STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

MINERALOGY OF GLACIAL TILLS AND THEIR WEATHERING PROFILES IN ILLINOIS

Part I. Glacial Tills

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ABSTRACT

The mineralogy of sand, silt, and clay fractions is used to characterize the tills in Illinois that were derived from several source areas. Tills from the northwest are distinguished by relatively high percentages of montmorillonite, epidote, and calcite, from the Lake Michigan basin by relatively high percentages of illite and dolomite, from Green Bay by the presence of abundant vermiculite, and from the Saginaw-Lake Erie lobes by relatively high percentages of garnet and illite. Within the state many of the stratigraphic units are also distinguishable by their mineral composition.

INTRODUCTION

Throughout most of Illinois the deposits lying immediately below the surface consist of loess or glacial drift of Pleistocene age. These near-surface deposits are important sources of construction raw materials; they are involved in virtually all types of construction work; they serve as raw material for ceramic products; they serve as aquifers and aquitards for ground-water supplies; and they are the parent materials for most of the soils of the state. Because of the importance of these deposits in Illinois, the State Geological Survey has been engaged in a regional study of their mineralogy, particularly of the sand, silt, and clay fractions that compose the predominant part of their bulk. Mineralogical data on Illinois loesses were reported in Circular 334 (Frye, Glass, and Willman, 1962) and the present report describes the results of studies of the glacial tills. The second part of the present study will describe the mineralogy of the weathered zones in the tills and of the accretion-gley deposits on them.

In addition to describing the mineralogy of the matrix of the tills in various parts of the state, the mineral composition is used to identify the areas crossed by the glaciers–the source areas of the deposits. Furthermore, the contrasts in the

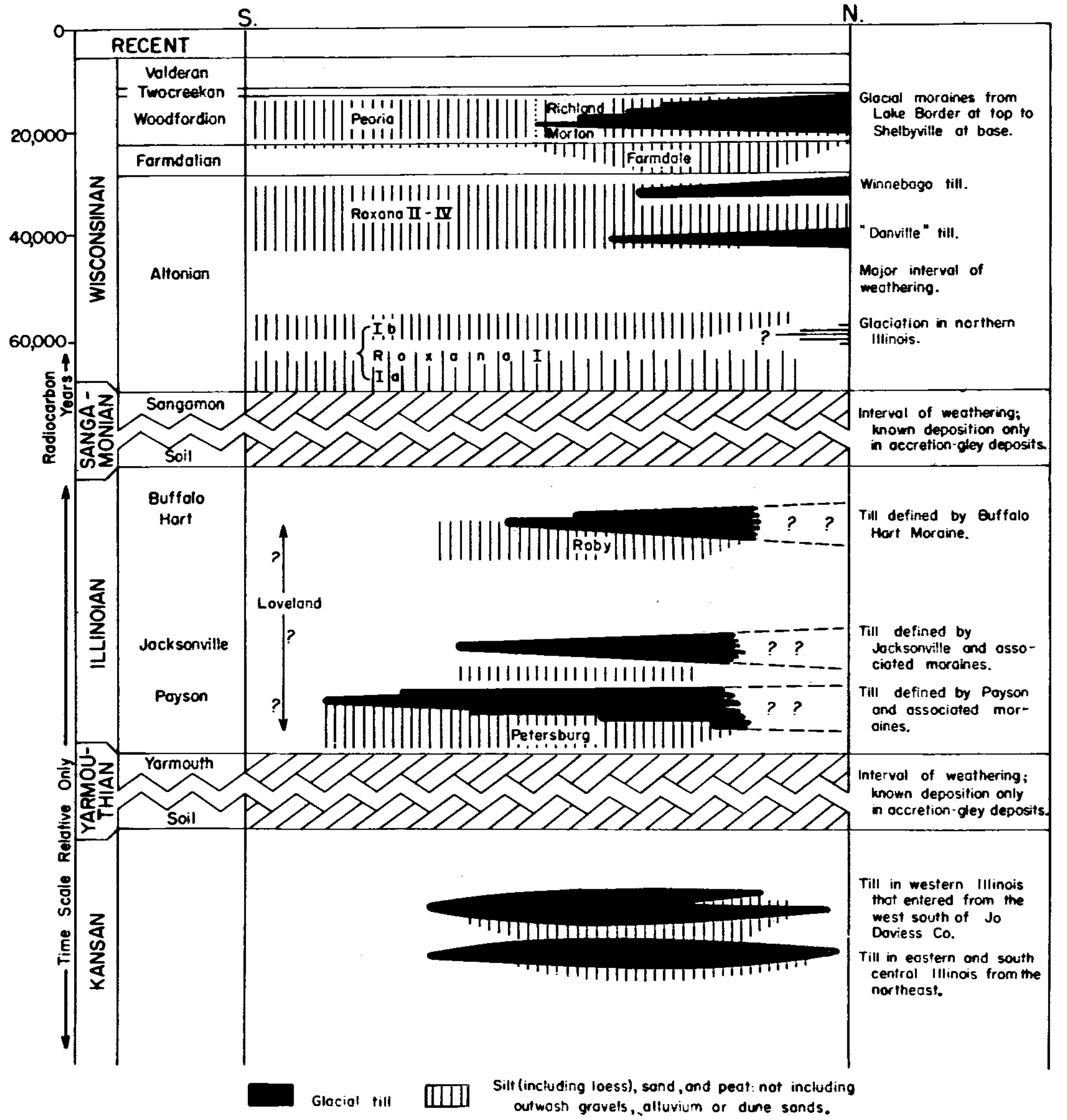

Fig. 1 - Time-space diagram of post-Nebraskan Pleistocene deposits in Illinois. Time control for the Wisconsinan is based on radiocarbon dates; all radiocarbon dates used were determined in the Washington laboratory of the U. S. Geological Survey. The diagram is arranged north-south, but it is a composite of an east-west belt the entire width of Illinois. Outwash deposits, alluvium, and dune sands are not shown.

mineralogy of the several tills can be used in many places to identify the various stratigraphic units within the till deposits.

Prior to the present study, few mineral analyses of Illinois tills have been available. In order to evaluate the geographic and stratigraphic variations in composition of the tills, mineral analyses of more than 350 samples from localities throughout the state were made. Some of these analyses were published in a report discussing gumbotil, accretion-gley, and the weathering profile (Frye, Willman, and Glass, 1960).

The X-ray analyses were made by Glass, the heavy-mineral separations and counts were made largely by Constantine Manos, the light-mineral counts were made by James Bloom and Manos, 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.

STRATIGRAPHY

The stratigraphy of the glacial deposits in Illinois is complex and diversified because the state was invaded by glaciers during all four major stages of Pleistocene glaciation (figs. 1 and 2) and by lobes from different directions. During the Kansan, Illinoian, and Wisconsinan Stages, ice sheets advancing from the northeast spread over large areas of Illinois. The Illinoian ice, reaching nearly to the southern tip, covered about 90 percent of the state. During the Nebraskan and Kansan Stages, glaciers advancing from the northwest spread over parts of western Illinois. With the exception of a small area in western Illinois, where Kansan drift is at the surface, the older drifts were everywhere overridden by the Illinoian ice sheet. Thus western Illinois, and a bordering area in eastern Iowa, is the only region south of the Driftless Area of Wisconsin and Illinois in which tills from northwestern source areas are overlain by till from northeastern areas. The stratigraphy of the Wisconsinan loesses of Illinois has been described in a previous report (Frye, Glass, and Willman, 1962).

Nebraskan

The Nebraskan glacier appears to have invaded western Illinois (Horberg, 1950, p. 100; Flint and others, 1959), but its deposits have been so extensively eroded that the area it covered is highly indefinite. Only a few exposures have been identified as Nebraskan till (Bell and Leighton, 1929; Wanless, 1957) and many of these are questioned. Deeply weathered gravel beneath Kansan till appears to represent Nebraskan outwash in a few localities. None of our samples were collected from Nebraskan till in Illinois, but one sample is from Nebraskan outwash near Peoria, and three samples represent Nebraskan till at Dubuque, Iowa.

Drift that may be Nebraskan in age has been noted in central Illinois (Horberg, 1953), but the evidence is not conclusive. Inclusions of weathered till in calcareous Kansan till at Danville have been interpreted as evidence of an eastern lobe of Nebraskan ice (Eveland, 1952), but the age of the till called Kansan has been questioned (Ekblaw and Willman, 1957). The existence in Illinois of an eastern Nebraskan glacier has not been demonstrated.

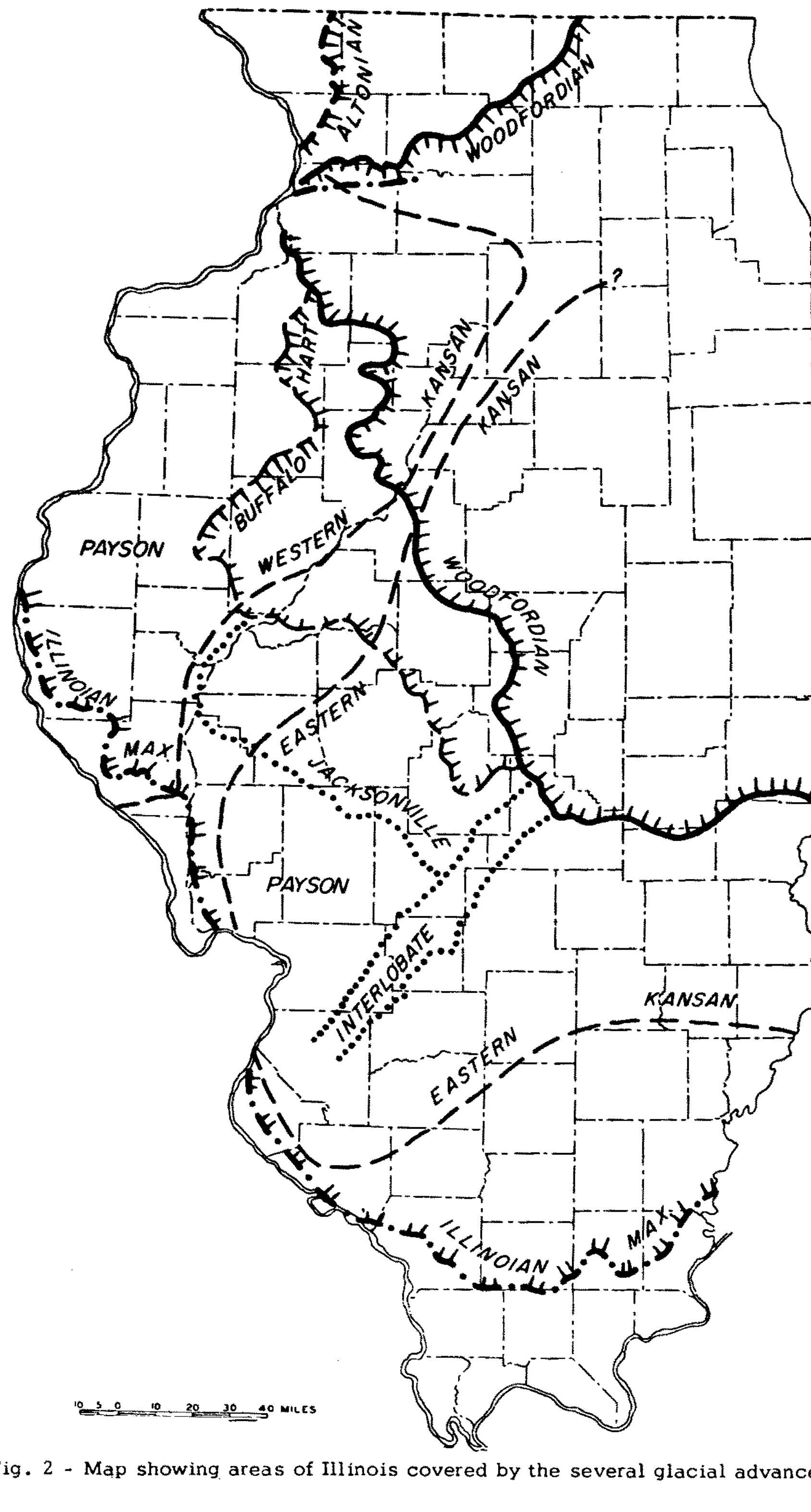

Fig. 2 - Map showing areas of Illinois covered by the several glacial advances.

Kansan

The Kansan glacier that advanced southward west of the Driftless Area to the Missouri Valley in Missouri spread eastward into Illinois, to approximately the present position of the Illinois Valley (Leverett, 1899; Horberg, 1956; Wanless, 1957; Flint and others, 1959). The mineralogical evidence given in this report strongly supports this general distribution for the western drift (fig. 2).

A lobe of Kansan ice also entered Illinois from the northeast and spread westward nearly to Illinois Valley and southwestward to Mississippi Valley. It appears not to have extended as far south as the later Illinoian glacier, but occurrences of the Kansan drift in southern Illinois are so scattered that the position of the Kansan boundary is indefinite.

The pre-Illinoian glaciation of central and eastern Illinois was recognized by Leverett (1899) and MacClintock (1929), although they did not specifically assign the drift to the Kansan. The degree of weathering of the eastern pre-Illinoian drift has been thought to be no greater than that of the western Kansan, and the designation of Kansan has become generally accepted.

As overlapping deposits of eastern and western Kansan till have not been demonstrated, there is at present no evidence as to their relative ages. The Kansan record is probably much more complex than has so far been recognized (fig. 1).

Illinoian

The Illinoian witnessed the greatest westward and southward flow of ice from the region of eastern Canada that occurred during the Pleistocene. The ice extended westward across Illinois into Iowa and southward until stopped by the slopes of the Shawnee Hills. The great extent may have resulted from a particularly strong flow of ice from the Erie and Saginaw lobes that diverted the Lake Michigan lobe glacier into a westerly direction.

The distinctive belt of ridged drift that rises above the nearly flat Illinoian till plain and extends from the Wisconsinan front near Pana southwest to the Mississippi Valley near Belleville appears to be an interlobate complex marking the zone of contact between the lobes. The pronounced differences in the mineralogy of the till on the two sides of the ridged drift, reported in this study, support the interpretation of the ridged drift as dominantly morainic and interlobate, which was suggested by Leverett (1899, p. 73) and long advocated by George E. Ekblaw, rather than dominantly crevasse deposits, as advocated by Ball (1940) and Leighton and Brophy (1961). The mineralogical data do not oppose the concept that the ridges mark the front of a lobe of ice that remained in southeastern Illinois after ice retreat from western Illinois, which was favored by Leverett (1899, p. 74). However, the many distinctive linear features and the absence of definite westward-facing fronts oppose its interpretation as a normal end moraine.

Although the Illinoian drift southeast of the interlobate ridges is essentially contemporaneous with that to the northwest, it lacks end moraines comparable to those that were formed during the retreat of the western ice and that serve as a basis for subdivision of the Illinoian Stage into the Payson, Jacksonville, and Buffalo Hart Substages. The moraines represent readvances after intervals of glacial retreat. Features suggesting stagnation of the ice are widely present in the area of Payson drift (Leighton and Brophy, 1961). The Buffalo Hart drift, particularly in the type region in Sangamon and Logan Counties, has a relatively fresh appearing morainic topography, not unlike much of the Wisconsinan drift, and suggests active ice during its retreat.

In many localities along Illinois Valley and its tributaries, Illinoian till overlies calcareous outwash silts and loess deposited during the advancing stage of the Illinoian glacier. This silt has been correlated with the Loveland Loess of the upper Missouri Valley (Leighton and Willman, 1950), but the type Loveland Loess is considered to be largely late Illinoian in age (Frye and Leonard, 1952). A local rock-stratigraphic name is needed for these deposits which in most localities consist of both water-laid and wind-deposited silts. The name Petersburg Silt is here proposed from an exposure in a road cut just south of Petersburg, Illinois, that is described in the Petersburg geologic section. At this locality the Petersburg Silt is overlain by Illinoian till and overlies the Yarmouth Soil. The name Petersburg has been used informally for these silts in previous reports.

The name Loveland will continue to be used for the Illinoian loess beyond the limit of Illinoian glaciation where the material is mostly, if not entirely, loess and represents the deposits of Illinoian age.

In some areas calcareous, fossiliferous silts, thought to occur beneath Payson till, as in the Carlinville area (Ball, 1952), have been interpreted as evidence of an interglacial climate, and the underlying till has been classified as Kansan. Because the underlying till is calcareous and essentially unweathered, the silts thin and nonpersistent, and the fauna meager, it seems more likely that these silts represent an interval of ice withdrawal during Payson time and that the till below as well as above these silts should be classed as Payson.

The Jacksonville drift is overlapped extensively by the Buffalo Hart in western Illinois (Wanless, 1957) and in this area sand, gravel, and silt deposits frequently mark the position of the missing Jacksonville till. Fossiliferous silts, recently named Roby (Johnson, 1962), separate the Buffalo Hart drift from Jacksonville drift in central Illinois.

Several soils have been found in the silt sequence of Illinoian age in Nebraska and Kansas (Frye and Leonard, 1954), but soil zones have not been recognized definitely within the Illinoian sequence in Illinois. If such soils are present, they may have been misidentified as the pre-Illinoian Yarmouth Soil, because of the assumption that the first soil beneath the Sangamon must be Yarmouth. As no evidence of leaching of carbonates has been demonstrated in the many exposures of intra-Illinoian deposits, an alternative possibility is that the Sangamon Soil in the Mississippi Valley and at its type locality is a composite of the several soils in the Missouri Valley, which therefore are by definition Sangamonian rather than Illinoian.

A soil which may be intra-Illinoian is exposed in the Pleasant Grove School Section, the type section of the Roxana Silt (Frye and Willman, 1960, p. 10). In that exposure the Wisconsinan loess rests on the Sangamon Soil which is developed on silt leached to a depth of about 10 feet. The lower part of the silt is calcareous and rests on weathered till which is leached to a depth of about 3 feet. If the till is Illinoian, and the surface till in this area is Illinoian, the soil on the till is intra-Illinoian. As the Illinoian till in this area is oldest Illinoian, the till may have been weathered before deposition of the overlying silt during late Illinoian time, and the weathered zone therefore would not necessarily be found where the Illinoian sequence is more complete.

On the other hand, the area was covered also by the Kansan galcier, and the till may be Kansan. In this case, the weathered zone on the till, which is much weaker than the normal Yarmouth Soil, was partly truncated before deposition of the overlying silt. It is completely truncated by the silt in part of the exposure. The silt would then probably correlate with the widespread Petersburg Silt. Development of the Sangamon Soil on the silt requires that the Illinoian till be eroded completely before or during early Sangamonian time, which is not improbable because of the bluff situation.

The mineralogical data are not conclusive in this case, but the slightly greater content of garnet than epidote (samples P-1, P-1A) is more characteristic of Payson till than either eastern Kansan or southeastern Illinoian tills in which garnet is generally several times more abundant than epidote. As the locality is a short distance west of the interlobate ridged drift of the Illinoian, the till can be Payson, but if Kansan it must be eastern Kansan. The high dolomite content of the samples may be even more suggestive because dolomite exceeds calcite in nearly all Illinoian samples, but calcite exceeds dolomite in all 11 samples of eastern Kansan. The high montmorillonite content is consistent with Payson composition, but Kansan drift in the bluff areas could be enriched in montmorillonite by the glacier riding over a possible western-derived loess and thereby modified to resemble Payson.

Indentification of tills by counting soils assigns automatically the till at Pleasant Grove to the Kansan. This interpretation may be preferable until the presence of intra-Illinoian soils in Mississippi Valley is definitely established. Nevertheless, intra-Illinoian soils, if present, are likely to be found among those previously called Yarmouth on this basis.

Wisconsinan

During the Wisconsinan Stage of glaciation, ice from the Lake Michigan lobe spread widely over northeastern Illinois. Two major episodes of glaciation are indicated in the Illinois sequence:

(1) The earlier, or Altonian, is represented by a sequence of loesses (Roxana Silt) best developed in the Illinois River bluffs beyond the Wisconsinan till plain and in the Mississippi Valley bluffs below the mouth of Illinois River, by surface drift in extreme northern Illinois, and by isolated occurrences of drift elsewhere.

(2) The later, or Woodfordian drift, represents the maximum extent of Wisconsinan glaciation in Illinois, except in extreme northern Illinois, and includes all the end moraines deposited in Illinois during the withdrawal of the ice into the Lake Michigan basin.

Altonian tills.–The Altonian drift exposed in northern Illinois was long assigned to the Illinoian, but when the degree of weathering was found to be much less than represented by the Sangamon profile on Illinoian drift farther south, it was assigned to an early Wisconsinan age and correlated with the Farmdale Loess (Shaffer, 1956). Reclassification of the Wisconsinan Stage, among other factors, was required by evidence that most of the loess assigned to the Farmdale had a different lithology and was older than type Farmdale. This made it desirable to apply a rock-stratigraphic term to the northern drift, and the name Winnebago was introduced (Frye and Willman, 1960, 1963). The Winnebago drift was assigned to the Altonian Substage of glaciation, and because of its slight depth of weathering beneath Peoria Loess and a radiocarbon date from similar drift in southern

Wisconsin, it was believed to correlate with the youngest of the Altonian loesses. More recent studies in northern Illinois have shown that the Altonian drift is complex with intervals of retreat and readvance indicated by relatively weak morainic ridges and changes in drift composition. Subsurface studies have shown a prominent readvance of the ice at Rockford (Hackett, 1960), and three distinctive till sheets have been differentiated in the Winnebago drift in Boone and McHenry Counties, largely by detailed lithologic studies of samples from closely-spaced borings along the Northwest toll road (Kempton, 1962). Several of the intervals of Altonian glaciation indicated by the loess sequence may be present in northern Illinois. However, as evidence of weathering between the Winnebago till sheets is completely lacking, the oldest Altonian loess (Roxana Zone I), which is strongly altered by weathering, probably was deposited before the earliest Altonian glaciation recognized to date in Illinois.

At Danville, a pre-Shelbyville till, tentatively referred to as the "Danville" till, occurs in a valley that was incised through the Sangamon Soil profile developed on Illinoian till and is assigned to the Altonian Substage. This till was first classed as Illinoian (Eveland, 1952), but later, like the drift in northern Illinois, was assigned to the Farmdale (Ekblaw and Willman, 1957). As radiocarbon dating of wood from the "Danville" till indicates an age greater than 40,000 years (W-197), the "Danville" till may be mid-Altonian in age.

Despite a conflict in radiocarbon dates available from silt exposed at the Lake Bloomington spillway (Leonard and Frye, 1960, p. 29), the underlying tills are pre-Woodfordian in age and appear to lie above the position of the Sangamon Soil and Illinoian till encountered in borings. These tills are assigned to the Altonian and may be comparable in age to the "Danville" till.

