associated with the Herrin coal, which is the only coal now mined in the area.

The Aux Vases formation includes all the Pennsylvanian beds between the base of the underclays of the Murphysboro coal (No. 2) and the top of the Herrin coal (No. 6). Its stratigraphic position in the formation is usually above the Ste. Genevieve, which generally consists of massive sandstone but includes several thin layers of limestone and sandstone. The shale is generally banded or planar, and its bedding is generally more angular than in most other parts of the area. It is characterized by its high porosity and permeability, which make it an important aquifer in the region.

Above the Paint Creek is the Cypress sandstone, which consists of massive cliff-forming sandstone 70 to 110 feet thick. The Okaw formation, which overlies the Cypress sandstone, is a sandstone or sandy shale, commonly water-bearing, which has been called the Vermilion sandstone number. Above this sandstone lies containing traces of coal and local lenses of sandstone. It consists of massive cliff-forming sandstone, which is overlain by calcareous beds beneath the underclays of the other coal beds of Illinois. The Kinkaid limestone, which generally consists of very pure limestone, consists of massive cliff-forming sandstone 70 to 110 feet thick. The Okaw formation, which overlies the Cypress sandstone, is a sandstone or sandy shale, commonly water-bearing, which has been called the Vermilion sandstone number. Above this sandstone lies containing traces of coal and local lenses of sandstone. It consists of massive cliff-forming sandstone, which is overlain by calcareous beds beneath the underclays of the other coal beds of Illinois. The Kinkaid limestone, which generally consists of very pure limestone, consists of massive cliff-forming sandstone 70 to 110 feet thick. The Okaw formation, which overlies the Cypress sandstone, is a sandstone or sandy shale, commonly water-bearing, which has been called the Vermilion sandstone number. Above this sandstone lies containing traces of coal and local lenses of sandstone. It consists of massive cliff-forming sandstone, which is overlain by calcareous beds beneath the underclays of the other coal beds of Illinois. The Kinkaid limestone, which generally consists of very pure limestone, consists of massive cliff-forming sandstone 70 to 110 feet thick. The Okaw formation, which overlies the Cypress sandstone, is a sandstone or sandy shale, commonly water-bearing, which has been called the Vermilion sandstone number. Above this sandstone lies containing traces of coal and local lenses of sandstone. It consists of massive cliff-forming sandstone, which is overlain by calcareous beds beneath the underclays of the other coal beds of Illinois. The Kinkaid limestone, which generally consists of very pure limestone, consists of massive cliff-forming sandstone 70 to 110 feet thick. The Okaw formation, which overlies the Cypress sandstone, is a sandstone or sandy shale, commonly water-bearing, which has been called the Vermilion sandstone number. Above this sandstone lies containing traces of coal and local lenses of sandstone. It consists of massive cliff-forming sandstone, which is overlain by calcareous beds beneath the underclays of the other coal beds of Illinois. The Kinkaid limestone, which generally consists of very pure limestone, consists of massive cliff-forming sandstone 70 to 110 feet thick. The Okaw formation, which overlies the Cypress sandstone, is a sandstone or sandy shale, commonly water-bearing, which has been called the Vermilion sandstone number. Above this sandstone lies containing traces of coal and local lenses of sandstone. It consists of massive cliff-forming sandstone, which is overlain by calcareous beds beneath the underclays of the other coal beds of Illinois. The Kinkaid limestone, which generally consists of very pure limestone, consists of massive cliff-forming sandstone 70 to 110 feet thick. The Okaw formation, which overlies the Cypress sandstone, is a sandstone or sandy shale, commonly water-bearing, which has been called the Vermilion sandstone number. Above this sandstone lies containing traces of coal and local lenses of sandstone. It consists of massive cliff-forming sandstone, which is overlain by calcareous beds beneath the underclays of the other coal beds of Illinois. The Kinkaid limestone, which generally consists of very pure limestone, consists of massive cliff-forming sandstone 70 to 110 feet thick. The Okaw formation, which overlies the Cypress sandstone, is a sandstone or sandy shale, commonly water-bearing, which has been called the Vermilion sandstone number.
wood, in the northeastern part of the basin. The thick "Blue Band" of the Dyerville coal, or "Bluine," is generally equivalent to the Belleville coal and to the Desmoines coal. A coal that lies 40 to 80 feet below the Herrin coal, is the Mississippian coal, or the "Blue Band," and it is believed to be 3 to 5 feet in thickness. Other beds of coal are present in this district, but they are of little value and have not been given geographic names. Lithology is known concerning them as to their proper correlative.

