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Evidence of Multiple Glaciation in the Glacial -Periglacial Area of Eastern Nebraska

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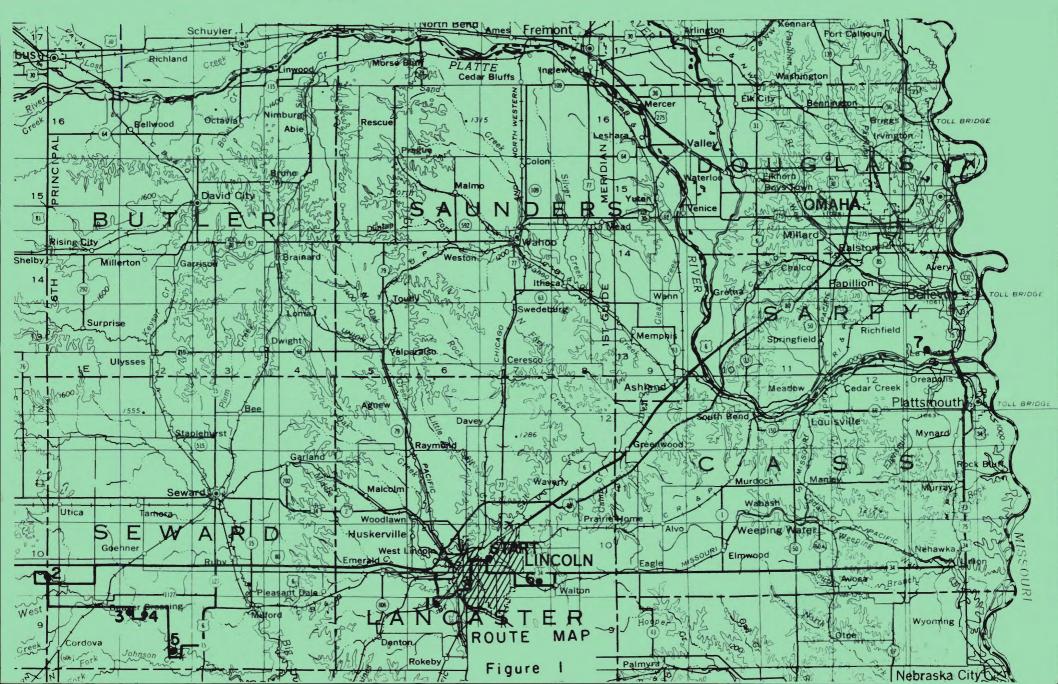
Authors E. C. Reed, V. H. Dreeszen, J. V. Drew, V. L. Souders, J. A. Elder, and J. D. Boellstorff

GUIDEBOOK

17th Annual Meeting of the Midwestern Section FRIENDS OF THE PLEISTOCENE May 21-22, 1966

EVIDENCE OF MULTIPLE GLACIATION IN THE GLACIAL PERIGLACIAL AREA OF EASTERN NEBRASKA

UNIVERSITY OF NEBRASKA
Nebraska Geological Survey
Department of Geology
Department of Agronomy
State Museum



GUIDEBOOK

17th Annual Meeting of the Midwestern Section Friends of the Pleistocene

Leaders: E. C. Reed, V. H. Dreeszen, J. V. Drew, V. L. Souders, J. A. Elder, J. D. Boellstorff

OUTLINE OF FIELD TRIP

The trip starts (fig. 1) in Salt Creek Valley between a major drainage divide to the west and another divide east of Oak Creek (figs. 2 and 3). The divides are marginal moraines of Cedar Bluffs Till. The first stop at a clay pit shows Wisconsinan loess and soils overlying buried soils and alluvial-colluvial deposits of Illinoian age. The trip proceeds west across the Cedar Bluffs terminal moraine and out into the terrace-plains area west of the Blue River. The area covered by stops 2, 3, 4, and 5 was intermittently a glacial and periglacial region during Nebraskan and Kansan time. The stops show stratigraphic succession and characteristics, and variation of fluvial and thin loess deposits of Illinoian and Late Kansan age. Several of the stops were visited during Conference D, INQUA, 1965.

Stop 6 is on upland slopes in the loess-mantled till hills. The landscape relationships of a Sharpsburg-Wymore soil sequence and the concept of soil development on upland slopes will be discussed and field and laboratory studies reviewed.

Stop 7 is at rock quarries which provide a unique opportunity to view three superimposed tills of early Pleistocene age.

GENERAL DISCUSSION

The general purpose of this field trip and meeting is to present evidence that earlier stages of Pleistocene glaciation, like the later stages, are complex. The concept of multiple glaciation of the Wisconsinan is well established; a like concept has been documented for the Illinoian stage in Illinois. Little evidence, however, has been presented on the complex nature of the Nebraskan and Kansan glaciations, mainly because deposits of the earlier glaciations in many parts of the country have been removed by erosion or buried by younger deposits. In Nebraska, marginal deposits and land forms associated with the early glaciers are well preserved, although obscured by erosion and

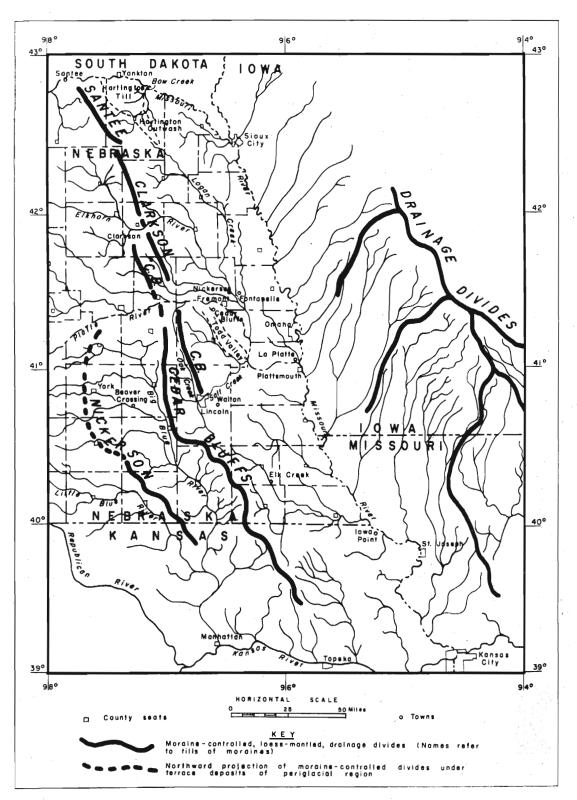
mantle of younger deposits. Erosion preceding each major advance of ice resulted in the partial removal of older materials so that deposits of succeeding episodes may lie side-by-side or on much older remnants, rather than being directly superimposed. However, the net effect of glaciation was to build an increasingly higher land surface in the eastern half of the state by shifts in centers of deposition.

Evidence from the periglacial region supports the concept of multiple glaciation in the later stages and strongly supports an interpretation of like complexities in the earlier stages. Broad terrace-plain surfaces underlain by relatively thick alluvial deposits merge with deposits of the glaciated region. The cyclic nature of the alluvial and thick loess deposits in the periglacial region along with profiles of weathering and soil development on their surfaces reflect the changing conditions of glacial advance and retreat. Although the deposits have a cut-and-fill relation-ship, they are extensive and present a nearly complete record of Pleistocene time. Relatively abundant vertebrate fossils occurring in both regions, but more commonly in the periglacial region, provide additional evidence for interpreting climate and depositional sequences.

Much of the evidence for our present understanding of glaciation in Nebraska has developed from a study of subsurface data compiled through investigation of the groundwater resources of the state. Systematic test drilling in cooperation with the Water Resources Division, U. S. Geological Survey, has been done in most of the eastern half of the state. The evidence obtained from the regional study of subsurface data has been used to evaluate and correlate the surficial geology.

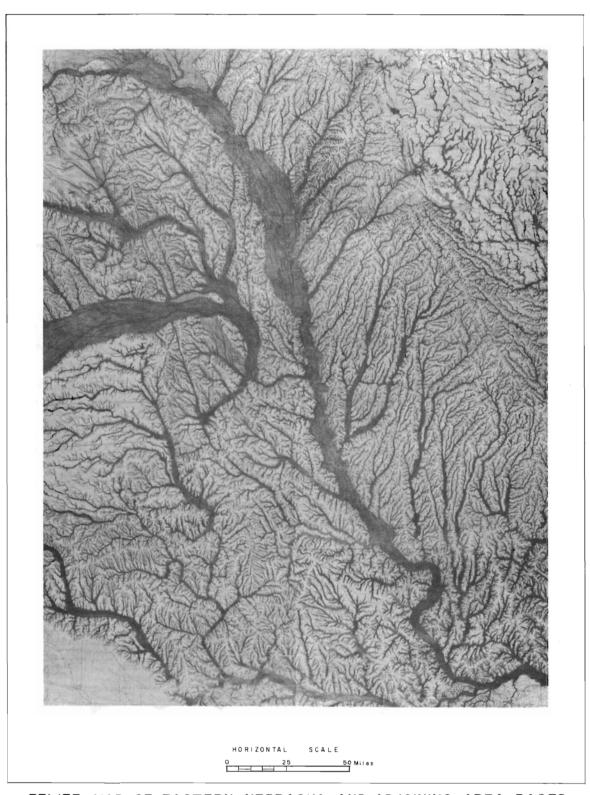
One of the most profound effects produced by continental ice sheets in eastern Nebraska was the repeated disruption and change of the drainage system. Ice and glacial debris, largely in the form of clay-till moraines, blocked eastwardly-flowing streams and diverted them generally southward. The regional pattern of divide ridges and drainage trends is believed to be an expression of lateral and marginal moraines. Preliminary studies of the regional geomorphology, as reflected by drainage divides in relation to subsurface data and surface exposures, resulted in a reclassification of the Pleistocene deposits in Nebraska (Reed and Dreeszen, 1965).

