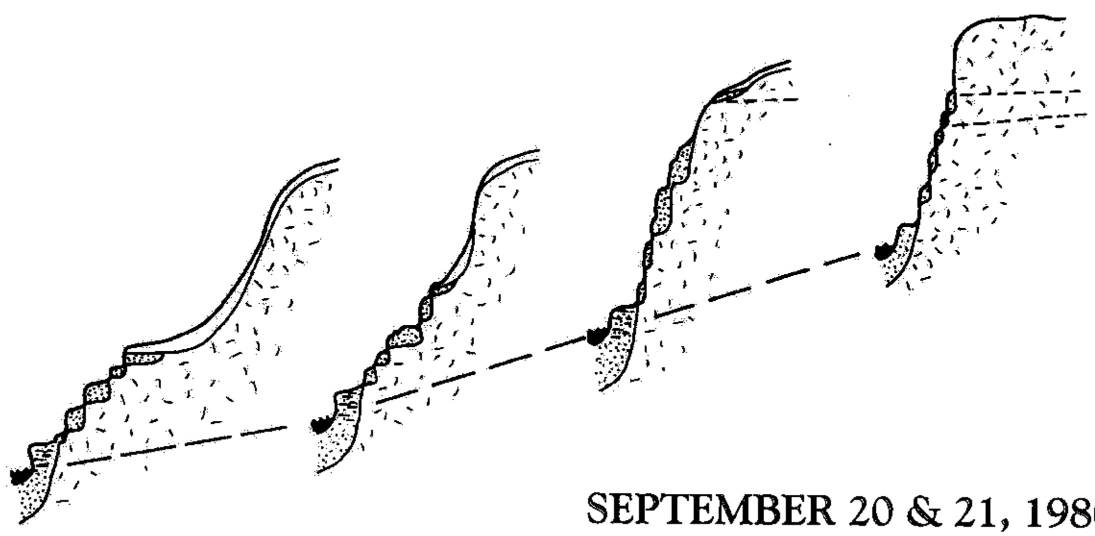
The GSI Fall Field Trip #34

GEOMORPHIC HISTORY OF THE LITTLE SIOUX RIVER VALLEY



SEPTEMBER 20 & 21, 1980

Led by Bernard E. Hoyer, Iowa Geological Survey

GEOMORPHIC HISTORY OF THE LITTLE SIOUX RIVER VALLEY

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Geomorphic History of the Little Sioux River Valley

I. Background Information

Introduction

Anyone familiar with northwest Iowa can recognize that the Little Sioux River and its tributaries are unique to the area. The valley is particularly scenic as it is cut deeply, canyon-like in some areas, with many terraces and gallery forest remnants preserved. Macbride (1901) vividly discussed its appearance and its relation to the geological past.

> Such is the topography of the Little Sioux valley... driving along the plain from the west, for example, the explorer approaches without the slightest fore-warning these wonderful ravines. Beautiful farms are thrust out like promontories into the valley of the river commanding, as the channel bends and winds, prospects romantic in the extreme, shining meadows, glittering waters, wooded slopes, sunny fields, and shadowed chasms.
>
> The proverbial sectionline road which elsewhere follows like a path of destiny the laws of the surveyor, here, for once, falls baffled, toils painfully up the channel of some lateral stream or ceases altogether, leaving the traveler by wide detours to find, if he may, some easier thoroughfare, some gentler gradient.
>
> Indeed, the freaks of erosion as displayed by these streams in the southwest corner of O'Brien county are unmatched so far in a prairie country. No photography can do justice to the subject. One is reminded of the Bad Lands and the Mesas of the distant west.

Perhaps Macbride is excessive, but the valley does have an appearance which gives it a special charm. And this charm is a direct consequence of its Pleistocene and Holocene history, the subject of this Geological Society of Iowa field trip.

Acknowledgements

Many people deserve credit for a field trip. The research was greatly aided by field assistance from Nyle Wollenhaupt and Timothy Kemmis. George Hallberg and Gerald Miller also have helped this research substantially. Further, Hallberg and Kemmis have provided data presented in this trip. E. Arthur Bettis suggested one site and has been very interested in this research. Steven Saye identified Lake Spencer drilling sites and allowed use of the Midwestern Consulting Laboratory's drilling rig. The directors of the Iowa Geological Survey, Samuel Tuthill, Stanley Grant and Donald Koch, have all supported this work. Illustrations were drafted by John Knecht. Laboratory analyses presented were conducted at Iowa State University, Department of Agronomy. Gregory Ludvigson provided help in planning logistics and publicity for this trip. Barbara Case typed the field trip guide.

Special thanks are extended to landowners who have allowed access to their land for this trip. Donald Grefe provided access to Stop 2, Richard Knapp allowed access to Stop 4 and Marvin Gutheridge granted permission on Stop 13. These men and their families deserve our special thanks.

Little Sioux River Basin

The Little Sioux River Basin is the largest in northwest Iowa. It drains about 6800 km^2, most of which is in Iowa, but about 600 km^2 is in Minnesota. The river is 345 km (210 miles) long and has an average gradient of .33 m/km (2.1 ft/mi). The average discharge is 19.3 m^3/sec (9.42 cm/yr) while the peak recorded discharge was 844 m^3/sec (USGS, 1977).

The Little Sioux River system is quite different from most western Iowa streams. The basin is divided into two distinct parts (Figure 1.1). The lower basin is straight and narrow, flowing directly southwest to the Missouri like most other western Iowa streams. The upper part, above Waterman Creek, flares out draining an area of about 4250 km^2. Streams in the upper part take a circuitous route before entering the lower basin. The Little Sioux presently flows along the western Des Moines Lobe margin and traverses the highest divide in order to flow into the Missouri River. Macbride (1901) and Carman (1917) determined that this upper basin became a part of the Missouri River drainage only after Wisconsinan ice blocked drainage to the Mississippi. Another feature unique to the Little Sioux system is the many terrace levels and remnants which are presently found in the valley. These contrast strongly with the more typical two terrace level system described by Corliss and Ruhe (1955). These Little Sioux terraces, too, are a result of the Cary ice which changed the drainage of northwest Iowa. However, the terraces are not a direct result of the glacial history, only the change in drainage. They were formed from what has been described as a complex response (Schumm, 1974, 1976). The Little Sioux system

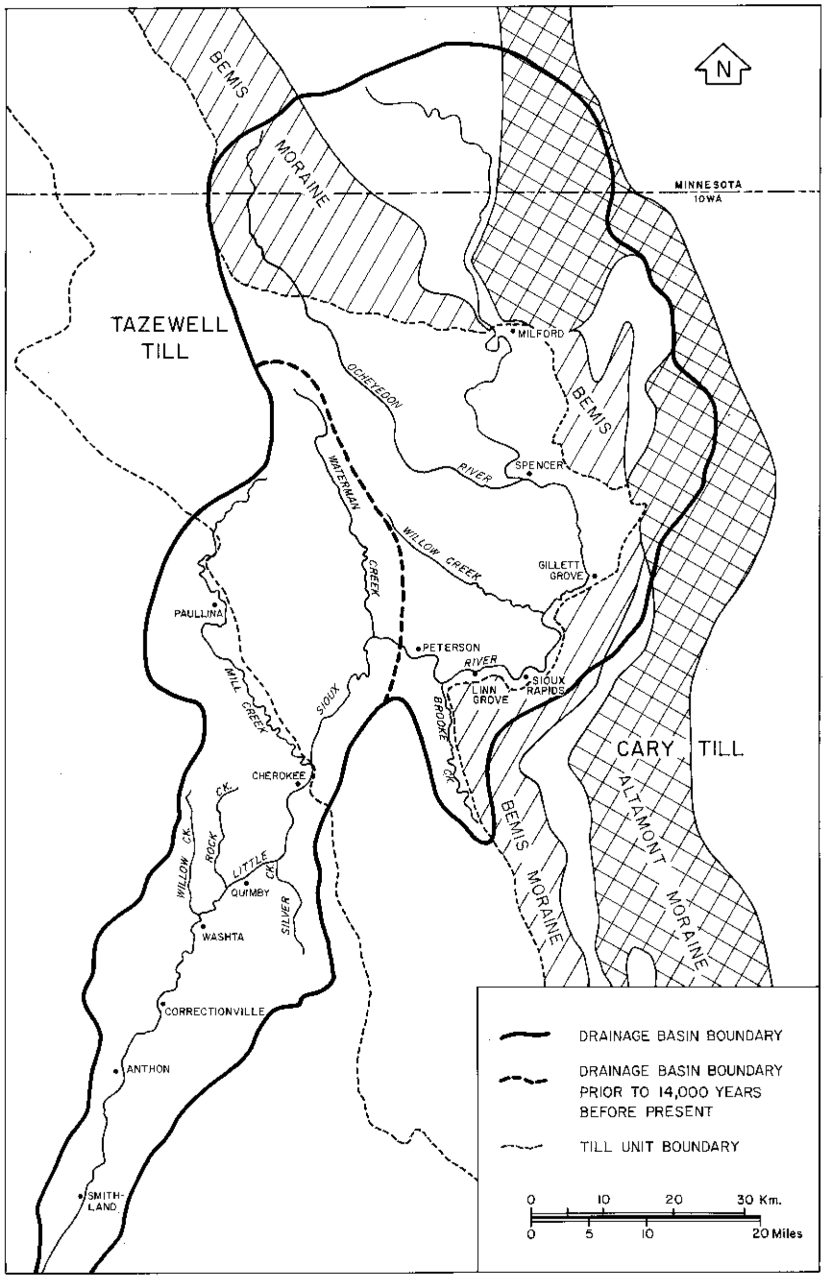


Figure 1.1 Little Sioux River drainage basin.

provides a good example of this mechanism which is inherent in fluvial systems.

Terraces

Carman (1917) was the first to attempt to describe and analyze the many terraces in the valley. He noted that they commonly contained boulders and that their gravels rested on unoxidized till. He identified two terrace levels, although he noted many levels near the town of Cherokee. Pedersen and Lohnes (1963) described three terrace levels, each cut into till. Further, they identified the fact that the distribution and occurrence of terraces varied in different sections of the valley. Hallberg, Hoyer and Miller (1974) reasoned that the distribution of terraces identified by Pedersen and Lohnes was related to the deposition of the Bemis and Altamont moraines.

Reconaissance field studies, aerial photographic analysis, and topographic map evaluation conducted since 1976 adds many observations to those previously made and both supplements and alters conclusions previously made.

Five terrace levels, defined by relative position in the field, are correlated here. These are designated as T1 through T5; T1 is the highest and oldest and T5 the lowest and youngest. T1, which was never correlated before, although remnants of it were mapped, can be separated from the other terraces by the occurrence of loess upon it. Generally 7 feet is preserved giving it a silt loam surface texture. The lower terraces have a loam or sandy loam surface. These lower terraces were correlated on the basis of relative position in the valley, relationship of one terrace remnant to another, relative prominence, and gradients derived from correlations made in the field. In general, T2 corresponds to the high terrace, T3 and T4 to the intermediate terrace, and T5 to the low terrace of Pederson and Lohnes (1963). The terraces in the field are complicated. Often one terrace (correlated) will exhibit several levels, especially where the terraces are vertically widely spaced.

T1 is the most simple and the one which can be most precisely defined. It can be traced in the Little Sioux Valley from the lower end up to Cherokee, the Tazewell glacial margin. In the lower reaches, T1 is rarely preserved, but along Mill Creek and in the uplands north of Cherkee, large remnants are commonly encountered. Within the Tazewell region it is not found in the valley. This distribution is shown in Figure 1.2. On Mill Creek it is traced directly into a Tazewell outwash channel. This distribution and the occurrence of 7 feet of loess, a similar amount to what is commonly found on Tazewell till, identifies it as Tazwewll outwash and dates it at 20,000 RCYBP (Ruhe, 1969).

T2 is the most problematical terrace to define. Like the lower terraces it is unpaired and possesses a loam surface. However, like T1, it is rare in the valley below Quimby and preserved only as small remnants. It rises up to a very high position within the Little Sioux valley at Waterman Creek. Apparently it continues up Waterman, but not further up the Little Sioux (Figure 1.2). If this is correct, then it was the active floodplain of the lower valley prior to the drainage changes which incorporated the upper valley. Lack of clear evidence to separate it from lower terraces makes this interpretation somewhat tenuous.

Terraces T3, T4 and T5 can conveniently be lumped together. T3 and 4 remnants are extensively preserved from Anthon to Spencer. T5

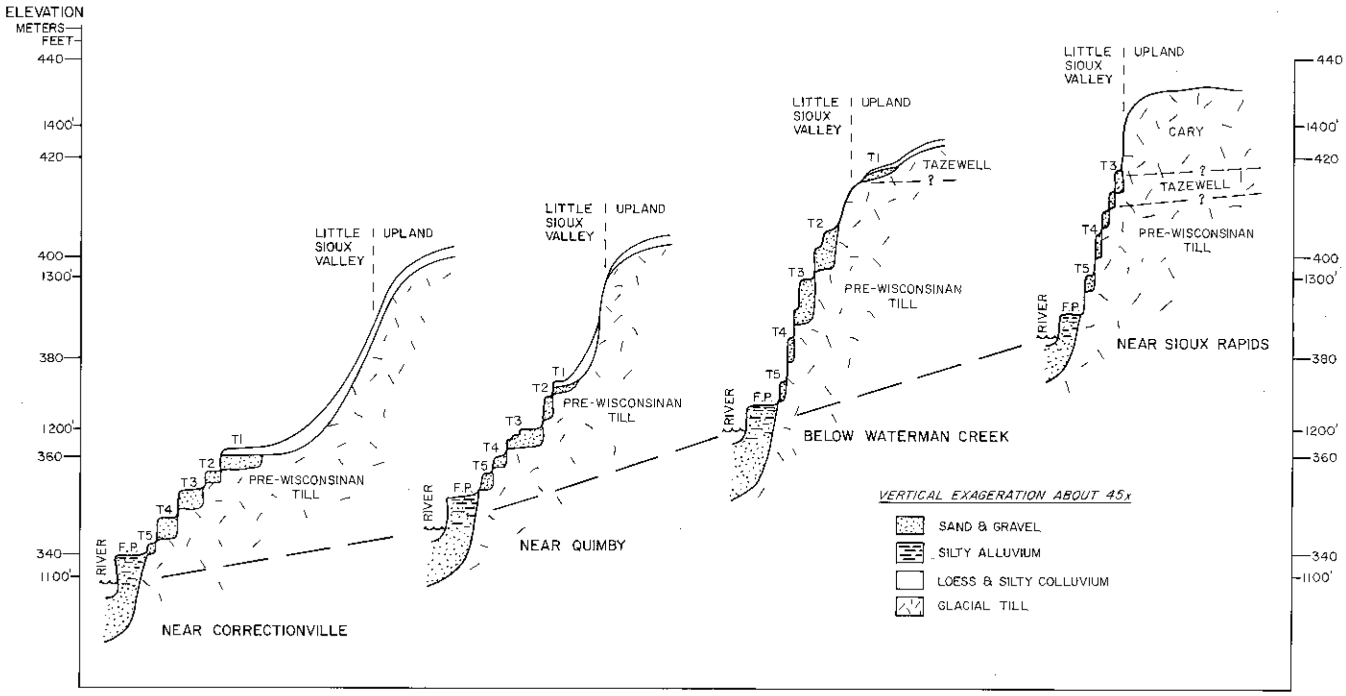


Figure 1.2 Sketch of terrace positions at four locations in the valley.

the lowest remnant, is less extensively found, but clearly can be identified. These also rise up in the valley relative to the floodplain (Figure 1.3). T3 is the highest terrace in the channel formed by the ice blocked drainage (Macbride, 1901 and Carman, 1917) and so is equated to the overflow of the impounded waters forming Glacial Lake Spencer. This dates T3 as about 14,500 (Ruhe, 1969). (If the terrace correlations are incorrect, T2 could mark this time.) A date from beneath the modern floodplain provides a limiting date for all terrace development at circa 10,000 RCYBP (Hallberg, Hoyer and Miller, 1974). Thus T3, T4 and T5 were all cut within about 4,500 years.

A Complex Fluvial Response

Schumm (1973, 1976) has shown from laboratory data, as well as field data, that a fluvial system does not respond in a simple cause-effect manner. A significant change in the fluvial system (one cause) will produce multiple adjustments (many effects). For example, Womack and Schumm (1977) presented an example of Douglas Creek which underwent as many as 7 episodes of cutting and filling because of the removal of native vegetation in 1882.

The complex response is not limited to multiple adjustments through time. The response is complex in place as well as time. Different segments of the fluvial system may undergo different processes at the same time. One segment may aggrade while another segment is undergoing degradation. Through time, these may reverse. Womack and Schumm (1977) could not identify any period where either cutting or filling affected the entire Douglas Creek valley at the same time. The valley was left with multiple levels of unpaired terraces which could not be correlated. The fluvial system responds quickly as a whole in a complex manner due to a series of feedback mechanisms which adjust the system. The Little

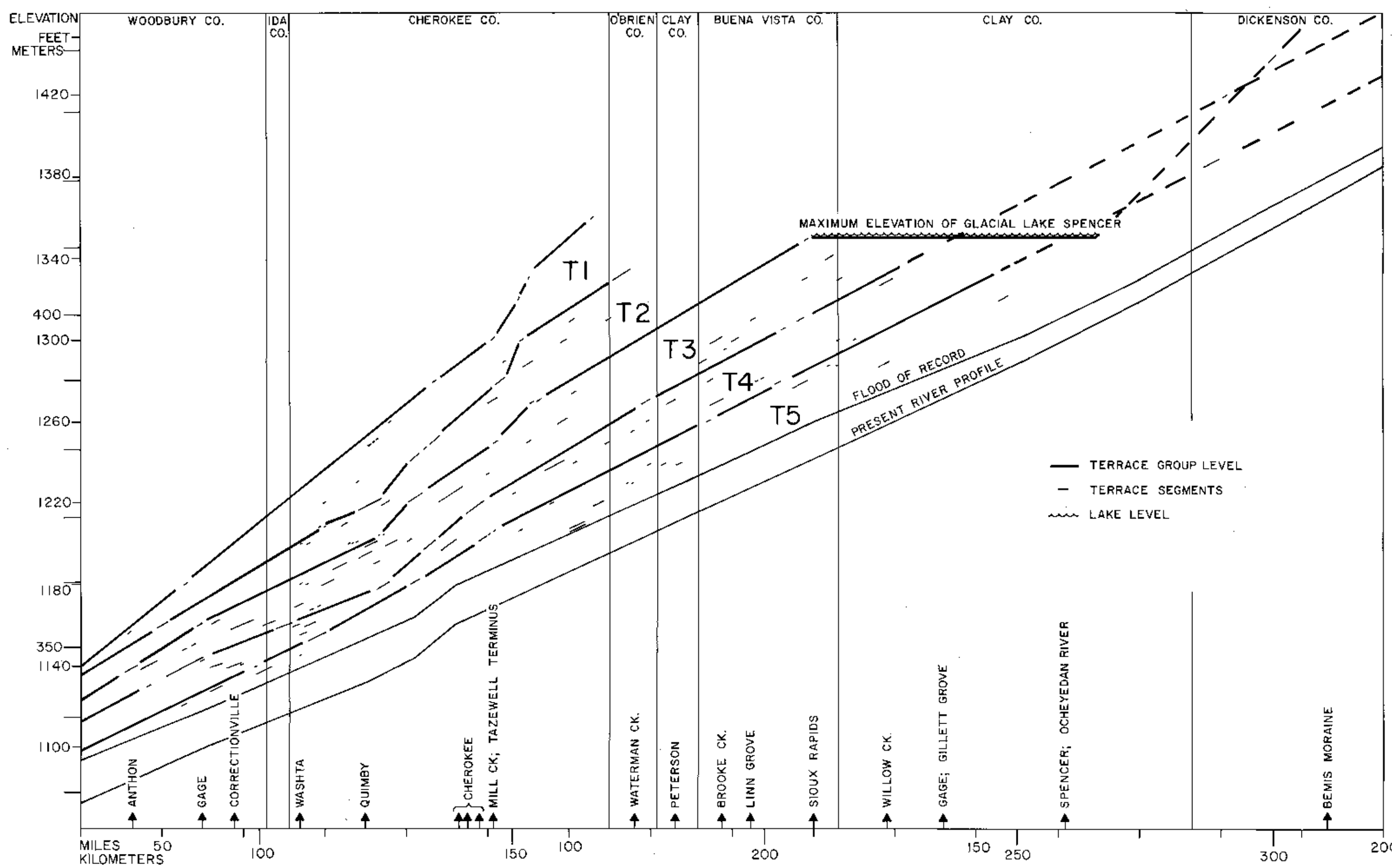


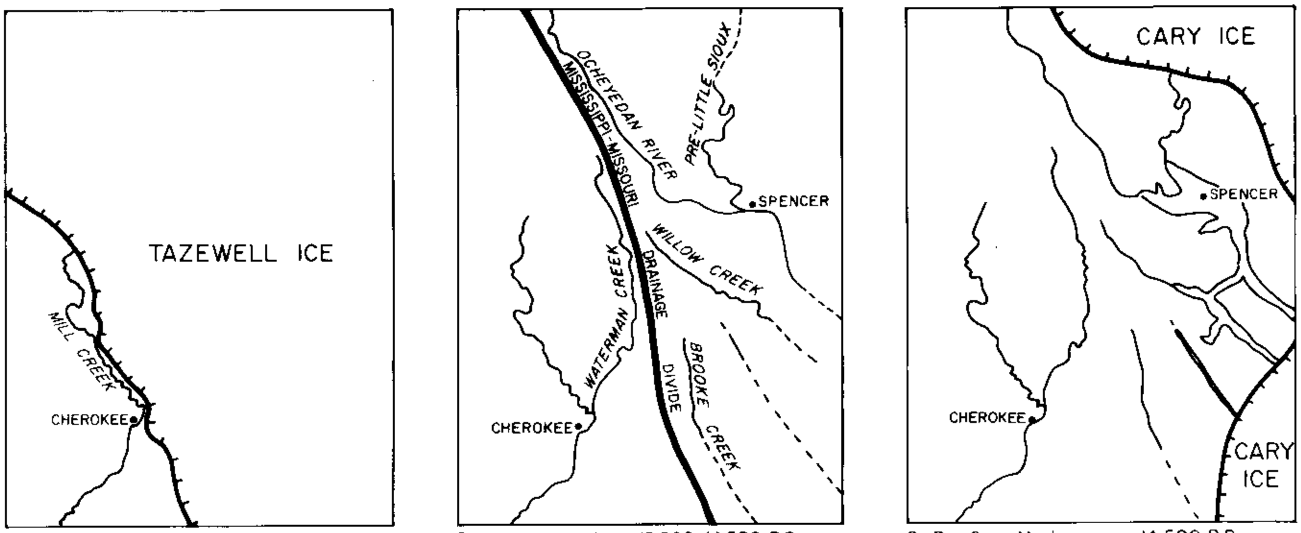
Figure 1.3 Correlation of terrace remnants along the Little Sioux River

Sioux Basin may provide a textbook example of the complex response. The capture of 4,250 km^2, flowing into a basin which formerly included about 2,550 km^2 at 14,500 RCYBP can certainly be considered a major fluvial change. The response, the rapid cutting and filling which produced the terraces T3 through T5, was rapid and complex. Furthermore the Holocene adjustment after the valley was cut, also seems to reflect the complex response (Hoyer, in press).