Because of these occurrences, Altonian glaciers are believed to have covered a large area in northeastern Illinois (Frye, Glass, and Willman, 1962, fig. 3).

Woodfordian tills.—The Woodfordian drift is classified into morphostratigraphic units based on the end moraines and associated drift sheets. A sequence of about 30 named units is present in the Illinois part of the sequence. Several minor moraines have not been named, and the larger moraines, such as the Shelbyville, Bloomington, Marseilles, and Valparaiso, consist of several superimposed moraines with traceable crests that also are not named separately. The Woodfordian drift is an outstanding example of the pulsating, cyclic nature of the retreat of a glacier front while the glacier remains active. The rough morainic topography is in marked contrast to the generally flatter topography, containing eskerine, crevasse, and ice-marginal features, of large parts of the Payson and Winnebago drifts, which may have resulted from stagnation of the glacial ice.

As required by the short time span of the Woodfordian (less than 10,000 radiocarbon years), individual cycles of retreat, readvance, and end moraine building must have been much shorter than has been generally assumed (Horberg, 1955). This is further indicated by the absence of leaching or even significant oxidation between the drift sheets, with the exception of local evidence of slight leaching between the Shelbyville drift and the LeRoy-Cerro Gordo drift (Ekblaw and Willman, 1957).

The absence of any one break in the sequence of moraines that is more significant than many of the others in length of time, in extent of retreat and readvance, in realignment of the ice front, in change in composition of the drift, or in lateral traceability resulted in adoption of the name Woodfordian for drifts previously differentiated in Illinois as Iowan (of Illinois), Tazewell, and Cary (Frye and Willman, 1960, 1963). The Tazewell-Cary differentiation was widely accepted in the mistaken belief that a significant time interval separated Marseilles and Minooka drifts in northeastern Illinois. The Tazewell-Cary differentiation used in adjacent states appears to correlate more nearly with the Valparaiso Moraine than with the Minooka Moraine.

Many of the individual till sheets of the Woodfordian have distinctive lithologies that permit surface tracing as well as identification in buried sequences. Differences in color and in content of clay, silt, sand, pebbles, and boulders may persist for 100 miles or more, but they also may change abruptly. Mineralogical characteristics determined in this study show much greater uniformity than mechanical analyses and field characteristics and therefore are less useful in differentiating the individual morphostratigraphic units.

Where lithology does not distinguish the individual Woodfordian till sheets, differentiation is based largely on the sequences of moraines, overriding relations at intersections of the moraines, and the presence of water or wind deposits within till sequences. The prevalence of readvance before deposition of successive moraines is indicated locally by sequences of as many as 6 or 7 till sheets separated by water-laid deposits.

The relative ages of the Woodfordian moraines referred to in this report are as follows:

Lake Border (youngest)
Valparaiso-West Chicago
Manhattan
Minooka
Marseilles
Farm Ridge
Cropsey-Gilberts
Marengo
Normal
Metamora
Bloomington
Urbana
Champaign
LeRoy-Cerro Gordo
Shelbyville-White Rock

The youngest one or two morainic units of the Woodfordian were deposited north of Illinois along the lake shore in Wisconsin. The first widely traceable interruption in the withdrawal of the Wisconsinan glacier from the Shelbyville front is marked by the Two Creeks Forest Bed, which terminates the Woodfordian Substage. Although short, this interval of ice withdrawal is much longer than those during the Woodfordian and its wide distribution justifies its recognition as a substage, named Twocreekan (Frye and Willman, 1960).

Valderan glaciation.—The Valderan glaciation, which followed the Twocreekan withdrawal, did not reach Illinois, but meltwaters discharged through Lake Chicago and its outlet into the upper Illinois Valley.

MINERALOGY

The glacial tills of Illinois have received intensive study with regard to their stratigraphy, to their morphology, to the geographic pattern of their end moraines, and to their age and correlation, but only minor attention has been given to their mineral composition. The results of 167 analyses by optical methods of the minerals in the fine and very fine sand (.062-.250 mm), 369 analyses by X-ray diffraction of clay minerals, dolomite, and calcite, and 7 chemical analyses of the gross samples, mostly from the tills of Illinois, are reported here. The geographic distribution of samples used in this study is shown in figure 3, the samples are described in table 1, and the results of analyses are presented in tables 2, 4, and 6 and figures 4, 5, and 6. Tables 3 and 5 give average analyses by stratigraphic unit and geographic region. Figure 7 gives the ranges in clay-mineral composition for Kansan and Illinoian samples, and figure 8 shows the geographic distribution of montmorillonite concentration in Illinoian and Wisconsinan tills.

The mineralogical studies have three major objectives: (1) descriptive characterization of the tills in Illinois, (2) differentiation of the several stratigraphic units by their mineral composition, and (3) development of information concerning the source of the materials in Illinois tills and the direction and route of movement of the transporting glaciers.

Tills have a complex mineral composition and may contain representatives of all the rock and mineral types that occur in the bedrock of the region traversed by the transporting glacier. However, irregularities in the depth and extent of erosion by the glacier from place to place, direction of ice movement, and amount of local deposition may cause significant differences in the mineral composition of the till deposited by a single glacial lobe. Within the tills of Illinois, igneous and metamorphic rocks and limestone and dolomite are dominant among the cobbles and boulders; quartz grains are dominant within the sand fraction; the clay fraction is composed largely of clay minerals; and other minerals have peaks of abundance in different size fractions.

As analyses of all size fractions of all samples were impractical, it was decided to concentrate on one fraction of sand and on the clay fraction. Clay is present in all samples, and even in well sorted sands sufficient clay for X-ray

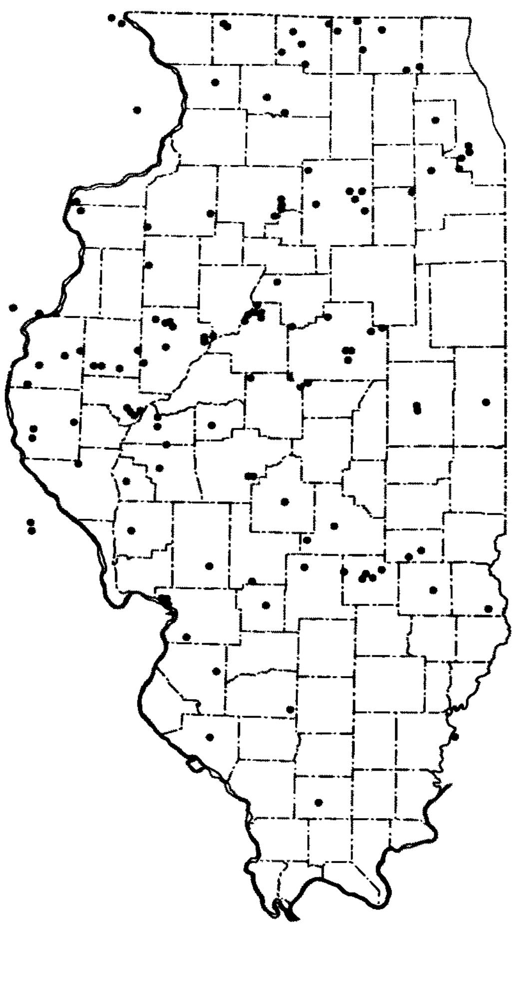

Fig. 3 - Distribution of sample localities.

analysis can be obtained generally by use of proper techniques. In the sand the combined fine and very fine sand fraction (62-250 microns) was found to be the coarsest material present in sufficient quantity through the entire range of samples, which include tills, loesses, weathering profiles, and outwash. By use of this size fraction the analytical data presented in our several related reports are comparable.

The degree of mineral differentiation was limited by the large number of samples involved in the study, and emphasis was placed on those minerals most indicative of differences in source areas. As the heavy minerals in the sand fractions of the tills are not common in Paleozoic sediments, they must have been derived largely from the more distant Precambrian rocks of the Canadian Shield. Variations in the composition of the sedimentary rocks eroded by the ice should be reflected in the X-ray analyses of the clay fraction. Geographic differences in clay minerals were anticipated because of the high montmorillonite content of Cretaceous sediments in the western region, which contrasts with the abundance of illite and chlorite in the Paleozoic sediments in Illinois and to the east. The dominance of dolomite over limestone in Lake Michigan lobe drift, in contrast with the dominance of limestone over dolomite in western drift (Horberg, 1956; Anderson, 1957; Wanless, 1957), reflects variations in the relatively local rather than distant bedrock. The relation of limestone to dolomite reported by earlier workers was determined by counts of pebbles, but as shown by the results reported here the relation of calcite to dolomite may be more readily evaluated by the X-ray analyses of the fine fractions in the tills.

Conventional methods were used in separating the heavy minerals. The sand fractions of the tills were acid treated, sieved, and heavy minerals separated from the 62-250 micron fraction using bromoform. The heavy minerals were mounted in balsam on slides and the percentages determined by counting 200 grains.

Using oriented-aggregate techniques, the amounts of montmorillonite, illite, chlorite, and kaolinite were calculated from X-ray diffraction data of the less than 2-micron fraction. Montmorillonite as used here includes all clay materials that expand to about 17Å with ethylene glycol. Mixed-layer clay minerals and expansible chlorite or vermiculite are included therefore with the montmorillonite. Chlorite includes all 14Å material that does not expand with ethylene glycol, and it includes any nonexpansible vermiculite. Illite and kaolinite are used as generally accepted. The values for kaolinite and chlorite are combined in the tables; the values for montmorillonite and illite are given for each. Determination of carbonate minerals was made by X-ray diffraction analysis of finely ground bulk samples and, therefore, reflects the composition of the combined sand, silt, and clay sizes. Data are expressed as X-ray counts per second, which indicates semiquantitatively the amount of calcite and dolomite.

Heavy Minerals

Certain heavy minerals provide an effective means of differentiating tills from different source areas, even though they comprise much less than one percent of most tills. The usefulness of heavy minerals has been particularly well shown in Ontario by the studies of Dreimanis, Reavely, Cook, Knox, and Moretti (1957).

The large variety of heavy minerals found in the sand fraction of the tills of Illinois is derived mainly from the Precambrian rocks of the Canadian Shield.

Heavy minerals in the Paleozoic sandstones are largely limited in variety and low in abundance. The Cambrian and Ordovician sandstones are mostly medium to coarse grained, and consequently have a low percentage of the sand fraction analyzed in this study. Northeast of Illinois, the Cambrian and Ordovician sandstones are not an important source of the sand in the till as they were overlapped by Middle Ordovician limestones.

Pennsylvanian and Mississippian sandstones and siltstones could, and probably did, contribute significant amounts to the sand fraction studied, but they also have a low percentage and limited suite of heavy minerals, generally dominated by zircon and tourmaline with minor amounts of garnet.

Contributions from the Paleozoic bedrock, therefore, did not significantly modify the heavy minerals, either in abundance or species, even where they made a major change in the composition of other fractions of the till. The heavy mineral suites in the Illinois tills are similar to those reported in the drift of Ontario (Dreimanis and others, 1957; Dreimanis,1960) where most of the till is derived directly from Precambrain rocks.

A relatively thin cover of Cretaceous and Pliocene sands and gravels on the erosional surface of the Paleozoic rocks is probably the source of the staurolite, kyanite, and andalusite in the tills from the western source areas. These minerals are most abundant in the deposits of the earliest glaciers which may have completely eroded the surficial veneers from large areas. The mineral composition of Cretaceous and Tertiary sands in the upper Mississippi Valley is recorded by Andrews (1958).

Our data show that tills deposited by glaciers that invaded Illinois from the west and northwest can be differentiated consistently from tills deposited by glaciers from the east and northeast by their heavy minerals. The western-derived drift is relatively high in epidote and low in garnet. It is also relatively high in tourmaline, zircon, kyanite, staurolite, and andalusite, but these minerals are individually low in amount, generally less than 5 percent of the transparent heavy minerals. The western drift generally has a higher content of black opaque minerals. Analyses of heavy minerals in the western tills in Iowa are reported by Kay and Graham (1943, p. 182) and Ruhe (1956). Arneman and Wright (1959) give heavy mineral analyses for tills in the Des Moines lobe in Minnesota.

The eastern-derived tills in Illinois appear to include deposits from four lobes. The Green Bay lobe eroded a trough in Maquoketa Shale along the position of Green Bay, in the area where the strike of the Maquoketa outcrop is parallel to the direction of ice movement. It is essentially a branch of the Lake Michigan lobe. In extreme northern Illinois, the relatively high epidote content of the Winnebago drift and of the northern part of the Woodfordian drift suggests derivation from the Green Bay lobe which has a high content of epidote (Murray, 1953). The source of the heavy minerals may be in the area north of Lake Superior where large percentages of epidote are reported by Dreimanis and others (1957, fig. 1).

The Lake Michigan lobe deeply eroded a trough in Devonian and Mississippian shales. The presence of a Lake Michigan lobe in Kansan time has not been demonstrated and the lobe may have first developed during Illinoian glaciation. Till deposited by the Lake Michigan lobe is characterized by the abundance of dolomite from the Niagaran (Silurian) and Galena (Ordovician) dolomites along the west side of the lobe, and of shale from beneath the lake. The heavy minerals appear to be characteristic of the Precambrian rocks north of Lake Huron, called the Superior Province by Dreimanis and others (1957, p. 153), and in particular they lack the high percentage of garnet present in the Grenville Province northeast of Lake Huron and Erie.

Most of the Woodfordian tills of Illinois were deposited by the Lake Michigan lobe, but a reentrant, marked by converging moraines near Gibson City in eastern Illinois, appears to represent a contact between the Lake Michigan lobe and either the Saginaw or Erie lobe. Heavy minerals of the Woodfordian tills in Illinois have been described by Wascher and others (1960).

The Saginaw lobe, consisting of ice flowing from the Lake Huron basin, may be the source of the Illinoian till of southeastern Illinois. It contains much more garnet than epidote, which indicates its derivation from the Grenville Province, but it contains more dolomite than calcite. This combination suggests that the ice moved from the Saginaw lobe across northern Indiana where the Silurian formations could supply the dolomite. Farther east in northeastern Indiana and northwestern Ohio, in the area crossed by the Erie lobe, the Silurian formations contain more limestone and the Devonian and Mississippian carbonate rocks are almost entirely limestone.

The Erie lobe appears to have been the source of the eastern Kansan till in Illinois because it contains the heavy minerals of the Grenville Province and more calcite than dolomite.

Nebraskan

Three samples of Nebraskan till from near Dubuque, Iowa, are from localities west of the Driftless Area and are representative of western-derived tills. They are similar to the western Kansan in that they contain about twice as much epidote as garnet (table 3). They also contain a significantly larger amount of kyanite, staurolite, and andalusite than all eastern drifts. These samples contain about 15 percent more hornblende than the samples of western Kansan till. The common presence of 2 to 3 percent of staurolite distinguishes both western Nebraskan and Kansan from the eastern tills which commonly contain only a trace of staurolite. The Nebraskan samples also average higher in percentage of black opaque minerals than the western Kansan and both contain more than the eastern tills. Diopside-augite minerals are rare in both western Nebraskan and Kansan tills.

Kansan

Western.—Western Kansan till commonly contains 2 to 4 times as much epidote as garnet (10 samples average 10% garnet, 23% epidote, table 3). The proportion of epidote was highest (3 to 5 times greater than garnet) in samples just west of the Mississippi River in Missouri and Iowa and in extreme western Illinois and lowest ($1\frac{1}{2}$ to $2\frac{1}{2}$ times greater) near Peoria. As there was no available garnet in the bedrock of western Illinois, the change in ratio may indicate a lateral change within the lobe and that ice flow was more from the north than the west.

The relatively high epidote content generally distinguishes the western Kansan from the overlying Illinoian till as only 12 of 49 Illinoian samples contained more epidote than garent, and in 7 of the 12 the difference was only 1 or 2 percent. The difference apparently results from both more garnet and less epidote in the eastern tills, rather than a large increase in one mineral.

A good example of the Kansan-Illinoian differentiation in western Illinois is at Eliza in Mercer County, as shown by the following analyses:

	Garnet	Epidote
Illinoian (P-541)	24%	17%
Kansan (P-538)	8%	23%

The relatively higher content of epidote in the western Kansan till distinguishes it even more clearly from the eastern Kansan in which garnet averages 4 times greater than epidote. However, only 4 samples of eastern Kansan till were analyzed.

Tourmaline and zircon are generally more abundant in the western Kansan till than in the tills from eastern source areas.

Hornblende averages less in western Kansan till (49%) than in any other group of samples (table 3), and black opaque minerals are more abundant than in most of the eastern tills.

As in the Nebraskan till, a low but persistent percentage of staurolite and andalusite distinguishes the western Kansan from the eastern Kansan till.

Eastern.—The eastern Kansan till, although represented by only 4 samples, appears to contain 4 times as much garnet as epidote, almost exactly the reverse from the western Kansan. This reflects the southerly distribution of the eastern Kansan and therefore contrasts Saginaw-Erie till (rather than Michigan lobe till) with the western Kansan. Such a large amount of garnet may not be found in the more northern part of the eastern Kansan till.

The samples of eastern Kansan till have an average of about 6 percent diopside-augite, which rarely exceeds 1 percent in other eastern tills and is very scarce or absent in the western tills.

The average of 5 percent hypersthene in the eastern Kansan till is matched only in the Wisconsinan Marseilles and Minooka tills.

Illinoian

All the samples of Illinoian till from Lake Michigan lobe drift west of the interlobate belt contain about equal quantities of garnet and epidote. The greatest variation is about half again as much of either mineral. Some of the more extreme variations may result from the glacier riding over the high-epidote western or high-garnet eastern Kansan till. The heavy mineral contents of the Payson, Jacksonville, and Buffalo Hart tills are similar and do not differentiate these tills.

The Lake Michigan lobe Illinoian till can be differentiated from the underlying eastern Kansan till by its higher percentage of epidote, as shown by the following analyses of samples at Taylorville, in Christian County:

	Garnet	Epidote
Illinoian (P-970)	24%	13%
Kansan (P-964)	26%	5%

In the Illinoian till southeast of the interlobate morainic complex, garnet exceeds epidote by $2\frac{1}{2}$ times. Consequently, it generally cannot be differentiated from the underlying eastern Kansan till which also contains abundant garnet. However, the Illinoian till appears to average somewhat higher than the Kansan in content of epidote, zircon, and tourmaline and lower in hypersthene and diopside-augite.

Tourmaline averages notably higher in all the Illinoian tills than in the Wisconsinan tills (3% to 1%), but zircon is about the same in both (2-3%).

Although the quantity of each is small (1% or less) the minerals rutile, titanite, kyanite, staurolite, and andalusite are present more consistently in the Illinoian tills than in the Wisconsinan tills.

Hornblende appears to be slightly less abundant in the Illinoian than in the Wisconsinan tills. Except for the Buffalo Hart till, the average hornblende percentages are generally in the 50's in the Illinoian and in the 60's in the Wisconsinan tills.

Wisconsinan

The Winnebago till differs from the Illinoian in averaging slightly higher in epidote than garnet, but in this and other respects its heavy minerals are similar to those in the bordering Woodfordian tills. The high content of epidote in the Winnebago till and in the more northerly part of the Woodfordian tills appears to be characteristic of the western part of the Lake Michigan lobe and particularly of till of the Green Bay lobe (Murray, 1953).

The Woodfordian tills differ from the Illinoian principally in averaging slightly higher in epidote than garnet, whereas the Illinoian averages slightly higher in garnet. Use of this criterion is complicated in the border area of the Woodfordian tills because the Shelbyville till, like the Illinoian, averages slightly higher in garnet than in epidote (table 3). However, there is a distinct change in the composition of the Shelbyville till about at the latitude of Peoria. Shelbyville till at Peoria and northward averages distinctly higher in epidote (17%) than garnet (13%), while that to the south and east averages more than twice as high in garnet (16%) as in epidote (7%). Consequently, in both areas there is a fair differentiation from the nearly equal garnet and epidote in the Illinoian. However, east of the city of Shelbyville the Illinoian till has a high content of garnet, so that the abundance of garnet is not a basis for differentiation.

In the Woodfordian tills of Bloomington age and younger, which were sampled in the area north and east of Peoria, the amount of epidote increases and reaches a maximum of about 2½ times more epidote than garnet in the Minooka and Valparaiso tills. The amount of epidote decreases again in the Tinley till, but only two samples were analyzed.

In addition to more epidote, the younger Woodfordian tills (Marseilles to Valparaiso) have about twice as much enstatite and hypersthene as the older Woodfordian tills. In general the Woodfordian tills have more enstatite and hypersthene than the Illinoian tills.

The general differences between the Woodfordian and Illinoian tills are well shown in several sections. In the Farm Creek Railroad Cut Section in Tazewell County, the Illinoian (P-131) contains equal garnet and epidote, whereas the overlying Wisconsinan (P-138) contains 1½ times as much epidote as garnet and also more enstatite and hypersthene.

At Depue in Bureau County a sample of Bloomington till (P-384) contains twice as much epidote as garnet, but garnet was equal to epidote in one Illinoian sample (P-374) and only 1½ times epidote in the other (P-376).

Near Danvers in Woodford County, there is a good distinction because the Shelbyville till (P-558) has the high garnet content characteristic of the southern area, but the Illinoian (P-550) has the equal garnet and epidote content characteristic of the area west of the interlobate ridged drift.

Light Minerals

Analyses of the light minerals in the sand fractions show some general differences, but are perhaps more outstanding for uniformity (table 3). The averages show potash feldspars ranging from 10 to 21 percent and soda-lime feldspars from 7 to 9 percent. Although no regional or stratigraphic trends are shown by the soda-lime feldspars, the potash feldspars are clearly 5 to 10 percent higher in the Wisconsinan tills than in the older tills. The lowest percentage of potash feldspars is in the eastern Kansan till, only 5 and 7 percent in two samples.

The relative abundance of the feldspars in the sand fractions is in large part related to the composition of the Precambrian rocks. From the composition of the Nebraskan, Kansan, and Illinoian tills, it would appear that the ratio of potash to soda-lime feldspars is similar in both the eastern and western parts of the Canadian Shield. The higher content of potash feldspars in the Wisconsinan tills may indicate a variation in the amount of material contributed by either closer or more distant parts of the eastern Precambrian.

