QUATERNARY DRAINAGE EVOLUTION OF THE MAQUOKETA RIVER VALLEY

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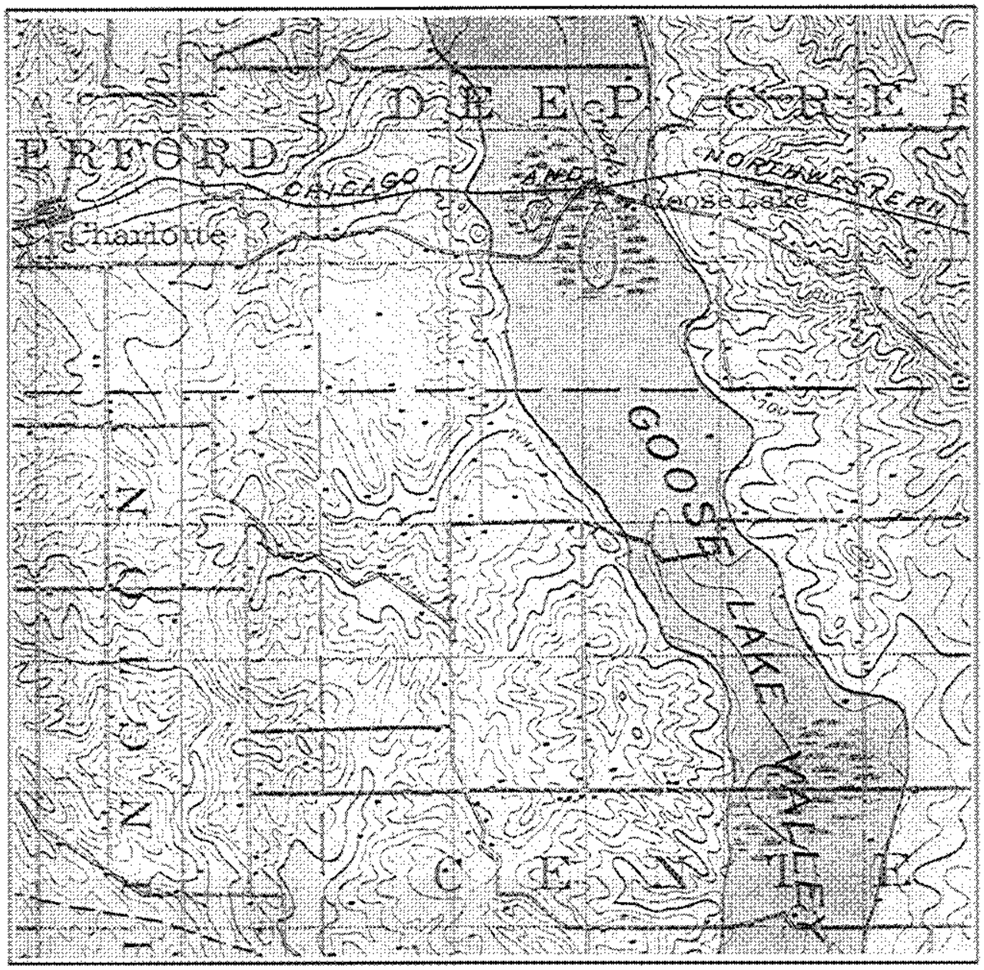

Geological Society of Iowa

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Cover illustration:

Topographic and surficial geologic map of of the Goose Lake area in northern Clinton County, Iowa, showing the drainage divide between the Maquoketa and Wapsipinicon river valleys on the floor of the Goose Lake Channel. From Plate I of Carman (1909).

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GEOLOGICAL SOCIETY OF IOWA
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INTRODUCTION TO MORNING STOPS

Welcome to the the fall 1992 GSI field trip, and to Hurstville Lime Kilns County Park. Although the focus of our excursion today is the Quaternary drainage evolution of the Maquoketa River Valley, the geology and history of our assembly area is also of interest.