A Brief Woodfordian and Holocene Geological History of the Valley

At about 20,000 RCYBP glacial ice (Tazewell) stood at the town of Cherokee (Figure 1.4A). Outwash was deposited in a southwesterly flowing, pre-existing valley and Mill Creek which drained into that valley and flowed along the ice front. The high sediment loads and seasonal and diurnal flows caused backfilling of small drainages. As the ice receded, outwash came off the glaciers as relatively unconfined flow until a drainageway formed in the location now called Waterman Creek. Following glaciation, Mill Creek and Waterman Creek formed the upper basin for a river formed at Cherokee (Figure 1.4B). This stream system cut down 3 to 4 meters into the old outwash and elevated it above the active floodplain. During this time, up to 7 feet of loess was deposited on T1.

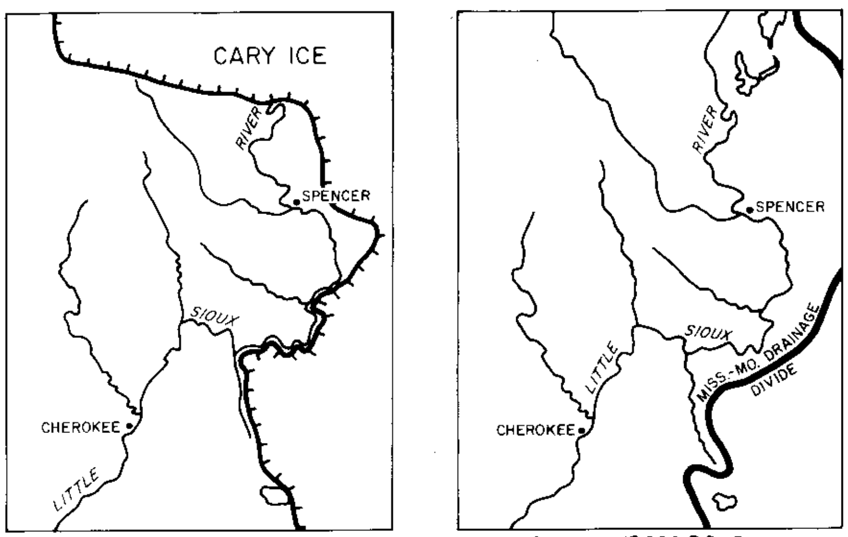
At about 14,500 RCYBP, glacial ice (Cary) readvanced southward. This blocked drainage to the Mississippi and formed one or more ice marginal lakes (Figure 1.4C). These persisted until waters rose high enough to overcome divides along the ice margin. At an elevation of at least 1350 feet, water finally flowed over a divide into Waterman Creek. The water cut down through the divides quickly along the Clay



A. Tazewell Maximum: ca. 20,000 B.P.

B. Post Tazewell: ca. 19,000-14,500 B.P.

C. Pre-Cary Maximum: ca. 14,500 B.P.



D. Cary Maximum: ca. 14,000 B.P.

E. Post Cary: ca. 13,000 B.P.-Present

Figure 1.4 Woodfordian and Holocene development of the Little Sioux River system.

Co. - Buena Vista Co. boundary as it flowed into the small valley (Figure 1.4D). In so doing it carved a deep channel and established its current drainage pattern (Figure 1.4E). The first flow cut down through the floodplain and removed most of it (T2). Valley degradation continued as alternate cycles of cutting and filling occurred in the valley above Anthon. This left the terraces T3, T4 and T5 found today. Tributaries responded by cutting headwards as they were able. Below Anthon, the erosional products from above were deposited as a broad plain. Finally by 10,000 RCYBP, the response of erosion from the steepened valley walls and tributary drainages was overloading the Little Sioux with sediment. Valley aggradation began as the alluvial fans and colluvial aprons encroached out into the valley. This process accelerated through the middle Holocene dry period. Since, the process has nearly ceased, and the system seems to have adjusted to the drainage derangement.

II. The Field Trip

Introduction

This field trip is designed to present the "big picture" story of the Little Sioux. The research presented is geomorphic and based on reconnaissance study. The drainage basin is large and different parts of it exhibit distinctly dissimilar features. It is interpreting these features which allows a "holistic" interpretation of the valley. The presence or absence of terraces, the kind and number of terraces their relative position in the valley, valley size and shape, the location of lacustrine and other slack-water deposits, the location of till bodies, the distribution of loess, known radiocarbon dating chronologies, and, of course, earlier research all enter into the interpretation presented in this field trip. An overriding emphasis on this trip concerns a geomorphic process, the complex fluvial response, which is well exhibited in the Little Sioux basin and which is used as perhaps, the major explanation for the valleys modern morphology. Also, Tazewell and Cary (early and late Woodfordian) glacial episodes and their effect on the valley's history are emphasized on the trip. The Holocene history of the valley, although studied more extensively, (Hoyer, in press) is not easily seen on a field trip. Therefore, it is not discussed extensively on this trip.

This trip also briefly visits two locations of interest which are not directly related to the history of the valley: a rare volcanic ash site and an exposure of Tazewell till.

As this trip is based on generalized information spread over a large area, there are many opportunities for detailed research in portions of the basin. Further research could greatly add to the details of the history, modify it, or increase our understanding about the geomorphic processes which have left the field data from which its history has been interpreted.

A river the length of the Little Sioux makes a difficult subject for a trip. As the evidence for the history is only found over many miles, the trip covers a long distance. Figures 2.1A, B and C provide an overview of the trip. A discussion of each valley segment is followed by the discussion of stops related to each segment. Most stops are rather short, but driving between may take considerable time. Therefore, a road log is provided in part III of this guidebook.

The Lower Valley: Below Anthon

The Little Sioux valley, below Anthon, appears much like other western Iowa valleys. The floodplain is broad, 1.5 to 3 miles wide, and flat. Thick loess situated in the surrounding uplands can be observed to "drape" over into the valley as colluvial aprons.

Only one terrace remnant is located in the lower valley. It is situated on the east side, one to two miles north of Smithland and can be seen across the river from the field trip route, although it is not easily identified. The terrace stands 60 or more feet above the floodplain, but this includes about 35 feet of loess overlying the gravel (Pedersen and Lohnes, 1963). The loess identifies this remnant as a T1 terrace. However, it clearly has much more loess deposited on it; this is not unreasonable because it is much closer to its Missouri River source. T1, which can be traced to the Tazewell till plain and can be identified as outwash also dates the terrace as early Woodfordian time, about 20,000 RCYBP. The terrace is at least 140 feet below the adjacent uplands, indicating that the lower valley was well

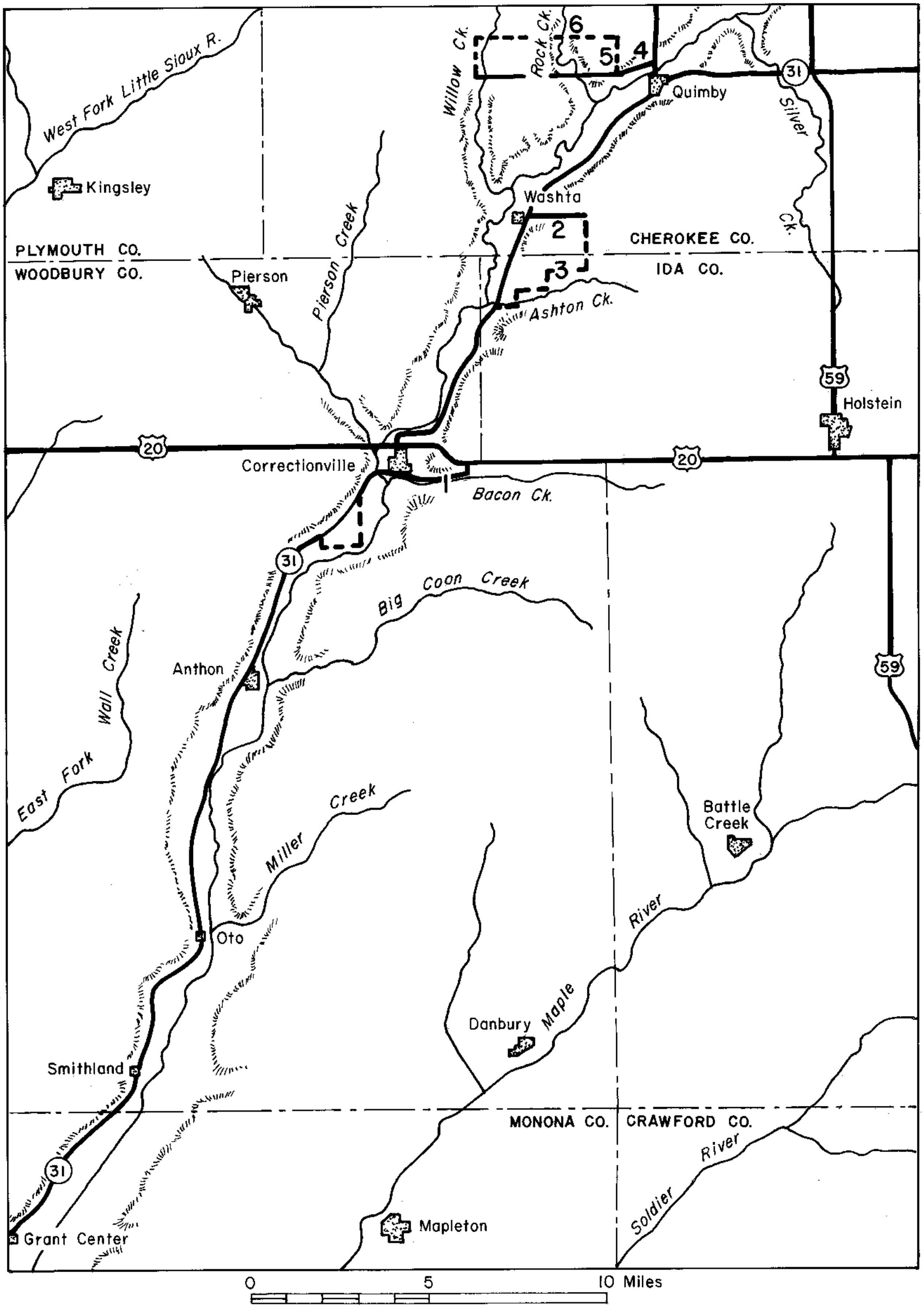


Figure 2.1A Field trip locations, lower Little Sioux valley.

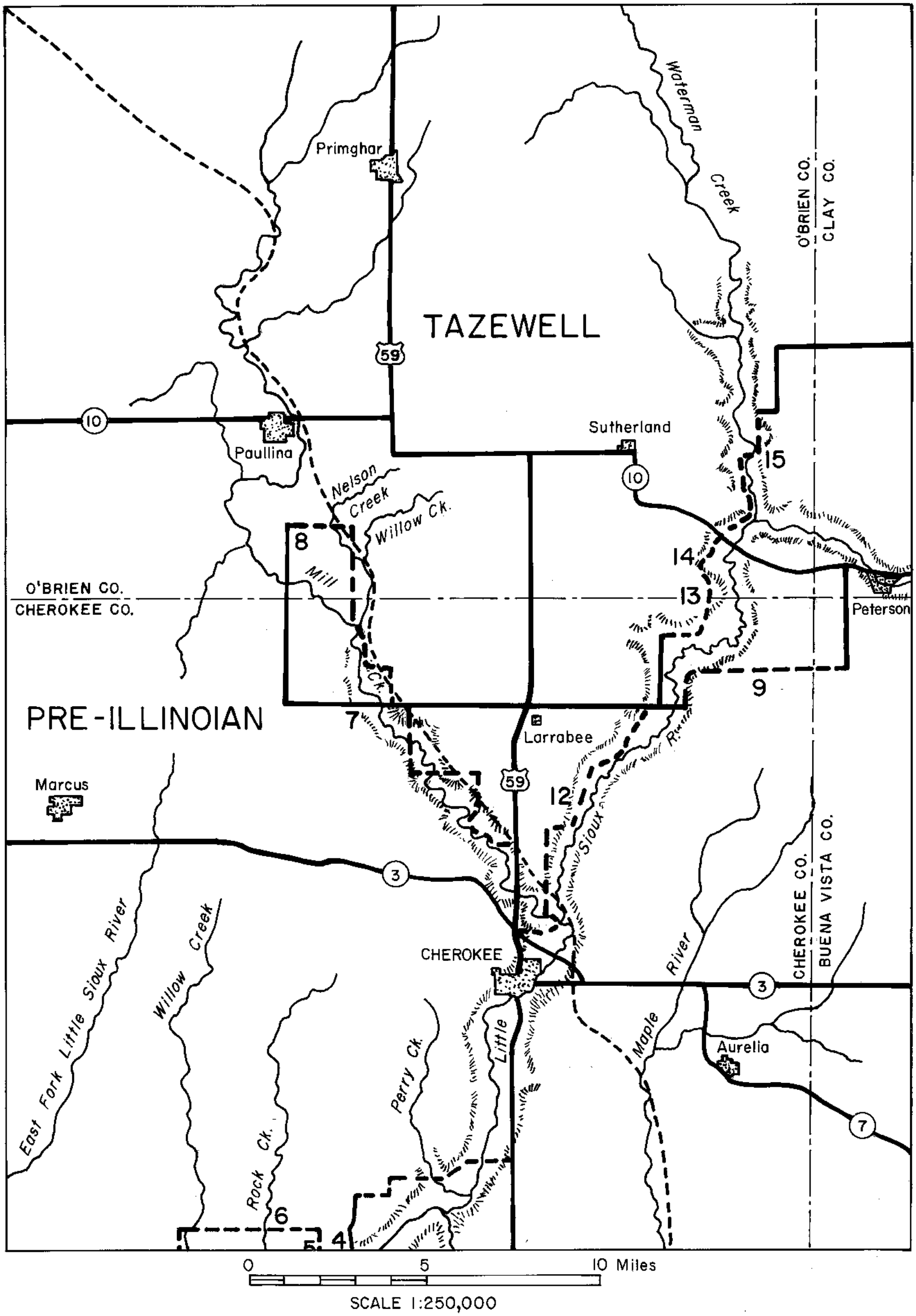


Figure 2.1B Field trip locations, middle Little Sioux valley.

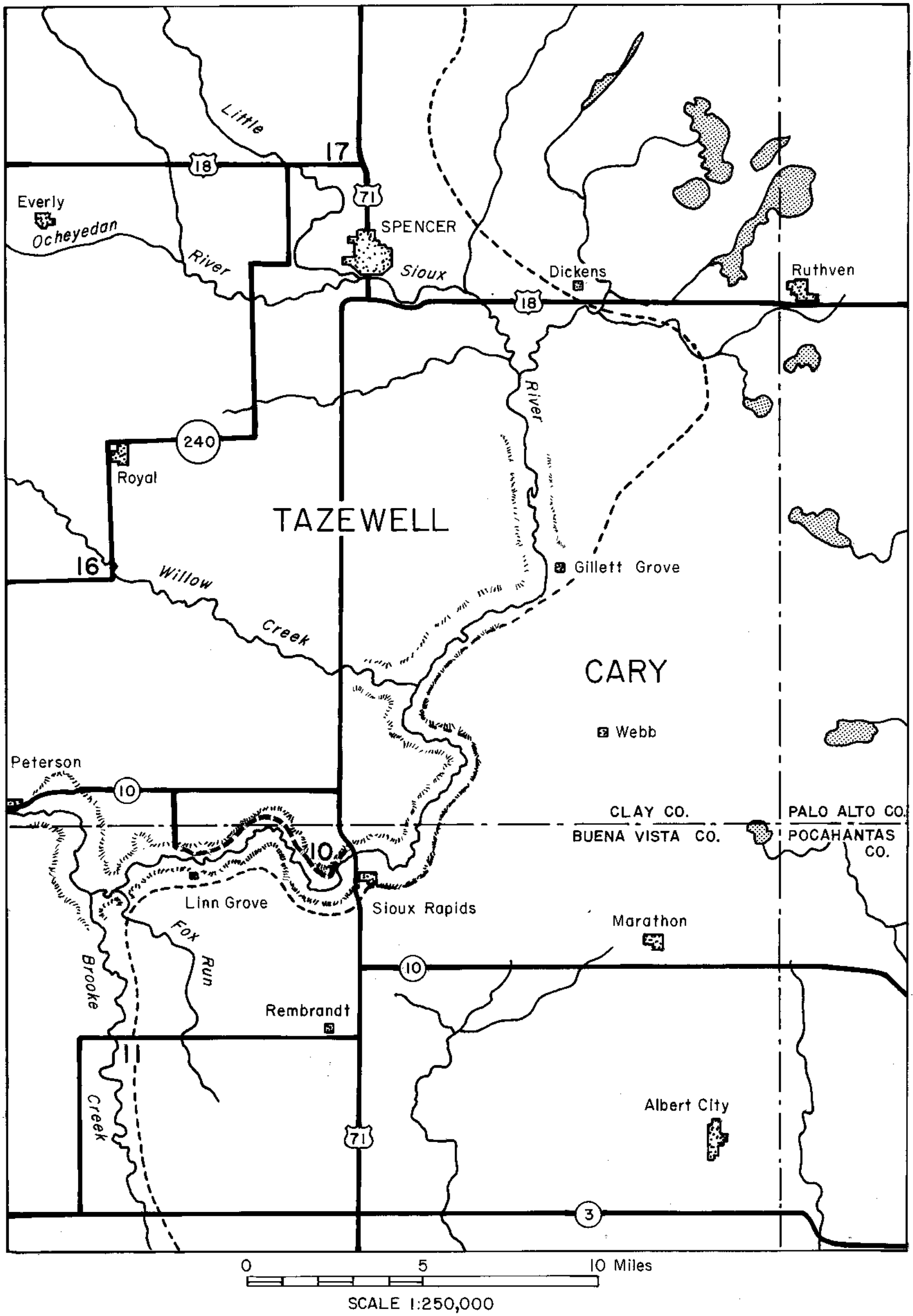


Figure 2.1C Field trip locations, upper Little Sioux valley.

established prior to Tazewell glaciation.

The most significant attribute of the valley segment is the absence of all terraces T2 through T5. This contrasts markedly from all other parts of the Little Sioux system. Figures 1.2 and 1.3 indicate that all of the terraces in the valley are found relatively lower in the valley towards the lower portion of the basin. The terrace remnants seem to merge together near Anthon. Pedersen and Lohnes (1963) correlated terraces throughout the valley and found that at Correctionville the low terrace was only 5 feet above the modern floodplain and they projected it beneath the floodplain further downstream at Anthon. Similarly, in Figure 1.3, the terraces can be projected beneath the floodplain south of Anthon. Further they would theoretically cross each other because the higher, older terraces have steeper gradients than the younger terraces. Each progressively younger terrace buries or at least, merges with the older terraces. Thus, simultaneous erosion and deposition are exhibited on the same system. Erosion exposes a former floodplain as a terrace in an upstream position while deposition buries the same aged floodplain in a downstream position. This is one manifestation of the complex response of fluvial systems.

No stops are planned in the lower valley. However, note the absence of terraces and compare this simplicity to that of all subsequent river reaches. The T1 terrace north of Smithland is not clearly evident, but it is observable.