The work of Mr. E. R. Whitlock on fossil plants shows that the Missourian or coal stage and the Herrin coal stage being possibly equivalent to the Upper Freeport coal, which is the uppermost layer of the Allegheny formation in the Appalachian coal basin.

**ILLINOIS GLEISLL**

**General Features.** The Illinoian formation, named from the town of McLeansboro, Ill., extends from the top of the Herrin coal to the uppermost Pennsylvanian rocks that are present in this district. It is composed of beds of coal, but the propamount of coal, and the proportion of sandstone in theIllinoian formation, is considerably smaller than that in the Carbondale formation below. Shale that is generally soft and clayey contains the major part of the formation.

**Tills between the Herrin coal and the Shoal Creek limestone member.** The Illinoian till, which is a deposit of the last glaciation of the Wisconsin stage, is generally overlain by shale 10 to 20 feet thick, but locally this shale is absent and the overlitter limestone rests directly on the coal. Most of the shale is gray and very sooty, but at the base it is generally black and hard.

The limestone that overlies the whole is very persistent, even though it is thin, and is evidence of the basin. The limestone, which is generally overlain by shale 10 to 20 feet thick, but locally this shale is absent and the overlatter limestone rests directly on the coal. Most of the shale is gray and very sooty, but at the base it is generally black and hard.

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**Character and thickness of the deposits.** The surface deposits of the area, which are generally 40 to 60 feet thick, belong to the Quaternary system. They consist of till, loess, and loess-like deposits of Pleistocene age. The till consists of an upper part and lower part, which is generally overlaid by a thin loess-like deposit.

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probably it is partly due to this fact that the soil is really
seen along the present slopes where its horizon reaches the
surface. It is found at depths ranging from 1 to 10 feet and
is directly overlain by the loess. It is well exposed just south
of the depot at Bentonville along the railroad 1 mile south of
Centralia. At these places it lies about 2 feet below the
surface.

As many places the Sangamon soil is obscurly developed,
and generally it seems to consist of two divisions of very differ-
cent appearance and constitution—light clayey lower member
and a darker clayey upper member. Above the Illinois Illa
commonly a grey or whitish clay containing few stones, the
origin and current classification of which is somewhat uncer-
tain. Its thickness generally is 5 to 7 feet, but it ranges from
1 foot to 10 feet. This clay differs from both the underlying
main body of till and the overlying loess. It differs from
the till not only in color and in including few stones but in being
generally more sticky or gummy. Fresh exposures are dark
in character, weathered surfaces are whitish. The few stones
it contains are well rounded pebbles of quartz and subangular
pebbles of stone. In places it is caped with loess and in its clays
nature. It may be part of the Sang-
mon soil, but so that it apparently consists of two dis-
tinct members. Above this clay but beneath the loess there is
a layer of clay, and silt are common in the form of terrace remnants whose
upper surface a foot or two or in places more of that material.

