PLEISTOCENE STRATIGRAPHIC SEQUENCE IN NORTHEASTERN KANSAS

JOHN C. FRYE AND A. BYRON LEONARD

ABSTRACT. The Pleistocene stratigraphy of northeasternmost Kansas is reinterpreted on the basis of several new exposures in the bluffs of the Missouri River Valley. Recognition of early Nebraskan David City gravel, and differentiation of Nebraska and Kansas glacial tills is based primarily on profiles of weathering and regional relationships. The thick late Pleistocene loess section was studied by making a chemical traverse of the deposits and by zonal collecting of the fossil mollusk faunas. Loveland, Peoria, and Bignell members of the Sunborn formation are recognized. Each of these members displays a prominent profile of weathering in its upper part.

INTRODUCTION

THE existence of early Pleistocene glacial deposits and late Pleistocene loess in northeastern Kansas has been recognized for many years. Largely because of lack of a well-exposed sequence of distinguishable stratigraphic units and paucity of subsurface data, however, the exact nature of the succession has been unknown. Recently information of much geologic importance has become available through work of the Kansas Highway Department in making several deep cuts. Excavation of Pleistocene deposits was made to secure material for subgrade fill for Kansas Highway 7 at the foot of the Missouri Valley bluff between White Cloud and Sparks in Doniphan County. The new exposures were studied by us during the summer and fall of 1948 and provide the basis for recognition of Pleistocene subdivisions known elsewhere in the Kansas-Nebraska region but not previously known in northeastern Kansas.

The supplemental data for this paper have been drawn from three special studies now under way by the State Geological Survey of Kansas. The first is a study of the late Pleistocene loess faunas by Leonard; the second is research on the ceramic properties of the loesses of northern Kansas by Frye, Plummer, and Runnels; and the third, in cooperation with the Ground Water Division of the United States Geological Survey, is a subsurface investigation of the Pleistocene deposits of the glaciated part of Kansas by use of the State Geological Survey's test drill. Stratigraphic classification presented here will be used in each of these studies.

The terminology of Pleistocene stratigraphic units employed in this paper is that officially adopted by the State Geological
Survey of Kansas. This makes distinction between (1) rock units, such as Yarmouth gravel, which have names consisting of proper nouns; and (2) time-stratigraphic and (3) time units, such as Aftonian Stage and Aftonian Age, which have names consisting of adjectives derived from a proper noun.

We express our thanks to R. C. Moore for helpful suggestions and criticism of the manuscript. A. R. Leonard and Norman Plummer accompanied us during part of the field work, and the chemical analyses reported in table 1 and figure 2 were made by Russell Runnels.

REGIONAL SETTING

The exposures described here occur within a relatively small area along the southwest bluff of the Missouri River Valley in the northeastern part of Doniphan County, the northeasternmost county of Kansas. They are situated adjacent to the Missouri state line, and a few miles south of the southern boundary of Nebraska (fig. 1). The locality is more than 60 miles within the mapped southwestern limits of early Pleistocene ice sheets (Schoewe, 1922, 1930), but a considerably greater distance south of the limits of late Pleistocene ice sheets that terminated in northeastern Nebraska and northwestern and central Iowa. Detailed studies of glacial geology in the region north and northeast of Kansas (Kay and Apfel, 1928; Kay and Graham, 1943; Smith and Riecken, 1947; Flint, 1947) preclude the possibility of the existence in Kansas of glacial tills other than those of Nebraskan and Kansan age, but indicate the existence of outwash floods in the Missouri Valley at the time of the retreat of the several Wisconsinan ice sheets. Although late Pleistocene outwash was not observed in the exposures studied, it is judged to have constituted the source for the extensive loess deposits of the Missouri Valley area.

The limits of glacial advance in Kansas have been established (Schoewe, 1930) in the vicinity of the Kansas River Valley westward from Kansas City, and northward to the Nebraska state line in central Washington County, Kansas, but clear differentiation of Nebraska and Kansas glacial tills has been made at very few places within the State. Differentiation of the two tills is made difficult by their lithologic similarity, the lack of adequate subsurface data, and exten-
sive post-Kansan erosion which has produced a discontinuity of existing deposits in much of the glaciated region.

