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STRATIGRAPHY AND MINERALOGY OF THE WISCONSINAN LOESSES OF ILLINOIS

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ABSTRACT

Loess deposits of Wisconsinan age cover more than three-fourths of Illinois and are important as ceramic raw materials, as parent materials of soil, in construction, and in the study of ground-water geology. This report contains the results of analyses by X-ray diffraction, petrographic microscopy, or wet chemistry of 583 samples of loess and related materials. The clay mineral and heavy mineral assemblages of the several stratigraphic units are significantly different and are characteristic of the units. The differences in mineral content also indicate from which major outwash-carrying valleys the several loesses originated and relate the loesses to the up-valley glaciers that provided the outwash. The striking decrease from west to east (Mississippi-Illinois Valley to Ohio-Wabash Valley) in the relative abundance of montmorillonite is consistent with the changes in the mineralogy of the tills.

INTRODUCTION

Loess of Wisconsinan age covers more than three-fourths of Illinois (Smith, 1942, fig. 3; Leighton and Willman, 1950, fig. 4). It ranges from a thin film to more than 50 feet thick and in much of the region it directly overlies glacial drift. Loess and the associated glacial drift compose the prime parent materials of Illinois soils, they constitute a widespread ceramic raw material, they exert a significant control on our ground-water supplies, and they are an important factor in the majority of the construction projects in the state. An adequate knowledge of the stratigraphy and mineral composition of these deposits obviously is needed. The State Geological Survey has been making a mineralogical analysis of these deposits, primarily of the clay-, silt-, and sand-size fractions that volumetrically compose most of their bulk. The results of these studies are reported in two Circulars—this Circular describing the studies of the loesses and outwash, and a subsequent one that will report data from the glacial tills.

For many years the origin and stratigraphy of the loess deposits of the Upper Mississippi Valley region have been subjects of interest (Udden, 1894, 1898; Chamberlin, 1897; Leverett, 1899; Savage, 1915; Leighton, 1917, 1931; Smith, 1942; Kay and Graham, 1943; Leighton and Willman, 1950; Horberg, 1953, 1956; Frye and Willman, 1960; Leonard and Frye, 1960), but little attention has been given to the mineralogy of the deposits. The present study is based on a representative sampling of loesses, tills, and outwash deposits throughout Illinois. The samples were studied by X-ray analyses of the less than 2-micron fraction, by microscopic determination of the light and the heavy mineral fractions within the very fine and fine sand, using methods previously used (Frye, Willman, and Glass, 1960), and by chemical analyses of the gross sample. The locations and stratigraphic positions of the loess samples used, results of X-ray analyses, light and heavy mineral determinations, and chemical analyses are given in tables 1 through 6 at the end of this report.

The X-ray analyses were made by Glass, the heavy mineral preparation and counts were made largely by Constantine Manos, the light mineral counts were made by James Bloom, and the chemical analyses were made by L. D. McVicker. We express our thanks to George E. Ekblaw and Paul R. Shaffer for helpful suggestions during the progress of the work. The radiocarbon dates used in this report were determined in the Washington laboratories of the United States Geological Survey.

STRATIGRAPHY

The classification of the Wisconsinan Stage and the regional stratigraphy and molluscan paleontology of the loesses in Illinois have been described (Frye and Willman, 1960; Leonard and Frye, 1960). Details of the loess stratigraphy are given in the 15 measured geologic sections published in the two earlier Circulars, in the 15 additional sections included with this report, and by the 29 graphic sections shown on plate 1.

The time-stratigraphic units recognized in the Wisconsinan Stage of Illinois include the Altonian Substage (60,000± to 28,000 radiocarbon years B.P.), the Farmdalian Substage (28,000 to 22,000 B.P.), the Woodfordian Substage (22,000 to 12,500 B.P.), the Twocreekan Substage (12,500 to 11,000 B.P.), and the Valderan Substage (11,000 to 5,000 B.P.).

Deposits of Altonian age recently have been classified in Ontario by Dreimanis (1960, 1961; also, deVries and Dreimanis, 1960) into the Dunwich Drift (at the base), the Port Talbot Interstadial bed, and the Southwold Drift. The Southwold Drift underlies Dreimanis' Plum Point Interstadial beds, which are dated within the time span of the Farmdalian Substage of the Illinois classification. Subdivisions of the Roxana Silt in Illinois may be equivalent to Dreimanis' three units (fig. 1), but, because of the lack of glacial till equivalent to the Dunwich and the lack of finite radiocarbon dates from Illinois older than the time span represented by the Southwold Drift of Ontario, the term Altonian Substage is retained for the entire Roxana sequence.

Thick, calcareous, fossiliferous loess occurs in the valley walls of the Mississippi and Illinois Valleys, but away from these valleys the loess becomes progressively thinner and finer grained (Smith, 1942), is leached, and is nonfossiliferous. Generally the loess deposits are significantly thicker along the east

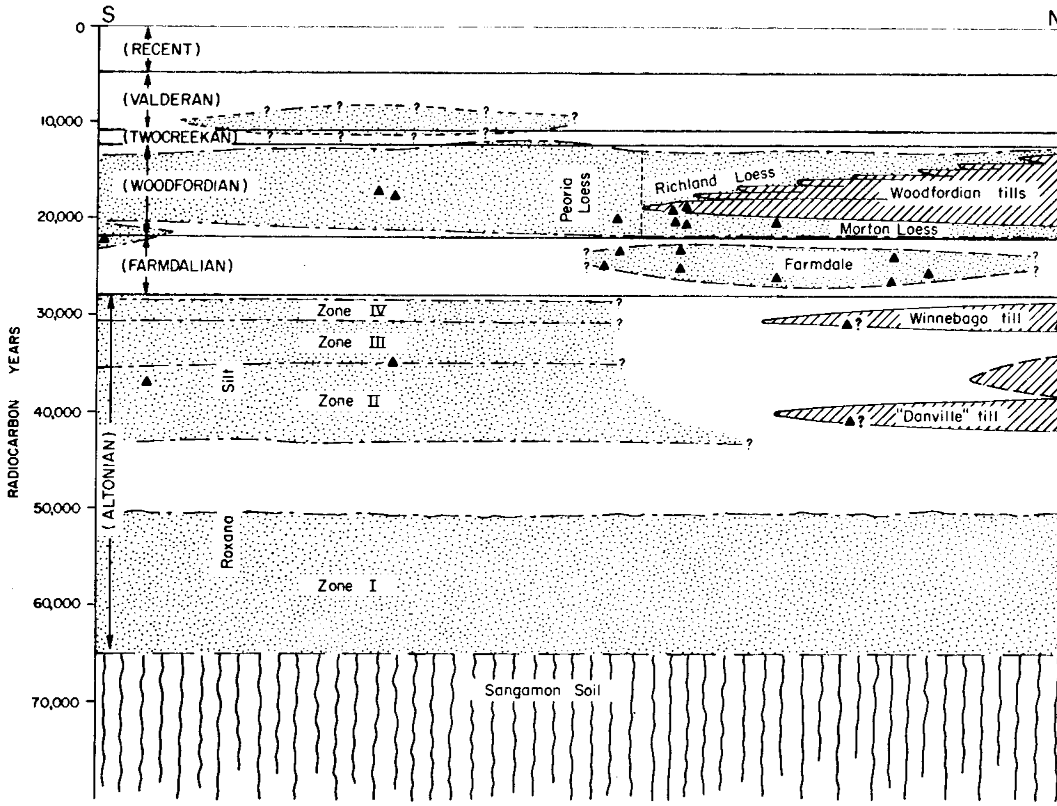

Fig. 1 — Time-space diagram of Wisconsinan deposits in Illinois. The time control by Carbon-14 dates is shown by solid triangles. All radiocarbon dates used were determined in the Washington laboratory of the U. S. Geological Survey. The diagram is arranged north-south, but it is a composite of an east-west belt the entire width of Illinois.

side of the valleys. The asymmetrical distribution of loess with respect to major valleys and the progressive decrease in thickness and grain size away from the valley bluffs generally is also true to the west of Illinois and into the Great Plains region (Kay and Graham, 1943; Frye and Leonard, 1951; Swineford and Frye, 1951) where the thickest loess is related to the valleys of the Missouri and Platte Rivers. Because of this persistent distribution pattern the stratigraphy of the loesses is based largely on the exposures in the major valley walls and the units established there are correlated into the regions of thin, leached loess.

The time and space relations of the loesses in Illinois to the substages of the Wisconsinan are shown by the schematic diagram in figure 1.

Silt Deposits of Altonian Age

The Roxana Silt was named and described by Frye and Willman (1960) from exposures in the east bluff of the Mississippi Valley below the mouths of the Illinois and Missouri Rivers, and includes all of the loess deposits of Altonian age. In its type region the Roxana Silt has been called Late Sangamon loess by Smith

(1942) and Farmdale Loess by Leighton and Willman (1950), but in 1960 Leighton (p. 536) correlated the Peoria Loess at the Roxana type section with the Bignell Loess, Zones II, III, and IV of the Roxana with the Peoria Loess, and Zone I of the Roxana with the Farmdale Loess. However, the radiocarbon date of 35,200 ± 1,000 (W-729) indicates that Zones II and III of the type Roxana are approximately 10,000 years older than type Farmdale, and the weathered Zone I at the base must be still older.

In the Illinois Valley south from Beardstown and along the Mississippi Valley below the mouth of the Illinois, the Roxana is thick and relatively well exposed. In this area distinct lithologic zones are present and can be traced for several hundred miles in a north-south direction. However, as the units are recognizable only where the Roxana is relatively thick and have not been traced into the Ohio, Wabash, or Upper Mississippi Valleys, they are not named as formal rock-stratigraphic units but will be described as informal lithologic zones.

Roxana Zone I is the basal unit of the Roxana. It is more variable and complex than any of the other zones and was weathered before Zone II was deposited. Everywhere that it has been examined it is leached and lacking in fossils, and it commonly rests on Sangamon Soil developed on tills as young as Buffalo Hart (youngest Illinoian). At a few places where Zone I consists largely of silt (e.g., Pleasant Grove Section), it has a weakly developed soil at the top. Commonly, at least the lower part of this zone consists of silty colluvium, with some sand and sparse small pebbles, that grades upward into massive silt. In some places it contains a fairly well sorted sand (e.g., Brown's Mound Section). It is generally brown to gray-tan. In places the basal part is gradational with the top of the underlying Sangamon Soil.

Locally Roxana Zone II overlies Zone I with a transition zone, but generally the contact is sharp (e.g., Cottonwood School Section). Zone II consists of massive, coarse loess that is light to dark pink to pink-tan. Where thick it is weakly dolomitic, and the upper part is fossiliferous. It grades into Zone III above, at some places through a transition of interbedded pink and gray-tan loess. Locally, lenses of eolian sand occur in the upper part.

Roxana Zone III is commonly transitional with the units both above and below. It consists of coarse, massive loess that is calcareous and fossiliferous where thick. It is distinguished by its gray to light yellow-tan color. At several places it contains discontinuous or lenticular bodies of gray to light tan sand, and at some places it is distinguished by abundant large limonite tubules.

Roxana Zone IV (uppermost) is massive, coarse, light pink-tan to gray-pink loess. At localities where Zone III is calcareous, Zone IV is at least weakly calcareous and sparsely fossiliferous in the lower part. However, in most places it is leached in the upper part and at the top has a weathered zone that distinctly separates it from the overlying Peoria Loess. No well developed B-zone has been observed, probably because the interval of weathering was relatively short and because all of the thick sections that have been studied are situated along the valley bluffs where truncation of the Roxana would have occurred during the weathering interval before deposition of the Peoria Loess.

Away from the belt along the Mississippi, Illinois, and Sangamon Valleys, the Roxana is thin and it generally is not possible to differentiate any zones within it. In the Upper Mississippi, Ohio, and Wabash Valleys, the Roxana consists of only a pink-tan to pink-brown loess that is locally sandy and generally grades downward into colluvium that rests on the Sangamon Soil. At only a few places (e.g., New Harmony Section) have any fossil snails been observed in the Roxana in these areas.

Deposits of Farmdalian Age

The name Farmdale was given by Leighton (1948) to the deposits previously called Late Sangamon. As used here the name Farmdale is restricted to the silt and peat deposits extensively exposed in the type area and dated by numerous radiocarbon dates (pl. 1, fig. 1). The type area of the Farmdale is used as the reference area for the Farmdalian Substage in Illinois. Leighton (1960) recently has applied the name Farm Creek to the peat and wood-bearing silts that have been called Farmdale and are overlain by the Morton ("Iowan") Loess. He reapplied the name Farmdale to some of the older silts, included here within the Roxana, and to the pre-Farmdalian glacial interval.

The Farmdale deposits contain bedded and laminated silt, massive silt, sandy silt, organic-rich silt, and silty organic muck or peat. In color the deposits range from black through various shades of brown and gray-brown to purple. Although generally noncalcareous and nonfossiliferous, at a few places they contain fossil snail shells (Leonard and Frye, 1960).

In some sections (e.g., Richland Creek; Danvers) logs with a maximum diameter up to 3 to 4 inches occur within the Farmdale deposits, but at many places its organic content is merely a humus stain. At the Wedron Section (Leonard and Frye, 1960) the Farmdale includes lacustrine silts that are calcareous, fossiliferous, and contain small flakes of wood.

Loess Deposits of Woodfordian Age

The loess of Woodfordian age is divided into three stratigraphic units distinguished on the basis of their relations to the glacial tills. All loess of this age beyond the limits of Woodfordian glaciation is classed as Peoria. Leverett (1898), p. 186) originally proposed the term Peorian to designate the interval of time between the top of the "Iowan" (Morton) Loess and the overlying Shelbyville till. The term Peorian was subsequently reapplied (Leighton, 1931) to all loess above the "Late Sangamon" (Farmdale Silt) beyond the limits of the Shelbyville Moraine. The Peoria (illustrated by many of the measured sections) is generally gray to yellow-tan, massive loess. It is relatively coarse, calcareous, and fossiliferous adjacent to the major valleys, and locally contains zones or lenticular masses of eolian sand. Away from the valleys it becomes thinner, finer textured, and is leached (e.g., New City and Wolf Creek Sections).

In the lower Illinois Valley and in the Mississippi Valley a weakly developed soil occurs a short distance below the top of the Peoria in a few sections (e.g., Cottonwood School, Frederick South, Collinsville). Radiocarbon dates and regional stratigraphy (pl. 1; fig. 1) suggest the possibility that incipient soils developed during Twocreekan time. However, there is as yet no evidence for excluding this minor soil and the uppermost part of the Peoria Loess from the Woodfordian. Although in the field the upper zone of the Peoria is recognizable only where an incipient soil is present, its mineralogy is distinctive from the main body of the Peoria Loess.

Inside the outermost end moraine (Shelbyville) of the Woodfordian tills, loess occurs both above and below the till. The loess below the Shelbyville till, formerly called Iowan, has been named Morton (Frye and Willman, 1960) from exposures in Tazewell County. The Morton is gray to yellow-tan, dolomitic, sparsely fossiliferous, massive loess. It ranges from a few inches to as much as 7 or 8 feet thick. Generally it is overlain by Shelbyville till but locally tills as young as Bloomington are in contact with it. At several places a layer of moss has been observed at the top of the loess below the overlying till. The Morton Loess commonly rests on Farmdale deposits but in places is directly in contact with Roxana Silt. The Morton Loess is the oldest stratigraphic unit within the Woodfordian Substage and radiocarbon dates (fig. 1) indicate that its age is from about 20,000 to about 22,000 radiocarbon years B.P. It is stratigraphically continuous with the lower part of the Peoria Loess outside the Shelbyville Moraine.

The Richland Loess (Frye and Willman, 1960), formerly called Tazewell Loess, is the loess that overlies the Woodfordian tills. It is stratigraphically continuous with the upper part of the Peoria Loess. The Richland is gray to yellow-tan, and the lower part is calcareous and fossiliferous where thick. Although its maximum thickness exceeds 20 feet, it does not in general exceed 10 to 15 feet. The base of this loess is a time-transgressing stratigraphic boundary as it rests upon tills ranging from Shelbyville, where the loess may exceed 18,000 radiocarbon years B.P., to late Woodfordian, where the base of the loess may be less than 15,000 radiocarbon years B.P. If the Richland contains any loess of Valderan age it has not as yet been recognized.

MINERALOGY

The loesses in Illinois have been studied with regard to thickness, texture, and carbonate content (Smith, 1942), but extensive studies of regional variations or similarities in their mineralogy have not been made previously. Reported here are the results of 185 analyses by optical methods of the minerals in the fine sand (.062 - .250 mm) fraction, 558 analyses by X-ray diffraction of clay minerals, dolomite, and calcite, and 32 chemical analyses of the gross sample. The geographic distribution of samples used in this study is shown by figure 2 and listed in table 1, and the results of analyses are presented in tables 2, 4, and 6. In tables 3 and 5 average analyses are listed by depositional province. The positions of the major streams during Altonian time are shown by figure 3.

The mineralogical studies reported here have three general objectives: (1) descriptive characterization of the loesses in Illinois, (2) differentiation of the several stratigraphic units by their mineral composition, and (3) acquisition of information concerning the origin of the loesses by relating their mineral compositions to drainage history and to the composition of the outwash and glacial tills that were their sources.

Clay mineral compositions were calculated from X-ray diffraction data (using oriented aggregate techniques) of the less than 2-micron fraction for montmorillonite, illite, chlorite, and kaolinite. Montmorillonite as used here includes all clay materials that expand to about 17Å with ethylene glycol. Therefore, any expansible chlorite or vermiculite is included with the montmorillonite. Chlorite includes all 14Å material that does not expand with ethylene glycol, and thus includes the non-expansible vermiculite-chlorite and vermiculite. Illite and kaolinite are used as generally accepted.

As kaolinite and chlorite are minor constitutents, their sum rarely exceeding 2 parts in 10, they are listed together in the tables. Montmorillonite and illite, however, may be dominant constitutents and values are given for each.

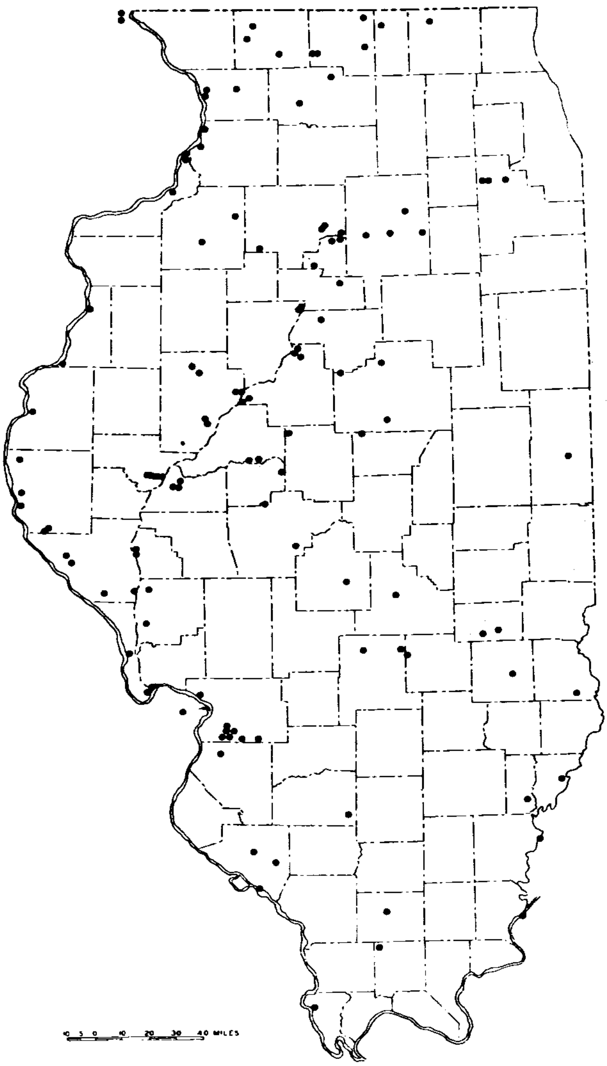

Fig. 2 — Geographic distribution of samples used in this study and listed in tables. Names of measured stratigraphic sections are given on plate 1 and in the described sections.

There is a wide range in the montmorillonite content in the clay mineral assemblages, and there also are differences in relative abundance among the other clay mineral components. In order to characterize these other clay minerals by a numerical value that could be plotted on graphs and tabulated, a diffraction intensity ratio, for convenience called the D.I. ratio, was devised. It was derived by dividing the X-ray diffraction intensity (counts per second) of the 10Å spacing for illite by that for the 7.2Å spacing for kaolinite and chlorite. The D.I. ratio has been found to be diagnostic for both calcareous and leached samples of loess, but is not useful in the B-zones of soils or deeply weathered colluvial zones.

Roxana Silt

The mineral composition of the Roxana Silt is shown on plate 1 and in tables 2 and 4. The Roxana generally is low or lacking in calcite, except along the Mississippi Valley below Alton, but Zones II and III and the lower part of Zone IV are dolomitic where the unit is thick. Illite ranges from an average of 14 percent of the clay minerals in the Ancient Mississippi Valley to an average of 38 percent in the Ohio Valley. The D.I. ratios are consistent, ranging from 0.5 in the Ancient Iowa Valley to 0.8 in the Ohio Valley. Montmorillonite is a major clay mineral in the Roxana but its proportion ranges widely from one depositional province to another. The many samples from the Ancient Mississippi Valley (fig. 3) average 70 percent montmorillonite in the clay minerals, those from the Ancient Iowa Valley average 64 percent, the one section in the Wabash Valley averages 55 percent, and the samples from the Ohio Valley average only 30 percent. For Illinois the amount of illite generally is less than the sum of kaolinite and chlorite.

Quartz is the predominant mineral in the very fine and fine sand fraction in all areas. K-feldspar content ranges from 13 percent to 18 percent, Na-Ca-feldspar from 7 percent to 10 percent, heavy minerals from less than 0.1 percent to more than 2 percent. The heavy mineral suites along the Ancient Mississippi Valley and the Wabash Valley appear to be similar, with the percentage of hornblende approximately twice that of epidote near the valleys but less in the thin leached sections farther from the valley. In the thin leached sections the relative content of tourmaline, zircon, garnet, and epidote generally is higher.