Along Kaskaskia River and its larger tributaries there see at
some places two low terraces, both of which are sometimes
called second bottoms. Both are above the reach of ordinary
high water and in places, particularly downstream of the
west of the Carlyle-Centralia district, both are considerably
above the reach of extreme high water. The material com-
pilating these terraces is better stratified than the alluvium
and consists more generally of finer layers of sand, silt, and
clay, whereas the alluvium generally consists of silt containing
layers of sand and clay. The upper terrace deposit seems to antedate the loess, or at
least that it is superposed on it. It is generally about 1 foot in
upper surface a foot or two in places more of that material.
It differs from the lower terrace deposit in rising gradually
upstream, though the dip of the beds is such that of the river, so
that the early filling and the alluvium gradually draw near to
each other, and in the Carlyle quadrangle they nearly merge and in places are both

LISK'S HORIZON

Throughout a large part of its extent the Illinois glacial
till is overlain by loess, a fine-grained clay silt. The loess is not
found in the southern part of the district, for it generally begins 10 miles east of Centralia,
in several small upland areas, from a few yards to several hundred yards across, where the
top is nowhere more than 1 foot below the surface. No loess was observed during the
entire district, but some was removed almost as fast as it was laid down and some has been
eroded away. Except in places where it has been removed by the streams and in the southeastern part of the
Centralia quadrangle, the loess is from 10 to 30 feet thick, overlies the Illinois Illa
and the Sangamon soil and immediately underlies the surface of the entire district.

The loess is composed of friable, unstratified fine-grained, unstratified or very imperfectly stratified, dustlike material
that contains a small amount of calcium carbonate. Though
very easily crumbled, it is sufficiently resistant to stand for a
long time with almost or quite vertical walls where it has been cut by streams or excavations. When wet it is somewhat
plastic but less so than average clay. So far as seen in the
Carlyle-Centralia district it contains no fossils, but a short
distance to the west, where it is considerably thicker and more
uniform in size of grains, it contains in place many shells of
air-breathing gastropods.

In the northern part of the State the main body of loess
passes beneath Wisconsin glacial till, and it is therefore older
than that formation and younger than the Illinois illa,
from each of which it is separated by a well-developed zone of soil.

A small amount of loess overlies the Wisconsin drift in places
on the low ridges and in places it is indistinguishable from the older loess are in places now occu-
much as the loess is about 200 feet thick, overlies the Illinois Illa
and the Sangamon soil and immediately underlies the surface of the
entire district.

Along the lower course of Kaskaskia River deposits of sand
and silt are common in the form of terraces remnants whose
underlying till and is directly overlain by the loess. It is well exposed just south
of the depot at Bentonville along the railroad 1 mile south of
Centralia. At these places it lies about 2 feet below the
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surface.
only a small part of the geologic history of the Carlyle-Centralia district can now be read in the rocks that are exposed at the surface or encountered in boreholes. The record of many of the principal events of the Carboniferous and Quaternary periods is preserved and is legible, but the record of pre-Carboniferous time is less clear or for so few of the surface that only the rocks showing its later part have been reached by the drill. That of the periods between the Carboniferous and Quaternary has been in large part eroded, though there is an indubitable record of the progress of erosion. However, many facts in the history of the district may be inferred from the results of studies made in other areas in the general region, for the processes that affected the district affected an extensive province around it. Evidence concerning many occurrences in pre-Carboniferous time is found in rocks that crop out in southern Illinois and just west of the Mississippi in Missouri. Much of the history of the smaller areas is therefore contained in the more complete record of the larger areas.

The Paleozoic era is a large area was intermittently submerged in an epicontinental sea, the shores of which were divided into many comparatively shallow seas, each of which were divided into many comparatively shallow seas, each of which shifted varied greatly. Since Paleozoic time the sea was kept quiet by the extremely rank vegetation. Bars and barrier shoals were formed. At times the water was too deep for the growth of peat-forming plants and at other times it was shallow enough to permit the formation of coal.

While the Carboniferous sediments were being laid down the sea was kept quiet by the extremely rank vegetation. Bars and barrier shoals were formed. At times the water was too deep for the growth of peat-forming plants and at other times it was shallow enough to permit the formation of coal.

The time of the greatest development of peat occurred at the end of Carbondale time, when the Herrin coal was formed. Presently, there is some indication of emergence and erosion. At the beginning of McLeansboro time the district was practically unaltered by erosion and so level that brackish or fresh-water marshes covered large areas, in which were accumulated beds of vegetal material that were afterward transformed into coal. Much of the sand may have been deposited on the bottom, but the limestone and some of the shale formed during this time contained remains of marine animals, showing conclusively that the rocks in which they are found were deposited in the sea.