Two horizons with distinctive characteristics and widespread occurrence have been used extensively as markers in regional correlation in this area and in adjacent states. The Pearlette Volcanic Ash, a persistent horizon in the Sappa Formation, is believed to be of Late Kansan age. It is easily recognized in field exposures and has been identified in numerous test holes. The volcanic ash is found in comparatively pure beds where it was deposited in water or in depressions that existed in either the lowlands or the uplands. Ash shards are a prominent constituent of alluvial sediments or loess deposited during and shortly after



DRAINAGE PATTERN AND MORAINE-CONTROLLED DRAINAGE DIVIDES IN EASTERN NEBRASKA AND ADJOINING AREAS (from NGS Bulletin 23)

Figure 2



RELIEF MAP OF EASTERN NEBRASKA AND ADJOINING AREA BASED ON U.S. GEOLOGICAL SURVEY 1:250,000 SCALE TOPOGRAPHIC MAPS (from NGS Bulletin 23)

Figure 3

_			CLA	SSIFICA	TION		_	RACES	FAUNAL ZONES
STE	IME RATI-		ROC		TIGRAPHIC		Schultz,	Reed,	20.120
GRA	PHIC	EOLIAN	FLUVI	ATILE	GLACIAL	SOILS	<u>et al.</u>	Dreeszen	
% -%C0	Late	Bignell Loess and Dunesand	Bignell {	silt sand - gravel	Absent		2 a 2 b	2	Late
Z - Z	Medial	Peoria Loess and Dunesand	Peoria Formation	silt Todd Valley	Manus	Brady	3	3	Pleistocene
N	Early	Gilman Canyon Loess		on Formation	Absent	Unnamed			
ANG L L	<u>AMON</u> IAN Late	Loveland Loess	Loveland Formation	Silf Crete sand-gravel	A bsent	Sangamon			
-02-	Medial	Beaver Creek Loess	Beaver Creek Formation	,	Santee Till	Unnamed	4	4	Medial
A N	Early Grafton Grafton Loess Formation		silt sand-gravel	Clarkson	Unnamed			Pleistocen	
AR <u>M</u> K	Late	TTTTTT Sappa Loess	Sappa Formation	Grand Island sand-gravel	Probably Absent	Yarmouth			
A N S	Medial	Walnut Creek Loess*	Walnut Creek Formation	$\begin{cases} \frac{\sin t}{\sin d - \text{gravel}} \end{cases}$	Cedar Bluffs Till	Unnamed		5	
A N	Early	Red Cloud Loess*	Red Cloud Formation	$\begin{cases} \frac{\text{silt}}{\text{sand - gravel}} \end{cases}$	Nickerson Till Atchison Sand	Fontanelle			 ??-
AF.] NEBRA	Late	Fullerion Loess*	Fullerton Formation	silt Holdrege sand - gravel	lowa Point Till	Afton	5		Early
RASKAR	Early	Seward Loess*	Seward Sormation	silt easal sand — gravel	Eik Creek David City Sd-Gr.	Unnamed		6	Pleistocene

CLASSIFICATION CHART OF THE PLEISTOCENE DEPOSITS OF NEBRASKA (from N.G.S. Bulletin 23)

Figure 4

the ashfall. The second horizon with an equal or even greater distribution than the Pearlette is a thin but persistent humusenriched horizon commonly found immediately above the Sangamon The horizon was named the Gilman Canyon Formation and was judged to be of Early Wisconsinan age (Reed and Dreeszen, 1965). Previous reference to the horizon has been as the "A" horizon of the Sangamon Soil and its inclusion as a part of the vertebraterich "Citellus Zone." A previously unpublished radiocarbon date, recently determined from disseminated carbon in a two-foot layer eighteen inches above the base of the formation at the type locality, is 32,300 -1,600 (I-1851). The type locality is in the Buzzard's Roost section in the west fork of Gilman Canyon in west-central Nebraska. The correlation of the horizon as Wisconsinan and the comparison of the single radiocarbon date with Wisconsinan radiocarbon dates in other areas suggest a considerable time gap (+30,000 years) between the Gilman Canyon and the Sangamon Soil. There is a good possibility that there may be alluvial equivalents of these earlier Wisconsinan deposits in local areas in the state as well as significant thicknesses of loess in some parts of eastern Nebraska, but more detailed studies are needed to establish this fact. We can be certain that there was a considerable amount of erosion on the pre-Wisconsinan surface before the deposition of the Gilman Canyon Formation.

The current classification of the Pleistocene of Nebraska, as used by the Nebraska Geological Survey (fig. 4), follows the generally accepted rules of stratigraphic nomenclature. Rock-stratigraphic names are utilized which are distinct from time-stratigraphic names and thus not to be confused. Historically, Pleistocene classifications have attempted to refer deposits to glacial and interglacial stages. These terms, however, seem to be understood and used with different implications, and in Nebraska we find the boundary between "glacial" and "interglacial" stages quite elusive.

Formational names in the periglacial region apply to depositional units. Previously established names for the upper, finetextured parts of these depositional units have been applied to the entire unit and previous names assigned to the lower, coarser textured parts of the depositional sequence as "formation" names continue to be used as members of the depositional sequence formation. Loesses that correlate with depositional sequences in the terrace deposits carry the same formation name as the terrace deposits, but are identified as loess. Local names have been assigned to all of the separately identifiable tills and some of the more extensive pro-till sands and gravels are named as forma-The present classification is tied to previous classifitions. cations where possible. The nomenclature used in this Guidebook is that of the Nebraska Geological Survey.

ACKNOWLEDGMENTS

Many individuals helped in the preparation of this trip and guidebook. Samuel B. Treves, C. Bertrand Schultz, and T. Mylan Stout, Department of Geology and State Museum of the University of Nebraska, helped organize the meeting and have contributed greatly through discussions in the field and through their long association with investigations of the Pleistocene. Frank A. Smith, Gerald R. Svoboda, H. Duane McCormick, and Marjorie B. Seidel of the Nebraska Geological Survey helped with the many details of organization and preparation.

Previously unpublished data are presented by James V. Drew, Agronomy Department of the University of Nebraska for Stop 6, and by John D. Boellstorff of the Nebraska Geological Survey for Stop 7.

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ROAD LOG

Saturday, May 21, 1966

ASSEMBLY POINT: Pioneers Park southwest of Lincoln, near Stop 1.

ASSEMBLY TIME: 8:00 a.m. Central Standard Time.

Use the City of Lincoln road map to get from the Nebraska Center, which is at 33rd and Holdrege streets, to the assembly point, or follow Holdrege St. west (this is away from the sun!) 1.4 miles to a one-way street going south. This is 16th St. Follow 16th St. 2.4 miles to South St. Turn right (west) on South St. and go 0.8 mile to Park Boulevard. Turn southwest on Park Boulevard and go 0.6 mile to Van Dorn St. (Caution: there are two dangerous railroad crossings on Park Boulevard). Turn west on Van Dorn St. and go 1.5 miles to a major road intersection. Continue west through this intersection and go 0.6 mile. Turn left into the north entrance of Pioneers Park and go south 0.5 mile. Turn left (east) to the parking area. This is the assembly point and Stop 1.

NOTE TO DRIVERS: There will be no police escort or flagmen, so please obey all traffic signs, signals, and laws. A Conservation and Survey Division car will be at the end of the caravan to assist anyone needing help.

STOP 1. Northeast Pit, Yankee Hill Brick Plant, near NW. cor. SW. 1/4 sec. 4, T. 9 N., R. 6 E., Lancaster County, Emerald Quadrangle, in press.

Thorp, Johnson, and Reed (1951) measured and described the deposits near the northeastern part of the present pit. Figures 5 and 6 show the deposits now exposed along the south wall. Thorp et al suggested that the humic horizon about 14 feet below the modern land surface was, at least in part, Wisconsinan. Reed and Dreeszen (1965) named the humic horizon and an overlying silt and soil the Gilman Canyon Formation and designated the type locality to be at the Buzzard's Roost Section, Lincoln County, in west-central Nebraska. A radiocarbon date of 32,300 years \(\frac{1}{2} \)000 years (I-1851) was determined from the upper 18 inches of humic silt at the type locality.

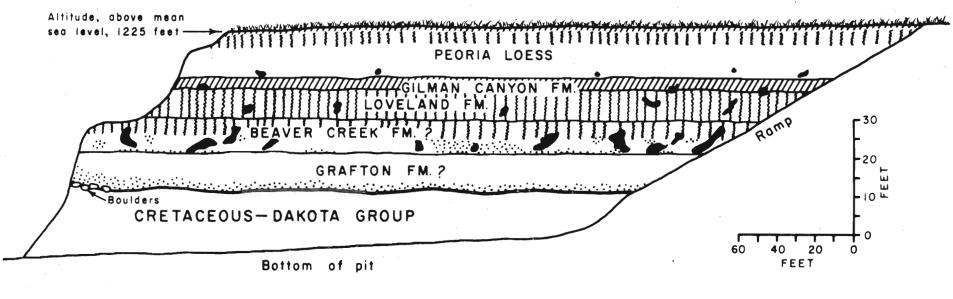
The upper and lower boundaries of the Gilman Canyon Formation are indefinite at Stop 1. Samples for radiocarbon analysis were recently submitted to Isotopes, Incorporated, but were sent too late to be analyzed before this meeting.

