

---

---

**PLEISTOCENE DEPOSITS BETWEEN  
MANILLA IN CRAWFORD COUNTY  
AND COON RAPIDS IN CAR-  
ROLL COUNTY, IOWA**

**BY**

**GEORGE F. KAY**

---

---



## PLEISTOCENE DEPOSITS BETWEEN MANILLA IN CRAW- FORD COUNTY AND COON RAPIDS IN CAR- ROLL COUNTY, IOWA

Many deep cuts were made recently in connection with the improvement of the Chicago, Milwaukee and St. Paul Railway between Manilla in Crawford county and Coon Rapids in Carroll county, a distance of more than thirty miles. These cuts, some of which have a depth of more than fifty feet, furnish most interesting exposures of drift and related deposits, the study of which has enabled some phases of the Pleistocene history of Iowa to be interpreted somewhat more clearly than was possible previously.

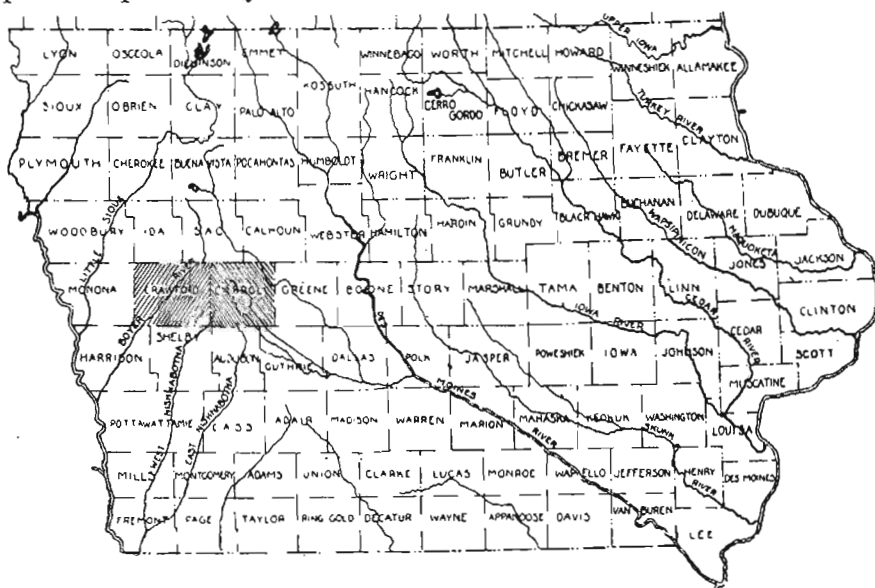


FIG. 16—Outline map of Iowa showing location of Crawford and Carroll counties.

The area through which the cuts have been made has been maturely dissected by the headwaters of Nishnabotna and Racoon rivers, and is mantled by loess. The larger valleys have

flat bottoms and maximum depths of more than one hundred feet. So thoroughly has the region been dissected that the only remnants of the uneroded uplands are a few narrow divides, which are much less extensive than the tabular divides of the maturely eroded drift areas of south-central Iowa.

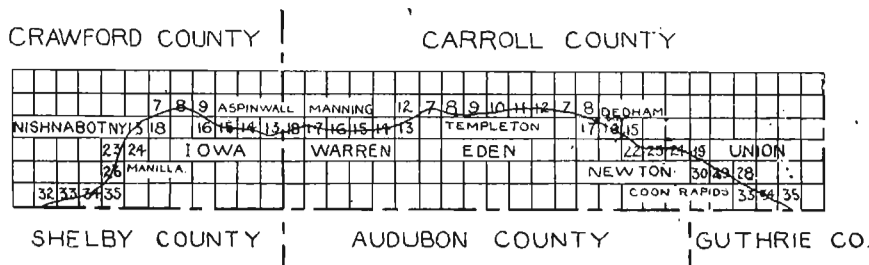


FIG. 17—Sketch map of parts of Carroll and Crawford counties showing route of the Chicago, Milwaukee and St. Paul railway.

Between Templeton and Manning in the western part of Carroll county is the main divide between the drainage of Mississippi river and the drainage of Missouri river. This divide is a remnant of a former, extensive plain, uneroded parts of which can be followed continuously southward through Audubon, Guthrie, Adair, Union and Ringgold counties into Missouri. From the south boundary of the state this uneroded upland rises gradually to the northward; at Tingley in Ringgold county its elevation is 1251 feet above sea level; at Creston in Union county, 1312 feet above sea level; at Adair in northwestern Adair county, about 1450 feet; and west of Templeton in Carroll county the elevation of the divide is nearly 1500 feet. The rise between Tingley and Templeton is about two hundred and fifty feet; the distance is about ninety miles.