The Hurstville Lime Kilns were operated by the Alfred Hurst and Company starting in 1871, following the completion of the Chicago, Milwaukee, and St. Paul railroad lines into Maquoketa. The kilns were used to burn locally quarried Silurian dolostones (Farmers Creek and Marcus-Sweeney members of the Hopkinton Formation) for the production of lime used in plaster and mortar. The kilns were fueled by locally cut timber, and were part of a large commercial operation with about 60 employees. Savage (1906) reported operations with 4 continuous feed kilns and an extensive network of tracks carrying quarried dolostone from both sides of the North Fork Maquoketa River.

All three of today's trip leaders each have independently developed research interests in the Quaternary landscape evolution of the Jackson County area. Art Bettis has long had interests in Quaternary fluvial processes/events in North America, and has worked in Jackson County (Bettis and Hajic, 1990) as well as much of the Missouri and Mississippi River valleys in the interior United States. Work on field mapping of the Plum River Fault Zone in Jackson County (Ludvigson et al., 1978; Bunker et al., 1985; Ludvigson, 1988; Ludvigson and Bunker, 1988) focused Greg Ludvigson's attention on the significance of ancient drainageways in the area. Greg's interpretations of bedrock topography and drainage evolution in Jackson and Clinton counties during the production of Iowa's groundwater vulnerability map (Hoyer and Hallberg, 1991) renewed his interests in the area, and led to his formulation of a hypothesis regarding the antiquity of the North Fork of the Maquoketa River Valley. Curt Hudak developed philosophical approaches to the analysis of Quaternary landscapes during his Ph.D. studies on the Turkey River Valley (Hudak, 1987), and later has had professional involvements in interpreting relationships in the Maquoketa River Valley (Hudak, 1989, 1990). The latter works also led to Curt's independent formulation of a hypothesis about the North Fork of the Maquoketa having originally developed as a pre-Illinoian trunk stream (Hudak, 1990).

The idea of leading this field trip was developed during conversations between Curt and Greg while both were attending the 1990 Midwest Friends of the Pleistocene field conference led by Art. The field trip project stemmed from initial enthusiasm over the convergence of two independent interpretations of the drainage evolution of the area--the idea that an exhumed ancient valley filled by pre-Illinoian deposits could be identified within the North Fork Maquoketa River Valley. Subsequent studies have not supported this hypothesis, but we are in agreement that there are still a number of interesting landscape features to challenge the imaginations of field trip participants. We each bring unique field experiences and backgrounds to the interpretation of the area, and we hope to share these with you during the course of today's trip. We emphasize that our observations and discussions lead to as many questions as answers, once again pointing to the rewards and frustrations inherent in geological field work. Perhaps the most positive outcome that we could hope for is that someone else will be stimulated to focus their energies on some of the problems we will pose during the trip.

This morning we will examine relationships between Quaternary landscapes and stratigraphy in the North Fork Maquoketa River (STOPS 1 and 2; see Fig. 1), and an abandoned drainageway south of the South Fork Maquoketa River (STOP 3 see Fig. 1).

QUATERNARY HISTORY OVERVIEW

Early geologic studies in eastern Iowa recognized a series of deep valleys cut into bedrock that were buried by glacial deposits and, in many cases, cross-cut by modern drainages. These buried valleys were usually interpreted as remnants of a pre-glacial drainage system. Hansen (1972) mapped the bedrock surface of east-central Iowa, showing the locations of buried bedrock valleys that had been given names by previous workers. Studies of the Quaternary stratigraphy of eastern Iowa undertaken in the 1970's by Hallberg utilized information from deep test holes drilled to rock to interpret the glacial sequence (Hallberg, 1980). Stratigraphic relationships among the glacial deposits in the bedrock valleys and those outside of the valleys showed that the buried bedrock valleys had formed subsequent to the earliest glaciation(s), and therefore were not pre-glacial in age (Hallberg et al., 1984; 1985).

Eastern Iowa was glaciated repeatedly during the pre-Illinoian portion of the Pleistocene. Burial and glacial erosion of the pre-existing landscape occurred to varying degrees during each glacial advance. During interglacial periods, drainage lines became integrated, entrenched, and an erosional landscape developed. The buried bedrock valleys are topographically low remnants of these landscapes. They are multi-generation, some have been occupied several times, and most importantly of all, they are not all part of a single integrated drainage network (Hallberg et al., 1985).

