1917

Pleistocene history of Lee county, Iowa

Arthur Howard Dewey

State University of Iowa

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THE STATE UNIVERSITY OF IOWA.

THE PLEISTOCENE HISTORY OF LEE COUNTY, IOWA.

by

Arthur Howard Dewey, B.A.

A thesis submitted to the Faculty of the Graduate College in partial fulfillment for the degree of Master of Science.

Iowa City,
1917.
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Previous work in the region.
Purpose of the investigation.

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Pleistocene history of Lee county.

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INTRODUCTION.

Location and extent of region.

Lee county is situated in the southeast corner of Iowa. It is separated from Illinois on the east by the Mississippi river, and from Missouri on the south by the Des Moines river. On the northeast the Skunk river separates it from Des Moines county. Van Buren and Henry counties bound the northwest quarter of the county.

The region lies between the parallels of 91° 4' and 91° 42' north latitude and the meridians 40° 17' and 40° 47' west longitude and has an area of about five hundred square miles.

The location of the region in the state and its relation to other states is shown in figure 1.

Previous work in the region.

Although considerable work has been done on the indurated rocks of Lee county, little detailed work has been done on the Pleistocene deposits. The most important work has been done by Leverett.

The following bibliography includes those publications which relate more or less directly to the Pleistocene of Lee county and from which important data have been obtained.


Purpose of the investigation.

This report describes the Pleistocene deposits of Lee county and discusses the geological interpretations of these deposits. It is the hope of the writer that this work may enlarge the knowledge of the Pleistocene of the state of Iowa.

The field work on which the report is based was done in the summer of 1916 under the direction of Professor George F. Kay, Head of the Department of Geology of the State University of Iowa.
The Indurated Rocks.

This outline of the indurated rocks of Lee county is taken from a preliminary report on the geology of southeastern Iowa and adjoining parts of Illinois and Missouri by Van Tuyl.¹ He has classified the geological formations as follows:

1. Van Tuyl, F.M., Master's Thesis, University of Iowa, 1912.

as follows:

<table>
<thead>
<tr>
<th>Paleozoic</th>
<th>Pennsylvanian</th>
<th>Des Moines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mississippian</td>
<td>St. Louis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Salem</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Warsaw</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Keokuk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Burlington</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kinderhook</td>
</tr>
</tbody>
</table>

The Mississippian System.

The Kinderhook:

The Kinderhook beds constitute the oldest rocks of the region. Although they are an important formation in Des Moines county to the north and Missouri to the south they have been recognized only in a single place in Lee county, namely, along the Skunk river near the crossing of the Chicago, Burlington and Quincy Railroad. Lithologically, the beds consist for the most part of "argillaceous shale, but..."
towards the top, layers of limestone and sandstone occur. Fossils are not often found.

The Burlington Limestone:

Three divisions are found in the county, namely, the Lower Burlington, Upper Burlington and Montrose cherts. The basis for subdivision is both faunal and lithological. The separation of the lower part into the Lower and Upper Burlington is necessitated only by a faunal change, it being lithologically a unit. "It consists essentially of a whitish or brownish crinoidal conglomerate." The limestone has resulted from the cementation of the stems and calyces of crinoids. These calcareous fragments have now become re-crystallized to calcite. The areal distribution of the Burlington is not great, being exposed only along the stream courses of the Skunk river and the Mississippi river. The upper part of the Burlington has been called the Montrose cherts. It is very cherty and is exposed along the Mississippi river between Montrose and Keokuk, Iowa.

The Keokuk Beds:

These beds overlie the Burlington limestone. They are divisible lithologically into two parts, namely, Upper Keokuk, a more or less argillaceous portion, and a Lower Keokuk or limestone member. "The Lower Keokuk consists, in the main, of bluish fossiliferous, crystalline limestone intercalated with which are bands of shale, and impure magnesian layers, the latter sometimes bearing imperfect geodes....... The Upper Keokuk consists essentially of a bluish, fossiliferous, crystalline and often crinoidal limestone with intercalated layers of shale which frequently
pinch and swell in short distances. The Keokuk beds overlie the Burlington conformably but their relationship to the overlying strata is complicated due to unconformity. The Keokuk beds may be overlain unconformably by the Salem or even St. Louis, instead of by the Warsaw as in the normal sequence. "The outcrops of the Keokuk beds in the region are for the most part disconnected. They do not come to the surface over large areas.

The Warsaw Beds:

The Warsaw consists at the base of an argillaceous shale, characterized by an abundance of geodes and paucity of fossils; above this is a member of variable thickness, which in turn is overlain by bluish argillaceous shale which bears discontinuous bands of limestone. The formation varies greatly in thickness being a great deal less at Keokuk, Iowa, than at its typical locality at Warsaw, Illinois. This difference in thickness may be due to irregularities in deposition or to post-Warsaw and pre-Salem erosion.

The St. Louis Limestone:

"The St. Louis limestone consists of a dense, hard, gray and white limestone, often brecciated and at times bearing beds of sandstone several feet in thickness. Towards the base it is generally interbedded with magnesium limestone, but it is found sometimes to be completely dolomitized. The upper portion of the formation is more thinly bedded than the lower and the marly partings are very fossiliferous." This formation constitutes the surface rocks over large areas in Lee county.
The Pennsylvanian System.

The Des Moines:

Lee county lies midway between the Eastern Interior and the Western Interior Coal fields. Sandstone and shale of Coal Measures age reach their greatest development in the north central and western parts of the county. "The formation is only occasionally represented by isolated outliers of limited extent........ Such outliers clearly indicate that the two great coal provinces were at one time continuous over the area."

Sub-glacial Topography.

It is impossible from the available well records to obtain accurate knowledge of the sub-glacial topography of the county, yet it is possible to obtain a general idea of the surface features previous to the deposition of the drift. Well records are somewhat numerous, but since there is no topographic map of the county, there are relatively few of these whose curb elevations are known.