The materials of this uneroded upland from the southern boundary of the state to the latitude of Templeton consist of loesslike clay or of loess, beneath which is gumbotil,<sup>1</sup> a gray to dark colored, leached, sticky clay, which is thought to be the result, chiefly, of the chemical weathering of drift. Beneath the gumbotil and closely related to it is a narrow zone of leached drift, below which is unleached drift with many lime concretions, the lime of the concretions having been dissolved in connection

<sup>1</sup>Kay, George F., Gumbotil, a New Term in Pleistocene Geology; Science, New Series, Vol. XLIV, Nov. 3, 1916.

with the formation of the overlying gumbotil and leached drift, carried downward, and later precipitated.

Since the gumbotil has not been described heretofore in these reports it is deemed desirable to reprint here the article from Science to which reference is made above. This statement is as follows:

The term gumbo has been used for many years by some geologists in America for a dense, impervious clay, which, when saturated with water, is sticky and tenacious. The name has had no relation to the origin of the material: in many cases it has been applied to alluvial deposits on the flood plains of streams: McGee, Leverett and others have applied it to a gray to drab-colored clay overlying drift, the origin of the gumbo having been attributed to various causes, some having considered it to be, mainly, of fluvio-glacial origin, others to be aqueous, and still others have thought it to be related to loess.

In a recent paper in volume 27 of the Geological Society of America, pages 115 to 117, the writer discussed a gumbo which lies on Kansan drift and which he had studied in considerable detail in southern Iowa. This gumbo is limited in distribution to tabular divides and other remnants of the Kansan drift plain. The view was there expressed that the field evidence suggested strongly that the gumbo is the result, chiefly, of the chemical weathering of Kansan drift. It was stated, also, that detailed chemical analyses of the gumbo and the underlying materials were being made by Dr. J. N. Pearce, of the chemistry department of the University of Iowa, to ascertain whether the analyses would strengthen or weaken the interpretations made from the field evidence. These analyses have now been completed and will soon be published. They seem to show clearly that the gumbo is the weathered product of the drift.

During the present summer, the writer has extended his studies into the western, northwestern and northern parts of Iowa, and at scores of places sections have been examined which show clearly the intimate relations between the gumbo and the underlying Kansan drift. Moreover, it is of interest that in many places a gumbo has been found on the Nebraskan drift, the relations of the gumbo to this drift being similar to those of the super-Kansan gumbo to the Kansan drift. Furthermore, after a somewhat careful study of the gumbo which lies on the Illinoian drift in southeastern Iowa, and which has been discussed by Leverett in Monograph XXXVIII of the United States Geological Survey, pages 28 to 33, the conclusion has been reached that here, also, the gumbo is so related to the drift

that it is undoubtedly the thoroughly weathered product of the Illinoian drift.

As a result of the field investigations and the chemical studies it is now proposed that the somewhat indefinite term "gumbo" be no longer used for these super-drift clays, but that the name "gumbotil" be used. Gumbotil is, therefore, a gray to dark-colored, thoroughly leached, non-laminated, deoxidized clay, very sticky and breaking with a 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, and it is thought best to use a simple rather than a compound word. Field work has already established the fact that in Iowa there are three gumbotils, the Nebraskan gumbotil, the Kansan gumbotil and the Illinoian gumbotil.

Northward from Templeton the main divide is near Arcadia, where the elevation is about 1440 feet above sea level. At Arcadia and farther northward the evidence suggests that the present summit of the divide is lower than was the surface of the original upland. Beneath the mantle of loess at Arcadia the thoroughly leached materials which are so characteristic of the uneroded uplands farther south are absent. Unleached drift with many calcareous concretions, some of which fill vertical cracks and crevices, lies directly beneath the loess. This unleached drift with concretions is similar in all respects to the zone of unleached drift with concretions in the cuts where it is overlain by leached drift and gumbotil. On a divide east of Kiron in the northern part of Crawford county is a thin remnant of gumbotil at an elevation of more than 1400 feet above sea level; at Holstein in northern Ida county, at an elevation of about 1440 feet, there is an exposure of unleached drift with many lime concretions beneath a mantle of loess. The section here is similar to that at Arcadia.

The history of northern Carroll county and farther to the north seems to have differed from the history of the Templeton region in having undergone still greater erosion. Northward from Templeton there are fewer and fewer remnants of the weathered zones until none are found. Moreover, in the region of Templeton there appears to have been more erosion than farther to the south. In south-central Iowa the uneroded rem-

nants of upland with gumbotil and leached drift are a somewhat distinctive feature of the topography.<sup>2</sup>

West of the main divide between Templeton and Manning there is a narrow divide between Aspinwall and Manilla which has many of the features of uneroded upland. Still other remnants of upland occur as narrow divides between Templeton and Coon Rapids.

The new cuts show clearly that, after a mature topography had been developed in the drift, loess was deposited. It mantles the crests and slopes throughout the area to depths of five to ten feet; in places in the cuts it is more than twenty-five feet thick.

Detailed studies were made of all important cuts between Manilla and Coon Rapids. On the basis of these studies the materials have been classified as follows:

Loess.

Kansan gumbotil.

Kansan drift.

Nebraskan gumbotil.

Nebraskan drift.