At times both local and general emergence and erosion seem to have occurred, though the erosion was not nearly so extensive as that at the beginning of the preceding Pottsville epoch. Conditions generally were more quiet than in that epoch. Beds of sand, in some places thick though not extensive, were formed, but more of the material laid down was clay. More post was formed in this epoch than in any other. The time of the greatest development of peat occurred at the end of Carbondale time, when the Herrin coal was formed. Presently, there is some indication of emergence and erosion. At the beginning of McLeansboro time the district was practically unaltered by erosion and so level that brackish or fresh-water marshes covered large areas, in which were accumulated beds of vegetal material that were afterward transformed into coal. Much of the sand may have been deposited on the bottom, but the limestone and some of the shale formed during this time contained remains of marine animals, showing conclusively that the rocks in which they are found were deposited in the sea.

The sediments deposited during Ordovician time consisted mainly of calcium carbonate and perhaps magnesium carbonate but included some argillaceous or muddy material. Many forms of life inhabited the sea, and their remains have been preserved in the rocks. In Silurian time more of the Mississippi basin was covered by a clear sea and extensive argillaceous deposits. During a part of the Devonian period also argillaceous deposits were formed, but at times the water was too deep for the growth of peat-forming plants and at other times it was shallow enough to form beds of coal.

The conditions that prevailed in Carboniferous time continued in Mississippian time with much change, but the formation of peat was widespread and was of shorter duration. The sea here lies between two faults that converge toward the north and east. Further warping elevated the surrounding country, so that the area of sedimentation gradually advanced northward and spread eastward and westward. Most of the sediments laid down at this time consisted of continental sand and mud, which now make up the Pottsville formation. The sand was double in part derived from the rocks of the Carboniferous group, which formed the western border of this portion of the Pottsville area of deposition, though as much of the sand of the Pottsville is coarose and more micaceous than that of the Chester, a large part must have come from elsewhere. The correlations and the great volume of the material show that the land from which it was derived must have stood considerably above sea level.

Early in the Pennsylvania epoch great post members began to form in Illinois and parts of adjacent States, and some of them persisted for a long time. Now and then conditions, so that mud or sand was washed upon the pest, sometimes in thin films and at others in deposits reaching a thickness of many feet. Most of these bodies of sediment were of lenticular form, but groups of them are so fitted together as to make a stratum, though not continuous. In the Potville epoch the accumulations of past were not so extensive as in later epochs, but local marls were developed in which layers of vegetable remains accumulated in quantities large enough to form seams of coal.

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At this time the deposition of the Upper Devonian beds and the time of the deposition of Carboniferous beds are not recorded, but the deposits of the former are slaty and the beds of the latter are hard. During the Mississippian epoch it was again extensively submerged. In Kinderhook time much fine sand and clay was carried to the sea by the rivers, and interbedded sand, though a subordinate but considerable amount was also deposited. At the close of the Kinderhook epoch the sea withdrew to the southern part of the region. When it returned it was kept quiet by the extremely rank vegetation. Bars and barrier shoals were formed. At times the water was too deep for the growth of peat-forming plants and at other times it was shallow enough to form beds of coal.

At the beginning of the Paleozoic era the surface of the region, so far as known, has been continuously submerged except during intervals of emergence and erosion. At the beginning of the Paleozoic era the surface of the region, so far as known, has been continuously submerged except during intervals of emergence and erosion. At the beginning of the Paleozoic era the surface of the region, so far as known, has been continuously submerged except during intervals of emergence and erosion. At the beginning of the Paleozoic era the surface of the region, so far as known, has been continuously submerged except during intervals of emergence and erosion. At the beginning of the Paleozoic era the surface of the region, so far as known, has been continuously submerged except during intervals of emergence and erosion. At the beginning of the Paleozoic era the surface of the region, so far as known, has been continuously submerged except during intervals of emergence and erosion. At the beginning of the Paleozoic era the surface of the region, so far as known, has been continuously submerged except during intervals of emergence and erosion.
Near the end of the Tertiary period the region was approximately subjected to a general uplift, which accelerated erosion and caused the streams to deepen their valleys. Well borings show that several such valleys, 75 feet or more in depth and now filled with drift, crossed the Carlyle-Centralia district. The general form of the present bedrock was not changed. It is probably much the same as the preglacial surface and may be discussed as such.

