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Property Variations in the Wisconsin Loess of East-Central Iowa

By C. A. Lyon, R. L. Handy and D. T. Davidson

Introduction

As part of a long-range project to investigate the stabilization of loess and glacial till for low cost road construction, property studies of the Wisconsin loess of east-central Iowa were carried on at the Engineering Experiment Station of Iowa State College during the year 1952-1953. Previous work [1,2,3,4] 1950-1952, dealt with the properties of the Wisconsin loess of southwestern Iowa; stabilization studies are now under way with the loess from that area. In east-central Iowa, the loess was studied with a two-fold objective: to determine the variations in properties pertinent to stabilization, and to compare these properties with those of the southwestern Iowa loess. This paper reports only on the property variations.

Sampling

In east-central Iowa, Wisconsin-Age loess is the most abundant surficial material. The east-central Iowa area studied is shown in Figure 1; it is bounded on the west by the Cary drift border*, and on the north by the Iowan and Tazewell drift borders.*

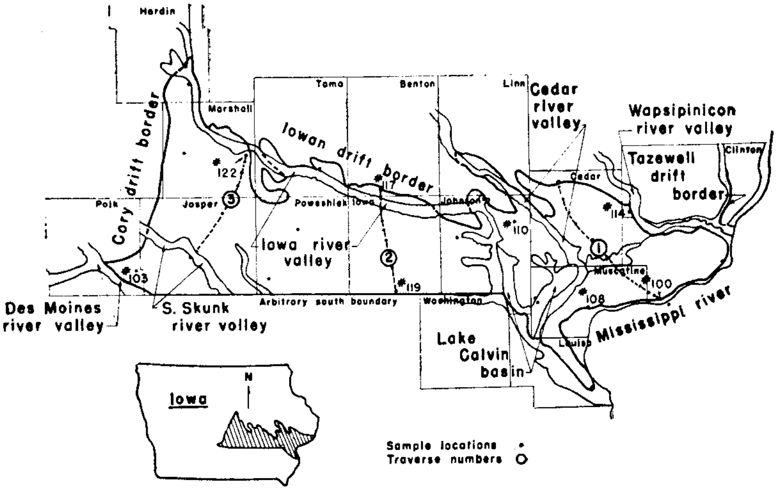

Fig. 1 Locations of samples and traverses in the east-central Iowa loess area.

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*Iowa Geological Survey, 1952.

Initial samples were taken from twenty-three loess sections exposed in road cuts or quarries. Locations of these sections are shown in Figure 2. Samples were taken to show the maximum soil profile development in each section, and to show any vertical variations in the loess. Sampling was done at hilltop positions, since the loess there is quite often thicker and less disturbed. A practical reason for sampling at hilltops is related to the present-day need for level roads, which requires that the hills be cut down, and the material used to fill in the valleys. Hilltop materials are therefore of importance for road construction.

In addition to the twenty-three sections studied in detail, single samples were taken from the C horizon at a constant depth of about 7½ feet along three traverses (Figure 1). The traverse samples were taken to show more precisely the areal variations in the loess. Since the data previously obtained from the twenty-three sections showed a more rapid change in properties near the Iowan drift border and near the Mississippi River, traverse samples were spaced more closely at these locations.

OCCURRENCE AND THICKNESS

In east-central Iowa, the loess occurs as a rather uniform mantle over erosional hills of older deposits (Plate 1A). Most commonly it overlies Kansan till upon which a soil profile has developed (i.e., gumbotil and ferreto). In the eastern part of the area, the loess occurs over Illinoian till and gumbotil (Figure 2). In some areas, the loess overlies alluvial or outwash deposits.

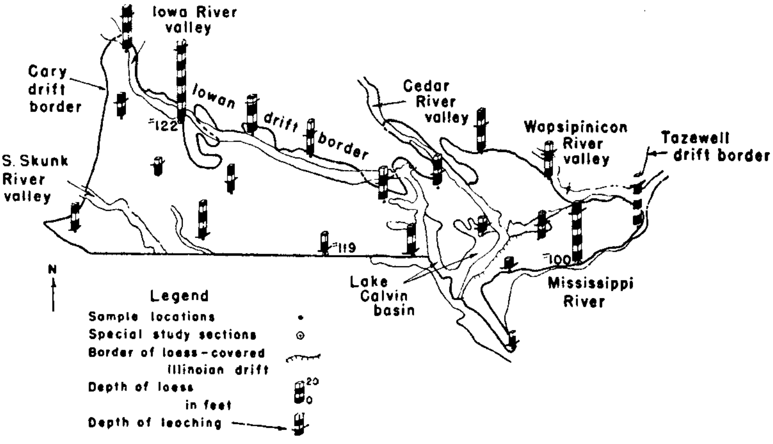

Fig. 2 Depth of Wisconsin loess at sampling locations in east-central Iowa

As shown in Figure 2, the loess is thickest along the Iowan drift border and along some of the major streams. Along the Mississippi River north of Muscatine, the Wisconsin loess in the two sections measured averages about 35 feet thick. Near the Iowan drift border a maximum thickness of about 50 feet was measured north of Le Grand (Section 122). Other thicknesses measured near the Iowan drift border average about 25 feet. Along the arbitrary south boundary of the area, the thickness measurements average about 15 feet, and a section adjacent to the Skunk River measured 23 feet. South of Muscatine, depth measurements indicate no increase in loess thickness adjacent to the Mississippi River floodplain, but show only a continuation of the trend of southeasterly thinning away from the Iowan drift border.