In the Ancient Iowa Valley staurolite is strikingly more abundant than in any other province, and black opaque minerals, tourmaline, and epidote generally are abundant. The heavy mineral suite in the Ohio Valley is distinctive, being characterized by relatively low content of black opaque minerals, garnet, epidote, and hornblende and relatively high content of tourmaline and zircon, which suggests a mixed source from the bedrock and from glacial outwash.

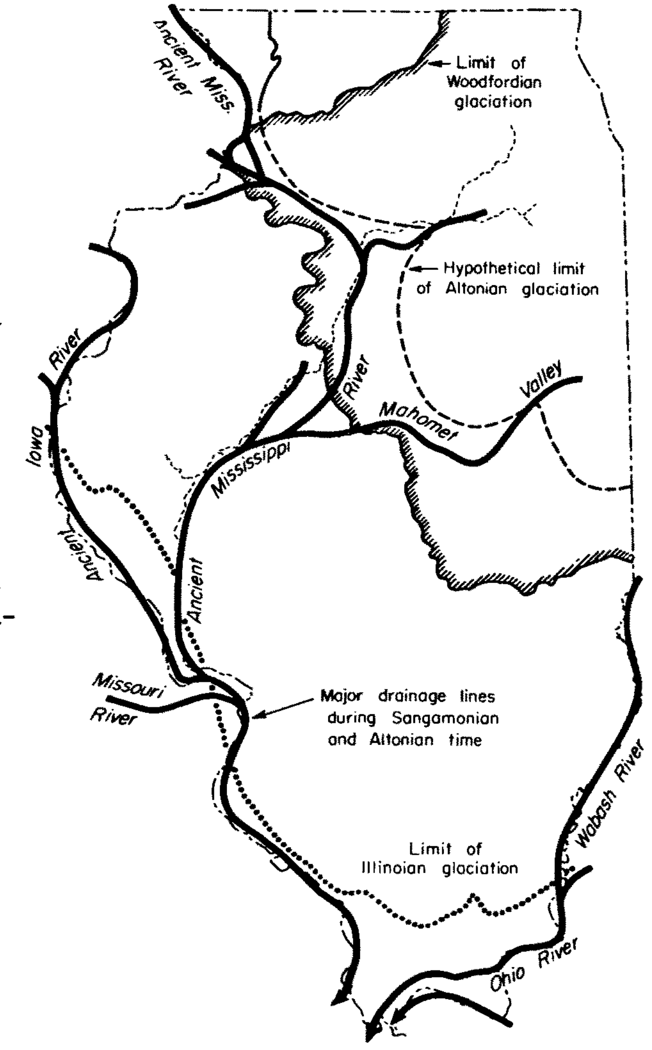

Fig. 3 — Locations and names of major rivers that were sources of loess during Altonian time. Maximum limits are shown for Illinoian and Woodfordian glaciers, and a hypothetical limit of Altonian glaciation also is shown.

Farmdale Silt

The Farmdale Silt contains no calcite and no dolomite except at the Wedron Section. At places where the Farmdale lacks organic material, its clay mineral composition is indistinguishable from that of the Roxana of the Ancient Mississippi and Ancient Iowa Valleys (pl. 1, tables 2, 3, 4). Commonly the Farmdale is characterized by an organic-rich appearance and the presence of peaty material, probably indicating local deposition by slow accumulation in a wet environment. It contains montmorillonite, vermiculite, and kaolinite, with little or no illite. Organic-rich Farmdale has an average montmorillonite content of 67 percent in the clay mineral fraction, an average illite content of only 9 percent, and a D.I. ratio of 0.3. The amount of illite is less than the sum of kaolinite and chlorite (vermiculite), similar to that observed for the Roxana. Moreover, in the Farmdale the amount of vermiculite generally exceeds that of illite. The identical assemblage of clay minerals has been observed in some accretion gleys (Frye, Willman, and Glass, 1960), which suggests similar modes of accumulation and environments of deposition. In a few places the clay minerals of the Farmdale are almost entirely kaolinite and vermiculite. The Farmdale heavy mineral content is 40 percent hornblende, a higher percentage than that of the strongly weathered Roxana Zone I of the same region, but lower than that of the higher zones of the Roxana.

Peoria Loess

The mineral composition of the Peoria Loess permits the recognition of a main body of loess and a discontinuous upper zone. There is greater contrast in mineral composition of the depositional provinces of the Peoria Loess than is found in the Roxana. This contrast is shown strikingly by variations in the amount of montmorillonite in the main body of the loess. Montmorillonite accounts for an average of 70 percent of the clay mineral content in the Mississippi Valley, 54 percent in the Illinois Valley, 26 percent in the Wabash Valley, and a low of 9 percent in the Ohio Valley. In the upper zone of the Peoria Loess an equally strong contrast is evident because montmorillonite composes 80 percent of the clay mineral content in the Mississippi Valley and only 42 percent in the Illinois Valley. In each depositional province the Peoria Loess is more illitic than the Roxana (table 5), and displays a much greater range in illite content — from 11 percent to 71 percent of the clay mineral content. The D.I. ratios of the main body of the loess range from an average 1.2 in the Mississippi Valley above Alton to 3.1 in the Wabash Valley. The average illite content of the Richland Loess and the upper zone of the Peoria of the Illinois Valley ranges from 11 percent of the total clay mineral content in the Mississippi Valley above Alton (D.I. ratio of 0.7) to 41 percent in the Illinois Valley (ratio of 3.0). However, in all areas studied the amount of illite is always greater than the sum of kaolinite and chlorite.

In the very fine and fine sand fraction, the average K-feldspar content ranges from 13 to 16 percent, and the average Na-Ca-feldspar content ranges from 6 to 11 percent. Among the heavy minerals, zircon content ranges from 3 percent (one sample only) in the Wabash Valley and 4 percent in the Richland Loess of the Illinois Valley to 15 percent in the Mississippi Valley below Alton. Garnet content ranges from an average of 6 percent in the Mississippi Valley above Alton to 19 percent in the Ohio Valley, and the amount of epidote ranges from 10 to 13 percent in the Wabash and Ohio Valleys to 26 percent in the Mississippi Valley below Alton.

Stratigraphic Differentiation

The mineral compositions and the D.I. ratios differentiate the several loesses within each depositional province (pl. 1, figs. 3, 5). The percentage of montmorillonite among the clay minerals of the less than 2-micron fraction is primarily characteristic of the source of sediment in the depositional province and identifies the loesses only within a particular province; their D.I. ratios are reliable indexes to their identity. The average D.I. ratios for the Roxana in all provinces are 0.8 to 0.5, whereas the average ratios for the Peoria in all provinces are 1.2 or higher, except for the upper zone in the Mississippi Valley above Alton where the average is 0.7.

The Farmdale Silt generally has the lowest D.I. ratio of all stratigraphic units studied, but individual samples fall within the range of the Roxana. Where the

Farmdale occurs in an organic-rich environment it has D.I. ratios of 0.2 to 0.3 and the amount of vermiculite exceeds that of illite; both characteristics serve to differentiate it from the Roxana and Peoria. Predominantly vermiculite and kaolinite compositions occur only in the Farmdale.

A transition zone locally occurs in the base of the Peoria (pl. 1) of the Ohio and Wabash Valleys. Its D.I. ratio (1.4) is within the general range of the Peoria Loess of Illinois, but both its D.I. ratio and illite content are significantly lower than those of the Peoria of the Wabash and Ohio Valleys.

Although the clay mineral composition of the upper zone of the Peoria varies widely, the zone, nevertheless, is distinguishable from the main body of the underlying Peoria in the Illinois and Mississippi Valleys by a sharp increase in the D.I. ratio. Where this break is marked by an immature soil (e.g., Collinsville Section on pl. 1) it occurs at the A-zone. In the Illinois Valley and in the Mississippi Valley below Alton the upper zone contains more illite and has a higher D. I. ratio than the underlying Peoria, but in the Mississippi Valley above Alton it contains less illite and more montmorillonite than does the main body of the Peoria.

In thick sections the Roxana Silt generally contains dolomite but only locally contains calcite, whereas calcite is commonly associated with dolomite in the Peoria Loess. The Roxana also generally contains more sand than does the Peoria.

Zone I of the Roxana, which is weathered, has significantly less hornblende and more garnet than do the higher zones. In general, garnet decreases in abundance upward through the Roxana.

Differentiation of Roxana from Peoria by heavy minerals is possible in some areas but not in others, depending on whether the deposits reflect a change in the gross drainage pattern and therefore the ultimate source areas after the deposition of the Roxana. Contrast in heavy mineral suites is most striking in the Mississippi Valley between Alton and Muscatine, where the average percentage of staurolite in the heavy minerals in the Roxana is 8 times that in the Peoria, the percentage of tourmaline is 3 times greater, the percentage of garnet is twice as great, and the percentage of hornblende is only about half as great.

A strong contrast in the heavy mineral suites in the Roxana and Peoria also occurs in the Ohio Valley, where the average percentage of tourmaline in the Roxana is 3 times, zircon 5 times, and garnet and hornblende only half that in the Peoria. The percentage of epidote also is slightly higher in the Roxana. Single samples also suggest a contrast of heavy mineral suites in the Roxana and Peoria in the Wabash Valley. In the Illinois Valley and in the Mississippi Valley below Alton, however, the differences in the heavy mineral suites are not sufficiently marked or consistent to serve as criteria for the differentiation of stratigraphic units.

To summarize, wherever the Roxana, Farmdale, and Peoria deposits are not strongly weathered, their total mineral assemblages provide reliable criteria for their differentiation, for the distinction of Zone I of the Roxana from the higher zones, and for the subdivision of the Peoria Loess.

ORIGIN

It is not our purpose here to review the long controversy relative to the eolian versus non-eolian origin of loess, as in our judgment the loess of the Midwest has been demonstrated to have an eolian origin (e.g., Udden, 1894, 1898; Smith, 1942; Leighton and Willman, 1950; Kay and Graham, 1943; Swineford and Frye, 1951, 1955; Leonard and Frye, 1954). We are concerned here with the source of the materials that compose the various loess sheets of Illinois.

The immediate source of loess is the fine-size fraction of the water-transported and water-deposited sediments of major valleys. The bulk of these sediments, however, was produced as outwash from continental glaciers, and to understand properly the ultimate source of the loess we must know the mineral composition of the glacial tills related to the outwash. However, the till related to the outwash is not the till now occurring immediately below the loess. Rather, it is the till that occurs up the drainage way, possibly a considerable distance from the loess deposit. It is therefore requisite that the courses of major streams carrying outwash during the several episodes of loess deposition be known.

Drainage History

Changes in the drainage patterns of the Upper Mississippi Basin during early Pleistocene time were complex and their history is controversial, but here we are concerned only with the patterns existing during post-Illinoian time (fig. 3). The major stream in Illinois was the Ancient Mississippi River, which coincided with the present Mississippi past Jo Daviess and Carroll Counties but in Whiteside County flowed southeastward to the position of the present valley of the Illinois River in southeastern Bureau County. From there the river followed the general trend of the Illinois southward. It is shown in figure 3 as parallel to, but 5 to 15 miles east of, the present Illinois River in parts of Woodford, Tazewell, and Mason Counties, returning to the present Illinois Valley by way of the lower Sangamon Valley, which was continuous with the Mahomet River from the east. It has been tentatively concluded by George E. Ekblaw (personal communication) that the present narrow segment of the valley at Peoria was initiated by the Jacksonville Stage of the Illinoian glaciation and was later overridden, but not deeply buried, by the Buffalo Hart till. It may be that both the eastern and western valleys were relatively open until the advance of the Shelbyville (earliest Woodfordian) glacier. Southward from Cass County the Ancient Mississippi followed the present Illinois Valley and then the present Mississippi Valley to the north end of what later became the Thebes Gorge.

The Ancient Iowa River, which drained the basin of the present Iowa River in Iowa, followed the present Mississippi Valley from Muscatine southward, gaining tributaries from the basin of the Des Moines River in Iowa and joining the Missouri River and the Ancient Mississippi at the mouth of the present Illinois River.

The Ohio River occupied its present valley to below Golconda and then flowed westward across northern Massac and Pulaski Counties by way of the Cache Valley. The Wabash occupied the existing valley along the eastern boundary of Illinois.

This drainage pattern is judged to have remained essentially unchanged from the time of the withdrawal of the Illinoian glaciers, throughout Sangamonian, Altonian, and Farmdalian time, until it was disrupted by the advancing Woodfordian glaciers. As shown in figure 3, the Altonian glaciers of the Lake Michigan lobe approached but did not cross the Ancient Mississippi River, although the data are far from conclusive. Thus, during Altonian time (when Roxana Silt was deposited) the Ancient Mississippi River could have carried outwash as well as locally derived alluvium from Minnesota and northern Iowa while also receiving local alluvium from Illinois and outwash from the Altonian glaciers that entered Illinois from the Lake Michigan lobe and perhaps from as far east as the Saginaw lobe.

In contrast, after the major stream was blocked in Bureau and Whiteside Counties by advancing Woodfordian glaciers (Shaffer, 1954), the part of this valley that later became the lower part of the Illinois River Valley received outwash only from the Lake Michigan lobe. This point in time occurs within the Morton Loess. Furthermore, the segment of the Mississippi Valley between Alton and Muscatine received sediments from only central and southeastern Iowa and northeastern Missouri during Altonian and Farmdalian time, but after the major diversion during Woodfordian time it received sediments from the entire upper part of the present basin of the Mississippi River.

The Wabash Basin received outwash during Altonian time from the glacier that deposited the till called "Farmdale" by Ekblaw and Willman (1955) at Danville, Illinois, and perhaps also from lobate fronts farther east in Indiana. In Woodfordian time the Wabash Basin received contributions largely from the glacial lobes that advanced southwestward across Indiana from Michigan and Ontario. Throughout Wisconsinan time the Ohio Valley east of the Wabash Valley received no sediment from a source in the Lake Michigan lobe or farther west.

Throughout Wisconsinan time the Missouri River also was contributing outwash to the Mississippi Valley below Alton from glaciers as far west as the Rocky Mountains.

Mineralogy of Glacial Tills

The mineralogy of the tills of Illinois is discussed in the forthcoming companion Circular to this report, but some generalities are summarized here. In many areas some of the older till was incorporated in the overriding younger glaciers, and beyond the limits of the younger glaciers it furnished sediments to the valleys that carried outwash from local erosion.

In general, the clay fraction of the tills west of Illinois is dominantly montmorillonite with minor amounts of illite and kaolinite, whereas east of Illinois, the clay fraction of the tills is dominantly illite and chlorite with minor amounts of montmorillonite. In northeastern Kansas (Iowa Point Section) the clay minerals of Nebraskan and Kansan tills contain more than 80 percent montmorillonite, whereas those in Kansan till of western Indiana (Cagle's Mill Section) contain less than 10 percent montmorillonite. In Illinois, the clay minerals of the western-source Kansan till west of the Illinois Valley are 60 to 70 percent montmorillonite.

The Illinoian tills in Illinois all contain some kaolinite and chlorite, whereas the percentages of illite and montmorillonite range widely. The clay mineral composition of Illinoian tills of extreme western Illinois approaches (45 to 65 percent montmorillonite) that of the Kansan till. In general the Jacksonville and Payson tills in the Illinois Valley region have a clay mineral fraction that is 20 to 30 percent montmorillonite. These tills in eastern Illinois contain about 15 percent montmorillonite, whereas the younger Illinoian Buffalo Hart till contains only 0 to 6 percent montmorillonite.

The clay mineral composition of the Wisconsinan tills of Illinois ranges less widely. The clay minerals in the mid-Altonian till at Danville, which presumably furnished outwash to the Wabash Valley, consist of 26 percent montmorillonite, 50 percent illite, and 24 percent kaolinite and chlorite. The late Altonian Winnebago till of north-central and northwestern Illinois has a clay mineral content that is up to 30 percent montmorillonite. It also contains prominent illite, some chlorite, but no kaolinite. The montmorillonite content in the clay minerals of older Woodfordian tills (Shelbyville-Bloomington) ranges from 0 to 15 percent. Illite and chlorite are the dominant clay minerals. In the eastern part of the state montmorillonite is present only in the outer part of the Shelbyville Moraine. Illite and chlorite predominate in Woodfordian tills younger than Bloomington; kaolinite and montmorillonite generally are absent.

Glaciers, therefore, that invaded Illinois from the northwest or those that invaded from the northeast and overrode tills that had been deposited by glaciers from the northwest furnished outwash sediments high in montmorillonite; glaciers entering Illinois from the northeast furnished outwash sediments high in illite and chlorite.

Mineralogy of Glacial Outwash

Outwash of Wisconsinan age was sampled in the Illinois and Mississippi Valleys. These samples range in texture from coarse sand and gravel to silty clay, and most of them yielded sufficient clay minerals for X-ray analysis. The montmorillonite content of the clay minerals segregated from Altonian outwash in the Mississippi Valley above Alton ranges from 29 to 72 percent and averages 56 percent, that from Woodfordian outwash ranges from 47 percent to 81 percent and averages 68 percent, and that from Valderan outwash averages 71 percent. In the clay minerals from 30 samples of Woodfordian outwash from the Illinois Valley, montmorillonite content ranged from 0 (six samples) to 60 percent, with an average of 24 percent. Kaolinite and chlorite generally constitute from 10 to 20 percent of the clay minerals present, and illite is the predominant clay mineral in Woodfordian outwash of the Illinois Valley. In the heavy mineral assemblages (tables 2, 3) outwash from the Mississippi Valley is distinctly higher in epidote than that from the Illinois Valley. Garnet is relatively high in Illinois Valley outwash.

Roxana Silt

With this general regional background,the sources of the materials in the several stratigraphic units within the loesses of the depositional areas is considered. The sequence of sections along the Ancient Mississippi River from DePue to Gale, plate 1, shows the generally high montmorillonite content of the Roxana. At the north end of the traverse the high montmorillonite content shows that the chief source of sediment was from the northwest. From the Richland Creek through the Farm Creek Sections the Roxana is thin and weathered. The lowest montmorillonite percentage in the Roxana along the Ancient Mississippi Valley occurs at Frederick South where the Roxana is quite sandy. The montmorillonite content irregularly increases southward because of the increasing contribution of loess from the Ancient Iowa Valley that converged from the northwest, and reaches a maximum (French Village Section) below the mouth of the Missouri River which contributed sediments from the montmorillonite-rich western areas. Calcite is more common in the Roxana Silt south of the Missouri River, because the western tills are high in limestone whereas those from the Lake Michigan lobe are high in dolomite.

The other sequence of sections on plate 1 crosses the major valleys and therefore illustrates the differences in composition of Roxana Silt derived from different source areas. At the north, the Fulton Quarry Section with its high percentage of montmorillonite is in the Ancient Mississippi Valley and reflects a northwestern source. The next three sections are in the Ancient Iowa Valley which drained a different and more local source area that provided sediments with a slightly lower montmorillonite content. At Frederick South and New City the composition of the Roxana is again controlled by the Ancient Mississippi Valley source. At New Harmony in the Wabash Valley the Roxana Silt has a slightly lower montmorillonite content. At the Newburg and Yankeetown Sections of the Ohio Valley the amount of montmorillonite in the Roxana Silt reaches its lowest value, whereas in The Rocks Section, in the Ohio Valley just below the mouth of the Wabash, it is intermediate to that in the deposits of the two valleys.

It seems probable that Zones II, III, and IV of the thick Roxana along the Ancient Mississippi River were deposited during successive advance and retreat of Altonian glacial lobes (fig. 1). The essentially similar mineralogy of the three zones indicates that the successive glaciers occupied similar areas and moved in identical directions. In contrast, Zone I generally differs significantly in mineralogy from the higher zones and generally is weathered, in some places intensely so. Below the mouth of the Missouri River, Roxana Zone I commonly contains leached loess gradationally above colluvium at the base, but regionally Zone I generally is sandy colluvium with little loess. These relations lead to the tentative conclusion that Zone I was produced largely from relatively local sources as the result of climatic change, and that if glaciers of this age invaded the basins of the Ancient Mississippi and Ancient Iowa Rivers they penetrated only short distances.

X-ray determinations of calcite and dolomite were made both on the less than 2-micron fraction and on the bulk sample (table 4). Dolomite was detected in the bulk sample taken at some localities from the top few inches of the Roxana but was not detected in the less than 2-micron fraction. It seems likely that in such places this thin zone is either the result of mixing during deposition or is the first slowly accumulating deposit of Woodfordian loess, leached of the very fine dolomite but retaining some of the silt-size dolomite grains.

At a few places (e.g., New Harmony Section) snail shells are sparsely present in loess that does not otherwise contain carbonate minerals. The effect produced by differences in grain size on the leaching of carbonate minerals was checked experimentally in the laboratory and it was demonstrated that not only could all the silt-size calcite be removed before the dolomite was appreciably affected, but the silt-size dolomite could be removed before massive snail shells were noticeably affected. These solubility differences explain the virtual absence of calcite in the fine fractions of the Roxana Silt.

Farmdale Silt

The Farmdale Silt shown on plate 1 occurs only in the Ancient Mississippi Valley. Generally, wherever it is thick and rich in organic matter it lies on thin, weathered Roxana Silt (pl. 1), indicating that the Farmdale Silt accumulated slowly in relatively poorly drained situations that did not exist in areas of thick Roxana. Such conditions probably account for the distinctive mineralogy of the Farmdale Silt, as minerals were supplied largely by local sheet wash from Roxana Silt and older tills, probably supplemented by a minor amount of eolian silt from the Ancient Mississippi Valley. The fact that this increment of loess was not large and was deposited slowly is consistent with its accumulation when the glaciers were remote and little if any outwash was being transported down the major valley, and with the fact that the Farmdale silts generally were laminated. A small amount of Farmdale loess with no organic matter may be indistinguishably included in the top of the Roxana Silt.

Loesses of Woodfordian Age

Loesses of Woodfordian age in Illinois include the Morton Loess, the Richland Loess, the Peoria Loess (except perhaps the uppermost zone, pl. 1, fig. 1), and at least part of the transition zone at the base of the Peoria in the Ohio Valley.