Clay Minerals

The clay-mineral content of glacial tills in the Midwest has in recent years been discussed for deposits in Ohio (Droste, 1956), in Indiana (White, Bailey, and Anderson, 1960; Murray and Leininger, 1956; Gravenor, 1954; Harrison, 1960), in Wisconsin (Brown and Jackson, 1958), in Minnesota (Arneman and Wright, 1959), and in Illinois (Beavers and others, 1955; Brophy, 1959; Frye, Willman, and Glass, 1960; Frye, Glass, and Willman, 1962; Wascher and others, 1960; Kempton, 1962; Johnson, 1961, 1962). However, most of these studies were concerned with problems of mineral alteration in the development of weathering profiles rather than the characterization of the unleached tills.

In Circular 334 on the mineralogy of loess (Frye, Glass, and Willman, 1962), the clay-mineral composition of tills in Illinois and adjacent states was briefly summarized. We present here a more comprehensive description of the clay minerals in the tills of Illinois by stratigraphic unit and source province. The clay-mineral assemblages in the tills reflect a source in the Paleozoic and Mesozoic rocks, generally within a few hundred miles of the point of till deposition. Tills deposited by glaciers that advanced from the northwest strikingly reflect the exceedingly high montmorillonite content of the Upper Cretaceous and younger deposits over which these glaciers advanced. In contrast, the tills deposited by glaciers that advanced from the northeast contain a high proportion of illite characteristic of the middle to late Paleozoic rocks that occur across Indiana, Michigan, northern Ohio, and southern Ontario, and the tills from the north strongly reflect the illite and chlorite of the Ordovician, Devonian, and Mississippian shales. In addition to these adjacent sources of clay minerals, the Pennsylvanian bedrock of Illinois has exerted an important influence on the clay-mineral composition of tills in all but the northernmost part of the state.

Nebraskan

No samples of Nebraskan till from Illinois were analyzed. In order to determine the general composition of Nebraskan till a few samples from Iowa, South Dakota, and northeastern Kansas (fig. 4) were analyzed. These samples all showed abundant montmorillonite (63% to 86%), minor amounts of illite and kaolinite, and virtual absence of chlorite (table 5). The Nebraskan till of the western region appears to be indistinguishable from the overlying Kansan till which was derived from the same general region.

Kansan

The Kansan till derived from the west is essentially indistinguishable from the Nebraskan till in the western province. Samples of Kansan till from west of Illinois are from the type region of Kansas (Frye and Leonard, 1952), and from South Dakota, Iowa, and Missouri. These samples were uniformly high (62% to 85%) in montmorillonite and contained minor amounts of illite and kaolinite, but virtually no chlorite.

In western Illinois (west of the fourth principal meridian) the range in clay-mineral composition of the Kansan till (figs. 4, 7) is similar to that farther west, with montmorillonite averaging 65 percent of the clay minerals. A consistent characteristic of Kansan till in this province is that the amount of kaolinite is always greater than illite. Eastward in Illinois the percentages of illite and chlorite progressively increase and that of montmorillonite progressively decreases (fig. 9, table 5). Montmorillonite averages only 43 percent at the easternmost extent of the till. This results from incorporation of illite and chlorite from the local Pennsylvanian bedrock.

The Kansan glaciers that entered Illinois from the east and northeast (fig. 3) deposited a till that contains a clay-mineral assemblage distinctively different from that of western Kansan. The clay minerals of the eastern Kansan till are characterized by abundant illite, some kaolinite and chlorite, and very little or no montmorillonite. This composition is typical of the clay minerals in the Paleozoic shales throughout the region lying east and northeast of Illinois. As the till is traced southwestward toward its maximum extent in Illinois, some montmorillonite appears in the clay-mineral assemblage (fig. 4, table 5), and it reaches a maximum of 24 percent in Macoupin County. In this case the local bedrock of the region crossed by the glacier contains relatively small amounts of montmorillonite, and it is judged that pro-Kansan or older loess from the Ancient Mississippi Valley was incorporated by the overriding glacier.

Illinoian

Glaciers of Illinoian age entered the state from the northeastern corner by way of the Lake Michigan lobe. Farther south in Illinois, glacial lobes that moved by way of Saginaw Bay or possibly the western part of the Lake Erie basin, deposited the southernmost till in Illinois (fig. 3). Several glacial pulses entered Illinois during the Illinoian Stage (fig. 1). As they contain different mineral assemblages (figs. 5, 7), it appears that their configurations and routes of movement, and perhaps also their areas of maximum erosion, were somewhat different.

Preceding the first advance of Illinoian glaciers, but presumably related genetically to the advancing glacial front, there was extensive deposition of both water-laid and eolian silts, the Petersburg Silt. In the type region in Sangamon

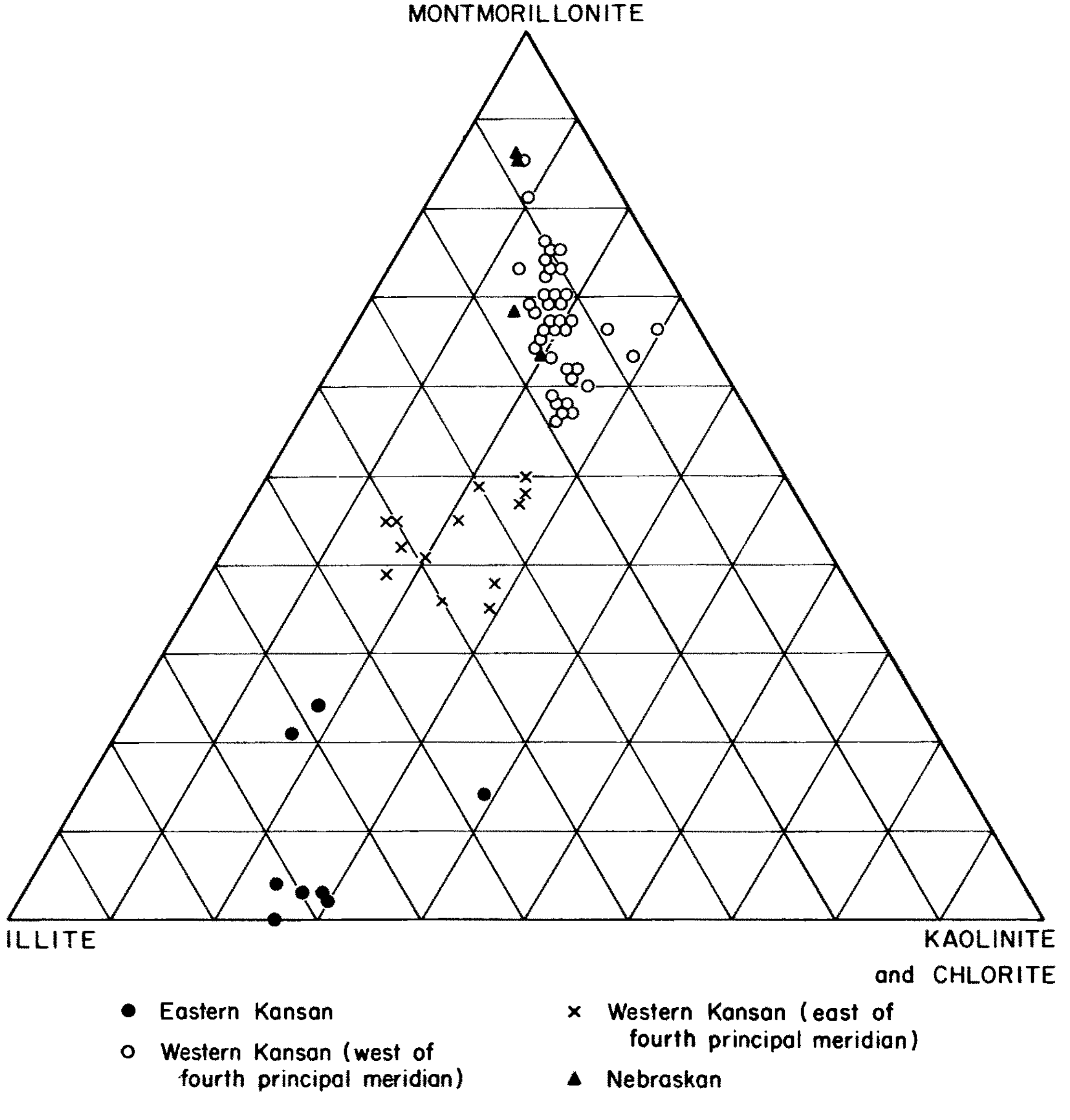

Fig. 4 - Three-component diagram showing the clay-mineral composition of Nebraskan and Kansan tills.

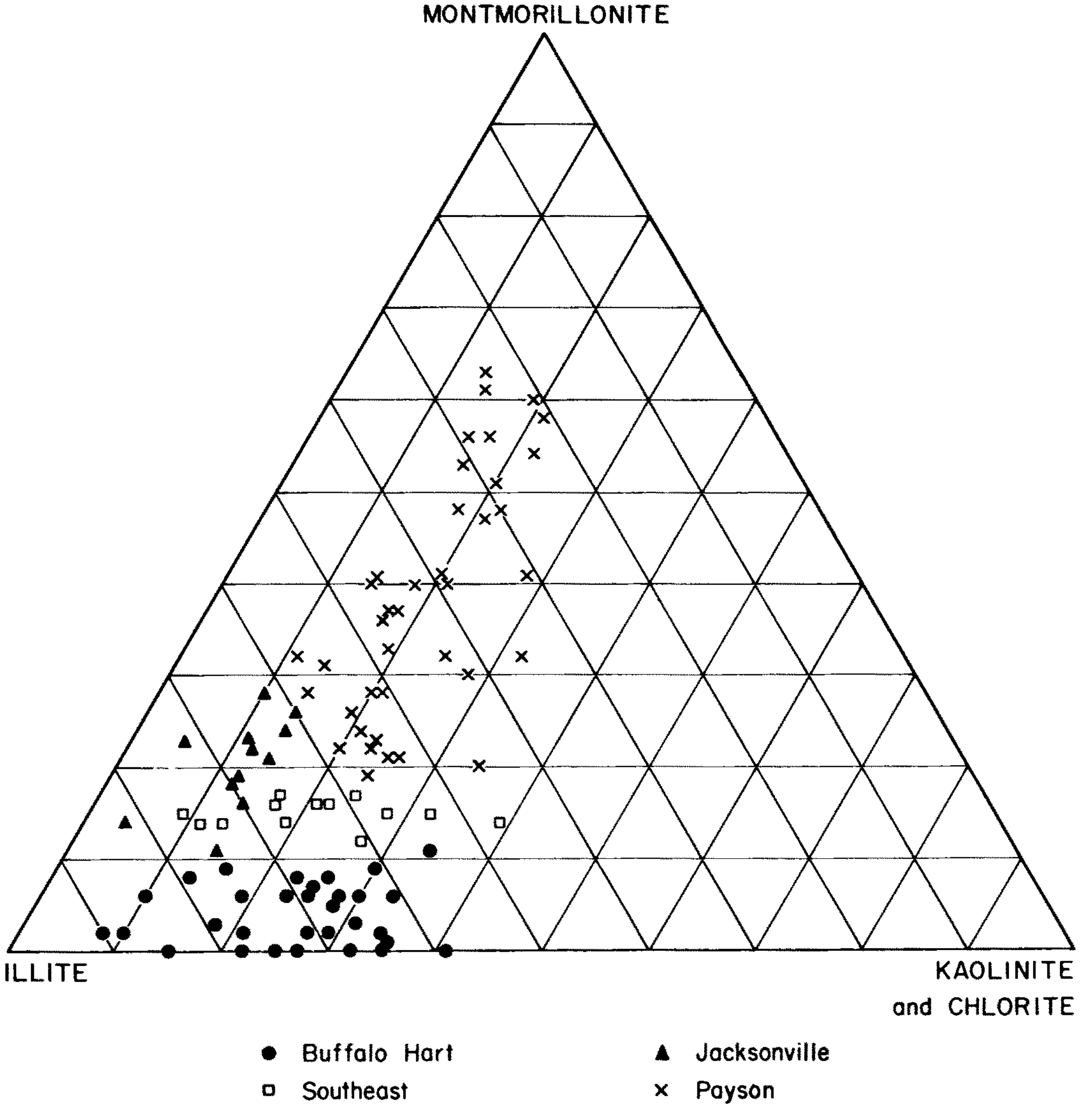

Fig. 5 - Three-component diagram showing the clay-mineral composition of Illinoian tills.

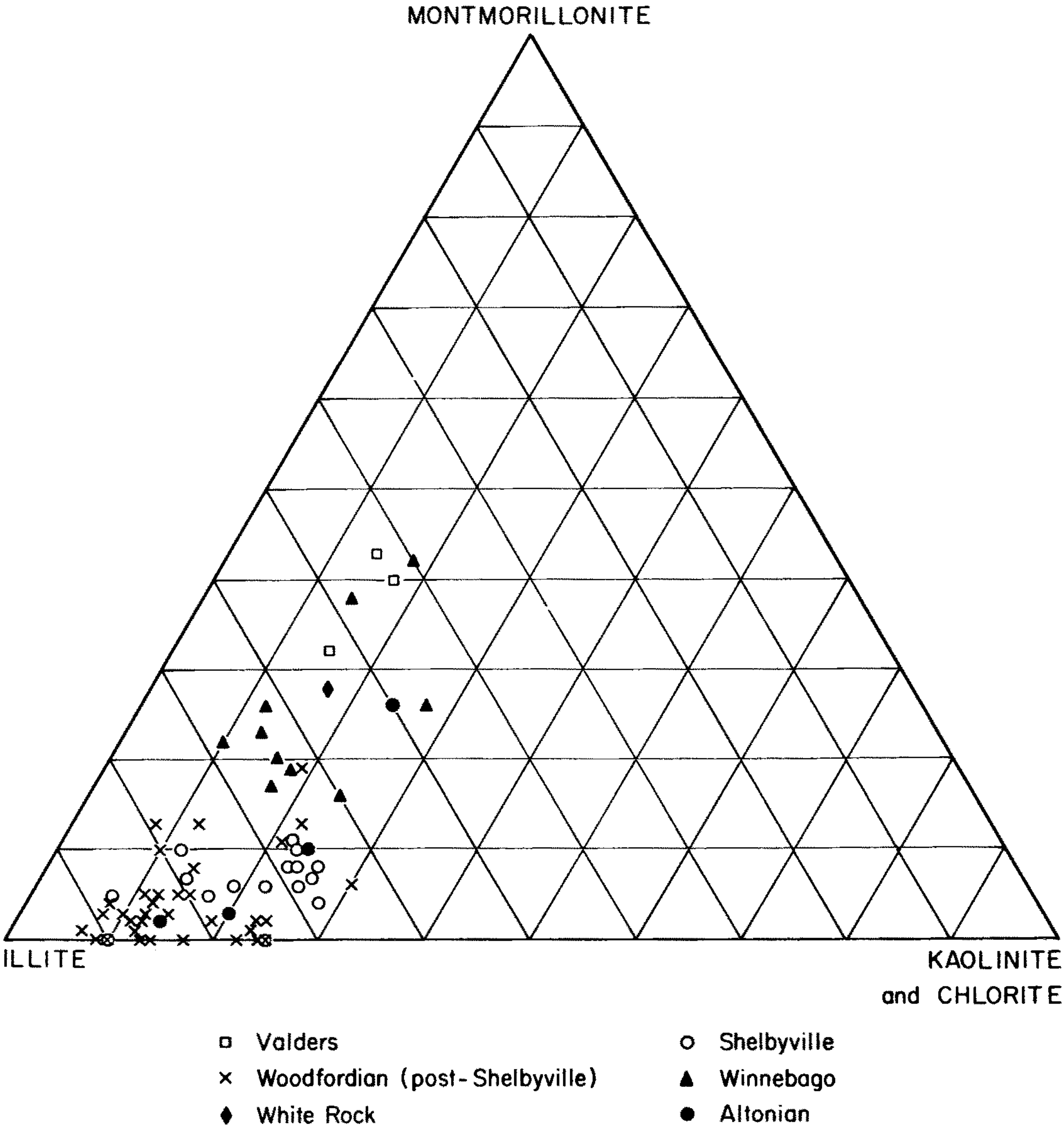

Fig. 6 - Three-component diagram showing the clay-mineral composition of Wisconsinan tills.

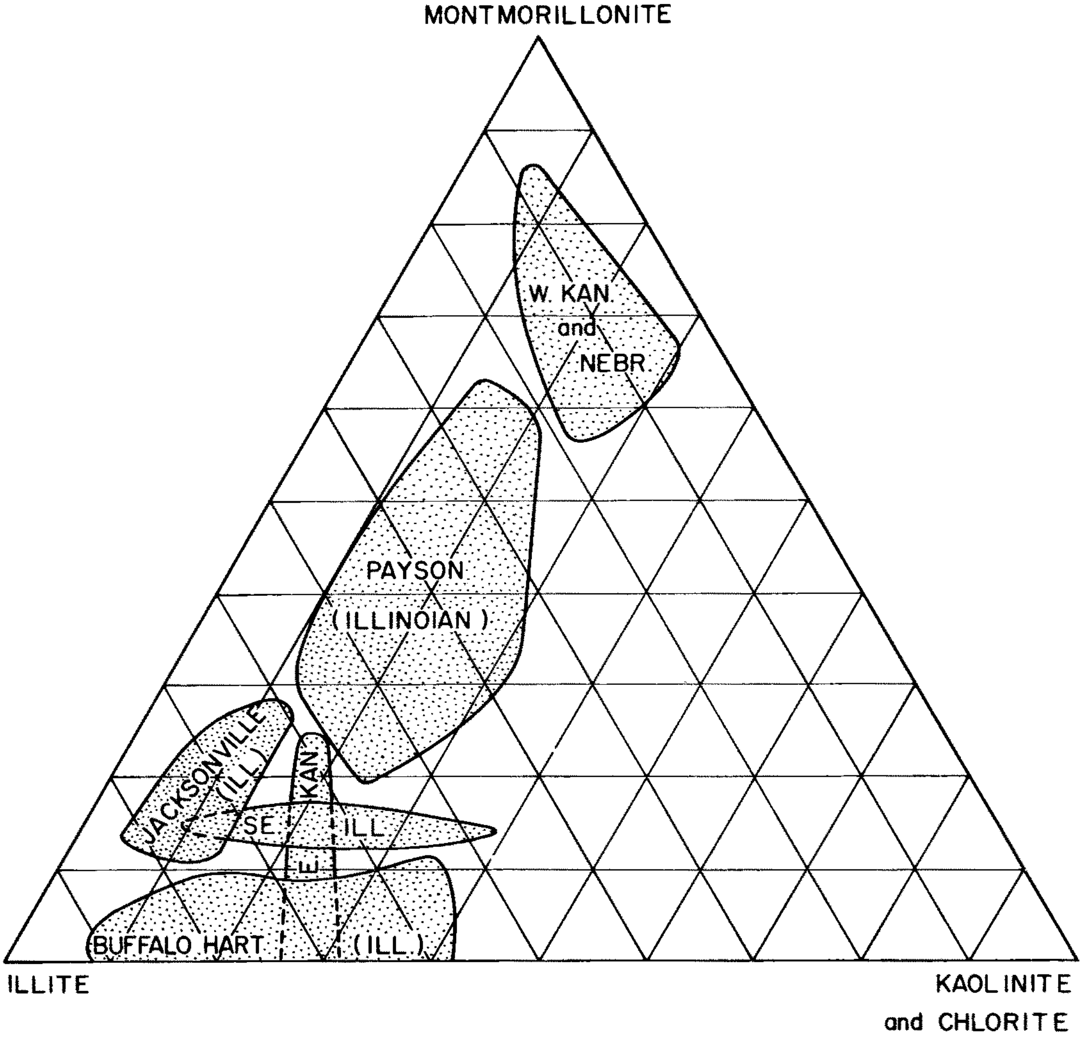

Fig. 7 - Three-component diagram contrasting clay-mineral compositions of the several Illinoian tills with western Kansan (exclusive of the eastern diluted margin) and eastern Kansan.

County, the Petersburg Silt is high in montmorillonite, averaging more than 50 percent of the clay minerals, with about 38 percent illite and small amounts of both kaolinite and chlorite. In western Illinois the montmorillonite ranges up to 85 percent, but unlike the underlying Kansan till it invariably contains some chlorite. The high montmorillonite content appears to be related to a western silt source by way of the Ancient Mississippi and Iowa Rivers (Frye, Glass, and Willman, 1962), but, as the front of the Lake Michigan lobe glacier approached and contributed a progressively larger portion of the deposit, the percentage of montmorillonite decreased and the illite and chlorite increased. This progressive upward change is well illustrated by the samples from Rock Island County (HK-32 to HK-43).

The first advance of the Illinoian glacier from the Lake Michigan lobe gave rise to the till classed as Payson. In Illinois the montmorillonite percentage in the Payson till shows the largest range (17% to 64%) of any unit studied, exceeding even the western Kansan. The montmorillonite content progressively increases toward the western and southwestern limits of the Payson advance (fig. 8), and the increase is attributed to the incorporation of materials from the Petersburg Silt and western Kansan till which were overridden by the advancing Payson glacier. Although the range in montmorillonite of the Payson overlaps that of the western Kansan, at any one locality the percentage in the Payson averages lower than that in the underlying western Kansan till and Petersburg Silt (fig. 9). In Payson till the sum of chlorite and kaolinite is always less than illite. In contrast, in extreme western Illinois (west of the fourth principal meridian), the western Kansan till contains more kaolinite than illite and has little or no chlorite. Therefore, the clay-mineral assemblage characteristic of the Lake Michigan lobe is recognizable at least to the Mississippi River.

The Illinoian till in the southeastern region, southeast of the interlobate area, generally has less montmorillonite than does the Payson till (fig. 8), but here also there is a distinctive increase in montmorillonite content as the periphery of Illinoian glaciation is approached. Inside the marginal areas the southeastern till is uniform and averages 16 percent montmorillonite, in contrast to a minimum of 17 percent and an average of 36 percent for the Payson till. Inasmuch as the glacier that deposited this till advanced along a route east of the Lake Michigan lobe, it could not acquire montmorillonite from either western Kansan till or western-derived Petersburg Silts, and therefore it reflects the clay-mineral composition of the bedrock over which it moved.

The clay-mineral composition of Jacksonville till differs from that of the southeastern till only by its somewhat greater montmorillonite and less chlorite-kaolinite content, but is distinctly different from that of the Payson till which has much more montmorillonite and less illite. The kaolinite-chlorite content of the Jacksonville is lower than that of any other Illinoian till (fig. 5, table 5), and therefore it can be distinguished from them by its clay-mineral composition.

The clay-mineral composition of the Buffalo Hart till is regionally uniform and is characterized by extremely low percentages of montmorillonite (fig. 5, table 5). The average montmorillonite content is the lowest of all Illinoian tills and falls within the ranges of only eastern Kansan and Woodfordian. The kaolinite-chlorite content, averaging about the same as that of the eastern Kansan, is on the average higher than that of the Wisconsinan tills. The end moraine shows the highest montmorillonite content within the Buffalo Hart till (figs. 8, 9), probably due to incorporation of underlying material in the marginal zone.