The Erosion Surface Valley: Anthon to Cherokee

Below Cherokee, the Little Sioux River resembles other western Iowa streams -- in the shape of its drainage basin.

Its valley is straight and narrow, and the river flows directly southwest to the Missouri (Figure 1.1). However, that is where the similarity ends. Five terraces become especially prominent through this reach, a markedly different situation from the two levels observed on other western Iowa streams. The terraces rise from relatively low landscape positions near Anthon to positions at the top of the valley walls just north of Cherokee.

T1, the loess covered terrace, is rarely found in the main valley. Where it is found it is generally a small remnant on the valley walls or at the mouth of a tributary. Stop 5 near Quimby is located at one of these largest preserved remnants in the main valley. Apparently, post-Tazewell valley cutting has removed or reworked most of T1.

The greatest number and the most extensive T1 remnants are associated with tributaries. Small remnants, such as visited at Stop 1, are common at the mouths of these streams. More extensive T1 terraces are found upstream. These tributary T1's apparently grade to the T1 elevations on the master stream. The remnants at the tributary proximal ends are high above the floodplain. However, because their gradients are much less than that of the modern stream 4 or 5 miles upstream the T1 terrace merges with the active floodplain.

The low T1 tributary gradients suggest that the tributaries were aggrading at the same time as Tazewell outwash was filling the Little Sioux. Fine-textured, slack-water deposits of silt and clay (Stops 2 and 3) constitute much of the T1 alluvium in the tributaries. Patton, Baker and Kochel (1979) suggest that such deposits can be caused by hydraulic damming which occurs when high main channel flows are concurrent with low tributary flows. Such would be the case often during T1 time as the tributaries in this portion of the Little Sioux did not receive the Tazewell outwash. The tributaries sediment would be dropped during such conditions. Reverse flow surges could also account for some of this sedimentation although structures related to such phenomena have not been observed. Sedimentological studies could easily test for a such a depositional mechanism. For example, if fining up-valley were noted, such surges would be suggested.

A textural coarsening appears towards the top of the terraces. Coarse gravels are found at the top, beneath the loess; then they grade downwards into sands, silts, and clays. The origin of the coarse materials is not clear. This characteristic has been observed at locations near the mouths of the tributaries. Certainly, Iowan Erosion could have served as a source to help fill these previously, rather deeply cut tributaries.

However, if these gravels do not continue up the tributaries very far, they could be derived from the Little Sioux, as Tazewell outwash filled the main valley and, perhaps, spilled out into adjacent available locations. Post-Tazewell flows have not been sufficient to remove them all. Regardless of their origin, these tributary T1 deposits provide a possible source of geomorphic or sedimentological research. It is not known if the sequence is replicated upstream. Are the gravels derived from upstream surges, or are they derived from the tributaries' basins? What mechanism exists to develop this coarsening?

The phenomena may be related to "Iowan erosion". This erosional episode is clearly coincident to the tributary backfilling in time (Ruhe et.al., 1968). Further this Little Sioux River segment is flowing through the Pre-Illinoian Iowan Erosion Surface and all the tributary

pg. 20 omitted

streams head on the Erosion Surface. Perhaps the stone line which represents a lag deposit on the erosion surface can be traced downslope to the gravel at the top of the T1 terrace. This would suggest that the gravel represents a similar erosional remnant of reworked alluvium. The other terraces, T1 through T5, are also well exhibited in this region. Broad expanses of each are found and the trip traverses some of those. They provide very rich sand and gravel resources for the region.

Stop 1 (Day 1, Mile 21.5) Bacon Creek; near Correctionville, Woodbury Co., Correctionville Quadrangle NE¼, SW¼, sec. 5, T 88N, R 42W. The area about Correctionville illustrates the lower Erosion Surface Valley of the Little Sioux very well. The town is built on three terrace levels, T5, T4 and T3 (Figure 2.2). They are only about 5, 15, and 25 feet above the modern floodplain. T1 is restricted To Bacon Creek, nearly 80 feet above the floodplain. The field trip route "stair-stepped" up the entire terrace sequence from Correctionville to Stop 1.

T1 has about 7 feet of loess overlying sand and gravel. An analysis of the loess from this site and other T1 sites is included in Table 1. As you leave to the west, note how much lower T1 is relative to the creek only one-half mile above STOP 1.

Table 2.1 Loess Textures on T1 Terrace Remnants

Location	Sand	Co. Silt	Fi. Silt	Clay
	>62μ	62-20μ	20-2μ	<2μ
Stop 1: Bacon Creek	11.5	41.4	26.6	20.5
Stop 2: Stratton Creek	1.4	36.5	32.0	30.1
Stop 3: Ashton Creek (1')	3.4	40.0	25.4	31.2
Stop 3: Ashton Creek (6')	1.4	48.0	25.8	24.8
Stop 5: Loess covered Terrace	2.0	41.2	26.9	29.9
Willow Creek (Sec. 6, T 90N, R 41W)	1.1	36.9	28.0	34.0
Little Sioux (Sec. 16, T 90N, R 41W)	1.6	40.8	23.0	34.6
Perry Creek (Sec. 30, T 91N, R 40W)	2.8	37.3	24.1	35.8

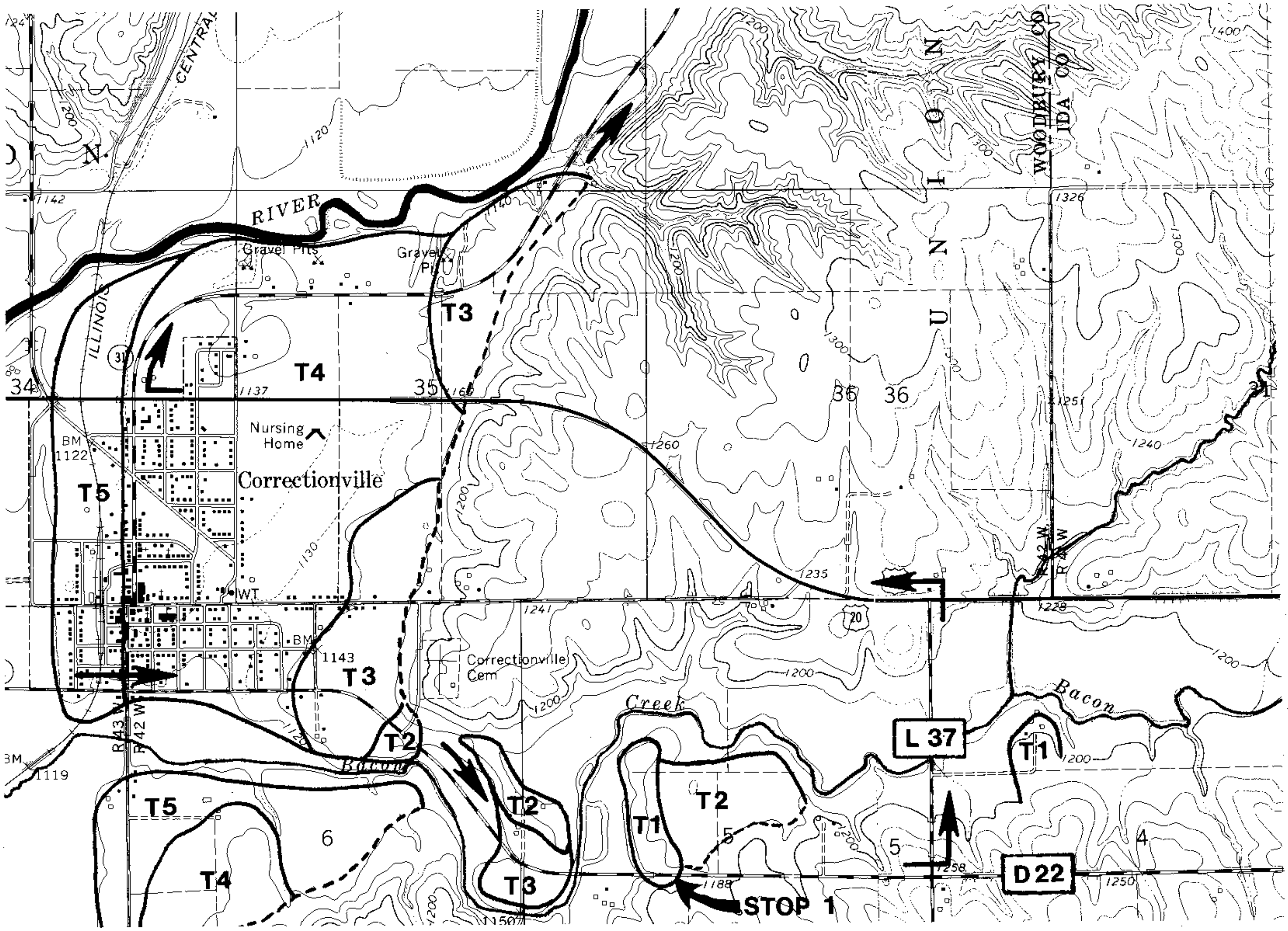


Figure 2.2 Correctionville area; Stop 1.

Stop 2 (Day 1, Mile 33.1) Stratton Creek; near Washta, Cherokee Co., Washta Quadrangle, SW¼, SW¼, sec. 28, T 90N, R 41W.

Special appreciation is extended to Donald Grefe and family for allowing access to this site.

The Stratton Creek section reveals the stratified alluvial materials forming the T1 terraces in the tributary streams. Laminated silts, which compose most of the section, grade upwards into sand and gravel (Figure 2.3). At the county road, 7 feet of loess caps the section. The thickness of this section, indicates that these tributary valleys were well developed prior to Tazewell time.

The slack-water origin of these silty deposits is suggested by the fine-textured laminations and the stratification. Their origin may be both from the Little Sioux valley caused by upstream surges and from the Stratton Creek Basin during runoff and hydraulic damming. The upper gravels are more problematical. Glacial striations on some clearly suggest relatively short transport distances and little re-working.

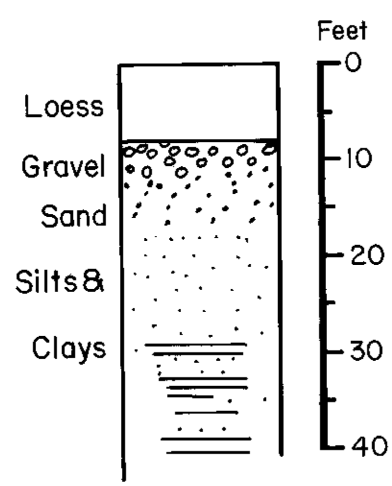


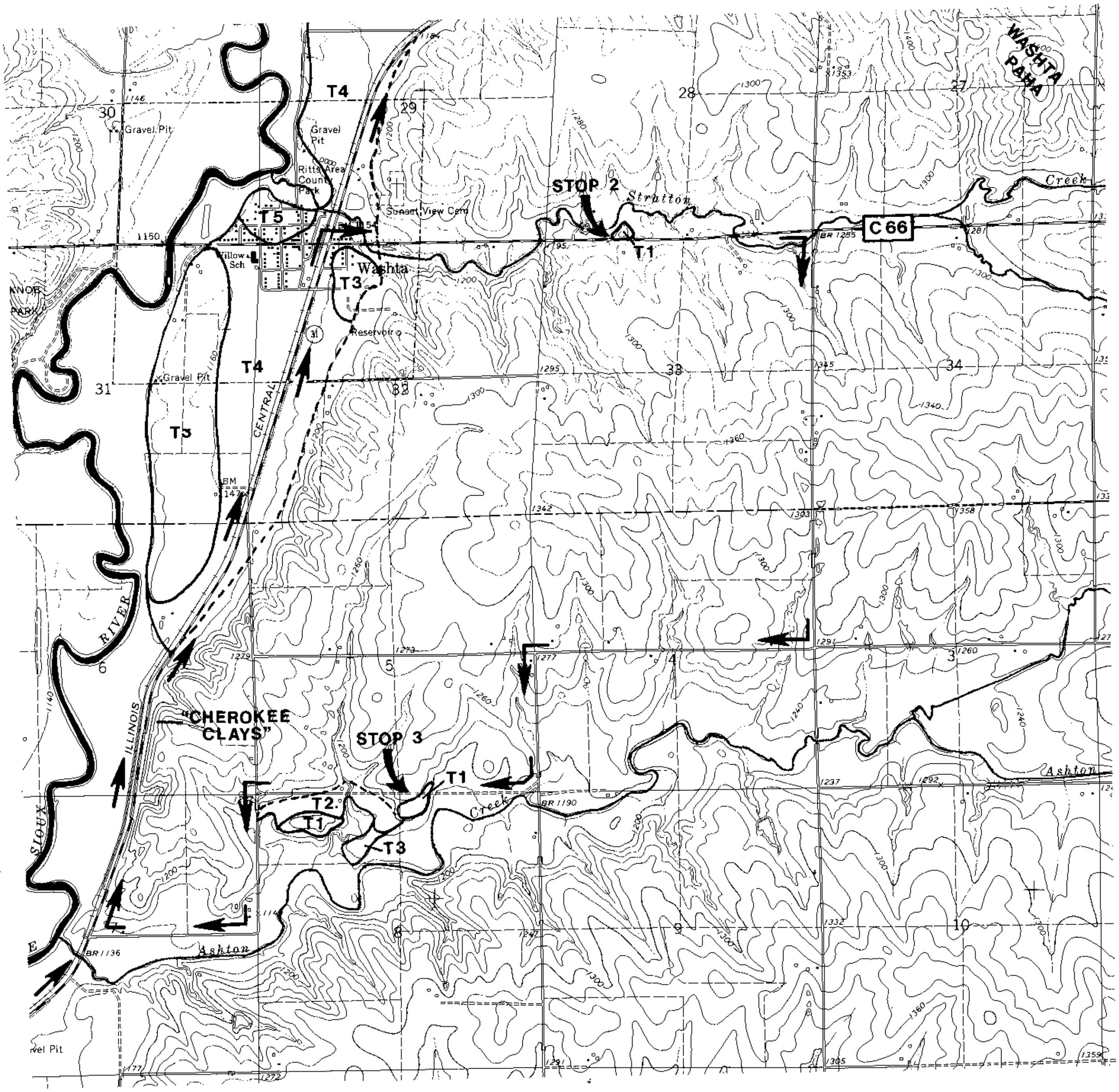
Figure 2.3 Sketch Section at Stratton Creek (Stop 2)

One mile east of Stop 2, Stratton Creek cuts through an unusual, elongated, high hill. This feature, named the Washta Paha on figure 2.4, begins at the Little Sioux and continues for many miles in a southeasterly direction.

A drilling log prepared by George Hallberg and Nyle Wollenhaupt (Description 1) indicates that internally it consists solely of loess, unlike eastern Iowa pahas (Ruhe, Dietz, Fenton and Hall, 1968). Thus, the Washta Paha is simply an unusually thick loess deposit sitting on the Iowan Erosion Surface.

Description 1 — Washta Paha Log

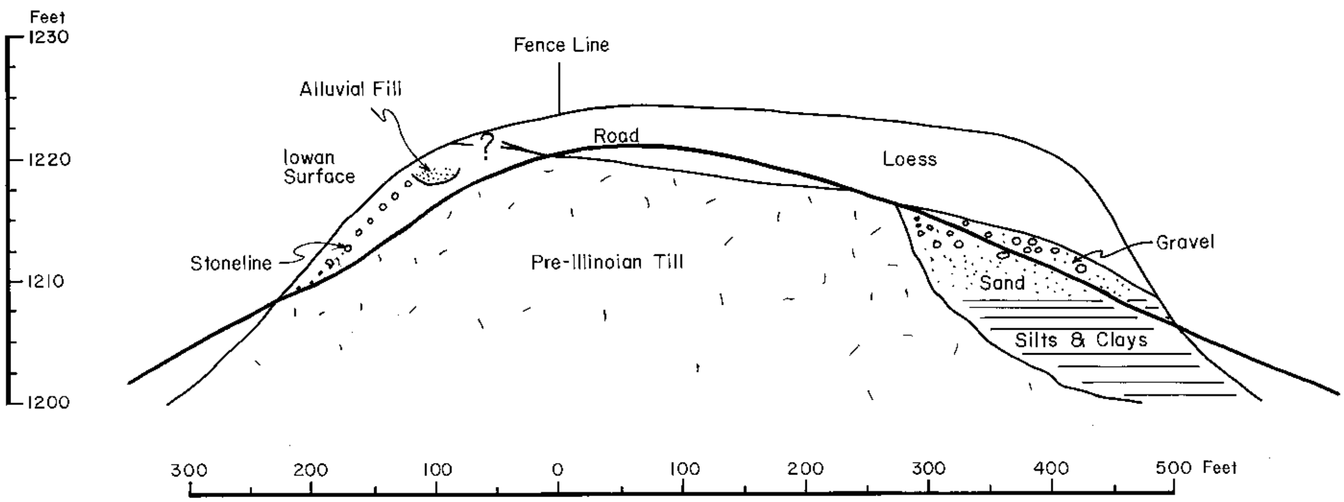
Depth (feet)	Description
0	Oxidized and leached loess
17.5	Mottled, oxidized and leached loess
46.5	Mottled, deoxidized and leached loess
53.8	Mottled, oxidized and leached stratified silty sediment
54.2	Mottled, oxidized and leached sand with stoneline
55	Oxidized and unleached glacial till
60	End of core



·Figure 2.4 Washta area; Stops 2 and 3.

Stop 3 (Day 1, Mile 37.5) Ashton Creek; near Washta, Ida Co., Washta Quadrangle, along road between sections 5 and 8, T 89N, R 41W.

The Ashton Creek site is situated in a somewhat confusing position on the nose of a hill. On the east end, a small T1 remnant again shows the upward-coarsening, back-filled sequence common to the tributaries of the Little Sioux (Figure 2.5). Slack water clays taken from near the base of the outcrop were found to contain 0.6% sand, 12.8% coarse silt, 44.2% fine silt, and 42.4% clay (under 2 microns). Outcrops on the west side of the site reveal clearly a stone line, developed on glacial till. The stone line apparently dips down into a small, sandy, drainageway. The association of the Iowan Erosion Surface developed within these tributary basins and the corresponding time of the development of the Erosion Surface and the Tazewell outwash (T1) strongly suggest that the backfilling may be related to the Erosion Surface history. Detailed evaluation of sites such as Stop 3, along with coring throughout a tributary basin, could provide answers to the origin of the stratified T1 deposits.



Sketch of Ashton Creek Site (Stop 3)

Figure 2.5 Sketch of Ashton Creek Site.

Stop 4 (Day 1, Mile 48.0) Quimby Ash Site; near Quimby, Cherokee Co., Quimby Quadrangle, NE¼, SE¼, sec. 2, T 90N, R 41W.

Special appreciation is extended to Richard K. Knapp and family for allowing access to this site.

This is a rather rare opportunity to visit a Midwestern volcanic ash site. The Quimby ash site is only the seventh volcanic ash site analyzed from Iowa. This site was discovered by Steven Saye after it was uncovered during the excavation for the Knapp home. Saye, Nyle Wollenhaupt and George Hallberg sampled it and provided the data included in this field trip guide. Figure 2.6 provides a sketch of the site and Table 2.2 contains relevant data from it. The ash is contained within fluvial silts which are stratigraphically located beneath Pre-Illinoian glacial till. The ash lenses were fortuitously preserved, unremoved by the fluvial activity and colluviation, represented in the overlying beds. The fluvial deposits above the ash may be Woodfordian terrace materials cut into the Pre-Illinoian drift and fluvial deposits. If they are, this site exhibits the expected erosional contact between the various terraces which are cut successively into glacial till (Pedersen and Lohnes, 1963).

Ash dates are obtained by a process known as fission-track dating. Glen Izett, USGS, has tentatively assigned the ash to the Pearlette Type-O ash (pers. communication to G. Hallberg, 1980). This would mean that it was deposited either 600,000 or 700,000 years before the present. This determination was made after examining the shard shape, refractive index, and degree of super-hydration, as well as following geochemical analyses and a study of the phenocryst assemblage, especially clinopyroxene,

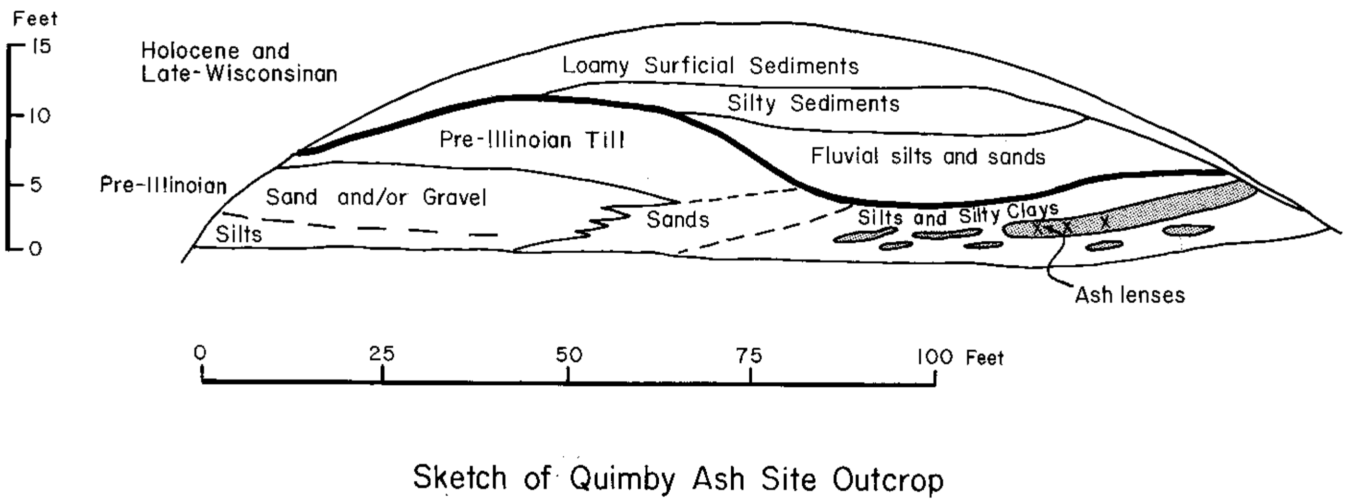


Figure 2.6 Sketch of Quimby Ash Site.

chevkinite, colorless zircon, magnetite and illmenite. Further analyses will continue on this ash to more definitively determine a date. Equally important, its precise stratigraphic position within the till rock units must also be determined. Such analyses are helping to correlate Pre-Illinoian tills for the first time. Further information on this research is available in Boellstorf (1978) and Hallberg (1978, 1980).