During the initial pulse of loess deposition in Woodfordian time, the Ancient Mississippi River (fig. 3) was carrying sediment from as far north as Minnesota. The region that is now the Illinois Valley was deprived of this northwestern source when the advancing Shelbyville glacier blocked the river in Bureau County and forced the drainage from the north to flow across the low divide above Muscatine. This diverted the uppermost part of the Ancient Mississippi River into the Ancient Iowa Valley and established the present course of the Mississippi River. The Woodfordian loess of the Illinois Valley strikingly records this change in sediment source that deprived the valley of the large contribution of montmorillonite from the northwest and restricted the outwash to the high illite-chlorite contribution that came largely from the advancing Lake Michigan lobe.

The Morton Loess, deposited in the valley during glacial advance and overlain by Shelbyville till, as well as the basal part of the Peoria Loess beyond the Shelbyville Moraine, also reflects this history. The upper boundary of the Morton Loess is time-transgressing because loess deposition continued during the advance of the glacial front from DePue to the outermost limit of the Shelbyville Moraine. At DePue a high montmorillonite content throughout the Morton reflects only the Ancient Mississippi Valley source. In the Farm Creek Railroad Cut Section the clay minerals in the lower part of the Morton, which is derived from the Ancient Mississippi Valley, contain 70 percent montmorillonite and only 17 percent illite, but the clay minerals in the upper part of the Morton, which was derived from the Illinois Valley after the diversion, contain only 29 percent montmorillonite and 46 percent illite. The low montmorillonite content of the Morton in the Illinois Valley south of the DePue Section reflects the blocking of the Ancient Mississippi River, as most of the Morton samples from this valley segment are from the upper part of the loess. The fact that the montmorillonite content in the lowermost samples from the Morton and Peoria Loesses of the Illinois Valley is the same as the average montmorillonite content of the main part of the Peoria in the Mississippi Valley suggests that these loesses had a similar source.

The main body of the Peoria Loess along the Illinois Valley contains significantly less montmorillonite (54 percent) than does that along the Mississippi Valley, but the much lower montmorillonite content (pl. 1) in the Peoria in the Wabash Valley (26 percent) and in the Ohio Valley (9 percent) reflects the paucity of this mineral in the glacial tills and bedrock of the Ohio River basin east of the Wabash Valley. Also, the fact that the mineral composition at The Rocks Section in the Ohio Valley, just below the mouth of the Wabash, is virtually an average of the loesses of these two valleys above their junction, demonstrates that the loesses, including their clay minerals, are derived from the adjacent source valleys.

The abundance of montmorillonite in the loesses in the Mississippi and Illinois Valleys is therefore a consequence of their derivation from the sediments in the valleys and can be accounted for without invoking long distance eolian transport from remote western sources (Beavers et al. 1955; Beavers, 1957).

The mineral composition of the Peoria Loess is consistent across the broad upland divide areas of south-central Illinois and is closely similar to the composition of the loess in the bluffs of the Illinois or Mississippi Valleys to the west-northwest. The decrease in grain size of the loess toward the east-southeast is accompanied by a slight increase in the percentage of montmorillonite in the clay mineral fraction. This slight increase may be accounted for by the finer particle size of the montmorillonite among the clay minerals of the source valleys. The admixture of sediments rich in illite and chlorite from the Wabash Valley, the first major source area to the east, is not recognizable in the Peoria Loess more than 20 to 30 miles to the west of the Wabash Valley.

The transition zone in the Ohio Valley appears to be derived from outwash from the advancing Woodfordian glacier. The Erie lobe probably would have entered the Ohio Valley somewhat earlier than the Michigan or Superior lobes entered the Illinois or Ancient Mississippi Valleys. The radiocarbon date supports this concept. The mineralogy indicates that the source of the transition zone must have also included materials derived from the Roxana and older deposits of the valley.

Although far less striking in their contrasts, the heavy mineral assemblages (table 3) of the Woodfordian loesses also reflect the source areas.

CONCLUSIONS

The position of Illinois on the North American continent is well suited for demonstration of the concept that the minerals in the loess were derived from the outwash transported through the major valleys. Illinois received sediments both from the regions to the west and northwest where montmorillonite predominates among the clay minerals and from the regions to the east and northeast where illite and chlorite predominate. Furthermore, drainage modifications during the Wisconsinan age resulted in shifting the sediment sources of central Illinois loess between these two regions.

From the data presented in this report, several general conclusions can be drawn.

(1) The source of the outwash from which the loess was in part derived may be hundreds of miles up the major valleys from the point of loess deposition, although the rocks adjacent to these valleys may furnish enough sediment by local erosion to produce a detectable effect on the relative abundance of mineral species in the loess.

(2) An abrupt change in the source of sediments, caused by the blocking of a valley carrying outwash, is sharply reflected in the mineral composition of the down-valley loess if the source areas involved possessed significantly different mineral assemblages.

(3) The non-carbonate mineral composition of a loess below the B-zone of the surface soil persists as a recognizable assemblage across the region east and southeast of one major source valley to the proximity of the next source valley.

(4) Both the clay and the coarser fractions of the loess were derived locally from the sediment transported through the source valleys.

(5) Differential leaching of calcite and dolomite, and differential leaching of very fine dolomite and silt size dolomite, both in transit and in situ, produced marked differences in the carbonate content of loess.

(6) The differences in mineral composition of the several stratigraphic units in the loesses of Illinois can be used for identification of the units.

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TABLE 1 — DESCRIPTION OF SAMPLES

Sample no.	Location 1/4 Sec., T., R., County	Stratigraphic unit	Thickness of unit	Feet below top of unit
8	Center SE, 20-3N-8W, Madison	Roxana-II	20.0	16.0
8-A	do.	Roxana-I	4.0	3.5
8-AA	do.	do.	4.0	3.0
8-B	do.	do.	4.0	2.0
8-BB	do.	do.	4.0	1.0
10	do.	Roxana-II	20.0	5.0
10-A	do.	Roxana-III	12.0	7.0
11	do.	Peoria	11.0	6.0
12	do.	Roxana-IV	15.0	10.0
17	SW SE NE, 31-3N-6W, Madison	Roxana	7.5	5.0
18	do.	do.	7.5	2.5
19	do.	Peoria	5.0	3.0
20	SE SW NE, 10-5N-10W, Madison	Peoria	12.0	9.0
21	do.	Roxana	19.0	10.0
22	do.	do.	19.0	16.5
23	do.	Roxana-I	2.0	1.0
30	Ft. Bellfontaine, St. Louis Co., Missouri	Roxana	10.0	8.0
31	do.	do.	10.0	5.5
32	do.	do.	10.0	3.0
33	do.	do.	10.0	1.0
34	do.	Peoria	15.0	14.5
35	do.	do.	15.0	8.0
36	do.	do.	15.0	4.0
39	SE SE, 32-10S-2W, Calhoun	Roxana	2.5	1.5
40	do.	Peoria	15.0	11.0
83	Center SE NW, 13-3N-8W, Madison	Peoria	13.0	9.0
84	do.	Roxana	14.0	5.0
85	do.	do.	14.0	9.5
86	do.	do.	14.0	12.0
87	NW NE SW, 32-3N-7W, Madison	Peoria	10.0	7.0
88	do.	Roxana	5.5	1.5
89	do.	do.	5.5	3.5
99	Center E. line, 11-18N-11W, Cass	Roxana	38.0	36.0
100	do.	do.	38.0	31.0
101	do.	do.	38.0	27.0
102	do.	do.	38.0	23.0
103	do.	do.	38.0	17.0
104	do.	do.	38.0	13.0
105	do.	do.	38.0	9.0
106	do.	do.	38.0	2.0
107	do.	Peoria	40.0	38.0
108	do.	do.	40.0	32.0
109	do.	do.	40.0	27.0
110	do.	do.	40.0	20.0
115	NE SE NE, 10-6N-5E, Fulton	Roxana	7.0	6.0
116	do.	do.	7.0	4.0
117	do.	do.	7.0	1.0
118	do.	Peoria	18.0	16.0
127	NE NW NE, 26-26N-4W, Tazewell	Farmdale	6.0	4.0
128	do.	do.	6.0	1.0

TABLE 1 — Continued

Sample no.	Location 1/4 Sec., T., R., County	Stratigraphic unit	Thickness of unit	Feet below top of unit
129	NE NW NE, 26-26N-4W, Tazewell	Morton	2.5	1.0
133	Center, 31-26N-3W, Tazewell	Roxana	0.8	0.4
134	do.	Farmdale	3.5	2.5
135	do.	do.	3.5	0.5
136	do.	Morton	4.0	3.0
137	do.	do.	4.0	1.0
140	SW NW SW, 12-26N-4W, Tazewell	Richland	10.0	9.0
144	SW NW NE, 1-25N-2E, McLean	Farmdale	2.5	1.0
152	SW NW SE, 15-36N-9E, Will	Valparaiso ow.*		
153	NE NE NW, 16-34N-9E, Will	do.		
154	NE NW SE, 32-14N-10E, Putnam	Woodf. ow.		
155	NE NW SW, 17-11N-9E, Peoria	Woodf. ow.		
156	SE SW SW, 16-23N-7W, Tazewell	do.		
157	do.	dune sand		
158	SW SW SW, 20-18N-11W, Cass	do.		
159	SE SE SE, 8-46N-2E, Winnebago	Valparaiso ow.		
160	NE NW NW, 5-44N-2E, Winnebago	do.		
161	NW SE NE, 29-25N-11E, Ogle	Winnebago ow.		
162	NW NE NW, 27-17N-5E, Henry	Dune sand		
163	SW SE NE, 23-24N-3E, Carroll	Mankato ow.		
164	SE NE SW, 34-21N-2E, Rock Island	Mankato ow.		
165	NW SW, 4-20N-2E, Rock Island	Dune sand		
166	NE NE SW, 15-11N-5W, Henderson	Mankato ow.		
175	NW SW NW, 30-33N-1W, Putnam	Woodf. ow.		
176	SE NE SE, 21-37N-12E, Cook	Lemont ow.		
177	NW SE NW, 36-30N-3W, Marshall	Woodf. ow.		
178	NE NW SW, 26-33N-1W, Putnam	do.		
179	NW SW NW, 30-33N-1W, Putnam	do.		
271	NE NW SE, 16-7S-2W, Pike	Roxana	4.0	3.0
272	do.	Peoria	8.0	6.5
281	NE SE, 27-14N-13W, Scott	Roxana	21.0	4.0
282	do.	Peoria	25.0	21.0
283	do.	do.	25.0	10.0
284	do.	do.	25.0	25.0
287	SW SE NW, 26-14N-13W, Scott	Peoria	25.0	15.0
288	do.	do.	25.0	8.0
310	NE NE NW, 10-18N-1E, Rock Island	Roxana	3.0	1.5
311	do.	Peoria	10.0	5.0
319	SW NW NW, 15-15N-5E, Henry	Peoria	10.0	6.0
324	SE cor. NE NW, 35-15N-6E, Bureau	Roxana	3.0	1.5
325	do.	Peoria	15.0	14.0
326	do.	do.	15.0	7.0
332	SE NE NW, 36-8N-2E, Fulton	Roxana	0.8	0.4
333	do.	Peoria	10.0	7.0
341	SE NE SE, 4-14N-4W, Sangamon	Roxana	3.0	1.5
342	do.	Peoria	6.0	4.5
342-A	do.	Roxana	3.0	2.5
342-B	do.	do.	3.0	2.0
342-C	do.	do.	3.0	1.0
342-D	do.	do.	3.0	0.5

TABLE 1 — Continued

Sample no.	Location 1/4 Sec., T., R., County	Stratigraphic unit	Thickness of unit	Feet below top of unit
342-E	SE NE SE, 4-14N-4W, Sangamon	Peoria	6.0	5.5
342-F	do.	do.	6.0	5.0
342-G	do.	do.	6.0	4.0
342-H	do.	do.	6.0	3.5
342-I	do.	do.	6.0	2.7
342-J	do.	do.	6.0	1.5
351	NW SE NE, 29-22N-4E, McLean	Richland	4.0	3.5
352	do.	do.	4.0	2.5
359	NW SE NW, 6-21N-4W, Mason	Peoria	7.0	6.5
360	do.	do.	7.0	5.0
361	SW SE SW, 2-23N-7W, Tazewell	Woodf. ow.	35.0	25.0
362	do.	do.	35.0	15.0
366	NW SE NW, 17-11N-9E, Peoria	do.	70.0	50.0
373	SE SE SW, 15-16N-10E, Bureau	Richland	5.0	4.0
379	SW SE SE, 27-16N-10E, Bureau	Roxana-I	1.3	0.5
380	do.	Roxana-II	1.0	0.5
381	do.	Roxana-III	4.0	2.0
382	do.	Roxana-IV	1.2	0.6
383	do.	Morton	2.0	1.0
385	do.	Lake Ill. silt	4.0	2.0
386	SE SW NE, 35-16N-11E, Bureau	Woodf. ow. (silt bed)	1.8	1.0
387	do.	Woodf. ow.	35.0	15.0
389	SW SW SW, 18-33N-3E, LaSalle	do.	15.0	10.0
393	NE NE NW, 22-36N-10E, Will	Valparaiso ow.	30.0	4.0
406	NE NW NE, 28-46N-6E, McHenry	do.	1.0	0.5
414	NE SW NW, 32-46N-3E, Boone	Peoria	1.0	0.9
420	Center E. line, 5-26N-10E, Winnebago	do.	4.0	3.0
425	SW SW NW, 6-26N-8E, Stephenson	do.	6.0	5.0
426	NE NE SE, 5-27N-6E, Stephenson	Roxana	2.0	1.0
427	do.	Farmdale	0.5	0.3
428	do.	Peoria	2.5	2.0
432	SE SW SW, 14-81N-6E, Clinton, Iowa	do.	40.0	30.0
433	do.	do.	40.0	35.0
434	NW NE NE, 21-21N-3E, Whiteside	Woodf. ow.	15.0	5.0
435	SE NW SW, 34-21N-2E, Rock Island	Woodf. ow.	15.0	3.0
436	do.	do.	15.0	5.0
452	SW SW SW, 16-3S-1W, Washington	Roxana	5.0	3.0
457	NW NW NE, 32-7S-6W, Randolph	Peoria	15.0	11.0
460	Center, 33-14S-3W, Alexander	Roxana-I	6.0	5.0
461	do.	do.	6.0	3.0
462	do.	do.	6.0	1.0
463	do.	Roxana-II	7.0	6.0
464	do.	do.	7.0	1.0
465-A	do.	Roxana-III	8.0	7.5
465-B	do.	do.	8.0	6.0
466	do.	do.	8.0	0.5
467	do.	Roxana-IV	6.0	2.5
468	do.	do.	6.0	0.3
469	do.	Peoria	25.0	24.9

TABLE 1 — Continued

Sample no.	Location 1/4 Sec., T., R., County	Stratigraphic unit	Thickness of unit	Feet below top of unit
470	Center, 33-14S-3W, Alexander	Peoria	25.0	23.5
471	do.	do.	25.0	18.0
472	do.	do.	25.0	12.0
473	do.	do.	25.0	6.0
477	1 mi. SE Shawneetown bridge, Ky.	Roxana	6.0	3.0
478	do.	do.	6.0	0.5
479	do.	Peoria(trans.)	5.0	2.5
480	do.	Peoria	20.0	18.0
481	SW SE NW, 26-7S-4W, Pike	Peoria	12.0	6.0
483	Center NE, 25-19N-5W, Menard	Roxana	3.0	1.5
484	do.	Peoria	10.0	9.0
485	NW NW NE, 33-20N-6W, Mason	Roxana	3.0	2.5
486	do.	do.	3.0	1.0
487	do.	Peoria	12.0	11.5
488	do.	do.	12.0	7.0
489	SE SE SW, 9-34N-4E, La Salle	Farmdale	35.0	25.0
490	do.	do.	35.0	12.0
491	do.	do.	35.0	9.0
493	do.	do.	35.0	2.0
501	SE NW NE, 31-85N-6E, Jackson, Iowa	Peoria	6.0	5.0
504	SW NW SE, 1-88N-2E, Dubuque, Iowa	Roxana	4.0	2.0
505	do.	Peoria	20.0	18.0
511	Center N. line, NW, 32-89N-2E, Dubuque, Iowa	Roxana	3.5	2.5
512	do.	do.	3.5	1.0
513	do.	Peoria	15.0	14.0
514	do.	do.	15.0	8.0
515	do.	do.	15.0	6.0
523	SW cor. NW, 11-24N-3E, Carroll	Roxana	8.0	7.0
524	do.	do.	8.0	4.0
525	do.	do.	8.0	1.5
526	do.	Peoria	25.0	23.0
527	do.	do.	25.0	8.0
533	NE NE SW, 21-22N-3E, Whiteside	Roxana-I	4.7	2.0
534	do.	do.	4.7	1.0
535	do.	do.	4.7	0.2
536	do.	Peoria	35.0	33.0
537	do.	do.	35.0	5.0
544	NW NE SE, 15-21N-1E, DeWitt	Roxana	4.5	4.0
545	do.	do.	4.5	2.5
546	do.	do.	4.5	1.0
547	do.	Morton	3.0	2.5
548	do.	do.	3.0	0.5
553	NW NE NW, 32-25N-1W, Woodford	Roxana	1.5	1.0
554	do.	Farmdale	5.5	4.5
555	do.	do.	5.5	3.0
556	do.	do.	5.5	1.0
557	do.	Morton	2.6	0.5
561	Center SE NE, 20-28N-2W, Woodford	Roxana	3.0	2.0
562	do.	Farmdale	7.5	6.5
563	do.	do.	7.5	4.0

TABLE 1 — Continued

Sample no.	Location 1/4 Sec., T., R., County	Stratigraphic unit	Thickness of unit	Feet below top of unit
564	Center SE NE, 20-28N-2W, Woodford	Farmdale	7.5	2.0
565	do.	Morton	3.0	1.0
567	NW NW NE, 16-30N-1W, Marshall	Roxana-I	1.0	0.5
568	do.	Roxana-II	1.2	0.6
569	do.	Roxana-III	2.8	2.2
570	do.	do.	2.8	1.6
571	do.	do.	2.8	0.8
572	do.	Roxana-IV	0.8	0.4
573	do.	Morton	5.0	4.0
574	SE NE NW, 36-20N-7W, Mason	Roxana	9.5	7.0
575	do.	do.	9.5	5.0
576	do.	do.	9.5	2.0
577	do.	Peoria	40.0	38.0
578	SE cor., 34-18N-6W, Menard	Roxana	10.0	9.0
579	do.	do.	10.0	4.0
580	do.	Peoria	15.0	12.0
587	SW NE NE, 18-1N-1E, Schuyler	Roxana-I	6.0	5.0
588	do.	do.	6.0	3.0
589	do.	Roxana-II	6.0	4.0
591	do.	do.	6.0	1.0
592	do.	Roxana-III	8.0	6.0
593	do.	do.	8.0	1.0
594	do.	Roxana-IV	7.5	3.5
595	do.	do.	7.5	0.2
596	do.	Peoria	26.0	24.0
597	do.	do.	26.0	17.0
598	do.	do.	26.0	11.0
599	do.	do.	26.0	8.0
600	do.	do.	26.0	3.0
606	SE NE NW, 16-1N-1W, Schuyler	Roxana	10.0	8.0
607	do.	do.	10.0	4.5
608	do.	do.	10.0	3.0
609	do.	do.	10.0	1.0
610	do.	Peoria	10.0	8.0
617	Center NE, 22-1N-1W, Schuyler	Roxana	5.0	1.0
618	do.	Peoria	12.0	11.0
623	SW SW NW, 23-1N-1W, Schuyler	Roxana	15.5	14.5
624	do.	do.	15.5	10.5
625	do.	do.	15.5	7.0
626	do.	do.	15.5	1.0
626-A	do.	do.	15.5	0.5
626-B	do.	Peoria	20.0	19.5
626-C	do.	do.	20.0	19.0
626-D	do.	do.	20.0	18.0
627	do.	do.	20.0	18.0
628	do.	do.	20.0	8.0
629	do.	do.	20.0	2.0
633	NW NE NE, 21-13S-1W, Calhoun	Valderan ow.	8.0	6.0
634	do.	do.	8.0	3.0
635	SE SE NE, 28-13S-1W, Calhoun	Altonian ow.	18.0	13.5

TABLE 1 — Continued

Sample no.	Location 1/4 Sec., T., R., County	Stratigraphic unit	Thickness of unit	Feet below top of unit
637	SE SE NE, 28-13S-1W, Calhoun	Altonian ow.	18.0	6.5
639	do.	do.	18.0	2.5
640	do.	Woodf. ow.	31.5	31.0
642	do.	do.	31.5	27.0
644	do.	do.	31.5	20.5
645	do.	do.	31.5	17.5
647	do.	do.	49.5	8.0
652	SW NE SW, 23-1N-1W, Schuyler	Roxana	25.0	24.5
653	do.	do.	25.0	22.0
654	do.	do.	25.0	17.5
655	do.	do.	25.0	12.0
656	do.	do.	25.0	7.0
657	do.	do.	25.0	1.0
658	do.	Peoria	13.0	12.0
659	do.	do.	13.0	10.0
660	do.	do.	13.0	8.0
661	do.	do.	13.0	5.0
662	do.	do.	13.0	3.0
663	SW SW NW, 23-1N-1W, Schuyler	Peoria	20.0	20.0
664	do.	do.	20.0	16.0
665	do.	do.	20.0	14.0
666	do.	do.	20.0	12.0
667	do.	do.	20.0	10.0
668	do.	do.	20.0	9.0
669	do.	do.	20.0	8.5
670	do.	do.	20.0	8.0
671	do.	do.	20.0	7.5
672	do.	do.	20.0	6.5
692	Center, 31-26N-3W, Tazewell	Roxana	0.8	0.4
693	do.	Farmdale	3.5	3.2
694	do.	do.	3.5	2.0
695	do.	do.	3.5	0.5
719	NW SW SE, 9-28N-6E, Stephenson	Roxana	1.0	0.5
720	do.	Peoria	3.0	2.0
723	SE SW NW, 8-23N-9E, Ogle	Morton	1.3	0.7
743	NW SW NW, 1-19N-12W, Vermilion	Shelbyville ow.	5.0	2.0
761	NW NW, 10-24N-5E, Carroll	Peoria	6.0	5.0
776	NE cor. NW, 3-14N-4W, Sangamon	Peoria	5.0	4.5
790	NW SW SW, 8-7N-3E, Fulton	Peoria	3.5	3.0
801	SE NW NE, 29-3N-8W, Madison	Peoria	71.5	60.0
802	do.	do.	71.5	38.0
803	do.	do.	71.5	37.5
804	do.	do.	71.5	35.5
805	do.	do.	71.5	35.0
823	SW NE, 21-33N-5E, LaSalle	Woodf. ow.	8.0	7.0
824	do.	do.	8.0	3.0
825	do.	do.	8.0	1.0
827	do.	do.	20.0	16.0
829	SW SE SE, 15-33N-3E, LaSalle	Woodf. ow.	20.0	1.0
830	do.	do.	1.0	0.8