In no one cut is it possible to see all of these kinds of material, nor are the two gumbotils exposed in a single cut. In some cuts the section shows loess, Kansan gumbotil and Kansan drift; in others there may be seen loess, Kansan drift and Nebraskan gumbotil; in still others, loess, Nebraskan gumbotil, and Nebraskan drift. The most comprehensive cut shows loess, Kansan drift, Nebraskan gumbotil, and Nebraskan drift. In some cuts where only loess and drift are exposed, it is not possible to determine definitely whether the drift is of Kansan or of Nebraskan age.

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.

The cut through the high upland between the Mississippi river drainage and the Missouri river drainage is in section 13,

<sup>2</sup>Kay, George F., Some Features of the Kansan Drift in Southern Iowa: Bulletin Geological Society of America, Vol. 27, pages 115-117. Reprinted in Iowa Geological Survey, Vol. XXV, pp. 612-615.

Warren township, Carroll county, about three miles west of Templeton (figure 18). Here the section is as follows:

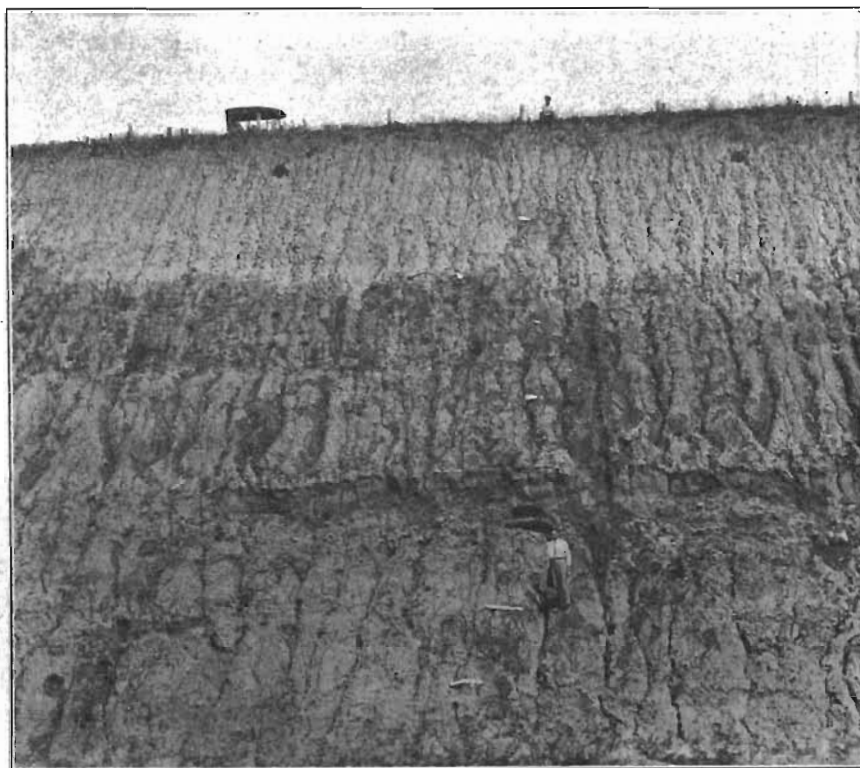


FIG. 18.—Railroad cut on Chicago, Milwaukee & St. Paul railway, about three miles west of Templeton, Carroll county. This is a divide cut, and shows loess, Kansan gumbotil, and Kansan drift.

	FEET	INCHES
4. Loess.		
Buff colored, leached.....	15	
Buff colored, unleached.....	10	
3. Gumbotil (Kansan), gray to dark drab to chocolate colored, upper few feet reddish, a few small siliceous pebbles .....	20	6
2. Drift (Kansan), oxidized yellow to buff, leached, closely related to number 3.....	7	
1. Drift (Kansan), oxidized, unleached; many calcareous concretions .....	8	

The drift in this cut is interpreted to be Kansan drift, chiefly because of its relation to the gumbotil which overlies it. This gumbotil when it is mapped southward can be shown to be continuous with gumbotil that overlies the Kansan drift of southern



Iowa.<sup>3</sup> The gumbotil at Templeton and the gumbotil in southern Iowa are thought from the evidence to be parts of a former, extensive, Kansan gumbotil plain. In the Templeton cut, in addition to the relation of the drift to the gumbotil, the mature erosional features of the area in which the cut is, and the nature of the materials themselves favor the interpretation that the drift is Kansan in age. That Kansan drift is distributed widely in this region was stated by Dr. H. F. Bain about twenty years ago.<sup>4</sup>

Between the Templeton cut just described and Manilla the only cut which has materials similar to those in the Templeton cut, and which, moreover, occupies the same topographic position as the Templeton cut is the divide cut between Aspinwall and Manilla in section 8, Iowa township (figure 19). Here is a section as follows:

	FEET
4. Loess.	
Buff colored, leached.....	12
Buff colored, unleached, shells and concretions, lighter in color than the leached loess; lower part gray in color, but closely related to the buff loess.....	12
3. Gumbotil (Kansan), dark gray to chocolate colored.....	3
2. Drift (Kansan), oxidized, leached, closely related to the gumbotil, contains disintegrating boulders.....	4
1. Drift (Kansan), oxidized yellowish to buff, unleached; abundant lime concretions, many of which are in vertical joints.....	17

The evidence indicates that several feet of gumbotil was eroded from here before the loess was deposited. The base of the gumbotil in this cut has an elevation of about 1440 feet above sea level, which is only about twenty feet lower than the base of the gumbotil in the Templeton cut, ten miles east.

