THE LOESS IN ILLINOIS: ITS ORIGIN AND AGE

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INTRODUCTION

In spite of the fear that it might appear presumptive to present a paper on the much discussed problem of the loess before this Academy, it seemed to the writer that there is need at this time of a more extended statement than can be made in the ordinary geologic reports of the main facts of the loess deposits and of the interpretation which those facts reasonably support.

The name loess is applied to the fine-grained silt-like deposit that, over portions of Illinois and elsewhere in the Upper Mississippi Valley, lies at and immediately beneath the surface to a variable depth of from 2 or 3 to 50 or more feet. On the hills it is generally yellow, but over the more level, poorly drained areas the soil developed at the top of the loess is colored dark with organic matter to a depth of 1 to 3 feet, below which the color grades through shades of gray to yellowish brown. The deposits rarely show any trace of stratification or lamination, and where cut by streams or excavations it tends to stand for a long time in nearly vertical cliffs. In the dryer places, especially in the thicker deposits on the hills, the loess contains numerous shells of species of air breathing gastropods that now inhabit forest-covered slopes. In its typical development the loess is practically limited to the Mississippi basin and in this region it sustains peculiar relations to certain topographic features and to certain beds of glacial drift.

DISTRIBUTION OF THE LOESS

The loess covered area in the Mississippi Valley is chiefly confined to the surface of the older (Kansan and Illinoian) drift sheets and the driftless area, and is mostly included between the Missouri and the Wabash rivers, occurring in its typical characters but a few miles west of the Missouri, and extending east of the Wabash in the vicinity of the Ohio river for several miles east of Cincinnati. South of the Ohio river the loess is chiefly limited to a rather narrow belt adjacent to the Mississippi, nearly to its mouth.

Within this general area the distribution of the loess presents the following significant peculiarities:

1. Except where local topographic features have modified the normal deposition, it is thickest, most typical and most generally fossiliferous on the bluffs bordering the east side of the larger stream valleys, as along the Missouri, Mississippi Illinois, Wabash and smaller rivers, the thickness generally decreasing with increasing distance from the streams. This peculiarity has been noted by all of the students of the loess.

Leverett[1] says that the general thickness of the loess on the east side of the Mississippi Valley from the driftless area southward the entire length of Illinois, is much greater than on the west side in Iowa and Missouri; probably twice as great; and a similar difference exists on the east and west sides of the Valley of the Wabash river.

Shimek[2] says that the bluffs of the Missouri river from Sioux City to Kansas City, and those bordering the Mississippi are higher, with thicker loess deposits on the east side than on the west.

In his report on the St. Louis Quadrangle, Fenneman[3] says that the loess is thickest on the east bluffs of the Mississippi and Missouri rivers where in some places it reaches 50 feet, but it thins to only 10 or 15 feet at a distance of only a few miles.

In many places along the rivers of Illinois as opposite Burlington and below Alton along the Mississippi, the loess has accumulated on the east bluff in dune-like ridges that stand 25 to 50 feet above the uplands farther east, and appear as billowy ridges fringing the east banks of the streams.

1. Frank Leverett: The Illinois Glacial Lobe. Mon. XXXVIII U. S. Geol. Survey, 1899, p. 183.

2. B. Shimek: Loess Papers. Bul. from the Laboratories of Nat. Hist. of the State of Iowa, Vol. V, No. 4, p. 371. Nov. 1904.

3. N. M. Fenneman: Geo. and Mineral Resources of the St. Louis Quadrangle. Bul. No. 438, U. S. Geol. Survey, 1911, p. 33.

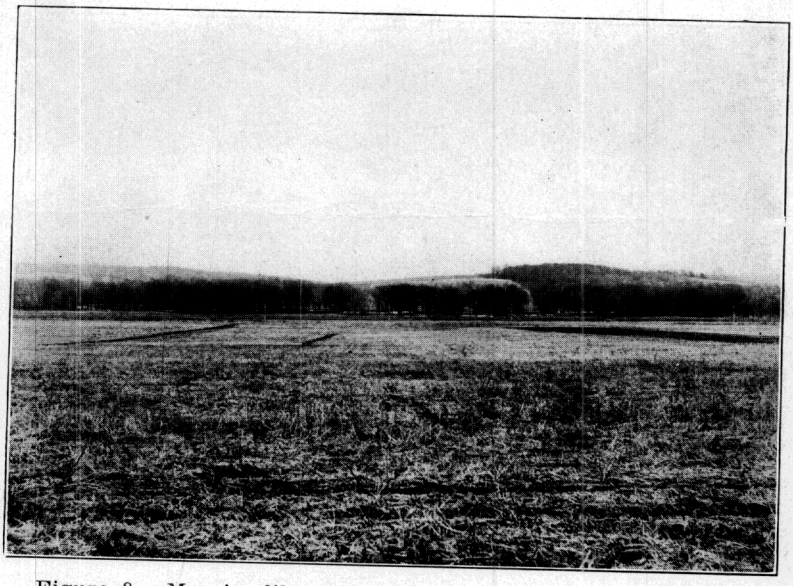


Figure 8. Moraine-like hills of loess bordering the Iowan drift margin in Tama county, Iowa.

2. A belt of moraine-like hills, composed of loess instead of till, borders the Iowan drift sheet in Iowa, as shown in figure 1, and continues as an unusually thick deposit, but with decreasing thickness for a considerable distance south and east of the margin of this drift sheet.