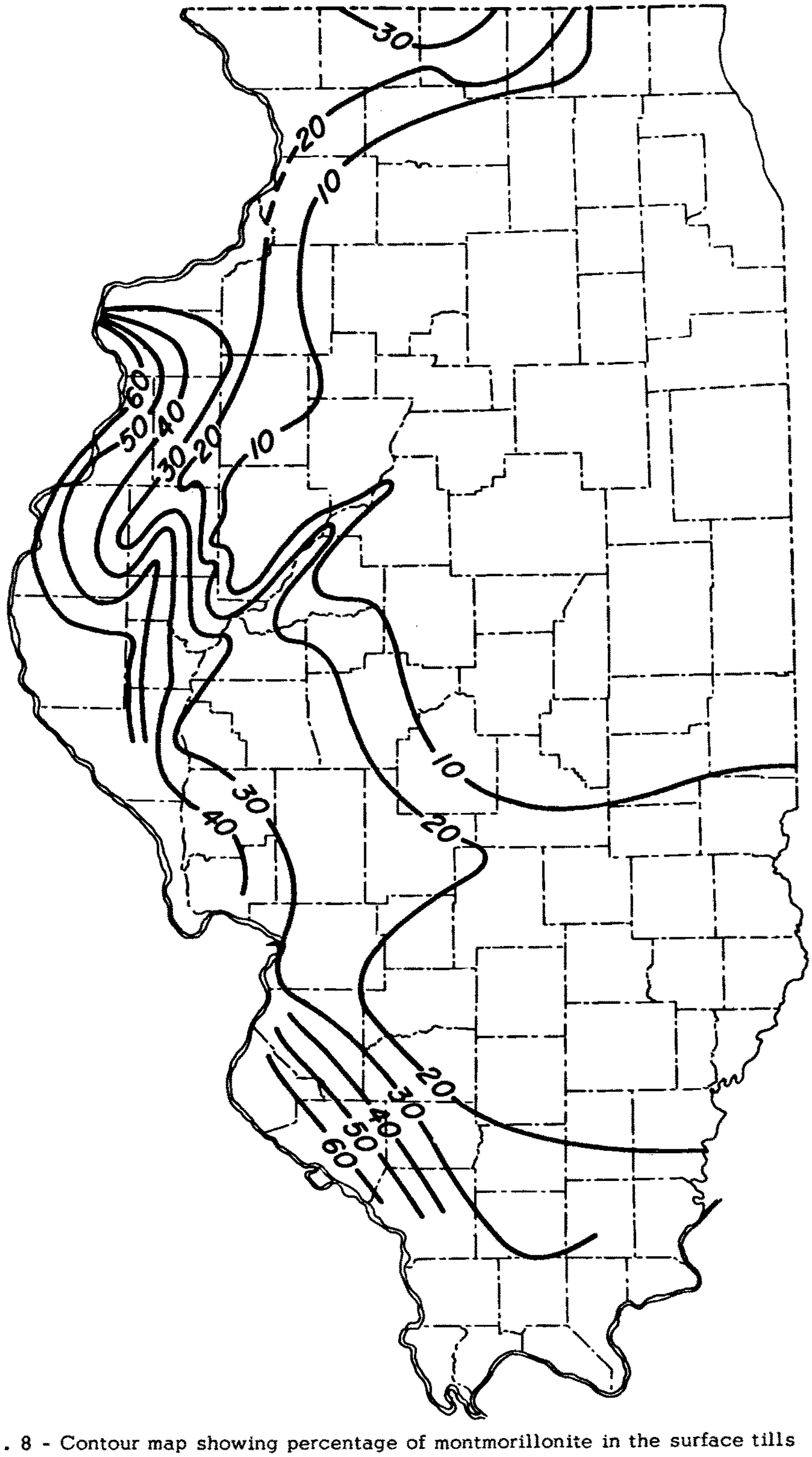

Fig. 8 - Contour map showing percentage of montmorillonite in the surface tills of Wisconsinan and Illinoian age.

Wisconsinan

The clay-mineral composition of the Wisconsinan tills reflect both stratigraphic units (fig. 6) and geographic position. These tills were predominantly derived from the Lake Michigan-Green Bay lobe, but in east-central Illinois some of the till may have had a source in the Saginaw lobe, or perhaps even farther east. The oldest Altonian tills examined are represented by an inadequate number of samples to permit firm generalization (fig. 6), but they are similar to Woodfordian tills and presumably were strongly influenced by local bedrock.

The late Altonian Winnebago till in north-central Illinois (the till described by Shaffer, 1956) contains a clay-mineral assemblage that differs from both the Illinoian tills and the Woodfordian tills. Winnebago till contains more montmorillonite than does the younger Wisconsinan tills, and virtually all of the expansible material consists of vermiculite or vermiculite-chlorite derived from chlorite and/or biotite micas. Therefore, the expansible material classed as montmorillonite in the Winnebago till is distinctly different from the indigenous western montmorillonite that occurs in Payson till, western Kansan till, and western-derived loess, but is similar to the expansible material in the younger Valders till (fig. 6) that was deposited by the Green Bay lobe. This relation, together with the absence of kaolinite (which can be derived from Pennsylvanian and Mississippian rocks) and the geographic pattern of distribution, suggests that the Winnebago till sampled in Illinois was deposited by the Green Bay lobe.

The Woodfordian tills (with the exception of the White Rock till which reflects a major incorporation of Winnebago material) possess a clay-mineral assemblage different from that of the Winnebago till (fig. 6). In general these tills resemble Buffalo Hart till because of their low montmorillonite and high illite content (table 5), but the Woodfordian contains little if any kaolinite. The similarity in clay-mineral composition seemingly reflects a similar origin in the Lake Michigan lobe, and the kaolinite in the Buffalo Hart till may merely reflect the fact that all samples of this till were from areas underlain by Pennsylvanian bedrock.

The Woodfordian tills have an average of 4 percent montmorillonite, and it appears that this expansible material is derived entirely from altered chlorite.

In the peripheral zone of the Woodfordian, particularly in the Shelbyville Moraine (fig. 6) and the LeRoy, Bloomington, and other moraines where they approach the limit of Woodfordian glaciation, there occurs a small but significant increase in the percentage of expansible materials, probably reflecting the incorporation of some loess, accretion-gley, and older till materials in the leading edge of the advancing glacier. A similar relation is shown in extreme northern Illinois where materials derived from the Winnebago till are incorporated in the White Rock, Marengo, and West Chicago Moraines. Inside of this peripheral zone, the composition of the Woodfordian tills is homogeneous and the amount of expansible material rarely if ever exceeds 5 percent.

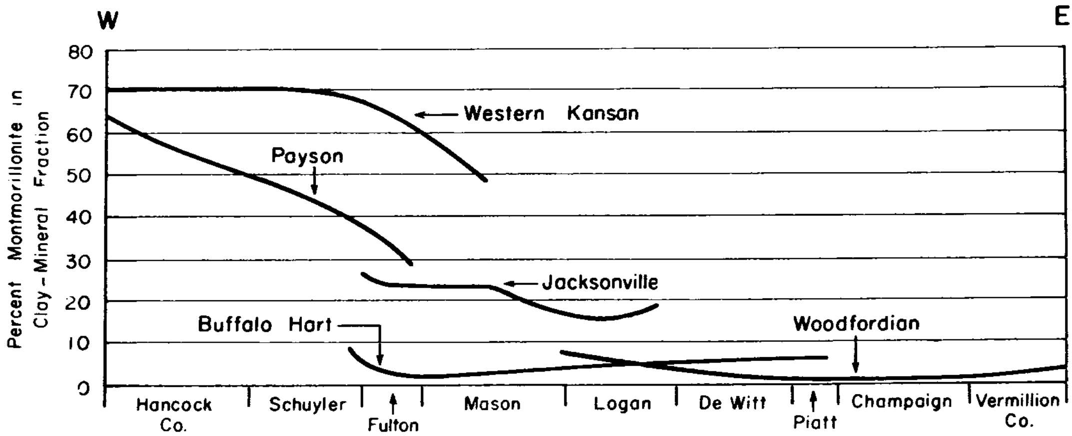

Fig. 9 - East-west cross section from Vermillion to Hancock County showing diagrammatically the percentage of montmorillonite in tills of various ages.

Carbonate Minerals

Based on pebble counts from tills in Illinois and eastern Iowa, Horberg (1956), Anderson (1957), and Wanless (1957) have demonstrated that till from the Lake Michigan lobe is characterized by more dolomite than limestone whereas the western tills contain more limestone than dolomite. In order to extend and refine this method of differentiation, semi-quantitative X-ray diffraction analyses of calcite and dolomite were made on the bulk samples from all localities used in this study. This method provides an analysis of the fine sand, silt, and clay material in contrast to the earlier studies that were concerned only with pebbles.

Data from these samples confirm the general conclusions of the earlier studies. Samples from the middle Missouri Valley (Kansas) show virtually no dolomite, but the dolomite percentage increases eastward in the western tills. At the eastern limit of the western Kansan till in Peoria, Putnam, and Bureau Counties, Illinois, dolomite exceeds calcite and thus reflects additions from the Ordovician and Silurian dolomites over which the eastern margin of the lobe passed.

Payson till from the Lake Michigan lobe contains markedly more dolomite than calcite throughout most of its extent, but as the Mississippi River Valley is approached the ratio diminishes, and at the westernmost localities in Illinois (in Hancock County) calcite and dolomite are approximately equal. The progressive westward increase in calcite reflects additions from the Mississippian and Pennsylvanian limestones and western Kansan till over which the Payson glacier passed.

In all other Illinoian and Wisconsinan tills in Illinois, dolomite exceeds calcite (table 5, 6). In contrast, the eastern Kansan till in east-central and southern Illinois contains more calcite than dolomite. This relation suggests that the source of the material was from the Lake Erie lobe (Dreimanis and Reavely, 1953; Anderson, 1957; Harrison, 1959, 1960).

SUMMARY AND CONCLUSIONS

Illinois, by virtue of its geographic position, is unique among regions in North America that were invaded by continental glaciers because it was invaded by glaciers from sources lying both to the northwest and to the northeast. Because the mineral composition of the rocks underlying these source regions are significantly different, strong contrasts occur in the mineralogy of the several tills in Illinois.

Nebraskan glaciers apparently reached only into the western part of the state and, as exposures of this till are exceedingly rare in Illinois, the mineralogical data presented here are from the Nebraskan west of Mississippi River. Kansan glaciers entered the state from the northwest, south of Carroll County and north of Calhoun County, and extended eastward approximately to the position of the present Illinois River. A Kansan glacier also entered Illinois from the east and, although it extended to the vicinity of St. Louis, it approached but did not cross the position of Illinois Valley.

During the Illinoian Stage a major lobe of ice entered the state by way of the Lake Michigan basin. In the east-central and southern parts of Illinois, the Lake Michigan lobe glacier was deflected to the west by lobes advancing from farther east, from the Lake Huron and possibly Erie basins. The latter extended to the Mississippi River Valley from St. Louis to Chester. The deflected Lake Michigan lobe spread westward across the Ancient Mississippi Valley (the present

Illinois Valley) and crossed the present Mississippi River Valley in the area from Hancock County to Rock Island County. The northeast-southwest belt of ridged drift in the Kaskaskia Valley is an interlobate morainic complex marking the contact of the Saginaw-Erie lobe with the Lake Michigan lobe.

The Illinoian Stage is complex but two major episodes of retreat and readvance resulted in deposition of the Jacksonville and Buffalo Hart end moraines which serve as a basis for three substages—Payson, Jacksonville, and Buffalo Hart. The Payson may include a major retreat and readvance. In large areas final wastage of the Payson glacier was by stagnation.

During the Altonian Substage of the Wisconsinan, glacial lobes from Green Bay, from the Lake Michigan basin, and probably also from farther east entered Illinois and extended as far south as Vermillion County. A major ice withdrawal occurred during Farmdalian time. During the Woodfordian Substage, the most extensive of the Wisconsinan glacial advances were made by the Lake Michigan and Saginaw-Erie lobes. These lobes withdrew by a series of pulses that gave rise to more than 30 named moraines.

The Valders glacier advanced through both Green Bay and the Lake Michigan basin but did not reach as far south as Illinois.

The glacial lobes that entered Illinois transported materials from five source-provinces that are distinctive mineralogically. The first of these is the northwestern source, represented in Illinois by tills deposited by the Nebraskan and Kansan glaciers that entered the state from Iowa and Missouri. The second and third source areas lie to the north and northeast and are represented by tills that were brought into Illinois by way of the Green Bay and Lake Michigan lobes, the fourth source area is farther east, more directly northeast, and is shown by the tills that were derived from the Saginaw (Lake Huron) lobe, and the fifth source area is still farther east and is represented by the tills that were derived from the Lake Erie lobe.

Tills from the western source are characterized by considerably more epidote than garnet and relatively large amounts of kyanite, staurolite, and andalusite among the heavy minerals. Among the clay minerals, montmorillonite is dominant (always more than 60%) and chlorite is virtually absent. Calcite is more abundant than dolomite.

Tills from the Lake Michigan lobe are characterized by approximately equal amounts of garnet and epidote, although epidote becomes relatively more abundant in the younger tills within the lobe. They contain more potash feldspars than tills from other lobes. Illite is dominant among the clay minerals and chlorite is consistently present. Dolomite is more abundant than calcite.

Tills from the Green Bay lobe are similar to the tills of the Lake Michigan lobe but have a much higher content of expansible minerals derived from the alteration of chlorite and possibly biotite micas and have a higher content of epidote.

Tills from source areas lying east of the Lake Michigan lobe are characterized by much larger amounts of garnet than epidote, by the dominance of illite, and by the presence of both kaolinite and chlorite. Tills deposited by glaciers that advanced across Michigan and northern Indiana from the position of Saginaw Bay contain more dolomite than calcite, whereas the tills from the Lake Erie lobe contain more calcite than dolomite.

The mineral composition of the tills derived from each of these source areas was progressively modified by the erosion of local bedrock and of older Pleistocene deposits along the route of advance.

Such modifications are well illustrated by the progressive westward increase in montmorillonite in the Payson till, the source of the montmorillonite being the western Kansan till and the western-derived Petersburg Silt over which the Payson glacier advanced.

In addition to characterizing the composition of the tills derived from the several source regions, the mineralogical data presented here also serve as a means of differentiating stratigraphic units. Western Kansan till can be readily distinguished from the overlying Illinoian by its much higher content of epidote than garnet whereas in the Illinoian these two minerals appear in about equal proportion, by their higher percentage of staurolite, by their higher content of montmorillonite, and by their high calcite content versus the high dolomite content of the Illinoian. Eastern Kansan is everywhere distinguishable from the overlying Illinoian by its higher percentage of calcite than dolomite, but it also generally has a higher percentage of hypersthene and diopside-augite and a lower percentage of tourmaline and zircon.

Among the Illinoian tills deposited by the Lake Michigan lobe the percentage of montmorillonite is generally higher in the Payson than in the Jacksonville and much higher than in the Buffalo Hart; the Jacksonville is generally lower in kaolinite and chlorite than either the Buffalo Hart or Payson tills.

Among the Wisconsinan tills the Winnebago is distinguished from Lake Michigan lobe Illinoian by the facts that its montmorillonite content is largely derived from expansible chlorite, vermiculite, and biotite micas and that it contains no kaolinite, whereas all Illinoian tills contain some kaolinite. The Woodfordian tills are distinguished from Payson, Jacksonville, and Winnebago tills by their much lower content of montmorillonite and from the Buffalo Hart till by the general absence of kaolinite in the Woodfordian tills; also, the Woodfordian tills generally contain more epidote than do the Illinoian.

REFERENCES

Anderson, R. C., 1957, Pebble and sand lithology of the major Wisconsin glacial lobes of the central lowland: Geol. Soc. America Bull., v. 68, p. 1415-1449.

Andrews, G. W., 1958, Windrow Formation of Upper Mississippi Valley region—A sedimentary and stratigraphic study: Jour. Geology, v. 66, p. 597-624.

Arneman, H. F., and Wright, H. E., 1959, Petrography of some Minnesota tills: Jour. Sed. Petrology, v. 29, p. 540-554.

Ball, J. R., 1940, Elongate drift hills of southern Illinois: Geol. Soc. America Bull., v. 51, no. 7, p. 951-970.

Ball, J. R., 1952, Geology and mineral resources of the Carlinville Quadrangle: Illinois Geol. Survey Bull. 77, p. 110.

Beavers, A. H., Johns, W. D., Grim, R. E., and Odell, R. T., 1955, Clay minerals in some Illinois soils developed from loess and till under grass vegetation: National Academy of Sciences—National Research Council, Third National Conference on Clays and Clay Minerals Proc., Pub. 395, p. 356-372.

Bell, A. H., and Leighton, M. M., 1929, Nebraskan, Kansan and Illinoian tills near Winchester, Illinois: Geol. Soc. America Bull., v. 40, no. 2, p. 481-490.

Brophy, J. A., 1959, Heavy mineral ratios of Sangamon weathering profiles in Illinois: Illinois Geol. Survey Circ. 273.

Brown, B. E., and Jackson, M. L., 1958, Clay mineral distribution in Hiawatha sandy soils of Wisconsin: NAS—NRC, Fifth Natl. Conf. on Clays and Clay Minerals Proc., Pub. 566, p. 213-226.

Dreimanis, A., 1960, Pre-classical Wisconsin in the eastern portion of the Great Lakes region, North America: Internatl. Geol. Cong., 21st Session, Norden, pt. IV, p. 108-119.

Dreimanis, A., and Reavely, G. H., 1953, Differentiation of the lower and the upper till along the north shore of Lake Erie: Jour. Sed. Petrology, v. 23, p. 238-259.

Dreimanis, A., Reavely, G. H., Cook, R. J. B., Knox, K. S., and Moretti, F. J., 1957, Heavy mineral studies in tills of Ontario and adjacent areas: Jour. Sed. Petrology, v. 27, p. 148-161.

Droste, J. B., 1956, Clay minerals in calcareous till in northeastern Ohio: Jour. Geology, v. 64, p. 187-190.

Ekblaw, G. E., and Willman, H. B., 1957, Farmdale drift near Danville, Illinois: Illinois Acad. Sci. Trans., v. 47, p. 129-138.

Eveland, H. E., 1952, Pleistocene geology of the Danville region, Illinois: Illinois Geol. Survey Rept. Inv. 159.

Flint, R. F., Colton, R. B., Goldthwait, R. P., and Willman, H. B., 1959, Glacial map of the United States east of the Rocky Mountains: New York, Geol. Soc. America.

Frye, J. C., Glass, H. D., and Willman, H. B., 1962, Stratigraphy and mineralogy of the Wisconsinan loesses of Illinois: Illinois Geol. Survey Circ. 334.

Frye, J. C., and Leonard, A. B., 1952, Pleistocene geology of Kansas: Kansas Geol. Survey Bull. 99.

Frye, J. C., and Leonard, A. B., 1954, Significant new exposures of Pleistocene deposits at Kirwin, Phillips County, Kansas: Kansas Geol. Survey Bull. 109, Pt. 3, p. 29-48.

Frye, J. C., and Willman, H. B., 1960, Classification of the Wisconsinan Stage in the Lake Michigan glacial lobe: Illinois Geol. Survey Circ. 285.

Frye, J. C., and Willman, H. B., 1963, Development of Wisconsinan classification in Illinois related to radiocarbon chronology: Geol. Soc. America Bull., v. 74; in press.

Frye, J. C., Willman, H. B., and Glass, H. D., 1960, Gumbotil, accretion-gley, and the weathering profile: Illinois Geol. Survey Circ. 295.

Gravenor, C. P., 1954, Mineralogical and size analysis of weathering zones on Illinoian till in Indiana: Am. Jour. Sci., v. 252, p. 159-171.

Hackett, J. E., 1960, Ground-water geology of Winnebago County, Illinois: Illinois Geol. Survey Rept. Inv. 213.

Harrison, W., 1959, Petrographic similarity of Wisconsin tills in Marion County, Indiana: Indiana Geol. Survey Rept. Prog. 15.

Harrison, W., 1960, Original bedrock composition of Wisconsin till in central Indiana: Jour. Sed. Petrology, v. 30, no. 3, p. 432-446.

Horberg, Leland, 1950, Bedrock topography of Illinois: Illinois Geol. Survey Bull. 73.

Horberg, Leland, 1953, Pleistocene deposits below the Wisconsin drift in northeastern Illinois: Illinois Geol. Survey Rept. Inv. 165.

Horberg, Leland, 1955, Radiocarbon dates and Pleistocene chronological problems in the Mississippi Valley Region: Jour. Geology, v. 63, p. 278-286.

Horberg, Leland, 1956, Pleistocene deposits along the Mississippi Valley in central-western Illinois: Illinois Geol. Survey Rept. Inv. 192.

Johnson, W. H., 1961, Weathering profile information on some Wisconsinan end moraines in east central Illinois: Univ. Illinois [Urbana] unpublished M.S. thesis.

Johnson, W. H., 1962, Stratigraphy and petrography of Illinoian and Kansan drift in central Illinois: Univ. Illinois [Urbana] unpublished Doctoral Dissertation.

Kay, G. F., and Graham, J. B., 1943, The Illinoian and post-Illinoian Pleistocene geology of Iowa: Iowa Geol. Survey, v. 38, p. 1-262.

Kempton, J. P., 1962, Stratigraphy of the glacial deposits in and adjacent to Troy bedrock valley, northern Illinois: Univ. Illinois [Urbana] unpublished Doctoral Dissertation.

Leighton, M. M., and Brophy, J. A., 1961, Illinoian glaciation in Illinois: Jour. Geology, v. 69, p. 1-31.

Leighton, M. M., and Willman, H. B., 1950, Loess formations of the Mississippi Valley: Jour. Geology, v. 58, p. 599-623.

Leonard, A. B., and Frye, J. C., 1960, Wisconsinan molluscan faunas of the Illinois Valley region: Illinois Geol. Survey Circ. 304.

Leverett, Frank, 1899, The Illinois glacial lobe: U. S. Geol. Survey Mon., v. 38.

MacClintock, Paul, 1929, Recent discoveries of pre-Illinoian drift in southern Illinois: Illinois Geol. Survey Rept. Inv. 19, p. 27-57.

Murray, H. H., and Leininger, R. K., 1956, Effect of weathering on clay minerals: NAS-NRC, Fourth Natl. Conf. on Clays and Clay Minerals Proc., Pub. 456, p. 340-347.