The following data, as given by Norton¹, show

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that the sub-glacial topography had considerable relief.
<table>
<thead>
<tr>
<th>Location</th>
<th>Curb elevation</th>
<th>Elevation at top of bed rock</th>
<th>Drift</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belfast</td>
<td>527</td>
<td>497</td>
<td>30'</td>
</tr>
<tr>
<td>Franklin</td>
<td>699</td>
<td>659</td>
<td>40'</td>
</tr>
<tr>
<td>Ft. Madison:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brown Paper Co.</td>
<td>528</td>
<td>466</td>
<td>62'</td>
</tr>
<tr>
<td>Atchison, Topeka and Santa Fe Hospital</td>
<td>553</td>
<td>441</td>
<td>112'</td>
</tr>
<tr>
<td>Atchison, Topeka and Santa Fe Shops</td>
<td>522</td>
<td>374</td>
<td>148'</td>
</tr>
<tr>
<td>Hillsboro</td>
<td>731</td>
<td>627</td>
<td>104'</td>
</tr>
<tr>
<td>La Crew</td>
<td>717</td>
<td>622</td>
<td>95'</td>
</tr>
<tr>
<td>La Harpe, Ill.</td>
<td>700</td>
<td>600</td>
<td>100'</td>
</tr>
</tbody>
</table>

1. Compiled from various data by the writer.

<table>
<thead>
<tr>
<th>Location</th>
<th>Curb elevation</th>
<th>Elevation at top of bed rock</th>
<th>Drift</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keokuk:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hubinger well</td>
<td>637</td>
<td>609</td>
<td>28'</td>
</tr>
<tr>
<td>Keokuk Poultry Co.</td>
<td>541</td>
<td>536</td>
<td>5'</td>
</tr>
<tr>
<td>Y.M.C.A.</td>
<td>580</td>
<td>550</td>
<td>30'</td>
</tr>
<tr>
<td>Popel-Miller Brewing Co.</td>
<td>523</td>
<td>483</td>
<td>40'</td>
</tr>
<tr>
<td>Mt. Clara</td>
<td>679</td>
<td>374</td>
<td>305'</td>
</tr>
<tr>
<td>Sandusky</td>
<td>506</td>
<td>470</td>
<td>36'</td>
</tr>
<tr>
<td>Sawyer</td>
<td>708</td>
<td>608</td>
<td>100'</td>
</tr>
<tr>
<td>Warren</td>
<td>707</td>
<td>607-637</td>
<td>70-100'</td>
</tr>
<tr>
<td>West Point:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Axhandle Factory</td>
<td>760</td>
<td>645</td>
<td>115'</td>
</tr>
<tr>
<td>Quinton, R.B. near Denmark</td>
<td>715</td>
<td>635</td>
<td>80'</td>
</tr>
<tr>
<td>Bell, Isaac; Sec. 21, Cedar township</td>
<td>700</td>
<td>610</td>
<td>90'</td>
</tr>
</tbody>
</table>
Fig. 2. Map Showing Sub-glacial Topography of Lee county.

The numbers indicate the elevation of bed rock.

(after Gordon)
From the foregoing records it is seen that the maximum relief of the sub-glacial surface was about 285 feet. The greater part of this area was an upland plain with slight relief, and traversed by a deep valley, probably formed by a pre-Pleistocene river, which occupied approximately the position shown in figure 2.

Cross sections of the sub-glacial valley indicated in figure 2 are as follows:

Scale: Horizontal, - same as the map. Vertical, - 1/16 in. to 10 ft.
Brief Outline of the Pleistocene History of Iowa.

In order that the Pleistocene history of Lee county may be better appreciated it may be well to outline briefly the Pleistocene deposits of the state in general.

For a long time the Pleistocene or Glacial Period was considered to have involved only one advance and retreat of the ice. It now seems to have been demonstrated that there were five glacial stages and four interglacial stages. These stages are named as follows:

Wisconsin glacial stage.
Peorian interglacial stage.
Iowan glacial stage.
Sangamon interglacial stage.
Illinoian glacial stage.
Yarmouth interglacial stage.
Kansan glacial stage.
Aftonian interglacial stage
Nebraskan glacial stage.

The first two stages of glaciation in Iowa affected larger areas than did those stages which followed. The first two stages are represented by two distinct drift sheets which are separated by soil bands, weathered zones, forest beds, and stream gravels. In Iowa the older of the two drifts is known as the pre-Kansan, sub-Aftonian, or Nebraskan; the younger is called the Kansan.
The Nebraskan glacial stage.

In western and southwestern Iowa\(^1\) the Nebraskan


is a blue-black drift resting on the older rocks of the region. It consists of a blue-black joint clay, sometimes more or less ferruginous; when dry it is hard and brittle and breaks up into very small angular blocks. It is almost impervious to water and when wet is very tough, tenacious and "rubber-like".

The Aftonian interglacial stage.\(^2\)


The Aftonian was a real interglacial interval and a very long one. In a paper in the Proceedings of the Davenport Academy of Sciences, volume ten, it was assumed that the waters which deposited the gravels had their origin in the melting of the pre-Kansan ice, as there could not have been such wide spread streams of such great volume and persistency as were required to transport such enormous quantities of sand and gravels as are found in Union county, for instance. In these sands and gravels are found the bones of animals which seem to have been contemporaneous in age with these deposits. These remains could not have been washed out from the pre-Kansan till for their state of preservation is nearly perfect. Since there must have been
abundant food such as vegetable matter to support such forms of life as the horse and elephant, the remains of which are found in the sands and gravels, there was necessarily an equable climate for plant growth. It appears that the gravels were not laid down at the beginning of the interval or at the end but at some intermediate stage; more precisely than this the age cannot be determined.

In some places the Aftonian interglacial epoch is represented by peat beds; one of the best exposures is at Oelwein where there is three feet of organic material containing tamarack forest, and great quantities of pressed moss in very fresh state of preservation.

"The Aftonian more than any other of the interglacial intervals was a time of luxuriant forests. In view of the evidence, clear and positive, ............ we can but repeat that the Aftonian was a real interglacial interval, an interval of long duration, an interval of moist climate and swollen streams, an interval when the winter's cold was not so severe and excessive as to preclude the continued occupation of the region by the great stag, the horse, the mastodon, and the elephant; an interval when modern types of river mollusks flourished in the streams of Iowa."

The Kansan glacial stage.

The Kansan drift of Cedar county, as described by Norton,¹ may be taken as a type for Kansan drift. In its

normal aspect the Kansan till is a dense, clayey till, jointed, and bluish drab in color. Pebbles a fraction of an inch in diameter are plentiful. Cobbles and boulders are rare except in the stream beds where the drift has been washed away. It contains much calcium carbonate, The Kansan has been deeply weathered. The lime has been carried downward by percolating waters and redeposited as nodules. The till has been so altered that it crumbles readily in the hand. To a depth of from six inches to several feet the till has been oxidized to a deep terra cotta red. This zone has been called the "ferretto" zone by Bain.\(^1\) Below this zone


the color grades downwards to a reddish-yellow and then to pale yellow and finally into the drab color of the unaltered till. The topography of the Kansan is one of practically complete drainage by means of dendritic drainage systems. The divides are narrow although flat.