TABLE 1 — Continued

Sample no.	Location 1/4 Sec., T., R., County	Stratigraphic unit	Thickness of unit	Feet below top of unit
831	SW SE SE, 15-33N-3E, LaSalle	Woodf. ow.	1.0	0.3
832	SE SW NE, 35-16N-11E, Bureau	do. (silt bed)	1.8	1.4
833	do.	do. do.	1.8	1.0
834	do.	do. do.	1.8	0.8
835	do.	do. do.	1.8	0.2
836	do.	do.	35.0	13.0
845	SW NE SE, 17-11N-9E, Peoria	do.	70.0	20.0
846	do.	do.	70.0	8.0
847	NE SE NE, 10-6N-5E, Fulton	Roxana	7.0	0.3
848	do.	Farmdale	0.5	0.2
849	do.	Peoria	18.0	17.8
850	do.	do.	18.0	17.3
851	do.	do.	18.0	16.8
852	do.	do.	18.0	16.3
853	do.	do.	18.0	15.8
854	do.	do.	18.0	15.0
855	do.	do.	18.0	14.0
857	NE SE SW, 2-4N-3E, Fulton	Roxana	8.5	7.5
858	do.	do.	8.5	6.5
859	do.	do.	8.5	5.5
860	do.	do.	8.5	4.0
861	do.	do.	8.5	2.5
862	do.	do.	8.5	1.5
863	do.	do.	8.5	0.5
864	do.	Farmdale	1.5	1.0
865	do.	do.	1.5	0.5
866	do.	Peoria	17.0	17.0
867	do.	do.	17.0	16.5
868	do.	do.	17.0	16.0
869	do.	do.	17.0	15.5
870	do.	do.	17.0	15.0
871	do.	do.	17.0	14.5
872	do.	do.	17.0	14.0
873	do.	do.	17.0	12.5
874	do.	do.	17.0	11.5
875	do.	do.	17.0	10.5
876	do.	do.	17.0	9.0
877	do.	do.	17.0	8.5
878	do.	do.	17.0	8.0
879	do.	do.	17.0	7.0
880	do.	do.	17.0	5.5
881	do.	do.	17.0	4.0
882	do.	do.	17.0	3.0
883	do.	do.	17.0	2.0
884	do.	do.	17.0	1.0
885	NW NW NE, 11-4N-3E, Fulton	Woodf. ow.	22.0	18.0
886	do.	do.	22.0	13.0
887	do.	do.	22.0	9.0
888	do.	do.	22.0	5.0
889	do.	do.	22.0	2.0

TABLE 1 — Continued

Sample no.	Location 1/4 Sec., T., R., County	Stratigraphic unit	Thickness of unit	Feet below top of unit
890	NW NW NE, 11-4N-3E, Fulton	Peoria	13.0	10.0
891	do.	do.	13.0	8.0
892	do.	do.	13.0	5.0
893	NE SE, 27-14N-13W, Scott	Roxana-I	7.0	6.5
894	do.	do.	7.0	4.0
895	do.	do.	7.0	1.5
896	do.	Roxana-II	6.0	5.0
897	do.	do.	6.0	3.0
898	do.	Roxana-IV	6.0	2.7
899	do.	do.	6.0	1.7
900	do.	do.	6.0	1.2
901	do.	do.	6.0	0.7
902	do.	do.	6.0	0.2
903	do.	Peoria	9.0	8.8
904	do.	do.	9.0	8.3
905	do.	do.	9.0	7.8
906	do.	do.	9.0	7.3
907	do.	do.	9.0	6.8
908	do.	do.	9.0	6.3
909	do.	do.	9.0	5.3
910	do.	do.	9.0	4.3
911	do.	do.	9.0	2.3
913	SW SW NE, 27-12N-13W, Greene	Roxana-I	6.0	5.0
914	do.	do.	6.0	3.5
915	do.	do.	6.0	0.5
916	do.	Roxana-II	3.5	3.0
917	do.	do.	3.5	1.7
918	do.	do.	3.5	0.5
919	do.	Roxana-III	7.0	6.5
920	do.	do.	7.0	4.5
921	do.	do.	7.0	2.5
922	do.	do.	7.0	0.5
923	do.	Roxana-IV	3.5	3.5
924	do.	do.	3.5	2.5
925	do.	do.	3.5	1.5
926	do.	do.	3.5	0.5
927	do.	Peoria	12.0	11.5
928	do.	do.	12.0	10.0
929	do.	do.	12.0	8.5
930	do.	do.	12.0	7.0
931	do.	do.	12.0	5.5
932	do.	do.	12.0	4.0
933	do.	do.	12.0	3.0
934	SW NE NE, 28-10N-13W, Greene	Roxana	3.0	2.5
935	do.	do.	3.0	1.0
936	do.	do.	3.0	0.5
937	do.	Peoria	30.0	29.5
938	do.	do.	30.0	28.5
939	do.	do.	30.0	26.5
940	do.	do.	30.0	24.0

TABLE 1 — Continued

Sample no.	Location 1/4 Sec., T., R., County	Stratigraphic unit	Thickness of unit	Feet below top of unit
941	SW NE NE, 28-10N-13W. Greene	Peoria	30.0	20.0
942	do.	do.	30.0	16.0
943	do.	do.	30.0	12.0
944	do.	do.	30.0	10.0
955	SE cor., 26-2N-9W, Adams	Roxana	4.0	2.5
956	do.	Peoria	22.0	20.0
957	do.		22.0	17.0
958	do.	do.	22.0	7.0
959	NW NE SW, 4-3N-8W, Madison	Peoria	20.0	10.0
960	do.	do.	20.0	6.0
961	do.	do.	20.0	3.0
975	NW NE SE, 16-12N-1W, Christian	Roxana	2.0	1.0
976	do.	Peoria	4.0	3.0
982	SW SW SW, 16-8N-1E, Fayette	Roxana	2.5	2.0
983	do.	do.	2.5	1.0
984	SE NW NE, 29-3N-8W, Madison	Peoria	71.5	71.0
985	do.	do.	71.5	68.5
986	do.	do.	71.5	66.0
987	do.	do.	71.5	62.0
988	do.	do.	71.5	56.5
989	do.	do.	71.5	52.0
990	do.	do.	71.5	45.0
991	do.	do.	71.5	40.0
992	do.	do.	71.5	35.5
993	do.	do.	71.5	32.0
994	do.	do.	71.5	27.0
995	do.	do.	71.5	22.0
996	do.	do.	71.5	17.0
997	do.	do.	71.5	12.0
998	do.	do.	71.5	6.0
999	NE NW NW, 25-2N-9W, St. Clair	Roxana-I	10.0	7.0
999-A	do.	do.	10.0	10.0
1000	do.	do.	10.0	5.0
1001	do.	do.	10.0	3.0
1002	do.	do.	10.0	1.5
1003	do.	do.	10.0	0.5
1004	do.	Roxana-II	12.0	11.0
1005	do.	do.	12.0	8.0
1006	do.	do.	12.0	6.0
1007	do.	do.	12.0	4.0
1008	do.	do.	12.0	2.0
1009	do.	do.	12.0	0.5
1010	do.	Roxana-III	7.0	6.5
1011	do.	do.	7.0	5.0
1012	do.	do.	7.0	3.5
1013	do.	do.	7.0	2.0
1014	do.	do.	7.0	0.5
1015	do.	Roxana-IV	14.0	13.0
1016	do.	do.	14.0	9.0
1017	do.	do.	14.0	5.0

TABLE 1 — Continued

Sample no.	Location 1/4 Sec., T., R., County	Stratigraphic unit	Thickness of unit	Feet below top of unit
1018	NE NW NW, 25-2N-9W, St. Clair	Roxana-IV	14.0	3.0
1019	do.	do.	14.0	1.0
1020	do.	Peoria	25.5	25.0
1021	do.	do.	25.5	23.5
1022	do.	do.	25.5	22.5
1023	do.	do.	25.5	18.0
1024	do.	do.	25.5	14.0
1025	do.	do.	25.5	10.0
1026	do.	do.	25.5	6.0
1028	SW SE SW, 7-6S-5W, Randolph	Roxana	5.5	4.8
1029	do.	do.	5.5	2.0
1030	do.	Peoria	4.0	2.0
1048	NW NE NE, 24-5S-7W, Randolph	Roxana-I	2.0	1.5
1049	do.	do.	2.0	0.5
1050	do.	Roxana	2.5	2.4
1051	do.	do.	2.5	2.0
1052	do.	do.	2.5	0.5
1053	do.	Peoria	6.5	6.0
1054	do.	do.	6.5	4.5
1055	do.	do.	6.5	3.5
1056	do.	do.	6.5	2.0
1059	Interstate 57, 8-11S-2E, Johnson	Roxana	2.5	1.2
1060	do.	Peoria	5.0	3.5
1071	Center SW, 11-9S-2E, Williamson	Roxana	3.5	2.0
1072	do.	Peoria	8.0	6.0
1078	1 mi. SE Shawneetown bridge, Ky.	Roxana	6.0	5.0
1079	do.	do.	6.0	3.0
1080	do.	do.	6.0	1.0
1081	do.	Peoria (trans.)	5.0	4.0
1081-A	do.	do.	5.0	2.5
1082	do.	do.	5.0	0.5
1083	do.	Peoria	20.0	18.0
1084	do.	do.	20.0	16.0
1085	do.	do.	20.0	13.0
1086	do.	do.	20.0	11.0
1087	do.	do.	20.0	9.0
1088	do.	do.	20.0	7.0
1089	do.	do.	20.0	5.0
1090	do.	do.	20.0	3.0
1091	do.	do.	20.0	1.0
1096	½ mi. N. Corydon, Henderson, Ky.	Roxana	2.0	1.0
1097	do.	Peoria (trans.)	2.0	1.0
1098	do.	Peoria	10.0	9.0
1099	do.	do.	10.0	5.0
1101	NE cor., Henderson, Henderson, Ky.	Peoria (trans.)	35.0	34.0
1102	do.	Peoria	35.0	32.5
1103	do.	do.	35.0	31.0
1104	do.	do.	35.0	28.0
1105	do.	do.	35.0	25.0
1106	do.	do.	35.0	22.0

TABLE 1 — Continued

Sample no.	Location 1/4 Sec., T., R., County	Stratigraphic unit	Thickness of unit	Feet below top of unit
1107	NE cor., Henderson, Henderson, Ky.	Peoria	35.0	17.0
1108	do.	do.	35.0	12.0
1110	1.1 mi. W. Green R. br., Henderson, Ky.	Peoria	10.0	6.0
1113	2 mi. W. Owensboro, Davies, Ky.	Peoria	15.0	12.5
1114	E SE of Lancaster Cem., Davies, Ky.	Peoria	14.0	14.0
1115	do.	do.	14.0	11.5
1116	do.	do.	14.0	9.5
1117	do.	do.	14.0	7.5
1118	do.	do.	14.0	6.0
1119	do.	do.	14.0	4.0
1122	NW SW NE, 10-7S-8W, Warrick, Ind.	Roxana	5.0	3.0
1123	do.	do.	5.0	1.0
1124	do.	Peoria	10.0	7.0
1125	do.	do.	10.0	3.0
1129	N½, 25-6S-9W, Warrick, Ind.	Roxana	3.0	2.0
1130	do.	Peoria (trans.)	1.0	0.5
1131	do.	Peoria	8.0	7.0
1132	do.	do.	8.0	4.0
1135	SE NW SW, 1-5S-14W, Posey, Ind.	Roxana-I	1.5	0.8
1136	do.	Roxana-II-IV	4.5	4.0
1137	do.	do.	4.5	2.5
1138	do.	do.	4.5	0.5
1139	do.	Peoria (trans.)	1.5	0.5
1140	do.	Peoria	34.0	29.0
1141	do.	do.	34.0	25.5
1142	do.	do.	34.0	22.0
1143	do.	do.	34.0	19.0
1144	do.	do.	34.0	16.0
1145	do.	do.	34.0	13.0
1146	do.	do.	34.0	10.0
1147	do.	do.	34.0	6.0
1148	do.	do.	34.0	2.0
1149	NE NE SE, 29-2S-14W, Edwards	Peoria	6.0	3.0
1150	do.	do.	6.0	5.0
1154	NE NW NE, 8-1S-12W, Wabash	Roxana	1.5	0.5
1155	do.	Peoria	6.0	5.0
1156	do.	do.	6.0	2.0
1159	SW NE SW, 6-5N-11W, Crawford	Roxana	1.0	0.5
1160	do.	Peoria	4.0	2.5
1168	NE NE NW, 34-7N-10E, Jasper	Peoria	5.0	2.5
1171	NE NW SW, 10-9N-9E, Cumberland	Peoria	2.0	1.0
1173	SW SW SW, 23-9N-8E, Cumberland	Peoria	3.0	2.0
1176	NW NW NW, 30-8N-4E, Effingham	Peoria	5.0	2.0
1178	SE SE NE, 24-8N-3E, Fayette	Peoria	6.0	4.0
1182	SE SE NE, 21-11N-3E, Shelby	Roxana	2.0	1.0
1183	do.	Peoria	3.0	1.5
1184	SW SE NE, 26-5S-6W, Pike	Roxana	3.0	1.5
1185	do.	Peoria	5.0	2.5
1191	NW NE SE, 9-5S-6W, Pike	Roxana	3.5	2.0
1192	do.	Peoria	7.5	6.8

TABLE 1 — Continued

Sample no.	Location 1/4 Sec., T., R., County	Stratigraphic unit	Thickness of unit	Feet below top of unit
1193	NW NE SE, 9-5S-6W, Pike	Peoria	7.5	5.0
1194	NW SW SW, 32-3S-7W, Adams	Peoria	8.0	8.0
1197	SW cor., 32-3S-7W, Adams	Roxana	4.0	2.0
1198	do.	Peoria	15.0	13.0
1199	do.	do.	15.0	10.0
1214	NW NE NW, 23-1S-9W, Adams	Roxana	4.0	0.5
1215	do.	Peoria	37.0	36.0
1216	do.	do.	37.0	34.5
1217	do.	do.	37.0	32.5
1218	do.	do.	37.0	30.0
1219	do.	do.	37.0	26.0
1220	do.	do.	37.0	22.0
1221	do.	do.	37.0	18.0
1222	do.	do.	37.0	15.0
1223	do.	do.	37.0	10.0
1227	SE cor., 26-2N-9W, Adams	Roxana	4.0	3.5
1228	do.	do.	4.0	1.5
1229	do.	do.	4.0	0.5
1230	do.	Peoria	22.0	20.0
1231	do.	do.	22.0	17.0
1232	do.	do.	22.0	13.0
1233	do.	do.	22.0	9.0
1234	do.	do.	22.0	6.0
1235	Center E½, 31-5N-8W, Hancock	Roxana	3.0	1.5
1236	do.	Peoria	6.0	4.0
1239	SW NE SW, 36-8N-7W, Henderson	Roxana	4.0	3.5
1240	do.	do.	4.0	2.0
1241	do.	do.	4.0	1.0
1242	do.	Peoria	31.5	30.5
1243	do.	Peoria	31.5	29.5
1244	do.	do.	31.5	26.0
1245	do.	do.	31.5	23.0
1246	do.	do.	31.5	21.0
1247	do.	do.	31.5	17.0
1248	do.	do.	31.5	11.0

* ow. = outwash

TABLE 2—HEAVY AND LIGHT MINERAL ANALYSES
(carbonate-free basis)

Sample no.	.062-.250mm fraction (%)	Heavy minerals in fraction (%)	Opaque		Transparent Heavy Minerals (%)																Light (%)				Percent soluble
			Black	Others	Tourmaline	Zircon	Garnet	Epidote	Rutile	Titanite	Kyanite	Staurolite	Andalusite	Sillimanite	Actinolite	Hornblende	Enstatite	Hypersthene	Diop.-Aug.	Others	Quartz	K-feldspar	Na-Ca felds.	Others	
8	7.6	-		51	4	23	9	22	3	-	-	-	1	-	5	23	-	-	-	1	-	-	-	-	15.4
10	7.6	-		50	2	20	13	17	2	-	-	-	1	-	3	27	-	2	4	9	-	-	-	-	23.6
11	1.2	-		24	6	7	7	17	-	1	-	-	3	-	10	39	-	1	1	8	-	-	-	-	21.8
12	2.2	-		50	1	22	9	24	-	-	-	-	1	-	10	21	-	1	3	7	-	-	-	-	10.6
17	-	-		53	3	6	24	39	2	-	-	-	-	-	1	25	-	-	-	-	-	-	-	-	-
18	-	-	15	16	-	20	9	33	-	-	-	-	-	-	-	35	3	-	-	-	-	-	-	-	-
19	-	-	20	13	-	25	5	35	1	1	-	1	-	-	4	26	2	-	-	-	-	-	-	-	-
20	0.8	-		49	6	13	16	25	1	-	-	-	-	-	6	32	-	-	-	1	-	-	-	-	21.6
21	1.8	-		32	4	17	10	13	-	-	-	-	2	-	9	21	-	1	-	23	-	-	-	-	9.2
22	4.6	-		29	11	4	11	13	1	1	-	-	1	-	7	39	-	1	4	7	-	-	-	-	11.0
23	12.0	-		40	7	17	15	29	1	2	-	-	-	-	4	17	-	3	2	3	-	-	-	-	9.8
30	-	-	19	8	3	10	13	41	-	1	-	1	-	-	-	23	5	-	2	1	83	12	4	1	-
31	-	-	20	12	1	8	12	40	-	-	-	-	-	-	1	35	3	-	-	-	-	-	-	-	-
32	-	-	19	12	1	8	10	39	-	-	-	-	-	-	1	36	4	-	1	-	70	23	7	-	-
33	-	-	24	11	1	11	14	44	1	-	-	-	-	-	2	24	1	-	2	-	-	-	-	-	-
34	-	-	19	10	3	8	15	34	-	-	-	-	1	-	1	34	1	-	3	-	75	16	7	2	-
35	-	-	25	13	3	14	9	39	-	-	-	2	-	-	5	22	2	-	4	-	-	-	-	-	-
36	-	-	27	12	2	20	7	23	-	-	-	-	-	-	7	33	4	-	4	-	76	16	6	2	-
39	-	-	35	15	3	11	10	34	-	-	-	1	-	-	-	30	4	-	7	-	75	14	7	3	-
40	-	-	21	8	1	1	11	41	-	-	-	-	1	-	5	39	-	-	-	1	85	7	5	3	-
76	3.7	2.1	32	4	3	1	19	19	-	-	-	1	-	-	2	42	1	3	7	2	72	17	6	5	17.5
77	23.3	2.4	26	9	7	5	11	21	1	-	-	1	-	-	5	35	1	4	5	4	-	-	-	-	12.5
83	2.4	1.2	5	5	2	3	9	13	-	-	-	1	-	-	-	56	-	-	1	5	66	15	17	2	18.5
84	-	-	8	7		5	5	13	-	-	-	-	-	-	-	75	-	-	-	2	77	16	6	1	4.5
85	13.3	1.3	38	12		10	10	22	-	-	-	-	-	-	-	54	-	-	-	4	66	21	10	3	4.0
86	30.1	0.8	30	13	3	16	18	28	-	-	-	-	-	-	-	33	-	-	-	2	73	15	8	4	4.5
87	1.7	0.3	12	7	5	2	2	26	-	1	-	-	-	-	13	41	2	2	1	5	70	14	13	3	3.0

