

DISTRIBUTION CURVES FOR LOESS*

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ABSTRACT. Loess distribution was studied in southwestern Iowa and northern Missouri by measuring maximum thickness at a number of points along two traverses which begin at or near the bluffs beside the flood plain of the Missouri River. The greatest measured thickness of Wisconsin loess is 1380 inches near Council Bluffs, Iowa. The loess thins to the southeast according to an exponential function, and the maximum thickness gradually drops off to as little as 50 inches on an uneroded divide in Boone County, Missouri. The slope of the curve showing loess thickness decreases with increasing distance from the source. The data obtained indicate that the equations already developed for loess distribution curves are valid within restricted geographic ranges but not over the full distance of loess deposition from a single source. The distribution pattern of the loess also suggests the need for further study of silty surface mantles in areas where loess has not been identified in the past.

The nature and distribution of loess formations in the Mississippi Valley, exclusive of the Missouri Valley, have been discussed recently by Leighton and Willman (1950), who cite curves for loess distribution in Illinois. The principal systematic measurements of loess thickness over sizable areas have been made in the Mississippi Valley, especially in Illinois (Smith, 1942). Systematic measurements have also been made in Kentucky, Tennessee and Mississippi (Wascher, Humbert and Cady, 1947), although no effort was made to develop curves for loess distribution patterns in those states. The curves and equations worked out by Krumbein (1937) and Smith (1942) were both based on data obtained in Illinois where possible traverses from single loess sources have maximum lengths of less than 100 miles. Traverses can be extended for approximately 3 times that distance across southwestern Iowa and northern Missouri without encountering important secondary loess sources. This permits the testing of equations for loess distribution curves over greater distances.

NATURE AND SCOPE OF INVESTIGATIONS

The observations of loess distribution in southwestern Iowa were part of an effort to improve the classification of soils for the soil survey of Taylor County (Scholtes, Smith and Riecken, in press). Earlier studies (Kay and Graham, 1943) had shown that the loess in Iowa was not uniform in thickness or composition. Moreover, studies by Bray (1937) and Smith (1942) had demonstrated that the nature of soils could be related to loess distribution patterns in Illinois. Consequently, it was believed that study of the distribution pattern of Wisconsin (Peorian) loess in southwestern Iowa, when coupled with investigations of soil morphology and composition, would improve the understanding and classification of the soils. Inasmuch as the data obtained in studies of soil morphology and composition in southwestern Iowa have been reported elsewhere by Hutton (1950) and Ulrich (1950), they will not be repeated here.

It now seems clear that the Peorian formation, as generally identified in the past, consists of more than one sheet of loess, as was suggested by Leigh-

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ton and Willman (1950). Ruhe (1952) has concluded that a major twofold division of Wisconsin drift and its loess equivalents exists in western Iowa. Mickelson (1950) has interpreted an exposure in western Iowa as indicating the presence of a post-Loveland pre-Iowan loess which might correlate with the Farmdale loess of Illinois. In the loess depth measurements reported in this paper, it was not possible to detect consistent breaks in the sections of loess above the Loveland formation. Moreover, the loess above the Loveland formation seems to have originated from the flood plain of the Missouri River along the western edge of the state.

Evidence for the Missouri River flood plain as the principal source of loess in southwestern Iowa and north-central Missouri seems overwhelming. The thickest deposits of loess, or the highest bluffs, lie immediately southeast of the widest segments of the flood plain. Where the flood plain becomes narrow the adjacent loess deposits are much thinner. Over much of western Iowa the loess was apparently laid down upon a dissected land surface, and the deposits are thickest on the southeast sides of the ridges. These are the lee sides to winds blowing from the northwest. The loess mantle is often deep on the southwest slope and very shallow or absent on the comparable northwest slope of a single ridge. With increasing distance to the southeast the loess becomes thinner according to an exponential function as was found earlier by Smith (1942) in Illinois. On the other hand, the thickness of loess in south-central Iowa is essentially constant along a line running from northeast to southwest or perpendicular to the direction chosen for the two traverses. The distribution pattern of loess in southwestern Iowa, together with changes in the nature of that loess with increasing distance from the Missouri River, is the basis for the conclusion that the Wisconsin (Peorian) loess was blown almost entirely from the flood plain of the Missouri River and that the sediments were carried mainly to the southeast. This is in accord with observations in Illinois (Smith, 1942), other observations in Iowa (Hunter, 1950; Simonson, Riecken, and Smith, 1952, p. 13-20, 58-60, 84), and studies of the lower Mississippi Valley (Wascher, Humbert and Cady, 1947). This interpretation forms the basis for laying out traverses in a southeasterly direction from the Missouri River.