The distribution of loess in northeastern Kansas is controlled by the location and orientation of the major outwash-carrying valley. In eastern Kansas the thickest deposits of loess occur south of the Missouri River Valley where it swings sharply to the east-southeast in Doniphan County (fig. 1). The

Figure 1. Maps showing location of sections studied in northeastern Doniphan County, and the location of Doniphan County within the State of Kansas.

greatest thickness of loess known in Doniphan County is 195 feet, penetrated in a test hole drilled in the SE1/4 NW1/4 sec. 22, T. 1 S., R. 19 E. South of Doniphan County, where the Missouri River Valley trends slightly east of south, the loess is generally less than 25 feet thick, and the upland loess mantle
thins rapidly westward from the valley bluffs. Westward from Doniphan and Brown Counties across the glaciated part of Kansas, the loess is represented only by thin, discontinuous upland remnants. Near the west and southwest glacial limit and 20 to 25 miles east of the Republican River Valley, one again encounters a thick and extensive upland loess mantle which thickens toward its source along Republican Valley.

Inasmuch as profiles of weathering, or fossil soils, are of great importance in classification and correlation of the Pleistocene deposits of northeastern Kansas, a consideration of present climate is pertinent. The nearest stations of the U. S. Weather Bureau are located at St. Joseph, Missouri, a short distance to the southeast in the Missouri River Valley, and at Horton, about 25 miles to the southwest on the uplands. For 60 years of record the average annual rainfall at Horton has been approximately 34 inches, and for a shorter period at St. Joseph, approximately 35 inches. Farther down the Missouri River Valley at Leavenworth, 110 years of record show an average annual rainfall of approximately 35 inches. The mean annual temperature at Horton is 53° F. and at St. Joseph about 1° F. higher. This slight temperature difference is reflected in the average length of the growing season which is 179 days at Horton and 192 days at St. Joseph. In different years the prevailing wind direction at Horton has been from the northwest, southwest, southeast, and south, whereas at St. Joseph it is generally from the south.

**STRATIGRAPHY**

The most significant among the new exposures studied by us during 1948 is situated in the NE¼ SE¼ sec. 6, T. 2 S., R. 20 E., about 20 miles northwest of St. Joseph, Missouri (pl. 1). At this locality continuously exposed deposits were differentiated and correlated, in ascending order, with the David City formation, Nebraska glacial till, Kansas glacial till, and the Loveland silt, Peoria silt, and Bignell silt, the three last-named being classed as members of the Sanborn formation. Aftonian, Yarmouthian, and Sangamonian interglacial intervals are represented, at least in part, by weathering profiles developed in the upper part of the Nebraska till, Kansas till, and the Loveland silt, respectively. This section presents the most complete record of Pleistocene time known
to be exposed at any one locality in Kansas. The succession of strata is described in the following measured section.

Section measured in quarry face and auger holes along Missouri River bluff, NE¼ SE¼ sec. 6, T. 2 S., R. 20 E., Doniphan County, Kansas.

Pleistocene
Sanborn formation
Bignell silt member
Silt, massive, structureless, buff, gray and tan; exposed in vertical face of quarry. Three to four feet at top and bottom partly leached of CaCO₃ but containing some etched fossil snail shells. Remainder of interval effervesces in dilute HCl; fossiliferous .......................... 38.0

Peoria silt member
Silt, massive, structureless, gray and tan. Well-developed Brady soil at top, represented by a few feet gray leached silt, grading downward to a more compact zone, faint reddish buff in color and locally containing abundant, large caliche nodules in lower part; 12 to 17 feet thick. A weakly calcareous zone occurs below the Brady soil and contains fossil snails. Below the fossiliferous zone a few feet of the silt is partly leached and lacks fossil snails. The basal several feet of silt effervesces in dilute HCl and contains fossil snail shells ........................................... 29.0