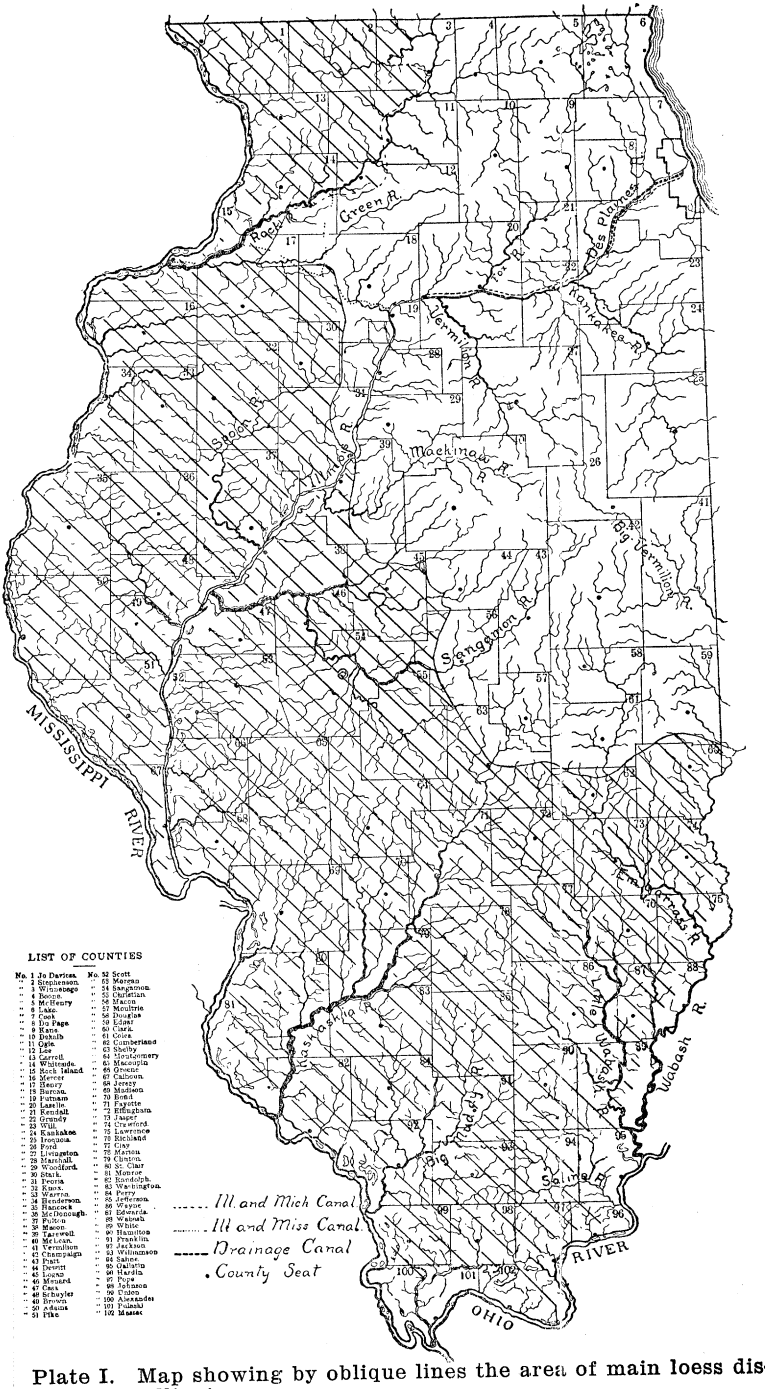
3. The loess is very thin and patchy or entirely absent, over the surface of the younger (Iowan and Wisconsin) drift sheets in all of this region.

4. Over the upland areas of the older (Kansan and Illinoian) drift sheets the loess has its greatest development in Iowa and northern Illinois, where its average thickness is 10 to 15 or more feet. The thickness diminishes notably towards the south and east, being only 1 to 4 feet over the interstream areas in southern Illinois south of the Kaskaskia river, and south of the Wisconsin drift sheet in Illinois, Indiana, and Ohio. In this region of thin loess the deposit is not so homogeneous as it is farther north; in many places the upper 12 to 18 inches being very porous, and of a white, ashy appearance, and often being referred to as "White Clay." Below this white superficial portion the material is brown and much more clayey and compact, and tends to break into small prismatic blocks when dry. This peculiarity is thought to have been developed by the finest particles of the surface loess having been carried downward by ground water, leaving the upper part very porous, but forming a compact deposit where these finer particles became lodged in the small cracks and interstices lower down. The general distribution of the loess in Illinois is shown on the accompanying map. (Plate 1).

COMPOSITION OF THE LOESS

The loess is composed of very small angular undecomposed mineral particles, of which quartz predominates and feldspar, hornblend, calcite, dolomite and other minerals are also common. The texture is usually quite uniform except for occasional pebbles ranging in size to one inch in diameter, which occur in the lower 2 to 5 feet of the deposit. It is thought that these pebbles were not originally deposited with the loess as will be shown later. Some of them are of chert or limestone or sandstone of local origin and others are of crystaline rock. Any kind of pebbles common in the underlying till may occasionally occur in the lower part of the overlying loess, not only on the hills and slopes, but also over the more level areas.

The following table of mechanical analyses of loess from a number of localities shows the texture of the upper part of this deposit in different parts of the state.



LIST OF COUNTIES

No.		No.	
1	Jo Daviess	52	Scott
2	Stephenson	53	Marcena
3	Winnebago	54	Sangamon
4	Boone	55	Christian
5	McHenry	56	Macon
6	Lake	57	Moultrie
7	Cook	58	Douglas
8	Du Page	59	Edgar
9	Kane	60	Clark
10	DeKalb	61	Coles
11	Ogle	62	Cumberland
12	Lee	63	Shelby
13	Carroll	64	Montgomery
14	Whiteside	65	Macoupin
15	Rock Island	66	Greene
16	Mercer	67	Calhoun
17	Henry	68	Jersey
18	Bureau	69	Madison
19	Putnam	70	Bond
20	Lasalle	71	Fayette
21	Kendall	72	Effingham
22	Grundy	73	Jasper
23	Will	74	Crawford
24	Kankakee	75	Lawrence
25	Iroquois	76	Richland
26	Ford	77	Clay
27	Livingston	78	Marion
28	Marshall	79	Clinton
29	Woodford	80	St. Clair
30	Stark	81	Monroe
31	Peoria	82	Randolph
32	Knox	83	Washington
33	Warren	84	Perry
34	Henderson	85	Jefferson
35	Hancock	86	Wayne
36	McDonough	87	Edwards
37	Fulton	88	Wabash
38	Mason	89	White
39	Tazewell	90	Hamilton
40	McLean	91	Franklin
41	Vermilion	92	Jackson
42	Champaign	93	Williamson
43	Piatt	94	Saline
44	Dewitt	95	Gallatin
45	Logan	96	Hardin
46	Menard	97	Pope
47	Cass	98	Johnson
48	Schuyler	99	Union
49	Brown	100	Alexander
50	Adams	101	Pulaski
51	Pike	102	Massac