Table 2.2 Quimby Ash Site

Name/Description	Sand	Silt	Clay
Loamy surficial sediment/oxidized leached coluvium	34.6 40.6 64.0	39.3 36.2 20.7	26.1 23.2 15.3
Silty Sediment/mottled, oxidized leached	3.1	75.0	21.9
Fluvial Silts and Sands/mottled, oxidized, leached and unleached	26.4 88.7	66.1 8.2	7.5 3.1
Pre-Illinoian Till/Mottled, reduced, leached with secondary carbonates	25.7 30.7	39.6 37.7	34.7 31.6
Pre-Illinoian Till/Mottled, reduced, unoxidized	24.2* 27.1* 33.1	42.0* 40.9* 39.1	33.8* 32.0* 27.8
Sands/unleached	86.1	7.3	6.6
Silts and Silty Clays/leached or almost leached	22.2 20.2	44.8 70.9	33.0 8.9

Chittick Carbonates for samples marked*

Calcite	Dolomite	Total Carbonate	C/D
4.7	4.0	8.7	1.2
4.4	5.5	9.9	.8

Stop 5 (Day 1, Mile 49.3) Loess Covered Terrace; near Quimby, Cherokee Co., Quimby Quadrangle Sw¼, SW¼, Sec. 2, T 90N, R 41W.

This is, perhaps, the best example of T1 in the main river valley (Figure 2.7). Most others are simply very small remnants plastered along the side of a hill. Almost all are managed as pasture because of their location and small areal extent. This remnant, however, is large enough to grow row crops. This site has 6 feet of loess over gravel which is exposed along the road. It is situated over 80 feet above the floodplain. The remnant at Smithland, downstream, was only about 60 feet above the floodplain, and that included 35 feet of loess. Thus, T1 is seen to be relatively climbing above the modern floodplain in the upstream direction on the Little Sioux.

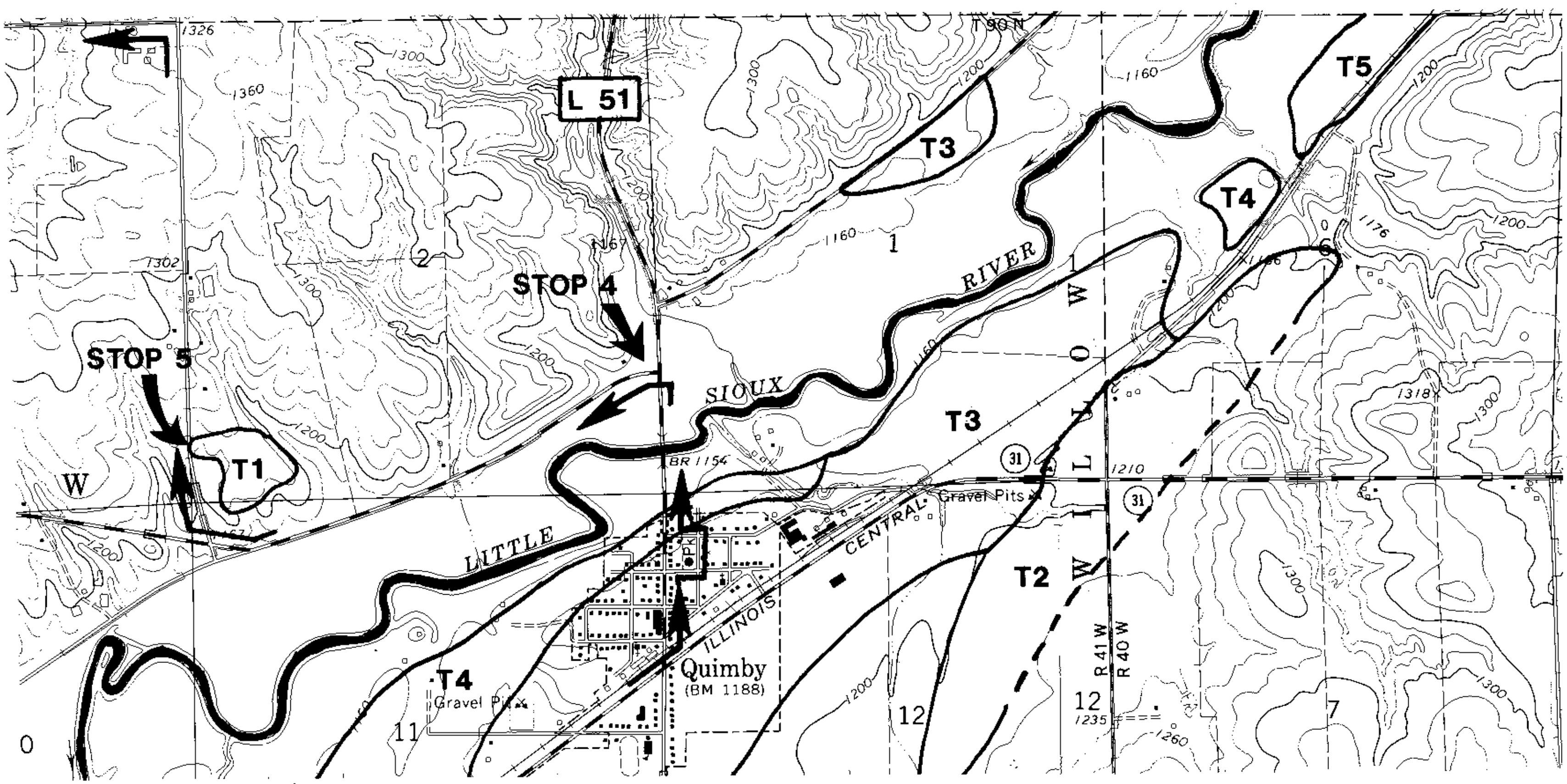


Figure 2.7 Quimby area; Stops 4 and 5.

Stop 6 (Day 1, Mile 51.6) Rock Creek; Cherokee County, Quimby Quadrangle, NW¼ Sec. 4, T 90N, R 41W.

The gradients of the modern tributary streams are greater than the T1 gradients in the same streams. Thus at the mouth of the tributary T1 is commonly about 100 feet above the stream whereas 5 or 6 miles upstream, the loess covered terrace sits only 10 or 20 feet immediately above the floodplain. Further upstream, T1 merges with the floodplain and may be buried by Holocene alluvium. On the tributaries, only small remnants of T1 are found near the Little Sioux, but further upstream there are more extensive remnants.

Stop 6 is located only 1½ miles above the Little Sioux valley. The T1 remnant at the stop is small and elevated more than 60 feet above Rock Creek. Small remnants of younger terraces are dramatically displayed south of the stop. Although Macbride (1901) was discussing an area north of this stop, in O'Brien County, he isolates in principle the formation of this landscape. "Once the Little Sioux had cut its deep channel, the Waterman, too. found opportunity to cut back and down to the level of the larger stream and has since then effected, in large part, what we see..." The tributaries responded in a complex fashion to the overall degradation of the Little Sioux. The timing probably was to the local responses of the Little Sioux through this time. However, the responses need not have been synchronous. The many unpaired terraces such as seen at this stop strongly suggest rapid downcutting and the complex response mechanism.

The valleys appearance at Stop 6 should be compared with the physiography at Willow Creek, two miles to the west (Figure 2.8). Where the field trip route first crosses Willow Creek, it is located

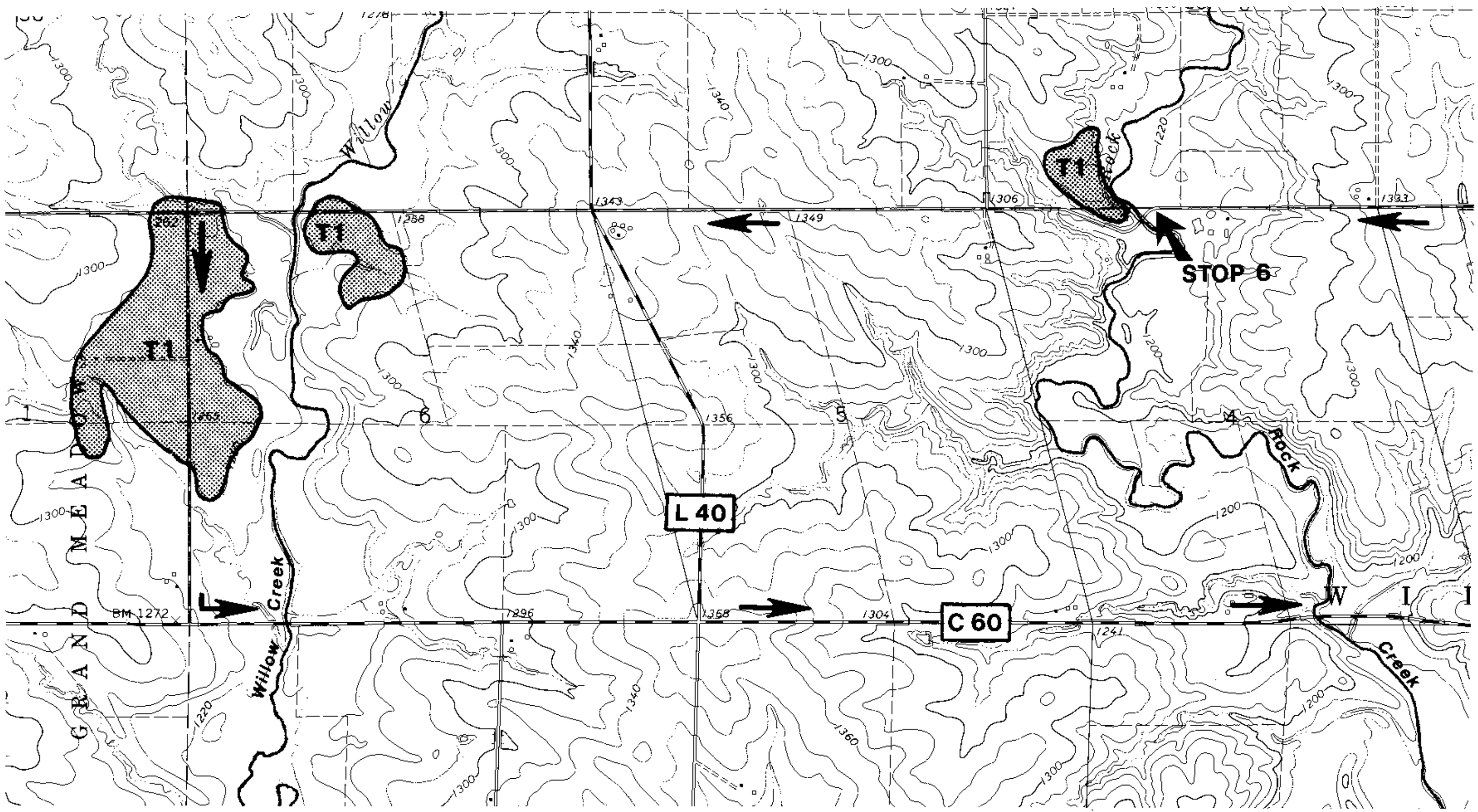


Figure 2.8 Rock Creek and Willow Creek area; Stop 6.

4 miles above the Little Sioux. The T1 terrace is extensive and little more than 20 feet above the creek. Lower terraces are not prominant as it appears that the stream has not been competent to remove the Tazewell materials this far upstream. The reason for this is not known, but the gravels capping T1 could provide part of the answer. This is an area which deserves to be researched further.

When traveling between Rock and Willow creeks, note the stepped erosion surfaces so well developed to the north of the road.

The Tazewell Valley: Cherokee to Waterman Creek including Mill Creek

The Tazewell Valley differs markedly from the valley below. Here the Little Sioux valley cuts into Tazewell till (Figure 2.1B). It narrows immediately above Mill Creek, the contact with the Tazewell till. Further upstream, north of Larrabee, it widens again, making several big bends. In this river segment, terraces become widely spaced in elevation, extending down from the top of the valley walls. The terraces are generally elevated more above the floodplain than those downstream. No loess covered terrace is found in this reach of the Little Sioux. Instead about 6 feet of loess is found in the adjacent uplands above either thin or thick sands or sand and gravel. Stop 9 will visit such a site which is common in the area.

Mill Creek and Waterman Creek are unlike downstream tributaries. The deep dissection extends further upstream from the Little Sioux and their valleys are comparable in size to that of the Little Sioux in this segment.

Mill Creek functioned as a Tazewell ice marginal channel for much of its course. Extensive T1 terraces are found high above its valley near its mouth. The extensive remnants continue up Willow and Nelson Creeks (Figure 2.1B) and eventually are observed on the upland divide between Nelson and Mill Creeks. This progression is followed on the field trip north of Cherokee to stops 7 and 8. In O'Brien County, where a modern soil survey has been completed, T1 is conveniently identified as a Galva silt loam, bench phase (T-310).

Waterman Creek must have carried outwash also, but only as Tazewell glaciation ended in this area. T1 is not identified in its lower reaches except outside the creek valley. T-310 has been mapped as a terrace in upstream reaches, however.

Both Mill and Waterman creeks exhibit spectacular erosion. Their lower valleys are similar in size and canyon-like form to that of the Little Sioux's. Multiple terrace levels are left at all elevations in their valleys. These creeks constituted the upper Little Sioux basin following Tazewell glaciation and prior to Cary glaciation (Figure 1.1). Mill Creek probably existed prior to Tazewell time, because T1 terraces are preserved within it. However, drainage from the Mill Creek area probably always flowed to the Missouri as it is west of the highest divide. Waterman Creek, on the other hand, flows across the highest divide to the Missouri. Pre-Tazewell drainage probably went to the Mississippi River.

The Tazewell Valley, as I have identified it, along with the Ice Marginal Channel above it, best display the complex response set up by the Cary drainage changes. After the new basin around Spencer was captured, and water had made its way around the Cary ice into the Waterman Creek drainage, erosion commenced rapidly. In this region 100 feet of valley cutting occurred between about 14,500 RCYBP and 10,000 RCYBP. The cutting occurred as sequencial steps of eroding till, depositing gravel, eroding this gravel and lower till, depositing a lower gravel, etc. The one change, an increase in the upper basin drainage area, set up a chain reaction of events. The net result, the excavation of the Tazewell Little Sioux Valley, is an example of how rapidly adjustments can occur, how much geologic work can be accomplished in a short time, and how the fluvial adjustments may occur.

The erosion left wide river bends in the area where the upper basin first entered the Waterman Creek basin, mostly on the Sutherland East Quadrangle. This area also exhibits features such as hanging valleys (Stop 13). These features suggest almost catostrophic flows which created the erosion and left the normal degradation process only partially completed.

Stop 7 (Day 1, Mile 84.8) Townhall Site: Cherokee County, Cleghorn Quadrangle, NE¼, Sec. 23, T 93N, R 41W.

On all tributaries, T1 has a gradient less than the modern stream. Mill Creek also shows this. At Cherokee, T1 is about 100 feet above the creek. At Stop 7, it is only about 60 feet above (Figure 2.9). However, T1 is clearly contained within the valley, in contrast to Stop 8. The loess thickness remains about 7 feet as is common on most T1 remnants and most Tazewell surfaces. Erosion has removed many T1 terraces, but Mill Creek and its tributaries have many extensive areas left.

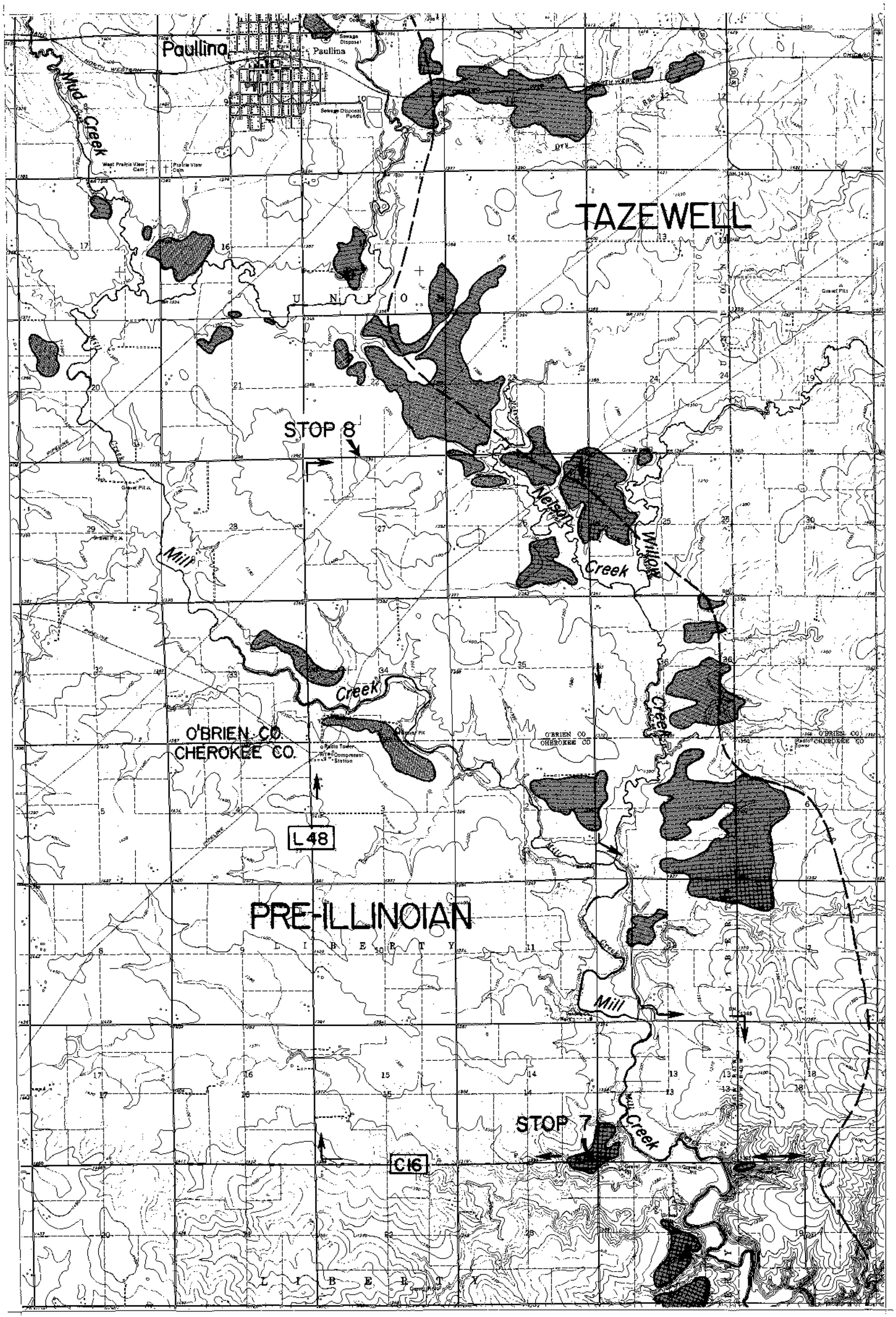


Figure 2. 9 Loess covered terrarces developed from Tazewell outwash in Mill Creek drainage; Stops 7 and 8.

Stop 8 (Day 1, Mile 94.9) Tazewell Outwash Channel, O'Brien County, Paullina Quadrangle, Sec. 22, T 94N, R 41W.

Stop 8 overlooks a low, flat, upland divide between Nelson and Mill Creeks. Ruhe (1950) and Van Zant (1974) identified this area in section 22 as the terminus of Tazewell glaciation (Figure 2.9). O'Brien County soil maps indicate Galva silt loam, bench phase in this area. Seven feet of loess overlies stratified outwash sands.

Thus at this site T1 is traced directly to Tazewell glaciation. This conclusively assigns T1 to Tazewell time.

North of Stop 8 one mile, exposures in a sand and gravel pit, developed in Tazewell outwash, reveal that the sequence coarsens to the top. In this pit which contains a vertebrate fauna, gravel is restricted to the top several feet beneath the loess. Below, sands and silts are all that are evident. This is curious as it apparently corresponds to the T1 sequence in tributary streams downstream. Is it a coincidence or are the sequences related?

Stop 9 (Day 1, Mile 113.8) Upland T1 Site; Cherokee County, Sutherland East Quadrangle, SW¼, Sec. 11, T 93N, R 39W.