Measurements were made along two traverses extending southeast from the flood plain of the Missouri River which forms the western boundary of Iowa. Traverse no. 1 begins 10 miles from the bluff in Monona County and runs southeast to the Iowa-Missouri state line in southwestern Wayne County. No reliable measurements of maximum loess depths were possible nearer the bluff in Monona County. Traverse no. 2 begins at the bluff in the northern edge of Council Bluffs and runs southeast into Ringgold County. Locations of the two traverses are shown in figure 1. Traverse no. 1 extended for a distance of approximately 170 miles and Traverse no. 2 about 90 miles within Iowa. Traverse no. 2 has been extended for a total distance of approximately 260 miles by the addition of measurements at three sites in Missouri.

Measurements of thickness were made by boring with a soil auger and extensions through the Wisconsin (Peorian) loess into the underlying material. three principal kinds of which occur in southwestern Iowa. In most of the

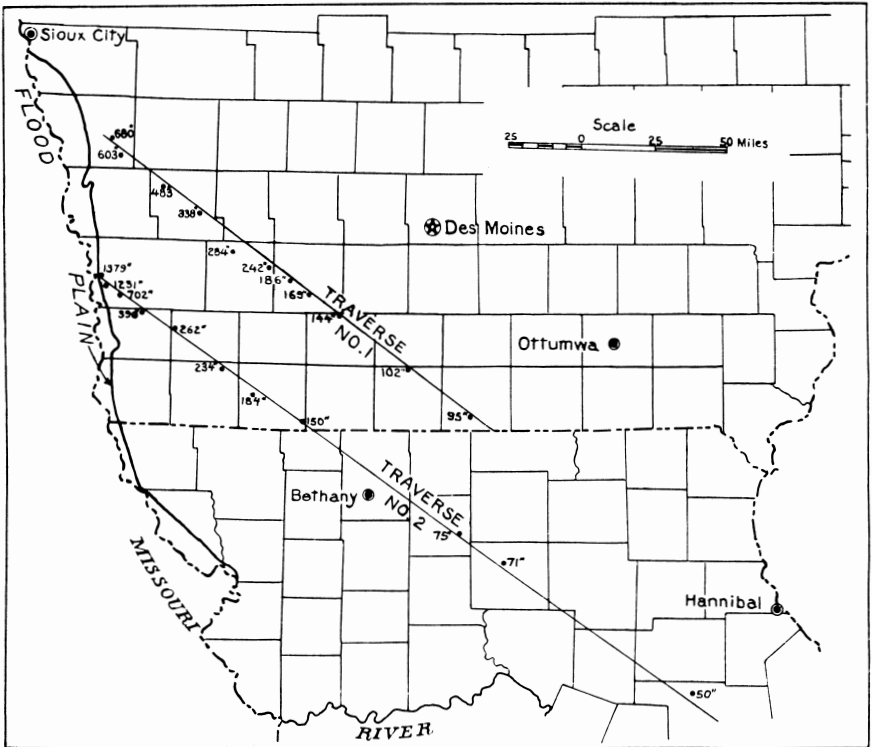


Fig. 1. Map showing approximate locations and loess depths along Traverses no. 1 and 2 in Iowa and Missouri.

area, the loess is underlain by fine-textured glacial till, and the contact between the loess and this till is commonly sharp. On the broad divides in south-central Iowa, the loess is commonly underlain by a soil profile formed from the till (Simonson, 1941), and the contact is seldom as sharp. Apparently, some mixing of the loess and the A horizon of the older soil took place during the early stages of loess deposition. Near the traverse origins, a fine-textured reddish-brown loess (Loveland) underlies the thicker Wisconsin loess in places. Measurements of thickness of Loveland loess were not made because the formation does not occur uniformly and is of limited importance as soil parent material in Iowa.