The present landscape of the field trip area has evolved during the last half million or so years since the last pre-Illinoian glaciation covered the area. The afternoon portion of the field trip route was also glaciated during the early part of the Illinoian, about 300,000 years ago. The present landscape owes most of its character to the presence of relatively shallow bedrock and events during the last 70,000 years, the Wisconsinan period. Most notable are periods of drainage entrenchment and backwasting of slopes forming "Late Sangamon" pediments before about 30,000 years ago, development of "Iowan" pediments during full-glacial conditions 21,000 to 16,500 years ago, and accumulation of Peoria Loess between about 21,000 and 12,500 years ago (Hallberg et al., 1978; 1984).

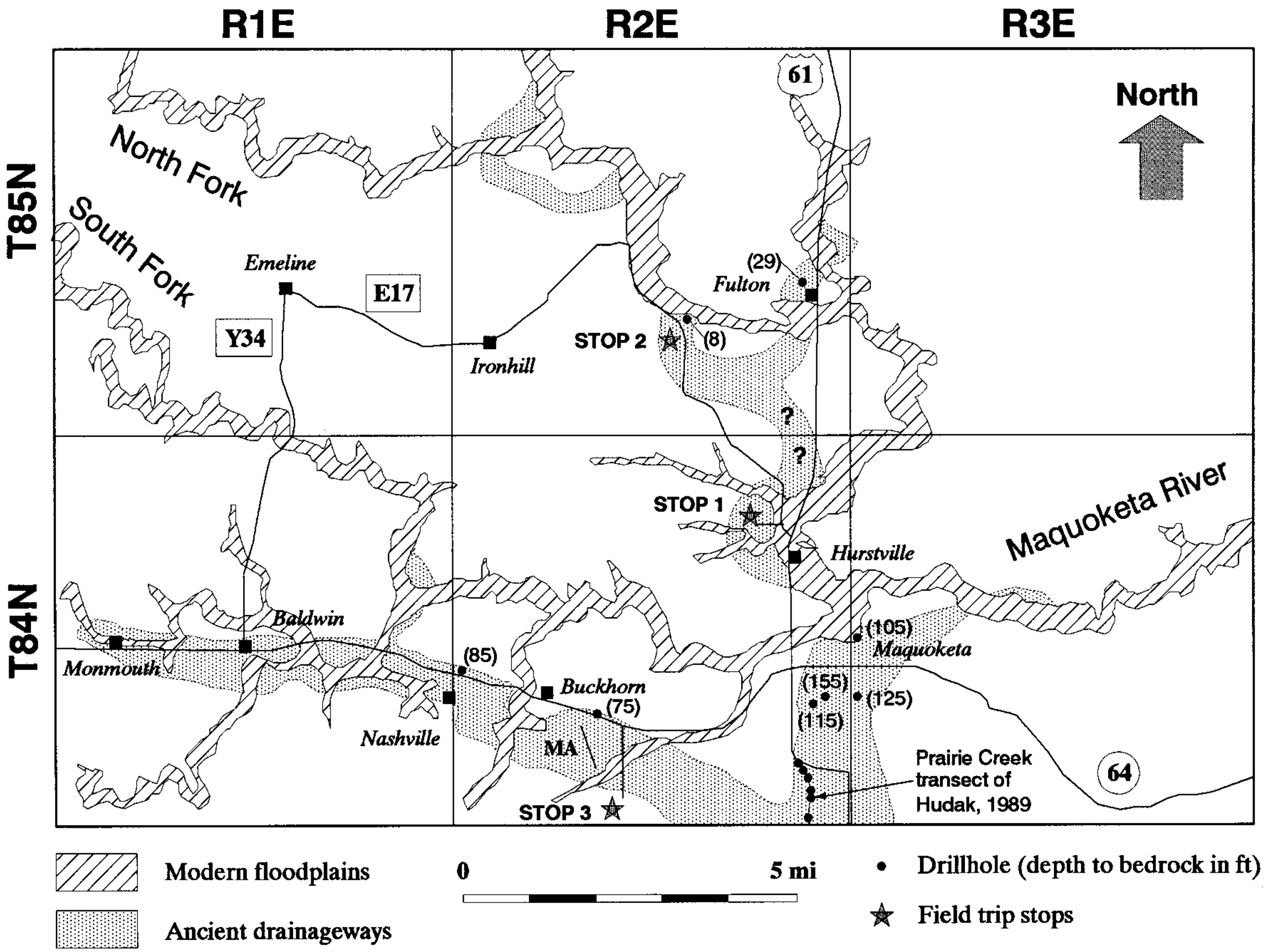

Figure 1. Location map for morning field trip stops. The Prairie Creek transect of Hudak (1989) shows the location of the profile in Figure 5.