Plate I. Map showing by oblique lines the area of main loess distribution in Illinois.

*MECHANICAL ANALYSIS OF THE LOESS IN ILLINOIS

Diam. in Millimeters	Conventional Name	E. Dubuque 1-15 in.	Rock Island 1-6 in.	Carrollton 1-15	Virginia City 4-48	Near Greenup 2-15 in.	Moweaqua 2-18 in.	Galatea 1-18	Champaign Bowlder Clay 30-42 in.
		Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
2-1	Fine gravel	0.00	0.00	0.00	0.00	0.30	0.00	0.00	1.04
1-.5	Coarse sand	0.00	0.00	0.00	0.00	1.05	0.08	0.00	1.98
.5-.25	Medium sand	0.04	0.02	0.01	0.00	3.42	0.77	0.02	6.85
.25-.1	Fine sand	0.74	0.17	0.04	0.01	3.30	0.11	0.30	6.23
.1-.05	Very fine sand	30.12	22.27	9.93	7.68	6.47	4.88	5.21	5.82
.05-.01	Silt	41.49	51.53	48.76	61.85	55.48	52.50	57.75	28.38
.01-.005	Fine silt	7.96	9.72	8.39	9.60	11.70	12.15	12.78	15.46
.005-.0001	Clay	14.44	12.08	23.65	15.15	14.90	22.10	20.36	30.00
	Total Mineral Matter	94.79	95.79	93.78	94.29	96.62	92.59	96.42	95.64
	Organic Matter Water Loss	5.21	4.21	6.22	5.71	3.38	6.61	3.58	4.36
	Loss by Direct Ignition	5.66	4.21	6.14	5.87	3.11	5.73	6.01	

* Whitney, Milton: Report on the examination of some soils from Illinois; report of the Illinois Board of World's Fair Commissioners, 1893, pp. 103-106.

From this table it may be seen that the greater part of the loess is composed of particles intermediate in size between sand and clay, but that it grades into sand on the one hand and into clay on the other. The table also shows that the loess in the vicinity of the larger streams, and in western Illinois, contains a larger percentage of coarser particles than that over the uplands some distance from the streams, and in the eastern part of the state. Compared with the drift or bowlder clay, shown in the right hand column, the loess contains a smaller percentage of either the coarse or very fine constituents and a relatively larger percentage of particles of intermediate size.

SOURCE OF THE LOESS MATERIALS

Two sources have been suggested for the materials of the loess. Some geologists have assumed that it has been blown by the winds from the arid regions of the Great Plains, while others think it has been derived from the rock flour of glacial till. The former theory is discredited by the following facts:

1. The small size of the particles of the surface soil of the arid regions. Merrill[4] says "the particles of adobe or surface soil of the Great plains vary in size from those too small for measurement, up to .08 millimeters in diameter. It will be seen from the former table that both the maximum and minimum size of the particles of the loess are larger than those of adobe, which is the opposite of what would be expected if the latter was the source of the loess.

2. The constituents of adobe contain a much larger proportion of calcium carbonate and of mineral matter derived from sedimentary rocks than does the loess.

3. The peculiar distribution of the loess in relation to the drift deposits of the upper Mississippi Valley. Chamberlin says, "The constitution of the loess of the Mississippi Valley taken with its two distributive relationships proves it to have a special origin from the glacial drift."

4. Adobe soil is much more variable in its chemical composition than the loess, as appears in the following comparative table of analyses in which columns 1 to 5 show the analyses of loess from different localities, and columns 6 and 7 are those of adobe soil.

The peculiar relations of the loess to the various drift sheets and to the streams of the glaciated region and the rseemblance of the loess in freshness and mineral composition to the finer parts of the till, furnish convincing evidence that the source of the loess material was glacial drift. It also seems reasonable to assume that the belts of greatest thickness of the loess are nearest the immediate sources of supply. If this is true the main immediate sources of the loess are, 1, river flood plains, and 2, the Iowan drift sheet.

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4. George P. Merrill: Rocks, Rock Weathering and Soils; p. 321, 1916.

*TABLE OF ANALYSIS OF LOESS AND ADOBE SOIL

	No. 1 Dubuque	No. 2 Galena	No. 3 Kansas City	No. 4 Vicksburg	No. 5 Near Terra Haute	No. 6 Adobe Santa Fe N- Mex	No. 7 Adobe Salt Lake City, Utah
SiO_2	72.68	64.61	74.46	60.69	79.77	66.69	19.24
Al_2O_3	12.03	10.64	12.26	7.95	9.95	14.16	3.26
Fe_2O_3	3.53	2.61	3.25	2.61	3.39	4.38	1.09
FeO	.96	.51	.12	.67			
TiO_2	.72	.40	.14	.52	.70		
P_2O_5	.23	.06	.09	.13		.29	.23
NnO	.06	.05	.02	.12		.09	Trace
CaO	1.59	5.41	1.69	8.96	.67	2.49	38.94
MgO	1.11	3.69	1.12	4.36	.26	1.28	2.75
Na_2O	1.68	1.35	1.43	1.17	1.08	.57	Trace
K_2O	2.13	2.06	1.83	1.08	2.05	1.21	Trace
H_2O*	2.50	2.05	2.70	1.14	2.55	4.94	1.67
CO_2	.39	6.31	.49	9.63		.77	29.57
SO_3	.51	.11	.06	.12		.41	.53
C (Organic)	.09	.13	.12	.19		2.00	2.96

*Contains H of organic matter in Nos. 1-4.