Deposits, mostly alluvial, underlie the humic horizon at this site and can be tentatively separated into three units which are probably all of Illinoian age. Scattered, iron-stained patches of sand, possibly Kansan in age, occur on top of the bedrock in this pit. The section measured by Thorp et al and the section in Figure 6 are very similar except for the lower units.

Mil Cum.	Leage Diff.	
· ·		Return to north entrance of Pioneers Park. Mileage starts.
0.0		Turn right (east) on Van Dorn St. and go 0.6 mile to Stop sign.
0.6	0.6	Turn left (north).
1.6	1.0	Stop sign, continue ahead.
2.6	1.0	Stop sign, turn left (west) on U. S. Highway 6 (4-lane).
3.1	0.5	Curve right onto access road to I-80. Till hills.
4.8	1.7	Descend to Illinoian terrace level near underpass.
8.2	3.4	Dakota sandstone and Fullerton silts on left.
15.7	7.5	Descend from Cedar Bluffs marginal moraine onto loess-mantled Illinoian terrace plain.
17.6	1.9	Curve right off I-80.
17.9	0.3	Stop sign. Continue across State Highway 15 and reenter I-80.
19.1	1.2	Big Blue River.
20.8	1.7	Loveland Formation exposed on right. Ascend onto Illinoian terrace plain. In this area, the Greenhorn Limestone (Late Cretaceous) caps a buried, east-facing cuesta and is exposed at a few places along the Big Blue River about 4 miles southeast near Milford. The limestone lies at a depth of less than 100 feet at the Milford interchange and under the Big Blue River valley along the route of travel.

A land surface slightly higher than the general terrace-plain level can be seen to the left of I-80 from several places. This higher surface is an eroded, loess-mantled outlier of till related to the Cedar Bluffs marginal moraine and located generally in the area of high bedrock. The outlier is separated from the main body of Cedar Bluffs Till to the east by Illinoian alluvial sediments.

Fluvial deposits, nearly contemporaneous with and slightly younger than the Cedar Bluffs Till, the Walnut Creek Formation and the Sappa Formation, border the till outlier on the southwest and western margin and have been identified in the subsurface

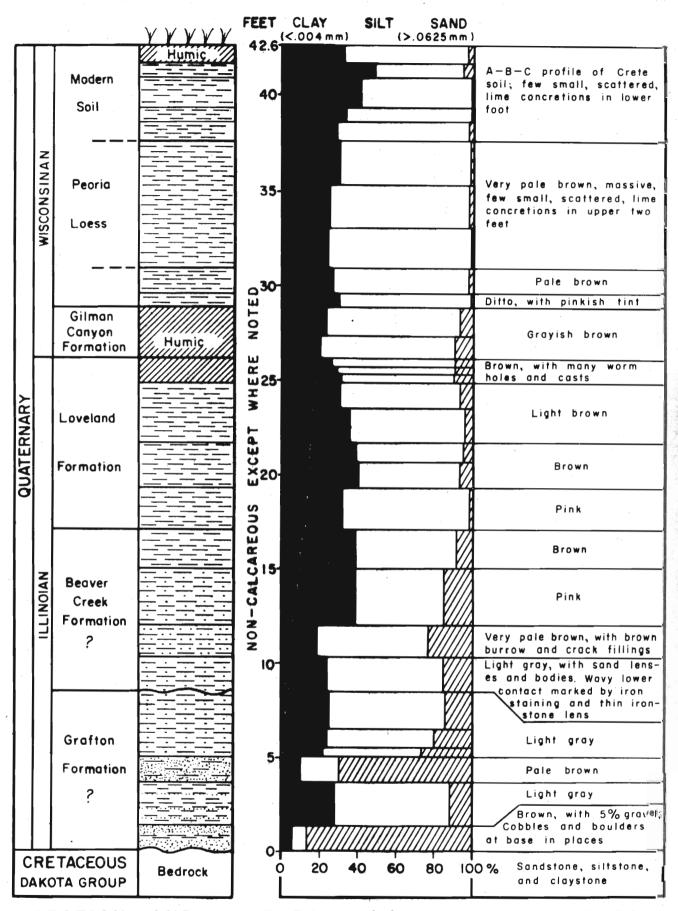


EXPLANATION

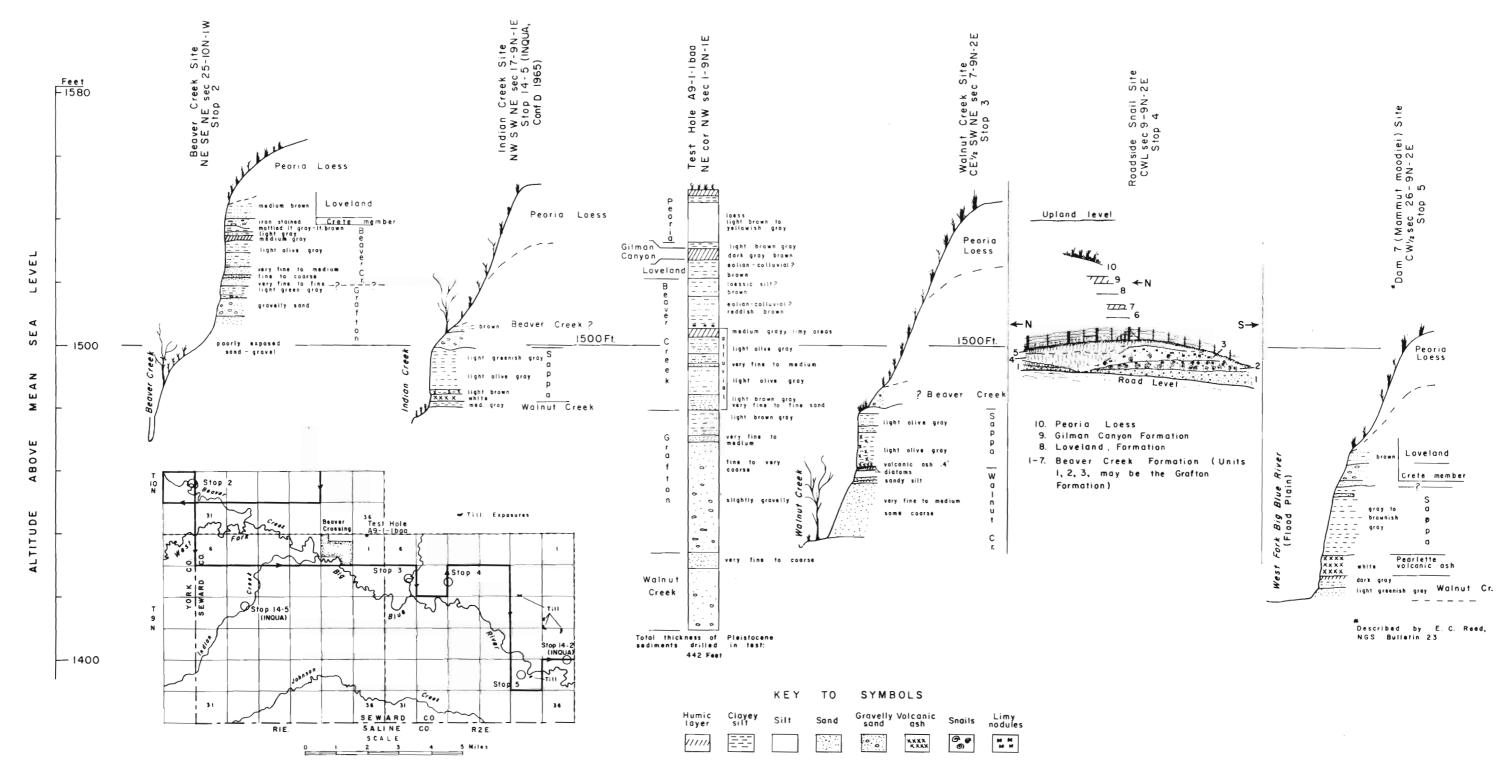
Clayey Silt Sand Weathered Humic Filled Horizons Openings