The maximum known relief of the preglacial surface was 120 feet, but if the deepest valleys are not considered it did not exceed 20 or 60 feet. The valleys were generally U-shaped and their slopes somewhat gentle and the divides were about as high above the valleys as those of to-day. In these respects the preglacial surface somewhat resembles the present surface. The valleys had a different arrangement, however, and the courses of the present streams have little relation to the ancient lowlands.

Kaskaskia's River is the most striking exception, for, in its course within the district it seems to lie almost entirely within the preglacial lowland. At only a few places, in an area 3 miles south of Carlyle, is bedrock in the Kaskaskia Valley as high as the present stream bed.

QUATERNARY PERIOD.

At the beginning of the Quaternary period the surface of the Carlyle-Centralia district, though in general much like the preglacial surface, differed from it in one striking particular. The configuration of the surface at that time was produced solely by erosion, whereas that of the present surface has been in part produced by the deposition of drift and in part by the erosion of the drift by streams.

PRE-ILLINOIAN TIME.

In the earlier part of the Pleistocene epoch ice sheets formed in Canada of different ages and roamed over the central interior region of the United States, probably covering part of Illinois. These ice sheets are known as the Nebraskan and Kansan, and after each sheet had melted there remained drift stages (Aftonian and Yarmouth, respectively) during which soils and in places lakes and stream deposits were formed. These pre-Illinoian stages appear not to be represented by deposits in the Carlyle and Centralina quadrangles, except possibly the Yarmouth deposits. In many valleys layers of gravel and sand have been reported, and in some with pieces of wood and materials that have somewhat the appearance of buried soils have been found, but in most of the district the drift seems to appear to be one continuous deposit, extending down to the preglacial residual material, which immediately overlies the bedrock surface.

In several places in southern Illinois a thin deposit of loess underlies the Illinoian till, and in the Carlyle-Centralia district material that appears to be loess is brought from beneath the till in well-drilling, though it is generally so much washed and mixed with the overlying and underlaying deposits that its identification is difficult. A rather extensive deposit of loess, however, was probably laid down in southern Illinois, perhaps in Yarmouth time, and this loess, like the deposits of gravel and sand, has been reported, and in some with pieces of wood and material that have somewhat the appearance of buried soils have been found, but in most of the district the drift seems to appear to be one continuous deposit, extending down to the preglacial residual material, which immediately overlies the bedrock surface.

ILLINOIAN TIME.

The events of the Illinoian glacial stage were of great significance in the history of the Carlyle-Centralia district. The Illinoian ice spread out from a center in Labrador and moved south, and in the central interior region of the United States, probably covering part of Illinois. The Illinoian ice of the Illinois area was at one time in the form of a sheet of ice but is now known to have been composed of a number of ice lobes or sheets, each of which covered Illinois or a part of the State. The Illinoian sheet was divided into several main lobes, one of which was the St. Louis lobe, which covered Illinois except for the southernmost point reached by any Pleistocene ice sheet. This lobe was the only one of the several main lobes the surface of which appears to have been affected by the Illinoian stage.

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After these conditions had continued undisturbed for some time, until the present valleys were fairly well developed and partly filled with stream deposits, favorable conditions arose for the accumulation of extensive deposits of alluvial material, probably deposited by glaciers spreading over the Sangamon soil and over the loess and eroded Illinoian till in places where the Sangamon soil was absent. Later this deposition of loesslike material was brought about probably by erosion, and the carving of valleys continued to Wisconsin time, when they had reached almost their present form.