It is interesting to speculate upon this absence of thick loess where it should be thickest, adjacent to a floodplain source, especially since here the floodplain is wider and was presumably a better source area.* An explanation may be that the Mississippi flows almost west above Muscatine, and here the deep loess is present north of the river in Iowa. A prevailing northwest wind might occasionally blow up-river from the west and deposit material on the north side of the river. South of Muscatine, the river valley runs south, so a major change in wind direction would be necessary for material to be carried to the west into Iowa.

Upland occurrences of fine sands were noted near the Iowan drift border and elsewhere in the east-central Iowa area. Sand deposits near the Iowan drift border are currently the subject of a Soil Research Laboratory study.

Studies were made of a section in the area of glacial Lake Calvin (Figure 2). The section from which soil samples were taken is located west of Nichols on the intermediate terrace mapped by Schoewe[6]. Since Lake Calvin is believed to have been drained prior to Wisconsin time, some Wisconsin loess would be expected to occur on the lake plain. The section sampled consists of about 17 feet of loess-like silt grading downward into fine sand. Schoewe[6], p.151... reports brownish loess-like material averages about 4 feet thick in the Lake Calvin area exclusive of the present floodplains. However, Lake Calvin materials constitute a separate engineering problem because of a high water table. The high ground water level and poor drainage also have affected soil profile development.

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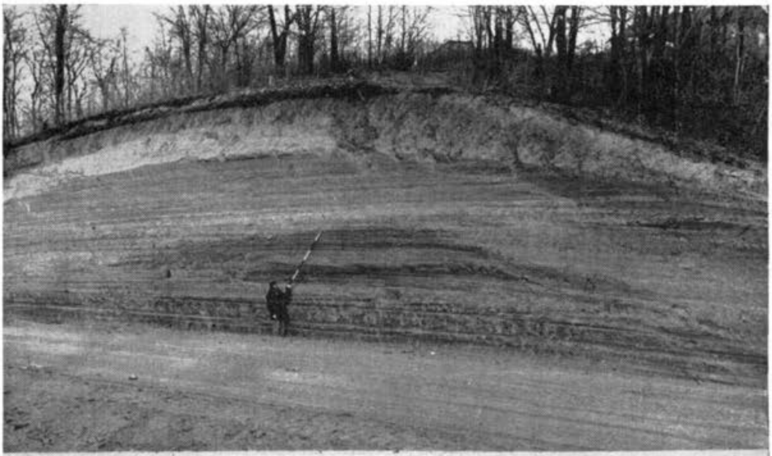
*Thick loess is present on the Illinois side of the river[5].

FIELD DESCRIPTION

Loess in east-central Iowa displays typical massive structure and commonly shows secondary lime concretions and iron concentrations, root tubules, etc. The more friable loess will stand in vertical cuts, as shown in Plate IB.



A. Wisconsin loess capping a hill in the dissected Illinoian drift plain adjacent to the Mississippi River. The location is at Le Claire, Iowa.

B. Sampling Section 100 in a quarry near Buffalo, Iowa. Studies indicate that adjacent to the Mississippi River floodplain the deep, friable loess is dolomitic and is not extensive in Iowa.

PLATE I

A faint pseudostratification sometimes may be observed in weathered cuts in the loess, as shown in Plate IIA. The stratification is not continuous and frequently is not horizontal, and pieces of the loess do not break along planes as do many alluvial silts. Such stratification has been described by Condra, Reed, and Gordon[7] as being due to modification of the loess by rain, puddling, and sheet wash during the time of deposition.

Layers and inter-fingerings of sand in the lower half of the loess were noted at a number of sampling locations. In many instances,

A. Pseudostratification in the loess at a sample location near the Wapsipinicon River. Such stratification is not common in the Wisconsin loess of east-central Iowa. Where present it is most noticeable on weathered cuts such as the one pictured.

B. Clay-rich bands in the lower B horizon. the location is the same as above. Fayette soil series.

PLATE II

a gray, gritty material under the loess appears to be part of the buried soil profile on the Kansan till.

In the section shown in Plate IIA, and in some other sections examined, banding was noticed in the transition from the B to the C horizon. The bands, shown in Plate IIB, are brownish in color, usually ½ to 2 inches in thickness, and are better cemented than the adjacent lighter-colored material. Differential thermal analyses indicate the bands to be primarily the result of clay concentrations.

Depths of leaching in the loess sections are shown in Figure 2. Along the Iowa River and near the Iowan drift border, the depth of leaching varies from 4½ to 10 feet; the lower values were observed in the northwestern part of the area. To the east, the deep loess adjacent to the Mississippi River floodplain is leached 7 or 8 feet. In the southeast part of the area, where the loess near the Mississippi is thin, the entire section is leached. In the remainder of the east-central Iowa area, leaching tends to be greater, and along the south border of the area, the sections are completely leached. A few of the calcareous loess sections contained basal leached zones, possibly equivalent to the Farmdale loess in Illinois. Loess of Loveland Age was not recognized in any of the sections.

Most of the loess-derived soils in the area studied are of the Tama, Muscatine, and Fayette soil series[10]. Profile development commonly extends to depths of 3 to 5 feet. The B horizon is in general 2 to 3 feet thick and shows a well-developed blocky structure. The transition into the C horizon is gradual, particularly in the more plastic loess, where the B horizon blocks increase in size and merge into the C horizon. In the shallower loess, the soil profile constitutes from one-third to one-half of the section.