Between the two cuts that have been described there are no cuts which show Kansan gumbotil. This is because erosion prior to the deposition of the loess brought the summits below the level of the base of the gumbotil of the former, Kansan gumbotil plain.

To the east of Templeton, Kansan gumbotil and Kansan drift are present in several cuts through upland divides. One of the most interesting of these cuts is about one and three-quarter

<sup>3</sup>Kay, George F., Some Features of the Kansan Drift in Southern Iowa: Bulletin Geological Society of America, Vol. 27, pp. 115-117.

<sup>4</sup>Bain, H. F., Geology of Carroll County: Iowa Geological Survey, Vol. IX, p. 76, 1898.

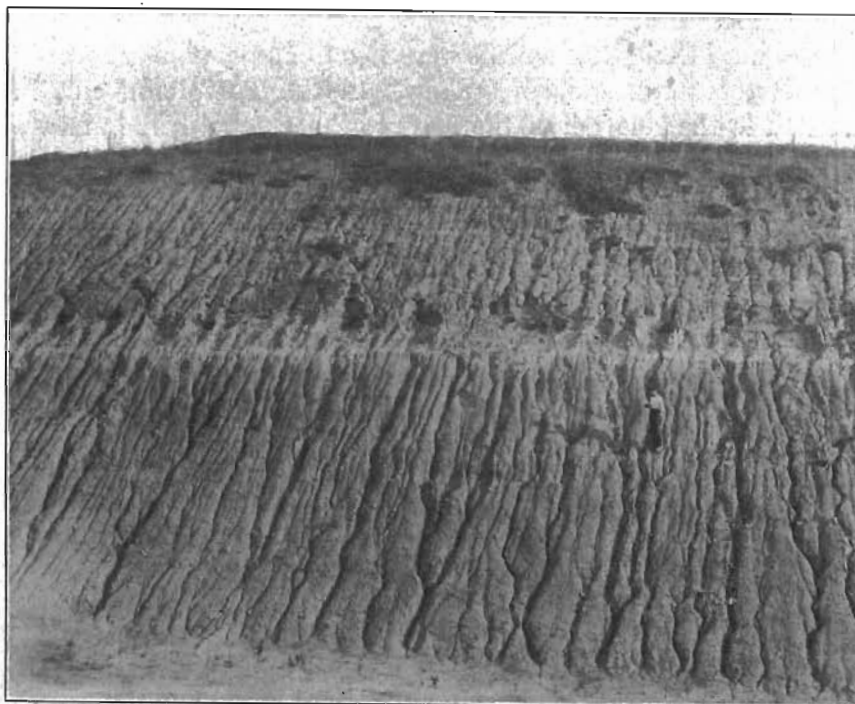


FIG. 19—Divide cut between Aspinwall and Manilla, Crawford county. The cut shows loess twenty-four feet thick, the upper twelve feet of which is leached, while the lower twelve feet is unleached. The lower part of the unleached loess is gray in color. Kansan gumbotil and Kansan drift underlie the loess.

miles west of Dedham in section 7, Newton township, Carroll county. This cut shows only a few feet of Kansan gumbotil, beneath which there is exposed the greatest thickness of Kansan drift revealed in any cut between Manilla and Coon Rapids (figure 20). This cut is known as the Green cut, and in the deepest part the following section was seen:

	FEET
4. Loess.	
Buff colored, the upper four feet leached and somewhat redder than the lower four feet, which is unleached .....	8
Gray, closely related to the buff loess, light colored on a dry surface; mottled chocolate colored; effervesces, but not so freely in general as the unleached buff loess; shells .....	6
3. Loesslike clay, leached, brownish to chocolate colored, with some pebbles; grades into number 2.....	1
2. Drift (Kansan), highly oxidized and leached, the upper three feet gumbotil-like.....	6