Loveland silt member
Silt, massive, reddish-buff. All included in the Loveland soil profile, but lower 0.5 foot effervesces in dilute HCl. Upper 7 feet is reddish-buff, partly leached of CaCO₃, and displays a joint pattern with CaCO₃, and limonite concentrated along some joint planes. In nearby exposures etched fragments of fossil snail shells occur in the lower part of this interval. The sharp boundary at the top of the Loveland and absence of an upper gray layer suggest that part of the Loveland soil may have been removed by erosion prior to the deposition of the overlying Peoria ................................. 7.5

Kansas till
Till; matrix of clay and silt containing pebbles and cobbles of limestone, pink quartzite, and igneous rocks. Irregular masses of brown sand are incorporated in the till. Gray and yellow mottled. Lower 7 feet highly
calcaneous. A post-Kansas pre-Loveland weathering profile is indicated by the upper 2 feet of leached till, and the absence of an upper dark layer from the profile caused by pre-Loveland erosion. Large caliche nodules were observed in the lower part of the leached zone and upper part of the calcaneous zone; these may represent the lime accumulation zone of the overlying Loveland soil profile .................................................. 9.0

Nebraska till
Till; matrix of clay and silt with pebbles and cobbles of limestone, igneous rocks, and a few of pink quartzite. Irregular masses of sand and gravel incorporated in till. At top is a well-developed post-Nebraskan pre-Kansan soil profile characterized by a black to dark-gray upper zone about 2 feet thick, leached of CaCO₃ and lacking limestone pebbles but containing quartzite pebbles and a few igneous rock pebbles. The upper zone grades downward into a medium gray to light brown leached and oxidized zone, which in turn grades downward into gray calcaneous till ................................................. 7.0

David City formation
Gravel; cobbles, boulders, sand, and silt; limestone, igneous rocks, and quartzite. Platy elements roughly shingled. Iron stained, calcaneous, locally cemented with CaCO₃ in upper part ................................. 10.0

Pennsylvanian
Deer Creek limestone
Limestone and shale exposed in quarry face, from level of Missouri River flood plain. Approximately .......... 30.0

Total thickness exposed ........................................ 130.5

GLACIAL DEPOSITS

The early Pleistocene glacial and glacio-fluvial stratigraphic units are clearly recognizable by lithologic characters observable in the field. The water-laid gravel at the base of the described section is considered to be pro-Nebraskan glacial outwash, which was over-ridden by the advancing Nebraskan ice. Water-deposited gravels, classed as pre-glacial in age, have been observed elsewhere in northeastern Kansas below glacial till (Todd, 1920; Frye, 1941). These pre-
glacial gravels consist predominantly of chert pebbles, and lack quartzite and igneous rock types. They reflect a source in the cherty limestones of the Flint Hills, approximately 100 miles west of the Missouri River. In strong contrast, the sub-till gravels considered to be pro-Nebraskan outwash are characterized by rock types similar to those occurring in the calcareous Nebraska till which overlies them. These gravels have not been subjected to prolonged weathering, as is evident from the abundance of unetched limestone pebbles which predominate throughout the deposit. The gravel is here assigned to the David City formation, which was named (Lugn, 1935, pp. 38-40) to include deposits occurring in a similar stratigraphic position in Nebraska. The position of such water-laid gravels resting on Pennsylvanian bedrock approximately 30 feet above the Missouri River flood plain suggests that the present topography has been carved largely since the advent of Nebraskan glaciation.