1. Nos. 1 to 5: Leverett, Frank: The Illinois Glacial Lobe. Mon. XXXVIII, U. S. Geo.. Survey, 1899, p. 164.

Nos. 6 and 7: Clark, F. W.; The Data of Geochemistry. Bul. No. 491, U. S. Geol. Survey, p. 487.

MODE OF ACCUMULATION OF THE LOESS

Orton suggested that the loess or white clay of southwest Ohio represented the fine materials brought up by earth worms and other burrowing animals from the underlying till. That the aggregate work of earth worms is considerable, no one will doubt, but the inadequacy of such agents in the accumulation of the loess will be readily seen in the places where the deposits have a thickness of several feet. It is also shown in the fact that in the same general region there is no perceptible difference in the thickness of the loess whether it is immediately underlain by drift or by such beds as gravel, sand, soil or peat, which contain no fine constituents resembling loess. The clear zone of contact that in most places separates the loess from the underlying bed shows that the disturbance produced by earthworms and other burrowing animals are relatively unimportant as far as loess accumulation is concerned. The indifference in the thickness of the loess to the character of the bed that lies beneath it, as stated above, indicates that the loess could not have been derived from the underlying deposit, but that it was transported, and laid down above the material upon which it rests. The homogeneous, well sorted character of the loess is proof that it has been carried and deposited either by wind or water, for no other geological agent is capable of so thoroughly sorting the material it deposits.

The general distribution of the loess, being thicker and coarser on the hills bordering the larger streams than over interstream areas (see figure 2), and especially thick on the tops of the hills, bordering the windward side of the valleys and around the border of the Iowan drift plain, in Iowa, and towards the north in Iowa and northern Illinois than farther south; the great range of relief shown in the loess deposits, being more than 600 feet in Illinois, and exceeding a thousand feet in the Mississippi basin; the fact that the loess does not tend to level the inequalities of the surface, but mantles the hills, prairies and lowlands; the general lack of stratification or lamination of the deposits; and the presence in the loess of entire shells (many of which are fragile and easily broken) of species of terrestrial gastropods that now live on dry woodland hills, are conclusive evidences that the loess in the Mississippi Valley region was carried and deposited by wind, rather than by water.

Water laid silts are distinguishable from true loess by the greater distinctness and horizontality of their stratification, by the more heterogeneous character of their constituent materials and by the fact that their fossils, when present, are aquatic. If sediments possessing these characters of aqueous deposition were never included under loess deposits, it would tend to clear up and prevent much of the confusion that is now so prevalent concerning the loess. There is no more reason for designating water laid deposits resembling loess in texture, or even derived from loess by the name loess, than there is for applying the name shale to fluviated deposits derived from beds of shale. In geologic mapping all such water laid deposits would be classed as alluvium.

Calvin[8] has pointed out that there are three things to account for in the proper explanation of loess deposition:

1. An extensive gathering ground of bare and dry surfaces as a direct source of the material.

2. An agent of transportation and deposition consistent with the source of supply and the sites of deposition.

3. Obstructions to the transporting agent, such as would result in deposition and lodgment in the places where such deposits now occur.

All the above conditions are completely satisfied in harmony with deposition of the loess by winds. The position of the thicker and coarser loess deposits on the bluffs bordering the windward side of the larger flood plains are in the places where the prevailing westerly winds, after sweeping over exposed

8. Samuel Calvin: The Iowan Drift. Journal of Geology, Vol. XIX, No. 7, 1911, p. 601.

flood plain areas, would have their velocity checked and so be compelled to drop a part of their load on the bordering banks, which then as now, were doubtless forest covered and so furnished lodgment for a part of the silts deposited upon them. A large part of the material would always be carried beyond the bordering hills and finally be dropped upon the interstream areas.

Even the details of thick loess distribution bordering the streams are in harmony with wind deposition, for the thickest loess is not where the winds blow straight across the valleys, but is on the bluffs bordering those portions of the valleys which trend oblique to the prevailing wind currents, so that the winds followed along the valley for some distance before their movements were obstructed by a bend in the channel. This is illustrated by the deposits along the Sangamon river in the Springfield Quadrangle. The deposits of the thick loess around the margin of the Iowan drift sheet and extending with decreasing thickness for many miles to the south and east are also consistently explained only by the agency of the wind The most striking characteristics of the Iowan drift sheet are, 1, the thinness of the drift; 2, the lack of the usual amount of fine material and the presence of great numbers of bowlders upon its surface, and, 3, the moraine like hills of loess bordering the area. All of these peculiarities would be developed as a result of winds blowing outward over the surface of the glacier, or over the dried mud flats of the drift sheet, after the glacier had retreated to the northward, but before a cover of vegetation had become established upon the drift surface. Winds sweeping unchecked over the bare drift surface during dry periods would pick up large quantities of the finer materials. A part of their load would be dropped when the forest that fringed the border of the Iowan drift area was encountered and a part would be carried farther forward. If such conditions attended the withdrawal of the Iowan ice sheet as resulted in the surface of the drift remaining bare of vegetation for a long time, the bowlders and coarser debris of the till would become concentrated at the surface by the removal by the winds of a large part of the finer constituents, reducing by this great amount the thickness of the Iowan drift.