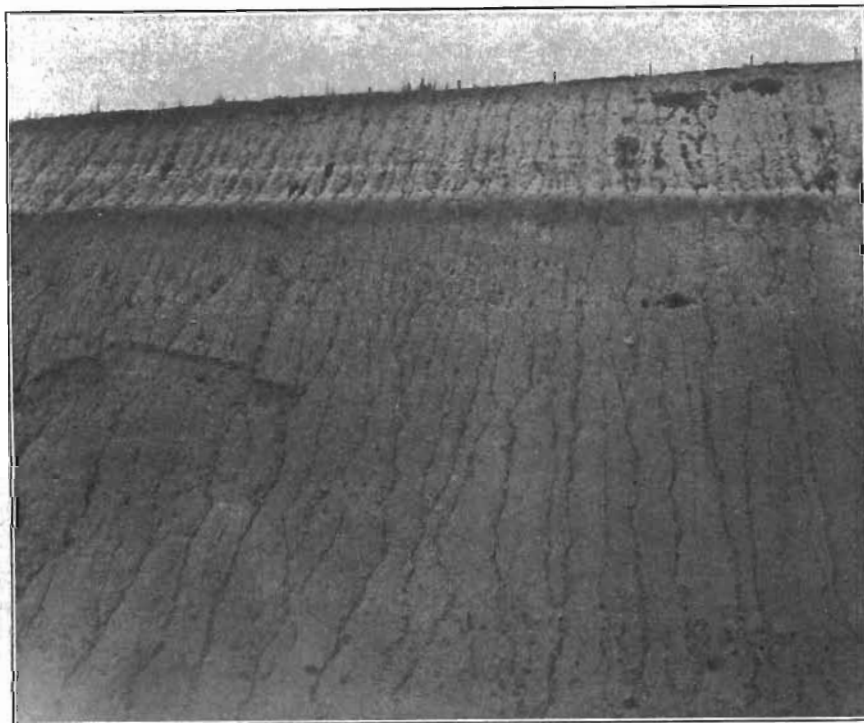


FIG. 20—Railroad cut known as Green's cut, on Chicago, Milwaukee & St. Paul railway about one and three-fourths miles west of Dedham Carroll county, Iowa. Section shows loess, Kansan gumbotil, and Kansan drift.

1. Drift (Kansan), unleached, oxidized yellowish except in lower part, where it is unoxidized and very dark colored ..... 45

A pebble analysis by W. C. Alden of the unleached Kansan drift from here gave results as follows:

	PER CENT
Limestone and dolomite.....	39
Granite and diorite.....	26
Greenstone, diabase, etc.....	20
Quartzite, mostly red.....	10
Quartz .....	1
Crystallines (identification doubtful).....	2
Shale .....	2

About two miles east of Dedham in section 22, Newton township, Carroll county, is a deep cut (figure 21) very similar in many respects to the Green cut. Here the section is as follows:



FIG. 21—Railroad cut on Chicago, Milwaukee & St. Paul railway about two miles east of Dedham, Carroll county, Iowa. Cut shows loess, ferretto zone, and Kansan drift.

	FEET INCHES	
5. Loess.		
Dark buff, leached.....	4	6
Buff, light colored, unleached, concretions and fossils.		
Gray, closely related to the buff loess; effervesces but not so freely as the buff, unleached loess. Less effervescence in the lower than in the upper part. Some seems not to effervesce at all. Where there are shells in the gray loess the effervescence is distinct.		
4. Loesslike clay, grayish, leached, grading down into number 3.....	1	
3. Ferretto zone with concentration of pebbles, highly oxidized, reddish.....	2	
2. Drift (Kansan), oxidized dark yellow, leached...	5	
1. Drift (Kansan), oxidized yellow, unleached, many concretions .....	38	

In this cut there is no distinctive gumbotil. However, the ferretto zone is interpreted to have been formed in connection

with the development of the ~~present topography~~ by erosion of the gumbotil plain. The gumbotil was higher topographically than is the surface of the ferretto zone.

Still farther east in the northeast quarter of section 24, Newton township, there is a cut which shows loess, Kansan gumbotil, and Kansan drift. The section is as follows:

	FEET	INCHES
4. Loess, buff.....	A few feet	
3. Loesslike clay, dark gray on dry surface, dark brownish when damp, few pebbles; grades into number 2.		
2. Gumbotil (Kansan), grading downward into narrow zone of oxidized and leached drift.....	20	
1. Drift (Kansan), oxidized, unleached.....	5	6

In this cut there is an intimate relationship between gumbotil and drift. In the transition zone between the two there are disintegrating boulders more than one foot in diameter.

The cuts which have been described show loess, Kansan gumbotil, and Kansan drift, and occupy topographically the highest divides of the region. Some cuts will be described below from localities where erosion has been sufficiently effective to bring their summits considerably below the elevations of the summits of the upland cuts. Here will be included the most comprehensive cut between Manilla and Coon Rapids. It shows loess and two drifts separated by gumbotil (figure 22). Its location is about one and one-half miles west of Manning in the southwest quarter of section 18, Warren township, Carroll county. Here the section is as follows:

	FEET	INCHES
6. Loess.		
Leached, yellowish gray on dry surface; yellowish brown to buff-brown on damp surface; no shells or concretions.....	7	
Unleached, lighter colored on dry surface than the leached loess, and when damp it is buff with gray streaks. Contains shells and concretions .....	5	
5. Drift (Kansan), yellow, unleached, with calcareous concretions; numerous pebbles including granites, quartzites, etc. Below the oxidized, unleached drift is gray drift with a few pebbles. It is gumbotil-like, but effervesces freely. It was probably picked up from the gumbotil zone below .....	5	
4. Soil band (Aftonian) containing carbonaceous material .....		4