The original and mode of accumulation has for many years been a problem for which there is little complete and universally satisfactory evidence that has ever been reached. Two general theories have been advanced—one that it was deposited by water and the other that it represents accumulations of wind-borne dust. Each of these theories seems to have many adherents, though the balance of opinion seems to favor the view that it was deposited by wind.

Some localities in Illinois are stratified and contain pebbles and aquatic fossils, which favors the opinion that it was deposited by water, while other localities show that it is composed of loess and contains pebbles, which indicates transportation by wind rather than water. It is thicker on the higher hills that border the large rivers than it is on the lowland 20 to 100 miles distant, and it is thickest on the south and west sides of the river-valleys—that is, on the sides opposite the streams—though it may be thinner on the sides of the valleys, and this loess, like the deposits of gravel and sand, has been reported. The source of the loess is an even more difficult problem. Some loesslike material is stratified and contains pebbles and aquatic fossils, which favors the opinion that it was deposited by water, while other localities show that it is composed of loess and contains pebbles, which indicates transportation by wind rather than water. It is thicker on the higher hills that border the large rivers than it is on the lowland 20 to 100 miles distant, and it is thickest on the south and west sides of the river-valleys—that is, on the sides opposite the streams—though it may be thinner on the sides of the valleys.

According to the Illinoian till, which with the exception of the drift ridges was somewhat more smooth than the preglacial surface, new lines of drainage were developed, and in the flattest parts of the interstream areas organic material did not accumulate in the Sangamon soil or was not preserved, and hence in many exposures the upper limit of the till is not definitely known. This system of ridges forms the middle one of three approximately parallel systems. The ridges may consist of interlobate morainic material deposited between two ice fields or they may be terminal or recessional moraines that mark the west border of an ice lobe which persisted in southern Illinois after the ice had retreated from the western part of the State. They may represent accumulations of material under the ice or they may consist of material collected in or upon it. There are indications that one of the lobes was a sheet of ice which covered Illinois or a part of the State, and the other two were sheets of ice which covered Illinois or a part of the State. The final ice front of the Illinoian stage did not extend south of the Illinois River. The Illinoian ice spread out from a center in Labrador and moved south, and in the central interior region of the United States, probably covering part of Illinois. The Illinoian sheet was divided into several main lobes, one of which was the St. Louis lobe, which covered Illinois except for the southernmost point reached by any Pleistocene ice sheet. As the Illinoian ice spread out from a center in Labrador and moved south, and in the central interior region of the United States, probably covering part of Illinois. The Illinoian sheet was divided into several main lobes, one of which was the St. Louis lobe, which covered Illinois except for the southernmost point reached by any Pleistocene ice sheet. As

COAL.

The mineral resources of the Carlyle-Centralia district, valued in approximate order of commercial value, are coal, oil and gas, soils, water, clay, and building stone.

The coal is in the southeastern part of the eastern interior region of the United States, probably covering part of Illinois. The Illinoian ice spread out from a center in Labrador and moved south, and in the central interior region of the United States, probably covering part of Illinois. The Illinoian sheet was divided into several main lobes, one of which was the St. Louis lobe, which covered Illinois except for the southernmost point reached by any Pleistocene ice sheet. As the Illinoian ice spread out from a center in Labrador and moved south, and in the central interior region of the United States, probably covering part of Illinois. The Illinoian sheet was divided into several main lobes, one of which was the St. Louis lobe, which covered Illinois except for the southernmost point reached by any Pleistocene ice sheet. As the Illinoian ice spread out from a center in Labrador and moved south, and in the central interior region of the United States, probably covering part of Illinois. The Illinoian sheet was divided into several main lobes, one of which was the St. Louis lobe, which covered Illinois except for the southernmost point reached by any Pleistocene ice sheet. As the Illinoian ice spread out from a center in Labrador and moved south, and in the central interior region of the United States, probably covering part of Illinois. The Illinoian sheet was divided into several main lobes, one of which was the St. Louis lobe, which covered Illinois except for the southernmost point reached by any Pleistocene ice sheet. As the Illinoian ice spread out from a center in Labrador and moved south, and in the central interior region of the United States, probably covering part of Illinois. The Illinoian sheet was divided into several main lobes, one of which was the St. Louis lobe, which covered Illinois except for the southernmost point reached by any Pleistocene ice sheet. As the Illinoian ice spread out from a center in Labrador and moved south, and in the central interior region of the United States, probably covering part of Illinois. The Illinoian sheet was divided into several main lobes, one of which was the St. Louis lobe, which covered Illinois except for the southernmost point reached by any Pleistocene ice sheet. As the Illinoian ice spread out from a center in Labrador and moved south, and in the central interior region of the United States, probably covering part of Illinois. The Illinoian sheet was divided into several main lobes, one of which was the St. Louis lobe, which covered Illinois except for the southernmost point reached by any Pleistocene ice sheet. As
However, it is overlain and underlain by soft clay and cut by numerous clay veinlets, which make mining difficult.