Murray, R. C., 1953, The petrology of the Cary and Valders tills of northeastern Wisconsin: Am. Jour. Sci., v. 251, p. 140-155.

Ruhe, R. V., 1956, Geomorphic surfaces and the nature of soils: Soil Science, v. 82, p. 441-455.

Shaffer, P. R., 1956, Farmdale drift in northwestern Illinois: Illinois Geol. Survey Rept. Inv. 198.

Wanless, H. R., 1957, Geology and mineral resources of the Beardstown, Glasford, Havana, and Vermont Quadrangles: Illinois Geol. Survey Bull. 82.

Wascher, H. L., Alexander, J. D., Ray, B. W., Beavers, A. H., and Odell, R. T., 1960, Characteristics of soils associated with glacial tills in northeastern Illinois: Univ. Illinois Agr. Exp. Sta., Bull. 665.

White, J. L., Bailey, G. W., and Anderson, J. U., 1960, The influence of parent material and topography on soil genesis in the Midwest: Purdue Univ. Agr. Exp. Sta. Research Bull. 693.

TABLE 1 - DESCRIPTION OF SAMPLES

Sample No.	Location ¼ Sec., T., R., County (Geologic Section No.)*	Stratigraphic Unit (feet below top)
P-1	Center SE, 20, 3N., 8W., Madison (29)*	Ill. (or Kans.) (4)
P-1A	do.	Ill. (or Kans.) (10)
P-26	SE, SW, NE, 10, 5N., 10W., Madison (1)	Ill. (10)
P-46	SE, SE, SW, 6, 4N., 8W., Hancock	Ill. (Payson) (4)
P-61	SE, SW, 13, 4S., 5W., Pike	Kans. (8)
P-63	NW, NW, 15, 53N., 4W., Pike Co., Mo.	Kans. (10)
P-65	NW, SW, 3, 52N., 4W., Pike Co., Mo.	Kans. (8)
P-90	NW, NW, NE, 23, 18N., 7W., Menard (28)	Petersburg Silt (20)
P-91	do.	Petersburg Silt (10)
P-94	do.	Ill. (Jacksonville) (18)
P-95	Center E.L., 11, 18N., 11W., Cass (7)	Ill. (Payson) (14)
P-96	do.	Ill. silt (9)
P-97	do.	Ill. (Jacksonville) (6)
P-113	NW, NE, 10, 6N., 5E., Fulton (2)	Ill. (Payson)(6)
P-119	SW, NE, 31, 7N., 6E., Peoria (39)	Kans. (34)
P-119A	do.	Kans. (34)
P-120	do.	Kans. (30)
P-121	do.	Kans. silt (27)
P-121A	do.	Kans. silt (27)
P-122	do.	Kans. sand (24)
P-123	do.	Kans. (11)
P-123A	do.	Kans. (6)
P-125	do.	Ill. (Payson) (23)
P-126	do.	Ill. (B. Hart) (8)
P-130	NE, NW, NE, 26, 26N., 4W., Tazewell	Shelbyville (50)
P-131	Center 31, 26N., 3W., Tazewell (11)	Ill. (B. Hart) (7.5)
P-138	do.	Shelbyville (48)
P-139	SW, NW, SW, 12, 26N., 4W., Tazewell	Metamora (1)
P-141	NW, SW, NE, 1, 25N., 2E., McLean (19)	Altonian (9)
P-142	do.	Altonian (6)
P-143	do.	Altonian (1)
P-144	do.	Morton silt (1)
P-145	do.	Shelbyville (2)
P-146	do.	Bloomington (1.5)

Sample No.	Location ¼ Sec., T., R., County (Geologic Section No.)*	Stratigraphic Unit (feet below top)
P-147	do.	Bloomington sand (1.5)
P-148	do.	Normal (2)
P-170	NW, NE, NE, 31, 36 N., 12E., Cook	Valparaiso
P-171	NW, NE, SW, 9, 34N., 4E., LaSalle	Bloomington
P-172	NE, SE, NW, 10, 5N., 3W., Bond	Ill.
P-173	SE, SE, NW, 36, 18N., 11W., Cass	Ill.
P-180	NW, SW, NW, 31, 8N., 3E., Fulton	Ill. (B. Hart)
P-181	do.	Ill. (B. Hart)
P-182	do.	Ill. (B. Hart)
P-195	Center 6, 7N., 6E., Effingham	Ill.
P-196	do.	Ill.
P-197	do.	Ill.
P-277	NE, SE, 27, 14N., 13W., Scott (4)	Ill. (Payson) (10)
P-301	SE, SW, 7, 82N., 4E., Clinton Co., Iowa	Kans. (9)
P-312	SW, NW, NW, 15, 15N., 5E., Henry	Ill. (B. Hart) (20)
P-327	SE, NE, NW, 36, 8N., 2E., Fulton	Ill. (B. Hart) (7)
P-335	SE, NE, SE, 4, 14N., 4W., Sangamon (23)	Ill. (Jacksonville) (17)
P-344	SE, NW, SE, 23, 25N., 6E., McLean	Cropsey (2)
P-346	SE, SE, SW, 35, 25N., 5E., McLean	Cropsey (3)
P-347	NW, NE, NW, 9, 23N., 4E., McLean	Normal (3)
P-349	NE, SE, SE, 8, 23N., 4E., McLean	Normal (4)
P-350	NE, SE, NE, 32, 23N., 4E., McLean	Bloomington (8)
P-355	NE, SE, NW, 5, 21N., 1W., McLean	LeRoy (4)
P-356	NE, NE, NE, 36, 21N., 1W., Logan	Shelbyville (5)
P-357	NW, SE, NW, 6, 21N., 4W., Logan	Ill. (B. Hart) (3.5)
P-365	NE, SW, SE, 12, 25N., 5W., Tazewell	Ill. (Jacksonville) (4)
P-369	NW, SE, SW, 18, 15N., 10E., Bureau	Ill. (B. Hart) (18)
P-371	NE, SE, SW, 15, 16N., 10E., Bureau	Cropsey (3)
P-372	SE, SE, SW, 15, 16N., 10E., Bureau	Cropsey (2)
P-374	SW, SE, SE, 27, 16N., 10E., Bureau (10)	Ill. (B. Hart ?) (19)
P-375	do.	Ill. sand (12)
P-376	do.	Ill. (B. Hart) (6)
P-384	do.	Bloomington (3)
P-388	SW, NW, SW, 1, 33N., 1E., LaSalle	Farm Ridge (4)
P-390	SE, SE, SW, 36, 34N., 4E., LaSalle	Marseilles (3)
P-391	SW, SW, SW, 14, 34N., 8E., Grundy	Minooka (2)
P-392	SE, SE, SE, 31, 36N., 10E., Will	Manhattan (5)
P-394	SW, SW, SW, 5, 36N., 12E., Cook	Valparaiso (2)
P-399	NW, NW, NE, 24, 37N., 12E., Cook	Tinley (3)
P-400	SW, SW, SW, 1, 37N., 12E., Cook	Tinley (2)

TABLE 1 - Continued

P-401	NW, SW, SW, 19, 43N., 9E., McHenry	West Chicago (2)
P-402	SW, SW, NE, 29, 43N., 8E., McHenry	Bloomington
P-403	do.	Gilberts
P-404	do.	Marsailles
P-405	SW, SW, NW, 12, 44N., 5E., McHenry	Marengo (2)
P-407	NE, NW, NE, 28, 46N., 6E., McHenry	West Chicago (1)
P-408	SW, NW, SW, 1, 46N., 4E., Boone	White Rock (2.5)
P-411	NE, SW, NW, 32, 46N., 3E., Boone	Winnebago (3.5)
P-412	do.	Winnebago (2)
P-415	SE, NE, SE, 11, 46N., 2E., Winnebago	Winnebago (3.5)
P-418	NW, SW, NE, 19, 28N., 11E., Winnebago	Winnebago (6)
P-421	NE, SW, SW, 5, 26N., 10E., Winnebago	Winnebago (3)
P-431	SW, SW, SW, 5, 28N., 6E., Stephenson	Winnebago (2)
P-447	SW, SW, SW, 16, 3S., 1W., Washington	Kans. (7)
P-448	do.	Kans. (4)
P-450	do.	Ill. (8)
P-495	SE, SE, SW, 9, 34N., 4E., LaSalle (41)	Shelbyville (1.5)
P-496	do.	Bloomington (13)
P-502	SW, NW, SE, 1, 88N., 2E., Dubuque Co., Iowa	Nebraskan ? (12)
P-506	Center N.L., NW, 32, 89N., 2E., Dubuque Co., Iowa	Nebraskan ? (20)
P-507	do.	Nebr. gravel (17)
P-508	do.	Kans. ? (12)
P-509	do.	Kans. ? (2)
P-538	NE, NW, SW, 17, 15N., 5W., Mercer	Kans. (5)
P-541	do.	Ill. (Payson) (20)
P-542	NW, NE, SE, 15, 21N., 1E., DeWitt (20)	Ill. (B. Hart) (5)
P-549	do.	Shelbyville (4)
P-550	NW, NE, NW, 32, 25N., 1W., McLean (9)	Ill. (B. Hart) (9)
P-558	do	Shelbyville (19)
P-559	Center SE, NE, 20, 28N., 2W., Woodford (30)	Ill. (B. Hart) (6)
P-566	do.	Shelbyville (18)
P-581	SE, NE, NE, 18, 1N., 1E., Schuyler (13)	Ill. (Payson) (3)
P-582	do.	Ill. (Payson) (1)
P-601	NW, SW, SW, 5, 1N., 1W., Schuyler (34)	Kans. (12)
P-604	do.	Ill. (Payson) (12)
P-612	SW, SW, NE, 16, 1N., 1W., Schuyler (33)	Kans. (1)
P-612A	do.	Kans. (0.5)
P-613	do.	Petersburg Silt (24)
P-613A	do.	Petersburg Silt (24.5)
P-614	do.	Petersburg Silt (21)
P-615	do.	Petersburg Silt (5)
P-616	do.	Ill. (Payson) (8)
P-619	SW, SW, NW, 23, 1N., 1W., Schuyler (32)	Ill. (Jacksonville) (15)
P-631	SE, SE, SW, 2, 5N., 10W., Madison	Ill. Payson
P-648	SW, NE, SW, 23, 1N., 1W., Schuyler (31)	Ill. (34)
P-674	SE, NE, NW, 36, 8N., 2E., Fulton	Ill. (B. Hart) (9)
P-674A	do.	Ill. (B. Hart) (10)
P-686	SE, SE, SE, 3, 6N., 5E., Fulton	Nebr. gravels
P-687	Center 31, 26N., 3W., Tazewell (11)	Ill. (B. Hart) (5.5)
P-696	do.	Shelbyville (10)
P-697	do.	LeRoy (15)
P-698	NW, NW, NW, 7, 43N., 1E., Winnebago	Winnebago (5.5)
P-705	Center E.L., 13, 27N., 11E., Winnebago	Winnebago (15)
P-706	do.	Winnebago (11.5)
P-713	NW, SW, SE, 9, 28N., 6E., Stephenson	Winnebago (7)
P-714	do.	Winnebago (6)
P-715	do.	Winnebago (5)
P-724	SE, SW, NW, 8, 23N., 9E., Ogle	Shelbyville (6)
P-726	NE cor., 10, 22N., 10E., Ogle	Shelbyville (4)
P-727	do.	Shelbyville (2)
P-731	NW, SW, NW, 1, 19N., 12W., Vermilion	Kans. ? (1)
P-732	do.	Ill. (5)
P-733	do.	Ill. (3)
P-734	do.	Ill. (0.5)
P-735	do.	Sangamon silt (2)
P-736	do.	Sangamon silt (0.5)
P-737	do.	Roxana Silt ? (2)
P-738	do.	"Danville" (5)
P-739	do.	Roxana Silt ? (0.5)
P-740	do.	Farmdale Silt ? (5)
P-741	do.	Farmdale Silt ? (4)

TABLE 1 - Continued

Sample No.	Location ¼ Sec., T., R., County (Geologic Section No.)*	Stratigraphic Unit (feet below top)
P-742	do.	Farmdale Silt ? (2)
P-743	do.	Shelbyville sand (2)
P-744	do.	Shelbyville (1)
P-745	do.	Champaign (3)
P-746	do.	Urbana silt (1)
P-747	do.	Urbana (3)
P-750	NW, SE, NW, 34, 15N., 4W., Sangamon	Ill. (Jacksonville) (9)
P-755	NW, NW, 10, 24N., 5E., Carroll	Winnebago gravel (6)
P-762	NW, SE, NW, 34, 15N., 4W., Sangamon	Ill. (Jacksonville) (9.5)
P-763	do.	Ill. (Jacksonville) (8.5)
P-777	NW, SW, SW, 8, 7N., 3E., Fulton	Ill. sand (2)
P-777A	do.	Ill. (B. Hart) (19)
P-777B	do. (18)	Ill. (B. Hart) (18)
P-778	do.	Ill. (B. Hart) (7)
P-795	Center NW, 13, 102N., 51W., Minnehaha Co., S. Dakota	Nebraskan
P-796	do.	Kans.
P-806	NE, NE, 7, 22N., 25E., Kewaunee Co., Wisc.	Valders
P-807	SE, SE, 29, 19N., 22E., Manitowoc Co., Wisc.	Valders
P-809	SE, NE, 32, 19N., 22E., Manitowoc Co., Wisc.	Valders
P-818	SW, NE, 21, 33N., 5E., LaSalle	Shelbyville sand (2)
P-819	do.	Shelbyville (5)
P-826	do.	Marsailles (8)
P-945	Center NE, 30, 8N., 2E., Fulton	Ill. (B. Hart) (2)
P-946	SE cor., 1, 5N., 1W., McDonough	Ill. (B. Hart)
P-947	NW, SE, NE, 8, 4N., 3W., McDonough	Ill. (Payson) (9)
P-948	SW, SE, NW, 10, 4N., 4W., McDonough	Kans. sand (2)
P-949	do.	Ill. (Payson) (28)
P-950	do.	Ill. sand (29)
P-951	SW, SE, SE, 15, 5N., 5W., Hancock	Ill. (Payson) (22)
P-952	NE, NW, NW, 22, 5N., 6W., Hancock	Kans.
P-953	SW, SW, SE, 13, 4N., 8W., Hancock	Kans.
P-954	SE, SE, SE, 31, 3N., 8W., Hancock	Ill. (Payson) (10)

Sample No.	Location ¼ Sec., T., R., County (Geologic Section No.)*	Stratigraphic Unit (feet below top)
P-963	SE, SE, NE, 36, 13N., 2W., Christian	Kans. silt
P-964	do.	Kans.
P-964A	SW, SW, NE, 36, 13N., 2W., Christian	Kans. (10)
P-964B	do.	Kans. (14)
P-970	do.	Ill. (Jacksonville) (2)
P-971	do.	Ill. (B. Hart) (4)
P-972	do.	Ill. (B. Hart) (1)
P-977	NE, NW, NE, 21, 10N., 1E., Shelby	Ill.
P-978	SW, SW, SW, 16, 8N., 1E., Fayette	Ill.
P-1037	NW, NE, NE, 24, 5S., 7W., Randolph (36)	Ill. (11)
P-1038	do.	Ill. (8.5)
P-1063	SE, 34, 9S., 2E., Williamson (6)	Ill. (9)
P-1133	SE, NW, SW, 1, 5S., 14W., Posey Co., Ind. (24)	Ill. (3)
P-1157	SW, NE, SW, 6, 5N., 11W., Crawford (12)	Ill. (6)
P-1165	NE, NE, NW, 34, 7N., 10E., Jasper	Ill. (22)
P-1169	NE, NW, SW, 10, 9N., 9E., Cumberland	Ill. (15)
P-1172	SW, SW, SW, 23, 9N., 8E., Cumberland	Ill. (10)
P-1174	N half 14, 8N., 6E., Effingham	Ill.
P-1175	NW, NW, NW, 30, 8N., 4E., Effingham	Ill. (8)
P-1181	SE, SE, NE, 21, 11N., 3E., Shelby	Ill. (B. Hart) (8)
P-1201	NW, NW, SW, 22, 2S., 8W., Adams	Kans. (6)
P-1203	NW, NE, SW, 35, 1S., 8W., Adams	Kans. (39)
P-1204	do.	Kans. (27)
P-1205	do.	Kans. (19)
P-1206	do.	Kans. (14)
P-1207	do.	Kans. (9)
P-1237	SW, NE, SW, 36, 8N., 7W., Henderson (8)	Ill. (Payson) (8)
P-1249	NW, SW, SE, 18, 19N., 9E., Champaign	Champaign (12)
P-1250	NE, SE, 6, 2S., 20E., Doniphan Co., Kans.	Nebraskan (7)
P-1251	do.	Nebraskan (6)
P-1252	do.	Kans. (7.5)
P-1253	½ mi. E. Gahanna, 1N., 16W., Franklin Co., Ohio	Altonian (12)

TABLE 1 - Continued

P-1254	do.	Altonian (1)
P-1256	do.	Woodfordian (30)
P-1264	1 mi. S. Sidney, SW, NW, 8, T.1, R.13, Shelby Co., Ohio	Altonian
P-1265	do.	Altonian gley
P-1266	do.	Woodfordian
P-1270	NW, SW, NE, 16, 39N., 10E., Du-Page	West Chicago (4.5)
P-1284	SE, SW, SW, 34, 8N., 5E., Effing-ham	Ill.
P-1294	NW, NE, 33, 68N., 4W., Lee Co., Iowa	Kans. (30)
P-1302	NE, NE, NW, 10, 68N., 6W., Lee Co., Iowa	Kans. (22)
P-1303	do.	Kans. (17)
P-1321	NW cor., SW, NE, 4, 7N., 5E., Effingham	Ill. (33)
P-1383	SW, NW, SW, 7, 10N., 12W., Greene	Ill. (Payson) (7)
P-1393	Center NW, NW, 19, 19N., 9E., Champaign	Champaign (20)
P-1394	SW, SW, SE, 23, 7N., 4W., Mont-gomery (26)	Ill. (Jacksonville) (11.5)
P-1434	SW, 24, 15N., 11W., Morgan	Ill. (Jacksonville) (8)
P-1435	NE, SW, NW, 3, 16N., 10W., Mor-gan	Ill. (Jacksonville) (5)
P-1461	NW, SW, SW, 8, 7N., 3E., Fulton (18)	Ill. (B. Hart) (6)
P-1470	NE, SW, SE, 30, 26N., 3W., Taze-well	Ill. (B. Hart ?) (2)
P-1471	do.	Ill. silt (1)
P-1472	do.	Ill. (B. Hart) (20)
P-1487	do.	Shelbyville (15)
P-1498	Center SE, 20, 3N., 8W., Madison (29)	Ill. (or Kans.) (4.5)
P-1516	NW, SE, NE, 11, 5N., 10W., Mad-ison	Ill. (Payson) (6)
SS-11269		
25	SW, NW, NW, 25, 6N., 2E., Fulton	Ill. (B. Hart) (10)
30	do.	Ill. (B. Hart) (15)
35	do.	Ill. (B. Hart) (20)
40	do.	Ill. (Payson) (5)
45	do.	Kans. (5)
50	do.	Kans. (10)
55	do.	Kans. (15)
60	do.	Kans. (20)
65	do.	Kans. (25)
75	do.	Kans. (35)
80	do.	Kans. (40)
SS-11269		
85	do.	Kans. (45)
90	do.	Kans. (50)
95	do.	Kans. (55)
105	do.	Kans. (65)
110	do.	Kans. (70)
SS-13054		
10	NW, NE, NE, 33, 36N., 1E., La-Salle	Cropsey (10)
20	do.	Cropsey (20)
25	do.	Cropsey (25)
45	do.	Cropsey (45)
50	do.	Cropsey (50)
55	do.	Cropsey (55)
60	do.	Cropsey (60)
65	do.	Bloomington (5)
70	do.	Bloomington (10)
75	do.	Shelbyville (5)
80	do.	Shelbyville (10)
85	do.	Farmdale ? (5)
90	do.	Farmdale ? (10)
95	do.	Winnebago (5)
100	do.	Winnebago (10)
105	do.	Winnebago (15)
165	do.	Ill. (Payson) (10)
170	do.	Ill. (Payson) (15)
195	do.	Kans. (5)
200	do.	Kans. (10)
205	do.	Kans. (15)
210	do.	Kans. (20)
SS-21158		
15	SW, SE, SE, 15, 4N., 2W., Mc-Donough	Ill. (B. Hart?) (5)
20	do.	Ill. (B. Hart?) (10)
25	do.	Ill. (B. Hart?) (15)
30	do.	Ill. (5)
35	do.	Ill. (Payson) (5)
40	do.	Ill. (Payson) (10)
45	do.	Ill. (Petersburg Silt) (5)
50	do.	Kans. (5)
55	do.	Kans. (10)
60	do.	Kans. (15)
65	do.	Kans. (20)
70	do.	Kans. (25)
75	do.	Kans. (30)
80	do.	Kans. (35)
85	do.	Kans. (40)
90	do.	Kans. (45)