TABLE 2—Continued

Sample no.	.062-.250mm fraction (%)	Heavy minerals in fraction (%)	Opaque		Transparent Heavy Minerals (%)																Light (%)				Percent soluble
			Black	Others	Tourmaline	Zircon	Garnet	Epidote	Rutile	Titanite	Kyanite	Staurolite	Andalusite	Sillimanite	Actinolite	Hornblende	Enstatite	Hypersthene	Diop.-Aug.	Others	Quartz	K-feldspar	Na-Ca felds.	Others	
88	1.8	4.4	23	5	2	6	7	35	-	1	-	-	-	-	8	36	1	1	3	-	70	20	8	3	2.5
89	3.6	0.7	10	7	4	2	14	36	1	-	-	-	-	-	4	32	2	-	2	3	75	13	9	3	2.5
99	4.0	0.7	13	7	2	2	14	25	-	-	-	2	-	-	2	52	1	-	-	-	63	16	16	5	5.0
100	2.2	0.4	8	7	1	2	4	29	-	-	-	1	-	-	8	53	1	-	-	1	60	23	8	9	4.5
101	4.0	0.3	24	14	1	2	16	36	.	-	-	1	-	-	2	41	-	-	1	-	72	16	11	1	18.0
102	-	-	40	10	-	15	3	40	-	2	-	-	-	-	-	35	3	-	-	2	53	26	11	10	18.5
103	1.2	4.4	14	16	1	6	8	35	-	-	-	-	-	-	7	43	-	-	-	-	77	10	8	5	19.5
104	0.6	-	35	13	1	15	14	30	-	-	-	-	-	-	-	35	5	-	-	-	72	18	7	3	11.5
105	1.4	-	24	8	1	11	15	30	-	4	-	-	-	-	3	32	-	-	4	-	70	22	7	1	3.5
106	0.4	-	19	8	-	7	7	38	1	1	-	-	-	-	5	39	1	-	1	-	-	-	-	.	16.5
107	0.2	-	31	7	1	8	11	26	-	1	-	-	-	-	2	50	-	-	-	1	71	18	7	4	40.0
108	-	-	32	9	-	12	6	29	-	1	-	-	-	-	1	43	4	-	2	2	68	13	13	6	21.0
109	0.6	-	34	13	-	10	6	27	-	-	-	-	-	-	1	55	-	-	1	-	65	19	10	6	39.0
110	0.4	-	23	10	-	5	6	36	-	2	-	-	-	-	1	48	1	-	-	1	71	15	9	5	30.0
115	30.4	-	20	20	3	6	15	31	-	2	-	-	-	-	-	40	1	-	-	2	-	-	-	-	5.5
116	13.2	-	15	17	2	11	10	34	-	1	-	-	-	-	-	40	1	-	1	-	-	-	-	-	5.0
117	2.8	-	15	7	-	3	8	38	1	-	-	-	-	-	1	41	4	-	2	2	-	-	-	-	6.0
118	0.2	-	27	14	-	3	17	47	-	-	-	-	-	-	-	28	3	-	2	-	-	-	-	-	24.0
133	13.4	0.4	20	13	1	14	15	32	-	1	-	-	-	-	-	29	-	-	-	8	75	14	7	5	5.5
134	0.4	-	16	10	-	8	9	19	-	-	-	-	-	-	-	55	-	-	-	9	73	17	7	3	6.0
135	0.4	-	20	13	-	13	19	20	-	1	-	-	-	-	-	47	-	-	-	-	68	20	10	2	6.0
136	-	-	15	9	1	9	13	14	-	-	-	-	-	-	-	63	-	-	-	-	72	15	8	5	36.5
137	0.4	-	20	9	1	6	12	11	-	-	-	-	-	-	-	67	-	-	-	3	70	18	7	5	30.0
140	5.2	-	22	11	1	6	9	17	-	-	-	-	-	-	-	65	-	-	-	2	70	17	9	4	31.0
144	-	-	7	15	-	12	8	19	-	-	-	-	-	-	-	61	-	-	-	-	79	9	9	3	40.5
147	11.5	1.8	41	11	2	31	23	-	-	-	-	-	-	-	1	38	5	-	-	-	63	14	16	7	41.5

TABLE 2—Continued

Sample no.	.062-.250mm fraction (%)	Heavy minerals in fraction (%)	Opaque (Black)	Opaque (Others)	Transparent Heavy Minerals (%): Tourmaline	Zircon	Garnet	Epidote	Rutile	Titanite	Kyanite	Staurolite	Andalusite	Sillimanite	Actinolite	Hornblende	Enstatite	Hypersthene	Diop.-Aug.	Others	Light (%): Quartz	K-feldspar	Na-Ca felds.	Others	Percent soluble
152	3.6	8.3	36	6	-	2	8	6	1	1	-	-	-	-	-	77	-	-	-	5	-	-	-	-	-
153	2.4	1.9	23	34	-	1	9	13	-	1	-	-	-	-	-	72	1	-	-	3	-	-	-	-	-
154	2.4	5.9	24	15	-	1	10	10	-	1	-	-	-	-	-	65	1	5	1	6	-	-	-	-	-
155	27.6	1.0	5	6	-	2	8	17	-	-	-	-	-	-	2	63	2	3	1	2	-	-	-	-	-
156	18.9	2.8	18	11	-	10	19	10	-	1	-	-	-	-	-	54	1	3	1	1	-	-	-	-	-
157	36.5	2.0	10	16	-	6	25	8	1	-	-	-	-	-	-	53	1	4	1	1	-	-	-	-	-
158	33.3	3.3	17	13	4	5	19	18	-	-	-	-	-	-	-	39		12	2	1	-	-	-	-	-
159	9.5	6.2	41	10	3		31	15	-	1	-	-	-	-	1	26		9	10	4	-	-	-	-	-
160	8.9	4.0	39	8	-	3	17	22	-	-	-	-	-	-	2	28		16	12	-	-	-	-	-	-
161	12.5	7.2	38	19	-	4	28	12	-	-	-	-	-	-	-	27		14	11	4	-	-	-	-	-
162	20.3	3.0	14	11	1	1	11	32	-	-	-	-	-	-	3	46		3	3	-	-	-	-	-	-
163	2.4	3.6	24	9	-	1	5	38	1	-	-	1	-	-	1	44	5	-	2	2	-	-	-	-	-
164	8.7	6.4	21	13	1	6	21	39	-	1	-	-	-	-	1	29	1	-	1	-	-	-	-	-	-
165	9.5	4.3	24	23	2	2	11	43	-	-	-	-	-	-	-	36		5	-	1	-	-	-	-	-
166	7.2	3.9	21	14	1	2	14	52	-	-	-	-	-	-	1	24	3	-	-	3	-	-	-	-	-
175	17.2	1.5	15	5	2	1	18	32	-	3	-	-	-	-	1	36	1	-	3	3	-	-	-	-	11.5
177	3.2	0.5	25	5	4	3	5	43	-	-	-	-	-	-	3	41	1	-	-	-	-	-	-	-	28.0
178	32.7	0.7	19	16	6	34	20	5	-	-	-	-	-	-	-	29	-	2	2	2	-	-	-	-	4.5
179	46.3	1.5	11	9	1	2	20	11	-	-	-	-	-	-	-	57	-	6	1	2	-	-	-	-	7.5
271	5.4	2.6	26	13	1	28	9	24	-	-	-	-	-	-	-	35	1	1	-	1	-	-	-	-	4.0
272	5.2	0.3	32	12	1	12	10	33	-	-	-	-	-	-	-	44	-	-	-	-	68	16	12	4	5.5
280	25.5	1.4	9	19	3	1	7	4	-	-	-	1	-	-	-	76	2	2	1	3	75	10	11	4	2.5
281	28.9	1.5	30	20	-	33	8	16	-	-	-	-	-	-	-	41	1	-	-	1	-	-	-	-	4.0
282	17.7	1.1	42	4	3	9	15	22	-	-	-	-	-	-	-	48	-	-	-	3	-	-	-	-	15.5
283	24.2	0.9	20	17	-	37	6	6	-	-	-	-	-	-	-	48	-	-	-	3	-	-	-	-	7.5
285	26.3	1.8	9	17	1	2	11	9	-	-	-	-	-	-	-	74	1	-	-	2	-	-	-	-	19.0
286	28.6	0.7	5	11	1	2	16	8	-	-	-	-	-	-	3	66	-	2	-	2	76	11	10	3	4.5

TABLE 2—Continued

Sample no.	.062-.250mm fraction (%)	Heavy minerals in fraction (%)	Opaque		Transparent Heavy Minerals (%)																	Light (%)				Percent soluble
			Black	Others	Tourmaline	Zircon	Garnet	Epidote	Rutile	Titanite	Kyanite	Staurolite	Andalusite	Sillimanite	Actinolite	Hornblende	Enstatite	Hypersthene	Diop.-Aug.	Others	Quartz	K-feldspar	Na-Ca felds.	Others	
310	3.5	-	10	17	1	4	9	20	-	-	1	-	-	-	-	63	1	-	1	-	67	12	8	13	19.0
311	4.5	3.2	20	15	1	4	6	24	-	-	-	-	-	-	-	60	-	-	-	5	74	17	6	3	25.5
332	5.4	trace	14	35	2	4	6	43	-	-	-	-	-	-	-	43	-	-	-	2	77	11	6	6	4.5
333	1.9	0.4	27	20	3	19	1	37	-	-	-	-	-	-	3	37	-	-	-	-	72	18	8	2	2.0
341	10.7	1.5	27	12	2	2	17	22	-	-	-	-	-	-	3	51	3	-	-	-	74	18	7	1	5.5
342	1.2	0.3	21	39	-	15	7	36	-	-	-	-	-	-	-	42	-	-	-	-	80	11	7	2	6.5
351	2.0	0.5	6	12	-	1	14	13	-	-	-	-	-	-	-	71	-	1	-	-	74	18	5	3	27.0
353	6.6	2.4	10	22	3	5	27	7	-	-	-	-	-	-	-	52	-	1	1	4	64	19	10	7	36.5
362	13.4	2.6	7	17	1	1	17	7	-	-	-	1	-	-	1	57	3	5	3	4	70	15	9	6	9.5
366	21.9	1.4	6	7	1	-	9	17	-	-	-	-	-	-	1	62	1	6	2	1	73	15	8	4	33.0
387	34.2	0.6	10	16	2	5	9	9	-	-	-	-	-	-	-	62	3	7	2	1	84	11	3	2	13.0
389	1.1	6.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	51	17	11	21	46.5
406	6.9	2.8	9	27	1	2	17	7	-	-	-	-	-	-	-	59	2	5	2	5	-	-	-	-	35.5
414	3.6	0.7	10	13	-	1	11	9	-	-	-	-	-	-	-	74	1	3	1	-	77	15	5	3	4.0
425	7.8	0.7	21	18	1	33	13	19	-	-	-	-	-	-	-	34	-	-	-	-	83	10	6	1	7.5
426	14.5	0.5	20	16	2	2	8	21	-	-	-	-	-	-	-	61	3	-	1	2	80	16	3	1	7.0
432	40.9	0.9	3	9	-	-	10	15	-	-	-	-	-	-	-	66	5	2	2	-	75	15	8	2	5.5
433	26.9	2.0	1	3	1	-	1	15	-	-	-	-	-	-	1	72	3	1	1	5	62	18	14	6	17.0
434	8.9	1.0	9	11	1	-	9	19	-	-	-	-	-	-	1	50	3	5	3	9	67	14	12	7	52.5
435	6.4	1.1	15	24	2	2	25	34	-	-	-	-	-	-	1	33	-	-	1	2	72	12	9	7	2.0
460	4.8	0.6	12	36	7	25	2	28	-	-	-	-	-	-	-	38	-	-	-	-	81	13	4	2	10.0
461	23.0	1.3	26	22	2	61	1	18	2	-	-	-	-	-	-	15	-	-	-	1	80	11	7	2	8.0
462	20.5	1.4	9	21	1	31	11	26	-	-	-	-	-	-	-	31	-	-	-	-	79	12	6	3	9.5
463	11.8	2.9	7	27	1	10	8	22	-	-	-	-	-	-	-	56	-	-	1	2	68	15	12	5	9.0
464	16.1	0.7	7	17	1	26	7	18								48					76	14	7	3	14.0
465-A	11.6	0.2	13	13	1	19	13	11	-	1	-	1	-	-	-	51	1	-	1	1	66	15	14	5	16.0
466	8.5	0.2	11	16	1	17	7	20	-	-	-	1	-	-	-	51	2	-	1	-	79	15	6	-	16.5

TABLE 2—Continued

Sample no.	.062-.250mm fraction (%)	Heavy minerals in fraction (%)	Opaque		Transparent Heavy Minerals (%)															Light (%)				Percent soluble
			Black	Others	Tourmaline	Zircon	Garnet	Epidote	Rutile	Titanite	Kyanite	Staurolite	Andalusite	Sillimanite	Actinolite	Hornblende	Enstatite	Hypersthene	Diop.-Aug.	Others	Quartz	K-feldspar	Na-Ca felds.	Others	
467	17.3	0.6	13	17	2	19	9	24	-	-	-	-	-	-	-	45	-	-	-	1	75	13	9	3	8.0
468	12.4	1.0	20	17	2	14	7	35	-	-	-	-	-	-	-	42	-	-	-	-	78	14	6	2	11.0
470	12.4	1.0	22	14	-	26	13	26	-	-	-	-	-	-	-	33	-	-	-	2	63	15	19	3	30.0
471	6.7	0.2	35	6	-	18	19	28	-	-	-	-	-	-	-	31	-	-	-	4	74	12	9	5	22.0
473	7.7	trace	40	12	2	34	14	26	1	-	-	3	-	-	-	20	-	-	-	-	75	14	9	2	16.5
477	12.8	3.9	19	17		22	12	32	-	-	-	2	-	-	-	32	-	-	-	-	78	12	8	2	8.0
478	5.2	5.6	7	24	2	11	12	19	-	-	-	-	-	-	-	55	-	1	-	-	75	16	6	3	14.5
479	11.9	3.2	11	4	1	7	31	8	-	-	-	-	-	-	-	51	-	1	-	1	79	13	7	1	29.5
480	8.3	4.2	6	10	-	3	17	8	-	-	-	-	-	-	5	57	4	1	4	1	78	12	8	2	25.5
481	0.7	5.3	2	12	1	-	21	-	-	-	-	-	-	-	-	75	-	-	-	3	67	17	12	4	24.5
483	3.4	0.8	17	10	1	3	25	14	1	-	-	-	-	-	-	56	-	-	-	-	-	-	-	-	8.0
484	0.6	0.1	8	20	-	3	10	16	1	-	-	-	-	-	3	62	2	-	-	3	-	-	-	-	25.0
494	21.6	1.4	3	24	-	-	12	8	-	-	-	-	-	-	-	55	1	3	3	18	70	20	8	2	21.5
504	1.1	0.8	28	14	4	6	4	31	1	-	-	2	-	-	-	49	-	-	-	3	-	-	-	-	9.0
505	0.4	0.8	7	24	3	3	3	19	-	-	1	-	-	-	3	57	4	1	2	4	-	-	-	-	23.0
525	0.4	trace	6	16	1	1	5	13	-	-	1	-	-	-	-	76	-	1	-	2	-	-	-	-	10.1
526	0.3	12.5	7	8	2	1	5	34	-	-	-	-	-	-	-	46	1	2	1	8	62	23	12	3	21.0
532	16.3	2.0	15	22	2	-	8	19	1	-	-	-	-	-	-	64	2	1	1	2	69	17	7	7	5.5
536	1.1	17.1	10	8	1	1	2	17	-	1	-	-	-	-	1	71	1	2	1	2	69	16	11	4	21.0
544	21.5	0.4	7	27	3	1	7	19	-	-	-	-	-	-	3	65	1	-	-	1	-	-	-	-	7.0
545	6.3	0.4	18	14	1	5	15	12	1	-	-	-	-	-	-	65	-	-	1	-	-	-	-	-	11.0
547	0.2	trace	13	18	3	1	4	18	-	-	-	-	-	-	3	64	1	-	-	6	-	-	-	-	17.5
557	0.1	trace	8	18	-	1	7	8	-	-	-	-	-	-	4	73	1	-	4	2	-	-	-	-	35.0
568	8.9	0.5	6	27	8	2	7	11	1	-	-	-	-	-	-	68	-	-	1	2	-	-	-	-	8.0
569	1.1	0.6	12	24	4	3	3	16	-	-	-	-	-	-	-	70	-	1	1	2	-	-	-	-	9.5
572	0.3	0.7	12	28	2	1	5	11	1	-	-	-	-	-	2	72	2	-	2	2	-	-	-	-	7.5
574	8.2	0.6	14	11	1	3	24	7	-	-	1	2	-	-	-	61	-	-	-	1	60	23	8	9	7.0

TABLE 2—Continued

Sample no.	.062-.250mm fraction (%)	Heavy minerals in fraction (%)	Opaque		Transparent Heavy Minerals (%)																Light (%)				Percent soluble
			Black	Others	Tourmaline	Zircon	Garnet	Epidote	Rutile	Titanite	Kyanite	Staurolite	Andalusite	Sillimanite	Actinolite	Hornblende	Enstatite	Hypersthene	Diop.-Aug.	Others	Quartz	K-feldspar	Na-Ca felds.	Others	
577	0.2	trace	7	19	-	1	4	12	-	-	-	-	-	-	3	68	5	1	3	3	-	-	-	-	32.5
588	5.8	0.5	8	13	2	1	2	30	1	-	2	1	-	-	-	60	1	-	-	-	-	-	-	-	11.5
589	3.1	0.6	5	13	5	-	5	8	-	1	-	-	-	-	-	76	1	-	2	2	-	-	-	-	11.5
590	7.6	0.6	6	18	5	-	3	8	-	-	-	-	-	-	-	80	-	-	1	3	-	-	-	-	26.0
592	36.4	0.9	11	23	3	1	8	23	-	-	-	-	-	-	-	58	-	2	4	1	-	-	-	-	18.0
594	0.9	0.5	11	7	2	-	2	12	-	-	-	-	-	-	-	80	1	1	2		-	-	-	-	9.5
633	56.4	2.4	12	14	1	-	15	15	-	-	-	1	-	-	-	61	-	5	1	1	67	20	7	6	4.5
720	2.0	0.7	10	19	4	1	11	20	-	1	-	-	-	-	-	58	1	1	2	1	67	18	11	4	15.0
725	3.8	8.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	47	24	17	12	58.5
729	20.2	0.6	15	15	4	4	20	22	-	-	-	-	-	-	-	49	-	1	-	-	82	12	4	2	11.5
755	10.4	2.8	24	13	2	-	10	9	-	-	-	-	-	-	-	79	-	-	-	-	66	18	9	7	38.0
818	25.0	1.3	13	22	2	2	16	4	-	-	-	-	-	-	-	70	-	2	2	2	-	-	-	-	
827	1.7	8.1	1	64	3	-	7	4	1	-	-	-	-	-	-	73	1	6	2	3	-	-	-	-	-
831	3.4	1.4	15	9	3	2	18	13	-	-	-	-	-	-	-	62	-	-	1	1	-	-	-	-	-
858	17.8	0.4	32	15	1	10	33	20	-	-	-	-	-	-	-	33	2	1	-	-	-	-	-	-	-
860	9.3	0.5	21	15	4	-	32	20	-	-	-	2	-	-	2	38	1	1	-	-	-	-	-	-	-
862	10.2	0.2	30	9	2	8	25	22	1	2	-	-	-	-	-	39	-	-	-	1	-	-	-	-	-
864	5.1	0.2	21	17	2	14	17	22	-	-	-	-	-	-	-	45	-	-	-	-	-	-	-	-	-
867	0.9	2.9	8	21	2	3	5	17	-	-	-	-	-	-	-	69	-	1	-	3	-	-	-	-	-
879	0.6	1.8	4	19	1	3	3	12	-	-	-	-	-	-	-	70	-	1	-	10	-	-	-	-	-
885	6.5	1.3	18	10	1	1	35	14	-	-	1	-	-	-	-	44	1	1	-	2	-	-	-	-	-
889	0.9	1.2	7	19	3	-	8	20	-	-	1	-	-	-	-	65	-	1	1	1	-	-	-	-	-
892	0.6	8.5	4	92	9	2	15	17	-	-	-	-	-	-	-	57	-	-	-	-	-	-	-	-	-
913	16.9	0.7	13	15	3	2	29	19	-	-	-	-	-	-	-	47	-	-	-	-	-	-	-	-	-
915	15.0	0.3	17	10	2	2	15	19	1	-	1	3	-	-	-	56	1	-	-	-	-	-	-	-	-

TABLE 2—Continued

Sample no.	.062-.250mm fraction (%)	Heavy minerals in fraction (%)	Opaque (Black)	Opaque (Others)	Transparent Heavy Minerals (%): Tourmaline	Zircon	Garnet	Epidote	Rutile	Titanite	Kyanite	Staurolite	Andalusite	Sillimanite	Actinolite	Hornblende	Enstatite	Hypersthene	Diop.-Aug.	Others	Light (%): Quartz	K-feldspar	Na-Ca felds.	Others	Percent soluble
917	7.9	0.4	24	22	4	11	11	27	-	1	-	-	-	-	-	45	-	-	-	1	-	-	-	-	-
920	10.0	0.3	13	8	1	9	9	16	-	-	2	-	-	-	-	63	-	-	-	-	-	-	-	-	-
924	3.0	0.8	16	14	1	11	6	29	-	-	-	-	-	-	-	52	-	-	-	1	-	-	-	-	-
928	2.0	1.4	18	16	1	6	9	17	1	-	-	-	-	-	-	62	-	2	-	2	-	-	-	-	-
933	2.7	1.3	10	29	1	7	4	16	1	-	-	-	-	-	-	70	-	-	-	1	-	-	-	-	-
1101	1.0	0.3	14	23	5	1	6	6	-	1	-	-	-	-	2	59	2	11	3	4	-	-	-	-	-
1122	3.2	0.6	2	55	28	48	1	7	-	-	1	1	-	-	1	9	-	-	-	4	-	-	-	-	-
1125	4.1	0.1	21	28	8	4	8	23	4	-	4	-	-	-	4	42	-	3	-	-	-	-	-	-	-
1137	3.0	0.3	24	12	1	12	16	21	-	-	1	-	-	-	-	49	-	-	-	-	-	-	-	-	-
1141	0.5	0.9	4	7	1	3	12	10	-	-	-	-	-	-	7	66	-	1	-	-	-	-	-	-	-
1214	16.0	0.2	36	17	4	12	4	41	4	-	-	16	-	-	-	15	2	-	-	2	-	-	-	-	-
1215	4.0	0.4	40	15	4	26	4	29	3	-	1	10	-	-	-	22	-	-	-	1	-	-	-	-	-
1217	3.0	0.3	13	8	-	9	11	22	-	-	-	-	-	-	-	57	-	-	-	1	-	-	-	-	-
1218	2.9	0.4	17	7	1	2	10	22	-	-	-	1	-	-	-	61	-	1	-	2	-	-	-	-	-
1220	2.5	0.4	17	4	1	7	6	22	-	-	-	2	-	-	-	59	-	-	-	3	-	-	-	-	-
1223	3.9	0.3	15	4	1	4	10	25	1	-	-	1	-	-	-	55	-	-	-	3	-	-	-	-	-
1228	9.4	0.7	32	16	8	2	14	24	-	-	1	8	-	-	-	41	-	-	-	2	-	-	-	-	-
1229	7.6	0.7	37	14	5	8	27	21	1	-	-	4	-	-	-	34	-	-	-	-	-	-	-	-	-
1231	0.6	0.9	8	8	1	1	4	17	-	-	-	-	-	-	-	68	2	1	-	6	-	-	-	-	-
1233	4.7	0.2	4	4	1	2	7	25	-	-	-	1	-	-	-	63	-	-	-	1	-	-	-	-	-
1239	18.7	0.3	33	16	8	15	7	33	-	-	-	5	-	-	-	30	-	-	-	2	-	-	-	-	-
1241	13.9	0.2	29	18	9	5	10	29	2	-	2	8	-	-	-	35	-	-	-	-	-	-	-	-	-
1242	6.9	0.2	26	18	2	3	9	24	-	-	-	3	-	-	-	57	-	2	-	-	-	-	-	-	-
1243	11.0	0.1	11	6	1	4	9	15	-	-	-	1	-	-	-	69	-	-	-	1	-	-	-	-	-
1245	7.5	0.1	14	7	1	5	5	19	-	1	1	1	-	-	-	67	-	-	-	-	-	-	-	-	-
1246	5.3	0.2	23	12	4	10	5	19	-	-	1	2	-	-	-	56	-	-	-	3	-	-	-	-	-
1248	16.5	1.0	10	5	-	10	6	17	-	-	1	1	-	-	-	64	-	1	-	-	-	-	-	-	-