Above the David City formation is till which may be recognized as comprising two distinct tills by the presence of a well-developed profile of weathering in the middle part of the till section. The lithology of these two tills is quite similar, for they both possess a clay-silt matrix which is highly calcareous below the leached zone in the upper part of each, and both are characterized by the presence of quartzite and igneous rock cobbles and boulders, associated with predominate limestone cobbles and boulders. The only observable lithologic difference between them is a seemingly higher percentage of pink quartzite in the upper of the two tills. The weathering profile in the top of the lower till is several feet thick. This profile is judged to represent a significant interval of weathering, (1) because the relatively impermeable nature of the parent material tends to retard deep weathering, (2) because limestone pebbles are entirely absent from the upper 2 to 2½ feet, and (3) because igneous rocks in this zone are weathered to crumbly incoherent masses. Auger holes bored through the upper till into beds showing this profile prove that the weathered zone is in place and does not represent slump from some higher level.

Correlation of the lower till as Nebraskan in age, and the upper till as Kansan in age is based on field relations to the north and northeast of Doniphan County (Kay and Apfel,
1928; Kay and Graham, 1943; Lugn, 1935) in territory where glacial advances of these two ages—and only these two ages—have been found to occur. The correlation also takes account of the deep profile of weathering between the tills, which excludes the possibility that the two tills studied here represent minor pulsations of one ice sheet. Aftonian time is judged to be represented by the development of the soil profile on the Nebraska till.

A weathered zone also occurs in the uppermost part of the Kansas till, but it is thinner than the Aftonian profile, and lacks the distinctive upper dark layer. These facts suggest that part of the weathering profile on the Kansas till may have been removed prior to the deposition of the overlying loesses. If this be true, the weathering profile on the Kansas till may represent only a part of Yarmouthian time.

In adjacent parts of Kansas and Nebraska water-laid deposits occur between Nebraska and Kansas tills (Hokkridge and Fullerton formations of Nebraska classification), unconformably above Kansas till but closely related to it (Meade formation containing Grand Island and Sappa members of Kansas classification), and conformably at the base of the Loveland silt (Crete member, Sanborn formation of Kansas classification).

LOESS DEPOSITS

Criteria for subdivision.—In northern Doniphan County massive silt, or loess, is known to attain a thickness of 195 feet and it constitutes the predominant lithology in the new exposures studied. Seventy-five feet of massive silt was measured above the Kansas glacial till at the locality here described. Superficially, the silt has a similar appearance throughout its entire thickness but subdivision into three correlatable stratigraphic units was made possible by several independent lines of study. The entire section was checked foot by foot with dilute hydrochloric acid in the field. The presence of two major buried profiles of weathering, which were in turn used for field classification, was defined by leached zones determined by acid, by irregular bands of nodular soil caliche, by variation in toughness due to variations in clay content, by slight differences in gross structure, by the range from unetched to etched snail shells, and by the local absence of snail shells. One to two hundred miles west of Missouri
River, in northern Kansas, these fossil soils are more readily recognizable by field inspection owing to the presence of a dark-colored upper layer. The regional differences in morphology of the fossil soils is judged to represent climatic and floral differences at the time of soil formation.

Bulk samples of silt containing fossil snails were collected from the two fossiliferous zones in the Peoria silt, and at regular intervals through the Bignell silt, which is fossiliferous throughout most of its thickness. Fifteen samples of silt were collected for chemical analysis, in order to check the reliability of acid effervescence in the field, and to determine other significant chemical properties of the silt (Table 1).

Chemical features.—The chemical analyses, when plotted as vertical traverses, exhibit an unforeseen stratigraphic significance. Figure 2 shows, at the top of each of the two weathering profiles, sharp breaks in the percentage of lime, magnesia, and ignition loss produced by downward leaching during the interval of time these units were not covered by younger deposits. The $R_2O_3$ content ($Al_2O_3, TiO_2, Fe_2O_3$) is slightly higher in the upper layer of each fossil soil, suggesting the accumulation of clay. A secondary high within the Peoria falls between the two fossiliferous zones. Some concentration of $K_2O$ may be noted in the upper part of the Loveland profile. The percentages of silica increase in the weathering profiles and decrease in the unweathered zones. Since much of the silica is present in silt-sized grains of quartz, probably it is the most stable constituent of the parent material, and therefore variations in silica content reflect the removal or addition of other more transferrable constituents rather than variations in absolute amounts of silica.