The Yarmouth interglacial stage.

The term Yarmouth is the term applied to the interglacial stage between the withdrawal of the Kansan ice and the coming of the Illinoian. The type locality is at Yarmouth, Iowa, where it was first recognized by Leverett,\(^2\)

\[^2\text{Leverett, Frank, The Weathered zone (Yarmouth) between the Illinoian and the Kansan Till-sheets: Jour.Geol. vol.6, pp. 238-243.}\]

in a well section. There is not only a soil band but also
evidence of pronounced erosion between the two sheets of drift. The section of the well at Yarmouth is as follows:

Soil and loess loam  4'
Yellow till,(Illinoian)  20'
Gray till,(Illinoian)  10'
Peat bed with twigs and bones,  15'
Gray and ashy clay containing fragaments of wood,  12'
Fine sand,  16'
Yellow sandy clay with few pebbles, (Kansan),  33'
Total,  110'

In a well one mile south of Yarmouth the mucky soil band was reached at a level about forty feet below that of the previously named well. This difference in level is interpreted to be due to one well having struck into a valley cut into the Kansan drift, while the other entered the Kansan drift near the level of the bordering upland. If these well records can be depended upon as good evidence it seems as though there was an erosion of the Kansan drift to at least a depth of forty feet prior to the deposition of the Illinoian till.

The Illinoian glacial stage.

As the ice advanced from the Labradorian centre it pushed a broad lobe across the Mississippi river and affected only a limited portion of Iowa, namely, the southeastern part of the state. The drift was deposited as a
band about twenty-five miles in width extending from Scott county on the north to Lee county on the south. The western margin is bordered by a terminal moraine. The Illinoian drift is described by Udden\(^1\) as follows:

\[
\begin{align*}
1. & \quad \text{Udden, J.A., Geology of Muscatine county: Iowa Geol.Surv. vol.9, p.340.} \\

\text{"It differs from the Kansan in being somewhat less leached, and in having a topography not quite as old, in presenting a fresher appearance, in containing a larger proportion of bowlders of Keweenawan rocks and in having more dolomitic limestone bowlders." It is grayish-blue in color below and yellow above.}
\end{align*}
\]

The Sangamon interglacial stage.\(^2\)

\[
\begin{align*}
2. & \quad \text{Leverett, Frank, The Weathered Zone (Sangamon) between the Iowan Loess and Illinoian Till-sheet: Iowa Acad.Sci., vol.5, pp.71-80.} \\
\end{align*}
\]

The Sangamon interglacial interval is represented, in the region in Illinois whence the name originated, by a bed of muck between the Illinoian till and the Iowan loess. The more common phase is the presence of a ferretto zone which may or may not be accompanied by the black soil band. The black soil band is well developed in southeastern Iowa. In places the till beneath the black soil is leached only to a depth of from one to two feet, but in some places to a depth of about six feet. Where the black soil is absent the leaching extends to about six feet below the loess. Many
excellent exposures of the Sangamon are found in southeastern Iowa.

The Iowan glacial stage.1

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Following the Sangamon interval there was a recurrence of glacial conditions and the Iowan drift was deposited. The Iowan ice, so far as it affected Iowa, came from the northwest, as the Kansan and Nebraskan had done, but the Iowan glacier stopped far short of the limits reached by its predecessors from the Kewatin centre. The main body of the ice failed to reach Iowa. A broad lobe was all that passed the northern border of the state, and this covered an area approximately one hundred miles long by eighty miles wide. The Iowan drift nowhere touches or overlaps the Illinoian drift. The surface of the Iowan is much more undulatory than that of the Illinoian due to the small amount of material carried by the Iowan ice as compared to that of either the Illinoian or Kansan. There was not enough of the Iowan to completely disguise the topography of the eroded surface upon which it was laid. One of the individual characteristics of the Iowan drift is the presence of large conspicuous, light-colored, coarse-grained granite boulders which are rich in feldspars, and which vary from ten to fifty feet in diameter. The boulders lie on the surface or partly embedded and give a striking feature to the Iowan landscapes.
The Peorian interglacial stage.  


The Peorian interglacial interval which followed the Iowan glacial stage was short. There are no known sections where the Wisconsin drift comes in direct contact with the Iowan drift but the loess upon which the Wisconsin rests in many places, is correlated with events which took place at the withdrawal of the Iowan ice. The interval as compared with the Yarmouth and Sangamon was very short. The Iowan is probably not more than twice as old as the Wisconsin.

The Wisconsin glacial stage.


The Wisconsin is something very distinct from the Iowan. It differs (1) in constitution; being very calcareous, the calcium carbonate being in the form of rock flour and limestone pebbles, (2) in color; the color is lighter yellow, (3) in habit; the Iowan thins at all the margins and may even be absent in the interior of the lobe. The Wisconsin was more abundant than the Iowan and covered all traces of Iowan topography. It has a well-defined ridge on the outer margin. The largest amounts of Pleistocene gravels in the state are related to the Wisconsin drift. There are many gravel trains and also continuous sheets of gravel.
In some counties the surface is covered with knobs of sand and gravel in the form of kames and eskers. Some of the other characteristic features of the Wisconsin are saucer-shaped kettle holes, and lakes and ponds in depressions among the moranic knobs.

Pleistocene History of Lee county.

Pre-Kansan History.

During the past field season the writer did not find any exposures of drift which could be proven definitely to be Nebraskan. Leverett\(^1\), however, states that, "along the Mississippi bluff above Ft. Madison there are exposures of drift 180 feet in height. The upper 50 to 60 feet consists of alterations of till with sand and gravel, and is referred mainly to the Illinoian. The remaining 120 feet is, however, characterized by stony parts that give it the appearance of being interbedded with gravel and cobble. These bands of stony material are very nearly horizontal. It is not certain that this should be referred to the Kansan; possibly it is pre-Kansan." Leverett also states that, "exposures in neighboring ravines indicate that the Illinoian drift on the bluffs at Ft. Madison is not more than 20 feet in depth." The remainder of the bluff (160 feet) he considers as Kansan.

with possibly some pre-Kansan. A section made by the writer in a ravine just north of Chatauqua Heights, north of Ft. Madison, shows the following:

4. Loesslike clay, upper one foot very light colored, grayish-yellow on dry surface, buff to yellow when damp 7'

3. Gumbotil (Illinoian) typical drab in color, dark, starch-like fracture, few pebbles; lower part more chocolate colored than upper part 4' 6"

2. Drift, (Illinoian) leached and oxidized 6'

1. Drift, (Illinoian) unleached and oxidized, exposed 15'

This section exposes about 32 feet of drift which all field evidence suggests as Illinoian in age. The top of the section is at the level of the Illinoian upland plain and the four zones grade very gradually into one another. A little farther down the ravine unchanged drift appears with a gradual transition zone between it and No.1 of the above section. This blue-black drift is thought, therefore, to be Illinoian in age and not Kansan or Nebraskan.