The color of the loess is mainly a function of the oxidation condition. The loess is well oxidized and yellowish-brown* or light yellowish-brown in color except where oxidation has been restricted by ground water conditions. Ground water is usually encountered above the loess contact with underlying less permeable materials.

In the flat upland areas of undissected Kansan and Illinoian till plains, much of the loess is below the water table. Below the water table, the loess is usually gray or brownish-gray in color. Frequently there is an intermediate zone of mottling above the gray loess, probably due to seasonal fluctuations in the height of the water table. Occasionally, the basal loess below the water table is bluish in color and has a swampy odor. In Nebraska, the

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*Moist Munsell color.

bluish color has been related to stagnate ground water conditions[7,p.40].

Secondary deposits of calcium carbonate and iron and manganese compounds are common in the loess. Carbonate concretions up to one-half inch in diameter commonly occur in calcareous loess above an impermeable layer, and small spots of lime may be found higher in the section but below the leached zone. The iron and manganese compounds occur as small black, yellow-brown, or red-brown spots, stains, and concretions throughout the loess. Iron cemented concretions, which may be either hard or soft, occasionally grow to several inches in diameter and because of the color difference are most noticeable in the gray basal portion of the loess.

PARTICLE SIZE

Mechanical analyses were performed to show textural variations with depth in the twenty-three sections shown in Figure 2. The tests were made by methods outlined by Davidson and Chu[8].

Particle size variations in three loess sections are shown in Figure 3. The Quarry section (No. 122) is typical of deep loess near the Iowa River, the Buffalo section (No. 100) is typical of the rather

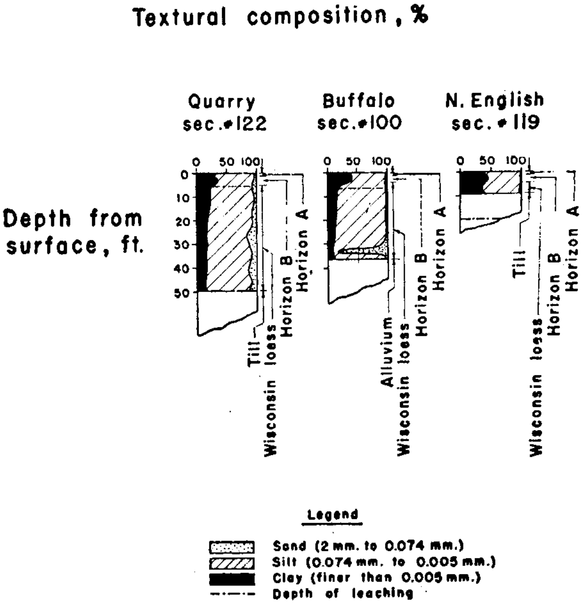

Fig. 3 Variation of textural composition with depth in three selected sections of Wisconsin loess.

limited deep loess on the Iowa side of the Mississippi River, and the North English section (No. 119) is typical of the shallow, plastic loess along the south boundary of the area.

Fine sand is common in the east-central Iowa loess, particularly in the deeper loess near the Iowan drift border and some major river valleys. Where abundant, the sand occurs in layers and thin lenses, and is usually more abundant in the lower parts of the sections. There is very little sand in the shallow, plastic loess in the south-central part of the area. Most of the sections show rather uniform clay contents below the influence of the B horizon, with slight increases in clay at the base of the loess. The sections in Figure 3 illustrate the gradual transition from the B to the C horizon.

Mechanical analyses of samples along the traverses shown in Figure 1 illustrate the textural variations in the area. These data, shown in Figure 4, represent C horizon samples taken usually at a depth of 7½ to 8 feet below the surface of the ground. The

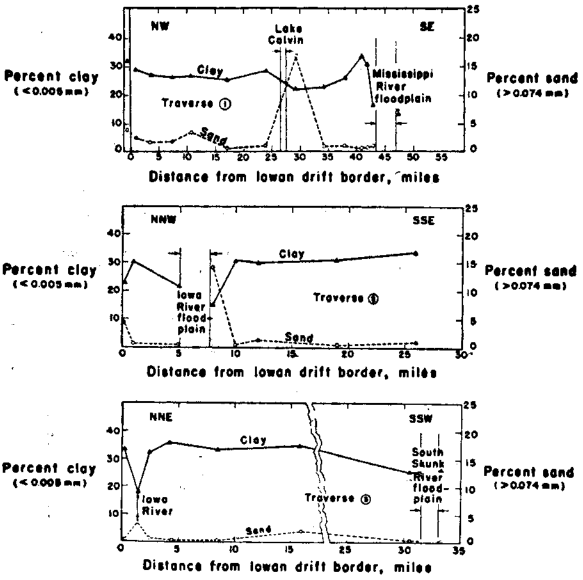

Fig. 4 Variation in clay and sand contents with distance from the Iowan drift border along traverses 1, 2, and 3.

percentages of sand in the loess show marked increases south of the Iowa River floodplain and southeast of the northeast arm of Lake Calvin. Along Traverse 2, the loess is sandy near the Iowan drift border. Traverse 1 includes a sample from thin loess on the Iowan drift; the sample was necessarily taken at a shallower depth, and may be influenced by soil profile development.

Clay percentages in the loess show sharp decreases near the Iowa River floodplain: The decrease is greater here than near the Iowan drift border. Traverse 2 shows these two separate influences. Along Traverse 3, decreases in clay are present in loess south of the Iowa River and near the South Skunk River floodplain. Small differences in clay contents in the traverse samples probably are not significant because of depth variations in the sections.