The chemical traverse indicates complexity of the Bignell silt, which is not apparent in the field. The upper part of this member is shown by the analyses to have a distinctly higher calcium carbonate content than the lower part.

Paleontological features.—The species of fossil snails recovered from each of the four fossiliferous zones shown on Figure 2 are listed in Figure 3. Etched fragments of fossil snail shells occur in the Loveland silt member where it is exposed in a new cut approximately one-half mile northwest of this locality, but identifiable material was not recovered.
TABLE 1

Chemical analyses of loess from locality of measured section in
the NE\(^1/4\) SE\(^1/4\) sec. 6, T. 2 S., R. 20 E., Doniphan County, Kansas.
Stratigraphic position of samples shown by letter on Figure 2.
(Analyses by Russells Runnels in the Laboratory of the State
Geological Survey of Kansas.)

<table>
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<tr>
<th>Sample</th>
<th>SiO(_2)</th>
<th>Al(_2)O(_3) +TiO(_2)</th>
<th>Fe(_2)O(_3)</th>
<th>CaO</th>
<th>MgO</th>
<th>P(_2)O(_5)</th>
<th>K(_2)O</th>
<th>Ign. loss</th>
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<td>R</td>
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<td>3.25</td>
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<td>0.15</td>
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<td>3.04</td>
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<td>0.15</td>
<td>2.63</td>
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<td>1.15</td>
<td>0.13</td>
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<td>F</td>
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<td>0.14</td>
<td>2.64</td>
<td>2.98</td>
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</table>

The faunal list shown in figure 3 gives only species so far
collected from one locality and is not a complete faunal list
for the members; studies of loess molluscan faunas are in
progress in an area extending across northern Kansas, but
this work is incomplete.

The most significant feature of the faunas, as far as
present stratigraphic considerations are concerned, is that the
fossils in the Peoria silt member at this locality are character-
istic of molluscan faunas in the Peoria silt elsewhere in north-
er Kansas, and especially similar to the molluscan fauna occur-
ing in this loess along the Republican River Valley approxi-
mately 125 miles west of this area. The two faunal zones in
the Bignell silt coincide remarkably with the change in the
chemistry of the silt (fig. 2).

Origin of the loess deposits.—The physiographic and strat-
igraphic relationships observed in the northeastern Kansas
deposits studied, the physical character of the loess, and the
contained faunas, the predominant species of which today in-
habit the moist lowlands near the water, indicate that the
massive silts in Doniphan County were deposited by wind action
and were derived from a near-by source on the valley flat of
Figure 2. Diagram showing variations in chemical constituents of the three loess members of the Sanborn formation described in the measured section and shown in Plate 1. Analyses by Russell Runnels in the laboratories of the State Geological Survey of Kansas (note table 1). Cemented nodules were not included in the sample for analysis from the caliche zone of the fossil Brady soil.
<table>
<thead>
<tr>
<th>Species</th>
<th>Peoria (lower zone)</th>
<th>Peoria (upper zone)</th>
<th>Bignell (lower zone)</th>
<th>Bignell (upper zone)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Stenotrema monodon aliciae</em> (Pilsbry and Vanatta)</td>
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<tr>
<td><em>Triodopsis multilineata</em> (Say)</td>
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<tr>
<td><em>Anguispira alternata</em> (Say)</td>
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<tr>
<td><em>Hendersonia occulta</em> (Say)</td>
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<tr>
<td><em>Gastrocopta armifera</em> (Say)</td>
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<tr>
<td><em>Helicodiscus parallelus</em> (Say)</td>
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<td></td>
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<tr>
<td><em>Succinea ovalis</em> Say</td>
<td></td>
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<tr>
<td><em>Succinea grosvenori</em> Leo</td>
<td></td>
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<tr>
<td><em>Discus shimeki</em> Pilsbry</td>
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<td><em>Euconulus</em> sp.</td>
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<td><em>Retinella electrina</em> (Say)</td>
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<tr>
<td><em>Vertigo milium</em> (Gould)</td>
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<td><em>Discus cronkhitei</em> (Newcomb)</td>
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<td><em>Pupilla blandi</em> Morse</td>
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<td><em>Succinea avara</em> Say</td>
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<td><em>Vertigo tridentata</em> Wolf</td>
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<tr>
<td><em>Hawaiiia minuscula</em> (Binney)</td>
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<td><em>Valonia gracilicosta</em> Reinhardt</td>
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</table>