The writer, in company with Professor Kay, visited an exposure, which some time before had been visited by Professor Kay and Mr. Leverett. This exposure is in the bed of a creek along the Chicago, Burlington and Quincy Railroad north of Ft. Madison, Sec. 33, Washington township. This section is as follows:
Oxidized silt and sand containing much wood, some of the pieces 5 to 6 inches in diameter. The material has a dipping surface beneath drift (Kansan ?) and contains bowlders, sand and highly oxidized silt; very sticky. For the most part it is leached. Depth of exposure where thickest 4' 6"

This may be a weathered Aftonian deposit. If so, there is a considerable thickness of Nebraskan drift exposed farther down the valley.

Kansan glacial stage.

Glacial deposits.

General distribution:

The Kansan is the oldest drift that is exposed at the surface within the county. It forms the surface deposits over the entire western two-thirds of the county. (see fig. 3) In the eastern part of the county the Kansan drift is exposed where the streams have cut through the Illinoian drift.

Character of the drift:

The materials of the uneroded Kansan upland consist of loesslike clay, beneath which is 4 gumbotil1, a gray to


dark colored, leached, sticky clay, which is thought to be
Fig. 3. Map showing areal distribution of Kansan and Illinoian drifts in Lee county.
the result, chiefly of the chemical weathering of drift. Beneath the gumbotil and closely related to it is a narrow zone of leached, oxidized drift, with many lime concretions, the lime of the concretions having been dissolved in connection with the formation of the overlying gumbotil and leached drift, carried downward and later precipitated. Below this is an unleached and unoxidized drift which is the unchanged drift deposited by the Kansan ice.

The Kansan drift which is exposed within the county presents the five zones outlined above, which although they grade gradually into one another, are separate and distinct zones.

The top zone, which forms the surface deposit on the Kansan upland plain, is a loesslike clay. In many places there are two slightly different phases of this zone. The upper part presents a light gray color and is much more like true loess than the underlying phase. The lower part is yellow to light brown in color on a dry surface, but when freshly cut into appears to have a more chocolate color. This phase is a distinctive joint clay. There is no line separating these two phases, the transition zone being several inches wide.

The lower phase of the loesslike clay grades downwards into gumbotil. This gumbotil, on a dry surface, is gray in color but on a fresh surface is drab in color. In some places there are spots of brown distributed throughout the mass especially in the lower part. It is very sticky when wet and when partly dry is so tough that a pick is extricated with difficulty when deeply implanted in it. This
zone is thoroughly leached of calcium carbonate. It contains some pebbles. The conspicuous feature of the gumbotil is the checked appearance on a dry surface. This feature can be recognized at a considerable distance.

Underlying the gumbotil is an oxidized and leached zone. This is entirely leached as is the gumbotil, but has a yellow to brown color due to the oxidation of the iron content of the drift. In many cases this drift contains patches of gray very similar to the overlying gumbotil.

Underlying this zone and not sharply set off from it is oxidized and unleached drift. This drift does not differ much in color from the overlying zone. It does, however, contain many limestone pebbles. In many places lime concretions are found in the drift either in small cavities as nodules or deposited along narrow fissures. The lime of these concretions was leached from the overlying drift.

Underlying this oxidized and unleached zone is the unchanged Kansan drift. This drift is a very stiff and compact, blue, bowlder clay. When wet it is very tough, and when dry it breaks into irregularly shaped angular pieces. This drift contains a large amount of calcium carbonate. It contains pebbles of various sizes many of the larger ones showing striated surfaces.

The most significant cuts will be described in order to show the characteristics of the different kinds
of deposit, their thicknesses and relationships, and to serve as a basis for some interpretations regarding the age and history of each sort of material.

A type section of the Kansan drift is situated in a railroad cut in Sec. 31, Jefferson township, along the Atchison, Topeka and Santa Fe Railroad, a short distance east of New Boston, Iowa. (see fig. 4.)

Fig. 4. Railroad cut in Sec. 31, Jefferson township, Lee county.

The section is exposed on the north side of the tracks and is as follows:
4. Loesslike clay, top two feet very light gray; below yellow to light brown on dry surface; when freshly cut into more chocolate colored; a joint clay. Grades into number (3) 12′

3. Gumbotil, (Kansan) typical. Gray on dry surface and has a checked appearance. When freshly cut into, it has a more drab color; very sticky; contains some spots of brown; contains small siliceous pebbles; leached; grades into (2) 12′

2. Drift, (Kansan) oxidized and leached; contains patches of gray similar to the gumbotil; many pebbles. Grades into (1) 5′

1. Drift, (Kansan) oxidized and unleached. Contains many pebbles and small boulders; many calcareous concretions.
To the bottom of the cut, exposed 27′

A few hundred yards farther down the tracks unchanged drift is exposed at the bottom of the cut. Where this unchanged drift appears, however, a good section could not be obtained since at this point the top of the cut does not reach the Kansan upland plain.

A pebble analysis shows the petrographic content of the various zones to be as follows:
In the following table,
No. 4 is Kansan loesslike clay, 6 pebbles taken. 
No. 3 is Kansan gumbotil, 100 pebbles taken.
No. 2 is Kansan drift, oxidized and leached, 122 pebbles taken.
No. 1 is Kansan drift, oxidized and unleached, 110 pebbles taken.

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<th>No. 4</th>
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The drift in this cut is interpreted to be Kansan drift, because the top of the cut is at the level of the undisputed Kansan upland plain and there is but one series of the various zones that a drift presents. The topography of the region presents mature erosional features, which suggest also that the drift is of Kansan age.

Another section of Kansan drift showing the same succession of zones with approximately the same thicknesses is on the south side of the wagon road in the southwest quarter of Sec. 6, T.67 N., R.5 W. The section is as follows:
5. Loesslike clay, grayish white in color; very few pebbles; grades into (4)

4. Yellow joint clay mottled with chocolate; no pebbles seen; grades into (3)

3. Gumbotil (Kansan) very sticky when wet, tough when partly dry; gray to drab in color, lower part mottled with brown; many pebbles; grades into (2)

2. Drift (Kansan) oxidized and leached; grades into (1)

1. Drift (Kansan) oxidized and unleached; to the bottom of cut.

A pebble analysis shows the petrographic content of the various zones to be as follows.