Along Traverse 1, the Lake Calvin influence appears to extend about 15 miles to the southeast, or almost to the Mississippi River floodplain. The peak clay content between Lake Calvin and the Mississippi River floodplain appears to be a continuation of the gradual rise in clay content away from the Iowan drift border. This peak content occurs within 2 or 3 miles of the Mississippi River floodplain. Closer to the floodplain, the clay content drops abruptly.

These data would indicate that the Iowa River floodplain was an important source area for the loess. However, this influence does not extend over 5 or 10 miles away from the river, indicating that a more distant area, such as the Iowan drift plain or outwash from the receding Iowan, may have contributed a major part of the loess. The direct influence of the *border* of the Iowan drift appears to be slight, and relationships previously ascribed to the drift border[9] are probably mainly due to the Iowa River source area. This is further illustrated by Traverse 1, where the Iowan drift border is not paralleled by the Iowa River, and no significant decrease in clay was found.

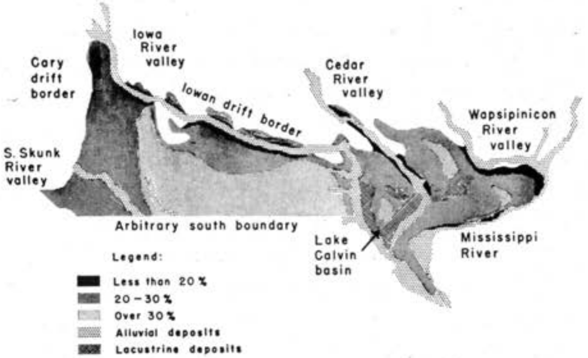

Fig. 5 Approximate areal variation in the clay content (<0.005mm) of the C horizon Wisconsin loess in east-central Iowa.

The decrease in clay contents near the northeast arm of Lake Calvin would indicate that this was a source area. While there is no major stream in this area now, the evidence suggests that it was a route for glacial outwash, possibly either Iowan or Tazewell or both.

The clay content data are summarized in Figure 5, which shows the areal variations in clay content in C horizon Wisconsin loess. The map is drawn from data from the sample traverses and sections, and is subject to revision. Present data are most limited in the Cedar and Wapsipinicon River areas.

Engineering Properties

Data in Table 1 are for three samples typical of the C horizon loess in the three sections shown in Figure 3. Complete particle-size accumulation curves for these three samples are shown in Figure 6. The sampling locations and depths are given in Table 2.

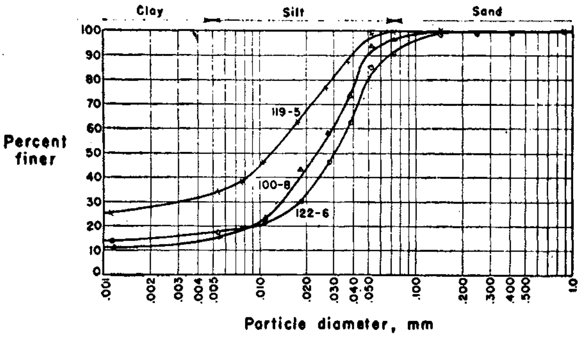

Fig. 6 Particle-size distribution curves for three selected east-central Iowa loess samples.

The plasticity index, which is the difference between the liquid limit and the plastic limit, is higher with higher clay contents; the shrinkage limit is lower with higher clay contents.* The Bureau of Public Roads engineering classification of soils is made with plasticity index, liquid limit, and particle-size data. Group A-4 includes friable, silty soils, and Group A-6 includes moderately plastic, clayey soils. The group index, indicated by a number in parenthesis, permits further evaluation within a group.

The capillary rise test is essentially a measurement of the maximum head of water a column of initially loose, wet soil will support before air breaks through. The data show trends similar to those found for southwestern Iowa loess. The trends are dis-

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*A low shrinkage limit indicates high shrinkage.

cussed by Handy, Davidson, and Chu[4]. In the Proctor density test, Sample 122-6 compacts to a higher density, probably because of the higher sand content and resulting less uniform gradation. This is also reflected in the higher bearing capacity of this soil, as measured by the California Bearing Ratio. The drop in bearing capacity after soaking is greatest for clayey Sample 119-5.

Table 1.
Engineering Properties of Three Selected C Horizon Loess Samples.

Engineering Properties		Sample No.			Test Method
		100-8[a]	122-6[b]	119-5[c]	
Liquid Limit, %		27.1	26.8	38.4	AASHO Method T89-49
Plastic Limit, %		19.8	17.6	17.2	AASHO Method T90-49
Plasticity Index		7.3	9.2	21.2	AASHO Method T91-49
Shrinkage Limit, %		20.6	18.9	17.4	AASHO Method T92-42
B. P. R. Engineering Classification		A-4 (8)	A-4 (8)	A-6 (13)	AASHO Method M145-49
Specific Gravity, 25° C		2.72	2.71	2.70	AASHO Method T100-38
Capillary Rise, In.		76	50	36	Essentially the same as the "Suggested Method of Test for Capillary Rise of Soil" submitted by Herman to ASTM[11].
Standard Proctor Density Test	Max. Dry Density lb./cu.ft.	110.6	113.2	110.3	AASHO Method T99-49
	Optimum Moisture Content, %	15.8	15.1	16.6	
California Bearing Ratio of Soil at Standard Proctor Density, %	At Optimum Moisture	18.4	27.6	13.1	Essentially the same as the "Suggested Method of Test For California Bearing Ratio of Soils" submitted by Corps of Engineers, U. S. Army to ASTM(11), except that specimens prepared are at maximum density and optimum moisture content determined by standard Proctor density tests.
	After 4-day Soaking	15.0	22.2	4.8	

[a]Representing friable loess adjacent to the Mississippi River floodplain.
[b]Representing friable loess near the Iowa River.
[c]Representing medium-textured loess in the south part of the east-central Iowa area.