DIAGRAM OF SOUTH WALL OF NORTHEAST PIT, YANKEE HILL BRICK PLANT

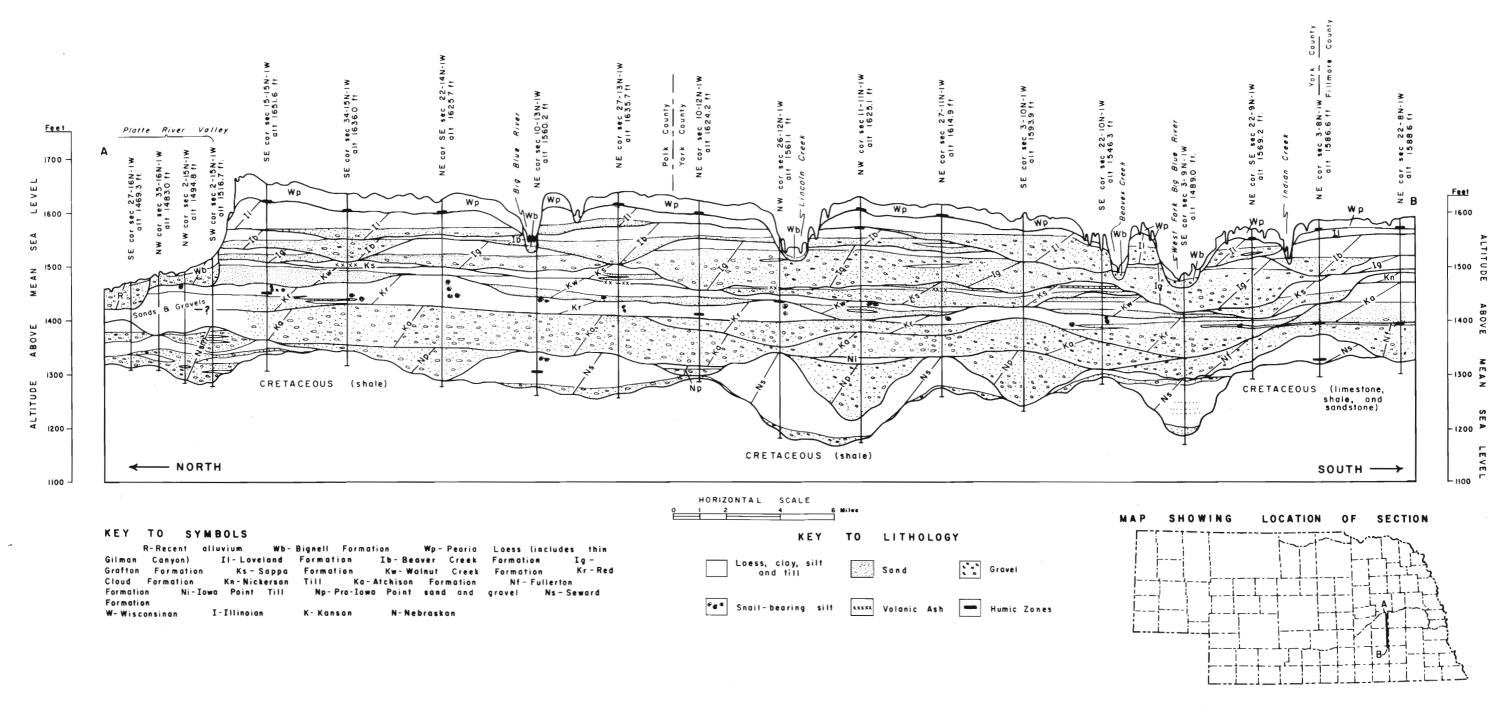
Figure 5



SECTION AND TEXTURAL ANALYSES OF SAMPLES FROM SOUTH WALL, NORTHEAST PIT, YANKEE HILL BRICK PLANT



RELATIONSHIP OF STRAIGRAPHY, STOPS 2 TO 5 (from Guidebook, Conference D, INQUA, VII Congress, fig. 14-62)
Figure 7



NORTH TO SOUTH GEOLOGIC SECTION IN EASTERN POLK AND YORK COUNTIES (from N.G.S. Bulletin 23)

Figure 8

and at scattered outcrops along the West Fork of the Big Blue River. These formations were mostly deposited in a valley system that was probably parallel to and west of the main body of Cedar Bluffs Till. Tributary valleys from the west and northwest joined this major system and all were alluviated. Some loess was deposited on the upland and interfluve areas.

Later, erosion associated with Illinoian drainage systems removed much of the Walnut Creek and Sappa deposits. Significant thicknesses of sediments, deposited during three episodes of Illinoian glaciation, filled channels, covered parts of the older terrace surface, and formed the broad terrace plain. Drainage apparently was from north to south along the old till border during at least Early to Medial Illinoian time, and it was joined by drains from the west.

The formations underlying this terrace plain are similar in texture, color, and composition; have cut-and-fill relationships; and are infrequently and poorly exposed. Consequently, it is difficult to identify the formation or formations at any single exposure without considering the regional relationships. Subsurface data and study provided much of the basis for evaluating and correlating the exposed deposits of the area.

- 30.8 10.0 Stop sign, leave I-80 and turn left (south) on State Spur 1127.
- 32.4 1.6 Turn right (west) onto gravel road.
- 37.4 5.0 Turn right (north).
- 38.4 1.0 Turn right (east).
- 39.4 1.0 Turn right (south).
- 39.8 0.4 STOP 2. Beaver Creek Site, NE. 1/4 SE. 1/4 NE. 1/4 sec. 25, T. 10 N., R. 1 W., York County, Utica Quadrangle. Site is located on farm owned by Martin Von Minden.

The Beaver Creek Site is the type locality for the Beaver Creek Formation (Nebr. Geol. Surv. Bull. 23). The section is described in Bulletin 23 (p. 60-61) and is shown diagrammatically on figure 7. The subsurface relationships on a line two miles west are shown on figure 8.

Three depositional sequences of the Illinoian are recognized at Stop 2 and are correlated as the Loveland Formation with the

Crete member, the Beaver Creek Formation, and the Grafton Formation. The maximum thickness of the deposits of Illinoian age in the area is about 150 feet. The three units thicken or thin as the result of cut-and-fill relationships. Each of the formations in their fluviatile occurrences are coarser to finer textured alluvium; upland phases of the depositional sequences are thin to thick loesses.

- 42.4 2.6 Turn left (east).
- 49.4 7.0 Turn right (south).
- 49.9 0.5 STOP 3. Walnut Creek Site, center E. 1/2 SW. 1/4
 NE. 1/4 sec. 7, T. 9 N., R. 2 E., Seward
 County, Utica Quadrangle. Site is located
 on farm owned by Adolph Hormes.

This site is the type locality of the Walnut Creek Formation of Late Kansan age (Nebr. Geol. Surv. Bull. 23). The section is shown diagrammatically on figure 7 and is described in Bulletin 23 (p. 55). The interval between the base of the Peoria Loess and the top of the Sappa Formation is about 50 feet. The interval is poorly exposed and we are uncertain about the correlation of the sand and gravel above the Sappa Formation; it may be either the Crete member of the Loveland Formation or a part of the Beaver Creek Formation. The Pearlette Volcanic Ash is very thin at this site and occurs in only parts of the exposure. The lower 9 feet of clayey silts above the ash horizon contain an abundance of ash shards.

- 50.4 0.5 Turn left (east).
- 51.4 1.0 Turn left (north).
- 51.9 0.5 STOP 4. Roadside Snail Site, near center of W. line, sec. 9, T. 9 N., R. 2 E., Seward County, Goehner Quadrangle.

This site was visited by the VIIth INQUA Conference and designated as Stop 14-3 in the Guidebook for Field Conference D, Central Great Plains, and is shown diagrammatically in figure 7, this guidebook. This exposure contains an unusual occurrence of snail-bearing beds for Illinoian deposits in this area. The relationships at the exposure are not clear and the identification of the formations is uncertain.

- 52.4 0.5 Turn right (east).
- 54.4 2.0 Turn right (south).

57.9 3.5 STOP 5. Dam 7 (Mammut moodiei) Site, near center W. 1/2, sec. 26, T. 9 N., R. 2 E., Seward County, Dorchester NW Quadrangle. Site located on the Gene Stauffner farm.

This site was visited by the VIIth INQUA Conference and designated as Stop 14-1 in Guidebook for Field Conference D, Central Great Plains and is shown diagrammatically on figure 7, this guidebook. The stratigraphy at this site has been discussed in Nebr. Geol. Surv. Bull. 23, p. 55-56, and by Schultz (1934, p. 372) and Schultz and Stout (1945, p. 237).

- 58.4 0.5 Turn left (east).
- 59.4 1.0 Turn left (north).
- 60.4 1.0 Turn right (east).
- 61.1 0.7 A roadside exposure on right visited by VIIth INQUA Conference and designated Stop 14-2 in Guidebook for Field Conference D, Central Great Plains.
- 62.4 1.3 Stop sign. Turn left (north) on U. S. Highway 6.
- 65.4 3.0 Curve right (east) on U. S. Highway 6.
- 66.4 1.0 Turn left (north) on State Highway 127.
- 69.8 3.4 Turn right onto I-80.
- 87.3 17.5 Turn right off I-80 onto West "O" St. exit.
- 87.5 0.2 Stop sign. Turn left on West "O" St. (U. S. Highway 6) and continue on "O" St. east to 33rd St. (about 4.9 miles).
- 92.4 4.9 Stop light. Turn left on 33rd St. and go north 1 mile to Nebraska Center.

NIGHT STOP. The annual dinner will be in the Omaha room at the Center at 7:00 p.m. The dinner will be followed by an informal discussion starting with problems involved with glacial-periglacial correlation and classification.

Sunday, May 22, 1966

Breakfast will be served at 6:30 a.m. in the Omaha Room for those who purchased breakfast tickets.

ASSEMBLY POINT: Nebraska Center, 33rd and Holdrege streets, Lincoln, Nebraska.

ASSEMBLY TIME: 7:30 a.m. Central Standard Time.

Mile Cum.	eage Diff.	Garanth and 20ml of Millions at automorphism at 20ml and
0.0		Go south on 33rd St. Mileage starts at 33rd and Holdrege streets.
1.0	1.0	Stop light. Turn left (east) onto "O" St. (U.S. Highway 34).
3.5	2.5	Turn right (south on 70th St.)
4.5	1.0	Turn left (east).
6.7	2.2	STOP 6. Walton Site, along the N. line NW. 1/4 sec. 36, T. 10 N., R. 7 E., Lancaster County, Walton Quadrangle, in press.

James V. Drew, Agronomy Department, University of Nebraska, has summarized the results of investigation at this site.

LANDSCAPE RELATIONSHIPS OF A SHARPSBURG-WYMORE SOIL SEQUENCE NEAR WALTON, NEBRASKA

The regional pattern of Monona, Marshall, Sharpsburg, and Wymore soils in southeastern Nebraska has been related to the age, thickness, and nature of Wisconsinan loess and is analogous to the distribution of soils in other areas where loess grades from a thick deposit near its source to a thin mantle with increasing distance from its source (fig. 9). Thus, Monona and Marshall occur in a narrow association adjacent to the Missouri River Valley, whereas Sharpsburg and Wymore with finer textured subsoils occur in wider belts with increasing distance toward the southwest. Sharpsburg has a silty clay loam subsoil that grades with depth to brown or grayish-brown loess, whereas Wymore has a more strongly developed subsoil of silty clay texture that grades with depth to a grayish-brown loess with prominent, reddish-brown segregations and mottles of iron oxide.