STOP 1: GEOMORPHOLOGY OF THE HURSTVILLE AND MAQUOKETA AREAS

Curtis M. Hudak

Well log data indicate that glacially-buried bedrock valleys are found in the Hurstville and Maquoketa areas. The City of Maquoketa is overlying one such valley and uses it as a portion of their water supply. This glacially-buried bedrock valley apparently trends north-northwest to south-southeast and runs to the west side of the bedrock knob at historic Hurstville (Hansen, 1972). Soil Conservation Service staff indicate that a deep red soil was found at the land surface within the elementary school yard at Maquoketa.

The South and North Forks of the Maquoketa River have their confluence approximately two kilometers east of the US Highway 61 bridge between Hurstville and Maquoketa. The South Fork Maquoketa River Valley consists mostly of bedrock benches with few alluvial fills preserved in the vicinity. Fills that are preserved were inaccessible because of the rugged terrain; therefore, most of the geologic fieldwork concentrated on the North Fork's terraces approximately two kilometers upstream from the confluence of these two rivers (i.e., Hurstville area).

Core samples from alluvial fills beneath terraces northwest and south of Hurstville yielded five radiocarbon dates. The North-Hurstville transect has four topographically visible terraces inset below the uplands (Fig. 2). Profile 41 was a core that sampled the strata beneath the highest recognized terrace. These strata include alternating massive silt loams (interpreted as loess) with bedded silts and fine to medium sands (interpreted as alluvium) over fluvially deposited, medium to coarse, pebbly sands.

Geomorphically inset below this terrace is a terrace fill of mostly fine to medium, well-sorted sands with few to common chert pebbles. The next lower terrace is very localized and is interpreted to be an erosional surface cut into these generally well-sorted sands. The lowest recognizable terrace is also the modern floodplain for the small tributaries to the North Fork. Profile 42 and other undescribed stream-cuts indicate that adjacent to the present tributary channels there may be up to a 2.5 m thick alluvial mantle, which contains historic debris (e.g., wooden wagon-wheel in Figure 3). The surface soils typically have AC or A-C profiles to depths less than 0.3 m. The C-horizon of these historically deposited sediments are noncalcareous, alternating laminar beds of unoxidized silts and oxidized fine sands. A late Holocene-aged soil (710 ± 80 yr. B.P.; Profile 37; Beta-27436) is buried by this post-settlement alluvium.

The highest recognized terrace from the North-Hurstville transect (Fig. 2) was correlated to the broad terrace west and southwest of Hurstville (Profiles 49, 57, and 62-64). The depositional environments of the terrace fill and surface soil at Profile 41 (North-Hurstville transect) is nearly identical to those at the south Hurstville transect (Fig. 4). The high terrace profiles of the South-Hurstville transect all have massive silt loams alternating with horizontally-bedded silts and sands to depths of approximately 3.0-5.0 m. These strata lie above pebbly, medium to coarse sands of loose consistency, which in turn overlie pebbly, medium to coarse sands that are weakly cemented. Sediments from near the lower boundary of the alternating silts and sands yielded a radiocarbon date of 28,370 ± 550 yr. B.P. (Fig. 4; Beta-28529).

The surface soils under this high terrace (including Profile 41) all have eluvial (E) and argillic (Bt) horizons. The C-horizons are usually deoxidized and are noncalcareous to depths of approximately 4.0 m. One clay horizon of nonpedogenic origin was identified in both Profiles 49 and 57. Laminar bedding was identified in this clay bed from Profile 57, while laminar bedding could only be identified in silt units immediately above and below the clay unit of Profile 49. Cores 49 and 57 were taken at the same elevation on the terrace and documented the clay layer at 1.68-1.95 m depth with clear upper and lower boundaries, and 1.68-1.91 m depth with abrupt upper and lower boundaries, respectively. Ped development has affected both clay beds in each respective core sample, although the ped development may not be related to the present surface soil processes. Other cores indicate that this clay horizon is apparently discontinuous. This clay unit is currently interpreted to be a slackwater deposit from an ancient oxbow lake while flowage occurred east of Hurstville.