In this table,-

No. 5 and 4 is loesslike clay, 46 pebbles taken.
No. 3 is Kansan gumbotil, 127 pebbles taken.
No. 2 is Kansan drift, oxidized and leached, 100 pebbles taken.
No. 1 is Kansan drift, oxidized and unleached, 100 pebbles taken.

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<td>11%</td>
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<td>Felsite</td>
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<tr>
<td>Felsite porphyry</td>
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<td>Schist</td>
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<td>Limestone</td>
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The drift in this cut is interpreted to be Kansan for the same reasons that the preceding drift was thought to be Kansan in age.
Thickness of the Kansan drift.

The thickest exposure of Kansan drift which was studied was about 75 feet in thickness, the lower 15 feet, however, was overgrown with vegetation so that detailed work could not be done on it. At Mt. Clara a well record shows that there is about 305 feet of drift, the surface being at the level of the Kansan upland plain. This may all be Kansan or the lower part may be Nebraskan. In some places the Kansan drift is only a few feet in thickness. Leverett (personal correspondence, May 5, 1917) considers that the average thickness of the Kansan drift is about 50 feet.

Topography of the Kansan drift.

The present streams have been at work for so long a time in the Kansan area that very little of the original plain remains. These streams have reduced the region to maturity and in so doing have drained the lakes and ponds which were probably present on the original drift plain. There are a few places in the county where there are broad, flat divides which have retained to a limited extent the characteristics of the original drift topography. These are found at a considerable distance from the large streams. On such divides there may be a few sloughs and marshes, the last vestiges of youth. As the larger streams are approached, the plain becomes more and more broken and near the streams hills and valleys comprise the topography and even bed rock may outcrop at the lower levels. The courses of all the streams within the Kansan area have been determined by drift
The Yarmouth interglacial stage.

The Yarmouth interglacial epoch represents the time between the retreat of the Kansan ice and the advance of the next great ice sheet, the Illinoian. This time is recorded in several ways, namely, by Kansan gumbotil, soil bands, peat beds, erosion and other features. The most conspicuous of these in the region under consideration is the gumbotil which is uniform in topographic position throughout the county. It is confined to the remnants of the Kansan upland plain.

"Gumbotil", as defined by Kay¹, "is a gray to dark colored, thoroughly leached, non-laminated, deoxidized clay, very sticky and breaking with starch-like fracture when wet, very hard and tenacious when dry, and which is, chiefly, the result of weathering of drift. The name is intended to suggest the nature of the material and its origin."


The Kansan gumbotil does not have a large areal distribution. It is exposed only where the Kansan upland plain has been dissected by streams or excavated by man.

The gumbotil has a fairly uniform thickness in all the exposures studied. In the New Boston cut the thickness is about 12 feet; in the cut in the southwest quarter of Sec. 6, T. 67 N., R. 5 W., the thickness is about 15 feet; on the east side of the railway cut north of Ft. Madison, in the extreme south edge of Sec. 28, T. 68 N., R. 4 W., it is 12 feet thick; in a cut along the road about one mile south
of New London in Sec. 34, New London township, Henry county, Iowa, it is about 16 feet in thickness. The average thickness is from 12 to 15 feet.

In a hand specimen, the gumbotil from the New Boston cut appears very light gray in color with a few stains of brown and yellow. It contains a few small pebbles uniformly scattered throughout. When studied under a lens (x 3) the small pebbles become more conspicuous and the gumbotil in general takes on a more sandy appearance as if made up largely of a white sand mixed with a very light colored clayey material. When studied under a binocular microscope (x 23) it appears to be composed of from sixty to seventy-five per cent of minute grains of transparent quartz, none of which are angular, and many of which are almost spherical.

A hand specimen from the cut on the south side of the wagon road in the south west quarter of Sec. 6, T. 67 N., R. 5 W., appears very similar to the New Boston specimen except that it contains more stains of brown. When studied with a lens (x 3) it appears slightly sandy and the small pebbles become more conspicuous. When studied under the binocular microscope (x 23) this sample of gumbotil appears similar to the New Boston specimen except that the percentage of quartz appears to be less, probably not more than forty to fifty per cent. As in the New Boston specimen the small transparent grains of quartz are very smoothly rounded, angular ones being conspicuously absent.
Origin of the Kansan Gumbotil and Related Materials.

The Kansan gumbotil of southern Iowa has been the source of much discussion among geologists, not alone in Iowa but in other states. At the Washington, D.C. meeting of the Geological Society of America, December, 1915, Professor Kay presented an outline of his studies of this problem up to that time, and with Professor Kay's permission this statement is reprinted here in full:


Some Features of the Kansan Drift in Southern Iowa.

"In county reports issued by the Iowa Geological Survey and in other publications many of the features of the Kansan drift of southern Iowa have been described, including the original Kansan drift plain, the present topography of the Kansan drift, the tabular divides, the characteristics of the weathered and unweathered zones of the Kansan drift, the gumbo, which is closely related to the Kansan drift, and the fine loesslike clay overlying the Kansan drift surface, and which has been interpreted by several investigators to be material of eolian origin deposited after a mature topography had been developed on the Kansan drift. The origin of the gumbo has been interpreted differently by different authors, the most recently published view being that of Tilton, who considers the material to have been
formed, in the main, during the retreating stages of the Kansan ice. To this gumbo and other materials which he considers to be related in age to the gumbo he has given the name Dallas deposits.

Detailed field studies which are still in progress in southern Iowa seem to warrant the author in making a preliminary statement involving some interpretations which differ from those previously advanced.

(1) The surface of the Kansan drift, after the Kansan ice withdrew, was, according to present evidence, a ground moraine plain, which from the main divide between the Mississippi and the Missouri rivers, sloped gently to the southeast and south toward the Mississippi and to the southwestward toward the Missouri. This drift plain was so situated topographically that weathering agents were very effective, but erosion was slight. As a result of the weathering during an exceedingly long time a grayish, tenacious, thoroughly leached and non-laminated joint clay, which has been named gumbo, was developed to a maximum thickness of more than 20 feet. This gumbo contains only a few pebbles, which are almost wholly siliceous, and grades downward into yellowish and chocolate colored Kansan drift from 3 to 7 feet in thickness, in many places with numerous pebbles, few, if any, of which are calcareous. This oxidized but non-calcareous drift, in turn, merges into unleached drift, oxidized yellowish for several feet, below which is the normal unleached and unoxidized dark-grayish to bluish-black Kansan drift. The gumbo is believed, therefore, to be essentially the result of the thorough chemical weathering
of the Kansan drift; but, subordinately, other factors, such as the wind, freezing and thawing, borrowing of animals, slope wash, etcetera, have undoubtedly contributed to its formation. The Kansan drift which has been changed to gumbo may have differed somewhat from the normal Kansan drift that lies below the gumbo.