The actual sites for measurement were chosen to provide data on maximum loess thickness and to space the borings along the traverses. In the hilly to rolling landscapes near the loess bluffs which border the flood plain most of the borings were made in deep road cuts. The loess deposits commonly reach maximum thicknesses of more than 300 inches in a belt ranging from 3 to 30 miles in width east of the Missouri River flood plain. A hand auger does not function effectively to depths much greater than 300 inches, and borings were therefore not feasible on the crests in higher divides unless road cuts were available. In the dominantly hilly to rolling uplands the estimates

of loess thickness are certain to be conservative and may be appreciably low. Some loess has doubtless been removed by erosion during and after the period of deposition. Beyond a distance of approximately 40 miles southeast from the bluff, the uplands include some high-lying tabular divides. These flat upland divides, especially common in south-central Iowa, were chosen as sites for measuring loess thickness. On these divides there has been little opportunity for removal of loess by erosion and it is believed that the measurements of maximum thickness have a high degree of accuracy.

DESCRIBING LOESS THICKNESS

In southwestern Iowa the maximum loess thickness on uneroded sites ranges from as much as 1380 inches near Council Bluffs in Pottawattamie County to 95 inches in Wayne County. The data on loess depths together with the locations at which borings were made are given in table 1. Included in table 1 are three measurements of loess thickness at points in

TABLE 1
Depths of Loess in Southwestern Iowa and Adjacent Missouri

Distance from Source in Miles	Depth of Loess in Inches	Location by Legal Subdivision				County	State
		Subdivision*	Township North	Range West			
<i>Traverse no. 1</i>							
10.3	680	NW NE NE 16	83	43	Monona	Iowa	
20.5	603	SW SE SW 14	82	42	Monona	Iowa	
33.0	483	NW NE NE 27	81	40	Shelby	Iowa	
55.0	338	NE NE 21	79	37	Shelby	Iowa	
65.5	284	NE NW NE 12	77	37	Cass	Iowa	
83.5	242	SE SW SE 14	76	34	Cass	Iowa	
88.0	186	NW NE 18	75	33	Adair	Iowa	
98.5	169	SE SE NE 3	74	32	Adair	Iowa	
117.5	144	NW 14	73	30	Union	Iowa	
155.0	102	SE SE 8	69	25	Decatur	Iowa	
167.5	95	NW NW SE 1	67	23	Wayne	Iowa	
<i>Traverse no. 2</i>							
0.1	1379	SW 11	75	44	Pottawattamie	Iowa	
1.6	1231	Council Bluffs	75	44	Pottawattamie	Iowa	
6.9	682	SW SE NE 2	74	43	Pottawattamie	Iowa	
16.4	390	SW NW NW 4	73	41	Mills	Iowa	
30.6	262	NE SE NW 1	71	40	Montgomery	Iowa	
46.8	234	SE SE SW 4	70	37	Page	Iowa	
66.4	184	Middle 20	68	35	Taylor	Iowa	
86.7	150	NW SW SW 33	67	32	Taylor	Iowa	
157.0	75	Sec. 26	61	24	Grundy	Mo.**	
175.0	71	Sec. 5	57	22	Livingstone	Mo.**	
257.0	50	Sec. 10	51	11	Boone	Mo.**	

* Legal subdivisions within sections are abbreviated by omission of the figure "1/4."
For example, a full description would read NW¹/₄ NE¹/₄ NE¹/₄ Sec. 16.