Table 2 presents data which show some property variations through the soil and weathering profiles in a few of the loess sections sampled. The data show the pronounced effect of soil

Table 2.

Property Variations Through the Soil and Weathering Profiles of Some Wisconsin Loess Sections.

Sample No.	Section Location	Soil Series	Horizon	Depth of Sampling, Ft.	Plastic Limit, %	Liquid Limit, %	Plasticity Index %	B.P.R. Classification	
								Engineering	Textural
100–1	Scott County Buffalo Township	Muscatine	A	¼-¾	18.7	41.5	22.8	A–7–6(14)	Silty clay
100–2	(T-77N,R-2E) N½SW¼ Sec. 13		B	2-2½	17.4	50.4	33.0	A–7–6(18)	Silty clay
100–4	(Along Mississippi River)		C**	5½-6	21.2	30.9	9.7	A–4(8)	Silty loam
100–8			C*	25-25½	19.8	27.1	7.3	A–4(8)	Silty loam
103–1	Polk County Beaver Township	Tama	A	0-¾	23.3	43.7	20.4	A–7–6(13)	Silty clay
103–2	(T-79N,R-22W) SE¼SE¼ Sec. 35		B	2½-3	18.9	52.9	34.0	A–7–6(19)	Silty clay
103–5	(At SW corner of area)		C**	8-8½	19.7	34.6	14.9	A–6(10)	Silty clay
108–1	Muscatine County	Fayette	A	0-½	21.6	32.1	10.5	A–6(8)	Silty clay loam
108–2	Bloomington Township		B	2½-3	19.8	52.2	32.4	A–7–6(18)	Silty clay
108–4	(T-77N,R-2W) NE¼SE¼ Sec. 33 (Along Mississippi River)		C**	6-6½	18.2	35.6	17.4	A–6(11)	Silty clay loam
110–1	Johnson County Graham Township	Fayette	A	0-½	25.1	37.6	12.5	A–6(9)	Silty clay loam
110–2	(T-80N,R-5W) SE¼SW¼ Sec. 9		B	3-3½	17.1	49.9	32.8	A–7–6(14)	Silty clay
110–4	(In E. central part of area)		C**	7½-8	18.0	37.9	19.9	A–6(12)	Silty clay loam
110–6			C*	15½-16	19.5	30.8	11.3	A–6(8)	Silty clay loam

* C horizon, oxidized.
**C horizon, oxidized and leached.
Unmarked: C horizon, unoxidized and unleached.

Table 2—Continued.

Sample No.	Section Location	Soil Series	Horizon	Depth of Sampling, Ft.	Plastic Limit, %	Liquid Limit, %	Plastic Index %	B.P.R. Classification	
								Engineering	Textural
114–1	Clinton County Spring Rock Township (T-81N,R-1E) SW¼SW¼ Sec. 22 (Along Wapsipinicon River)	Fayette	A	0-½	21.2	33.1	11.9	A–6(8)	Silty clay loam
114–2			B	2-2½	18.8	49.3	30.5	A–7–6(18)	Silty clay
114–5			C**	7-7½	19.2	29.1	9.9	A–4(8)	Silty loam
114–7			C*	15-15½	19.2	26.6	7.4	A–4(8)	Silty loam
117–1	Benton County Leroy Township (T-82N,R-11W) NW¼SW¼ Sec. 34 (Along Iowan drift border)	Fayette?	A	0-½	23.2	34.1	10.9	A–6(8)	Silty clay loam
117–2			B	2-2½	17.9	47.7	29.8	A–7–6(17)	Silty clay
117–5			C**	7-7½	19.1	38.1	19.0	A–6(12)	Silty clay
117–7			C	15-15½	20.3	33.6	13.3	A–6(9)	Silty clay loam
119–1	Iowa County Fillmore Township (T-78N,R-10W) NE¼NW¼ Sec. 31 (Along S. edge of area)	Fayette	A	0-½	24.1	38.5	14.4	A–6(10)	Silty clay
119–2			B	1⅚-2⅓	19.4	52.9	33.5	A–7–6(19)	Silty clay
119–5			C**	6-6½	17.2	38.4	21.2	A–6(13)	Silty clay
122–1	Marshall County LeGrand Township (T-83N,R-17W) NE¼SE¼ Sec. 3 (Along Iowa River)	Tama	A	0-½	25.9	43.9	18.0	A–7–6(12)	Silty clay loam
122–2			B	1⅚-2⅓	17.1	44.0	26.9	A–7–6(16)	Silty clay
122–4			C*	6-6½	21.0	31.4	10.4	A–4(8)	Silty loam
122–6			C*	14-14½	17.6	26.8	9.2	A–4(8)	Silty loam
122–8			C*	24-24½	17.9	24.7	6.8	A–4(8)	Silty loam
122–10			C*	34-34½	19.5	26.4	6.9	A–4(8)	Silty loam

profile development on engineering properties. As seen in Figure 7, the plasticity index increases with increasing clay content regardless of soil horizon. Not only is this important from the standpoint of soil stabilization, but it suggests either a uniformity in clay mineral composition or perhaps a uniform clay mineral variation depending on clay content. In southwestern Iowa, the ratio of montmorillonite to illite increases with increasing clay content in the C horizon loess[3].