TABLE 1 – Continued

Sample No.	Location ¼ Sec., T., R., County (Geologic Section No.)*	Stratigraphic Unit (feet below top)	Sample No.	Location ¼ Sec., T., R., County (Geologic Section No.)*	Stratigraphic Unit (feet below top)
SS-21158			HK-39	NW, NW, 30, 16N., 5W., Rock	Petersburg Silt (2.2)
95	SW, SE, SE, 15, 4N, 2W, McDonough	Kans. (50)		Island (H-56-5)	
100	do.	Kans. (55)	HK-40	do.	Petersburg Silt (2)
105	do.	Kans. (60)	HK-41	do.	Petersburg Silt (2)
110	do.	Kans. (?) (5)	HK-42	do.	Petersburg Silt (0.8)
115	do.	Kans. (?) (10)	HK-43	do.	Petersburg Silt (0.2)
120	do.	Kans. (?) (15)	HK-44	do.	Ill. (Payson) (14.5)
125	do.	Kans. (?) (20)	HK-45	do.	Ill. (Payson) (11.2)
130	do.	Kans. (?) (25)	HK-46	do.	Ill. (Payson) (10)
135	do.	Kans. (?) (30)	HK-47	do.	Ill. (Payson) (9.8)
140	do.	Kans. (?) (35)	HK-48	do.	Ill. (Payson) (4.5)
145	do.	Kans. (?) (40)	HK-49	do.	Ill. (Payson) (4.2)
150	do.	Kans. (?) (45)	HK-50	do.	Ill. (Payson) (3.8)
155	do.	Kans. (?) (50)	HK-51	do.	Ill. (Payson) (3.2)
160	do.	Kans. (?) (55)	HK-52	do.	Ill. (Payson) (2.8)
SS-22409			HK-53	do.	Ill. (Payson) (2.2)
15	SE, SE, SE, 32, 5N., 1E., Fulton	Ill. (B. Hart) (5)	HK-54	do.	Ill. (Payson) (1.8)
20	do.	Ill. (B. Hart) (10)	HK-55	do.	Ill. (Payson) (1.2)
25	do.	Ill. (B. Hart) (15)	HK-56	do.	Ill. (Payson) (0.8)
55	do.	Ill. (B. Hart) (45)	HK-57	SE, NE, 13, 12N., 5W., Putnam	Kans. (Cagle Silt) (3.9)
70	do.	Ill. (B. Hart) (60)		Co., Indiana	
HK-1	NE, NE, NE, 34, 16N., 10E., Bu-	Ill. (Payson) (3)	HK-61	do.	Kans. (Cagle Silt) (2.8)
	reau (H-53-4)		HK-64	do.	Kans. (Cagle Silt) (1.2)
HK-2	do.	Ill. (Payson) (1)	HK-68	do.	Kans. (Cagle Silt) (0.1)
HK-3	do.	Ill. (B. Hart) (23)	HK-71	do.	Kans. (14.5)
HK-4	do.	Ill. (B. Hart) (20)	HK-72	do.	Kans. (14)
HK-21	do.	Bloomington (1)	HK-73	do.	Kans. (11.5)
HK-23	NW, NW, 30, 16N., 5W., Rock	Kans. (7)	HK-74	do.	Kans. (11.5)
	Island (H-56-5)		HK-84	do.	Ill. (16.9)
HK-24	do.	Kans. (6)	HK-85	do.	Ill. (15.6)
HK-25	do.	Kans. (5)	HK-86	do.	Ill. (13.5)
HK-26	do.	Kans. (4)	HK-87	do.	Ill. (12.2)
HK-27	do.	Kans. (3)	HK-88	do.	Ill. (8.0)
HK-28	do.	Kans. (2)	HKW-106	SE, 22, 8N., 7W., Macoupin	Ill. (Payson) (5)
HK-29	do.	Kans. (1)	HKW-107	do.	Petersburg Silt (1)
HK-30	do.	Kans. (top)	HKW-108	do.	Petersburg Silt (6)
HK-31	do.	Petersburg Silt (6.8)	HKW-109	do.	Petersburg Silt (11)
HK-32	do.	Petersburg Silt (6.2)	HKW-110	do.	Kans. (2)
HK-33	do.	Petersburg Silt (5.5)	HKW-111	do.	Kans. (7)
HK-34	do.	Petersburg Silt (5)	HKW-112	do.	Kans. (12)
HK-35	do.	Petersburg Silt (4.5)	HKW-117	do.	Ill. (Payson) (2)
HK-36	do.	Petersburg Silt (4)	HKW-118	do.	Ill. (Payson) (4.5)
HK-37	do.	Petersburg Silt (3.5)	HKW-119	do.	Ill. (Payson) (7)
HK-38	do.	Petersburg Silt (3)	HKW-120	do.	Ill. (Payson) (9.5)

TABLE 1 - Continued

HKW-121	SE, 22, 8N., 7W., Macoupin	Petersburg Silt (2)	HKW-145	SE, 4, 11N., 1E., Knox	Ill. (Payson) (21)
HKW-122	do.	Petersburg Silt (7)	HKW-153	NE cor., NE, NE, 19, 14N., 1E., Henry	Ill. (Payson) (10)
HKW-134	SW, SW, NE, 32, 1N., 6W., St. Clair	Ill. (5)	HKW-154	do.	Ill. (Payson) (15)
HKW-144	SE, 4, 11N., 1E., Knox	Ill. (Payson) (16)			

*Numbers in parentheses refer to published geologic sections identified in the following list:

1. Alton Quarry (Circular 304)
2. Banner (Circular 304)
3. Bluffdale (Circular 304)
4. Browns Mound (Circular 304)
5. Bunker Hill, this report, pt. 2.
6. Chamness, this report, pt. 1.
7. Cottonwood School (Circular 304)
8. Dallas City (Circular 334)
9. Danvers (Circular 334)
10. Depue (Circular 334)
11. Farm Creek Railroad Cut (Circular 285)
12. Flat Rock, this report, pt. 1.
13. Frederick South (Circular 304)
14. French Village (Circular 334)
15. Fulton Quarry (Circular 334)
16. Gale (Circular 285)
17. Hillview (Circular 334)
18. Hipple School, this report, pt. 2.
19. Lake Bloomington Spillway (Circular 304)
20. Long Point Creek, this report, pt. 2.
21. Marion Northwest (Circular 334)
22. Mason County (Circular 304)
23. New City (Circular 334)
24. New Harmony (Circular 334)
25. North Quincy (Circular 334)
26. Panama A, this report, pt. 2.
27. Patton South (Circular 334)
28. Petersburg, this report, pt. 1
29. Pleasant Grove School (Circular 285)
30. Richland Creek (Circular 334)
31. Rushville (0.1W), this report, pt. 1
32. Rushville (0.4W) (Circular 285)
33. Rushville (2.4W), this report, pt. 1
34. Rushville (4.5W), this report, pt. 1
35. Savanna (Circular 304)
36. Schuline, this report, pt. 1
37. Seehorn (Circular 334)
38. The Rocks (Circular 304)
39. Tindall School, this report, pt. 1
40. Varna (Circular 334)
41. Wedron (Circular 304)
42. Wolf Creek (Circular 334)

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

			Opaque		Transparent Heavy Minerals (%)														Light (%)				
Sample no.	.062–.250mm fraction (%)	Heavy minerals in fraction (%)	Black	Others	Tourmaline	Zircon	Garnet	Epidote	Rutile	Titanite	Kyanite	Staurolite	Andalusite	Actinolite	Hornblende	Enstatite	Hypersthene	Diop.–Aug.	Others	Quartz	K Feld.	Na–Ca Feld.	Others	Percent soluble
P– 1	18.6	–	32		11	6	16	12	2	–	–	–	–	11	32	–	–	1	9	45	14	7	34	23.0
P– 1A	16.8	0.9	7	19	1	1	19	10	–	–	–	–	–	–	67	1	–	–	–	67	20	6	7	28.0
P– 26	20.2	–	37		5	10	27	9	4	–	–	–	–	1	27	–	1	–	16	69	13	6	12	9.2
P– 46	–	–	45		11	4	11	18	3	–	1	2	1	4	36	–	1	–	8	78	10	9	3	–
P– 61	36.8	–	43		12	18	13	21	1	–	–	–	6	2	18	1	–	–	8	76	13	6	5	4.4
P– 63	24.4	–	49		5	4	28	45	1	–	–	–	–	2	6	–	–	–	9	77	11	6	6	15.2
P– 65	20.4	–	47		8	7	5	30	2	1	–	–	1	5	36	–	2	–	3	78	10	10	2	17.4
P– 90	1.65	0.2	12	2	7	3	8	13	–	1	1	–	–	6	49	1	–	8	3	65	19	10	6	16.0
P– 91	.9	0.5	21	4	2	3	14	22	–	–	–	1	–	1	47	3	1	3	3	81	12	4	3	31.0
P– 94	21.5	0.7	16	4	4	3	17	19	–	2	–	1	–	6	36	2	1	6	3	68	17	5	10	27.0
P– 95	17.1	1.9	14	3	1	2	23	17	1	4	1	1	–	4	40	2	–	1	3	70	15	14	1	2.5
P– 96	5.8	0.6	15	5	4	1	29	16	1	–	–	–	–	6	34	1	1	3	4	85	7	6	2	6.5
P– 97	23.8	0.7	10	10	1	3	13	19	–	–	–	–	–	4	60	–	–	–	–	70	18	9	3	26.0
P– 113	15.7	1.6	13	20	1	4	16	20	–	1	–	–	1	2	54	1	–	–	–	70	10	5	15	20.0
P– 119	12.5	1.6	15	13	3	1	17	28	–	–	–	–	–	2	42	3	–	1	3	71	15	7	7	21.5
P– 120	14.0	1.9	14	42	–	2	10	15	1	–	–	–	–	1	68	1	1	–	1	73	11	7	9	26.5
P– 121	0.4	–	23	19	1	7	13	38	2	–	–	–	–	–	32	3	3	1	–	–	–	–	–	23.0
P– 122	54.9	0.9	19	17	4	6	10	31	1	–	–	–	–	–	40	2	2	2	2	–	–	–	–	11.0
P– 123	14.8	1.5	17	22	7	2	15	28	–	1	–	–	–	–	45	–	–	–	2	77	15	7	1	23.0
P– 125	10.7	1.3	39	21	7	1	21	16	1	1	1	–	–	5	36	1	1	4	5	81	13	5	1	24.5
P– 126	11.7	1.7	16	26	3	3	8	9	–	–	1	–	–	1	72	–	–	1	2	70	17	7	6	33.0
P– 131	10.5	2.2	8	47	2	2	9	9	–	–	–	–	–	–	76	1	–	–	1	64	16	6	14	28.5
P– 138	15.6	1.5	9	28	–	3	10	16	–	–	–	–	–	–	65	2	2	–	2	75	16	7	2	33.0
P– 139	16.7	0.6	15	12	1	3	20	18	–	–	–	–	–	–	57	1	–	–	–	77	17	6	–	35.0
P– 141	21.5	3.1	17	6	1	1	15	9	–	–	–	–	–	2	66	2	3	1	–	55	10	13	22	32.5
P– 142	18.8	1.2	11	6	–	4	19	15	–	–	–	–	–	–	55	2	2	2	1	63	15	15	7	28.0
P– 143	18.5	1.1	26	15	1	4	18	16	–	–	–	–	4	–	52	–	4	–	1	65	14	12	9	30.0
P– 144	–	–	7	15	–	12	8	19	–	–	–	–	–	–	61	–	–	–	–	79	9	9	3	40.5
P– 145	14.7	1.3	13	15	2	1	8	4	–	–	–	–	–	–	76	–	5	1	3	77	15	7	1	33.0
P– 146	10.9	1.1	23	22	1	7	13	19	–	–	–	–	–	–	53	2	4	–	1	72	20	8	–	30.5
P– 147	11.5	1.8	41	11	2	–	31	23	–	–	–	–	–	1	38	2	3	–	–	63	14	16	7	41.5
P– 148	7.4	0.5	16	13	1	3	14	14	–	1	1	–	–	–	63	1	1	1	–	73	19	7	1	25.5
P– 170	6.2	1.6	16	3	1	1	7	24	–	1	–	–	–	1	63	1	–	1	–	–	–	–	–	–
P– 171	21.3	1.2	15	9	1	1	24	15	1	–	–	–	–	–	55	1	1	–	1	–	–	–	–	12.6
P– 172	19.5	1.5	26	10	2	5	14	34	–	1	–	–	–	1	39	2	–	–	2	–	–	–	–	26.2
P– 173	12.3	1.9	17	16	–	2	12	33	–	1	–	–	–	1	48	1	–	1	–	–	–	–	–	28.4
P– 180	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	71	15	7	7	24.0
P– 181	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	72	13	7	8	27.0
P– 182	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	74	13	7	6	21.5

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	Actinolite	Hornblende	Enstatite	Hypersthene	Diop.–Aug.	Others	Light (%): Quartz	K Feld.	Na–Ca Feld.	Others	Percent soluble
P– 195	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	72	14	10	4	28.0
P– 196	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	66	15	11	8	23.5
P– 197	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	65	17	13	5	28.5
P– 277	14.8	1.8	8	12	1	2	11	9	–	1	–	–	–	1	73	–	1	–	1	75	13	10	2	–
P– 301	9.4	1.4	12	17	4	4	9	29	–	–	–	–	–	2	50	2	–	–	–	75	13	10	2	6.5
P– 312	–	–	13	41	2	4	16	12	–	–	–	–	–	1	47	3	8	1	6	–	–	–	–	34.5
P– 327	10.5	0.8	20	15	2	3	14	16	–	–	–	–	1	–	62	–	–	2	–	78	9	9	4	14.0
P– 335	14.9	1.1	10	15	2	3	10	11	–	–	–	–	–	1	69	–	3	1	–	74	18	5	3	29.0
P– 344	4.4	0.7	7	27	2	4	7	18	–	–	–	–	–	3	62	1	–	1	2	72	12	12	4	32.5
P– 346	5.1	1.5	5	10	2	1	8	6	–	1	–	–	–	1	75	2	2	2	–	58	27	7	8	28.0
P– 347	10.1	trace	3	14	–	3	6	13	–	–	2	–	–	–	68	–	–	3	5	63	20	12	5	30.0
P– 349	3.1	2.3	6	9	–	1	13	3	–	–	–	–	–	2	72	2	5	2	–	62	19	11	8	31.5
P– 350	10.1	1.2	6	23	2	3	13	16	–	1	–	–	–	–	63	–	2	–	–	64	23	9	4	26.5
P– 355	15.3	0.6	7	9	–	2	15	10	–	–	–	–	–	–	70	–	3	–	–	62	22	9	7	20.5
P– 356	13.7	1.5	13	11	1	–	19	7	–	–	1	–	–	–	68	–	3	1	–	61	21	9	9	25.0
P– 357	14.2	0.7	5	21	1	1	14	20	–	–	–	–	–	–	61	3	–	–	–	75	12	10	3	20.5
P– 365	12.9	0.9	10	9	1	–	16	16	–	–	–	–	–	–	65	–	–	–	2	68	21	6	5	27.5
P– 369	9.6	0.8	12	17	1	–	7	10	–	–	–	1	–	1	67	2	7	2	2	67	19	5	9	25.5
P– 372	11.1	0.9	9	7	–	1	10	24	–	–	–	–	–	–	61	–	2	–	2	71	19	6	4	38.5
P– 374	20.6	0.8	4	25	1	–	17	17	–	–	–	–	–	2	56	3	2	1	1	64	23	7	6	32.0
P– 375	5.8	2.0	19	12	1	2	6	9	–	–	–	–	–	–	70	1	4	1	6	61	19	12	8	56.5
P– 376	17.0	1.0	13	18	1	2	8	12	–	–	–	–	–	1	72	1	–	1	2	79	12	8	1	29.0
P– 384	13.7	1.0	9	12	1	1	7	15	–	–	–	–	–	–	66	2	7	1	–	66	23	5	6	33.5
P– 388	6.2	1.3	6	6	2	–	6	11	–	–	–	–	–	–	68	2	7	2	2	66	22	6	6	40.0
P– 390	3.1	1.8	12	11	–	1	7	22	–	–	–	–	–	1	63	2	1	1	2	61	21	11	7	38.5
P– 391	4.6	1.8	11	11	–	–	4	24	–	–	–	–	–	–	59	4	6	–	3	60	21	7	12	40.0
P– 392	6.0	1.8	5	12	1	2	10	13	–	–	–	1	–	–	63	–	5	4	1	63	18	10	9	38.5
P– 394	3.7	1.0	5	11	1	1	13	20	–	–	–	–	–	3	57	1	3	1	–	58	21	10	11	30.0
P– 399	3.8	0.9	3	6	–	2	8	5	–	–	–	–	–	–	82	–	3	–	–	67	18	5	10	20.5
P– 400	1.7	1.3	2	11	1	1	6	15	–	–	–	–	–	2	70	2	–	–	3	64	23	8	5	29.0
P– 401	12.2	2.8	13	6	–	1	6	22	–	–	–	–	–	–	45	11	9	2	4	67	20	8	5	47.5
P– 402	13.8	1.1	5	10	1	4	13	18	–	1	–	–	–	–	58	3	1	–	1	80	14	5	1	42.0
P– 403	17.8	1.2	4	12	2	–	15	13	–	1	–	–	–	–	62	1	6	–	–	78	16	5	1	38.0
P– 404	2.9	2.6	11	10	1	–	7	16	–	–	–	–	–	–	61	2	8	–	5	73	18	7	2	31.0
P– 405	13.2	1.2	3	4	1	1	8	11	–	–	–	1	–	–	66	4	3	2	3	62	25	10	3	45.0
P– 407	16.7	1.9	10	6	–	1	10	17	–	–	–	–	–	–	63	4	2	1	2	63	23	10	4	47.5
P– 408	14.0	1.1	8	16	1	2	14	23	–	–	–	–	–	1	54	–	2	3	–	73	19	7	1	38.0
P– 411	13.1	1.3	7	8	1	3	11	21	–	–	–	–	–	–	59	1	2	1	1	75	18	7	–	40.0
P– 412	22.3	0.9	5	17	1	1	15	18	–	–	–	1	–	–	62	–	1	–	1	78	15	6	1	16.0
P– 415	18.6	0.9	7	9	4	1	17	18	–	–	–	–	–	1	55	1	3	–	–	73	18	7	2	33.5

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	Actinolite	Hornblende	Enstatite	Hypersthene	Diop.–Aug.	Others	Quartz	K Feld.	Na-Ca Feld.	Others	
P– 421	8.5	1.2	13	8	–	1	12	15	1	–	–	–	–	–	65	3	2	–	1	69	20	5	6	64.5
P– 431	5.5	1.5	16	4	1	1	9	11	–	–	–	–	–	–	72	–	3	1	2	67	10	21	2	45.5
P– 447	24.6	1.0	14	36	3	1	33	5	–	–	–	–	–	–	44	1	6	7	–	87	5	6	2	24.0
P– 450	15.2	0.9	11	17	3	2	17	15	–	–	–	–	–	1	58	1	1	1	1	76	12	8	4	22.5
P– 495	23.6	1.1	8	19	–	1	10	12	–	–	–	–	–	2	60	1	–	–	14	67	19	11	3	30.0
P– 496	15.8	1.2	26	11	3	1	12	19	–	–	–	–	–	–	63	–	–	1	1	65	20	9	6	35.5
P– 502	15.9	1.8	17	12	1	–	11	21	–	–	–	3	–	–	62	1	1	–	–	75	13	7	5	8.5
P– 506	18.9	1.4	14	21	–	1	10	20	–	–	2	2	1	–	62	–	–	–	2	74	14	8	4	16.0
P– 507	20.3	1.0	17	15	1	1	7	14	1	–	1	4	–	–	71	–	–	–	–	–	–	–	–	16.0
P– 508	17.4	1.5	14	20	3	3	9	14	1	–	2	2	–	–	62	–	2	–	2	–	–	–	–	10.0
P– 509	20.3	0.4	9	24	7	6	7	25	–	–	1	10	–	–	43	–	–	–	1	–	–	–	–	12.0
P– 538	21.3	1.6	6	11	3	–	8	23	–	–	–	1	–	–	60	4	–	–	1	72	17	9	2	15.5
P– 541	15.9	0.9	11	20	–	4	24	17	–	–	1	1	–	–	52	–	–	–	1	–	–	–	–	24.0
P– 542	21.7	0.5	17	11	1	–	14	9	–	–	–	–	–	–	76	–	–	–	–	–	–	–	–	12.0
P– 549	12.8	1.2	10	6	1	–	12	9	–	–	–	–	–	–	76	–	1	1	–	–	–	–	–	26.0
P– 550	15.0	0.7	9	19	2	–	11	11	1	–	1	–	–	–	69	–	1	–	4	–	–	–	–	27.5
P– 558	12.3	1.2	31	6	1	1	20	9	–	–	–	–	–	–	68	–	–	1	–	–	–	–	–	29.0
P– 559	16.3	1.8	9	22	1	–	8	4	–	–	–	–	–	–	85	–	1	1	–	–	–	–	–	30.0
P– 566	14.4	1.6	42	9	–	2	14	17	–	–	–	–	–	1	55	3	4	3	1	–	–	–	–	32.0
P– 581	14.1	0.7	6	10	3	3	12	9	–	–	–	–	–	3	66	–	3	1	–	–	–	–	–	33.0
P– 601	10.8	0.8	22	21	8	–	12	25	–	–	–	–	–	1	50	2	–	–	2	78	9	9	4	17.5
P– 604	10.5	0.6	17	20	3	1	8	14	1	–	–	4	–	–	68	–	–	–	1	–	–	–	–	18.0
P– 612	8.2	1.9	17	26	5	4	29	17	2	–	–	–	–	–	43	–	–	–	–	–	–	–	–	16.0
P– 613A	4.3	–	8	6	1	2	17	11	–	–	–	1	–	–	64	1	1	2	–	–	–	–	–	23.0
P– 614	0.2	trace	6	5	–	1	6	11	–	–	–	–	–	–	78	–	–	1	3	69	20	6	5	7.0
P– 619	15.2	1.4	9	16	2	3	22	18	–	1	–	–	–	1	52	1	–	–	–	70	15	12	3	16.5
P– 631	3.2	5.3	27	9	2	–	13	13	–	–	–	–	–	–	67	1	3	–	1	67	15	10	8	13.0
P– 674	15.9	0.8	8	29	4	9	19	18	–	–	–	–	–	–	50	–	–	–	–	82	11	4	3	17.5
P– 686	19.4	0.8	20	15	5	2	20	16	–	–	1	4	–	–	50	–	2	–	–	81	7	8	4	22.0
P– 687	14.7	0.3	1	47	9	1	12	10	–	–	–	–	–	2	62	1	–	–	3	71	12	13	4	25.0
P– 698	24.7	1.2	23	8	1	2	11	8	–	–	–	–	–	–	70	–	4	3	1	66	21	7	6	23.0
P– 705	23.9	0.7	4	11	1	1	13	19	–	–	–	1	–	2	61	–	1	–	1	76	18	4	2	36.0
P– 706	21.5	1.0	11	15	3	1	13	21	1	–	–	–	–	–	58	–	3	–	–	82	14	3	1	22.5
P– 713	14.4	1.0	12	6	4	1	11	24	–	–	–	–	–	–	50	2	6	1	1	67	19	12	2	42.5
P– 714	12.8	1.0	12	16	1	1	10	21	–	–	–	–	–	2	58	–	5	1	1	72	17	8	3	37.5
P– 715	15.4	0.6	15	17	1	1	14	21	–	–	–	–	–	–	62	–	1	–	–	77	18	5	–	37.0
P– 724	10.2	2.6	15	18	4	2	8	12	–	–	–	–	–	4	69	–	–	–	1	70	19	8	3	31.0
P– 726	15.6	0.7	5	19	3	1	12	20	–	–	–	–	–	–	60	–	4	–	–	71	19	7	3	36.0
P– 727	18.0	0.7	7	12	–	1	18	22	–	–	–	–	–	2	50	1	4	2	–	77	16	4	3	30.5
P– 731	13.1	4.4	7	3	1	–	10	2	–	–	–	–	–	–	66	2	7	11	1	60	18	15	7	33.5