A part of the material gathered by the winds from the river flood plains or from the Iowan drift surface would be dropped at the immediate border, a part would be carried for a longer or shorter distance before finding permanent lodgment in the vegetation that covered the uplands. Another part dropped in places not well protected with vegetation, was doubtless again

picked up, together with fine material from other sources and carried forward for some distance and again dropped, and the process was repeated again and again until the fine silt was spread widely over the interstream areas, and much of it is now a long distance from its original source.

SOURCE OF THE PEBBLES IN THE LOESS

Pebbles are rare in the loess, but a few occur in the lower 2 to 5 feet of the deposit over practically all of the loess area, being more frequent where the loess is thin than where it is best developed. The presence of occasional pebbles in the lower part of the loess has been considered by some geologists as evidence of the aqueous origin of at least this portion of the deposit, but it is just as difficult to explain how occasional pebbles could be included in the midst of an otherwise homogeneous, fine grained, unstratified deposit laid down by water as in such a deposit made by wind.

A study of the process of accumulation of the loess now forming over the surface of the early Wisconsin till has furnished valuable information concerning the probable source and manner of inclusion of the pebbles in the lower part of the loess in other regions. The higher portions of the surface of the early Wisconsin till in Champaign county are in places covered with 1 to 3 feet of porous, fine grained, loess-like material which, like the loess in other places in the State, is largely composed of minute, fresh, angular fragments of quartz, feldspar, hornblende, and other minerals derived from igneous rocks. In this recent loess small pebbles are somewhat more numerous than in the lower part of thicker loess deposits over the Illinoian and Kansan drift sheets, probably on account of the slower rate of accumulation of the loess now forming on the Wisconsin drift, compared with the rate at which the loess accumulated in early Peorian time.

Over the more dry, uncultivated areas of this surface burrows of ground squirrels and other animals are common. Many of these burrows pass through the thin loess mantle into the unlerlying till, and the dirt thrown out around the tops of the holes often contains a few small pebbles. In poorly drained areas crayfish holes are in places almost as numerous as the burrows on the higher lands. In the craters built up around the tops of these holes a few pebbles ranging in size up to one inch in diameter were collected. Pebbles are also occasionally carried from areas where no loess is present to areas where loess is accumulating in the mud on the feet of hoofed animals.

In all of these ways occasional pebbles are now being scattered on the surface of, and becoming imbedded in, the loess accumulating upon the Wisconsin till, but each of these agencies gradually becomes less effective and will eventually fail to scatter any pebbles, as the thickness of the loess increases. It is believed that by means similar to the above the pebbles became incorporated in the lower part of the loess deposit as it was in process of accumulation over the main loess covered regions.

RELIEF OF THE PRE-LOESSIAL SURFACE

The relief of the surface of the Illinoian drift sheet at the time the loess was laid down upon it was worked out in detail in the Avon and Canton quadrangles in the northcentral part of the State where the loess is well developed. This was determined by finding the elevation of the upper surface of the drift, and thus of the lower surface of the loess at a large number of places where the contact was exposed as shown on the map, (plate 2). The relief of the surface of the drift beneath the loess in the Canton quadrangle was found to exceed 150 feet, and the general slope of the top of the drift beneath the loess in this region was found to correspond in a general way to the slope of the present surface. The main divides of the region at the time the loess was deposited were the same as at present. In the Canton quadrangle the main highland which then, as now, lay between Farmington and Norris, extended a little south of west past the town of Fairview. From this highland the pre-loessial surface declined southward along Copperas Creek as much as 100 feet in a distance of 6 miles. Along Big Creek, from its sources in the vicinity of Norris to the town of St. David, the total difference in the elevation of the drift surface beneath the loess exceeds 125 feet. From the headwaters of Put Creek to the place where it leaves the quadrangle near the southwest corner, the surface declines more than 100 feet. A like difference in the altitude of the upper surface of the drift is shown between the head waters of Turkey Creek and Coal Creek and the top of the drift bordering these streams at the west side of the quadrangle. From the sources of Littlers Creek to its junction with Spaan River the pre-loessial drift surface declined 150 feet.

The topography of the Illinoian drift surface beneath the loess in the Avon quadrangle resembles that of the Canton quadrangle described above, as does also the pre-loessial surface of the drift in the Sumner and Hardinville quadrangles in Southeastern Illinois, and the Herrin quadrangle in the southern part of the state.