** Personal communication from G. D. Smith and W. D. Shrader.

Missouri which represent an extension of Traverse no. 2. These three sites lie 150 to 260 miles from the point of origin of the traverse. Some question may be raised about the inclusion of the three measurements in Missouri. The

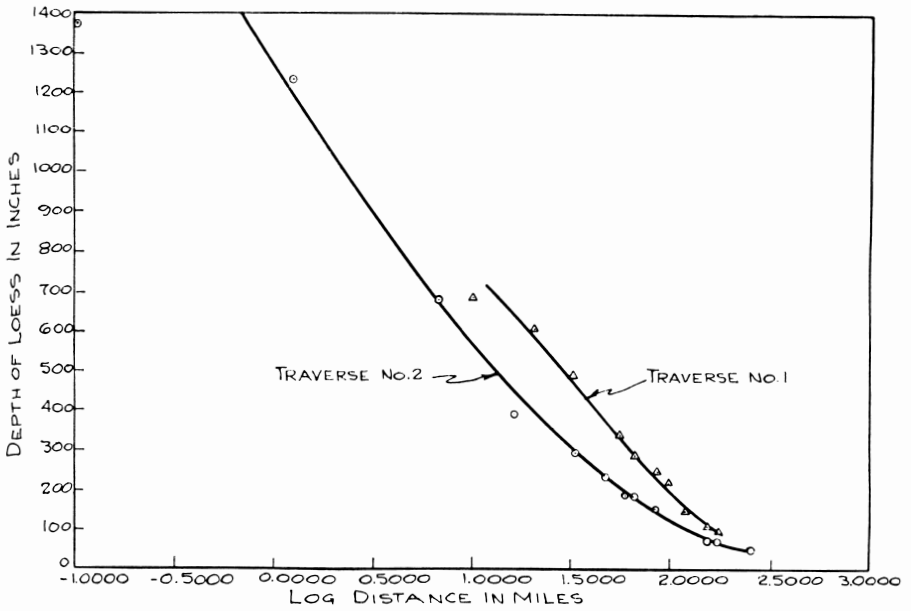


Fig. 2. Graph showing relationship of maximum depth of loess to the logarithm (to base 10) of distance from the source.

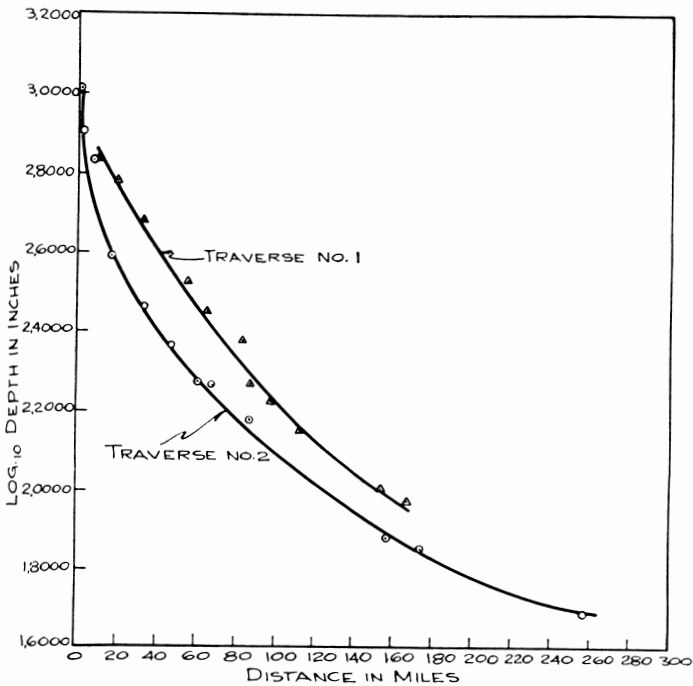


Fig. 3. Graph showing relationship of the logarithm (to base 10) of the maximum depth of loess to the distance from source.

validity of extending the curve on the basis of those measurements cannot be fully tested until more measurements are available. Examinations of loess thicknesses in south-central Iowa and northern Missouri in the course of field trips, however, indicate that maximum loess thickness can be predicted with a high degree of accuracy from the curves along the full extent of Traverses no. 1 and 2. Data for both traverses indicate the gradual thinning of the loess with increasing distance from the Missouri River.