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	Actinolite	Hornblende	Enstatite	Hypersthene	Diop.–Aug.	Others	Quartz	K Feld.	Na–Ca Feld.	Others	
P– 715	15.4	0.6	15	17	1	1	14	21	–	–	–	–	–	–	62	–	1	–	–	77	18	5	–	37.0
P– 724	10.2	2.6	15	18	4	2	8	12	–	–	–	–	–	4	69	–	–	–	1	70	19	8	3	31.0
P– 726	15.6	0.7	5	19	3	1	12	20	–	–	–	–	–	–	60	–	4	–	–	71	19	7	3	36.0
P– 727	18.0	0.7	7	12	–	1	18	22	–	–	–	–	–	2	50	1	4	2	–	77	16	4	3	30.5
P– 731	13.1	4.4	7	3	1	–	10	2	–	–	–	–	–	–	66	2	7	11	1	60	18	15	7	33.5
P– 732	15.6	2.7	3	9	1	–	23	3	–	–	–	–	–	2	64	1	3	2	1	63	16	13	8	36.0
P– 733	18.0	2.0	8	8	2	–	21	9	–	–	–	–	–	–	59	2	1	3	3	–	–	–	–	12.5
P– 734	17.2	1.6	6	8	–	4	26	5	–	–	1	–	–	–	59	3	1	1	–	–	–	–	–	10.0
P– 735	16.5	1.4	6	15	1	3	28	9	–	–	1	–	–	1	50	1	1	1	4	–	–	–	–	12.0
P– 736	5.8	2.2	10	5	2	3	30	5	–	–	1	–	–	–	53	3	1	1	1	–	–	–	–	10.5
P– 737	0.1	1.8	12	8	1	1	2	6	–	–	–	–	–	–	74	1	4	3	8	67	19	8	6	34.0
P– 738	7.3	4.2	6	9	–	1	24	4	–	–	1	–	–	2	63	–	2	–	3	65	17	9	9	29.0
P– 739	19.0	0.7	23	10	2	2	40	21	–	1	–	–	–	–	29	–	–	1	4	–	–	–	–	18.0
P– 740	0.1	0.2	1	10	–	11	10	4	–	–	–	–	–	–	70	1	1	2	1	–	–	–	–	7.0
P– 742	3.5	1.3	43	22	4	3	48	13	–	–	3	–	–	3	22	–	–	–	4	–	–	–	–	12.0
P– 743	52.8	0.9	4	9	1	–	16	8	–	–	–	–	–	–	68	1	6	–	–	75	15	7	3	1.0
P– 744	19.7	1.0	4	14	–	1	15	4	–	–	–	–	–	–	74	1	3	1	1	64	22	10	4	28.0
P– 745	15.0	0.9	4	14	2	8	30	6	–	–	–	–	–	–	48	–	3	2	1	66	20	9	5	28.5
P– 746	5.6	0.8	5	11	2	3	24	5	–	–	–	–	–	–	59	1	3	2	1	–	–	–	–	26.0
P– 747	8.4	1.0	6	8	1	2	11	4	–	–	–	–	–	–	79	1	2	–	–	68	22	6	4	23.0
P– 750	15.0	0.5	1	20	3	2	17	16	–	–	–	–	–	5	47	1	3	2	4	73	13	11	3	29.5
P– 755	10.4	2.8	24	13	2	–	10	9	–	–	–	–	–	–	79	–	–	–	–	66	18	9	7	38.0
P– 762	15.0	0.7	5	15	2	2	14	18	–	1	–	–	–	1	56	1	–	–	5	69	18	7	6	29.0
P– 763	19.2	0.5	4	17	3	2	16	15	–	–	–	–	–	1	60	–	–	1	2	68	18	6	8	13.5
P– 777	15.0	1.0	10	29	2	2	23	25	–	–	–	–	–	–	38	1	2	2	5	68	12	5	15	21.0
P– 778	4.7	0.9	4	20	5	10	16	15	1	–	–	–	–	–	49	–	1	–	3	68	13	7	12	7.6
P– 795	14.0	–	6	7	2	3	17	12	–	–	–	2	–	–	64	–	–	–	–	–	–	–	–	33.5
P– 796	10.8	–	10	6	2	1	10	10	–	–	1	2	–	–	70	1	1	1	1	–	–	–	–	27.5
P– 818	25.0	1.3	13	22	2	2	16	4	–	–	–	–	–	–	70	–	2	2	2	–	–	–	–	–
P– 819	19.7	1.5	16	35	1	1	15	14	–	–	–	–	–	–	59	–	6	1	3	–	–	–	–	–
P– 826	2.8	1.2	17	22	2	6	7	4	–	–	–	–	–	–	72	–	7	2	–	–	–	–	–	–
P– 945	5.7	2.0	10	43	1	2	4	6	–	–	–	–	–	1	77	3	4	1	1	–	–	–	–	–
P– 946	12.7	1.0	7	18	5	–	16	10	1	–	1	–	–	–	61	1	2	–	3	–	–	–	–	–
P– 947	13.9	0.9	14	13	7	1	10	12	–	–	–	1	–	–	64	1	3	–	1	–	–	–	–	–
P– 948	16.9	1.0	16	6	4	1	21	15	1	–	–	4	–	–	53	–	1	–	–	–	–	–	–	–
P– 950	63.1	0.7	13	12	2	–	14	8	–	–	1	2	–	–	67	2	1	1	2	–	–	–	–	–
P– 951	12.2	0.9	9	18	2	1	15	16	1	–	1	1	–	–	56	1	3	1	2	–	–	–	–	–
P– 952	28.9	0.4	19	19	6	7	10	18	–	–	–	11	–	–	46	1	1	–	–	–	–	–	–	–
P– 953	19.9	1.0	21	16	3	3	9	21	2	–	1	1	–	–	59	–	–	–	1	–	–	–	–	–
P– 954	13.9	0.7	10	15	3	3	13	13	–	–	–	3	–	–	62	1	–	–	2	–	–	–	–	–

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	Actinolite	Hornblende	Enstatite	Hypersthene	Diop.–Aug.	Others	Quartz	K Feld.	Na–Ca Feld.	Others	
P– 964	19.2	3.8	15	7	–	2	26	5	–	–	–	–	–	–	59	1	3	3	1	–	–	–	–	–
P– 970	18.2	1.2	17	11	–	3	24	13	–	–	–	–	–	–	58	–	2	–	–	–	–	–	–	–
P–1038	22.5	0.2	10	10	–	5	38	12	–	1	–	–	–	1	41	–	1	–	1	–	–	–	–	–
P–1063	17.8	0.7	13	25	4	2	18	6	–	–	1	–	-	3	58	–	–	1	7	–	–	–	–	–
P–1133	25.5	0.7	8	24	4	6	22	9	1	–	–	1	–	1	51	–	–	1	4	–	–	–	–	–
P–1165	16.1	1.4	11	11	3	3	13	8	–	–	–	–	–	–	67	–	3	1	2	–	–	–	–	–
P–1174	24.8	1.3	24	6	1	2	22	11	–	–	–	–	–	1	61	1	1	–	–	–	–	–	–	–
P–1175	16.9	1.1	11	12	3	1	12	8	–	–	–	–	–	1	73	–	1	–	1	–	–	–	–	–
P–1201	19.2	0.4	19	8	2	4	6	21	–	–	–	–	–	–	65	1	–	–	1	–	–	–	–	–
P–1203	19.8	0.6	7	8	–	2	11	22	–	–	–	4	–	–	57	4	–	–	–	–	–	–	–	–
P–1207	20.4	0.8	14	10	1	5	11	14	–	–	1	4	–	–	63	–	1	–	–	–	–	–	–	–
P–1237	19.1	0.6	20	13	1	3	15	15	1	–	1	4	–	–	59	–	–	–	1	–	–	–	–	–
P–HK71	14.7	3.5	8	9	–	1	16	9	–	–	–	–	–	1	69	1	5	3	2	82	7	9	2	29.0

TABLE 3 – AVERAGES OF HEAVY AND LIGHT MINERALS FOR STRATIGRAPHIC UNITS

Stratigraphic Unit	Number of samples	Black opaque	Transparent heavy minerals (Complete analyses in table 2)															Light minerals				
			Tourmaline	Zircon	Garnet	Epidote	Rutile	Titanite	Kyanite	Staurolite	Andalusite	Actinolite	Hornblende	Enstatite	Hypersthene	Diop.-Augite	Others	Number of samples	Quartz	K feldspar	Na-Ca feldspar	Others
Wisconsinan (all)	55	11	1	2	12	14	tr.	tr.	tr.	tr.		1	64	1	3	1	1	45	70	19	8	4
Tinley	2	3	1	2	7	10		tr.		tr.		1	59	3	4	1	2	9	71	19	7	3
Valparaiso, West Chicago	4	11	1	1	9	21		tr.				1	57	4	4	1	1	3	63	21	9	7
Minooka, Manhattan	2	8	1	1	7	18				1			61	2	5	2	2	2	62	19	9	10
Marseilles, Farm Ridge	4	12	1	2	7	13						tr.	66	2	6	1	2	3	67	20	8	5
Cropsey, Gilberts	4	6	2	2	10	15		1				1	65	1	3	1	1	4	70	18	8	4
Bloomington, Normal, Metamora, Marengo	11	11	1	3	13	15	tr.	tr.	tr.	tr.		tr.	63	1	2	1	1	10	69	20	8	3
Shelbyville, LeRoy, Champaign, Urbana (all)	16	12	1	2	14	12			tr.			1	64	1	3	1	1	12	69	20	7	4
North	8	14	1	2	13	17			tr.			1	59	1	3	1	2	6	72	18	7	3
South	8	11	1	2	16	7			tr.				69	tr.	3	1	1	6	66	21	8	5
Winnebago	12	12	2	1	12	17	tr.			tr.		tr.	62	1	3	1	1	12	72	17	8	3
Illinoian (all)	51	12	3	3	16	13	tr.	tr.	tr.	tr.	tr.	1	59	1	1	1	2	38	71	14	9	6
Buffalo Hart	15	10	3	3	12	11	tr.		tr.	tr.	tr.	tr.	66	1	1	1	2	12	73	13	8	6
Jacksonville	8	9	2	2	16	16		tr.		tr.		2	57	1	1	1	2	7	70	18	7	5
Payson	13	15	3	2	16	15	tr.	1	tr.	1	tr.	2	55	1	2	tr.	2	7	73	13	9	5
Southeast	11	11	3	3	22	9	tr.	tr.	tr.	tr.		1	56	1	1	1	3	6	68	15	10	7
Kansan (eastern)	4	11	1	1	21	5						1	58	1	5	6	1	3	76	10	10	4
Kansan (western)	15	14	4	4	10	23	1	tr.	tr.	2	1	1	49	1	1		2	6	76	12	8	4
Nebraskan	3	16	1	1	9	18	tr.		1	3	tr.		65	tr.	tr.		1	2	74	13	8	5

The above averages are based on the following samples:

Tinley: P-399, 400
Valparaiso: P-170, 394
West Chicago: P-401, 407
Manhattan: P-392
Minooka: P-391
Marseilles: P-390, 404, 826
Farm Ridge: P-388
Gilberts: P-403
Cropsey: P-344, 346, 372
Marengo: P-405
Normal: P-148, 347, 349
Metamora: P-139

Bloomington: P-147, 171, 350, 384, 402, 496
Urbana: P-747
Champaign: P-745
LeRoy: P-355
Shelbyville: P-138, 145, 356, 408, 495, 549, 558, 566, 724, 726, 727, 744, 819
Winnebago: P-411, 412, 415, 421, 431, 698, 705, 706, 713, 714, 715, 755
Illinoian (Southeast): P-26, 195, 196, 197, 450, 732, 733, 734, 1038, 1063, 1133, 1165, 1174, 1175
Buffalo Hart: P-126, 131, 180, 181, 182, 312, 327, 356, 369, 376, 542, 550, 559, 674, 687, 778, 945, 946

Jacksonville: P-94, 97, 335, 365, 750, 762, 763, 970
Payson: P-46, 95, 113, 125, 277, 541, 581, 619, 631, 947, 951, 954, 1237
Kansan (Eastern): P-447, 731, 964, HK-71
Kansan (Western): P-61, 63, 65, 119, 120, 123, 301, 508, 509, 538, 601, 952, 953, 1201, 1203, 1207
Nebraskan: P-502, 506, 507

TABLE 4 - CLAY MINERAL AND CARBONATE X-RAY ANALYSES

Sample number	X-ray diffraction intensity in counts per second: Bulk sample: Calcite	Bulk sample: Dolomite	Clay minerals in < 2μ fraction: Percent montmorillonite	Percent illite	Percent kaolinite and chlorite	Chlorite	Kaolinite	Sample number	X-ray diffraction intensity in counts per second: Bulk sample: Calcite	Bulk sample: Dolomite	Clay minerals in < 2μ fraction: Percent montmorillonite	Percent illite	Percent kaolinite and chlorite	Chlorite	Kaolinite
P-1	18	105	36	51	13	+	+	170	–	185	–	83	17	+	+
1A	90	100	22	58	20	+	+	172	30	430	16	63	21	+	+
26	11	90	41	45	14		+	173	105	225	12	63	25	+	+
46	–	–	54	24	22		+	180	35	30	–	65	35	+	+
61	–	–	67	13	20		+	181	15	24	–	65	35	+	+
63	–	–	81	9	10		+	182	14	14	–	59	41	+	+
65	–	–	62	15	23		+	195	18	100	17	59	24	+	+
90	–	120	56	32	12	+	+	196	22	85	16	62	22	+	+
91	29	190	47	43	10	+	+	197	20	70	14	67	19	+	+
94	32	115	24	62	14	+	+	277	75	250	21	53	16	+	+
95	–	–	41	40	19		+	301	–	–	65	15	20		+
96	–	31	68	19	13		+	312	18	135	–	78	22	+	+
97	13	125	24	62	14	+	+	327	–	–	6	61	33	+	+
113	28	122	28	51	21	+	+	335	25	200	11	75	14	+	+
119	27	105	36	40	24	+	+	344	–	90	–	83	17	+	
119A	17	75	49	30	21	+	+	346	10	95	–	78	22	+	
120	31	63	39	44	17		+	347	22	130	–	83	17	+	
121	50	120	26	48	26	+	+	349	28	50	–	83	17	+	
121A	30	52	28	43	29	+	+	350	–	100	3	83	14	+	
122	–	23	*	*	*		+	355	–	20	13	79	8	+	
123	21	65	45	40	15		+	356	10	70	5	87	8	+	
123A	20	40	45	41	14		+	357	10	60	6	84	10	+	+
125	44	100	37	46	17	+	+	365	15	90	18	70	12	+	+
126	38	200	2	88	10	+	+	369	4	43	6	75	19	+	+
130	65	175	7	79	14	+	+	371	20	37	4	88	8	+	
131	21	110	3	79	18	+	+	372	20	150	3	89	8	+	
138	17	280	6	69	25	+	?	374	30	170	6	71	23	+	+
139	28	300	13	75	12	+		375	85	530	3	74	23	+	+
141	85	105	10	66	24	+	?	376	29	150	2	90	8	+	+
142	24	200	2	84	14	+	?	384	14	85	8	78	14	+	?
143	35	125	3	77	20	+	?	388	15	125	–	87	13	+	
144	90	350	*	*	*			390	5	80	–	91	9	+	
145	40	450	–	75	25	+	?	391	17	150	–	90	10	+	
146	75	330	4	84	12	+	?	392	12	225	5	83	12	+	?
147	90	440	–	88	12	+		394	17	105	5	84	11	+	
148	27	125	1	92	7	+		399	–	70	2	86	12	+	

TABLE 4 - Continued

P-400	18	90	3	85	12	+		P-674A	18	25	3	66	31	+	+
401	20	380	5	80	15	+		686	–	–	53	27	20		+
402	35	220	11	68	21	+		687	75	85	–	85	15	+	+
403	22	290	11	68	21	+		696	20	125	8	69	23	+	
404	15	100	1	87	12	+		697	20	90	6	72	22	+	
405	–	225	19	62	19	+	?	698	–	40	22	68	10	+	
407	20	545	13	65	22	+		705	24	740	15	72	13	+	
408	5	185	28	55	17	+	+	706	–	15	26	47	27	+	
411	10	210	20	64	16	+		713	–	620	42	40	18	+	
412	–	120	23	64	13	+		714	5	155	52	36	12	+	
415	18	360	19	63	18	+		715	–	340	62	29	9	+	
418	18	205	38	48	14	+		724	–	135	–	90	10	+	
421	–	800	17	66	17	+		726	18	160	–	90	10	+	
431	25	280	26	62	12	+		727	–	150	5	78	17	+	+
447	20	6	14	47	39	+	+	731	70	30	–	74	26	+	+
448	30	–	24	47	29	+	+	732	55	90	5	67	28	+	+
450	12	42	15	57	28	+	+	733	28	–	34	39	27	+	+
495	16	305	6	75	19	+		734	–	–	47	26	27	+	+
496	20	155	6	64	30	+		735	–	–	44	27	29	+	+
502	–	9	63	17	20		+	736	–	–	49	19	32	+	+
506	55	40	51	15	34		+	737	5	115	15	58	27	+	+
507	–	–	42	19	39		+	738	27	55	26	50	24	+	+
508	14	15	66	9	25		+	739	–	–	78	10	12		+
509	–	–	66	4	30		+	740	–	–	52	11	37	+	+
538	50	20	68	15	17		+	741	–	–	44	21	35	+	+
541	20	75	63	24	13		+	742	–	–	68	10	22	+	+
542	–	–	6	66	28	+	+	743	–	–	12	71	17	+	
549	15	125	10	78	12	+		744	30	135	8	66	26	+	?
550	–	155	2	71	27	+	+	745	23	90	2	87	11	+	
558	10	145	10	67	23	+		746	10	95	1	90	9	+	
559	38	385	–	75	25	+	+	747	–	40	3	87	10	+	
566	20	105	4	68	28	+	?	750	18	80	16	70	14	+	+
581	22	75	28	58	14	+	+	762	18	95	14	82	4		+
582	28	110	31	55	14	+	+	763	–	30	23	71	6		+
603A†	–	–	61	15	24		+	777	47	26	–	92	8	+	+
604	12	5	19	57	24		+	777A	35	10	8	69	23	+	+
612A	–	–	73	11	16		+	777B	18	12	2	64	34	+	+
613	–	30	53	32	15	+	+	778	–	–	–	68	32	+	+
613A	–	70	56	31	13	+	+	795	100	12	68	17	15		+
614	–	–	70	18	12	+	+	796	110	–	73	14	13		+
615	–	140	49	31	20	+	+	806	25	55	32	53	15	+	+
616	20	40	26	55	19	+	+	807	10	305	43	43	14	+	+
619	–	80	22	66	12	?	+	809	–	200	40	43	17	+	+
631	7	37	32	43	25	+	+	818	18	85	–	69	31	+	+
648	13	40	11	56	34	+	+								

* Quantitative evaluation of clay-mineral composition impractical.
† Identical with 601.

TABLE 4 – Continued

Sample number	X-ray diffraction intensity in counts per second: Bulk sample: Calcite	Dolomite	Clay minerals in < 2μ fraction: Percent montmorillonite	Percent illite	Percent kaolinite and chlorite	Chlorite	Kaolinite	Sample number	X-ray diffraction intensity in counts per second: Bulk sample: Calcite	Dolomite	Clay minerals in < 2μ fraction: Percent montmorillonite	Percent illite	Percent kaolinite and chlorite	Chlorite	Kaolinite
P-819	12	125	–	75	25	+	?	P-1207	16	14	70	13	17		+
826	12	65	–	86	14	+		1237	13	13	47	32	21		+
945	25	115	11	55	34	+	+	1249	14	130	–	75	25	+	
946	28	165	9	62	29	+	+	1250	48	–	86	8	6		+
947	7	32	58	21	21	+	+	1251	–	–	85	8	7		+
949	15	26	48	30	22	?	+	1252	–	–	85	8	7		+
951	18	60	33	48	19	+	+	1253	12	40	–	77	23	+	+
952	–	–	63	8	29		+	1254	14	30	–	81	19	+	+
953	35	17	70	11	19		+	1256	15	40	–	80	20	+	+
954	12	40	60	21	19	+	+	1264	43	58	9	75	16	+	+
963	75	165	3	70	27	+	+	1265	–	–	25	68	7	?	+
964	45	75	2	68	30	+	+	1266	40	40	13	80	7	+	+
964A	55	18	3	68	29	+	+	1270	16	80	5	81	14	+	
964B	58	8	3	70	27	+	+	1284	26	95	17	59	24	+	+
970	23	150	19	69	12	+	+	1294	160	45	66	13	21	?	+
971	30	85	9	75	16	+	+	1302	30	15	62	15	23		+
972	18	95	8	79	13	+	+	1303	35	18	60	14	26		+
977	23	50	16	67	17	+	+	1321	15	80	12	61	27	+	+
978	20	90	21	65	14	+	+	1383	7	50	40	46	14	+	+
1037	9	–	56	27	17		+	1393	15	125	1	76	23	+	
1038	21	7	48	34	18		+	1394	25	95	28	62	10	+	+
1063	15	14	28	52	20	+	+	1434	20	100	23	66	11	+	+
1133	–	–	14	47	39		+	1435	26	110	26	60	14	+	+
1157	–	–	15	53	32	+	+	1461	16	42	14	62	24	+	+
1165	17	50	17	66	17	?	+	1470	10	35	7	68	25	+	+
1169	40	70	14	73	13	+	+	1471	25	90	4	71	25	+	+
1172	25	70	14	73	13	+	+	1472	10	125	2	69	29	+	+
1174	20	135	14	75	11	+	+	1487	15	80	11	67	22	+	?
1175	18	85	15	76	9	+	+	1498	13	50	36	54	10	+	+
1181	310	–	–	73	27	+	+	1516	13	195	30	58	12	+	+
1201	7	–	67	12	21		+	SS11269-25	–	55	3	58	39	+	+
1203	110	6	69	12	19		+	30	35	75	2	60	38	+	+
1204	24	17	75	9	16		+	35	25	55	1	64	35	+	+
1205	18	6	66	15	19		+	40	45	60	41	31	28	+	+
1206	13	4	70	12	18		+	45	–	–	63	18	19	?	+