3. Gumbotil (Nebraskan), gray to drab colored, few pebbles. The upper six feet is fine-grained, gray, and is less sticky and gumbotil-like than the lower seven feet, which is leached, but has some calcareous concretions..... 13
2. Drift (Nebraskan), oxidized, apparently leached, but has calcareous concretions, upon which are films of manganese dioxide..... 2
1. Drift (Nebraskan), unleached, oxidized, light yellowish color on dry surface, mottled brownish with gray when damp, many calcareous concretions, especially in upper ten feet..... 17

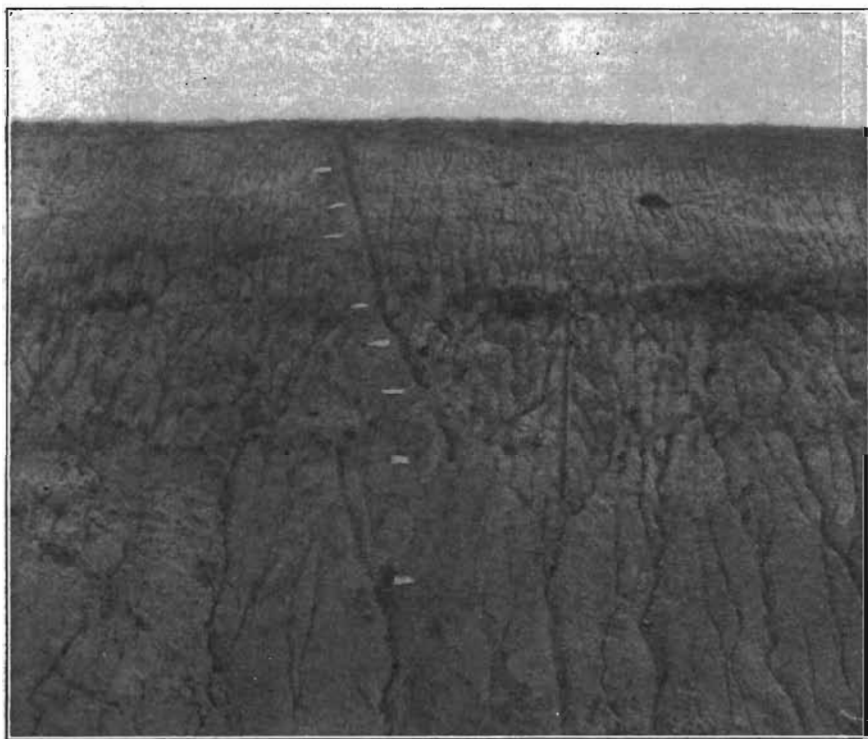


FIG. 22—Railroad cut just east of viaduct one and one-half miles west of Manning, Carroll county, Iowa. The cut shows, from the surface, the loess, Kansan drift, soil band, Nebraskan gumbotil, and Nebraskan drift.

The upper till is unleached. At this place the Kansan gumbotil and leached Kansan drift were entirely eroded in connection with the development of the preloessial topography. The history of the unleached Kansan drift here has been much the same as that of the unleached Kansan drift in those cuts already described where the Kansan gumbotil and leached Kansan drift

have not been removed. The gumbotil in this cut is interpreted to be chiefly the result of weathering of the lower till. Since the upper till has been interpreted to be Kansan drift this lower till must be Nebraskan, on top of which is Nebraskan gumbotil, which was formed during the Aftonian interglacial epoch. The preloessial surface in this cut is very irregular. In places the loess lies on the Kansan drift, in places on the Nebraskan gumbotil, and in still other places on the Nebraskan drift. Pebble estimates made in this cut by Dr. W. C. Alden in the unleached Kansan drift and in the unleached Nebraskan drift gave results as follows:

	KANSAN DRIFT PER CENT	NEBRASKAN DRIFT PER CENT
Limestone and dolomite.....	46	35
Granite and diorite.....	16	31
Greenstone, diabase, etc.....	19	26
Quartzite, mostly red.....	17	7
Chert .....	0	1
Red sandstone.....	1	0
Quartz .....	1	0

A cut just west from the "station one mile" post east from Aspinwall also shows the Kansan and Nebraskan drifts with intervening Nebraskan gumbotil (figure 23). The section is as follows:

	FEET
5. Loess, yellow.....	4
4. Pebble band on which is about one foot of leached, loess-like clay with small pebbles.....	
3. Drift (Kansan), oxidized and leached.....	4
2. Gumbotil (Nebraskan), gray, sticky, starchlike fracture, some concretions .....	5
1. Drift (Nebraskan), oxidized, in lower part calcareous...	5

In the west end of this cut one foot of gray loess lies conformably below the yellow loess. A study of the pebbles in the two drifts in this cut shows more red quartzite in the Kansan drift than in the Nebraskan drift.