TABLE 3—AVERAGES OF SELECTED HEAVY AND LIGHT MINERALS FOR STRATIGRAPHIC UNITS AND DEPOSITIONAL PROVINCES

Depositional province and stratigraphic unit	Number of samples	Black opaque	Translucent heavy minerals (complete analyses in table 2)										Light minerals		
			Tourmaline	Zircon	Garnet	Epidote	Staurolite	Actinolite	Hornblende	Enstatite	Hypersthene	Diopside-augite	K-feldspar	Na-Ca feldspar	Others
Illinois River Valley															
Peoria Loess	18	20	1	8	8	22	0	1	55	1	tr.	tr.	15	9	76
Morton Loess	5	13	1	6	8	14	0	1	64	1	0	1	14	8	78
Richland Loess	3	14	1	4	14	17	0	0	58	0	1	0	16	6	78
Rock River Valley															
Peoria Loess	4	15	2	9	8	16	0	0	56	1	1	1	15	6	79
Mississippi Valley above Alton															
Peoria Loess	20	15	2	5	6	23	1	tr.	59	tr.	1	tr.	16	9	75
Mississippi Valley below Alton															
Peoria Loess	11	22	3	15	11	26	tr.	4	33	1	tr.	1	15	11	74
Ohio River Valley															
Peoria Loess	3	13	3	5	19	13	0	3	50	1	2	1	13	8	79
Wabash River Valley															
Peoria Loess	1	4	1	3	12	10	0	7	66	0	1	0	-	-	-
Illinois Valley (upper)															
Farmdale Silt	3	19	tr.	11	13	22	0	0	40	0	0	0	17	9	74
Ancient Mississippi Valley (fig. 3)															
Roxana Silt, Zone IV	13	18	1	12	9	26	0	2	45	1	tr.	1	17	7	76
Roxana Silt, Zone III	9	18	2	10	10	25	tr.	1	49	1	tr.	1	18	9	73
Roxana Silt, Zone II	16	16	3	11	11	19	tr.	2	51	1	tr.	1	16	10	74
Roxana Silt, Zone I	14	17	4	10	14	26	tr.	1	32	1	tr.	1	13	8	79
Roxana Silt, undiff.	14	19	2	8	11	28	tr.	1	45	2	tr.	1	14	8	78
Ancient Iowa Valley (fig. 3)															
Roxana Silt, undiff.	5	33	7	8	12	29	8	0	31	tr.	0	0	-	-	-
Ohio River Valley															
Roxana Silt, undiff.	3	9	10	26	8	18	1	tr.	31	0	0	0	14	7	79
Wabash River Valley															
Roxana Silt, undiff.	1	24	1	12	16	21	0	0	49	0	0	0	-	-	-

TABLE 3—Continued

Depositional province and stratigraphic unit	Number of samples	Black opaque	Translucent heavy minerals (complete analyses in table 2)										Light minerals		
			Tourmaline	Zircon	Garnet	Epidote	Staurolite	Actinolite	Hornblende	Enstatite	Hypersthene	Diopside-augite	K-feldspar	Na-Ca feldspar	Others
Upper Mississippi Valley															
Late Woodfordian outwash	6	20	1	2	15	37	tr.	1	36	1	1	1	16	8	76
Illinois and Rock River Valleys															
Late Woodfordian outwash	6	30	1	2	16	13	0	1	52	2	2	5	17	11	72
Illinois River Valley															
Early Woodfordian outwash	26	15	2	3	16	15	tr.	1	51	1	3	2	16	9	75
Northwestern Illinois															
Winnebago outwash	3	29	1	2	19	13	0	0	53	-	-	11	21	13	66

TABLE 4 — CLAY MINERAL AND CARBONATE X-RAY ANALYSES

Sample number	X-ray diffraction intensity in counts per second				D. I. Ratio	Clay minerals in < 2 μ fraction			Sample number	X-ray diffraction intensity in counts per second				D. I. Ratio	Clay minerals in < 2 μ fraction		
	Bulk sample		< 2 μ Fraction			Percent montmoril-lonite	Percent illite	Percent kaolinite and chlorite		Bulk sample		< 2 μ Fraction			Percent montmoril-lonite	Percent illite	Percent kaolinite and chlorite
	Calcite	Dolo-mite	Calcite	Dolo-mite						Calcite	Dolo-mite	Calcite	Dolo-mite				
8	12	60	-	15	.9	52	27	21	311	18	100	-	9	.4	66	12	22
8A	21	-	-	-	.9	70	17	13	319	15	295	20	19	1.3	61	26	13
8AA	-	-	14	-	.6	72	13	15	324	-	-	-	-	.3	79	7	14
8B	-	15	36	7	.6	72	13	15	325	10	170	32	24	1.3	65	23	12
8BB	13	42	8	-	.9	63	22	15	326	9	75	-	13	1.4	56	30	14
10	25	95	72	15	.6	63	18	19	332	-	-	-	-	.4	55	17	28
10A	8	60	7	22	.8	67	18	15	333	-	-	-	-	1.0	68	19	13
11	45	13	-	140	.7	60	20	20	341	-	-	-	-	.7	68	16	16
12	-	-	-	-	.9	52	27	21	342	-	-	-	-	1.6	61	27	12
17	-	-	-	-	1.0	44	34	22	342A	-	-	-	-	.7	49	25	26
18	-	-	-	-	1.0	57	27	16	342B	-	-	-	-	.4	62	13	25
19	-	-	-	-	.9	62	22	16	342C	-	-	-	-	.5	65	14	21
20	4	85	-	6	.8	65	19	16	342D	-	-	-	-	.5	68	14	18
21	-	10	-	-	1.3	51	32	17	342E	-	-	-	-	.9	58	24	18
22	-	-	-	-	1.1	62	24	14	342F	-	-	-	-	1.4	57	29	14
23	-	-	-	-	2.3	38	48	14	342G	-	-	-	-	1.2	61	25	14
39	-	-	-	-	.8	62	21	17	342H	-	-	-	-	1.1	61	25	14
40	-	110	-	14	.9	55	26	19	342I	-	-	-	-	1.1	61	25	14
83	-	125	-	5	1.8	49	37	14	342J	-	-	-	-	1.4	47	36	17
84	-	-	-	-	1.0	50	30	20	351	15	110	-	20	1.4	58	29	13
85	-	-	-	-	1.0	53	28	19	352	-	-	-	-	2.0	61	29	10
86	-	-	-	-	.9	65	20	15	359	-	-	-	-	3.8	46	46	8
87	-	-	-	-	1.3	73	18	9	360	-	-	-	-	1.5	61	27	12
88	-	-	-	-	.6	74	12	14	361	15	170	12	25	2.9	9	73	18
89	-	-	-	-	.6	84	7	9	362	40	85	-	30	2.4	2	80	18
99	-	-	-	-	.7	71	15	14	366	23	165	-	10	3.5	4	81	15
100	-	-	-	-	.8	60	22	18	373	-	-	-	-	1.0	76	15	9
101	-	155	-	17	.8	71	16	13	379	-	-	-	-	1.1	65	22	13
102	-	90	‡	†	†	†	†	†	380	-	-	-	-	.3	68	11	21
103	-	120	-	7	.5	87	6	7	381	-	-	-	-	.7	76	12	12
104	-	70	-	15	.6	77	11	12	382	-	-	-	-	.5	62	15	23

105	-	-	-	-	.6	58	20	22	383	-	130	-	25	1.3	65	23	12
106	-	38	-	11	1.1	55	28	17	385	35	150	17	42	4.0	14	74	12
107	22	500	-	25	1.6	53	33	14	386	8	120	-	24	1.7	60	29	11
108	32	200	-	15	1.2	57	28	15	387	20	115	-	22	1.8	28	52	20
109	5	455	-	14	1.6	45	39	16	389	13	410	-	27	3.1	2	81	17
110	10	265	-	15	1.7	45	39	16	393	-	1450	-	34	2.6	14	69	17
115	20	-	-	-	2.4	*	*	*	406	13	330	13	80	3.0	10	73	17
116	-	-	-	-	1.1	*	*	*	414	-	-	-	-	.6	55	21	24
117	-	-	-	-	.6	52	23	25	420	-	-	-	-	.8	68	17	15
118	-	170	-	19	1.1	51	30	19	425	-	-	-	-	1.3	75	17	8
127	-	-	-	-	.2	76	6	18	427	-	-	-	-	.4	76	8	16
128	-	-	-	-	.6	58	21	21	428	-	-	-	-	1.0	70	18	12
129	-	265	-	18	1.7	49	36	15	432	12	7	8	17	1.8	44	41	15
133	-	-	-	-	.5	55	18	27	433	26	85	10	6	.9	63	21	16
134	-	-	-	-	.1	63	7	30	435	-	-	-	-	2.0	47	40	13
135	-	-	-	-	.3	65	12	23	436	10	-	-	-	.8	74	14	12
136	-	285	-	16	.9	70	17	13	452	-	-	-	-	.4	71	11	18
137	-	185	-	20	1.2	29	46	25	457	-	-	-	-	1.3	67	22	11
140	52	230	13	17	3.6	35	55	10	460	-	-	-	-	.6	61	18	21
154	95	400	-	40	2.6	5	75	20	461	-	-	-	-	.7	76	12	12
155	390	440	8	28	3.1	-	82	12	462	-	-	-	-	.9	69	18	13
157	-	-	-	-	.7	†	†	†	463	-	-	-	-	.5	68	14	18
158	-	-	-	-	1.6	†	†	†	464	-	40	-	14	.8	72	15	13
161	50	525	-	26	2.0	29	53	18	465A	-	28	-	7	.9	69	18	13
162	-	160	-	33	.9	66	20	14	465B	10	45	-	10	1.0	66	21	13
163	-	-	-	-	1.0	57	26	17	466	-	75	-	7	.8	73	14	13
166	-	-	-	-	4.4	53	41	6	467	-	-	-	-	1.2	58	27	15
175	40	80	-	17	2.9	2	78	18	468	-	5	-	-	.9	61	23	16
176	55	130	6	6	3.0	1	81	18	469	-	55	-	10	1.3	61	25	14
177	40	375	15	36	2.6	4	76	20	470	-	65	-	11	1.6	66	24	10
271	-	-	-	-	1.3	47	35	19	471	-	65	-	8	2.1	73	20	7
272	-	-	-	-	1.3	53	31	16	472	-	45	-	7	1.3	76	16	8
281	-	12	-	-	.9	61	22	17	473	-	55	-	-	2.0	80	15	5
282	8	140	-	-	1.0	71	17	12	481	-	85	7	18	.9	70	17	13
283	-	60	-	23	1.3	63	24	13	483	-	-	-	-	.4	63	15	22
284	-	490	-	28	3.0	50	40	10	484	-	80	-	10	1.2	67	21	12
287	-	160	-	11	1.4	37	43	20	485	-	10	-	-	.8	64	19	17
288	12	145	5	28	2.1	32	52	16	486	-	-	-	-	1.0	53	28	19
310	-	-	-	-	.5	66	14	20	487	-	240	-	10	1.7	59	30	11

* Material sufficiently weathered that a quantitative evaluation of clay mineral composition is impractical.
† Dune sand containing essentially vermiculite and kaolinite in the clay minerals.
‡ No data.

TABLE 4 — Continued

Sample number	X-ray diffraction intensity in counts per second: Bulk sample, Calcite	Bulk sample, Dolomite	< 2 μ Fraction, Calcite	< 2 μ Fraction, Dolomite	D. I. Ratio	Clay minerals in < 2 μ fraction: Percent montmorillonite	Percent illite	Percent kaolinite and chlorite	Sample number	X-ray diffraction intensity in counts per second: Bulk sample, Calcite	Bulk sample, Dolomite	< 2 μ Fraction, Calcite	< 2 μ Fraction, Dolomite	D. I. Ratio	Clay minerals in < 2 μ fraction: Percent montmorillonite	Percent illite	Percent kaolinite and chlorite
488	12	85	-	18	2.4	45	43	12	623	-	-	-	-	.8	46	30	24
489	30	36	19	10	.5	12	38	50	624	-	-	-	-	.9	58	24	18
490	30	65	23	40	.8	12	41	41	625	-	-	-	-	.6	68	15	17
491	42	80	25	25	1.7	9	65	26	626	-	-	-	-	.8	61	21	18
493	30	120	40	70	1.7	11	63	26	626A	-	-	-	-	.4	72	11	17
501	-	40	-	17	1.1	68	20	12	626B	-	-	-	-	.8	67	18	15
504	-	-	-	-	.2	58	11	31	626C	-	75	-	12	.6	73	12	15
505	-	75	-	16	1.2	75	16	9	626D	-	85	-	25	2.0	67	25	8
511	-	-	-	-	.4	*	*	*	627	-	100	-	15	.7	69	16	15
512	-	-	-	-	.4	57	17	26	628	-	95	-	12	1.1	64	23	13
513	5	95	22	30	1.5	61	27	12	629	-	-	-	-	1.6	68	23	9
514	-	60	-	23	1.2	64	23	13	633	8	21	50	21	1.4	72	19	9
515	-	-	-	-	1.1	75	16	9	634	35	85	60	23	1.1	61	24	15
523	-	-	-	-	.6	68	15	17	635	5	55	-	-	.4	72	10	18
524	-	-	-	-	.6	58	19	23	637	-	-	-	-	.7	62	20	18
525	-	-	-	-	.6	69	14	17	639	-	10	-	-	.9	68	18	14
526	-	75	-	15	1.3	71	19	10	640	13	40	8	13	1.1	81	12	7
527	16	40	55	17	1.3	62	25	13	642	-	25	-	22	1.6	76	17	7
533	-	-	-	-	.4	61	15	24	644	10	25	-	6	1.6	71	20	9
534	-	-	-	-	.5	78	9	13	645	5	55	-	16	1.8	69	23	8
535	-	-	-	-	.3	75	8	17	647	-	-	-	-	3.2	54	36	10
536	55	170	10	33	1.4	67	22	11	652	-	-	-	-	1.0	58	25	17
537	24	90	26	23	.7	79	12	9	653	-	-	-	-	.9	59	23	18
544	-	-	-	-	.9	47	30	23	654	-	-	-	-	.8	58	23	19
545	-	-	-	-	.5	72	12	16	655	-	38	-	12	1.1	72	17	11
546	-	-	-	-	.3	72	9	19	656	-	-	-	-	1.1	53	29	18
547	-	30	-	5	.7	76	12	12	657	-	65	-	16	1.0	63	22	15
548	6	55	-	10	1.0	73	16	11	658	-	150	-	21	1.6	66	24	10
553	-	-	-	-	.5	70	13	17	659	-	36	-	5	1.1	58	26	16
554	-	-	-	-	+	**	**	**	660	12	90	-	7	1.0	63	22	15

556	-	20	-	-	.8	50	26	24	661	-	-	-	-	1.3	70	20	10
557	-	135	-	12	1.1	31	42	27	663	-	55	-	15	.7	71	15	14
561	-	-	-	-	1.8	22	59	22	664	-	70	-	8	.8	65	19	16
562	-	-	-	-	.3	64	10	26	665	5	65	-	17	.7	62	20	18
564	15	80	-	-	.4	58	15	27	666	-	45	-	11	1.0	56	26	18
565	-	90	-	-	.9	39	34	27	667	-	115	-	12	1.3	64	24	12
567	-	-	-	-	.7	53	24	23	668	-	80	-	10	1.6	65	25	10
568	-	-	-	-	.4	53	17	30	669	-	90	-	11	2.0	62	28	10
569	-	-	-	-	.6	70	14	16	670	-	90	-	11	2.0	55	34	11
570	-	-	-	-	.4	77	9	14	671	-	-	-	-	2.2	68	25	7
571	-	-	-	-	.5	79	9	12	672	-	-	-	-	2.3	66	26	8
572	-	-	-	-	.6	67	15	18	692	-	-	-	-	.5	59	18	23
573	-	140	-	27	1.0	42	35	23	693	-	-	-	-	.3	64	14	22
574	-	-	-	-	.8	36	36	28	694	-	-	-	-	.2	72	5	23
575	-	-	-	-	.8	65	19	16	695	17	-	-	-	.3	58	14	28
576	-	-	-	-	.6	48	25	27	719	-	-	-	-	.8	78	12	10
577	-	130	-	35	1.0	42	35	23	720	-	-	-	-	.9	73	16	11
578	-	-	-	-	.7	72	14	14	723	-	115	-	30	1.6	51	34	15
579	-	-	-	-	1.0	55	27	18	761	-	-	-	-	1.3	68	21	11
580	-	115	-	16	1.1	58	26	16	776	-	-	-	-	.8	61	21	18
587	-	-	-	-	.5	69	13	18	790	-	-	-	-	.5	51	21	28
588	-	-	-	-	.6	64	17	19	801	25	85	70	7	1.1	62	23	15
589	-	-	-	-	.5	46	23	31	802	-	65	-	10	1.5	76	17	7
591	-	60	-	20	.7	54	23	23	803	-	75	-	10	1.6	74	18	8
592	9	45	-	25	.5	52	20	28	804	-	-	-	-	2.0	49	38	13
593	-	30	-	12	.8	72	15	13	805	-	100	-	15	2.2	48	40	12
594	-	-	-	-	.7	55	22	23	828	12	105	7	32	4.7	-	88	12
595	-	24	-	11	.9	55	26	19	824	30	70	19	42	3.8	-	85	15
596	12	65	-	14	1.0	60	24	16	825	20	65	10	20	4.3	-	87	13
597	-	70	-	10	1.0	61	23	16	827	17	380	12	-	5.1	-	88	12
598	-	120	-	10	2.6	54	37	9	829	17	410	7	17	4.3	11	77	12
599	-	145	-	22	2.1	25	57	18	830	12	50	-	14	1.6	49	36	15
600	-	-	-	-	1.6	69	22	9	831	14	95	8	21	1.6	48	36	16
606	-	-	-	-	1.0	48	31	21	832	10	310	11	22	2.8	19	65	16
607	-	-	-	-	.9	58	24	18	833	43	75	-	16	1.5	55	32	13
608	-	-	-	-	1.0	51	29	20	834	13	60	10	37	1.3	58	28	14
609	-	-	-	-	1.0	47	32	21	835	16	75	8	26	1.4	53	32	15
610	-	30	-	9	1.1	57	27	16	836	10	70	13	13	1.6	23	54	23
617	-	-	-	-	.2	85	3	8	845	16	140	15	35	2.3	15	66	19
618	-	110	-	14	1.0	80	12	8	846	95	180	7	15	2.7	13	70	17

* Material sufficiently weathered that a quantitative evaluation of clay mineral composition is impractical.
‡ No data.
** Organic-rich silts composed essentially of vermiculite and kaolinite in the clay minerals.