Stop 9 finds stratigraphy which is like the conversational T1 terrace, i.e., loess over sand and gravel. This site is analygous to the upland T1 in the outwash channel (Stop 8) except that no obvious channel exists. Upland T1 positions like this one (Figure 2.10) are common near the Little Sioux. Sometimes, they consist of loess over a thin (1 inch) stringer of sand over till. Other times, substantial sands and gravels are found. This suggests that much relatively unconfined outwash was associated with Tazewell recession near the newly formed Little Sioux Valley.

Sands and gravels like this may help to explain why the Tazewell uplands may be so flat, and why erosion has been restricted to areas adjacent to major streams which flow through canyon-like valleys.

> "Waterman...cut back and down...cutting what was once almost a level plateau into the holes and chasms we have already described...in Grant and Waterman townships"

> "South of Spencer is a wide plain, thousands of acres as level as a floor; a Wisconsin plain with no evident kettle-holes, and no perceptible or evident drainage, save here and there a few shallow, far-reaching creek bottoms; no sculpture, except in the immediate neighborhood of the river. Here, however, the carving is always notable, emphatic, in deep relief, the sides of the channels steep, precipitious, the valleys narrow as in a land where limestone and not simple drift had formed the subject matter on which the sculptor had plied his art." (Macbride, 1901).

Perhaps, the gravels above the till such as seen at Stop 9, or within the till, such as can be seen 2.5 miles to the west along the road between sections 8 and 17 (T 93N, R 39W), act to enchance infiltration and subsurface drainage witb a resultant reduction in overland flow and erosion. In this way, Tazewell gravels may act as a resistant rock unit.

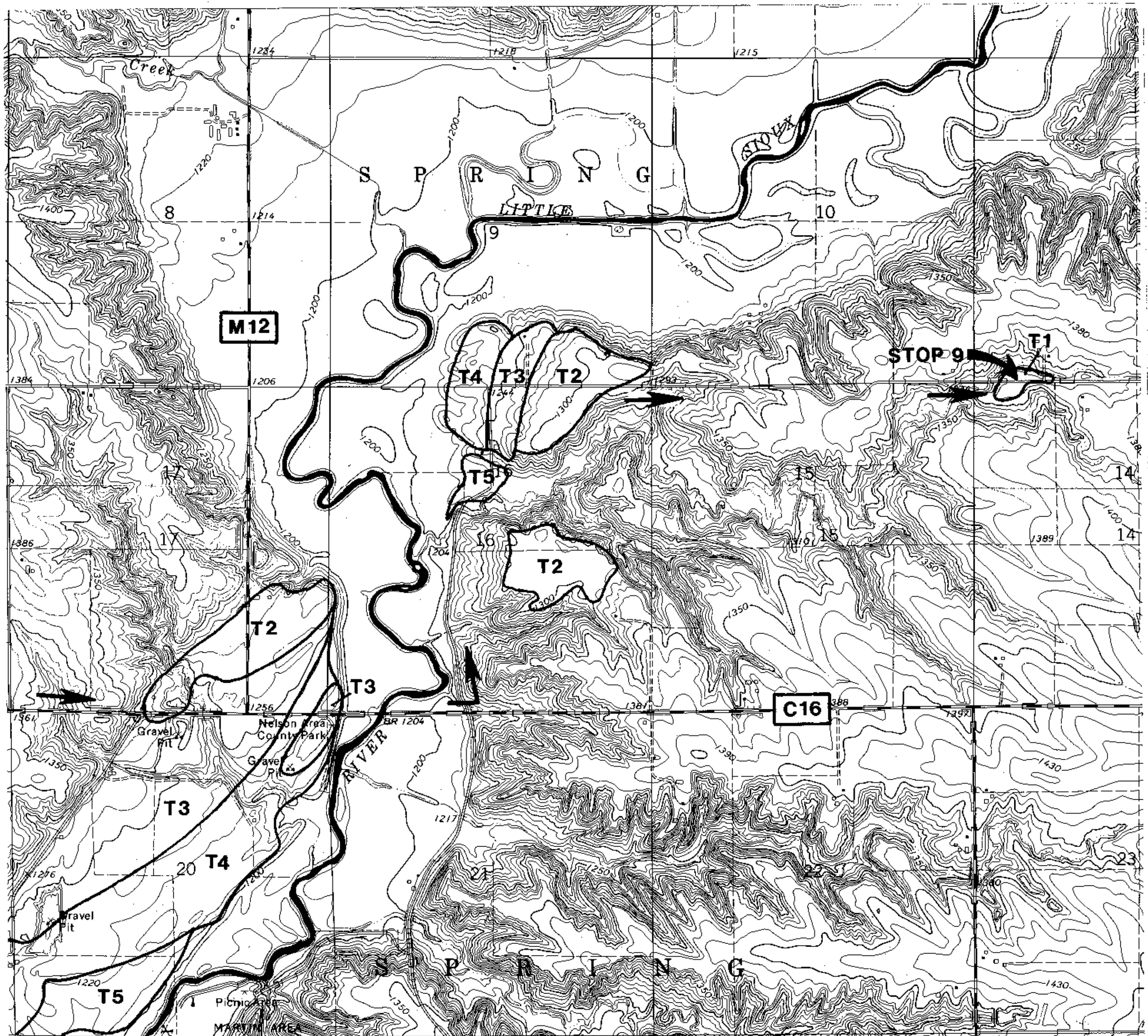


Figure 2.10 Complex terraces on the Little Sioux River; upland T1 site; Stop 9.

Stop 12 (Day 2, Mile 6.7) Holocene Alluviation; Cherokee County, Cherokee North Quadrangle, SW¼, Sec. 36, T 93N, R 40W.

The Holocene history of the Little Sioux River is far less spectacular than its Wisconsinan history. Following the rapid valley degradation, beginning circa 14,500 RCYBP, the Holocene record is a tranquil record of aggradation and stability.

Stratigraphic analysis of the Corrington alluvial fan and the associated buried floodplain at the Cherokee Sewer Site indicates that intermittent aggradation of the valley has been the dominant Holocene process. A radiocarbon date of 10,030 RCYBP taken from the floodplain at the contact between coarse basal fill and silty alluvium indicates the time when the aggradation began. Conclusions Hoyer (in press) has made suggest that the side valley alluvium aggraded concurrent with the floodplain alluvium from 10,000 to 6,000 RCYBP. Figure 2.11 shows this aggradation. Since then, the fans continued to develop until about 2,500 RCYBP while the floodplain either remained relatively constant or started degrading. Stability has been evident since about 2,500 RCYBP on the fans. Sedimentation was shown to be intermittent, with periods of stability and soil formation following short episodes of deposition.

Hoyer (in press) explained the sedimentation as a complex response to the rapid degradation of the Little Sioux between 14,500 and 10,000 RCYBP. Upward-fining alluvial beds were interpreted as adjustments to the valley cutting. This sedimentary model corresponds closely to the concept of the complex response as presented from experimental data by Schumm (1976).

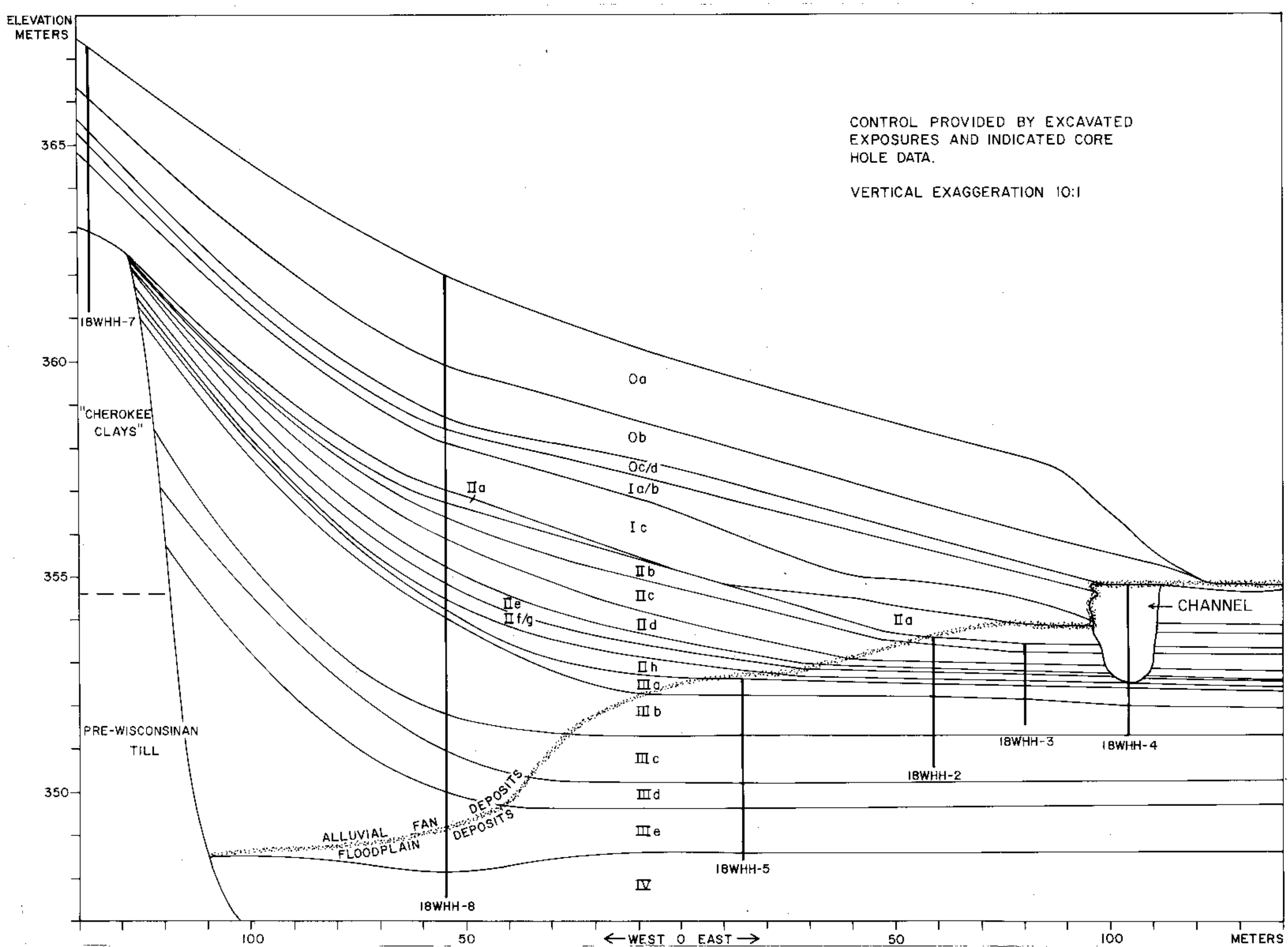


Figure 2.11 Cross section of Corrington alluvial fan, Cherokee Sewer Site.

No research was conducted on the alluvial fan at Stop 12 (Figure 2.12). It is merely a good example of the fans so common to the valley. However, the record from four alluvial fans suggest that this fan's stratigraphy can be predicted because the others exhibit similar responses. Much work needs to be done on this subject, but the correlations presented in Figure 2.13 indicate that the fans are responding in a similar intermittent fashion. Moreover, radiocarbon dates and/or physical similarities suggest that they may be responding synchronously through the Holocene. This would support research reported by Knox (1976) that proposes world wide, synchronous, fluvial discontinuities.

One major Holocene event may have affected the whole river system. At about 7,700 RCYBP oak pollen makes a dramatic reduction in a Lake Okoboji pollen record. At a similar time (7,800 and 8,100 RCYBP) charcoal rich sediment was deposited on alluvial fans. Contained within high magnitude flood deposits at the Cherokee Sewer Site, these deposits may represent floods resulting from far ranging fires which removed the oak forests from northwest Iowa. This corresponds to the onset of known dry climatic conditions in Iowa (Van Zant, 1979).

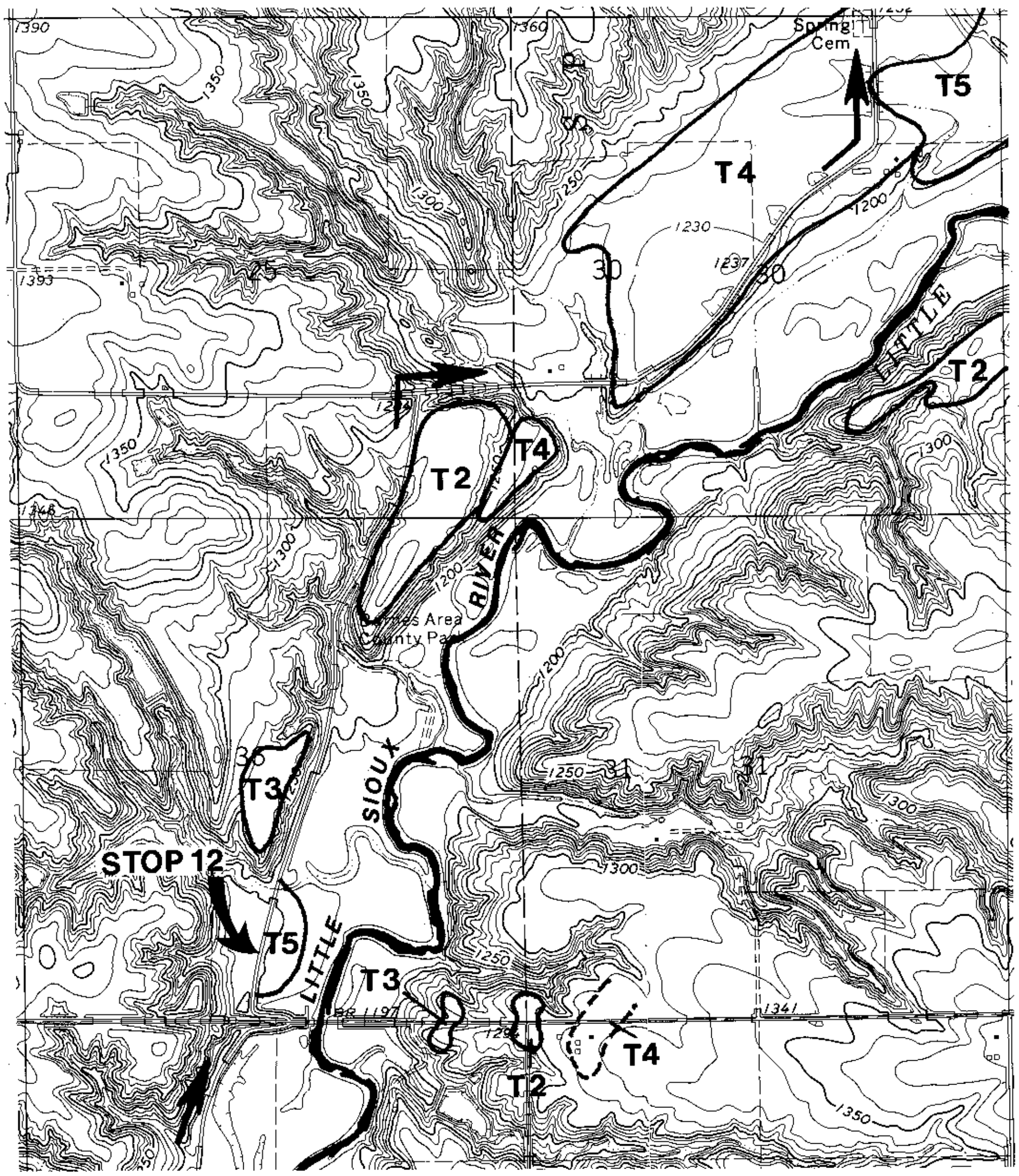


Figure 2.12 Area around Stop 12.

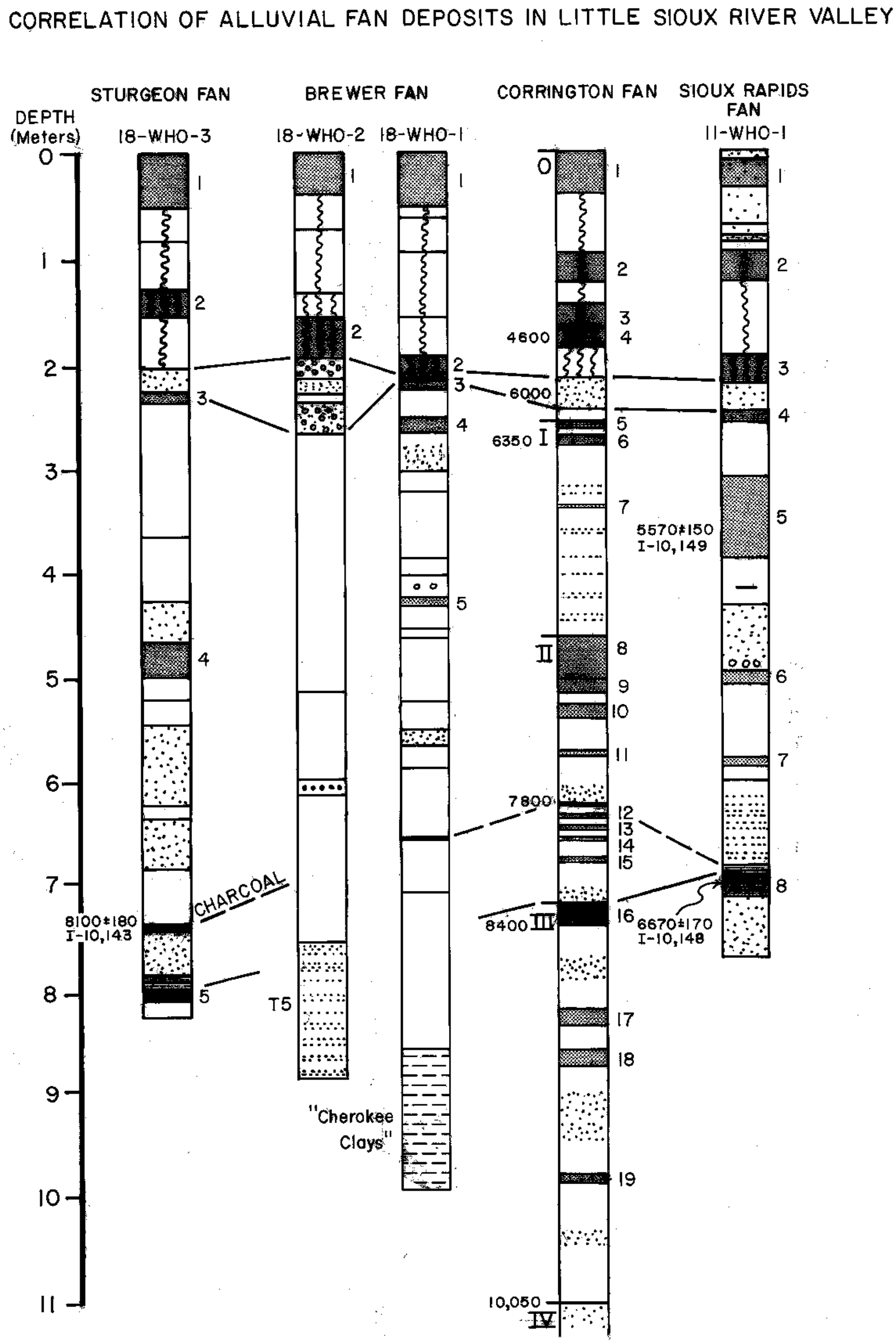


Figure 2.13 Correlation of alluvial fan deposits in the Little Sioux River valley.

Stop 13 (Day 2, Mile 15.9) Hanging Valley; O'Brien County, Sutherland East Quadrangle, W½, Sec. 34, T 94N, R 39W.

Special appreciation is extended to Marvin Gutheridge and family for allowing access to this site.

This hanging valley is certainly an unusual physiographic feature. The upper end of the hanging valley, where this trip views the site, sits about 70 feet above the Little Sioux Valley floor (Figure 2.14). No drainage enters the upper end now even though it is cut 50 or more feet down beneath the upland. The lower part of the hanging valley has been extensively modified by man and subsequent erosion from modern drainage. It grades down to terraces on the Little Sioux. Sand and gravel at a depth of 4 feet in the upper end as well as the valleys morphology assure us that it carried the Little Sioux or Waterman Creek in earlier times.