Inset below this high terrace is another terrace fill, which includes 2.0-2.8 m of mostly silty clay loams overlying a 1.0-4.5 m thick sandy loam to coarse sand unit. These units overlie a massive clay loam diamicton interpreted to be pre-Illinoian till (Profiles 33-34; Fig. 4). The basal silty clay loam (above the sandy loams) yielded a radiocarbon date of 9,790 ± 130 yr. B.P. (Beta-27434), and apparently represents deposition in a slackwater environment.

The surface soils on this terrace are cummulic (sedimentation rates relatively high compared to pedogenic rates), and may have cambic horizons (Bw) depending on local rates of sedimentation (relatively slow sedimentation rates would allow time for the Bw-horizon to develop). Several buried carbon-rich beds and/or A-horizons were documented in Profile 33. These beds/horizons must be younger than the stratigraphically lower 9,790 yr. B.P. radiocarbon date.

The Hurstville wetland (west of Hurstville) was previously a low terrace associated with the small tributaries now found to the northwest of Hurstville (see historic photograph at the Hurstville Lime Kilns Interpretation Center). The present wetland is man-made (personal communication with local landowners, 1988). A hand-held, soil probe helped to identify a complex suite of interfingering alluvial sands and silts in the wetland. When present the surface soils were composed of A-C or O-C profiles.

SOUTHWEST MAQUOKETA AREA

Seven cores were taken across the Prairie Creek valley (see Fig. 1; Fig. 5), which is one of the broad valleys mentioned above. Four of these cores reached bedrock although only one core sample yielded a radiocarbon date. This radiocarbon date of 26,110 ± 410 yr. B.P. (Beta-27433) was from the high terrace fill, which contained interbedded alluvium and loess. Geomorphically inset below this high and broad terrace are at least three bedrock benches with relatively thin alluvial mantles. Clay loam diamictons were present stratigraphically under the alluvial mantles and above the bedrock. These diamictons are interpreted to be pre-Illinoian aged tills or colluvium derived from these tills.

Hansen (1972) indicated that the glacially buried bedrock valleys are very close to this transect of cores. These modern valleys have apparently not eroded the tills from the pre-Illinoian aged bedrock network of valleys. The "uplands" in this area have stratigraphic profiles indicating alternating massive silt loams (loess) and laminar silts and fine sandy loam beds. The basal silts contain carbon flecks, which overlie crudely bedded, silty clay loam diamictons of reddish hues (5YR-7.5YR4/6). The diamicton is interprted to be till-derived colluvium, and is probably part of the "Sangamon" pedisediment.

DISCUSSION

Broad valleys developed/aggraded between approximately 29,000 and 16,000 yr. B.P. What could cause the broad valleys west and south of Maquoketa and also the second valley west of Hurstville? Working hypotheses must now include the possibility that these broad valleys are NOT ancient remnants of the pre-Illinoian aged, drift-filled, bedrock valleys because these broad valleys do not necessarily follow the drift-filled bedrock valleys. These broad valleys have high terrace fills that have yielded radiocarbon dates of 28,370 and 26,110 yr. B.P. Furthermore, core samples from local headwater valleys have yielded four radiocarbon dates between 20,000 and 19,000 yr. B.P. The oldest radiocarbon dated terrace fill inset below the high terrace yielded radiocarbon dates of 13,320 and 13,280 yr. B.P. Mounting evidence continues to point towards the possibility that large amounts of water moved along these broad valleys during the mid to late Wisconsinan.