**General features**—The Herrin coal is by far the most valuable and best-known coal in the district. It is worked extensively near Carbon and Sandoval and as far as is known is persistent. It ranges in thickness from 2 feet 6 inches to 6 feet 10 inches and averages about 6 feet. It is overlain generally by hard black shale, which forms a good roof, and is underlain by a hard sandy clay, which does not creep rapidly. In a few places the bed appears to fall below the general minimum of 5 feet 6 inches, and in a small area west of Carlyle the coal seems to be absent. Throughout extensive areas, however, little is known concerning the coal, and hence it is somewhat unsafe to assume that the coal is present in all but a few small areas.

In the following statements of analyses the figures showing the chemical character of the coal have been compiled from analyses made by the direction of Prof. S. W. Parr in the laboratories of the University of Illinois. The three producing sands, the Carlyle, the Stein, and the Benoist in the lower part of the Renault or Herrin formation, and the Benoist in the lower part of the Renault or Herrin formation. On the whole, gas and oil showings of oil and considerable gas have occurred when two wildcat wells, about 1,000 feet deep, had previously been drilled just south of Carlyle, and one of them found a showing of gas but hardly enough to stimulate prospecting. Since these pools were found many other wells have been sunk elsewhere in the area and the surrounding region, in the search for other pools, but so far, although the structure in second place is favorable, none have been discovered. Showings of oil have been found, however, particularly at Beredale and east of northwest of Centralia.

Each of the two producing oil pools yielded a maximum of about 5,000 barrels of oil a day. The individual pools produced at first from 19 to 1,000 more barrels a day, the average being probably less than 100 barrels. A year after each of the pools had been fairly completely drilled its production had decreased to about 2,000 barrels a day, and since the production has not yet been dwindled.

The three producing sands, the Carlyle, the Stein, and the Benoist, lie respectively about 600, 700, and 800 feet below the Herrin coal.

The Carlyle sand probably corresponds to the Cypress sandstone, the Stein sand belongs in the Ravina formation, and the Benoist in the lower part of the Ravina or perhaps the upper part of the Assiniboe sandstone.

The producing pools showings of oil and considerable gas have been found in other sandstone deposits in the Pottsville formation. At Carlyle showings of oil have been found 330, 440, and 580 feet below the coal, and in the western part of the pool showings of oil have been published. The bripotigating and gas-producer tests show that the coal is also well adapted to use in gas production for bripotigating, and that, with the development of these industries, the demand for the coal should increase.

**CHEMICAL CHARACTER.**—The chemical character of the coal, like the physical character, differs greatly from place to place. In the following statements of analyses the figures showing the chemical character of the coal have been compiled from analyses made by the direction of Prof. S. W. Parr in the laboratories of the University of Illinois.
Although considerable gas flows from all the wells, almost none of it has been used, except in the work of developing the pools. Experiments to determine the amount of natural-gas gasoline that can be made from the gas show that it varies considerably from several gallons to the thousand cubic feet, but no gas line has been formed.