Figure 3. Chart showing species of fossil snails obtained from two zones in the Peoria member and two zones in the Bignell member.
the Missouri River. Furthermore, these facts indicate that the most effective wind direction was from the west-northwest. The extreme thickening of loess within the eastward loop described by the Missouri River, the pronounced thinning of the loess mantle within a distance of 20 miles west of the river, and distribution of loess thicknesses in adjacent parts of Missouri, serve as indicators of effective wind direction. That the loess (except locally along steep gully sides) has not moved down slope colluvially is demonstrated by the facts that the fossil soils possess horizontal continuity, are not distorted, and exhibit the physical and chemical characters of weathering in situ. It is also proved by the distinctiveness of the four fossiliferous zones, by the existence of the greatest known thickness of loess directly under the highest elements of the local topography, and by the exposure of the top of Pennsylvanian bedrock not far above the flood plain of the Missouri River Valley and the floor of tributary valleys. Water deposition of the loess is precluded by the facts that it occupies the highest elements of local topography, lacks stratification, and possesses a high degree of textural uniformity through a known thickness of 195 feet; that the Bignell displays a gradational contact at the top of the Brady soil; and that aquatic species were not found among the fossil snails in all zones studied, and the fossil shells are not crushed or abraded.

The weathering profiles, although the most important, are not the only secondary features. Small calcium carbonate concretions occur sparsely throughout the loess as a result of the action of percolating ground waters. A more striking effect of ground water may be seen in some exposures where the position of a prolonged stand of the water table is marked by a thin, loosely iron-cemented zone, appearing as a narrow rust-red band. A color contrast in the silt, which may be seen more readily in the field than the important old soils, occurs at this line. Above it, the loess is a uniform tan color, whereas below it, the loess is distinctly grayish, except where iron has been concentrated around former roots, producing conspicuous, more or less vertical, rust-red concretions or streaks, which begin abruptly above and taper off below (pl. 1C). That this change in color and local distribution of iron is related to the water table has been shown by auger borings elsewhere in Kansas made by us through loess into the water table and
by the general similarity of the shape of this band to the local topography. In fresh cleavage breaks on vertical bluffs of loess, thin color laminae which may represent annual stands of the water table below the more prominent iron-stained band have been observed. Control of these features by the former position of the water table is suggested by their general conformity in shape to the upper prominent band and their lack of conformity to the position of weathering profiles.

Correlation.—The three stratigraphic units established by the foregoing facts are here correlated with the three widespread late Pleistocene loesses of the Kansas-Nebraska region, classed in Kansas as the Loveland, Peoria, and Bignell silt members of the Sanborn formation (Frye and Fent, 1947; Frye, Swineford, and Leonard, 1948).

Kansas glacial till, which has a weathering profile in the top, immediately underlies the loess, and so it may be presumed that the lowest loess unit in this area cannot be older than

PLATE 1

A. Bignell silt member (b) and upper part of Peoria silt member (a) of the Sanborn formation exposed in upper part of highway borrow pit, NE1/4 SE1/4 sec. 6, T. 2 S., R. 26 E., Doniphan County, Kansas. Man in middle distance is standing on upper fossiliferous zone of the Peoria silt member. The stratigraphic section included in this paper was measured at this locality, and the fossil snail faunas listed in figure 3 and the samples for chemical analyses given in table 1 and figure 2 were collected here. (July 1948)

B. Shows method of sampling the Bignell silt member. The Brady soil of the Peoria silt member (a), lower fossiliferous zone of the Bignell silt member (b), and upper fossiliferous zone of the Bignell silt member (c). Same locality as A. (October 1948)