Also significant in Figure 7 is the fact that all of the A-4 samples are from the C horizon of sections near the floodplains of the Iowa, Wapsipinicon, or Mississippi rivers.

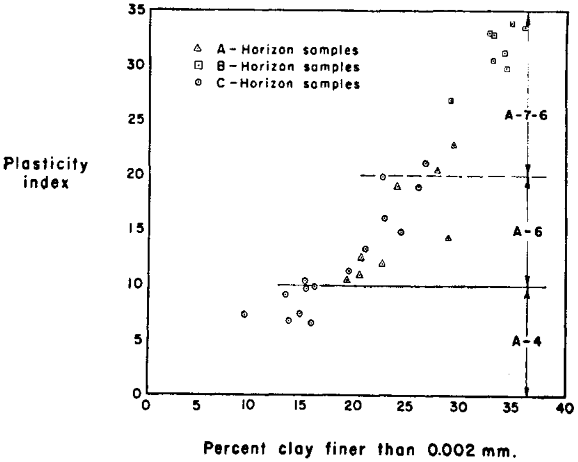

Fig. 7 Relationship between plasticity index and clay content. The B.P.R. classification for engineering use is shown to the right. Note that B horizon samples are grouped high in the A-7-6.

In-place densities and field moisture contents were measured at various depths in the three detailed study sections; the locations are numbered in Figure 2. Data are shown in Figure 8. The effect of soil profile development on in-place density and field moisture content is marked, and in general, both properties show increases in the B horizon. In the C horizon below the influence of soil profile development, the in-place density increases slightly with depth, from 80 or 85 lb. per cu. ft. to about 90 lb. per cu. ft. In Section 100, there is a large increase in density near the base of the loess section, suggesting a puddling influence from the water table. The clay content in the lower few feet of this section, as in most of the other loess sections, gradually increases towards the basal contact of the Wisconsin loess with underlying material. In many of the sections, immediately above the zone of clay increase, there is a zone low in clay, suggesting possible movement downward caused by a fluctuating water table.

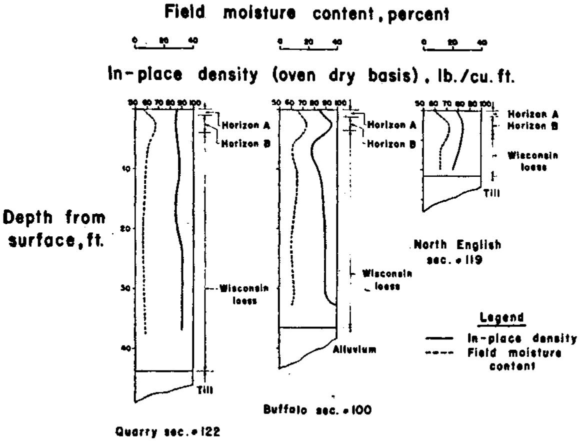

Fig. 8 Variation of in-place density and of field moisture content with depth in three selected sections of Wisconsin loess.

PETROGRAPHY

Methods

Detailed petrographic studies were made on three C horizon samples from the detailed study sections. Sample 100-8 represents the deep, friable, calcareous loess adjacent to the Mississippi River floodplain; 122-6 represents deep, friable calcareous loess near the Iowa River, and 119-5 represents shallow, moderately plastic, leached loess in the south-central part of the area. The samples were dispersed as for a mechanical analysis and separated into size fractions by elutriation[4]. Each size fraction down to 0.005 mm. was then separated into heavy and light mineral fractions and analyzed under a petrographic microscope. Clay minerals in the three loess samples have so far been studied by clay-mineral staining[12] and by differential thermal analysis of the whole loess. In addition, chemical properties of these and other loess samples were determined with chemical tests and differential thermal analysis.

Microscopic Studies

Results of microscopic studies of the sand and silt fractions are presented in Table 3. The dominant minerals in all samples are quartz and feldspar. Heavy mineral percentage exclusive of dolomite is about 4 to 5 percent. Carbonate percentages vary from a trace in the leached sample (119-5) to over 20 percent in the Mississippi River sample (100-8). The latter includes at least 5.3 percent dolomite determined on the basis of specific gravity. The proportion of dolomite in the carbonates is probably even higher than indicated, since the calcite-dolomite separation at specific gravity 2.89 favors calcite.

Table 3.

Mineralogical Composition of Three Loess Samples
(All Percentages are by Volume of the Solids in the Whole Sample)

MINERAL COMPOSITION	100-8	122-6	119-5
WHOLE LOESS, TOTALS			
Quartz	45.2	49.4	50.3
Feldspar	16.6	17.1	12.0
Carbonate	20.3	12.8	0.3
Heavy Minerals[a]	4.6	4.4	5.1
Others	1.3	0.5	0.3
Clay[b], <0.005 mm.	12.0	15.8	32.0
LIGHT FRACTION			
Undifferentiated quartz	41.3	46.0	46.2
Iron-oxide coated quartz	1.7	1.6	1.5
Clay-coated quartz	2.2	1.8	2.6
Undifferentiated feldspar	14.7	13.9	10.5
Plagioclase	0.1	Tr	......
Microcline	0.1	......	......
Altered Feldspar	1.7	3.2	1.5
Calcite	15.0	11.7	0.3
Muscovite	0.4	......	0.4
Clay aggregates and rock fragments	0.4	0.3	Tr
Glauconite	0.2	0.2	Tr
HEAVY FRACTION			
Dolomite	5.3	1.1	......
Amphibole	0.7	1.1	1.0
Pyroxene	0.2	0.3	0.2
Iron-oxides	2.1	2.2	3.0
Biotite and muscovite	0.3	0.2	0.5
Topaz	0.4	0.2	0.2
Tourmaline	0.2	0.2	Tr
Epidote	0.4	0.2	Tr
Kyanite	Tr	Tr	0.2
Others	0.3	Tr	Tr

[a] Dolomite is included in the carbonate percentage.
[b] This material not analyzed microscopically.