Determining exactly when the hanging valley was active is somewhat problematical. The field crossed between the gravel road and the valley is apparently a T1, probably an upland T1 position. Loess was probably stripped off the gravel by erosion in the vicinity of the old gravel pit while the valley was active. A T2 terrace across the Little Sioux in sections 26 and 35 (Figure 2.14) attains an elevation at the top of the valley walls of 1330 feet. If T2 truly represents the valley development during post-Tazewell and pre-Cary time, then the hanging valley probably represents valley adjustments immediately after the Glacial Lake Spencer drained. Thus, the hanging valley can be equated to T3 and formed about 14,500 RCYBP. This is my preferred interpretation of the valley. The adjustments occurred so fast after the drainage change, that

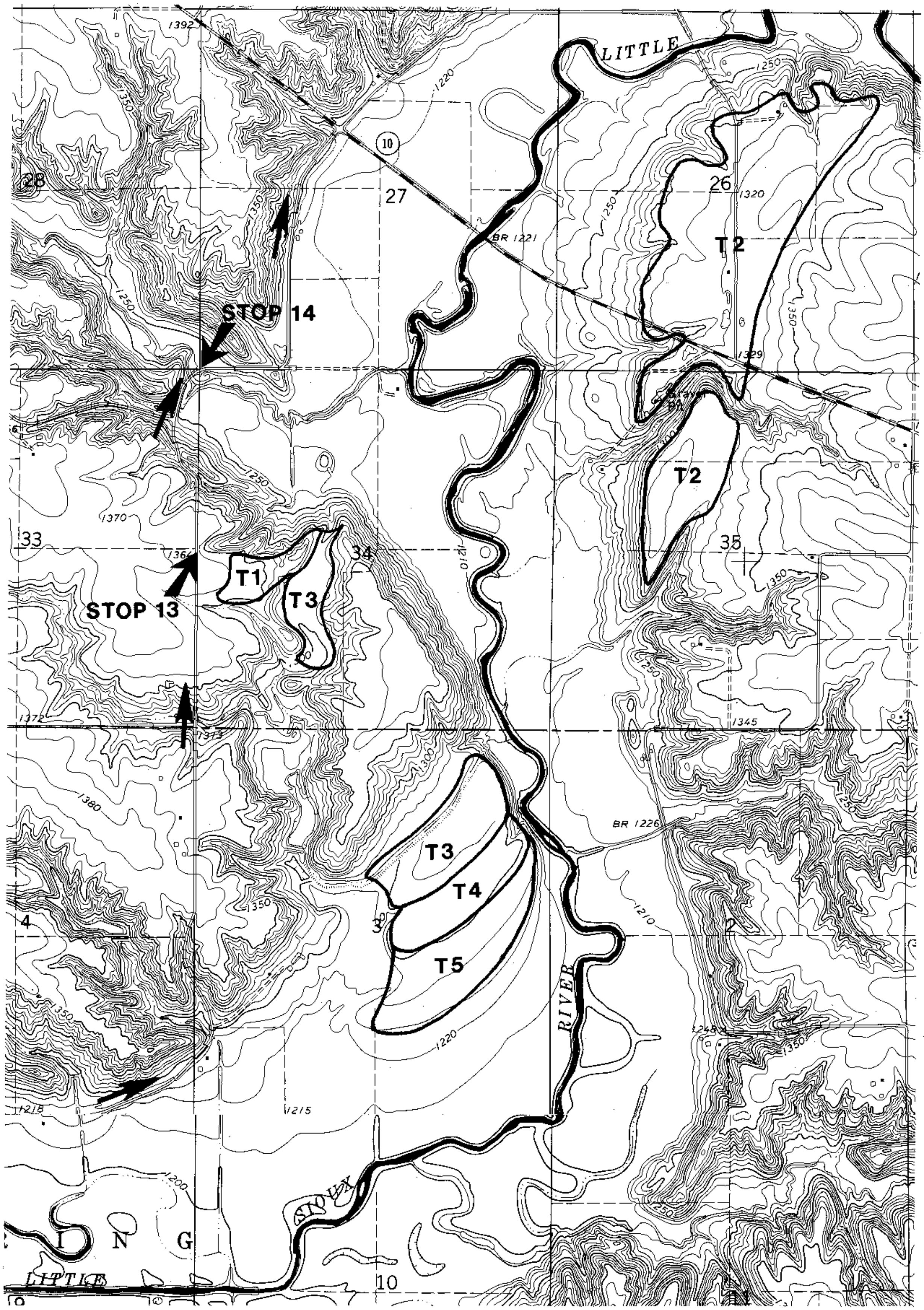


Figure 2.14 The hanging valley on the Little Sioux River; Stops 13 and 14.

this Little Sioux valley was cut, perhaps catastrophically, and was then abandoned as cutting continued, but at a reduced, more nearly normal rate.

An alternate explanation would be that the T2 terrace across the river represents development from the initial drainage piracy. However, adjustments continued rapidly leaving the valley at Stop 13. Clearly, the valley dates from near the time that Cary ice changed the drainage about 14,500 RCYBP.

Another possibility exists that the hanging valley developed in T2 time. While cut below the T2 opposite it in the valley, it could represent a Waterman Creek drainageway active sometime after the T2 across the river was active.

The valley could contain important paleoenvironmental data. A hand probed hole revealed 8 feet of organic-rich alluvial and colluvial deposits ranging from loam to silty clay loam textures. Beneath was about 8 feet of organic rich sediment containing plant macrofossils. Till, alluvium, or simply a rock limited our probing at 16 feet. The plant macrofossils probably date from about 14,000 RCYBP or soon afterwards.

Stop 14 (Day 2, Mile 16.4) <u>Dog Creek Hanging Meander Scar</u>, O'Brien County, Sutherland East Quadrangle, NE¼ Sec. 33 and NW¼, Sec. 34, T 94N, R 39W.

Why the hanging valley was left hanging is unclear. Obviously, an abandoned channel of that size is unusual, but leaving channels elevated to lesser amounts is not rare.

A meander scar on Dog Creek (Figure 2.14) has been left elevated above the active channel. In this case, it was a meander cutoff which produced the abandoned channel. However, post-cutoff degradation has left the old channel elevated. Should degradation continue, the old channel might never be reoccupied. It represents a "hanging valley" in miniature.

Stop 15 (Day 2, Mile 20.8) Tazewell Till; O'Brien County, Sutherland East Quadrangle, SW¼, Sec. 11 and NW¼, Sec. 14, T 94N, R 39W.

Stop 15 is located at a large exposure of Tazewell till (Figure 2.15). It provides an excellent example of the gradation of oxidized to unoxidized till. Note the depth to unoxidized till decreases to the east end as the hill slope increases and infiltration is reduced and erosion increased. Also note the jointed zone between the two zones where oxidation occurs along joints.

Descriminating till rock units can be difficult, but it is essential if the rock units are to be mapped. From the exposure it is obvious that one cannot call one till the yellow till and another the "blue" till.

Carman (1931) described the till, now identified as the Tazewell till, as having higher amounts of limestone and dolostone pebbles (55%). Van Zant (1973) descriminated the same property using the .25-.50 mm sand fraction. He found the Tazewell till contained 16% total carbonate in contrast to Cary (8%) and Pre-Illinoian (7%) tills.

Calcite/dolomite (C/D) ratios of Tazewell and Cary are relatively similar, however. Lucas (1971) found the Tazewell C/D as 3.19 and the Cary C/D as 3.78. These contrast sharply with the Pre-Illinoian C/D, 11.20.

Shale content can be used to descriminate Tazewell till from Pre-Illinoian tills. Tazewell tills ranged from 9-42% silicious shale, Pre-Illinoian less than 5% (Van Zant, 1973). Lucas (1977) who statistically analyzed the rock types found in the 1-2 mm sand fraction found the results tabulated below in Table 2.3. The Cary

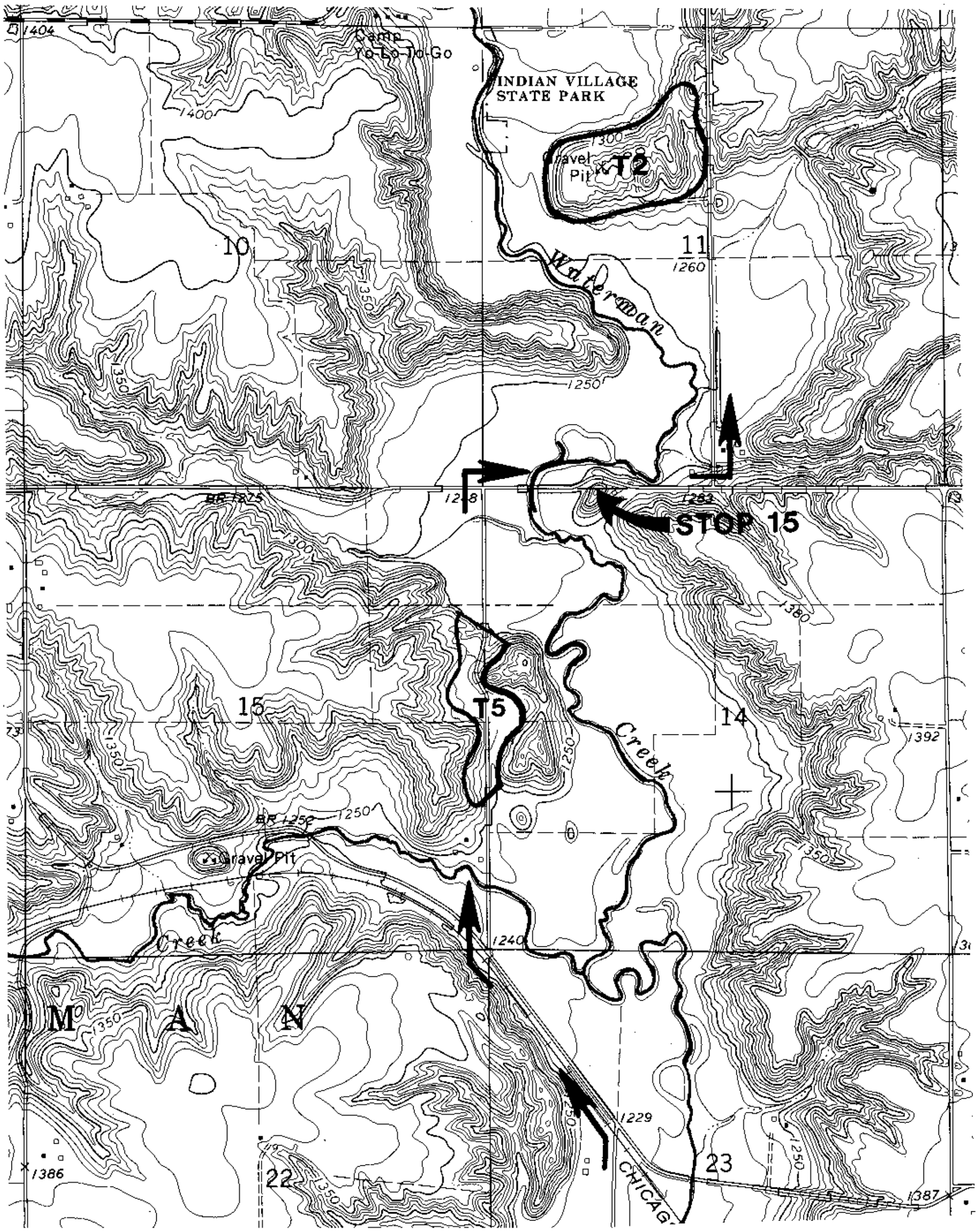


Figure 2.15 Lower Waterman Creek; Stop 15.

and Tazewell tills provide a sharp contrast with the Pre-Illinoian tills samples.

Table 2.3. Rock content of 1-2 mm sand in tills.

Till	Shale %	Carbonate %	Crystalline %
Cary	19.6	28.0	52.4
Tazewell	15.5	34.4	47.1
Pre-Illinoian	3,8	29.4	66.8

Textures also separated the Wisconsinan tills from those earlier. Pre-Illinoian tills are heavier textured than the Wisconsinan one. However, the Tazewell and Cary tills are not clearly separated on texture alone (Lucas, 1977).

The clay minerological data is interesting as it seems to show a trend with age. Kaolinite-Chlorite content increases with age (Table 2.4).

Table 2.4. Clay Mineralogy of Tills (Lucas, 1977)

Till	Expandable %	Illite %	Kaolinite-Chlorite %
Cary	73	17	10
Tazewell	67	20	13
Pre-Illinoian	62	21	17

Van Zant (1973) studied the till at or very near our field stop. Samples 97A and B and 101 were recovered from here and fit conclusively within the Tazewell ranges.

The Ice Marginal Valley: Peterson to Gillett Grove

The character of the Little Sioux valley changes upstream from Waterman Creek. The valley is smaller and more intimate, seeming a little like a private canyon.

> "...the valley itself suddenly becomes narrower and deeper, the stream winds between high banks that are steep, precipitous, though of clay, cut on each side and gashed by sharp ravines, canyons of present or recent erosion. This feature becomes so marked that in Herdland township and in Lee township (Buena Vista county) immediately south of it, the river valley has long been designated as the "straits", often no more than half a mile wide and at the railway bridge above Sioux Rapids even much less."
>
> The bluffs of clay are in some places two hundred feet high, and the effect is picturesque in the extreme. The railways have laid their tracks across the valley by bridges, eighty feet above the water, and the trains go swinging and creaking and winding about the sharp turns of the precipitous face of the clay bluffs and through channel-like cuts as if we were indeed in a land of mountains and rocks.
>
> The narrowness of the river channel from Gilletts Grove to Sioux Rapids, the very fact of the rapids, used by the pioneer for milling purposes, the peculiar erosion features a the mouths of all tributary streams, of Mill Creek and Waterman, the erosion now in progress, every bank gashed with narrow gullies, steep and trough-like as the valleys of a roof, eroded with every summer shower -- all these things seem easily explainable only on the theory that the Little Sioux river has only recently, as things geologic go, made its way across the divide and found an outlet by way of Waterman valley down the Missouri drainage slope. The Little Sioux would thus seem to be a tributary to Waterman Creek rather than the reverse. Macbride (1901)

Macbride clearly understood the significance of this valley segment. Little can be added to Carman's discussion of the events that formed this valley.

> The bend east of Spencer apparently was caused by the damming of the eastward flowing stream (pre-Wisconsin Ocheyedan) by the Wisconsin ice-front. The ponded waters then ascended the valley which headed southward toward Gillett Grove, and broke over to another valley leading southward.

> A short distance below its southward bend at the mouth of the Dickens outlet, the Little Sioux valley is narrower and deeper and the sides are steeper. At Gillett Grove the valley reaches the Wisconsin drift-boundary, and from here southwest to Linn Grove it follows this boundary. Throughout southeastern and southern Clay, northern Buena Vista and southwestern O'Brien counties, the valley is narrow and deep, and the valley sides rise steeply to the level of the upland plain, 100 to 125 feet above the river. This course apparently was established during the Wisconsin epoch, but the courses of the various pre-Wisconsin valleys which are represented in this valley are only partly known. The successive damming of eastward flowing streams, with the resultant ponding and breaking over to more southerly and westerly valleys, would, could we but read it correctly, be an interesting and instructive record of events. Carman (1915)

Cary ice blocked the Ocheyedan River drainage to the Mississippi River forming Lake Spencer. Other drainages, too, were probably shut off (Stop 11). Regardless, lakes persisted until they overflowed into some new drainage, cut down the divide between and flowed around the ice into Waterman Creek. The course it found was the present valley from Peterson to Gillett Grove. The process left the upper Little Sioux Basin which lays on the Mississippi River side of the highest divides. Further it left the unusual circuitous drainage pattern found in Clay and Buena Vista Counties.

> As a result of the peculiear course of the Little Sioux with respect to its western tributaries, some very indirect water routes exist. Where the Little Sioux leaves the southwest corner of Clay county, it is only nine miles from the headwaters of Willow creek, although it is more than fifty miles by the route the water follows. The distance between the Ocheyedan valley in northeastern O'Brien and the Little Sioux valley in southeastern O'Brien is only twenty-one miles, but the water route is eighteen miles eastward into Clay county and follows an irregular course of more than sixty miles. Carman (1915)

It is this drainage change, which caused the valley degradation downstream and lead to the many terraces. The Cary aged drainage change doubled the drainage area of the post-Tazewell basin. It is this highly significant hydrologic change which caused the complex fluvial response noted in the lower valley.

Differences in this portion of the valley are readily apparent. The valley is much narrower and steeper, except at major bends in its course. Terrace segments are mostly found only at the inside of river bends. They are generally small and rather high above the modern river, although they are clearly contained within the valley. The highest terraces are at about 1350 to 1360 feet (Stop 10). Several are at this elevation between Peterson and Sioux Rapids. This suggests the minimal elevation to which lakes must have risen before they spilled out to Waterman Creek. No loess covered terraces have been identified, on the Little Sioux here, but their occurrence would indicate an earlier drainage to the Mississippi. Stop 16 on Willow Creek provides an opportunity to visit a loess covered (T1) terrace which was formerly draining that way.

Stop 10 (Day 1, Mile 132.1) "The Straits", near Sioux Rapids, Buena Vista County, Sioux Rapids Quadrangle, SE¼, Sec. 2, T 93N, R 37W.

"The Straits" is a term Macbride (1901) used to describe part of the valley region marginal to the Cary ice. Cary ice to the east and south forced water draining to the Mississippi along its margin and into the Waterman Creek Drainage. This diversion has remained up to the present time and carved the narrow, deep valley presently found between Peterson and Gillett Grove.

Stop 10 (Figure 2.16) is located on the inside of a large river bend, where, typically in this reach of the river, a complex of terraces are preserved. T3 west of our stop represents the highest terrace remnant preserved and suggests a minimal elevation to which Glacial Lake Spencer must have risen. Gravel is being removed from these terraces, but till is probably not at great depth as the downcutting was probably very rapid. These terrraces, too, represent a complex fluvial response to the drainage changes. Note that T1 and T2 are not mapped in the portion of valley (Figure 2.16). They are only located in post-Tazewell/pre-Cary drainages and "The Straits" are a Cary development.

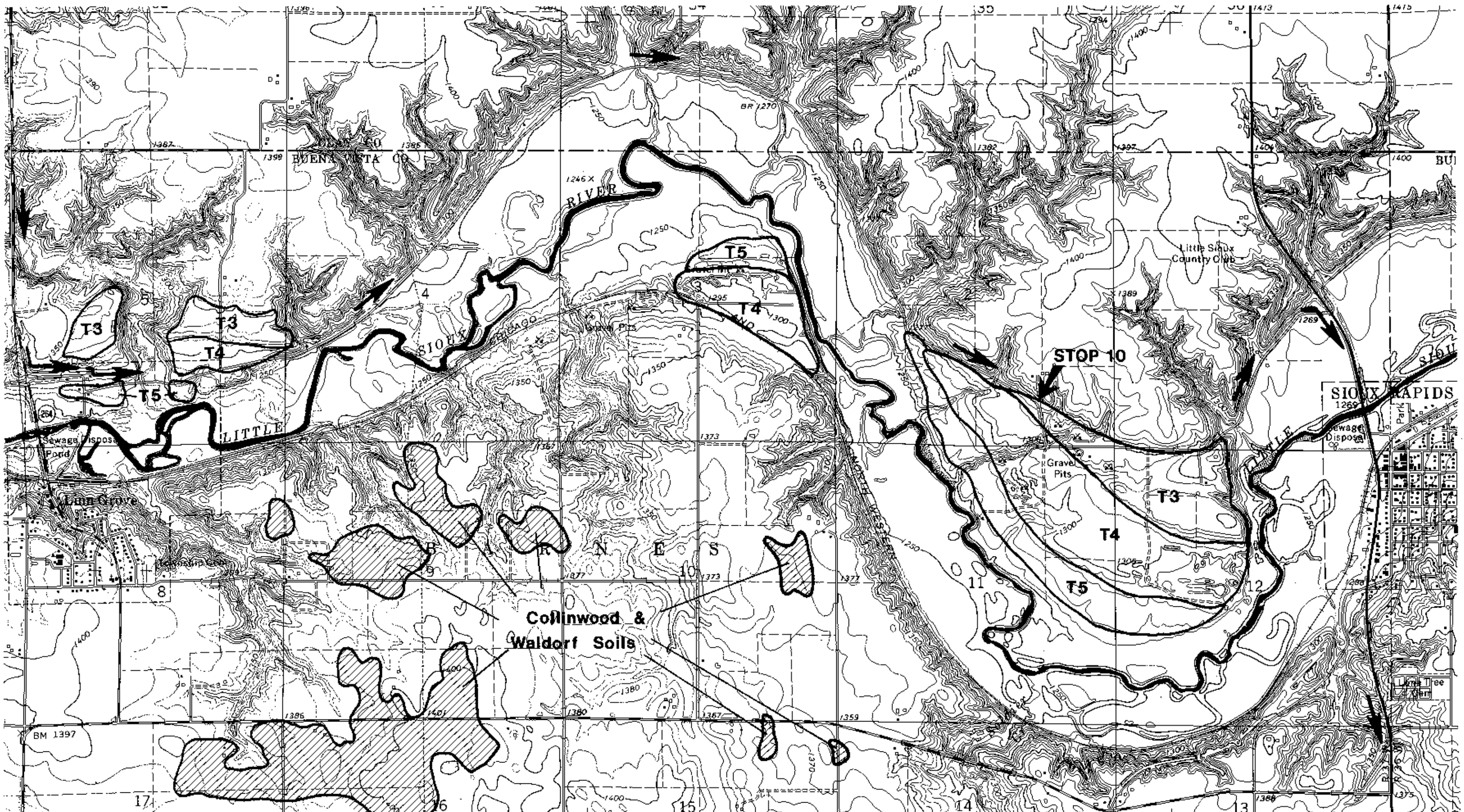


Figure 2.16 The Ice Marginal Channel of the Little Sioux River; Stop 10.

Stop 11 (Day 1, Mile 145.9) Brooke Creek Site, Buena Vista County, Peterson SE Quadrangle, SW¼, Sec. 36, T 93N, R 38W.

Brooke Creek marks the western edge of the Des Moines Lobe (Figure 2.17). The Bemis Moraine stands out as a prominent ridge between Fox Run and Brooke Creek. Note, however, that the Tazewell upland to the west stands up 100 feet higher than the moraine. Clearly, this Tazewell upland stopped the westward progress of the advancing Cary ice.