TABLE 4 - Continued

SS11269-	50	–	–	60	18	22	?	+	SS21158-	90	37	22	58	17	25		+
	55	35	25	61	24	15	+	+		95	35	25	57	17	26		+
	60	75	55	42	41	17	+	+		100	37	26	58	18	24		+
	65	65	50	41	39	20	+	+		105	34	22	60	14	26		+
	75	65	50	38	34	28	+	+		110	11	11	76	10	14		+
	80	45	45	35	36	29	+	+		115	17	8	67	14	9		+
	85	20	–	48	21	31	?	+		120	–	–	63	16	21		+
	90	45	38	37	35	28	+	+		125	–	10	68	13	19		+
	95	55	30	30	37	33	+	+		130	22	9	67	13	20		+
	105	40	35	33	36	31	+	+		135	28	18	64	17	19		+
	110	45	25	30	37	33	+	+		140	15	13	66	13	21		+
SS13054-	10	23	150	5	75	20	+	?		145	10	9	69	12	19		+
	20	50	180	–	76	24	+	+		150	15	7	39	17	44		+
	25	27	160	1	74	25	+	?		155	–	–	59	10	31		+
	45	17	36	2	75	23	+	?		160	45	25	67	13	20		+
	50	23	34	2	79	19	+	?	SS22409-	15	30	90	13	66	21	+	+
	55	16	24	2	79	19	+	+		20	35	55	12	68	20	+	+
	60	25	35	2	73	25	+	?		25	28	60	11	66	23	+	+
	65	26	33	–	76	24	+	?		55	35	90	10	61	29	+	+
	70	28	40	2	74	24	+	+		70	45	135	9	61	30	+	+
	75	36	145	7	67	26	+	+	HK-	1	45	70	12	61	27	+	+
	80	38	100	8	68	24	+	+		2	55	70	22	55	23	+	+
	85	–	?	53	29	18	+	+		3	25	35	2	77	21	+	?
	90	–	37	54	30	16	+	+		4	25	45	2	77	21	+	?
	95	?	32	10	66	24	+	+		21	28	38	10	80	10	+	+
	100	30	170	16	60	24	+	+		23	36	28	69	15	16		+
	105	30	165	6	69	25	+	+		24	45	14	66	17	17		+
	165	30	100	21	54	25	+	+		25	45	25	74	11	15		+
	170	27	115	24	55	21	+	+		26	40	20	73	10	17		+
	195	14	48	47	27	26	+	+		27	35	28	70	11	19		+
	200	12	50	50	25	25	+	+		28	20	13	69	13	18		+
	205	10	45	48	26	26	+	+		29	–	–	75	10	15		+
	210	–	55	45	34	21	+	+		30	–	–	72	12	16		+
SS21158-	15	–	–	12	61	27		+		31	–	–	*	*	*		
	20	16	28	8	66	26	+	+		32	–	–	73	8	19		+
	25	17	25	6	66	28	+	+		33	–	–	69	12	19		+
	30	27	20	59	19	22	?	+		34	–	–	72	10	18		+
	35	26	25	40	39	21		+		35	–	–	68	12	20		+
	40	60	33	40	42	18		+		36	–	–	57	18	25	?	+
	45	–	–	78	6	16		+		37	–	–	56	23	21	+	+
	50	19	10	67	12	21		+		38	–	?	52	29	19	+	+
	55	40	25	62	14	24		+		39	–	90	57	28	15	+	+
	60	46	30	59	19	25		+		40	75	115	41	40	19	+	+
	65	40	30	57	18	25		+		41	35	60	33	49	18	+	+
	70	40	26	59	18	23		+		42	40	50	27	51	22	+	+
	75	38	32	56	19	25		+		43	–	–	56	25	19	+	+
	80	36	16	61	15	24		+		44	–	55	56	29	15	+	+
	85	43	20	57	17	26		+		45	–	40	53	31	16	+	+

TABLE 4 - Continued

Sample number	X-ray diffraction intensity in counts per second: Bulk sample Calcite	Dolomite	Clay minerals in < 2μ fraction: Percent montmorillonite	Percent illite	Percent kaolinite and chlorite	Chlorite	Kaolinite	Sample number	X-ray diffraction intensity in counts per second: Bulk sample Calcite	Dolomite	Clay minerals in < 2μ fraction: Percent montmorillonite	Percent illite	Percent kaolinite and chlorite	Chlorite	Kaolinite
HK- 46	-	60	64	19	17	?	+	HK- 86	25	75	6	62	32	?	+
47	-	35	23	52	25	?	+	87	38	54	6	65	29		+
48	25	150	39	45	16	+	+	88	22	50	6	64	30		+
49	30	55	43	43	14	+	+	HKW-106	25	115	26	63	11	+	+
50	45	100	41	42	17	+	+	107	-	-	85	7	8		+
51	45	105	37	46	17	+	+	108	-	-	80	12	9	+	+
52	35	100	35	49	16	+	+	109	-	-	84	7	9	+	+
53	45	85	35	48	17	+	+	110	-	-	37	48	15	+	+
54	40	100	42	41	17	+	+	111	55	6	21	62	17	+	+
55	40	90	37	45	18	+	+	112	42	36	24	58	18	+	+
56	20	115	36	47	17	+	+	117	-	75	23	69	7	+	+
57	-	-	4	20	76	+	+	118	16	125	22	59	19	+	+
61	16	165	7	51	42	+	+	119	28	125	18	61	21	+	+
64	11	210	7	63	30	+	+	120	23	105	23	54	23	+	+
68	58	60	1	55	43	+	+	121	-	-	83	9	8	?	+
71	41	49	8	52	40	+	+	122	-	-	79	10	11		+
72	38	70	9	62	29	+	+	134	38	68	30	42	28	+	+
73	60	90	4	72	24		+	144	29	75	17	49	34	+	+
74	50	35	4	79	17		+	145	40	50	20	46	34	+	+
84	40	50	4	53	43	+	+	153	30	60	31	39	30	+	+
85	21	30	3	57	39	+	+	154	40	70	32	36	32	+	+

TABLE 5 - AVERAGES OF CLAY MINERAL DATA BY STRATIGRAPHIC UNIT

Stratigraphic Unit	Average Composition (in percent)						Range of Composition (in percent)		
	Number of samples	Montmorillonite	Illite	Kaolinite and chlorite	Chlorite	Kaolinite	Montmorillonite	Illite	Kaolinite and chlorite
Wisconsinan									
Woodfordian	61	4	79	17	+		0–19	62–92	7–30
Winnebago	10	25	59	16	+		15–42	40–72	10–27
Illinoian									
Buffalo Hart	40	5	69	26	+	+	0–14	55–90	8–41
Jacksonville	12	21	68	11	+	+	11–28	60–82	4–14
Southeast	17	16	63	21	+	+	12–28	47–76	9–39
Payson	47	36	45	19	+	+	17–64	19–69	7–34
Petersburg Silt	20	66	19	15	+	+	47–85	6–43	8–25
Kansan									
Western Kansan west of 4th principal meridian	39	66	13	21		+	56–85	4–19	7–30
Western Kansan east of 4th principal meridian	13	43	35	22	+	+	35–50	25–44	14–29
Eastern	11	8	65	27	+	+	0–24	47–79	17–40
Nebraskan	4	76	12	12		+	63–86	8–17	6–20

(Continued)

TABLE 5 - Continued

The above averages are based on the following samples:

Woodfordian: P-130, 138, 139, 145, 146, 148, 170, 344, 346, 347, 349, 350, 355, 356, 371, 372, 384, 388, 390, 391, 392, 394, 399, 400, 401, 402, 403, 404, 405, 407, 495, 496, 549, 558, 566, 696, 697, 724, 726, 727, 744, 745, 747, 819, 826, 1249, 1270, 1393, 1487
HK-21, 13054-10, 13054-20, 13054-25, 13054-45, 13054-50, 13054-55, 13054-60, 13054-65, 13054-70, 13054-75, 13054-80

Winnebago: P-411, 412, 415, 418, 421, 431, 698, 705, 706, 713

Buffalo Hart: P-126, 131, 180, 181, 182, 312, 327, 357, 369, 374, 376, 542, 550, 559, 674A, 687, 732, 777A, 777B, 778, 945, 946, 971, 972, 1181, 1461, 1470, 1472, HK-3, HK-4, 11269-25, 11269-30, 11269-35, 21158-20, 21158-25, 22409-15, 22409-20, 22409-25, 22409-55, 22409-70

Jacksonville: P-94, 97, 335, 365, 619, 750, 762, 763, 970, 1394, 1434, 1435

Illinoian (Southeast): P-172, 195, 196, 197, 450, 977, 978, 1063, 1133, 1157, 1165, 1169, 1172, 1174, 1175, 1284, 1321

Payson: P-1, 1A, 26, 46, 95, 113, 125, 277, 541, 581, 582, 616, 631, 947, 949, 951, 954, 1237, 1383, 1498, 1516, HK-2, HK-44, HK-45, HK-46, HK-49, HK-50, HK-51, HK-52, HK-53, HK-54, HK-55, HK-56, HK-106, HK-117, HK-118, HK-119, HK-120, HK-144, HK-145, HK-153, HK-154, 11269-40, 13054-165, 13054-170, 21158-35, 21158-40

Petersburg Silt: P-90, 91, 613, 613A, 614, 615, HK-32, HK-33, HK-34, HK-35, HK-36, HK-37, HK-38, HK-39, HKW-107, HKW-108, HKW-109, HKW-121, HKW-122, 21158-45

Kansan (Western)

West of 4th principal meridian: P-61, 63, 65, 301, 508, 509, 538, 603A, 612A, 796, 952, 953, 1201, 1203, 1204, 1205, 1206, 1207, 1252, 1294, 1302, 1303, HK-23, HK-24, HK-25, HK-26, HK-27, HK-28, 21158-55, 21158-60, 21158-65, 21158-70, 21158-75, 21158-80, 21158-85, 21158-90, 21158-95, 21158-100, 21158-105

East of 4th principal meridian: P-119, 119A, 120, 123, 123A, 11269-60, 11269-65, 11269-75, 11269-80, 13054-195, 13054-200, 13054-205, 13054-210

Kansan (Eastern): P-447, 731, 964, 964A, 964B, HK-71, HK-72, HK-73, HK-74, HKW-111, HKW-112

Nebraskan: P-502, 795, 1250, 1251

TABLE 6 – CHEMICAL ANALYSES OF GLACIAL TILL IN ILLINOIS
(Analyses by L. D. McVicker, in the laboratories of the Illinois State Geological Survey

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
VALPARAISO TILL															
P-394	50.30	.59	12.21	2.83	1.42	5.36	9.51	.69	2.98	3.59	1.12	11.05	.05	14.57	100.36
BLOOMINGTON TILL															
P-350	57.12	.55	9.72	2.53	.96	5.54	7.38	.68	2.70	2.82	.56	10.15	.01	12.68	99.86
WINNEBAGO TILL															
P-415	65.55	.21	5.48	1.08	.42	4.95	8.43	.78	1.51	1.13	.13	11.20	.00	12.02	100.43
SANGAMON ACCRETION-GLEY															
P-785	74.50	.68	12.14	4.75	.25	.93	.70	.67	1.70	4.37	2.67	.00	.00	4.14	100.46
ILLINOIAN TILL															
P-782	70.92	.68	13.63	5.32	.50	1.09	.66	.85	2.48	4.19	1.30	.00	.00	4.07	100.20
P-125	63.31	.54	10.15	2.29	.71	3.41	6.71	1.02	1.89	2.69	.98	7.57	.03	10.13	100.16
KANSAN TILL															
P-119	62.39	.64	9.84	1.32	1.17	3.61	7.35	.95	1.67	2.76	.82	8.53	.14	11.05	99.99

SELECTED GEOLOGIC SECTIONS

Following are eight of the measured geologic sections used in this report; thirty additional sections also used in this study were published in Illinois State Geological Survey Circulars 285, 304, and 334. 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.

CHAMNESS SECTION

Measured in cuts along Interstate Highway 57, SE¼ sec. 34, T. 9 S., R. 2 E., Williamson County, Illinois (1961). This is the southernmost exposure of glacial till studied.

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
4. Loess, brown to tan, darker in lower part, leached, compact; surface soil in upper part (Sample P-1066 near base)	20.0
Illinoian Stage	
3. Sangamon Soil B-zone; clay with some silt, brown to red-brown, leached, compact, sharp contact at top (Sample P-1065)	2.0
2. Till, silty and clayey, pinkish tan in lower part grading upward to red-brown, jointed, calcareous, massive; very few scattered pebbles; gradational top and bottom Sample P-1064)	2.5
1. Till, tan, silty, compact, massive, calcareous; scattered pebbles up to 2 inches in maximum diameter; well developed joints with calcite filling approximately 1/3" thick along joint planes; base on Pennsylvanian sandstone (P-1063, lower)	5.0
Total	29.5

FLAT ROCK SECTION

Measured in cuts along Illinois highway 1, SW¼ NE¼ SW¼ sec. 6, T. 5 N., R. 11 W., Crawford County, Illinois (1961).

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
4. Loess, tan-brown, leached, massive, compact; some mottling in lower part; surface soil in top (P-1, (P-1160)	4.0
3. Colluvium of silt with sand, becoming sandy and containing pebbles in lower part; gradational with loess at top; tan-brown, leached (P-1159)	1.0
Illinoian Stage	
2. Sangamon Soil B-zone; red, micro-blocky, compact; clay skins, Mn-Fe pellets; gradational at base (P-1158)	3.0
1. Till, yellow-tan, mottled with gray and brown, massive with some jointing, clayey, leached, tough (P-1157 lower)	4.0
Total	12.0

PETERSBURG SECTION

Measured in cuts along county road in NW¼ NW¼ NE¼ sec. 23, T. 18 N., R. 7 W., Menard County, Illinois (1957).

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
4. Loess, tan, massive, noncalcareous; surface soil in top	5.0
Illinoian Stage	
3. Till, massive, calcareous, compact, blue-gray, pebbly and cobbly (P-94, 2 feet above base); truncated Sangamon Soil at top	20.0
2. Till, silty, massive, tan; contains fossil snails similar to those in the unit below (P-93 top; P-92 bottom)	2.0
Petersburg Silt	
1. Silt, massive, compact, gray-tan in upper part and purplish brown in lower part, calcareous (P-91 middle; P-90 lower); contains fossil snails in upper half; a burried soil was penetrated in auger hole a few feet below base of section	20.0
Total	47.0

RUSHVILLE (0.1 WEST) SECTION

Measured in new highway cuts in SW¼ NE¼ SW¼ sec. 23, T. 1 N., R. 1 W., Schuyler County, Illinois (1959)

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage

	Thickness (feet)
Peoria Loess	
10. Loess, massive, gray-tan, calcareous below the surface soil (P-658, P-659, P-660 from calcareous loess; P-661, P-662 from surface soil)	13.0
Altonian Substage	
Roxana Silt	
9. Loess, massive, calcareous, pale pinkish to gray-tan (P-656 base; P-657 top)	8.0
8. Loess, massive, friable, calcareous, medium dark gray-brown (P-655)	8.0
7. Loess, massive, pink-brown, calcareous (P-654).	3.0
6. Loess, massive, medium gray-brown, calcareous (P-653)	5.0
5. Silt with a few pebbles and some sand (colluvium), calcareous, gray-brown (P-652)	1.0
Illinoian Stage	
4. Sangamon Soil; developed in till intermixed with silt, sand, and gravel suggesting an ice-contact deposit (P-651 from soil; P-650 from calcareous lower part)	10.0
3. Gravel, fine to coarse, poorly stratified, calcareous (P-649)	23.0
2. Till, blue-gray, massive, compact, calcareous, locally oxidized (P-648)	2.0
Pennsylvanian System	
1. Shale, gray	4.0
Total	77.0

RUSHVILLE (2.4 WEST) SECTION

Measured in new highway cuts in SW¼ SW¼ NE¼ sec. 16, T. 1 N., R. 1 W., Schuyler County, Illinois (1959).

	Thickness (feet)
Pleistocene Series	
Illinoian Stage	
4. Till, pebbly with silty matrix, calcareous in lower part (P-616); well developed Sangamon Soil in top; thickens laterally and becomes extremely silty	8 to 20.0
Petersburg Silt	
3. Silt, yellow, gray and tan, calcareous, banded with limonite in upper part (P-615); gradational at base; in upper part contains fossil snails	15.0
2. Silt, pink in top (P-614) to purple-brown in lower part (P-613; P-613A); some thin limonite cemented zones; basal 2 feet gray and sandy	10.0
Kansan Stage	
1. Till, leached, clayey, gray and tan (P-612; P-612A); rests on Pennsylvanian shale and clay	2.0
Total	40.0

RUSHVILLE (4.5 WEST) SECTION

Measured in new highway cuts in NW¼ SW¼ SW¼ sec. 5, T. 1 N., R. 1 W., Schuyler County, Illinois (1959, 1960).

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
9. Loess, massive, tan, noncalcareous; well developed surface soil in upper part	6.0
Farmdalian Substage	
Farmdale Silt	
8. Silt, red-brown, massive, noncalcareous	2.0
Altonian Substage	
Roxana Silt	
7. Loess, massive, tan to gray, noncalcareous	1.5
6. Silt with some sand and a few pebbles (colluvium), noncalcareous, gray-tan	2.0
Illinoian Stage	
5. Sangamon Soil developed in till; brown, clay-rich B-zone with Mn-Fe staining on joint surfaces and in small pellets; at base gray, gradational (P-605 from B-zone)	8.0
4. Till, gray and tan, massive, calcareous, bouldery (P-604)	8.0
3. Till, brown and gray, few boulders and large cobbles, calcareous; this zone pinches out westward; eastward sand and gravel in base on till below. In local channels in till below, this till interbedded with noncalcareous, red-brown, sandy and clayey silt (P-603F)	1-10.0
Kansan Stage	
2. Yarmouth Soil developed in till; dark red-brown, clay-rich B-zone (P-603 B, C, D, E), grading downward into tan-brown CL-zone (P-603A)	6.5
1. Till, massive, calcareous, fine textured; contains abundant shale with some coal and weathered pebbles and cobbles; locally contains some masses of noncalcareous sand (P-601, P-602)	10.0
Total	54.0

SCHULINE SECTION

Measured in road cut and nearby creek bank, NW¼ NE¼ NE¼ sec. 24, T. 5 S., R. 7 W., Randolph County, Illinois (1961)

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
9. Loess, massive, friable, light brown to tan with gray-tan mottles, leached; surface soil in top (P-1053 at base to P-1057 from B-zone of surface soil)	6.5
Altonian Substage	
Roxana Silt	
8. Loess, massive, reddish brown, mottled with and containing black streaks and pellets of Mn-Fe; weathers to a platy structure (P-1050 base; P-1051; P-1052 top)	2.5
Sangamonian Stage	
7. Sangamon Soil; colluvium of silt, sand and some clay, brown, tan and gray micro-mottled, leached; contains a few small pebbles; attenuated A-zone and upper part of the B-zone of the Sangamon Soil; upper part gradational upward with overlying Roxana Loess (P-1048 base; P-1049 top)	2.0
Illinoian Stage	
6. Sangamon Soil B-zone; developed in till, brown, becoming darker upward, mottled with light tan at top, oxidized and leached; Mn-Fe pellets and crust on joint surfaces; laterally grades into a BG-zone and at base is gradational with CL-zone (P-1042 BG-zone; P-1043 top of CL-zone; P-1044 to P-1047 upward through B-zone)	3.5
5. Till (CL-zone), oxidized, leached, tan-brown with some staining with Mn-Fe (P-1040 base; P-1041 top)	2.0
4. Till, calcareous, mottled gray and tan-brown; some $CaCO_3$ nodules near top; well jointed with joint planes marked by gray zones bordered by limonite rinds (P-1037 base; P-1038; P-1039 top)	5.5
Petersburg Silt	
3. Silt, massive, pinkish brown with gray mottles, generally noncalcareous but locally weakly calcareous and sparsely fossiliferous in upper part; locally in upper part till interbedded with gray silt (P-1033, 3 feet above base, to P-1036 top)	7.0
2. Silt, gray with a few rusty streaks, contains some clay, massive, Mn-Fe pellets and nodules in lower part (P-1032 base)	2.0
1. Covered to level of abandoned creek channel	6.0
Total	37.0

TINDALL SCHOOL SECTION

Measured in borrow pit excavation along north bluff of Illinois River Valley, SW¼ NE¼ sec. 31, T. 7 N., R. 6 E., Peoria County, Illinois (1957, 1958, and 1960).

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
16. Loess, massive, upper 5 feet leached and contains soil profile; lower part weakly calcareous, tan to gray; streaked with limonite tubules, scattered nodules and indistinct lamination	12.0
Farmdalian and Altonian Substages	
Farmdale and Roxana Silts	
15. Silt, massive to laminated, weakly calcareous in mid-part but noncalcareous above and below, light gray with thin, dark, humic bands in upper part.	4.5
Illinoian Stage	
14. Sangamon Soil, A and G-zones, leached; top 1 foot of A-zone dark gray, granular to massive, grading downward into massive gley, gray mottled with tan	5.0
13. Till (Buffalo Hart), gray, thoroughly interlaced with veinlets of hard limonite, brown, noncalcareous in gray matrix but locally calcareous in iron-cemented veinlets	2.0
12. Till, calcareous, unevenly oxidized, well jointed, gray-tan, gradational at top and bottom (P-126)	3.0
11. Silt and some sand, red, tan, and gray; thin zones cemented with $CaCO_3$; southward the silts pinch out and a cobble zone is at same stratigraphic position	2.0
10. Till, oxidized, calcareous, jointed, brown	3.0
9. Sand and gravel in discontinuous lenses, locally cemented, brown	3.0
8. Till (Payson), calcareous, pebbly, blue-gray, well jointed throughout with oxidized rinds on joints (P-125 three feet above base)	18.0

		Thickness (feet)
Kansan Stage		
7.	Yarmouth Soil, truncated to the B_2-horizon at top, leached, clayey, dark brown; locally spots of secondary carbonate; siliceous pebbles and cobbles present throughout; gradational with calcareous till at base and sharp contact at top except locally where blocks of this soil are incorporated in overlying till (P-124)	4.5
6.	Till, calcareous, gray with mottled patches of brown (P-123A) in upper part, jointed throughout with oxidized rinds along joints; lenticular, irregular masses of gray silt and fine sand incorporated in middle part (P-123)	18.0
5.	Sand, fine to medium, calcareous, brown with locally dark gray streaks at top; upper and lower contacts irregular (P-122)	4.0
4.	Silt and very fine sand, massive to laminated, gray; locally soft limonite in streaks and contorted bands (P-121; P-121A)	2.0
3.	Till, compact, clayey, calcareous, oxidized; contains scattered pebbles and cobbles, streaks and pods of silt, and flakes of coal (P-120)	5.0
2.	Till, compact, calcareous, clayey, blue-gray (P-119; P-119A)	1.0
1.	Silt, calcareous, gray, contains fossil snails	3.0
	Total	90.0

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