In the three samples quartz increases and feldspar tends to decrease with increasing clay content. Similar trends in the Wisconsin loess of southwestern Iowa are believed due to greater weathering in the high-clay-content loess[3].

Shapes of individual mineral grains may be expressed as sphericity, a perfect sphere having a sphericity of 1.0. The average sphericity of grains in each of the three samples is 0.76. The same value for sphericity was measured in the loess of southwestern Iowa[4]. The sharpness of the grain corners, which is measured independent of sphericity, averages between angular to subangular.

Clay coatings and iron-oxide stains are common on the loess grains. Frosting and pitting of grain surfaces was also commonly noted.

Clay Minerals

Clay-mineral studies of the east-central Iowa loess are only partially completed. Staining tests of minus 0.005 mm. clay indicated montmorillonite in the three samples. Differential thermal curves for the three whole loess samples are shown in Figure 9. The clay-mineral reactions are very similar to those found in southwestern Iowa loess, where the minerals are identified as montmorillonite and illite[3].

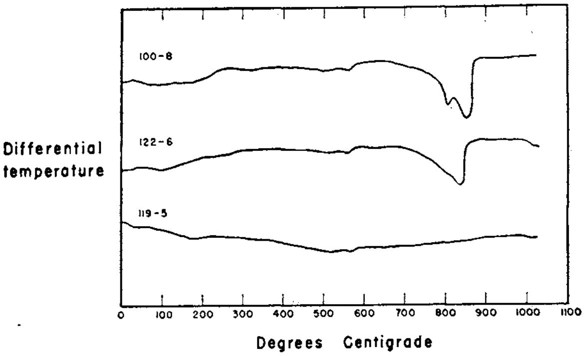

Fig. 9 Thermal curves of three selected whole loess samples.

Chemical Tests

Table 4 presents chemical data for some of the samples in a few loess sections sampled. The sampling depths and locations of the sections are given in Table 3. The three samples analyzed petrographically were studied in somewhat more detail, and these chemical data are also included in Table 4. In these three samples, soluble chlorides and sulfates were found to be absent. The cation exchange capacity increases with increasing clay content; the pH is lowered by leaching.

Chemical tests through the soil profile indicate that for soil stabilization purposes, organic matter is very high in the A horizon

Table 4.
Chemical Data on Samples from Selected Loess Sections

Sample No.	Soil Horizon	Organic Matter %[a]	Total Ca^{++} & Mg^{++} Det. by leaching[b]	Ca^{++} & Mg^{++} Expressed as % $CaCo_3$[a]	pH	Free Iron, %[a]	Cat. Exch. Cap.[b]
100-1	A	1.2	28				
-2	B	0.3	23				
-4	C*	0.1	24				
-8	C	0.2	200	20.0	7.9	0.5	3.79
103-1	A	3.2	22				
-2	B	0.4	27				
-5	C	0.2	79	7.9			
108-1	A	2.1	23				
-2	B	0.4	23				
-4	C*	0.2	16				
110-1	A	2.9	17				
-2	B	0.3	25				
-4	C*	0.1	24				
-6	C	0.2	103	10.3			
114-1	A	2.1	17				
-2	B	0.5	23				
-5	C*	0.1	20				
-7	C	0.1	143	14.3			
117-1	A	2.4	14				
-2	B	0.4	30				
-5	C*	0.2	24				
-7	C	0.2	99	9.9			
119-1	A	4.6	17				
-2	B	0.7	24				
-5	C*	0.3	18		5.7	1.1	15.28
122-1	A	4.6	24				
-2	B	0.4	30				
-4	C	0.1	150	15.0			
-6	C	0.1	131	13.1	8.0	0.4	4.28
-8	C	0.1	77	7.7			
-10	C	0.1	68	6.8			

[a]Percent of oven-dry weight of whole soil sample.
[b]Expressed as m.e. per 100 gm. of oven-dry soil.
*C Horizon, leached.

and significant in the B horizon. From 2 to 4 percent is usually present in the A horizon and, in some cases, over 0.5 percent was found in the B horizon. In the C horizon the organic matter content is low and rather uniform. In stabilization work, the effect of organic matter depends also upon its reactivity, so the values given may not be true indications of engineering behavior.

In Table 4 are shown calcium and magnesium ion contents determined by leaching the samples with 1.5 N. HCl and titrating with versenate. For A and B horizon samples and leached C horizon samples, the values are probably due to Ca and Mg cations from the exchange sites of the organic matter and clay minerals. High Ca-Mg contents in the unleached C horizon samples are mainly due to the presence of carbonates, and these calculated as calcium carbonate are shown in Table 4. The carbonate contents determined in this way correlate closely with those from microscopic examination. The highest carbonate contents were measured in C horizon samples near the Iowa, Wapsipinicon, or Mississippi Rivers.