(2) After the gumbo plain had been developed by weathering processes on the Kansan drift plain, diastrophic movements seem to have occurred, the plain having been elevated to such an extent that erosion became effective and valleys began to be cut into the gumbo plain. Erosion of the gumbo plain progressed to such an extent that some valleys were cut to a depth of more than 150 feet before grade was reached and a mature topography was developed. Only remnants of the original gumbo plain remain, the most conspicuous of these being flat, poorly drained areas, known as tabular divides. Where creep and slumping have occurred, the gumbo, in places, may be found on slopes at an elevation several feet below the level of the gumbo plain. The tabular divides are more prevalent east of a line drawn north and south through south-central Iowa than west of such a line. In the southwestern part of the state the Kansan gumbo which is in situ, is found only where the divides, which are no longer distinctly tabular, retain the level of the former gumbo plain.

(3) While there is, in places, loess of eolian origin on the Kansan drift of southern Iowa, much of the
material which has been described as loess is thought to be not of eolian origin, but to be related more or less closely to the gumbo. The upper few feet of the Kansan gumbo, which is now limited to the tabular divides, is a fine-grained, loesslike, joint clay, in which, if diligent search is made, it is possible to find a few very small siliceous pebbles similar to those in the normal gumbo, and it is thought that this loesslike clay is the result of changes that have been going on at and near the surface of the gumbo during the great length of time since the normal gumbo was formed. The loesslike clay which is now found as a mantle on the Kansan drift on the slopes and divides that have been brought by erosion considerably below the level of the original gumbo plain is believed to be the product not primarily of wind action, although wind may have been a factor, but chiefly the product of the weathering and concentration of the gumbo and to some extent of the underlying Kansan drift, where erosion has not kept pace with the weathering.

(4) The evidence indicates that the time taken to develop the present topography from the gumbo plain stage, although it represents a great length of time, is short when compared with the time taken to develop the gumbo plain from the Kansan drift. It is thought that the formation of the main part of the gumbo and the development of the present mature topography of the Kansan drift were effected between the close of the Kansan epoch and the advance of the Illinoian ice into Iowa; in other words, during the Yarmouth inter-Glacial epoch. All the evidence undicates that the Yarmouth epoch was an exceedingly long interval of time.
Detailed chemical analyses of gumbo, loesslike clay, etcetera, are now being made in the chemical laboratory of the University of Iowa by Dr. J. N. Pearce. The results of these analyses will go far to strengthen or weaken the interpretations given above from field evidence.

These analyses have now been completed and will soon be published. Professor Kay says that they seem to show clearly that the gumbo is the weathered product of the drift.

Besides the Kansan gumbotil the Yarmouth interglacial epoch is represented by soil bands and peat beds. Leverett\(^1\) states that "between West Point and Denmark, a distance of seven miles, records of thirteen wells have been obtained in which a soil was found between the Illinoian and Kansan till sheets. The thickness of the soil ranges from 2 to 5 feet and its depth below the surface ranges from 16 to 45 feet; the usual distance to the soil is about 30 feet." Leverett\(^2\) also says that "gummy clay" (referring to the Kansan gumbotil) "has usually a blackened surface due to humus, a feature which indicates that it was exposed to conditions favorable to plant growth." Bits of wood were found by Leverett in an exposure along the Santa Fe Railway,
near New Boston, Iowa, and identified by F. N. Knowlton of the United States National Museum as a species of conifer not native to this region. This must therefore be an old soil band formed during Yarmouth time. Time is also recorded by erosion. There is distinctive evidence of erosion of the Kansan drift prior to the deposition of the Illinoian drift. Near Yarmouth, Iowa, a valley was cut to a depth of at least 40 feet.

If the rate of weathering was approximately the same during Yarmouth time as it is at present, and we have no reason to believe that it was different, an immense length of time is recorded by the presence of the gumbotil. Since erosion was probably but very slight during the formation of the gumbotil, the length of time taken to erode the surface of the Kansan must be added to the time required to form the gumbotil in order to obtain the length of time recorded by the Yarmouth interglacial interval. The duration of this interglacial stage must, therefore, be much longer than is usually accredited to it.

This view has been emphasized recently by Kay1.


"That the time interval between the retreat of the Kansan ice and the advance of the Illinoian ice into Iowa was of long duration is suggested strongly by recent studies in the area of Kansan drift in southern Iowa. This view regarding the Yarmouth Inter-glacial epoch is supported by evidence as followst: (1) On the Kansan drift where erosion
has been slight there is a thoroughly leached, non-laminated, tenacious clay called gumbo, twenty feet or more in thickness, which is thought to have been formed chiefly by chemical weathering of the upper part of the Kansan drift. (2) Diastrophic movements subsequent to the formation of the gumbo, the country having been elevated one hundred and fifty to two hundred feet. (3) A mature topography which was developed by erosion after the diastrophism and, apparently, in the main, before the close of the Yarmouth epoch."
The Illinoian glacial stage.

Glacial deposits.

General distribution:

The Illinoian drift forms the upland surface deposits of the eastern one-third of the county. (fig. 3) The extreme eastern part of the county is the flood plain of the Mississippi river, known as Green Bay Bottom.

Character of the drift:

As in the case of the Kansan drift, the Illinoian drift is composed of five distinct zones very gradually grading into one another.

The upper zone, the top of which is at the level of the Illinoian upland plain, is composed of two phases. The upper phase, constituting the upper one foot is a loess-like clay, very light gray on dry surface; when cut into it is a joint clay grayish in color. The lower phase is also a joint clay, gray to grayish-yellow on dry surface, when cut into, gray to brownish yellow, with chocolate mottling. It is thoroughly leached. Pebbles were found up to within one and one-half feet of the surface of the Illinoian upland plain.