Another cut which shows Kansan and Nebraskan drifts with gumbotil between is the first cut east of Manilla in section 13, Nishnabotany township, Crawford county. In one part of this cut the following section was seen:

	FEET
3. Drift (Kansan), oxidized, unleached.....	6
2. Gumbotil (Nebraskan), few pebbles.....	3
1. Drift (Nebraskan), oxidized, upper part leached.....	8

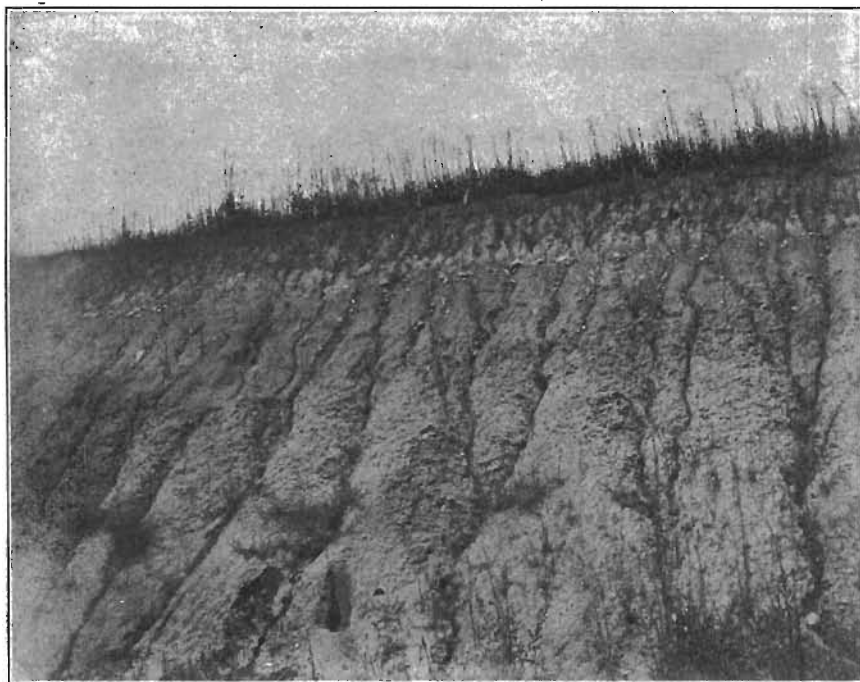


FIG. 23—Railroad cut on Chicago, Milwaukee & St. Paul railway one mile east of Aspinwall, Crawford county. The section shows loess, Kansan drift, Nebraskan gumbotil, and oxidized Nebraskan drift.

In the first big cut east of Manning in section 15, Warren township, Carroll county, is a section showing loess, calcareous till and gumbotil, the gumbotil having a very uneven upper surface apparently due to the overriding of the later ice sheet.

There is a most interesting cut one mile west from Coon Rapids. The section is as follows:

	FEET
5. Loess and loesslike clay.....	5
4. Drift (Kansan), oxidized, leached, concentration of pebbles at the top.....	5
3. Drift (Kansan), yellow, unleached, lime concretions....	1
2. Gumbotil (Nebraskan), gray to drab colored, a few pebbles .....	5
1. Drift (Nebraskan), oxidized, unleached in lower part...	2

In all of the cuts that have been described thus far either Nebraskan gumbotil or Kansan gumbotil is present. Each of these gumbotils occupies a fairly definite position in relation to the topography of the region. As has been stated already, the Kansan gumbotil is found only where the cuts are through



divides which still retain approximately the elevations of the original upland plain; the Nebraskan gumbotil outcrops only in cuts whose summits are considerably below the upland level.

In the few cuts between Manilla and Coon Rapids where only gumbotil overlain by loess is found, the gumbotil, since it occurs considerably below the uplands, has been interpreted to be Nebraskan gumbotil.

The elevation of the base of the Kansan gumbotil in the cut through the main divide west of Templeton is about 1460 feet above sea level. Ten miles farther west in the divide cut between Aspinwall and Manilla the base of the Kansan gumbotil is about 1440 feet above sea level. These facts suggest that the original Kansan gumbotil plain had a gentle dip westward from the main divide. To the east of the main divide the base of the Kansan gumbotil in the Green cut, west of Dedham, has an elevation of about 1360 feet above sea level, and in a cut about two miles east of Dedham the base of the Kansan gumbotil has an elevation of about 1345 feet. Still farther east the Kansan gumbotil has an elevation of less than 1300 feet above sea level. These facts suggest that the Kansan gumbotil plain had a greater dip eastward than westward from the main divide. A study of the exposures of Nebraskan gumbotil shows that this gumbotil where it is found west of the main divide is about forty-five feet lower than the Kansan gumbotil, and has an elevation of about 1400 feet above sea level. To the east of the main divide the only cut which shows Nebraskan gumbotil is about one mile west of Coon Rapids. This cut has been described. Here the elevation of the gumbotil is about 1180 feet above sea level, and this is about one hundred feet lower than the elevation of the Kansan gumbotil in a cut three miles farther west.