Carbonates are indicated more specifically on differential thermal curves, and dolomite may be differentiated from calcite. The top curve in Figure 11 is for Sample 100-8 without pretreatment. The large peak at about 850° C. indicates the final decomposition of calcium carbonate, whereas the smaller peak at about 800°C. indicates the breakdown of magnesium carbonate*. Microscopic analysis of this sample also revealed at least 5 percent dolomite. Since north of sample location 100, the Mississippi River cuts through large amounts of dolomitic rocks, this is evidence that the river and its floodplain were probably the source for the small area of deep, friable loess on the Iowa side of the river. Considerable dolomite has been reported in the loess of Illinois[13], and during a recent southern trip, samples of Wisconsin loess were collected at 13 locations down the Mississippi River Valley from Illinois to south of Natchez, Mississippi. The locations of the Iowa and some of the Illinois samples are shown in Figure 10. Other sampling locations are east of the lower Mississippi River floodplain. The thermal curves in Figure 11, representing samples from locations in Figure 10, indicate the presence of dolomite in the loess as far south as Mozier, Illinois. Dolomite was also indicated in Wisconsin loess samples from the following locations: south of East St. Louis near Dupo, Illinois; in northwest Tennessee near Tiptonville; in northwest Mississippi near Eudora; east of Greenwood, Mississippi; and south of Vicksburg, Mississippi, near the Big Black River. The dolomite thermal reactions in these samples are about the same as in the sample from Mozier, Illinois, shown in Figure 11. Exceptions are the Eudora and Big Black River samples, which gave very strong dolomite reactions. Samples from three locations in the vicinity of Natchez, Mississippi, show only traces of dolomite. These and other reactions shown by the thermal curves of the 13 samples indicate a similarity in composition and therefore a possible similarity in stabilization behavior.

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*Since the mineral dolomite is $CaMg(CO_3)_2$, part of the large reaction at 850°C. is due to the calcium carbonate in this mineral.

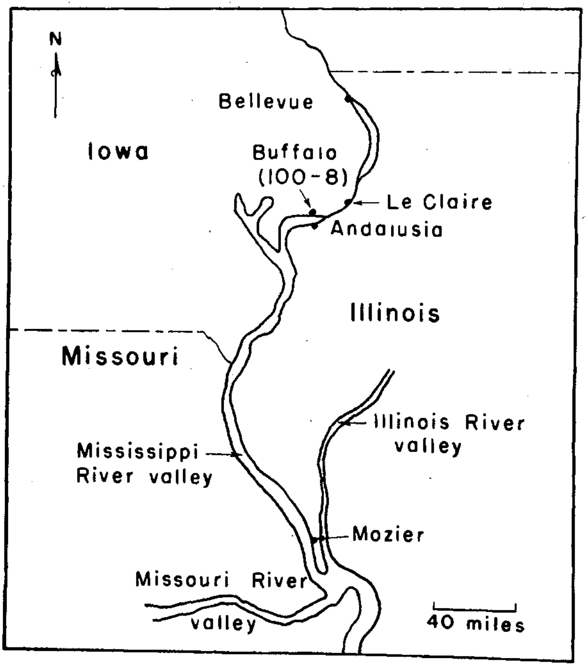

Fig. 10 Sketch map showing locations of samples used for the thermal curves in Figure 11.

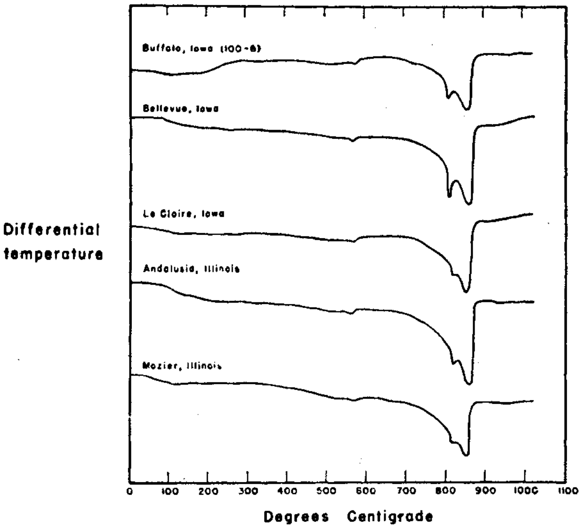

Fig. 11 Thermal curves of loess samples taken within one-half mile of the Mississippi River floodplain.

CONCLUSIONS

Some of the conclusions drawn from this study are as follows:

1. Particle-size data along two traverses indicate a more pronounced relationship of deep, friable loess to the Iowa River than to the Iowan drift border.

2. Deep, friable loess near the Mississippi floodplain is of very limited extent on the Iowa side of the river, and contains appreciable amounts of dolomite. The dolomite nature of this loess makes it unique from other loess studied in east-central Iowa and southwestern Iowa. Dolomite is present in Wisconsin loess near the Mississippi River floodplain as far south as Vicksburg, Mississippi.

3. Engineering properties of the loess depend mainly on clay content. Most of the C horizon loess in east-central Iowa classifies as A-6 by the Bureau of Public Roads system. The deep loess which usually occurs near the major river valleys, commonly classifies as A-4.

4. The influence of soil profile development commonly extends to depths of over 5 feet in the loess. The B horizon material, which constitutes a major portion of the soil profile, usually classifies as A-7-6.

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