Water is found in all the wells, the main body lying just beneath the oil in the same sand, and great care is required in drilling to avoid a large flow of salt water.

The thickness of the productive part of the oil sands averages 10 or 12 feet. As the pure space is 10 or 15 per cent, only one-fourth to one-third has been leased out, or the total amount of oil originally in each pool was between 6,000,000 and 20,000,000 barrels. The amount recoverable, however, is considerably less, depending largely upon the movements of the water.

The gravity of the oil in a generally a little 32° Be, specific gravity 0.868; some of it is as high as 32° or 33° (specific gravity 0.880). The oil is similar to that obtained in the southern part of the State and contains much grease and illuminating oil.

CLAY.

The clay resources of the Carlyle-Centralia district are extensive but have been little exploited. The principal source of clays is the shale covering the beds of the district, though in the same place shale in the Carboniferous system could possibly be worked to advantage in connection with suitable clays. By far the most abundant source of clay in the basin, which immediately underlies the surface almost throughout the district and is everywhere useful for making ordinary clay products. It is especially useful for making bonded brick.

LIMESTONE.

The only limestones that occur in the district are those of the McLeansboro formation, and the purest and most valuable is the Shale Creek limestone which outcrops along the western part of the district. This limestone has been quarried at several places along Shale Creek near the western boundary of the Carlyle quadrangle for making lime and rough building stone. Generally the limestones in the district are either too thin or too impure or the overburden is too great for extensive operation.

SAND AND GRAVEL.

Sand suitable for plaster and cement occurs in the form of beds in the river alluvium, but not in large commercial quantities. Most abundant supplies of well-washed sand and gravel are contained in the drift ridges in the vicinity of Keyport. Soil.

Most of the soil of the Carlyle-Centralia district has been derived from the loess. In places it has been derived chiefly from the glacial till, and in a few small tracts it is made up largely of detritus of the underlying bedrock. The streams of the district are bordered by alluvial terraces along the interstream areas, and as these areas are usually almost continuously covered by loess and alluvial sand is largely derived from the loess, but it is usually covered and derived from the alluvial sand.

The soil of the district consists of a great variety of more or less decomposed minerals. In its formation there seems to have been a general lowering of the land surface, compensated in some places by the addition of limy from limestone and marine silts. The loess soil has the consistency that would be expected of a soil composed of dust particles that have been somewhat modified by weathering. It is comparatively open and coarse and contains a large amount of sand and gravel of various sizes, which form the loam layer in the surface soil. In general the proportion of clay increases with the distance from the Mississippi, so that the soil in the eastern part of the district is much heavier and less porous than that in the western part. The porous soil is yellowish gray, and the more compact soil is light gray. In some places, especially on the alluvial bottoms, the soil is light gray or black.

The period for each month of the year, and the average rainfall for the month, are given in the table below. The numeral at the end of a column indicates the number of days on which rain fell during the month.

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<th>Month</th>
<th>Mean Monthly Temperature</th>
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<td>September</td>
<td>42.0</td>
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<td>December</td>
<td>24.0</td>
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</tr>
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</table>

Southern conditions.—By far the most serious question in the way of any supply in its sanitary quality. Details referring to this subject belong in the field of work of national and State health organizations, but geologic conditions may have far-reaching effects.

The minerals found in the waters of this district that are regularly used for drinking are of comparatively little importance. The real danger is the contamination of drinking water with bacteria that produce disease, notably typhoid fever. Even though water may be badly polluted with gases and other extraneous matter, the absence of the germs of typhoid fever or other infectious diseases may enable those who drink it to escape ill effects. The fact that water from some sources has not caused disease, however, is no guarantee that it will not do so as soon as polluting matter containing the germs of certain diseases is introduced to it.

Deep wells are generally the safest. Shallow wells are generally open to suspicion, but they are occasionally the most efficient and economical.


Sanitary considerations.—By far the most serious question in the way of any supply in its sanitary quality. Details referring to this subject belong in the field of work of national and State health organizations, but geologic conditions may have far-reaching effects.

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