> In pre-Wisconsin time Brooke Creek was on the east side of the great watershed. Its upper part probably drained to the south and then passed eastward across Washington township to Raccoon river, and possibly the entire drainage course was reversed. When this valley, probably in section 21 of Washington township, was closed by the Wisconsin ice, the water was ponded and broke over to the north along the ice-margin, and then with the greater ponded areas from the northeast, broke across the great watershed along the present course of the Little Sioux. (Carman, 1915).

Carman (1915), was probably correct in saying that Brooke Creek flowed south and east. However, regardless of that fact, Brooke Creek probably existed because lake sediment, represented by Collinwood and Waldorf soils, are mapped on the west side of the creek (Figure 2.17) in terrace-like positions.

The Collinwood and Waldorf silty clay loam soil series are mapped on fine-textured lacustrine deposits (Seaholm, 1977). They differ in drainage classes mostly, with the Waldorf being poorly drained in contrast to the somewhat poorly drained Collinwood mapped at Stop 11. Major areas of these soils are mapped at about 1,350 to 1,380 feet. They are only mapped on the outside of the Bemis Moraine from Sioux Rapids (Figure 2.16) west along the Little

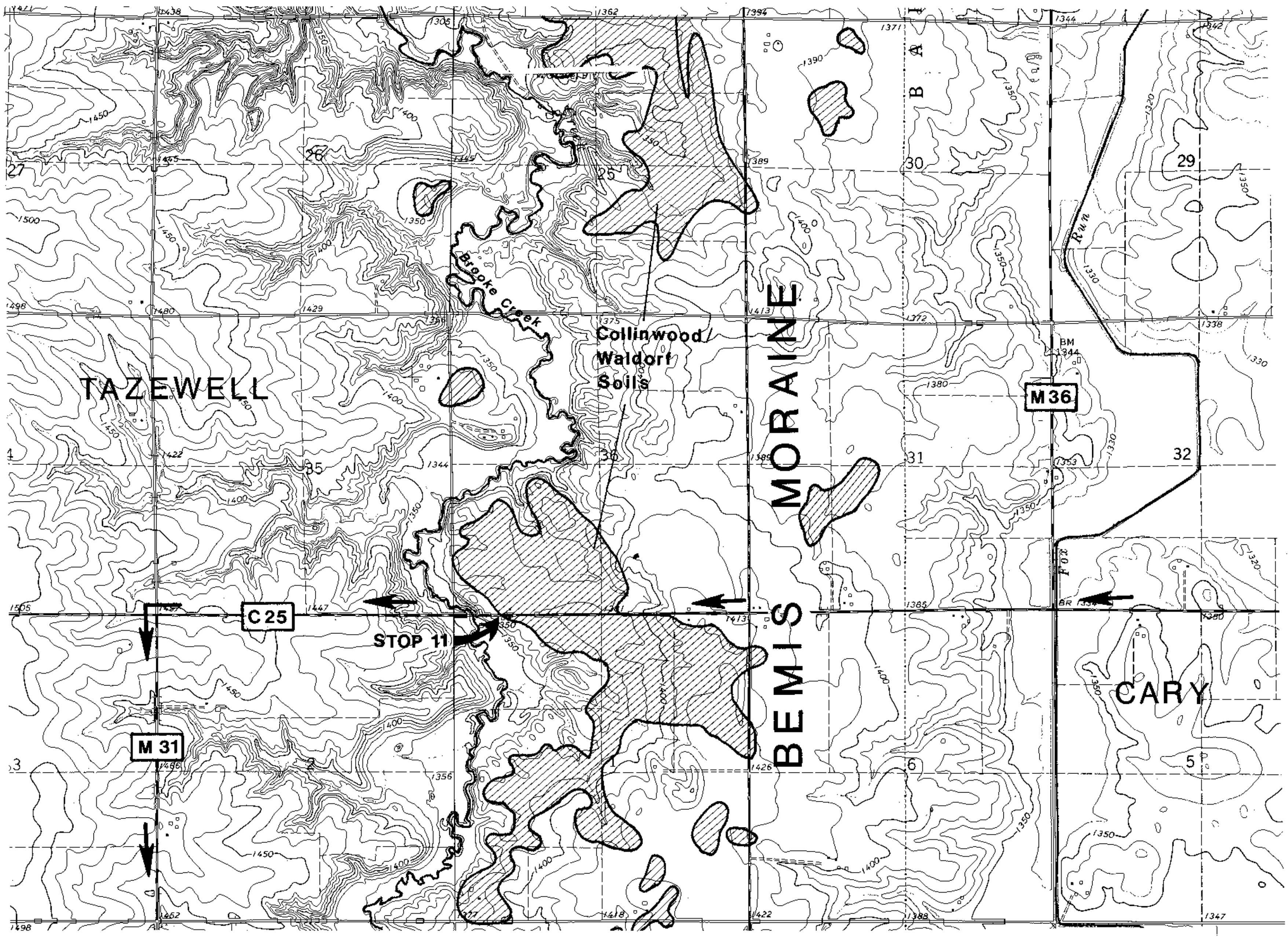


Figure 2.17 Brooke Creek and the Bemis Moraine; Stop 11.

Sioux to Brooke Creek and then south, up Brooke Creek. Their sedimentological character and their vertical and areal distribution suggest that the lacustrine sediment, upon which these soils were developed, was deposited as drainage to the Mississippi was blocked. Thus, these deposits represent time equivalents to Glacial Lake Spencer and are a part of the process by which Lake Spencer was eventually drained.

The surficial materials in this area must be reevaluated in light of this hypothesis. Soil maps, which are not geoloic maps, suggest this hypothesis. However, the soil maps also map these soils up to elevations of about 1,420 feet and also suggest a gradient upstream along Brooke Creek. Van Zant (1976) noted the distribution of the Carrinton silt loam, an old soil mapping unit which essentially mapped the soil association which now includes the Collinwood and Waldorf soils. He suggested these materials were the Buena Vista diamicton and considered them a Cary till variant or mudflow materials. A careful evaluation of these materials in this area is necessary in the future.

Stop 16 (Day 2, Mile 31.0) Willow Creek Site, Clay County, Royal Quadrangle, SE¼, Sec. 26, T 95N, R 38W.

Tazewell aged till typically is buried by about 7 feet of loess. Tazewell outwash on the Little Sioux and Mill Creek supports this general observation. This terrace site (Figure 2.18) has about 6 feet of loess over sand. It likewise is T1. The Clay County soil survey maps it as Galva silty clay loam, bench phase (6bA). (Fisher, 1969).

Willow Creek Flows into the upper portion of the Ice Marginal Valley. The presence of T1 on Willow Creek and its absence downstream all the way to Cherokee is conclusive evidence that Willow Creek drainage flowed to the Mississippi River in post-Tazewell, pre-Cary time. This stratigraphic evidence adds to the evidence presented by Macbride (1901) and Carman (1915).

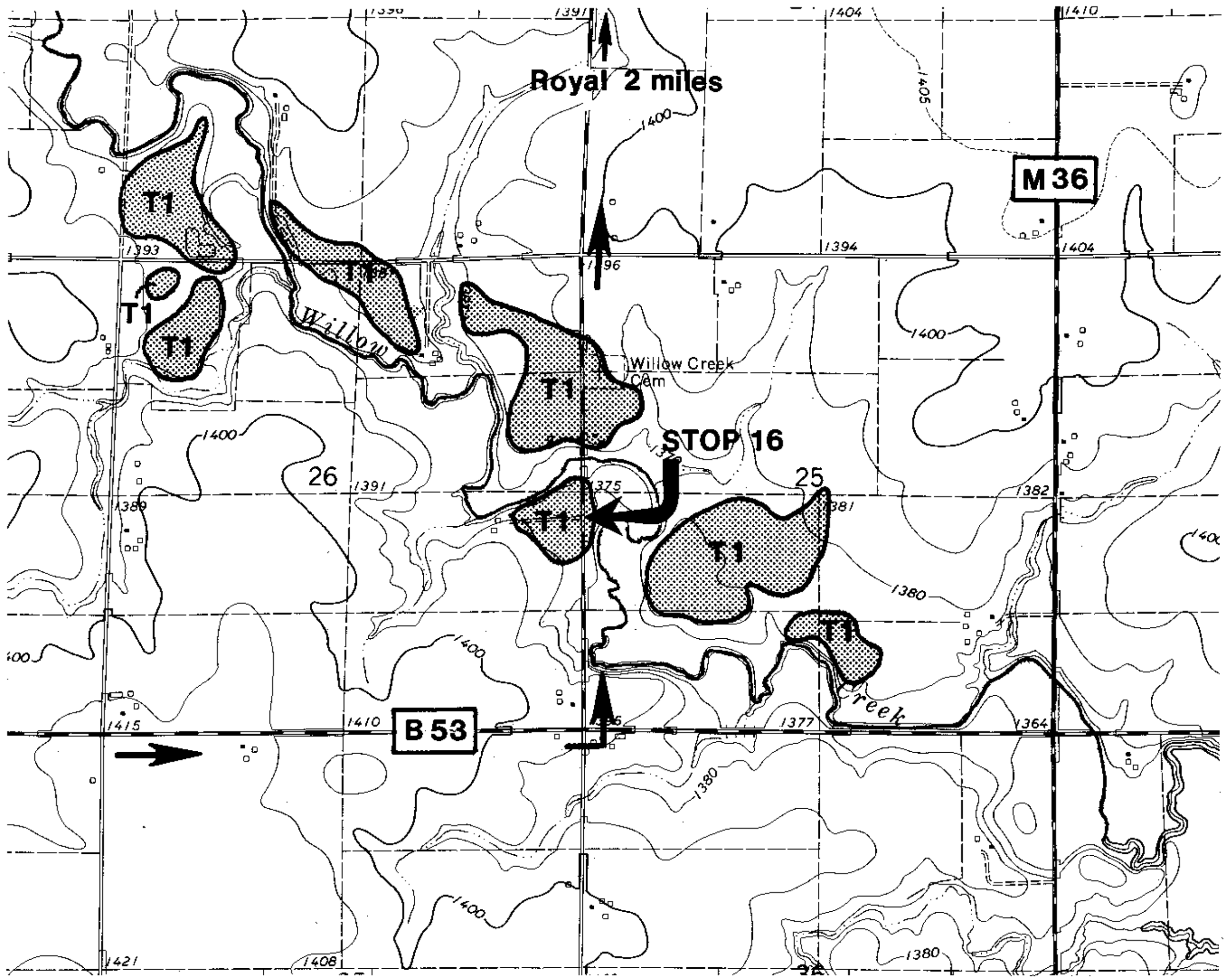


Figure 2.18 Willow Creek; Stop 16.

The Upper Valley: Gillett Grove to Minnesota including the Ocheyedan River

Above Gillett Grove, the Little Sioux River system is very different from anything below. Cary outwash dominates the valley. Broad outwash terraces are found from near Dickens, through the Spencer area and on up to the Iowa Great Lakes north of Milford. Above Milford the Little Sioux is found in a narrow, small valley, much like other small streams on the Des Moines Lobe. The Ocheyedan too has a broad, outwash terrace which merges with the Little Sioux's west of Spencer.

> The Little Sioux drainage system above Spencer consists of two principal streams, the Ocheyedan and the Little Sioux proper. Above their union the Ocheyedan river is longer than the Little Sioux,and below their union at Spencer, they continue eastward for four miles in a course which is the direct continuation of the Ocheyedan valley, and this course is then continued farther eastward by the Dickens outlet which enters the Little Sioux at its southward bend. It seems therefore that the Ocheyedan should be considered the headwaters of the system. Professor Macbride inferred that the Dickens outlet past Ruthven to the Des Moines river and carried with it the drainage of the present Little Sioux system above its southward bend east of Spencer. This interpretation probably is correct, and some of the low marshy areas of eastern Freeman township, as in sections 27, 26 and 24, and Elbow lake south of Ruthven may mark parts of this course. (Carman, 1917).
>
> The Okoboji outlet, which drains the lakes of north-central Dickinson county, joins the Little Sioux southwest of Milford. This course was the outlet of enormous floods of water during the Wisconsin ice epoch and there are great gravel deposits along the outlet and along the Little Sioux to the south. Gravel exposures are found in the valley sides and in pits on the terrace. The thickness of the gravel is 10 to 20 feet and it is coarser and more rusty than is the gravel of most of the deposits that are beyond the reach of the Wisconsin ice drainage...
>
> This gravel area extends as a terrace down the Little Sioux valley to the county line and south to Spencer. At Milford the terrace is 70 to 80 feet above the river, but it declines to 50 feet at the county line, and to 20 feet at Spencer...

In this distance the river falls 70 feet while the terrace drops about 120 feet. The fall of the terrace measured along the center line of the filled belt is 6 2/3 feet per mile. The fall of the river from west of Milford to Spencer, measured along its winding course, is 2 2/3 feet per mile.

In the pits south of Milford the gravel is overlain by two to three feet of brown sandy, noncalcareous material with few pebbles. It is not the usual leached loess but bears some resemblance to it and, considering the location of the region, where the loess is almost absent on the upland, this may be the equivalent of the loess. Such an interpretation of the overlying material would make the gravel of the Milford bench pre-Wisconsin and place it with the valley gravels of the Iowan age...

The valley flats of the Ocheyedan, Stony creek and the Little Sioux all unite in Riverton township west of Spencer in a large gravel area (Spencer flat) which extends from Everly eastward through Spencer to the southward bend of the Little Sioux southwest of Dickens. It covers the north half of Riverton township, a strip about two miles wide across Sioux township, and continues west and north up the Ocheyedan and Little Sioux valleys. About half of this area is a terrace 15 to 20 feet above the river. Gravel exposures appear at many places. At the pit of the Spencer Cement Tile Company, the gravel is worked to a depth of about 20 feet by a suction-dredge which pumps the gravel from beneath ground water level. About 10 feet of material is exposed above water level, and this consists of cross-bedded fine gravel and sand. Blue clay is said to underlie the gravel, and bowlders have been encountered toward the base of the gravel, and bowlders have been encountered toward the base of the gravel. The gravel is overlain by a brown sandy material similar to that over the gravel at Milford. (Carman, 1931).

While Carman suggests in the preceding excerpts that the highly sloping terrace between the Iowa Great Lakes and Spencer may be pre-Cary in age, this seems unlikely. The sediment overlying the gravel may be local wind blown deposits, and they may be found on all deposits near Spencer, including the Glacial Lake Spencer. The modern stream gradient is less than the terraces' and they almost merge at Spencer. Cary glaciofluvial and glaciolacustrine fill the valley there and make the "flats".

Stop 17 (Day 2, Mile 49.6) <u>Glacial</u> <u>Lake</u> <u>Spencer</u>, near Spencer, Clay County, Spencer Quadrangle, SE¼, Sec. 25, T 97N, R 37W.

Macbride (1901) first identified a lake in the area about Spencer and wrote of its history.

> At any rate the drainage from the melting ice found a wide lake bed where today stands the town of Spencer, and procedded to fill it up with sand. Here, it would appear, was in those days a lake far wider than any now existent in northern Iowa. We may read its limits by traversing a plain of sand; we may follow its low shores north of Spencer, if so we may call this prehistoric water, included perhaps all of Lost Island lake and the whole system round about it. To the east its waters may have filled in part the Lagon township slough. However we may attempt to explain it, the fact is evident that for some time Spencer lake received all the drainage from melting ice in this part of Iowa, and its whole area, as well as the broad areas now occupied by the Ocheyedan and the upper Little Sioux, was in this way filled with sand and gravel. Lost Island lake was out of the course of drainage and remained deep. The case is parallel to that of Spirit Lake and that of Okoboji in Dickinson county.* The deposition seems to have gone on steadily until the gravel had filled up not only Spencer lake from east of Dickens almost to Everly, but had choked up all the affluent streams as well, at least as far back as Milford... This out of the, erosion began at what we now call Sioux Rapids, cut through the divide of Wisconsin clay that limited our Spencer lake waters to the south, possibly near Gilletts Grove, the "Straits" were excavated, and Lake Spencer drained. (Macbride, 1901).

Little is known about this glacial lake. Macbride's history may or may not be correct, although in grass form it probably is correct. The story may be much more complicated and interesting. From a little core drilling and some other observations, it can be said that confusing deposits are found in the area. However, remains of the lake can be found. No shoreline is followed "easily" as Macbride (1901) indicated, but valuable paleoenvironmental data could be obtained. Sufficient deposits probably remain so that detailed transect drilling could be used to unravel Glacial Lake Spencer's history.

Figure 2.19 reveals areas where Glacial Lake Spencer deposits are probably preserved. The distribution is based on a few observations and the Clay County Soil Survey (Fisher, 1968). Ocheyedan loam is mapped in the preserved lake deposits in association with Marna, Guckeen and Webster soils. The Ocheyedan soil identifies loamy sediment over sands or silts over heavy textured lake deposits. Toward the Cary ice front, the deposits became more till-like. This suggests a diamicton facies of lake deposits. Cary till may also overlie some lake deposits to the east. West of the preserved lake deposits, coarse glacial outwash covers the area. However, lake sediment could persist at depth. Macbride was clearly correct that outwash entered the lake during its existence. With possible heavy sediment sources coming into the lake from the east, north and west the lake deposits could be very complex including overlapping deltaic deposits.

Macbride correctly determined that a lake once occupied the area around Spencer. However, the details about the lakes history are apparently difficult to interpret. Based on elevations of terraces near Sioux Rapids, the lake level must have risen to at least 1,360 feet. Macbride suggested in the previous excerpts that a shoreline could easily be followed. This is clearly not the case. To date, I have not found a clear cut shoreline. Perhaps they are buried beneath windblown or colluvial deposits or they are mistaken for windblown deposits.

Figure 2.19 reveals the areas where Glacial Lake Spencer deposits are most likely preserved. The distribution is based primarily on the Ocheyedan-Webster-Guckeen-Marna soil association (Fisher, 1968)

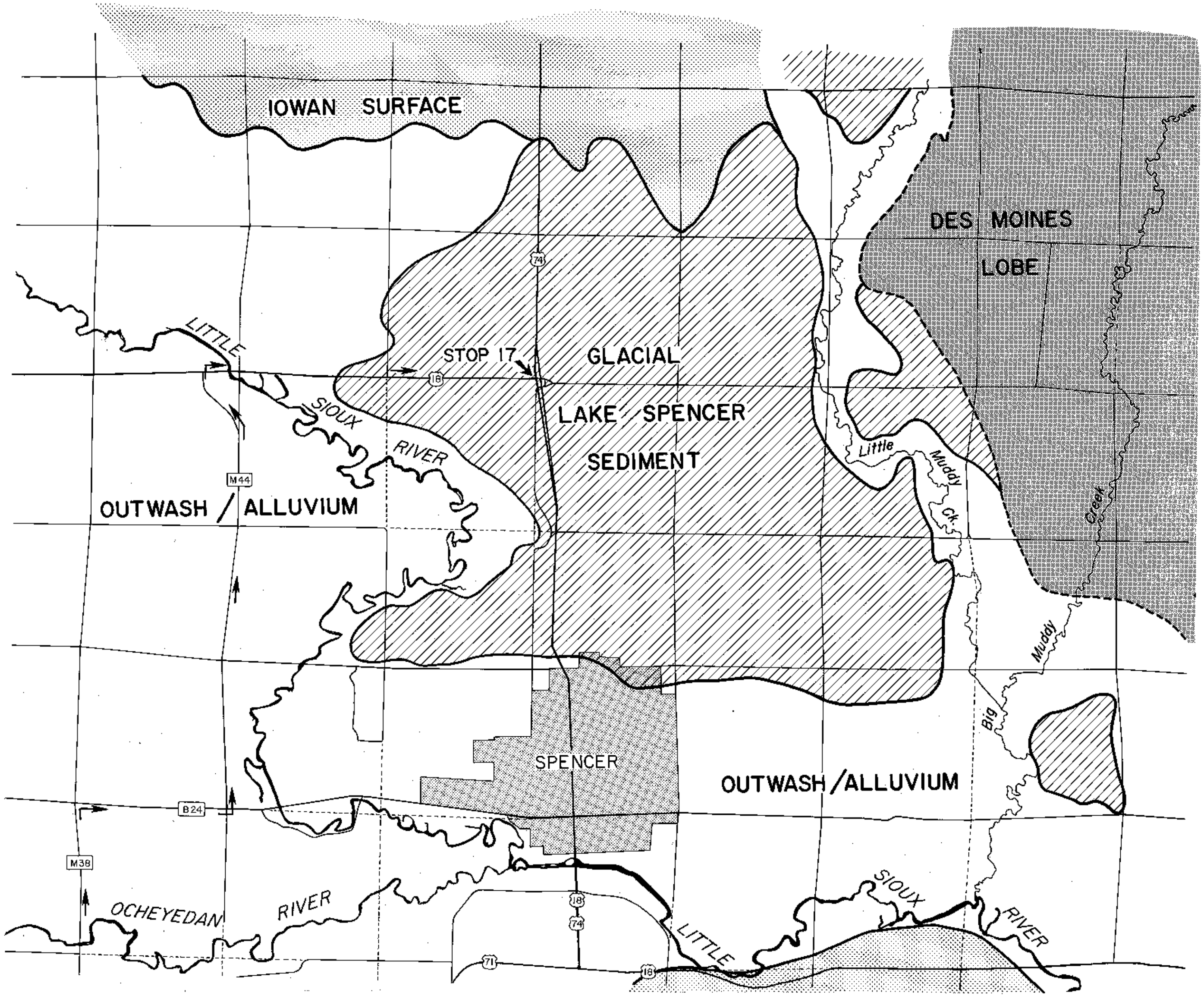


Figure 2.19 Glacial Lake Spencer; Stop 17.

which apparently marks the distribution of the preserved lake sediment. The Guckeen and Ocheyedan soils particularly appear to identify positions where stratified lake deposits are preserved. Stratified silts or sand is buried beneath 3 to 5 feet of sediment. Two miles west of Stop 17 in an area mapped as Ocheyedan loam, coarse sand with flattened cobbles and pebbles were found at a depth of 4 feet. This could be a buried shoreline at an elevation of about 1,340 feet.