In those cuts in which neither Kansan gumbotil nor Nebraskan gumbotil is exposed, but only drift overlain by loess, it has not been possible to determine whether the drift is Nebraskan drift or Kansan drift. However, where such outcrops are not far from the outcrops of Nebraskan gumbotil, and are, moreover, stratigraphically above the horizontal extension of this gumbotil, it may be fairly safe to consider that the drift is Kansan drift. There are several cuts of this nature, both east and west

of the main divide (figure 24). Where cuts expose drift which occupies a topographic position lower than that of the Nebraskan gumbotil in an adjacent cut it is impossible to state definitely whether the age of the drift is Nebraskan or Kansan, although perhaps such evidence would favor the interpretation that the drift is Nebraskan drift rather than Kansan drift. There is such a cut within one mile west from Manning.

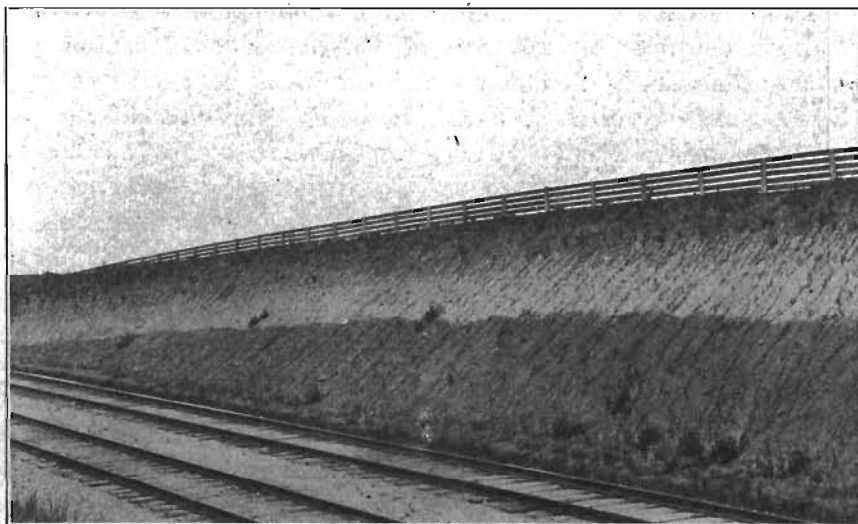


FIG. 24.—Railroad cut on Chicago, Milwaukee & St. Paul railway, about one and one-half miles east of Templeton, Carroll county. The section shows loess mantling unleached, oxidized Kansan drift.

#### Resume.

The most significant features that have been revealed by a study of the Pleistocene deposits in many deep cuts made recently between Manilla in Crawford county and Coon Rapids in Carroll county, by the Chicago, Milwaukee, and St. Paul Railway Company, may be summarized as follows:

1. The chief kinds of material exposed are loess, Kansan gumbotil, Kansan drift, Nebraskan gumbotil, and Nebraskan drift. In no one cut is it possible to see all of these materials, nor are the two gumbotils exposed in a single cut. In some cuts the section shows loess, Kansan gumbotil, and Kansan drift; in other cuts there may be seen loess, Kansan drift, and Nebraskan gumbotil; in still others loess, Nebraskan gumbotil, and Ne-

braskan drift. The most comprehensive cut is about one and one-half miles west of Manning. It shows loess, Kansan drift, Nebraskan gumbotil, and Nebraskan drift.

2. The two drifts, the Nebraskan and the Kansan, are much alike lithologically, and both appear to have undergone similar changes. On each of the drifts gumbotil has 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 Nebraskan gumbotil is about thirteen feet, and of the Kansan gumbotil more than twenty feet. The zone of oxidation of the Nebraskan drift is not fully exposed in any of the cuts; the greatest depth of oxidation seen was seventeen feet. The zone of oxidation of the Kansan drift has a maximum thickness of about forty feet. Beneath this oxidized zone, in a few cuts there was seen less than ten feet of very dark, tenacious, unleached and unoxidized Kansan drift.

4. The Kansan gumbotil is limited in distribution to a few, narrow divides which are erosion remnants of a former, extensive, Kansan gumbotil plain. These divides are the present uplands of the region. The Nebraskan gumbotil is exposed only in those cuts the summits of which have been brought by erosion considerably below the elevations of the summits of the upland cuts.

5. The loess is present as a mantle over the maturely dissected surfaces. It varies in thickness from a few feet to more than twenty-five feet. In general it thickens from the crests of the ridges down the slopes, and is apparently thicker on east slopes than on west slopes. The upper parts of the ridges have been broadened more than heightened by the deposition of the loess. In places the loess lies on Kansan gumbotil; in places it is on Kansan drift; in other places it mantles the Nebraskan gumbotil, and where there has been the most extensive erosion previous to the deposition of the loess, it is on Nebraskan drift.

6. The loess has two phases, the upper of which is buff in color, the lower, gray. In many places the buff loess is leached for a few feet from the surface; in a few cuts the depth of leaching is about fifteen feet. The buff and the gray phases of the loess are closely related, and the evidence indicates that the differences are the result of chemical reactions rather than of different epochs of deposition.