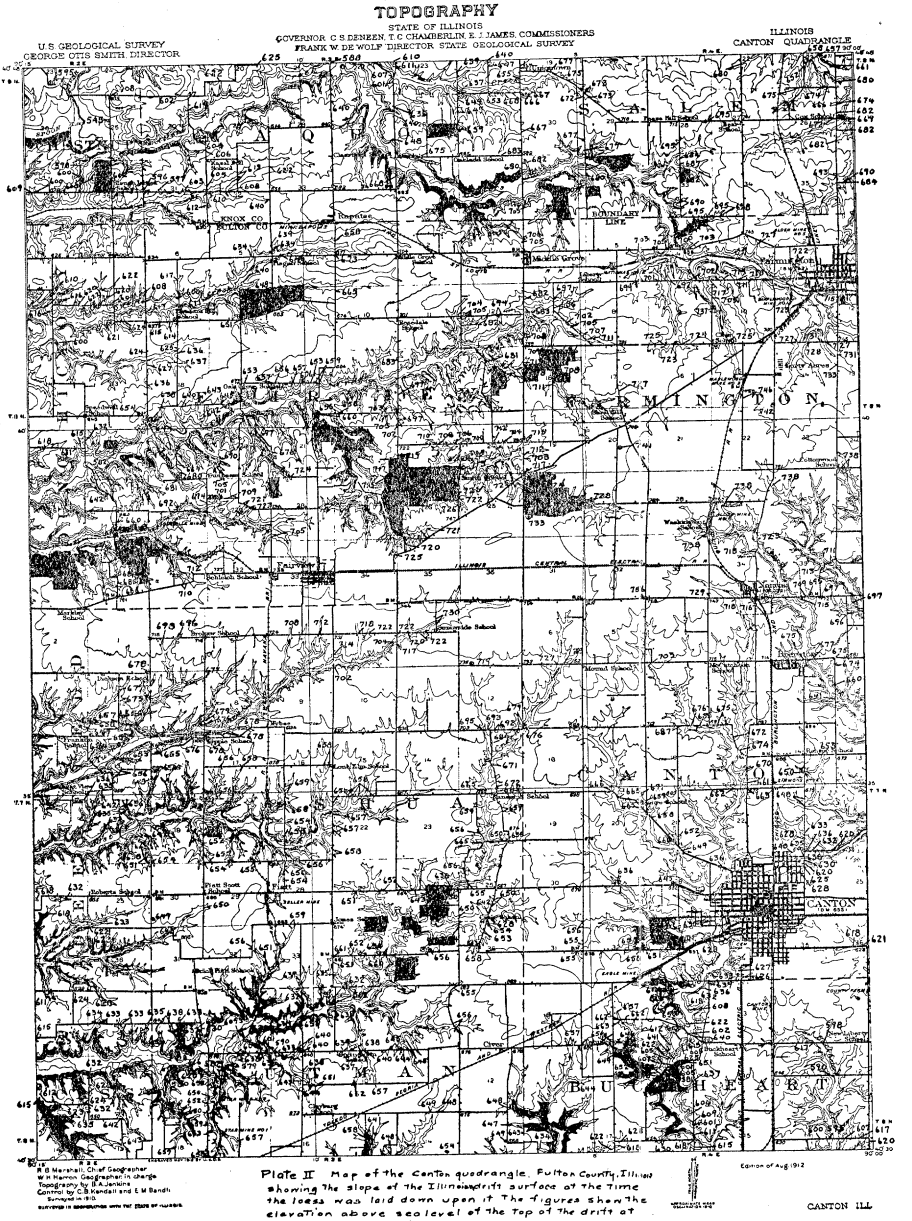

Plate II Map of the Canton quadrangle, Fulton County, Illinois showing the slope of the Illinoian drift surface at the time the loess was laid down upon it. The figures show the elevation above sea level of the top of the drift at different places in the area.

Plate II. Map of the Canton quadrangle, Fulton county, Illinois, showing the slopes of the Illinoian drift surface at the time the loess was laid down upon it. The figures show the elevation above sea level at the top of the drift at different places in the area.

From the detailed study of these and other areas it seems certain that the development of erosion slopes on the surface of the Illinoian drift previous to the deposition of the loess was several times that at present attained on the surface of the Early Wisconsin drift, indicating a correspondingly longer interval for its accomplishment than has elapsed since the withdrawal of the Wisconsin ice sheet.

It might be suggested that the surface of the Illinoian till, beneath the loess, reproduced the topography of the pre-Illinoian surface as a result of the present streams following pre-Illinoian channels that were not completely filled by the Illinoian till. Some of the larger streams in the Canton quadrangle are following pre-Illinoian channels, but only in a part of their courses, and many of the smaller streams have no place found buried channels. However, the slopes of the Illinoian till, beneath the loess, bordering the portions of the stream valleys, where they do not follow pre-Illinoian channels, are just as gradual as in the places where they do. The thickness of the Illinoian till in this region averages about 24 feet, which depth is sufficient to entirely obliterate all of the smaller pre-Illinoian valleys and many of the larger ones also, as the field study shows it has done. Hence the generally gradual slopes of the surface of the till, beneath the loess, bordering the smaller as well as the larger streams, could have been developed for the most part only by stream erosion on the surface of the Illinoian till, before the overlying loess was laid down.

TIME OF THE MAIN LOESS DEPOSITION

In the Mississippi Valley and elsewhere dust is at present being carried and deposited by the winds, and doubtless under favorable conditions of gathering and lodgment, the winds have carried and deposited such materials throughout past geological periods. It seems certain, however, that peculiar conditions unusually favorable for loess deposition, prevailed over the Mississippi valley during very late Iowan and early Peorian stages of the Pleistocene. This is shown, (1) by the intimate relations of the loess to the border of the Iowan drift plain above described, and (2) by the very slight development of loess on the surface by the Iowan and Wisconsin drift sheets compared with its much greater thickness over the older Kansan and Illinoian till.

That the most important loess deposition did not take place after the Iowan period of glaciation is shown by the absence of anything like such thickness of loess over the Iowan