Underlying this loesslike clay is gumbotil. This is gray on the surface, checked when dry. (This is a characteristic feature of gumbotil of whatever age.) When freshly cut into it is very dark drab to black in color and is very sticky. When partly dry it is very tough and rubber-like. This gumbotil contains a few pebbles.
Underlying the gumbotil is the oxidized and leached drift. This is generally brown in color and in many exposures contains spots of gray throughout but more frequently in the upper part near the gumbotil. This zone contains many pebbles.

Oxidized and leached till underlies this zone. This drift is similar to the unaltered drift below except that it is not quite as compact and has been oxidized to a brown or reddish-brown color. It contains many calcareous concretions.

Underlying this zone is the unchanged drift which is both unoxidized and unleached. Because of insufficient erosion there are but few places where the unchanged drift appears at the surface. Where it does outcrop it is a very compact, blue-black, tough till. When dry it breaks into irregular angular pieces of various sizes. It contains many pebbles and small bowlders of both sedimentary and igneous origin. Many limestone pebbles are contained in the drift.

Some of the more significant cuts will be described in order to show the characteristics of the drift, as well as thicknesses and relationships upon which data the interpretations of the history and age can be based.

In some places the Illinoian drift is fairly thin and one section will show part of the Kansan drift as well as the entire section of the Illinoian. A good section of this kind is found in a railroad cut on the east side of the track north of Ft. Madison, in Sec. 28, Washington township. This section is as follows:
5. Gumbotil (Illinoian), gray to ashen color on dry surface; fresh surface gray, mottled with brown; small pebbles; leached. At the top of the cut but a few feet below the upland, 4' 6"

4. Drift (Illinoian) oxidized, brownish with some patches of gray. Less gray in the lower part than in the upper. Contains bowlders and many pebbles. All but the lower foot is leached; this one foot breaks into irregularly shaped pieces. 6' 6"

3. Gumbotil (Kansan) dark drab in color, starch-like fracture, very sticky; in the upper part some patches of brown; pebbles throughout. Thoroughly leached. There are calcareous concretions in it. 8' 6"

2. Drift (Kansan) oxidized, some patches of gray, leached; contains many pebbles.

1. Drift (Kansan) oxidized and unleached. Calcareous concretions, breaks with irregular fracture; exposed 12'

In this section the loesslike clay is not present overlying the gumbotil because of erosion of the Illinoian upland plain.
Fig. 5. Railroad cut on the Chicago,
Burlington and Quincy Railroad,
Sec. 28, Washington township,
Lee county.

A pebble analysis of the drift in this cut shows the petrographic content to be as follows:

No. 5 is Illinoian gumbotil, 100 pebbles taken.
No. 4 is Illinoian drift, oxidized and leached, 100 pebbles taken.
No. 3 is Kansan gumbotil, 100 pebbles taken.
No. 2 is Kansan drift, oxidized and leached, 108 pebbles taken.
No. 1 is Kansan drift, oxidized and unleached, 100 pebbles taken.
In a railroad cut in Sec. 10, T. 68 N., R. 5 W., at the top of Pitman Creek hill, on the north side of the track the following section shows the thickness of the loesslike clay on the upland above the gumbotil.

3. Loesslike clay; upper one foot very light gray on dry surface. When cut into it is a grayish joint clay.

Grades into (2)

2. Joint clay, gray to grayish-yellow on dry surface; when cut into, gray to brownish-yellow, chocolate mottling; leached. Pebbles seen in the lower foot and up to within one and one-half feet of the surface. Seem to grade into (1) 1 and 2

1. Gumbotil (Illinoian), normal, gray sticky, few pebbles exposed.
This section is of special interest in that it shows the normal thickness of the loesslike clay overlying the gumbotil. The top of the section is on a level with the Illinoian upland plain. The contact between the loesslike clay and the gumbotil is horizontal.

A good section to show the thickness of the Illinoian drift is situated about one mile south of New London, Sec. 34, New London township, Henry county, which is a few miles north of the Lee county line. This section is as follows:

7. Loesslike clay, very fine textured, drab colored; grades into (6) 2'
6. Joint clay; drab color on dry surface; when cut into gray to brown; grades into (5) 1'
5. Gumbotil (Illinoian) yellow to brown, mottled with chocolate, very sticky; grades into (4) 10'
4. Drift (Illinoian) oxidized and leached; grades into (3) 11'
3. Drift (Illinoian) oxidized and unleached, variously colored, as yellow, brown, etc., many pebbles. An abrupt line between 3 and 2 29'
2. Gumbotil (Kansan) black and very sticky; about 16'
1. Drift (Kansan) oxidized and leached; many pebbles; to the bottom of the cut.
There is a good section about one and one-half miles northeast of West Point, in the road between Sec.3, T.68,N.,R.5 W. and Sec.34, T.69 N.,R.5 W. This section is as follows:

4. Loesslike clay, 8'
3. Gumbotil (Illinoian), 3'
2. Drift (Illinoian) oxidized; lower part unleached, 11'
1. Gumbotil (Kansan), exposed, 13'

This section is in a place where the Illinoian drift is very thin. In contrast to this there is a very thick section exposed at Black Hawk Heights just east of Ft. Madison. This section is as follows:

4. Loesslike clay; this extends up to the Illinoian upland plain which is at an elevation of 690 feet (aneroid reading) 15'
3. Drift (Illinoian), oxidized, chocolate colored, gumbo-like with pebbles; leached, 3'
2. Drift (Illinoian) oxidized and unleached, with lime concretions, 27'
1. Drift (Illinoian) unoxidized and unleached; contains some sandy pockets and lenses; this unchanged drift contains light spots which are due to deposits of salts from solution, more in sandy spots, more or less in cracks and crevices, exposed 115'
Another good section to show the Illinoian drift is on the west side of the wagon road in the extreme southwest corner of Sec. 28, Washington township. The following is exposed:

4. Loesslike clay, mottled with brown; grades into (3) 6'
3. Gumbotil (Illinoian) grayish on the surface, checked when dry; when freshly cut into, very black in color; gummy consistency; few pebbles; grades into (2) 5'
2. Drift (Illinoian) oxidized and leached; this drift is brown in color with spots of gray in it; grades into (1) 5'
1. Drift (Illinoian) oxidized and unleached; many pebbles; exposed, 11'

Thickness of the Illinoian drift.

The thickness of the Illinoian drift varies greatly in different parts of the county. The section of the Illinoian drift in the railroad cut (page 39) is 11 feet. In this exposure, however, the loesslike clay has been eroded away. Taking the normal thickness of the loesslike clay as 8 feet (page 41) the total thickness of the Illinoian drift would be about 19 feet. At Black Hawk Heights, east of Ft. Madison, there is exposed about 190 feet of what is interpreted to be Illinoian drift. It is possible that this
unchanged drift, which appears at the river level in this cut, extends to the bottom of the sub-glacial valley which which would make the total thickness about 315 feet. From the various exposures the evidence indicates that the topography over which the Illinoian ice came had a relief of at least 170 feet.