C. Peoria silt member, northeastern Doniphan County, Kansas. Former position of the water table is marked by the pronounced iron-cemented band about midway of the hammer handle. Above the iron-cemented band the loess is a uniform tan; below, a medium gray with iron cement concentrated in long tubules around root remains. (July 1948)

D. Kansas till at same locality as A. Note pebbles of igneous rock types, and caliche nodule (upper center) judged to represent accumulation from the weathering of the overlying Loveland silt member. (October 1948)

E. Caliche nodules at the base of the Brady soil profile in the upper part of the Peoria silt member, 15 to 17 feet below top of Peoria; 53 to 55 feet below top of exposure. Same locality as A. (October 1948)
late Yarmouthian or Illinoian. The weathering profile (Loveland soil) and presence of mineralized joints in the Loveland indicate a significant unconformity between the Loveland and the overlying Peoria. The Loveland is the only named loess unit in Kansas and Nebraska known to occupy a stratigraphic position above Kansas till soil and below Peoria loess. It is our judgment that the Loveland silt of this locality was derived from valley train material carried down the Missouri Valley in late Illinoian time.

The second major stratigraphic unit (Peoria silt) within the loess is confined above the Loveland soil and below the top of its contained profile of weathering (Brady soil, (Schultz and Stout, 1945)). It has yielded a molluscan fauna typical of the Peoria silt in central and western Kansas. The Peoria of the Missouri Valley region is judged to be of early Wisconsinan age. As Iowan ice is known to have crossed the present Missouri Valley less than 200 miles north of this area (Flint, 1947), adequate valley train source material probably was available at that time. A minor time break is suggested in the lower part of the Peoria member by the presence of a partial leached zone which lacks a fauna. It is not known, however, whether this should be interpreted as indicating two episodes of deposition during Iowan time, or Iowan deposition followed by post-Iowan deposition.

In north-central Kansas a transition zone commonly occurs at the base of the Peoria silt. This zone has been interpreted as the initial slow accumulation of the colian deposits of Peorian age at a rate allowing partial leaching contemporaneously with deposition. In the Doniphan County localities studied, such a transition zone at the base of the Peoria is thin or nonexistent, whereas a well-developed transition zone occurs in the basal part of the overlying Bignell silt member.

The uppermost stratigraphic unit, the Bignell silt (Schultz and Stout, 1945; Condra, Reed, and Gordon, 1947; Frye and Fent, 1947), rests on the deep Brady soil profile in the top of the Peoria silt. Therefore, it must be late Wisconsinan and possibly Recent in age. Presumably it was derived from outwash of the relatively near-by Mankato glacial lobe and possibly also from slightly younger or older ice of the Missouri Valley region of South Dakota (Flint, 1947). Although the faunas so far recovered from the Bignell farther west in Kansas are not adequate to permit firm paleontological cor-
relation with the Doniphan County area, the stratigraphic position of the deposit leaves no alternative but to correlate it with this described unit in Nebraska and north-central and western Kansas.

Nowhere in Kansas has a zonation previously been observed in the Bignell silt. Although a weathering profile within it was not recognized in the field, its two-fold nature in Doniphan County is indicated both by the distinctly higher percentage of calcium carbonate in the upper part and the dissimilarity of fossil snail species in its upper and lower zones. The change in faunal elements coincides with the change in calcium carbonate content. These facts, however, in the absence of a well-developed profile of weathering, do not necessarily demand an interval of nondeposition but might be interpreted as the result of an increased rate of deposition in the upper part, a slight change in the nature of source material or local climate, or a change in the cover of vegetation on the surface of sedimentation. The ecological implications of the snail faunas suggest the last of these possibilities. Regardless of which explanation is correct, the vertical change in lithology and fauna imply a change in one or more environmental factors, which, in turn, indicates that the deposition of the Bignell was not sudden but involved an appreciable interval of time.

References


Pleistocene Stratigraphic Sequence


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