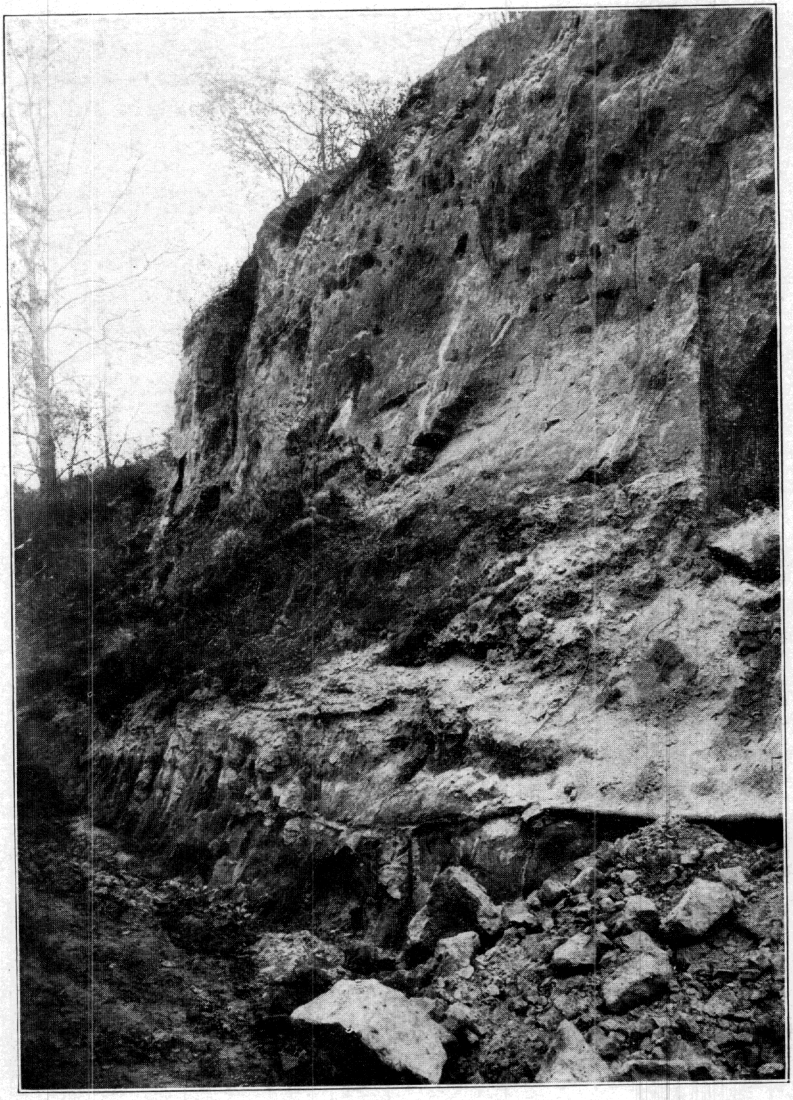

Figure 9. Bluff of loess along the Mississippi River in Calhoun county, Illinois.

and Wisconsin drift sheets as is present over the surface of the older Illinoian and Kansan till. The maximum loess deposition did not occur until a long time after the Illinoian till was deposited as shown by the fact that (1) before the loess was deposited sufficient time elapsed for the development, on the surface of the Illinoian till, of erosion slopes and relief quite similar to those of the present surface; and (2) the interval between the deposition of the Illinoian till and of the overlying loess in Illinois was sufficiently long for the development in many places upon the surface of the Illinoian drift of the Sangamon soil horizon and beds of peat, and in others of an oxidized and weathered zone, and in still others of a zone of concentrated pebbles on the slopes by the removal of the finer constituents of the till, such as are found above the Illinoian till and below the loess in many places in Sangamon, Fulton, Menard, Champaign and other counties in Illinois.

Some loess-like material was doubtless deposited by the winds during each of the interglacial stages, for thin deposits of such character are known between the Kansan and the Illinoian and the Kansan and the Iowan drift sheets at numbers of places in the Mississippi Valley. However, the thickness of the loess between the Kansan and Illinoian till or between the Kansan and the Iowan is not nearly so great as that over the surface of the Kansan and the Illinoian till sheets. The pre-Iowan loess appears to have been limited in its distribution, compared with the present loess deposits, as is indicated by the following facts: (1) The loess is thin, only one to three feet, and of relatively rare occurrence between the Illinoian and the Kansan or between the Kansan and the Iowan drift sheets, while a thickness of several feet is common between the Illinoian and the Wisconsin till. (2) Masses of typical fossiliferous loess, in size up to 15 feet long and 4 feet thick, are often found incorporated in the Wisconsin till, but they are rarely or never found in the till of earlier age, in which masses of sand of corresponding size are not uncommon.

The relations of the loess to the drift varies with the valley slopes. In many places where the banks bordering the valleys of the larger streams are steep, the loess breaks off abruptly near the top at the uppermost exposed level of the till. In many other places where the bordering slopes are gentle and are favorably situated with respect to areas of flood plain and the direction of prevailing winds, a mantle of normal loess covers the slope to a thickness of from two or three to six or eight feet, often extending down almost or entirely to the level of the flood plain.

In the places where the loess terminates abruptly near the tops of the hills, at the uppermost level of the till, the banks are usually precipitous, and the streams have undercut their banks and thus widened their valleys since the time of major deposition of the loess. In this process the loess that was deposited in the earlier slopes has been removed as the work of valley widening by side cutting of the streams was accomplished. At these places the undercutting has taken place so recently that the banks are still steep and no appreciable amount of loess in excess of what has been eroded, has since been deposited upon them.

In some places where the loess continues down the slopes for a considerable distance below the upper level of the drift, the slopes are usually gentle, showing that undercutting has not there been in progress for a long time.

The presence of the loess over the slopes below the upper level of the drift may be accounted for in two possible ways: (1) It may be assumed to have been brought down from higher levels by slumping and sheet wash; and (2) It may have been carried up by winds from flood plain or other exposed areas and deposited on the slopes where it is now found. By the first assumption practically all the loess on such slopes would be of secondary origin, while by the second this loess would be largely in its original position.

The first assumption is open to the following objections:

1. Although landslides and slumping were doubtless important factors in the development of the gentle slopes, after undercutting had ceased, yet these processes would not result in the development over the surface of a mantle of fine homogeneous loess material, unmixed with till, after the gentle slope had been developed. 2. The effective action of sheet wash on slopes of rather uniform gradient tends to increase with the distance down slope from the top, so that any material transported for a distance near the top would tend to be carried to the foot and not deposited on the middle or lower part of the slope. 3. The thickness of the loess at the top of the hill, in places where the loess continues down the slope to the flood plain, is as great as it is in the places where it does not extend below the highest level of the drift. An immense quantity of material would be required to cover a slope ⅛ to ¼ mile in length to a depth of three to six feet, yet in not one of such places observed was there any diminution in the thickness or amount of the loess at the tops of the hills, showing conclusively that the loess on the slopes could not have been derived from the loess at the top of the hill.

Supporting the view that the loess which mantles the slopes below the highest level of the drift is an original deposit, is the general relation of such loess covered slopes to areas of flood plain and to the direction of prevailing winds.