TABLE 4 — Continued

Sample number	X-ray diffraction intensity in counts per second: Bulk sample Calcite	Bulk sample Dolomite	< 2 μ Fraction Calcite	< 2 μ Fraction Dolomite	D. I. Ratio	Clay minerals in < 2 μ fraction: Percent montmorillonite	Percent illite	Percent kaolinite and chlorite	Sample number	X-ray diffraction intensity in counts per second: Bulk sample Calcite	Bulk sample Dolomite	< 2 μ Fraction Calcite	< 2 μ Fraction Dolomite	D. I. Ratio	Clay minerals in < 2 μ fraction: Percent montmorillonite	Percent illite	Percent kaolinite and chlorite
847	-	36	-	5	.7	59	20	21	919	-	12	-	-	.5	75	11	14
848	-	80	-	10	1.0	53	28	19	920	-	24	-	-	.5	79	9	12
849	24	90	-	6	1.1	68	20	18	921	-	-	-	-	.6	75	12	13
850	-	120	-	10	1.2	69	20	11	922	-	-	-	-	.6	77	11	12
851	-	80	-	10	.9	66	19	15	923	-	-	-	-	.5	77	10	13
852	-	90	-	17	.9	60	23	17	924	-	-	-	-	.3	78	7	15
853	-	85	-	18	.8	53	25	22	925	-	-	-	-	.3	82	5	13
854	-	75	-	15	.8	64	21	15	926	-	20	-	-	.5	63	17	20
855	-	45	-	20	1.0	59	25	16	927	-	75	-	13	1.1	64	23	13
857	-	-	-	-	.4	59	14	27	928	-	100	-	12	1.5	57	30	13
858	-	-	-	-	.5	56	19	25	929	-	65	-	16	1.5	50	35	15
859	-	-	-	-	.5	62	16	22	930	-	195	-	14	.9	58	25	17
860	-	-	-	-	.4	56	17	27	931	-	70	-	8	.7	56	22	22
861	-	-	-	-	.4	56	18	26	932	-	75	-	15	1.0	55	27	18
862	10	-	-	-	.5	65	17	18	933	-	110	-	21	1.6	32	48	20
863	11	-	-	-	.5	76	10	14	934	-	-	-	-	.5	64	15	21
864	10	-	-	-	.4	60	16	24	935	-	-	-	-	.6	71	14	15
865	-	-	-	-	.4	64	14	22	936	-	12	-	8	.6	52	22	26
866	-	100	-	12	.8	61	21	18	937	-	120	-	25	1.1	53	29	18
867	-	75	-	11	.9	63	21	16	938	-	160	-	28	1.1	59	25	16
868	-	115	-	12	1.1	67	20	13	939	-	100	-	16	1.4	60	27	13
869	-	140	-	11	.8	69	18	13	940	-	120	-	16	.7	53	24	23
870	-	105	-	20	.8	65	19	16	941	-	75	-	7	1.5	57	30	13
871	-	100	-	14	.8	59	22	19	942	-	105	-	10	2.4	53	37	10
872	-	80	-	10	.8	62	21	19	943	-	160	-	6	2.7	57	34	9
873	-	80	-	12	.7	58	22	20	944	-	155	-	16	2.8	49	41	10
874	-	90	-	11	.8	59	22	19	955	-	-	-	-	.6	36	30	34
875	6	50	-	10	.8	56	24	20	956	-	-	-	-	1.4	67	23	10
876	6	55	-	17	1.1	48	32	20	957	-	-	-	-	.5	75	11	14
877	-	90	-	21	1.4	45	37	18	958	-	-	-	-	.6	70	15	15

878	10	160	-	22	2.1	38	47	15	959	-	70	-	10	2.4	63	29	8
879	-	105	-	21	2.0	24	62	14	960	25	125	10	16	3.0	63	30	7
880	-	145	-	11	2.1	40	46	14	961	25	100	-	12	3.3	54	38	8
881	-	10	-	-	2.6	47	42	11	975	-	-	-	-	.6	88	6	6
882	-	-	-	-	2.7	57	34	9	976	-	-	-	-	.6	78	11	11
883	-	-	-	-	1.9	64	27	9	982	-	-	-	-	.7	79	10	11
884	-	-	-	-	2.0	57	32	11	983	-	-	-	-	.4	70	11	19
885	17	45	15	30	1.0	54	28	18	984	-	75	-	-	1.2	75	16	9
886	25	37	20	22	1.5	49	35	16	985	35	50	54	-	1.5	75	17	8
887	40	42	29	25	1.0	60	24	16	986	30	60	100	12	1.3	63	25	12
888	25	70	40	25	1.2	57	27	16	987	-	140	-	20	.8	68	18	14
889	21	75	50	35	1.0	57	26	17	988	20	100	10	25	1.1	66	21	13
890	18	38	13	22	6.7	-	91	9	989	6	-	10	25	1.3	68	21	11
891	30	80	25	16	3.2	42	48	10	990	12	70	40	10	1.2	64	23	13
892	25	80	6	18	4.6	27	64	9	991	10	80	20	14	1.4	80	13	7
893	-	-	-	-	.9	*	*	*	992	-	35	-	10	2.3	72	21	7
894	-	-	-	-	1.0	58	25	17	993	12	55	-	11	2.3	71	22	7
895	-	-	-	-	.5	67	14	19	994	-	70	8	11	2.0	60	30	10
896	-	-	-	-	.6	80	9	11	995	10	50	-	17	2.7	62	30	8
897	-	40	20	15	.5	73	12	15	996	15	35	6	23	2.2	44	43	13
898	-	-	-	-	.5	68	14	18	997	10	55	-	25	2.0	44	42	14
899	-	5	-	-	.5	70	13	17	998	-	-	-	-	2.1	66	26	8
900	-	5	-	-	.4	70	12	18	999A	7	-	-	-	.8	63	20	17
901	-	15	-	-	.6	66	17	17	999	12	-	16	-	.8	80	11	9
902	-	40	-	-	.5	62	17	21	1000	5	-	8	-	.8	80	11	9
903	-	110	-	15	1.4	48	35	17	1001	12	-	6	-	.8	84	9	7
904	-	115	-	18	1.4	49	35	16	1002	26	20	13	-	.8	82	10	8
905	-	140	-	20	2.2	54	35	11	1003	6	16	-	-	.8	81	10	9
906	-	125	-	20	1.3	46	36	18	1004	8	21	-	-	.8	81	10	9
907	-	155	-	22	1.1	54	29	17	1005	6	40	-	-	.7	79	10	11
908	-	150	-	14	1.2	53	30	17	1006	6	11	10	5	.8	78	12	10
909	-	140	-	18	1.3	47	35	18	1007	7	11	25	5	.7	77	12	11
910	-	165	-	15	1.7	44	40	16	1008	-	90	10	12	.8	73	15	12
911	-	85	-	18	1.6	63	26	11	1009	14	27	5	14	.8	72	15	13
913	-	-	-	-	.5	70	13	17	1010	9	38	11	15	.8	71	15	14
914	-	-	-	-	.7	74	13	13	1011	7	85	7	15	1.0	76	14	10
915	-	-	-	-	.5	74	11	15	1012	5	55	21	15	.8	76	13	11
916	-	-	-	-	.7	75	13	12	1013	-	155	8	13	1.0	80	10	10
917	-	-	-	-	.5	65	15	20	1014	-	155	6	11	1.0	81	11	8
918	-	8	-	10	.5	73	11	16	1015	-	70	-	-	1.0	77	14	9

* Material sufficiently weathered that a quantitative evaluation of clay mineral composition is impractical.

TABLE 4 — Continued

Sample number	X-ray diffraction intensity in counts per second: Bulk sample, Calcite	Bulk sample, Dolomite	$< 2\mu$ Fraction, Calcite	$< 2\mu$ Fraction, Dolomite	D. I. Ratio	Clay minerals in $< 2\mu$ fraction: Percent montmorillonite	Percent illite	Percent kaolinite and chlorite	Sample number	X-ray diffraction intensity in counts per second: Bulk sample, Calcite	Bulk sample, Dolomite	$< 2\mu$ Fraction, Calcite	$< 2\mu$ Fraction, Dolomite	D. I. Ratio	Clay minerals in $< 2\mu$ fraction: Percent montmorillonite	Percent illite	Percent kaolinite and chlorite
1016	-	40	-	14	.7	81	10	9	1132	-	-	-	-	2.4	18	64	18
1017	-	22	-	6	.8	78	12	10	1135	-	-	-	-	.4	13	33	54
1018	-	17	-	-	.9	70	18	12	1136	-	-	-	-	.3	34	20	46
1019	-	80	-	10	1.0	62	22	16	1137	-	-	-	-	.8	50	27	23
1020	-	110	-	20	1.5	70	21	9	1138	-	27	-	-	.5	59	18	23
1021	-	130	-	21	1.9	69	23	8	1139	-	80	-	16	1.4	33	46	21
1022	-	105	-	14	3.3	70	25	5	1140	-	75	-	20	2.5	21	62	17
1023	13	52	-	-	1.5	73	19	8	1141	8	135	-	20	3.3	13	72	15
1024	-	160	-	30	1.6	66	24	10	1142	20	95	-	11	4.1	28	62	10
1025	-	40	-	27	1.5	67	23	10	1143	35	125	-	7	3.5	27	61	12
1026	-	47	-	32	1.8	70	22	8	1144	12	100	-	22	2.2	27	56	17
1028	-	-	-	-	.8	30	37	33	1145	25	80	-	12	3.4	27	61	12
1029	-	-	-	-	.7	45	27	28	1146	15	120	-	22	2.9	24	62	14
1030	-	-	-	-	2.1	55	34	11	1147	15	120	-	17	2.6	33	53	14
1048	-	-	-	-	.6	42	26	32	1148	35	145	21	17	2.5	61	31	8
1049	-	-	-	-	.6	47	24	29	1149	-	-	-	-	.9	42	32	26
1050	-	-	-	-	.5	60	17	23	1150	-	-	-	-	1.3	47	35	18
1051	-	-	-	-	.3	70	10	20	1154	-	-	-	-	.7	7	47	46
1052	-	-	-	-	.5	69	13	18	1155	-	15	-	-	2.3	28	56	16
1053	-	-	-	-	.7	56	22	22	1156	-	85	6	13	2.9	24	62	14
1054	-	-	-	-	1.0	70	18	12	1159	-	-	-	-	.8	40	32	28
1055	-	-	-	-	1.3	56	29	15	1160	-	-	-	-	2.2	28	55	17
1056	-	-	-	-	1.5	70	21	9	1168	-	-	-	-	.7	34	35	31
1059	-	-	-	-	.9	40	35	25	1171	-	-	-	-	1.4	64	24	12
1060	-	-	-	-	1.4	54	31	15	1173	-	-	-	-	1.2	60	26	14
1071	-	-	-	-	.5	39	26	35	1176	-	-	-	-	.7	65	18	17
1072	-	-	-	-	1.1	66	21	13	1178	-	-	-	-	1.2	73	17	10
1078	-	-	-	-	.9	22	45	32	1182	-	-	-	-	.8	62	21	17
1079	-	-	-	-	.5	45	24	31	1183	-	-	-	-	1.6	50	35	15
1080	-	-	-	-	.8	44	30	26	1184	-	-	-	-	.6	37	30	33

1081	-	50	-	10	1.5	24	53	23
1081A	12	125	-	26	1.5	27	50	23
1082	12	100	-	25	1.8	26	54	20
1083	-	125	-	15	2.2	19	63	18
1084	-	60	-	15	2.4	17	65	18
1085	-	60	-	15	2.9	13	71	16
1086	20	55	-	16	2.3	14	67	19
1087	12	90	-	16	2.9	14	70	16
1088	15	125	-	15	3.0	10	74	16
1089	22	100	-	16	2.8	22	63	15
1090	15	55	-	12	2.4	13	68	19
1091	10	95	-	15	2.1	23	58	19
1096	-	-	-	-	✦	*	*	*
1097	-	-	-	-	1.8	32	50	18
1098	-	-	-	-	4.1	14	74	12
1099	-	-	-	-	2.1	13	66	21
1101	-	50	-	-	1.2	4	67	36
1102	-	55	-	11	3.6	9	77	14
1103	-	35	-	12	3.6	11	75	14
1104	10	110	-	20	3.5	5	80	15
1105	-	23	-	12	2.8	5	77	18
1106	-	-	-	-	2.6	6	75	19
1107	-	-	-	-	2.9	6	76	18
1108	-	-	-	-	2.5	11	70	19
1109	-	-	-	-	1.4	31	47	22
1110	-	-	-	-	2.5	12	70	18
1113	-	-	-	-	.6	19	37	43
1114	-	-	-	-	2.6	13	69	18
1115	-	-	-	-	2.7	11	72	17
1116	-	-	-	-	3.8	8	78	14
1117	-	-	-	-	2.8	5	77	18
1118	-	-	-	-	2.5	8	72	20
1119	-	-	-	-	2.6	9	73	18
1122	-	-	-	-	.7	16	43	41
1123	-	-	-	-	.9	25	44	31
1124	-	-	-	-	2.1	7	70	23
1125	-	-	-	-	1.6	21	56	23
1129	-	-	-	-	1.0	25	45	30
1130	-	-	-	-	1.8	13	64	23
1131	-	-	-	-	2.4	9	71	20

1185	-	65	-	15	1.1	72	18	10
1191	-	-	-	-	.3	66	11	23
1192	-	-	-	-	.8	77	13	10
1193	-	40	-	13	1.2	75	16	9
1194	-	80	-	-	1.3	76	16	8
1197	-	-	-	-	.9	68	18	14
1198	-	-	-	-	1.1	68	20	12
1199	-	30	-	6	.8	81	11	8
1214	-	-	-	-	.4	62	15	23
1215	-	-	-	-	.8	73	14	13
1216	-	35	-	-	1.3	73	18	9
1217	-	65	-	10	1.2	74	17	9
1218	7	52	7	25	1.4	77	16	7
1219	12	75	27	22	1.3	71	18	11
1220	8	70	10	20	1.1	73	17	10
1221	13	75	25	21	1.0	74	15	11
1222	8	90	-	20	.7	79	10	11
1223	-	40	-	10	.7	82	9	9
1227	-	-	-	-	.7	*	*	*
1228	-	-	-	-	.4	39	22	39
1229	23	-	-	-	.6	47	26	27
1230	-	35	-	-	1.2	70	19	11
1231	-	50	-	10	1.2	69	20	11
1232	-	65	-	15	.8	74	14	12
1233	-	-	-	6	1.3	79	14	7
1234	-	-	-	-	1.1	79	13	8
1235	-	-	-	-	✦	*	*	*
1236	-	-	-	-	1.2	79	13	8
1239	-	-	-	-	.2	44	15	41
1240	-	-	-	-	.1	62	4	34
1241	-	-	-	-	.4	69	11	20
1242	-	55	-	5	.7	75	13	12
1243	10	110	-	22	1.2	71	18	11
1244	7	105	-	21	1.1	71	17	11
1245	-	40	-	16	.7	81	10	9
1246	-	140	-	18	.8	80	11	9
1247	-	125	-	12	.8	80	11	9
1248	-	40	-	12	.8	75	14	11

* Material sufficiently weathered that a quantitative evaluation of clay mineral composition is impractical.
✦ No data.

TABLE 5—AVERAGES OF CLAY MINERAL DATA BY STRATIGRAPHIC UNIT AND DEPOSITIONAL PROVINCE

Stratigraphic unit and depositional province	% in clay mineral fraction			D.I. ratio
	Mont-morill-onite	Illite	Kaolin-ite + chlorite	
Richland Loess and Upper Zone Peoria Loess				
Illinois River Valley	42	41	17	3.0
Mississippi Valley above Alton	80	11	9	.7
Mississippi Valley below Alton	66	26	8	2.3
Peoria Loess (major part) and Morton Loess				
Illinois River Valley	54	30	16	1.3
Mississippi Valley above Alton	70	19	11	1.2
Mississippi Valley below Alton	71	22	7	1.5
Wabash River Valley	26	61	13	3.1
Ohio River Valley	9	71	20	2.5
Farmdale Silt				
Illinois River Valley	62	17	21	.5
Transition Zone				
Ohio and Wabash Valleys	21	55	24	1.4
Roxana Silt				
Ancient Mississippi Valley (fig. 3)	70	14	16	.6
Ancient Iowa Valley (fig. 3)	64	16	20	.5
Wabash River Valley	55	22	23	.6
Ohio River Valley	30	38	32	.8

TABLE 6 — CHEMICAL ANALYSES OF ILLINOIS LOESSES

Sample Number	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O+ (>110°)	H_2O- (<110°)	CO_2	SO_3	Ignition loss	Total
PEORIA LOESS															
11	64.99	.60	9.06	2.09	.58	4.05	6.89	1.66	2.01	1.33	.67	7.47	.11	8.70	100.63
19	75.60	.78	11.62	3.41	.34	.85	1.08	1.67	2.41	2.79	1.41	.00	.03	2.63	100.39
108	58.88	.55	8.42	1.65	.68	5.73	8.98	1.59	1.58	1.10	.42	11.28	.11	12.38	100.44
342-F	74.62	.81	12.10	3.94	.44	1.07	.95	1.29	2.58	3.24	1.91	.00	.00	3.07	100.90
470	58.58	.48	8.55	1.81	.54	5.87	8.40	1.36	1.65	1.78	.79	11.36	.04	12.79	100.02
473	69.53	.73	10.87	2.96	.28	2.73	3.75	1.55	1.82	2.77	1.36	3.87	.00	6.23	100.45
536	64.90	.66	8.71	1.85	.61	3.79	7.16	1.53	1.64	1.65	.64	8.15	.01	9.40	100.25
537	62.95	.48	9.21	2.11	.54	3.76	7.96	1.64	1.52	1.95	.82	8.57	.00	10.14	100.31
597	63.48	.69	8.76	2.16	.62	4.53	6.81	1.54	1.88	1.81	.58	8.47	.02	9.96	100.43
599	54.67	.54	6.90	2.06	.62	6.57	10.46	1.17	1.75	1.75	.39	13.99	.02	15.44	100.18
MORTON LOESS															
136	55.23	.58	7.86	1.55	.78	6.51	10.00	1.63	1.73	1.84	.43	12.99	.09	14.46	100.51
137	57.10	.98	7.75	1.27	1.20	5.88	8.83	1.31	1.83	2.50	.62	11.30	.52	13.75	99.90
FARMDALE SILT															
691	73.76	.69	13.14	3.52	.66	1.00	.81	.83	1.88	4.31	2.60	.00	.00	4.29	100.58
695	76.04	.86	11.15	1.78	1.07	.98	1.55	1.81	2.52	2.63	.96	.00	.00	2.57	100.33
ROXANA SILT															
8	70.87	.63	9.68	2.26	.51	2.57	4.31	1.81	2.21	1.29	.67	4.03	.09	5.38	100.23
8AA	75.09	.69	11.55	2.57	.61	1.05	2.05	1.76	2.21	2.36	1.30	.65	.03	2.67	100.25
10	63.91	.61	8.60	2.03	.56	3.94	7.38	1.40	2.04	1.52	.63	8.37	.03	9.65	100.12
12	75.12	.78	10.06	2.38	.71	1.62	2.58	1.74	2.40	1.59	.74	1.55	.06	2.95	100.34
18	76.73	.85	11.00	3.13	.38	.77	1.00	1.60	2.35	2.66	1.11	.00	.04	2.48	100.29
99	75.80	.64	11.79	2.70	.58	1.17	1.43	1.76	2.04	2.13	1.54	.10	.11	2.39	100.30
101	65.65	.66	9.72	2.95	.42	3.82	5.49	1.59	2.06	1.50	.89	6.35	.13	8.03	100.39
103	64.97	.56	9.52	2.59	.42	4.24	5.99	1.49	1.77	1.68	1.22	7.26	.11	8.95	100.50
105	76.65	.91	10.89	2.59	.81	1.00	1.59	1.91	2.62	1.47	.78	.04	.12	1.63	100.60
342-D	76.44	.76	11.09	3.16	.41	.82	1.06	1.88	2.31	2.59	1.61	.00	.00	2.55	100.48
462	75.90	.68	11.37	2.75	.53	1.08	1.29	1.78	2.18	2.92	1.42	.00	.00	2.81	100.37
463	73.35	.71	10.69	2.50	.52	1.07	3.48	1.85	2.22	2.71	1.10	1.83	.00	4.03	100.42
466	68.39	.55	9.54	2.27	.52	3.25	4.91	1.61	2.04	2.25	.79	5.44	.00	7.36	100.44
467	77.07	.78	10.90	2.69	.56	1.07	1.37	1.75	2.26	2.14	1.44	.00	.02	1.97	100.42

SELECTED GEOLOGIC SECTIONS

Following are fifteen of the measured geologic sections used in this report; fifteen additional sections also used in this study were published in Illinois State Geological Survey Circulars 285 and 304 in 1960. The numbers enclosed in parentheses, for example (P-565), are sample numbers used in the tables and illustrations in this report. The sections are arranged alphabetically by name.

DALLAS CITY SECTION

Measured in overburden of quarry in SW¼ NE¼ SW¼ sec. 36, T. 8 N., R. 7 W., Henderson County, Illinois, 1961.

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
7. Loess, coarse, friable, calcareous, yellow-tan, massive but with indistinct bedding in lower part, sparsely fossiliferous; surface soil in top (P-1248 middle; P-1247, 5 ft. above base; P-1246 base)	22.0
6. Loess, coarse, calcareous, massive, gray to light tan, brown mottled; abundant limonite tubules; a few fragmentary snail shells (P-1245 top; P-1244; P-1243 base)	8.0
5. Silt, gray, mottled brown, very weakly calcareous; contains limonite tubules; limonite streak at top (P-1242)	1.5
Altonian Substage	
Roxana Silt	
4. Clayey silt, compact, massive, gray, noncalcareous; limonite streak at top and gradational at base (P-1241)	1.5
3. Silt with some sand, becoming sandy in lower part, noncalcareous, brown in lower part to gray and brown mottled at top, massive, compact; contains some clay (P-1240 top; P-1239 base)	2.5
Illinoian Stage	
2. Sangamon Soil developed in till, leached, brown; Sangamon Soil in top; B-zone (P-1238) strongly developed with splotches of brown clay in gray matrix, grading downward into leached, brown till	6.0
1. Till, silty, calcareous, blocky, tan, brown, and gray; contains few cobbles (P-1237); rests on Salem Limestone	5.0
Total	46.5

DANVERS SECTION

Measured in NW¼ NE¼ NW¼ sec. 32, T. 25 N., R. 1 W., Woodford County, Illinois, in cutbank on south side of Rock Creek (near the locality of section 22 of Horberg, 1953), 1959.

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Bloomington Moraine	
10. Till, pink, bouldery, calcareous, compact	10.0
9. Gravel, tan, calcareous, locally cemented in upper 1 to 2 feet, generally fine grained but with cobbles up to 3 to 4 inches in diameter	8.0
Shelbyville Moraine	
8. Till, gray to gray-tan, bouldery, massive, calcareous (P-558); 2-foot oxidized zone at top	20.0
Morton Loess	
7. Moss, clay and silt, lenticular, light gray to tan, calcareous; organic matter throughout, but for a few millimeters the moss is a compact mat (W-483, 20,500 ± 600 years B.P.)	0.1
6. Loess, dove gray streaked with tan, massive, slowly calcareous to vigorously calcareous in upper 3 inches (P-557), fossiliferous	2.5
Farmdalian Substage	
Farmdale peat and silt	
5. Peat and silt; silty black peat at base, streaked with brown and tan silt in upper part and chocolate-brown silt at top (W-406, 25,150 ± 700 years B.P.) (P-555; P-556)	3.5
4. Silt, medium gray to purple-tan, massive, compact (P-554)	2.0
Altonian Substage	
Roxana Silt	
3. Silt, clayey silt and silty clay, very dark gray and finely mottled; pebbles very rare; organic staining throughout; platy to crumb structure; noncalcareous, gradational contacts (P-553)	1.5
Illinoian Stage	
2. Colluvium of till and silt grading upward into accretion gley; blue-gray to green-gray, grading upward to dark gray to black; becomes quite clayey in top with small blocky structure, noncalcareous (P-551 lower; P-552 upper) Sangamon Soil in top	5.0

	Thickness (feet)
1. Till, calcareous, becoming weakly calcareous at top, irregularly oxidized in upper part; gray pendants extend downward into tan (P-550)	4.0
Total	56.6

DEPUE SECTION

Measured in SW¼ SE¼ SE¼ sec. 27, T. 16 N., R. 10 E., Bureau County, Illinois, 1959.