Within the major associations of these soils, the degree

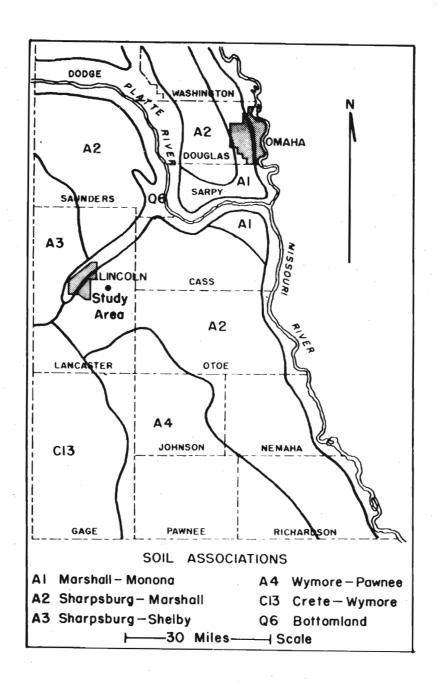


Figure 9. Soil associations of southeastern Nebraska and the location of the study area in Lancas ter County, Nebraska.

of soil development is frequently related to the position of the soil on the landscape. For example, in the central and eastern portion of the Sharpsburg-Marshall association, Sharpsburg occurs on the highest and most stable positions of interfluves, and Marshall or Monona with less well-developed subsoils occurs on younger land surfaces of interfluve slopes.

In a transition zone 5 to 10 miles wide at the western edge of the Sharpsburg-Marshall association, however, a different soillandscape situation exists. Here Sharpsburg occurs on the highest and most stable portions of interfluves and gives way to Wymore with a finer textured subsoil on interfluve slopes at lower elevations. Figure 10 illustrates a pattern of Sharpsburg and Wymore within this transition zone. The genesis of Sharpsburg and Wymore at this location provides an interesting problem.

Soil profiles at sites 1, 2, and 3 (fig. 10) are described in Table 1 and occur at successively lower elevations from Sharpsburg (site 1) near the highest elevation to Sharpsburg (site 2) and Wymore (site 3) on the sloping side of the interfluve. Particle size analyses (Table 2) indicate that these profiles increase in degree of subsoil development in the order Sharpsburg (site 1) - Sharpsburg (site 2) - Wymore (site 3). Eastward from site 3, the silty clay subsoil of Wymore extends beneath recent alluvium in which Colo soil has formed. Wisconsinan loess ranges in thickness from 14 feet at site 1 to 10 feet at site 3, and includes three zones that differ in color and mottling, as shown in Figure 3.

Weathering ratios (figs. 12 and 13) computed from mineralogical data from the very fine sand and coarse silt of these profiles (Table 3) indicate that the profiles increase in degree of development in the order Sharpsburg (site 1) - Sharpsburg (site 2) - Wymore (site 3). Coarse clay (2.0 - 0.2µ) within the profiles contains moderate amounts of montmorillonite, illite, and kaolinite, smaller amounts of vermiculite, and detectable amounts of quartz and feldspar. Fine clay (<0.24µ) contains abundant montmorillonite, smaller amounts of a mixed layer component, and small amounts of illite.

Concepts of soil development in relation to the evolution of upland slopes indicate that strongly weathered soils should exist on the highest and most stable land surfaces, whereas less strongly weathered soils should occur on younger surfaces formed by slope retreat. Wymore soil at site 3 is associated with a surface that apparently bevels the lowest of the three zones recognized in the Wisconsinan loess. Thus, this surface should be younger than the surface on which Sharpsburg has formed at site 1. Yet Wymore (site 3) exhibits a greater degree of soil development than Sharpsburg (site 1).

The pattern of Wymore on lower slopes suggests that this soil may have formed in a buried, clayey paleosol truncated by slope retreat. Subsurface borings and roadcut exposures, however,

failed to reveal a buried, clayey paleosol in the zones of Wisconsinan loess. Thus, the Wymore profile at site 3 has not formed in a clayey paleosol exposed by slope retreat.

The particle size distribution and mineralogy of the C horizons of Sharpsburg (site 1), Sharpsburg (site 2), and Wymore (site 3) are similar (Tables 2 and 3). Thus, the increase in subsoil clay from Sharpsburg (site 1) to Wymore (site 3) is not related to an increase in silt, clay, or weatherable primary minerals within the C horizons of these profiles.

Possibly soil moisture conditions on slopes at sites 2 and 3 are more favorable for clay formation than at higher elevations. Locally, where Wisconsinan loess is thin, seepage following heavy rains may occur from the contact between Wisconsinan loess and underlying, less permeable material. It is difficult, however, to relate the weathering associated with Wymore at site 3 to seepage water when the loess mantle is 14 feet thick.

Perhaps the occurrence of Sharpsburg and Wymore at sites 1, 2, and 3 reflects different rates of accumulation in the upper portion of the loess mantle on divides vs. slopes. Westerly outliers of Medial to Late Wisconsinan loess may have accumulated in relatively thick increments on the highest positions of interfluves and divides during the same time interval in which thin increments accumulated on slopes. Thus, Sharpsburg formed on the highest surfaces whereas the solum of Wymore developed in thin, more thoroughly weathered increments of Medial to Late Wisconsinan loess deposited over beveled Early Wisconsinan loess on lower slopes. No mechanism is at hand, however, to account for the influence of slope characteristics on the differential accumulation of loess required to support this view.

What other hypotheses will explain the distribution of Sharpsburg and Wymore soils in this locality?

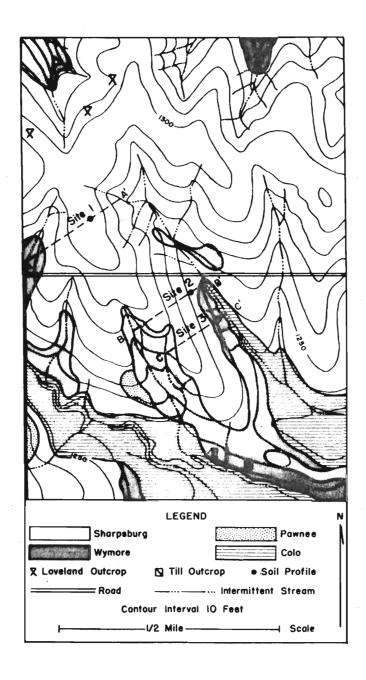


Figure 10. Soil and topographic map of the study area in Lancaster County, Nebraska, and the location of Sharpsburg and Wymore profile sites.

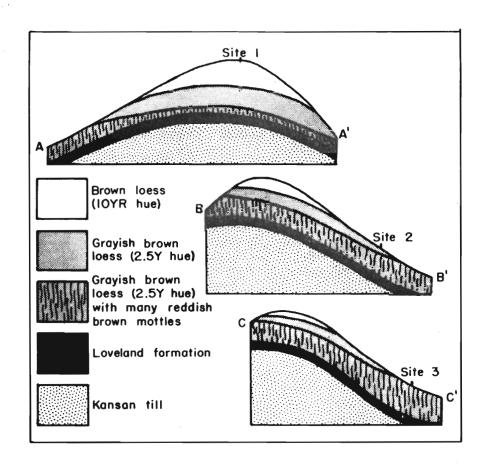


Figure 11. Cross sections of an interfluve along t transects shown within the study area i Figure 10.

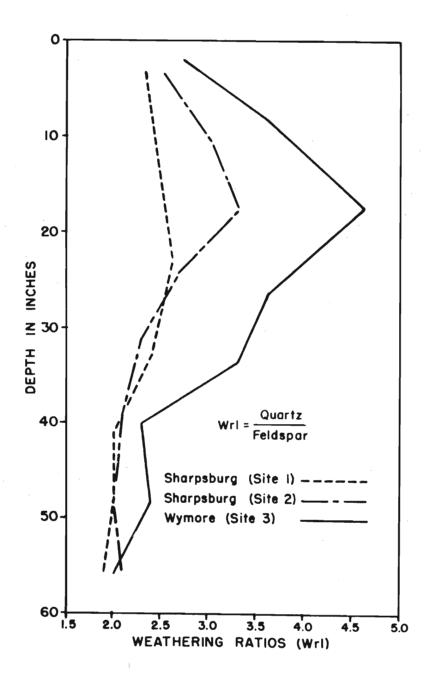


Figure 12. Changes with depth in weathering ratios computed from light mineral data in Sharpshurg (site 1), Sharpshurg (site 2), and Wymore (site 3).

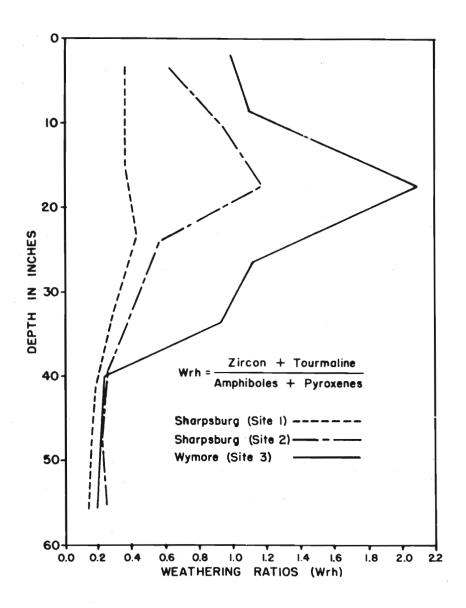


Figure 13. Changes with depth in weathering ratios computed from heavy mineral data in Sharpsburg (site 1), Sharpsburg (site 2), and Wymore (site 3).