These broad valleys are not necessarily long, nor do they have an extensive drainage network by todays standards. So how do these valleys develop when it seems apparent that large volumes of water moved along them. Bettis and Kemmis (1992) suggested that rainfall on frozen ground (permafrost) could produce large run-off to create the thick coarse-grained fill found beneath the high terrace in the present-day large valleys of Iowa. Perhaps these broad valleys in the Maquoketa area fed the major modern-day valleys with their gravel trains, and/or developed as a result of these main modern-day valleys being choked with sediment. The latter hypothesis would explain the reason why one of these broad valleys has a divide located within it that suggests flowage occurred in opposite directions. The high terraces in other valleys of northeastern Iowa also have radiocarbon dates that correlate closely in time with the mid to late Wisconsinan (Hudak, 1987).

ACKNOWLEDGEMENTS

Data for parts of the field trip was collected during cultural resource assessment studies along the proposed U.S. Highway 61 right-of-way and proposed alternative routes conducted by BRW, Inc. and funded by the Iowa Department of Transportation (BRW, 1989).

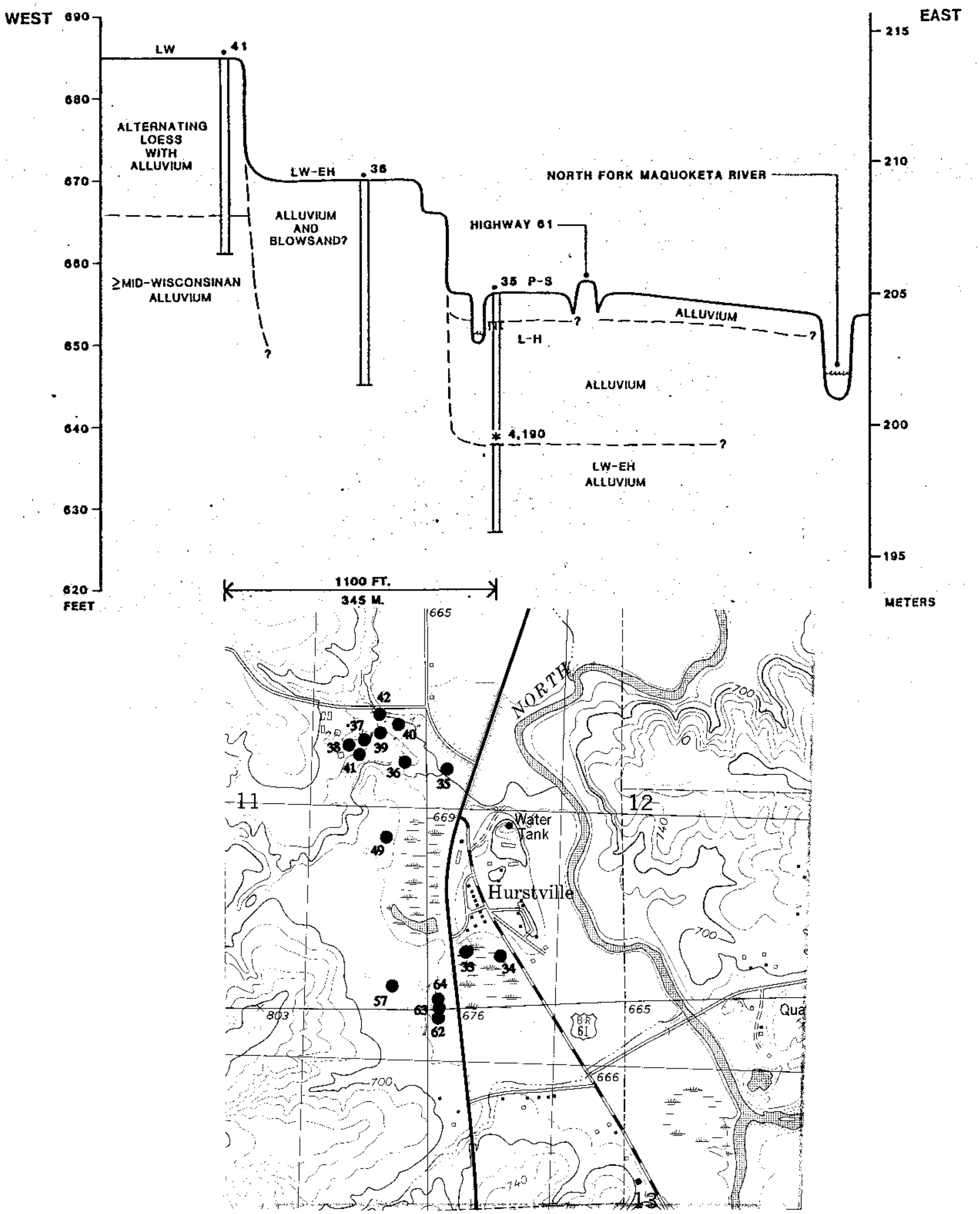

Figure 2. North-Hurstville cross-valley profile. Note Post-Settlement alluvial mantle on Late Holocene terrace. LH = Late Holocene terrace and terrace fill; LW-EH = Late Wisconsin-Early Holocene terrace and terrace fill. Asterisks and adjoining numbers represent organic materials and radiocarbon date in years Before Present. Map shows locations of profiles for figures 2, 3, and 4.

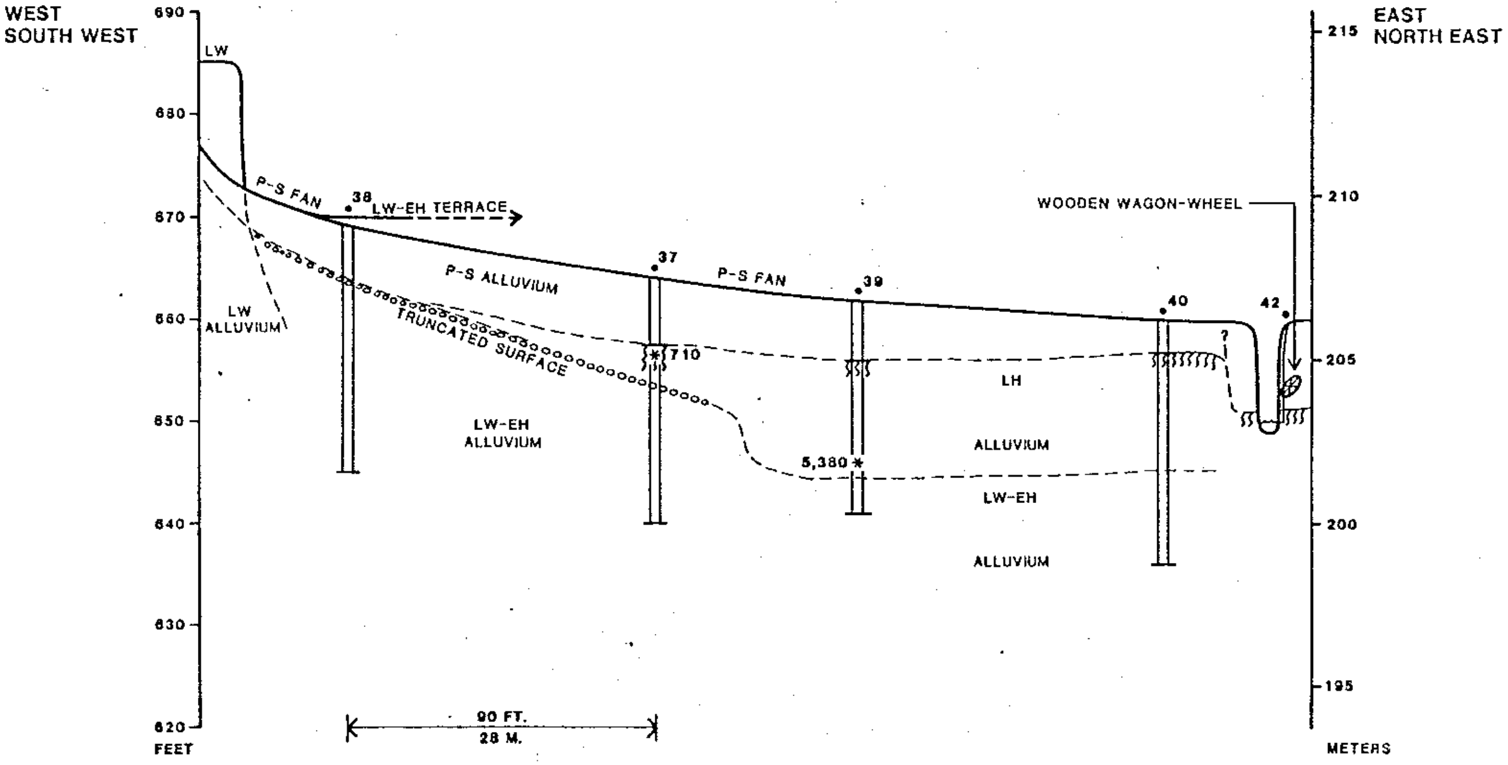

Figure 3. Post-Settlement alluvial fan. See Figure 2 for legend.