The data given in table 1 are shown graphically in figures 2 and 3. In figure 2, the depth of loess in inches is represented on the "y" axis, and the logarithm to the base 10 of the distance in miles from the bluff is given along the "x" axis. This method for plotting the data follows that of Smith (1942). In figure 3, the logarithm to the base 10 of loess depth in inches is plotted along the "y" axis, whereas the distance in miles from the bluff is plotted on the "x" axis. This follows the method used by Krumbein (1937). The relationships between loess thickness and distance from source, as indicated in figures 2 and 3, are essentially similar to those demonstrated earlier by Krumbein and Smith. The loess becomes thinner with increasing distance from source according to an exponential function. The curve for Traverse no. 2 in figure 2 also shows a discontinuity or break comparable to that observed earlier by Smith (1942). A similar break is not evident in the curve for Traverse no. 1, but the observations nearest the bluff are 10 miles from the edge of the flood plain. A discontinuity in the curve could occur between that point and the bluff itself.

The traverses made in Iowa were longer than those possible in Illinois (Smith, 1942; Krumbein, 1937), and they could be extended into Missouri without danger of encountering important secondary sources of loess. The traverses made by Krumbein (1937) and Smith (1942) have maximum lengths of 13 and 70 miles respectively. Traverse no. 1 was 170 miles long in Iowa, whereas traverse no. 2 was 260 miles long when extended to cover the observations in Missouri. These observations over longer distances indicate that the slope of the loess distribution curve changes as the distance increases.

When the distribution curve for loess is extended beyond points that are 100 miles from the source, the slope begins to change and the curve becomes asymptotic to the "x" axis. This trend is evident in both figures but is more prominent in figure 3. The rate of thinning decreases sharply 170 to 200 miles from the loess source. Thus, the curves in figures 2 and 3 indicate that equations already developed to describe loess distribution are valid within certain geographic limits. They cannot be extended with confidence to cover the entire distance over which loess may be deposited from a given source. Although this study indicates that previous equations are not fully adequate to describe loess distribution, the data obtained do not seem adequate in themselves for the development of new equations. The curves presented in either figure 2 or figure 3 can be used to estimate maximum loess thickness with a high degree of accuracy in southwestern Iowa and north-central Missouri. Moreover, the studies of soils (Hutton, 1950; Ulrich, 1950) have indicated that there is a close relationship between the nature of the soils formed from loess and the maximum thicknesses of the deposits in southwestern and south-central Iowa.

The shape of the distribution curve for loess in south-central Iowa and north-central Missouri is also of interest because it suggests that loess may be deposited in quantity much further from the source than has been commonly supposed. This emphasizes the need for further investigation of silty surface mantles which have not been considered loess in the past. It does not demonstrate that all silty mantles are loess. It does, however, indicate that the study of silty mantles ought to include as one working hypothesis the possible origin of the sediments as loess. For example, occasional areas of Dewey and Etowah soils in Franklin County, Tennessee are far more silty in the upper horizons than is common. The Dewey soils are normally derived from limestone which is relatively low in chert and other impurities, whereas Etowah soils have been formed from alluvial material in stream terraces. The topographical position of the soils in the present landscape would permit them to have been covered by a shallow mantle of loess in the past, but it is hard to imagine conditions which would allow deposition of silty sediments by other means. Yet the area is far removed from important loess sources such as the Mississippi and Ohio Rivers. The fact that loess has been carried great distances across southern Iowa and north-central Missouri suggests re-examination of the thin silty mantles in areas such as south-central Tennessee and northern Alabama. Similar problems may exist in other areas. These surface mantles are of importance to the formation and classification of soils even when they comprise but part of the soil profile. More effective consideration can be given to such mantles when their nature and origin is understood.

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