The lake must have received outwash from three directions. To the east the Des Moines Lobe ice front must have advanced up to or, perhaps, advanced over part of the lake. Surficial deposits become increasing till-like to the east perhaps reflecting the ice front. This could, perhaps, be described as a diamicton facies (Shaw, 1975) and suggests that the ice front had advanced to the maximum position in this area during some phase of the lakes existence. To the north, outwash would enter via Little Muddy Creek and the Little Sioux River. From the west, sediment could be derived from the Ocheyedan River which also carried outwash. Considering the many outwash sources, and a maximum size of about 8 x 18 miles at an elevation of 1,350 feet, it is not surprising that the deposits may be confusing. Furthermore, these streams served to remove lake deposits, or bury them, beneath outwash and alluvium deposited after the lake drained. Outwash along the Little Sioux and the Ocheyedan, especially, apparently removed large amounts of the lake as they are cut beneath the preserved deposits. Perhaps the most remarkable fact is that fine textured, laminated lacustrine sediment was both deposited and preserved at all. However, these deposits were found in three cores and each contained some sediment believed to be varves. These were first identified by Steven Saye.

Perhaps three poorly studied core holes do not supply enough data to allow patterns to be made, but following is a generalized section based on brief field descriptions made on site which are included at the end of this discussion.

Generalized Glacial Lake Spencer Section

Thickness	Description
3 - 5'	loamy sediment
5 - 7'	stratified sands and silts
3 - 5'	very firm, fine textured stratified deposit with weakly exhibited or contorted thick laminations
4 - 8'	strongly laminated, varved, fine-textured deposits,
0 - 2'	silts
-	reduced, unleached till at 20 feet

Varves consist of a dark and light colored couplet. The dark portion is fine textured clays representing winter deposition; the light portion is siltier representing summer deposition. Microscopic analysis would probably reveal that graded bedding exists within each laminae. The varves at Stop 1 are about 3 mm thick with the two parts about equal in thickness. These couplets are rather thin suggesting relative sediment starvation (Ashley, 1975). Such could occur from distant sediment sources or deep water. Above the varves, the very firm "contorted" lacustrine sediment could be from turbidity currents and represent deposition closer to a sediment source, perhaps in a medial deltaic position. The overlying silts and sands suggest a higher energy condition which could represent shallow water and a nearby source of clastic materials. Such a sequence could be interpreted as a rather simple sequence of events. The lake rapidly rose to maximum depth as the Cary ice blocked drainage to the Mississippi. This deposited the varves found near the center of the lake at Stop 17. The ice moved closer and outwash continued filling the lake. Varve development lasted a maximum of about 750 years. Deltaic deposits continued encroaching into the lake depositing sediment in shallower water. Was this a result of sedimentation, proximity to the ice front or the beginning of the lake draining? These questions, and many more can only be answered by detailed study. Transect drilling, detailed sedimentological studies and associated floral analysis could provide a chance to fill in some gaps to our understanding of Iowa's Pleistocene history.

Public Safety No. 1

Location: 25' east and 60' north of southeast corner of Iowa Department of Public Safety building, SE¼, SE¼, sec. 25, T 97N, R 37W. Canisteo silty clay loam

Date: June 4, 1980

Staff: B. Hoyer, T. Kemmis

Depth (feet)		Description
0	A1	Black (10YR2/1) silty clay loam, pebbles, manganese concretions
2.3	B1	Grey (10YR5/1) silty clay loam, very dark grey (3/1) and dark yellowish brown (4/4) mottles, (MDL)
2.7	B2	Grey (10YR5/1) silty clay loam, few yellowish brown (5/4) mottles, strong fine angular blocky structure, weakly calcareous (DL)
4.3	B3	Mottled greyish brown (10YR5/2) and dark yellowish brown (4/4) silty clay loam, strongly calcareous, carhonate concretions near bottom (MDL).
5.0		Mottled yellowish brown (10YR5/6) and gray (6/1) silt loam, weak stratification, poor recovery of core, very wet. (MOU)
9.9		Yellowish brown (10YR5/4) silt loam, few grayish brown (5/2) mottles, iron stains, stratified, (OU)
11.6		Mottled very dark grey (10YR3/1) and yellowish brown (5/4) silty clay loam, stratified, MOU
14.8		Very firm very dark gray (10YR3/1) silty clay loam, few yellowish brown (5/4) mottles, fine laminations, gypsum, OU
16.3		Very dark grey (2.5Y3/2) silty clay laom, laminated, UU
18.4		Very dark grey (2.5Y3/2), dark grey (4/0) and dark yellowish brown (4/4) varved silty clay loam
19		Refusal, bottom of hole in varves

Public Safety No. 2

Location: approximately 200 feet west of gas pipeline building, SE¼, NE¼, Sec. 36, T 97N, R 37W. Guckeen clay laom

Date: June 4, 1980

Staff: B. Hoyer, T. Kemmis, S. Saye

Depth (feet)		Description
0	A11	Black (10YR2/1) silty clay loam, calcareous.
.8	A12	Black (10YR2/1) heavy loam, calcareous
2.3	A 3	Very dark gray (10YR3/1) silty clay loam, calcareous
3.9	B2	Grey (10YR5/1) silty clay loam, strong, fine angular blocky structure, calcareous, DU
4.8	B3	Dark greyish brown (10YR4/2) loam, few dark yellowish brown (2.5YR4/4) mottles, calcareous
5.8		Coarse and medium sand, calcareous, very wet, OU
6.6		Mottled greyish brown (10YR5/2) and yellowish brown (5/6) light silty clay loam, stratified, calcareous, DU
8.8		Mottled brown (5/6) silt loam, stratified, calcareous DU
9.6		Very firm, greyish brown (2.5Y4/1) silty clay loam, stratified, calcareous, DU
12.5		Greyish brown (2.5Y4/1) light silty clay loam, laminated, calcareous laminations increase to the bottom where they are almost varved. UU
17.3		Refusal, bottom of hole in varve-like sediment

Public Safety No. 3

Location: 35' east and 2' north of the southeast corner of Iowa Department of Public Safety building, SE¼, SE¼, Sec. 25, T 97N, R 37W. Canisteo silty clay loam

Date: June 5, 1980

Staff: B. Hoyer, T. Kemmis

Depth		Description
0		Fill
.8	B2	Greyish brown (10YR5/2) silty clay loam, strong fine angular blocky structure, very wet, DU
3.2		Mottled yellowish brown (10YR5/4) and light brownish grey (6/2) sands, calcareous, very wet, MOU
6.1		Mottled yellowish brown (10YR5/4 and 5/6) silt loam, OU
6.7		like 3.2' above, MOU
8.9		oxidized silt loam, OU
9.5		Mottled yellowish brown (10YR5/6) and very dark greyish brown (3/2) silty clay, laminations, contorted, crossbedded, wavy or bioturbated, firm, MOU
10.3		Mottled very dark greyish brown (10YR3/2) and yellowish brown (5/6) silty clay, exceptionally firm, laminations as above, MUU
11.4		Very dark greyish brown (2.5Y3/2) and very dark grey (N3) laminations forming varves 3 mm thick, silty clay loam, UU.
16.4		Very dark greyish brown (2.5Y3/2) and dark grey (3/1) laminations, silt loam, UU
16.8		Dark grey (2.5Y3/1) silt loam, very wet, poor recovery, UU

Depth	Description
17.8	Very dark greyish brown (2.5Y3/2) silt loam, UU
18.3	Mottled, reduced, calcareous glacial till, MRU
19.8	Abandoned hole in till

III Road Log

September 20, 1980; Day 1

Start: Smithland City Park

Miles	Quadrangle	Discussion
0	Smithland	Leave Smithland City Park, turn west on Hwy 141.
.3		Turn north on Hwy 31.
1.5	Oto	Loess covered terrace, T1 located across the river.
2.5		Oto
6.5	Correctionville NW	
.5	Correctionville	T3; Anthon rests on T3 terrace with T4 terrace east and south of town.
1		Leave T3
3		T2 on left; farmstead sits on the terrace.
.5		T3
.5		Turn east (right) on gravel road onto T5 terrace.
.5		T4; T3 remnant to the south.
1		Entrance to Little Sioux County Park.
.5		Turn north on Hwy 31.
1		Cross Little Sioux River
.5		Enter Correctionville on T5; see Figure 2.2.
.2		Intersection with E-22; continue east (straight) on E-22 and proceed onto T4.
.4		T3
.4		T2 on left
.4		Cross Bacon Creek
.3 (Day 1 Total 21.5)		Stop 1: Bacon Creek Site continue east on E-22.

Miles	Quadrangle	Discussion
.5	Cushing	
.1		Turn north on L-37
.3		Cross Bacon Creek; T1 on the right above creek. Note how relatively low it is above the creek when compared with relationship at Stop 1.
.3		Turn west on U.S. 20
.1	Correctionville	
1.3		T3 at valley margin
.2		T4
.7		Turn north on Hwy 31; T5 is just west of intersection.
.8		Proceed onto T3
.4		Floodplain meander scar
.6	Pierson	Large T3 terrace remnant across the river.
.9	Washta	T4, travel on T4 next mile.
.7		Enter Ida County;
.5		Bitter Creek
.7		Ashton Creek; see Figure 2.4
1		Outcrop of "Cherokee Clays" behind fence at foot of valley wall.
.2		T4; T3 is on the left to Washta
.5		Enter Cherokee County
1		Washta; Turn east on C-66.
.1		Stratton Creek
.6		Stratton Creek
.1 (Day 1 Total 33.1)		Stop 2: Stratton Creek Site; Turn left into driveway at Don Grefe farm. continue east on C-66 after stop.

Miles	Quadrangle	Discussion
.9		Turn south on gravel road. A "paha" is located east of this intersection. Coring by G. Hallberg and N. Wollenhaupt into the paha revealed 54' of loess overlying glacial till. No paleosol was present at the contact.
1		Enter Ida County
.5		Turn west on gravel road
1		Turn south on gravel road
.5		Turn west on unimproved road
.5	(Day 1 Total 37.5)	Stop 3: Ashton Creek Site; continue west after stop.
.5		Turn south on gravel road; Look east at striking terrace levels on Ashton Creek.
1.1		Turn north on Hwy 31.
1.4		Enter Cherokee County
1.3		Washta
.1		Stratton Creek
.1		T5
.5		T4; T3 remnants on left. Next 4.8 miles cross a terrace complex of T4, T3 and T2 remnants.
1.5		T3 remnant on left
1.1		High remnants on left north of Stieneke Area County Park and south of Fourmile Creek are T2
1.		Fourmile Creek
.5		T3
.4	Quimby	See Figure 2.7
.3		Quimby; turn north on L-51 through town.

Miles	Quadrangle	Discussion
.2		Possible Rest Stop; turn east one block to city park; return to L-51 and proceed north.
.2		Little Sioux River
.2		Turn west on C-60
.1 (Day 1 Total 48.0)		Stop 4: Quimby Ash Site; turn right into drive, and park immediately. The beautiful home and ash site are owned by Richard Knapp. Continue west on C-60 after stop.
1		Turn north on gravel road
.3 (Day 1 Total 49.3)		Stop 5: Loess Covered Terrace; continue north after stop.
.7		Turn west on gravel road; see Figure 2.8
1.6 (Day 1 Total 51.6)		Stop 6: Rock Creek Site; Rock Creek; Note well developed terraces. Continue west after stop. Note beautiful Iowan Erosion. Surface stepped landscape positions evident to the north of road over the next mile after climbing out of Rock Creek Valley. Continue west after stop.
2.		Descend onto T1 terrace
.2		Willow Creek
.3		Turn south on gravel road. Travel next .6 mile on T1 terrace. Note wide expanse and relatively low position of T1 on Willow Creek 5 miles above its junction with the Little Sioux, and compare this to multiple. high terraces seen at Stop 6, Rock Creek, just 2 miles above the Little Sioux.
1		Turn east on C-60
2.5		Rock Creek
2.5		Turn north on L-51
1.7		Turn east on gravel
.9	Cherokee South	

Miles	Quadrangle	Discussion
.1		Turn north on gravel
.5		Turn east on gravel
.9		T1 terrace
.1		T2 terrace
.5		Perry Creek
.6		Turn north on L-56; on T3 terrace group level.
.3		Turn east on gravel; T4 is to the north.
.4		T5 terrace.
.4		Little Sioux River.
.1		T3 terrace
.6		Turn north on US 59
1		T2 terrace
.5		Pilot Rock Lookout historic location. Pilot Rock is a large boulder exposed on Iowan Erosion Surface from Pre-Illinoian Tills.
1.9		Cherokee Municipal Airport located on T3. Cherokee Sewer Site is located across river from the airport. This site was the subject of an extensive multidiscipline study of Holocene alluvial deposits.
1		Little Sioux River
.3 (Day 1 Total 71.9)	Cherokee North	Downtown Cherokee, Lunch break
.8		Hy Vee Food Store; meet to continue trip. Go north on US 59.
.7		Intersection with Hwy 3; continue north.
.5		T1 terrace remnant at drive-in theatre

Miles	Quadrangle	Discussion
.5		Mill Creek; Mill Creek was an ice marginal stream and marks the boundary between Tazewell glacial till on the north from Pre-Illinoian glacial till on the south.
.3		T1 remnant on north side of valley.
1.2		Turn west on gravel road
.3		T2 terrace
.5		Road curves north, facing ridge is T2 gravel
.6		Cross nose of ridge; Note many terrace levels throughout this deep valley.
.3		Turn north on gravel road
1.7		Turn west on gravel at T-junction.
1		Terrace at left is loam surfaced, T2
.3		Mill Creek, T3, T4, T5 terraces in area.
.7		Turn north on gravel road
.7		Mill Creek, T5 on north side
1.3		Turn west on C-16
.5		Gravel pit at junction on south side of the road is developed in T1. See Figure 2.9
.1	Cleghorn	Mill Creek
.9 (Day 1 Total 84.8)		Stop 7: Townhall Site; continue west C-16 after stop.
2		Turn north on L-48
.6	Paullina	
2.4		Enter O'Brien County
3.		Mill Creek

Miles	Quadrangle	Discussion
.2		T1 remnant; soils mapped as Galva Silt Loam, Bench Phase (T-310). This soil is the key to mapping T1 in O'Brien County as the completed soil survey recognizes the stratigraphy of loess overlying gravel very well.
1.5		Turn east on gravel
.4 (Day 1 Total 94.9)		Stop 8; Tazewell Outwash Channel T1 is divided between Nelson & Mill Creeks. Continue east on gravel after stop.
1		Nelson Creek, terraces are T1; note how extensive they are and how low they are above stream.
.6		Turn south on gravel road; cross T1 for .6 mile
.6		Nelson Creek valley
.3		Nelson Creek
.1		T1 terrace
1		Enter Cherokee County
.3		Descend onto T1
.5		Turn east on gravel road
.2		Willow Creek at junction with Mill Creek
.5		T1 terrace
.6		Turn east on gravel road
.6	Sutherland West	
.1		Turn south on gravel road
.4	Cherokee North	
.6		Turn east on C-16
4		US 59; continue east

Miles	Quadrangle	Discussion
2.2	Peterson SW	
.3		Deeply incised intermittent stream valley with terraces
1		Enter Little Sioux River valley; extensive, complex terraces in this area; see Figure 2.10
.8		Little Sioux River
.3		Turn north on gravel road
.7	Sutherland East	
.1		T3 level at road; T4 below
.3		Road turns east
.3		T2
1.5	(Day 1 Total 113.8)	Stop 9: Upland T1 site; continue east after stop
1.8		Enter Buena Vista County
.6	Peterson	
.4		Turn north on M-27
2		Enter Clay County
1		Turn east on Hwy 10
.5		Little Sioux River
.4		Peterson
5.2	Sioux Rapids	Turn south on Hwy 264
1		Enter Buena Vista County
.7		Turn east on road at valley margin; see Figure 2.16
.3		Turn east on gravel road on T5 terrace.
.2		Creek
.1		T5 terrace

Miles	Quadrangle	Discussion
.2		T4 terrace
1.2		Enter Clay County
1.2		Enter Buena Vista County
1.5 (Day 1 Total 132.1)		Stop 10: "The Straits"; T4 above T5; continue east after stop
.3		T3 terrace levels
1.1		Turn south on U.S. 71
.4		Little Sioux River
.2		Sioux Rapids; cross Cary from near the top of the valley south of town all the way to stop 11.
1.4	Rembrandt	
3.6		Turn west on C-25
5	Peterson SE	Fox Run; See Figure 2.17
.2		Bemis Moraine
.8		Crest of moraine
.5		Waldorf silty clay laom and Collinwood silty clay loam, both soils thought to represent lacustrine sedimentation by the soil surveys, are mapped along here
.3 (Day 1 Total 145.9)		Stop 11; Brooke Creek Site;
.1		Continue east after the stop. Brooke Creek
1.1		Turn south on M-31
4.9	Alta	
.1		Turn west on Hwy 3
.4	Aurelia	
.6		Enter Cherokee County
5.8	Cherokee South	
.8		Continue west at intersection of Hwy 3 (right turn) and old 3, straight ahead into town.

Miles	Quadrangle	Discussion
2.1 (Day 1 Total 161.8)		Downtown Cherokee; trip ends.

September 20, 1980; Day 2

Start: Cherokee, U.S. 59 north, Hy Vee Food Store

Miles	Quadrangle	Discussion
0	Cherokee North	Trip begins at Hy Vee Food Store parking lot, U.S. 59
.7		Turn east on Hwy 3
.2		Turn east (left) on gravel road
.2		T1 terrace
.3		T3 terrace, a former channel
.2		T2 terrace
.3		Turn north on gravel; T4 terrace
.2		T5 terrace below on right
.3		Mill Creek
1		T2 above road on left, T3 below on right.
1.8		Turn east on gravel road
.8		Descend onto T4; road turns north
.6		Continue across road beside bridge; see Figure 2.12.
.1 (Day 2 Total 6.7)		Stop 12: Holocene Alluviation; alluvial fan and T5 terrace; continue north after stop
.3		Road is below T3 terrace on left
.4		Enter small ravine; T2 terrace is above on the right
.6		Turn east on gravel; T2 terrace is to the south and east.
.5	Peterson SW	Road curves to the northeast and north across a large T4 terrace. The terrace has various levels and approaches the elevations expected in this reach for T3 terraces about .3 mi. beyond curve where it overlooks the Little Sioux River floodplain

Miles	Quadrangle	Discussion
1.2		Cross small intermittent drainage
.3		Road climbs up onto valley wall toe slopes. Broad terrace complex to the east includes sequences included within T2, T3, T4 and T5 terrace level groups. This area is one of the best to illustrate the complex response which operated in cutting the valley between 14,500 and 10,000 RCYBP.
.7		Turn east on C-16
.3		Turn north on M-12
.2		T2 terrace
.3		Oxidized and unoxidized Tazewell till exposed in roadcut
.2	Sutherland East	
1.3		Turn east on gravel road
1.4		Road turns to the north out of valley; see Figure 2.14
.8		Enter O'Brien County
.7 (Day 2 Total 15.9)		Stop 13: Hanging Valley; access made available by Marvin Gutheridge; continue north after stop.
.5 (Day 2 Total 16.4)		Stop 14: Dog Creek Hanging meander scar; continue ahead after stop
.9		Continue northeast across Hwy 10 on gravel
1.1		Turn north on gravel
.6		Continue north (left) at intersection; see Figure 2.15
.5		Turn north (right) at intersection
.2		Murray Creek
.2		Enter Waterman Creek hanging valley
.6		Turn east on gravel

Miles	Quadrangle	Discussion
.1		Water Creek
.2 (Day 2 Total 20.8)		Stop 15: Tazewell Till; continue east after stop.
.3		Turn north on gravel
.6		High gravel terrace, T2, on left
.7		Turn east on B-53
1.4	Harley SW	
.8		B-53 turns sharply east
1		Enter Clay County
.7	Royal	
4.3		Turn north on asphalt road; see Fig. 2.18
.4 (Day 2 Total 31.0)		Stop 16: Willow Creek Site; continue north after stop
.1		Willow Creek
3.5		Turn east on Hwy 240 and B-40; note flat loess-covered Tazewell uplands in this area.
2	Greenville	
2		Turn north on M-38
3.9	Spencer	See Figure 2.19
.2		Ocheyedan Rvier
.9		Turn east on B-24
1		Turn north on M-44
3		Turn east on US 18
2 (Day 2 Total 49.60)		Stop 17: Glacial Lake Spencer; park at Department of Public Safety Office;
Trip Total 211.4		End of Field Trip

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