Topography of the Illinoian drift.

The Illinoian drift topography, since it is much younger than the Kansan drift, has retained to a large extent the characteristic features of a young drift plain. There are very few undrained areas, such as sloughs and marshes, because the streams have cut distinct channels, but there are broad tabular areas of the original plain remaining which form large level divides. Along the western margin of the Illinoian drift there is a low terminal moraine. This moraine is more conspicuous when viewed from the western side, since along this side the temporary channel of the Mississippi river lowered the Kansan drift somewhat below the surrounding topography.

Post-Illinoian History.

The Sangamon interglacial stage.

The conspicuous feature by which the Sangamon interglacial interval is interpreted is the Illinoian gumbotil. This gumbotil has a wider areal distribution.
than the Kansan gumbotil and is limited in distribution to the Illinoian upland plain. It is exposed only where the Illinoian upland plain has been dissected by streams or excavated by man.

The Illinoian gumbotil appears gray to brownish in color with chocolate mottling. It has a starch-like fracture. It contains a few siliceous pebbles. Under a lens (x 3) a few more pebbles are seen than with the naked eye and the gumbotil in general appears rather sandy. Under a binocular microscope (x 23) the gumbotil appears to be composed of very smoothly rounded pieces of quartz in a matrix of gray, yellow and brown clayey material. The small pieces of quartz vary considerably in size but all have rounded angles and corroded surfaces.

A sample of the gumbotil from a ravine on the north side of Chatauqua Heights, north of Ft. Madison is, in a hand specimen, gray to drab in color with very few brownish spots. It has a starch-like fracture. There are very few pebbles visible. When studied with a lens (x 3) a considerable number of pebbles are seen. Otherwise it appears quite similar to the material observed with the naked eye. Under a binocular microscope (x 23) the gumbotil appears to be composed of a very light gray to almost white matrix in which are a few rounded pieces of quartz, varying considerably in size, the smallest being minute sparkling points; the surfaces of the larger ones appear corroded. Other samples of Illinoian gumbotil appear very similar when studied in the same way.

The thickness of the Illinoian gumbotil is considerably less than that of the Kansan gumbotil. In one
section (New London) about 10 feet is exposed, the average, however, is about 6 to 8 feet.

Origin of the gumbotil.

Field evidence seems to indicate that the Illinoian gumbotil was formed in the same way as the Kansan gumbotil was formed. (see page 30).
The following chart has been compiled from the pebble analyses of the different zones in sections of the Kansan drift and the Illinoian drift.

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In the preceding chart the analyses are from the following locations:

1. New Boston railway cut (Kansan).
2. Sec.6, T.67 N.,R.5 W. (Kansan)
3. Railway cut, Sec.28, Washington township. (Kansan)
4. Cut one mile south of New London, Iowa. (Kansan)
5. Cut one mile south of New London, Iowa. (Illinoian)
6. Railway cut, Sec.28, Washington township. (Illinoian)
DRAINAGE HISTORY.

Changes in drainage.

From the discussion of the sub-glacial topography (page 6) it is seen that the drainage basin of the Mississippi river at present is different from the system of drainage before the drift was deposited. The Mississippi river at present may be occupying parts of several sub-glacial valleys. Referring to the map on the following page it will be seen that the present valley of the Mississippi river varies considerably in width. For a short distance above Keokuk it is narrow and then broadens out to 3 to 6 miles. Leverett¹

1. Leverett, Frank, Old Channels of the Mississippi in southeastern Iowa: Annals of Iowa, Series 3, April, 1901.

states that "these narrow portions are the places where the river has departed from old lines of drainage while the broad portions denote places where it is utilizing the old valleys."

Changes resulting from Kansan glaciation.

Leverett² states that "when the ice had melted at

2. Same reference as (1).

the close of the Kansan stage of glaciation, the drift which it had deposited seems to have so completely filled the old channel in Lee county that the stream found a lower passage along a new course. . . . . . . Indeed there is a possibility
if not a probability that a considerable portion took a course farther east. . . . . Owing to disturbances produced by the succeeding stage of glaciation, the Illinoian, it will probably be difficult to map the system of drainage which prevailed on the eastern border of Iowa, in this, the Yarmouth interglacial stage."

Changes resulting from Illinoian glaciation.

By reference to the map on the preceding page it will be seen that the western border of the Illinoian drift lies west of the Mississippi river. The presence of this drift on the west side of the river leads us to suspect that the drainage of the river was disturbed if not completely displaced. The temporary displacement channel is shown on the map on the preceding page (fig. 6.). With the withdrawal of the Illinoian ice the waters of the Mississippi river found lower levels than that over which it had flowed while blocked by the Illinoian ice and began to cut the valley in which it is now flowing. The tributaries within the county are all post-Pleistocene in age.

CONCLUSION.

The most significant features that have been revealed by a study of the Pleistocene deposits in Lee county during the past summer may be summarized as follows:
Fig. 6. Map showing the relation of the present drainage to former drainage.

1. Sub-glacial valley
2. Temporary channel of the Mississippi river.
3. Present valley of the Mississippi river.
1. The chief kinds of material exposed are, Illinoian loesslike clay, Illinoian gumbotil, Illinoian drift, Kansan loesslike clay, Kansan gumbotil, and Kansan drift. In most of the sections there is but one drift exposed. The best exposure to show both the Illinoian and the Kansan drifts including the two gumbotils is in the railroad cut in the south part of Sec. 28, Washington township.

2. The two drifts are much alike and both appear to have undergone somewhat similar changes. On each of the drifts loesslike clay and gumbotil have been developed, below which there is a narrow zone of leached drift, which grades downward into unleached drift with many concretions.

3. The maximum thickness of the Illinoian loesslike clay is about 15 feet, the average thickness is about 8 feet; the thickness of the Kansan loesslike clay is about 12 feet. The maximum thickness of the Illinoian gumbotil is about 11 feet and of the Kansan gumbotil more than 16 feet. The zone of oxidation of the Illinoian drift is about 45 feet, that of the Kansan more than 55 feet. There was only a few feet of the unleached and unoxidized Kansan drift seen in any one exposure. In one bluff of Illinoian drift, however, a thickness of 115 feet is exposed.