Table 1. Morphology of Sharpsburg and Wymore profiles. (Color notations refer to moist conditions).

	Table 1. Horphology of Sharp	SDGI (g and wymore profites. (Coron notati	LOHS	refer to morst conditions).
	Sharpsburg (site 1)		Sharpsburg (site 2)		Wymore (site 3)
Ар	0 to 7 inches, very dark brown (10YR 2/2) silty clay loam; moderate, very fine granules.	Ap	0 to 7 inches, very dark brown (10YR 2/2) silty clay loam; moderate, very fine granules.	Ap	0 to 4 inches, very dark brown (10YR 2/2) silty clay loam; moderate, very fine granules.
A3	7 to 10 inches, very dark brown (10YR 2/2) silty clay loam; moderate, very fine, subangular blocks.	B1	7 to 14 inches, very dark grayish- brown (10YR 3/2) silty clay loam; moderate, fine, angular blocks.	B21	4 to 13 inches, very dark brown (10YR 2/2) silty clay; moderate, very fine, angular blocks.
B1	10 to 19 inches, very dark grayish-brown (10YR 3/2) silty clay loam; moderate, fine, subangular blocks.	B21	14 to 21 inches, dark grayish-brown (10YR $4/2$) silty clay loam; moderate, fine, angular blocks.	B22	13 to 22 inches, very dark grayish-brown (10YR 3/2) silty clay; fine, angular blocks.
В2	19 to 28 inches, dark grayish-brown (10YR $4/2$) silty clay loam; moderate fine angular blocks.	B22	21 to 27 inches, dark grayish- brown (10YR 4/2) silty clay loam; moderate, medium, angular blocks.	B23	22 to 31 inches, dark grayish- brown (10YR 4/2) silty clay; moderate, medium, angular blocks.
в3	28 to 37 inches, dark brown (10YR 4/3) silty clay loam; moderate, medium, angular blocks; few, fine, prominent, very dark brown (10YR 2/2) mottles.	В3	27 to 35 inches, grayish-brown (2.5Y 5/2) silty clay loam; moderate, medium, angular blocks; common, fine and medium, prominent, reddish-brown (XYR 4/4) mottles of iron oxide, ranging from soft segregations to occasional, vertically oriented pipestems.	ВЗс	brown (2.5Y 4/2) silty clay loam; moderate, medium, angular blocks; few, fine, prominent, reddish-brown (5YR 4/4) mottles; scattered hard lime concretions 1/8 to 1/4 inch in diameter.
C1	37 to 45 inches, brown (10YR 5/3) silty clay loam; weak, coarse, angular blocks; few, fine, prominent, strong brown (7.5YR 5/6) and very dark brown (10YR 2/2)	C1	35 to 43 inches, grayish-brown (2.5Y 5/2) silty clay loam; weak, coarse, angular blocks; common, fine and medium, prominent, reddish-brown (5YR 4/4) mottles as in horizon above.	C1	36 to 44 inches, grayish-brown (2.5Y 5/2) silty clay loam; weak, coarse, angular blocks; many coarse, prominent, reddish-brown (5YR 4/4) mottles of iron oxide; common, hard lime concretions 1/8 to 1/2 inch in diameter.

Table 1--Continued

	Sharpsburg (site 1)	Sharpsburg (site 2)	Wymore (site 3)				
C2	45 to 52 inches, brown (10YR 5/3) silty clay loam; weak, coarse, angular blocks; few, fine, prominent mottles as in horizon above.	2 43 to 51 inches, grayish-brown (2.5Y 5/2) silty clay loam; weak, coarse, angular blocks; common, fine and medium, prominent mottles as in horizon above.	C2 44 to 52 inches, grayish-brown (2.5Y 5/2) silty clay loam; weak, coarse, angular blocks; many medium, prominent, dark brown (7.5YR 4/4) mottles of iron oxide ranging from soft segregations to vertically oriented pipestems (1/8 to 1/2 inch in diameter; scattered, hard lime concretions 1/8 to 1/4 inch in diameter.				
C3	52 to 60 inches, brown (10YR 5/3) (silty clay loam; massive; few, fine, prominent mottles as in horizon above.	3 51 to 60 inches, grayish-brown (2.5Y 5/2) silty clay loam; massive; common, fine and medium, prominent mottles as in horizon above.	C3 52 to 60 inches, grayish-brown (2.5Y 5/2) silty clay loam: massive; many, coarse and medium mottles and scattered lime segregations as in horizon above.				

Table 2. Particle size distribution and chemical data for Sharpsburg and Wymore profiles.

-	: ::		Par	ticle si	ze diame	ter range	2				NH40A	- extra	ctable	cations
Hori- zon	: Depth : inches : : : : :	2.0- : 0.1 mm. %	0.1-: 0.05: mm.: %:	0.02 mm.	2.0μ : %	μ %	2.0- 0.2µ %	:<0.2 : µ : %		CEC me/ 100 g.	: Ca : : : : : : : : : : : : : : : : : :	Mg : me/ : 100 : g :	Na	: K :
					Sharpsb	arg silty	y clay	loam (Sit	e 1)					
Ap	0-7	0.5	1.4	38.0	24.4	35.8	17.7	18.1	5.6	21.5	11.8	4.3	0.3	1.3
A 3	7-10	0.1	0.8	29.4	32,9	36.8	17.5	19.3	5.6	22.6	14.5	6.5	0.3	1.1
B1	10-19	0.1	0.5	26.3	36.0	37.1	17.5	19.6	5.9	23.0	15.6	6.5	0.2	0.8
В2	19-28	0.2	0.6	29.2	31.5	38.5	18.3	20.2	6.3	23.4	17.5	7.3	0.3	0.6
В3	28 - 37	0.1	0.7	34.7	30.5	34.0	17.8	16.2	6.6	22.2	14.8	6.7	0.3	0.6
C1	37 - 45	0.1	1.0	34.4	31.9	32.6	17.9	14.7	6.7	20.2	14.5	6.4	0.4	0.6
C2	45 - 52	0.1	0.9	36.4	31.7	30.9	16.9	14.0	6.9	20.1	14.8	7.2	0.4	0.6
С3	52 - 60	0.1	1.0	39.6	30.2	29.0	17.5	11.5	7.1	20.1	14.1	6.5	0.4	0.6
					Sharpsb	urg silty	y clay	loam (Sit	te 2)					
Ap	0-7	0.7	1.4	32.3	28.0	37.6	18.1	19.5	5.9	26.2	13.6	4.7	0.3	0.9
B1	7-14	0.2	1.0	31.1	26.4	41.2	20.3	20.9	5.8	27.9	16.1	5.2	0.5	0.7
B21	14-21	0.1	1.0	28.0	29.1	41.8	21.1	20.7	6.2	27.7	16.4	7.0	0.4	0.6
B22	21-27	0.1	1.0	30.0	30.4	38, 5	19.6	18.9	6.4	24.5	17.2	9.1	0.3	0.6

Table 2--Continued

_		:		Par	ticle siz	e diamet	er range			_:	:	:NH40	A _c - extr	actab1	e cation	ıs
	Hori- zon	Depth : inches :		: 0.1- : 0.05 :	•	• •		: 2.0- : 0.2µ : %	: < 0.2 : µ : %	: 1:1, :	′ .	: Ca :	Mg : me/ : 100 : g.	Na	K	
	В3	27-35	0.3	1.5	32.8	29.3	36.1	17.7	18.4	6.5	23.3	15.6	10.6	0.3	0.5	
	C1	35-43	0.6	1.5	34.0	32.4	31.4	17.2	14.2	6.8	20.8	15.5	7.8	0.5	0.6	
	C2	43-51	0.2	1.7	34.7	30.9	32.3	17.6	14.7	7.1	20.5	13.9	8.0	0.4	0.7	
	С3	51-60	0.3	1.7	37.6	30.4	30.1	16.9	13.2	7.3	20.9	14.9	7.4	0.4	0.6	
						Wymo	re silty	clay 1	oam (Sit	e 3)						
	Ар	0-4	0.3	1.5	37.6	20.6	40.0	17.6	22.4	5.8	27.4	14.1	5.6	0.3	0.9	
	B21	4-13	0.2	1.7	32.5	20.9	44.8	22.1	22.7	6.1	30.1	16.1	4.2	0.4	0.7	
	B22	13-22	0.2	1.3	30,1	20.6	48.0	20.7	27.3	6.5	33.6	18.3	10.6	0.8	0.7	
	B23	22-31	0.1	1.1	32.4	26.0	40.5	17.4	23.1	7.1	27.6	20.1	8.9	1.0	0.6	
	B3ca	31-36	0.1	0.9	33.2	27.3	38.5	20.1	18.4	7.6	24.3	27.7	8.8	1.3	0.6	
	C1	36 -44	0.2	1.1	36.2	29.4	33.0	19.7	13.3	7.6	21.0	28.1	9.2	1.1	0.5	
-	C2	44-52	0.1	1.1	39.4	29.0	30.3	15.5	14.8	7.8	21.1	23.0	8.4	1.4	0.5	
	C3	52- 60	0.1	1.4	37.0	32.1	29.6	17.0	12.6	7.7	20.8	26.1	8.9	1.6	0.7	

Table 3. Data for total and selected heavy minerals in Sharpsburg and Wymore profiles. (Values for total heavy minerals are shown as percent by weight of the very fine sand and coarse silt. Values for selected heavy minerals are shown as count percentages of the heavy mineral fraction minus magnetite.)