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
15. Silt (Lake Illinois silts), gray, calcareous, thin bedded (P-385)	4.0
Bloomington Moraine	
14. Till, pink, compact, calcareous (P-384)	4.0
Morton Loess	
13. Sand, very fine, and silt, calcareous, gray; contains fossil snails (Circular 304)	0.5
12. Loess, gray, calcareous, compact (P-383)	1.5
Altonian Substage	
Roxana Silt	
Zone IV	
11. Loess, weakly calcareous, purple, compact, massive (P-382)	1.2
Zone III	
10. Loess, gray, weakly calcareous locally but generally noncalcareous; locally streaks of yellow-tan (P-381)	4.0
Zone II	
9. Loess, purple with rusty streaks, noncalcareous, compact (P-380)	1.0
Zone I	
8. Loess, gray to dark gray, compact, noncalcareous (P-379)	0.8
7. Colluvium of silt with some sand and pebbles, noncalcareous, gray	0.5
Illinoian Stage	
6. Sangamon Soil, B-zone, reddish brown with well developed structure and clay skins (P-378)	1.5
5. Till, gray, leached, blocky (P-377)	2.5
4. Till, calcareous, gray, compact, pebbly, blocky (P-376)	7.0
3. Sand and gravel with limonite streaks, gray and brown (P-375)	6.0
2. Till, calcareous, gray, compact, pebbly, blocky (P-374)	5.0
1. Covered interval to bottom of ditch	6.0
Total	45.5

FRENCH VILLAGE SECTION

Measured in large pit in Mississippi Valley bluff in NE¼ NW¼ NW¼ sec. 25, T. 2 N., R. 9 W., St.Clair County, Illinois, 1961.

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
9. Loess, gray-tan to yellow-tan with pinkish cast in lower part, calcareous, fossiliferous, indistinct textural bands in lower part (samples range upward from P-1022 at base, to P-1026 at 6 feet below top)	23.0
8. Loess, pale pinkish tan, massive, calcareous, sparsely fossiliferous, gradational contact at base (P-1020 lower; P-1021 upper)	2.5
Altonian Substage	
Roxana Loess	
Zone IV	
7. Loess, pink to light pinkish brown, massive, compact, calcareous in lower part, fossiliferous (P-1017 base; P-1018 middle; P-1019 top)	5.0
6. Loess, gray-tan to pale pinkish gray-tan, massive, calcareous, fossiliferous, gradational top and bottom (P-1016 lower)	5.0
5. Loess, pink, massive, calcareous, fossiliferous, compact (P-1015 lower)	4.0
Zone III	
4. Loess, coarse, containing some very fine sand, gray-tan, massive, calcareous, fossiliferous, friable; gradational contacts at top and bottom (samples range from P-1010 at base to P-1014 at top)	7.0
Zone II	
3. Loess, dark pink in base becoming lighter pink upward, massive; some clay and very fine sand; fossiliferous in upper part with sparse shells in lower part (samples range from P-1004 near base to P-1009 near top)	12.0
Zone I	
2. Silt, with some clay and fine sand, brown to gray-brown, massive, weakly calcareous but contains nodules of $CaCO_3$ (samples range from P-999 at base to P-1003 near top)	7.0
1. Colluvium in hole below floor of pit; silt, and clay, brown, noncalcareous (P-999-A)	3.0
Total	68.5

FULTON QUARRY SECTION

Measured in overburden of inactive quarry in NE¼ NE¼ SW¼ sec. 21, T. 22 N., R. 3 E., Whiteside County, Illinois; section modified in 1959 from section measured by Paul R. Shaffer in 1954.

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
8. Surface soil A- and B-zones developed in loess	2.5
7. Loess, gray to light yellow-tan, coarse, mostly weakly calcareous but contains a few shell fragments (P-537 upper)	6.5
6. Loess, partly covered by slump, coarse, massive, calcareous, gray to light yellow-tan, very sparsely fossiliferous (P-536 near base)	26.0
Altonian Substage	
Roxana Silt	
Zone I	
5. Silt, coarse, pink-tan, noncalcareous, massive (P-535)	0.2
4. Silt, with some very fine sand; humic staining gradational downward suggesting an A-C soil profile, dark gray mottled with tan and some granular structure, noncalcareous (P-534)	1.5
3. Silt and fine sand, dark gray to dark brownish gray, friable, massive, noncalcareous(P-533 upper; P-532 lower)	3.0
Illinoian Stage	
2. Sangamon Soil, A-zone; sand, with some silt and clay, dark gray to gray-brown; crumb structure becoming prismatic downward (P-531)	1.0
1. Sand; B-zone at top (P-530), dark red to red-brown, clay-rich; grades downward into loose, tan, medium, noncalcareous sand (P-529) with locally thin gravel at base on Silurian dolomite	8.0
Total	48.7

HILLVIEW SECTION

Measured in roadcut in SW¼ SW¼ NE¼ sec. 27, T. 12 N., R. 13 W., Greene County, Illinois, 1961.

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
7. Loess, massive, yellow-tan to gray-tan with mottles and streaks of rusty brown below a 3-foot surface soil profile, calcareous; basal contact transitional through 3-foot zone (P-927 base, P-928, P-929, P-930, P-931, P-932, P-933 9 feet above base)	12.0
Altonian Substage	
Roxana Silt	
Zone IV	
6. Silt, massive, pink to pink-tan, noncalcareous but with secondary $CaCO_3$ nodules (P-923 base, P-924, P-925, P-926 top)	3.5
Zone III	
5. Silt, massive, gray-tan to dark gray, weakly calcareous; gradational contacts (P-919 base, P-920, P-921, P-922 top)	7.0
Zone II	
4. Silt, massive, clayey, dark pink to reddish tan, somewhat lighter in uppermost part; gradational contacts, noncalcareous to very weakly calcareous (P-916 base, P-917, P-918 top)	3.5
Zone I	
3. Silt and very fine sand, massive, dark gray-brown, noncalcareous (P-914 base, P-915 top)	4.0
2. Colluvium of silt with some sand and clay and sparse small pebbles; gradational at top (P-913)	2.0
Illinoian Stage	
1. Sangamon Soil, truncated, developed in till; sandy, clayey silt with a few pebbles and cobbles, a pebble concentrate at top; red-brown, noncalcareous (P-912)	4.0+
Total	36.0

MARION NW SECTION

Measured in cuts on Interstate 57, in cen. SW¼ sec. 11, T. 9 S., R. 2 E., Williamson County, Illinois, 1961.

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
5. Loess, light tan-brown, massive, leached; surface soil in top (P-1072)	8.0
Altonian Substage	
Roxana Silt	
4. Loess, reddish brown with micro-mottling of gray-tan and black, clayey, massive, leached, gradational at top (P-1071)	3.5
Illinoian Stage	
3. Till, clayey and sandy with a few dispersed pebbles, tan to brown, mottled, Mn-Fe staining on joint surfaces, leached, massive (P-1070). Sangamon Soil in top 2.5 feet; strongly developed red to red-brown B-zone	8.0
Pennsylvanian System	
2. Yarmouth Soil developed in Pennsylvanian shale; B-zone 1 to 1.5 feet thick, brown, yellow, and black mottled with Mn-Fe pellets, massive to irregularly platy, clayey, tough, grading downward into green weathered shale that rests on nodular, weathered limestone(P-1068 green shale; P-1069 B-zone)	2.0

Thickness (feet)

1. Pennsylvanian shale, limestone, and siltstone to level of interstate highway grade — 5.0

Total — 26.5

NEW CITY SECTION

Measured in roadcuts in SE¼ NE¼ SE¼ sec. 4, T. 14 N., R. 4 W., Sangamon County, Illinois, 1961.

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

5. Loess, tan, massive, noncalcareous; surface soil in top (P-342-E base; 342-F; 342; 342-G; 342-H; 342-I; 342-J at 4½ feet above base in B-zone) — 6.0

Altonian Substage
Roxana Silt

4. Loess, purple-brown, massive, clayey, noncalcareous; colluvium of brown silt with some sand in basal ½-foot (342-A base; 342-B; 341; 342-C; 342-D top) — 3.0

Illinoian Stage

3. Sangamon Soil, A-zone of silt with very few pebbles (P-340) — 1.5
2. Accretion gley (BG-zone) at top, clayey, well structured, Mn-Fe pellets, gray above grading downward into dark reddish brown (B-zone)with gray mottling (P-339); lower part of B-zone developed in till, greenish gray, yellow-brown, and brown, sandy with some pebbles (P-338); grading downward into oxidized and leached till (P-337; P-336) — 5.5
1. Till, oxidized in upper part (P-335), calcareous throughout; grading downward into compact, tough, blue-gray till containing a prominent zone of sand and gravel — 9.0

Total — 25.0

NEW HARMONY SECTION

Measured in pits 1 mile south of intersection in New Harmony, Posey County, Indiana (SE¼ NW¼ SW¼ sec. 1, T. 5 S., R. 14 W.), 1961.

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

4. Loess, yellowish tan, massive, coarse, compact, friable, calcareous to within 1 foot of top, fossiliferous throughout and abundantly so in lower part; 5 feet below top an incipient soil but not leached of carbonate; concretions of $CaCO_3$ below the incipient soil and more sparsely throughout (samples range from P-1139 at base to P-1148 at 2 feet below top) — 34.0

Thickness (feet)

Altonian Substage
Roxana Silt

Zones II to IV

3. Loess, brown, noncalcareous, massive, darker in upper part, some limonite tubules in lower part; contains very sparse Allogona profunda (P-1136 base; P-1137 middle; P-1138 top) — 4.5

Zone I

2. Colluvium of silt, sand, and a few pebbles, mottled brown, red, and gray, gradational upward into loess; the colluvium appears to truncate the B-zone of the Sangamon Soil below but may contain some A-zone material related to the Sangamon Soil (P-1135) — 1.5

Illinoian Stage

1. Till, clayey, tan-gray in base grading upward into the red-brown B-zone of the truncated Sangamon Soil at top (P-1133 base; P-1134 B-zone) — 3.0

Total — 43.0

NORTH QUINCY SECTION

Measured in roadcuts in NW¼ NE¼ NW¼ sec. 23, T. 1 S., R. 9 W., Adams County, Illinois, 1961.

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

10. Loess, yellow-tan, coarse, calcareous below surface soil, massive, friable, sparsely fossiliferous (P-1223 lower third; P-1222 base) — 16.0
9. Loess, yellow-tan and gray in indistinct beds, calcareous, sparsely fossiliferous, coarse, friable (P-1221) — 4.0
8. Loess, yellow-tan, calcareous, coarse, massive, friable, very sparsely fossiliferous (P-1220 upper; P-1219 lower) — 8.0
7. Loess, mottled gray and tan with some brown spots, calcareous, massive, coarse, friable (P-1218) — 4.0
6. Loess, somewhat clayey, gray, dolomitic, massive; sharp contact at top but gradational at base (P-1217 top; P-1216 middle; P-1215 base) — 5.0

Altonian Substage
Roxana Silt

5. Silt with some clay and fine sand, purplish brown, noncalcareous, some brown mottling (P-1214) — 1.0
4. Sand, medium to coarse, tan-brown with slight pink cast, noncalcareous, massive; contains some angular chert fragments (P-1213) — 3.0

	Thickness (feet)
Illinoian Stage	
3. Sangamon Soil developed in sand and gravel; B-zone dark red, clayey, tough, grading downward into sand and gravel locally cemented; contains chert grains (P-1212 upper; P-1211 lower)	5.5
2. Clayey silt, gray with brown mottling, noncalcareous, columnar jointing, tough (P-1210 upper)	4.5
1. Covered in lower part; sand, coarse, red (P-1209 upper)	5.0
Total	56.0

PATTON SOUTH SECTION

Measured in NE¼ NW¼ NE¼ sec. 8, T. 1 S., R. 12 W., Wabash County, Illinois, 1961.

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
4. Loess, gray-tan with mottling of gray and some brown, darker color in lower part, leached, massive, compact; well developed surface soil in top (P-1155 lower; P-1156 upper)	6.0
Altonian Substage	
Roxana Silt	
3. Colluvium of sand, silt, and some small pebbles with little clay, brown, massive, gradational at top (P-1154)	1.5
Illinoian Stage	
2. Sangamon Soil, B-zone developed in till, red-brown, micro-blocky, tough, Mn-Fe pellets, gradational at base (P-1153)	1.5
1. Till, gray with brown mottling, clayey with dispersed pebbles of granite and other rocks, leached; to bottom of road ditch (P-1152)	2.0
Total	11.0

RICHLAND CREEK SECTION

Measured in cen. SE¼ NE¼ sec. 20, T. 28 N., R. 2 W., Woodford County, Illinois (2 miles west of Lowpoint, Illinois, and near Horberg's sec. 18), by John C. Frye, A. Byron Leonard, and H. B. Willman, 1959.

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Shelbyville-Bloomington Moraines	
9. Till, bouldery, compact, calcareous, gray with pink in uppermost part (P-566 near base)	20.0
Morton Loess	
8. Loess, tan to dove gray, calcareous, compact and platy; contains shell fragments of <u>Succinea gelida</u> (P-565)	3.0
Farmdalian Substage	
Farmdale silt and peat	
7. Peat, interbedded with silt, more silty upward, noncalcareous to weakly calcareous in upper part, dark gray and dark brown; contains logs, sticks, and twigs (P-563 lower; P-564 upper silt)	5.0
6. Silt, gray, massive, compact, noncalcareous, some charcoal flakes, gradational at base (P-562)	2.5
Altonian Substage	
Roxana Silt	
5. Sandy silt, greenish gray, noncalcareous; some clay in lower part; gradational at top and bottom	1.5
4. Colluvium of clay and silt with some sand and pebbles, greenish gray, noncalcareous, massive, compact; gradational at top but with sharp contact at base (P-561)	1.5
Illinoian Stage	
3. Truncated Sangamon Soil; colluvium of pebbles and sand, unoriented, with some silt, noncalcareous, brown	1.5
2. Sand and some gravel, calcareous at base but noncalcareous in upper part, brown to tan (P-560)	2.0
1. Till, blue-gray, clayey, calcareous, compact (P-559)	3.0
Total	40.0

SEEHORN SECTION

Measured in roadcuts in SW cor. sec. 32, T. 3 S., R. 7 W., Adams County, Illinois, 1961.

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
5. Loess, with deep surface soil in upper part (P-1200); lower part tan to yellow-tan, weakly calcareous, massive, some brown mottling (P-1199); soil above tan-brown, leached, B-zone mottled and with clay skins, 8 feet thick	12.0
4. Silt, gray-brown, massive, leached, some brown mottling (P-1198) (basal contact not exposed)	3.0
Altonian Substage	
Roxana Silt	
3. Silt with some sand and a few small angular chert fragments, leached, light brown with some mottling; colluvium (P-1197)	4.0
Illinoian Stage	
2. Sangamon Soil developed in colluvium of clay, silt, and some sand with scattered pebbles of angular chert, red to brownish red, leached (P-1196)	4.0

	Thickness (feet)
Kansan Stage	
1. Yarmouth Soil developed in rubble of angular chert fragments, clay and silt, dark red, tough, blocky, with Mn-Fe staining on joint surfaces; grades downward into brown clay and silt with angular chert; extends to bottom of roadcut (P-1195)	3.5
Total	26.5

VARNA SECTION

Measured in NW¼ NW¼ NE¼ sec. 16, T. 30 N., R. 1 W., Marshall County, Illinois (cutbank exposure along tributary to Sandy Creek; ½-mile downstream from Horberg's sec. 16), by John C. Frye, A. Byron Leonard, and H. B. Willman, 1959.

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Shelbyville Moraine	
12. Till, locally slumped, calcareous where not in surface soil, gray; thickens laterally and has sand and gravel zone at base; maximum thickness 15 feet	3.0
Morton Loess	
11. Loess, tan to gray-tan, calcareous, meagerly fossiliferous; some color banding and rusty crenulate zones in upper part (P-573, 1 foot above base)	5.0
Farmdalian Substage	
Farmdale Silt	
10. Loess, pale purplish-pink, calcareous, friable; laterally variable in thickness	0.5
Altonian Substage	
Roxana Silt	
Zone IV	
9. Loess, noncalcareous, rusty brown with 1-inch dark brown streak at base, friable, massive (P-572)	0.8
Zone III	
8. Loess, gray, pink and rusty brown interzoned, locally organic-rich, noncalcareous, massive (P-571)	1.5
7. Loess, discontinuous color band, light gray, noncalcareous, massive, (P-570)	0.3
6. Loess, banded pink and tan, noncalcareous, massive but with some color banding (P-569)	1.0
Zone II	
5. Loess, pink, noncalcareous, massive (P-568)	1.2
Zone I	
4. Silt, with some sand and very few pebbles; colluvium, gray to streaked gray and rust, noncalcareous, massive (P-567)	1.0
Illinoian Stage	
3. Sangamon Soil; silt, sand, and a few pebbles, medium gray to dark gray, noncalcareous, friable, massive; locally faintly pelletized structure; A-zone of Sangamon Soil, but gradational with colluvium above	0.5
2. Sangamon Soil; B-zone developed in till, red-brown in upper part grading downward to tans, leached; upper part has crumb to micro-blocky structure, some clay skins and a few Mn-Fe pellets	2.5
1. Glacial till, gray to blue-gray, calcareous, compact, pebbly; in upper part some zones of tan till; a few small lenses of sand and gravel	20.0
Total	37.3

WOLF CREEK SECTION

Measured adjacent to Interstate Highway 57, 1.9 miles south of Williamson County line, sec. 8, T. 11 S., R. 2 E., Johnson County, Illinois, 1961.

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
4. Loess, massive, gray-tan, leached, friable, locally mottled with pink-tan; medium to fine silt; gray zone occurs below the B-zone of the surface soil (P-1060)	5.0
Altonian Substage	
Roxana Loess	
3. Loess, pink-tan, gradational top and bottom, darker than above unit, massive, leached (P-1059)	2.5
Illinoian Stage	
Loveland Loess	
2. Loess, dark pink-brown, mealy but compact, leached, massive (P-1058)	1.5
Pennsylvanian System	
1. Strongly developed red B-zone in Pennsylvanian sandy shale	
Total Pleistocene	9.0

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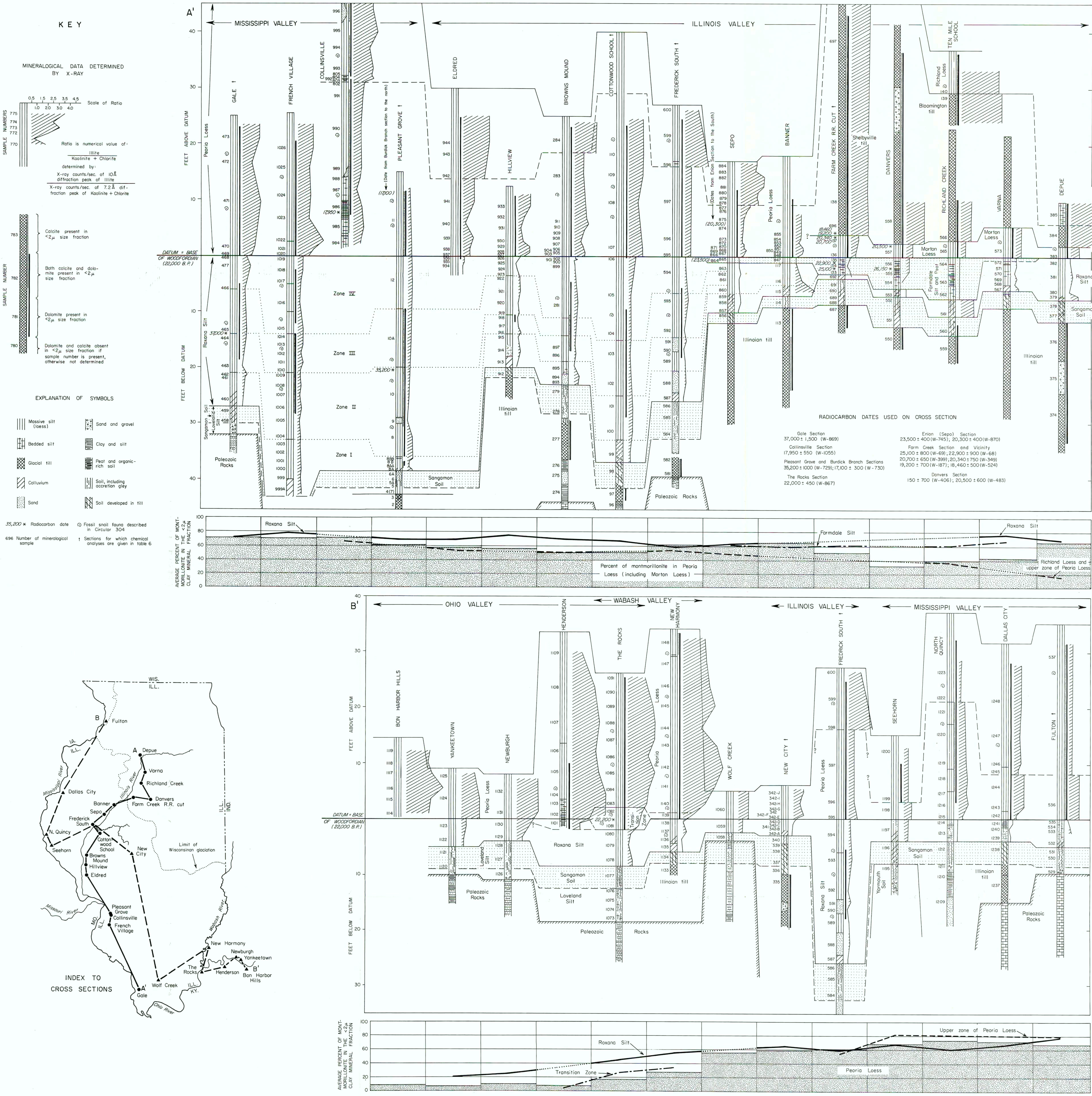

LOESS STRATIGRAPHY AND MINERALOGY OF MEASURED SECTIONS

JOHN C. FRYE, H. D. GLASS, AND H. B. WILLMAN

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ILLINOIS STATE GEOLOGICAL SURVEY

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