Bordering the east bank of Spoon river, in Secs. 19 and 20, T. 9 N., R. 3 E., and Secs 24 and 25, T. 9 N., R. 2 E., and farther south in Secs. 10, 15, and 22, T. 8 N., R. 2 E., the till is entirely concealed down to the level of the flood plain by a covering of wind blown material, in some places loess and in others sand. The only evident source of the sand in this region is the adjacent flood plain of Spoon river to the westward, and this sandy alluvium would furnish a ready supply both of the sand and the finer loess material. Observations show that both sand and loess are at present being deposited on the slopes on the east side of the valley by the winds which gather the most of the material from the surface of the adjacent flood plain.

Relations similar to those in the vicinity of Spoon river generally exist between the thicker sand and loess deposits, not only on the bluffs, but also on the more gentle slopes bordering the windward side of the valleys and the areas of flood plains along the Sangamon and Illinois, and the other rivers, as well as many of the smaller streams, in Iowa and Illinois.

Some of the fine material gathered from the flood plain of the river may be carried by the wind for several miles, and this material, together with the dust swept by the winds from exposed portions of the intervening uplands, may be lodged on the bluffs and opposing slopes along smaller streams at a distance from the river and thus supplement the local supply.

The general relations of the loess covered slopes to the direction of the prevailing winds and the possible source of supply of the material together with the lack of any trace of removal or diminution in the quantity of the loess material at the tops of the hills in such places, make it practically certain that the loess occurring on the slopes below the uppermost level of the drift has been mainly deposited by winds since the present, gentle gradient of the slopes was developed, and that it is largely in its original position.

CLIMATAL IMPLICATIONS OF THE LOESS

Wind deposits are characteristic of arid climates, hence some geologists have assumed that arid conditions must have prevailed in the upper Mississippi Valley during the time of max-

imum loess deposition. Leverett[1] thinks that, since loess occurs in a few places between the Kansan and Illinoian drift sheets as well as more generally above the Illinoian and below the Wisconsin till, there must have been two periods of aridity in this region during Pleistocene time.

In his recent paper on the "Solar Hypothesis of Climatic Changes," Huntington[2] has assumed that arid conditions prevailed in the loess area of the Mississippi Valley during each of the stages of glaciation.

However, the following facts make it very improbable that anything like desert or even semi-arid conditions could have accompanied the deposition of the loess:

1. The regularity, or very gradual change, in the thickness of the loess over the uplands. Wind deposits in arid regions are notoriously dune-like and irregular. The level, loess covered prairies of the Illinoian drift plain present none of the irregular features characteristic of wind deposits in arid regions where a dense cover of vegetation did not control the permanent lodgment of the material.

2. The presence throughout the thicker loess deposits of shells of species of land snails that live at present on woodland hills in the same regions, indicates that similar conditions of habitat had existed throughout the time of accumulation of the loess deposits.

3. The absence of glacio-fluvial or other water laid deposits associated with the Iowan drift is also evidence opposed to an arid or semi-arid climate during that time, for under arid conditions the rains would be concentrated during a short season of the year, making the streams more effective in the transportation and deposition of coarse debris.

4. The uniformly fine grain of the deposit, which was derived from sources rich in coarser sand material, also precludes the possibility of arid conditions in which the winds had any greater efficiency than at present. The texture of the main portion of the loess deposits is as fine as that of the uppermost part which was presumably deposited under present climatal conditions in more recent time, and in any exposure there is generally no line or zone in which any change in the texture of the materials of the deposit can be detected.

In the loess deposits bordering the Embarrass and Wabash rivers in Crawford and Lawrence counties, Illinois, a bed of

1. Frank Leverett: Weathering and Erosion as Time Measures. Am. Jour. of Science, Vol. XXVII, May, 1909, p. 361.
2. Ellsworth Huntington: The Solar Hypothesis of Climatic Changes. Bul. Geol. of Am., vol. XXV, No. 4, 1914, p. 577.

typical, yellowish-gray, fossiliferous loess, presumably of the Iowan age, in places rests directly upon the Illinoian drift, and is overlain by 1 to 5 feet of brown, homogeneous silt, the texture of which is similar to that of the lower loess. This brown loess-like clay, which in some places overlies the typical fossiliferous loess, mantles the surface over all of this region, and is thought to indicate a less rapid rate of accumulation of the upper loess, the deposition of this bed being so slow as to permit the complete oxidation of the material while it was being laid down, while the lower oxidized Iowan loess is thought to have accumulated so rapidly that the material did not become so thoroughly oxidized before it was buried. The texture of the material is similar throughout and does not indicate any difference in the power of the winds during the time both phases of loess were deposited.

Evidence of the lack of conspicuous flooded conditions of the streams attending the melting of the Iowan ice sheet, is clearly seen in the lack of association with this drift sheet of outwash deposits, gravel trains, eskers, and other glacio-fluvial features, associated as compared with the abundance and extent of such water sorted deposits in association with the Wisconsin till, or with the earlier Kansan and Illinoian drift sheets. This absence is doubtless due to the very slow rate of melting of the Iowan glacier, which slow rate of melting probably resulted from the prevalence of a somewhat unusually low temperature in the region during the melting of the Iowan ice sheet, and was not due to the existence of arid conditions during this time.

The loess deposits demand a climate so nearly like that of the present that the hills and uplands were covered with vegetation practically as today; that the winds were no more efficient in gathering or transporting materials than at present; that the land snails could live on the same forest covered hills which they now inhabit. These facts, together with the general lack of glacio-fluvial deposits associated with the Iowan drift are not consistent with arid conditions. It seems to the writer they can be better explained by assuming a slightly lower temperature during the melting of the Iowan ice sheet than attended the melting of the other ice sheets of the Pleistocene period, and continuation of this low temperature for a considerable time after the withdrawal of Iowa glacier, such as would retard for a time the establishment of vegetation upon the Iowan drift surface, and also delay the renewal of vegetation over the mud flats of river flood plains after they were overflowed by the streams.