_	Horizon		Total heavy minerals, %	Zircon %		Tourmaline, %	: : : : : : : : : : : : : : : : : : : :	Garnet, %	: : : : : : : : : : : : : : : : : : : :	Epidote, %	: : : : : : : : : : : : : : : : : : : :	Zoisite, %	: : : : : : : : : : : : : : : : : : : :	Biotite, %	: : : : : : : : : : : : : : : : : : : :	Pyroxene, %	: : : : : : : : : : : : : : : : : : : :	Hornblende,
	Sharpsburg silty clay loam (Site 1)																	
	Ap		2.2	6		5		5		7		4		15		11		15
	Å 3		2.0	6	•	5		5		7		5		17		10		17
	В1		2.2	6	•	. 5		5		5		5		14		10		16
	В2		2.2	6	•	5		5		5		4		13		11		14
	В3		2.5	6	•	4		4		8		5		18		12		21
	C1		2.7	4	+	3		2		5		3		20		13		23
	C2	÷	2.5	4	+	2		4		5		3		20		16		22
	C3		2.5	3	3	2		3		3		3		19		15		23
					Sh	arpsb	urg	silt	у с1	.ay 1	oam	(Sit	e 2	2				
	Ap		1.3	10)	5		6		7		4		11		10		14
	B1		1.3	14		5		5		8		4		13		7		11
	B21		1.0	15	·	8		5		9		5		12		8		9
	B22		1.3	10)	5		4		7		3		13		10		16
	В3		1.4	8	3	5		5		6		5		13		10		18
	C1		1.5	6	•	4		4		5		4		14		11		23
	C2		1.6	6	1	3		6		5		4		16		12		25
	С3		1.6	6	1	3		5		4		2		14		13		25

Table 3--Continued

Horizon	Total heavy minerals, %	Zircon, %	Tourmaline,%	Garnet, %	Epidote, %	Zoisite, %	Biotite, %	Pyroxene, %	Hornblende,%					
Wymore silty clay loam (Site 3)														
Ap	0.7	17	7	2	11	3	7	7	13					
B21	0.5	18	6	5	9	5	6	7	11					
B22	0.7	22	11	3	8	4	5	7	6					
B23	0.8	17	9	3	6	4	6	. 7	11					
ВЗса	0.8	16	9	4	7	3	. 7	8	15					
C1	1.1	7	4	3	5	.4	9	12	23					
C2	1.0	6	3	4	6	4	9	14	23					
 С3	1.3	5	4	4	5	3	8	14	25					

8.0	1.3	Turn left (north) just past Walton Community School.								
9.0	1.0	Stop sign. Turn right (east) onto U. S. Highway 34.								
42.4	33.4	Stop sign. Turn left (north) onto U. S. Highway 73-75.								
59.3	16.9	South end of Platte River Bridge.								
60.5	0.2	Turn right (south) at school house.								
60.7	0.2	Bear to the right.								
60.9	0.2	Highway underpass. Continue ahead.								
63.1	2.2	Bear left at intersection.								
63.4	0.3	STOP 7. City Wide Rock and Excavation Company and Welsh Stone Company Quarries, approximately 3 miles west of La Platte, Nebraska, in the NE. 1/4 NW. 1/4 and the NW. 1/4 NE. 1/4 sec. 29, T. 13 N., R. 13 E., Sarpy County, Plattsmouth Quadrangle.								

CAUTION: Stay away from vertical faces because of the danger of slumping. Watch your step.

Generalized Composite Section (descriptions by Frank A. Smith) shown diagrammatically in Figure 14.

	Thickness (feet)
Wisconsinan:	
Peoria Loess	2
Illinoian:	
Loveland Formation: Silt, slightly clayey, slightly	
sandy, noncalcareous, light yellowish-brown with	
manganese stains; sand is very fine; contains	
some manganese grains	14
Medial Kansan:	
Cedar Bluffs Till:	
Till: Clay, silty, sandy, slightly gravelly,	
noncalcareous, pale-yellow with iron and man-	
ganese stain; contains some clay grains; matrix	
leached; contains abundant carbonate con-	
cretions as crack fillings	2

	(feet)
Till: Clay, silty, sandy, slightly gravelly, moderately calcareous, light-gray with iron and manganese stains; contains limy nodules;	
contains more manganese stain than above Till: Clay, very silty, sandy, slightly gravelly, slightly calcareous, gray; contains some	10
carbonate nodules and limestone fragments; contains occasional blocks of interbedded sand	4
and siltEarly Kansan:	4
Nickerson Till: Till: Clay, silty, sandy, slightly gravelly,	
<pre>moderately calcareous, pale-yellow with some light-gray; contains limestone fragments, few</pre>	
ironstone fragments; contains abundant limy nodules in upper 5 feet; lower part contains occasional sand blocks, iron-stained; sand is	
very fine to medium with some coarse, contains limestone grains	16.6
Till: Silt, very clayey, sandy, slightly gravelly, moderately calcareous, yellowish-brown with some light-gray; contains limestone fragments and ironstone; contains silt blocks, very slightly	
clayey, slightly sandy, moderately calcareous, pale-yellow	4.7
blocks, moderately clayey, moderately sandy, very calcareous, pale-yellow; sand is very fine	. 1
to very coarse, principally limestone grains and fossil fragments	1.2
Late Nebraskan: Afton Soil Complex: Silt, moderately clayey, non-	
calcareous, grayish-brown to light-gray; contains a trace of very fine sand	. · · 3
Silt, moderately clayey, slightly sandy, noncal- careous, pale-brown with slight manganese stain; sand is very fine to fine with a trace of medium; contains ironstone	1.5
Silt, slightly to in part moderately clayey, slightly sandy, very slightly to noncalcareous, very pale-brown with pinkish tint; sand is very fine to fine with a trace of medium; contains	
<pre>small limy areas, interbedded sand lenses, limy nodules and rootlet holes at top</pre>	4.5
areas and limestone grains; limy nodules at top	4.5

	Thickness (feet)
<pre>Sand, slightly silty, slightly clayey, iron- stained, yellow; sand is very fine to very coarse with some fine gravel; contains lime- stone fragments, chert fragments, rare fossil</pre>	
fragments	2
stone fragments Early Nebraskan:	3.5
<pre>Elk Creek (?) Silt-sand: Silt, slightly clayey, moderately sandy, very cal- careous, pale-yellow; sand is very fine with some</pre>	
<pre>fine and a trace of medium; contains limestone fragments; limy nodules at top Sand, slightly silty, iron-stained, yellow; sand</pre>	3
<pre>is very fine to very coarse with some fine gravel; contains limy grains, limestone frag- ments, ironstone, and interbedded silt lenses Elk Creek Till:</pre>	4
Till: Silt, moderately clayey, sandy, slightly gravelly, slightly calcareous, pale-yellow with some gray mottling; contains some limy areas; contains sandstone, ironstone, and limestone; contains lime-filled cracks in upper part; boulder layer 8 feet above base; lower 8 feet	
moderately calcareous	19

This exposure was called to our attention by Joseph Benak who studied the engineering characteristics of the Pleistocene deposits in this area. The results of this study were presented in his Ph.D. dissertation at the University of Illinois.

An apparent break in deposition can be seen in the Elk Creek Till at the Welsh Quarry exposure. This is evidenced by the apparent planation of silt-sand bodies (in situ channel deposits?) at the break, the presence of sand-silt inclusions above the break, and a color change from pale-yellow to brownish-gray above the break. This break was not observed at the City Wide exposure and its significance has not been evaluated.

Striations on the Winterset Limestone bedrock strike approximately N. 25° E. Fabric analyses indicate a preferred pebble orientation of N. 6° E. for the Nickerson Till and N. 12° E. for the Cedar Bluffs Till.

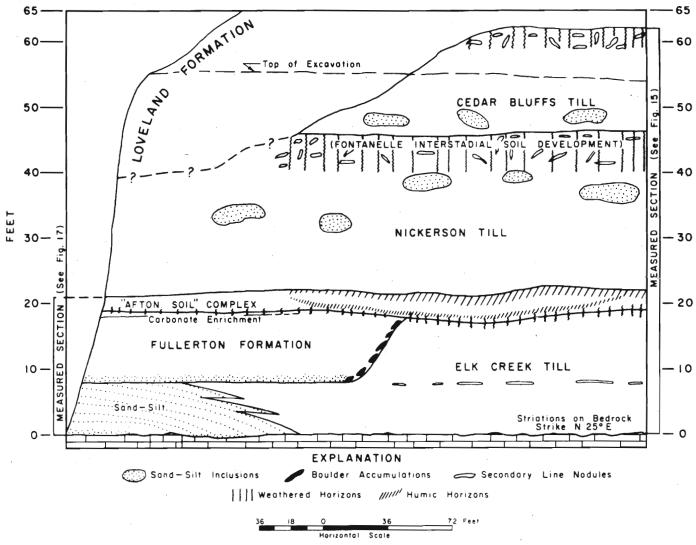
Texturally, the clay content of the tills increases upsection (see figs. 15 and 18). Most of this increase is at the expense of silt.

The percent of nonsedimentary rocks increases up-section

(see figs. 19 and 20). This trend occurs within each till as well as throughout the entire till section. This may be due to a decrease in the availability of sedimentary rocks as drift cover increases, to a shift in source area, to an increase in availability of nonsedimentary rocks due to removal of surface sedimentary rocks, or to a combination of these factors. Weathering appears to accentuate this trend (see figs. 15 and 20).

The progressive increase in hornblende and decrease in opaque minerals, especially limonite, up-section is probably due to one or more of the above factors (see Table 4). Note the occurrence of "wad" and the increase in pyrite in the Afton Soil Complex.

In the Cedar Bluffs Till there is an increase in percent of matrix soluble in hydrochloric acid up-section accompanied by a decrease in percent carbonate pebbles (see fig. 14). This indicates the transfer of carbonate from pebble to matrix by weathering processes. This probably accounts for the sharp increase in nonsedimentary pebbles in the weathered horizon (see fig. 20). This also occurs in the Nickerson Till but is not apparent in the Elk Creek Till. If such a weathered horizon did form, it may have been removed by erosion.



NORTH FACE OF CITY WIDE ROCK & EXCAVATION COMPANY QUARRY Figure 14

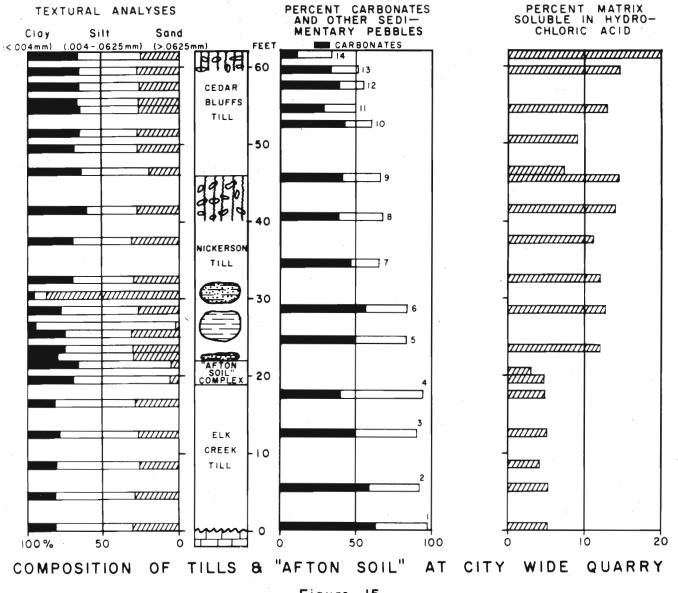
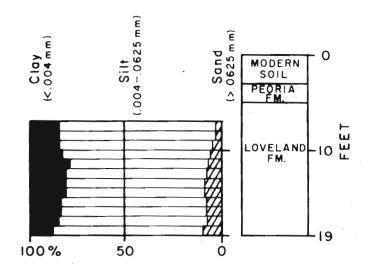


Figure 15



TEXTURAL ANALYSES OF LOVELAND FORMATION, WELSH QUARRY

Figure 16

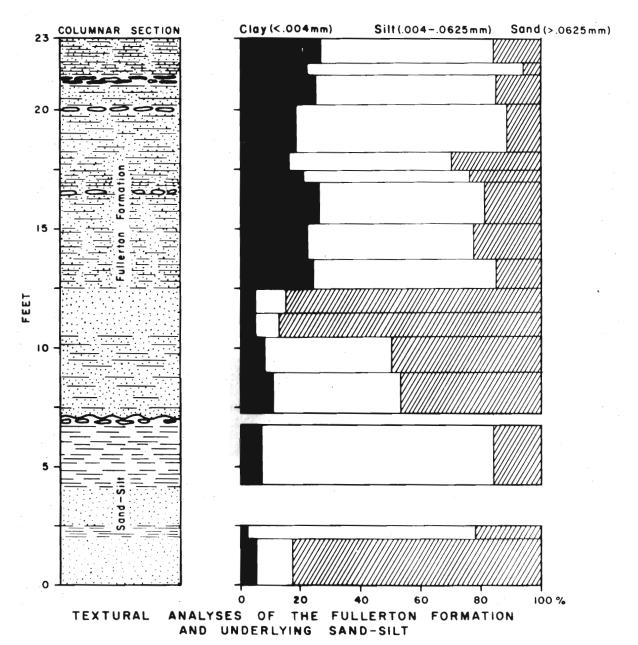


Figure 17

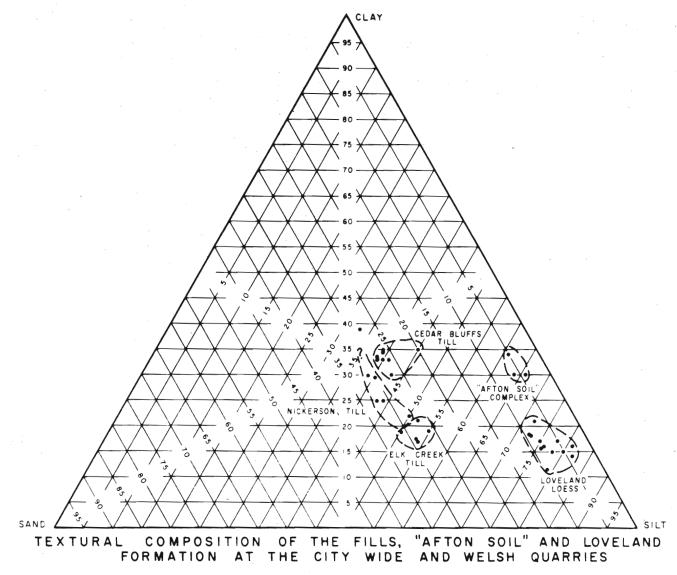
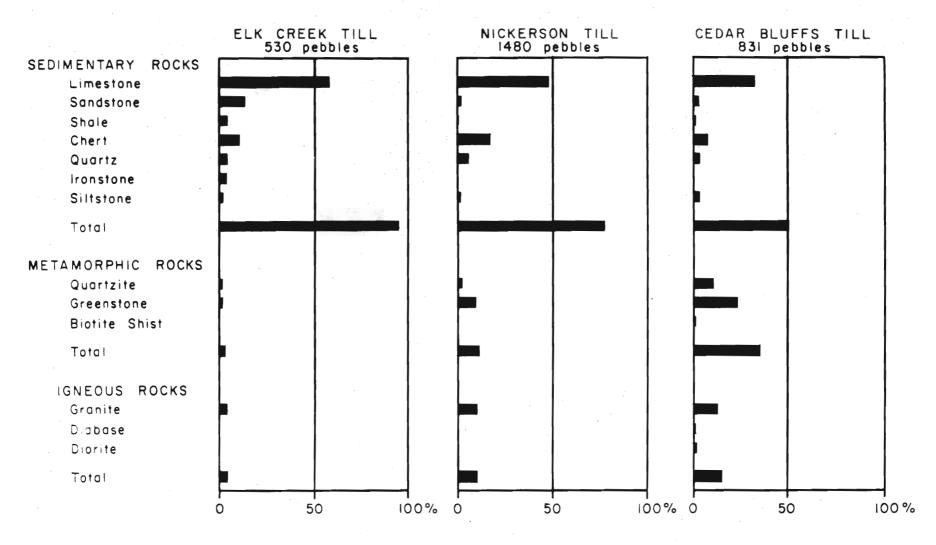
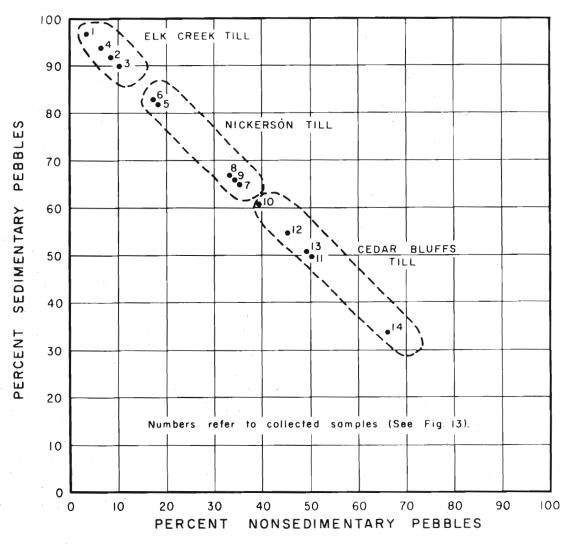


Figure 18



AVERAGE PEBBLE COUNTS OF THE TILLS, CITY WIDE QUARRY

Figure 19



SEDIMENTARY - NONSEDIMENTARY PEBBLE RELATIONSHIPS IN TILLS EXPOSED AT CITY WIDE QUARRY

Figure 20

Table 4. Values of Selected Heavy Minerals

	llornb1ende	Epidote	Biotite	Muscovite	Spinel	Limonite	Leucoxene	Hematite	Ilmenite	Pyrite	"Wad" ?	Total Opaque Minerals
Loveland Formation	37.5	14.7	15.0	8.4	.3	6.7	2.0	1.3	.20	.3		12.3
Cedar Bluffs Till	*27.7 29.3	20.7 16.0	4.0 7.0	1.0 1.3	4.0 5.3	11.7 3.0	4.0 4.0	3.7 2.7	2.3 2.3	.3		22.0 12.3
Nickerson Till	*26.0 19.3	16.3 11.7	2.7 5.0	0.3	6.3 5.3	17.7 12.3	1.7 4.7	1.3 4.0	0.7 2.7	.3 1.0		28.0 24.7
Afton Soil Complex	11.3	13.3	3.3	1.7	2.3	24.0	4.3	4.7	3.0	8.7	9.7	56.7
Elk Creek Till	9.4 7.0	10.7 10.7	2.9 1.0	1.0 1.0	6.8 4.3	28.0	11.7 8.0	6.2 8.3	3.3 3.3	1.3 1.7		50.5 60.6

^{*} Weathered Zones

Other Minerals Present Are: Andalusite, apatite, chlorite, metamict, allamite, beryl, basaltic hornblende, garnet, hypersthene, kyanite, magnetite, monazite, rutile, sphene, spodumene, staurolite, topaz, tourmaline, and zircon.