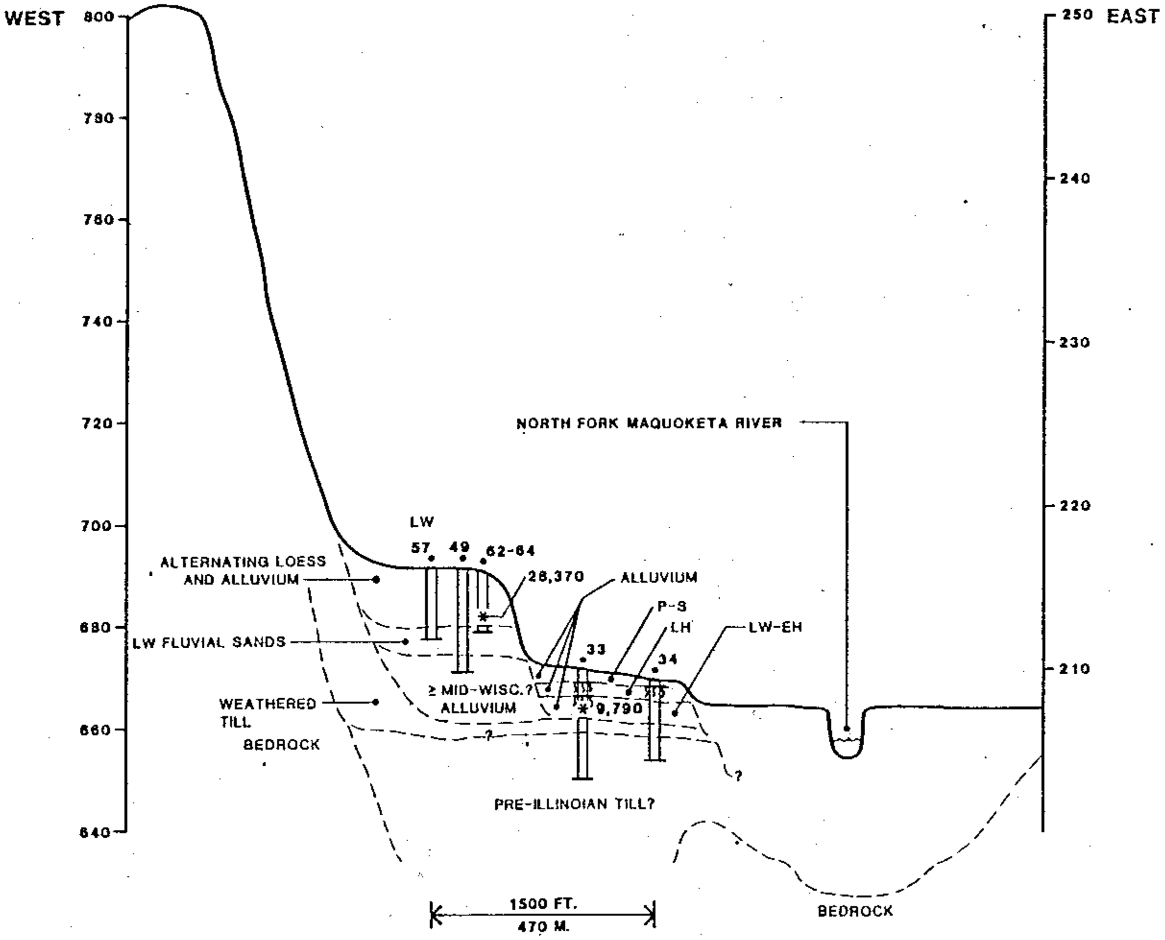

Figure 4. South Hurstville cross-valley profile. See Figure 2 for legend.

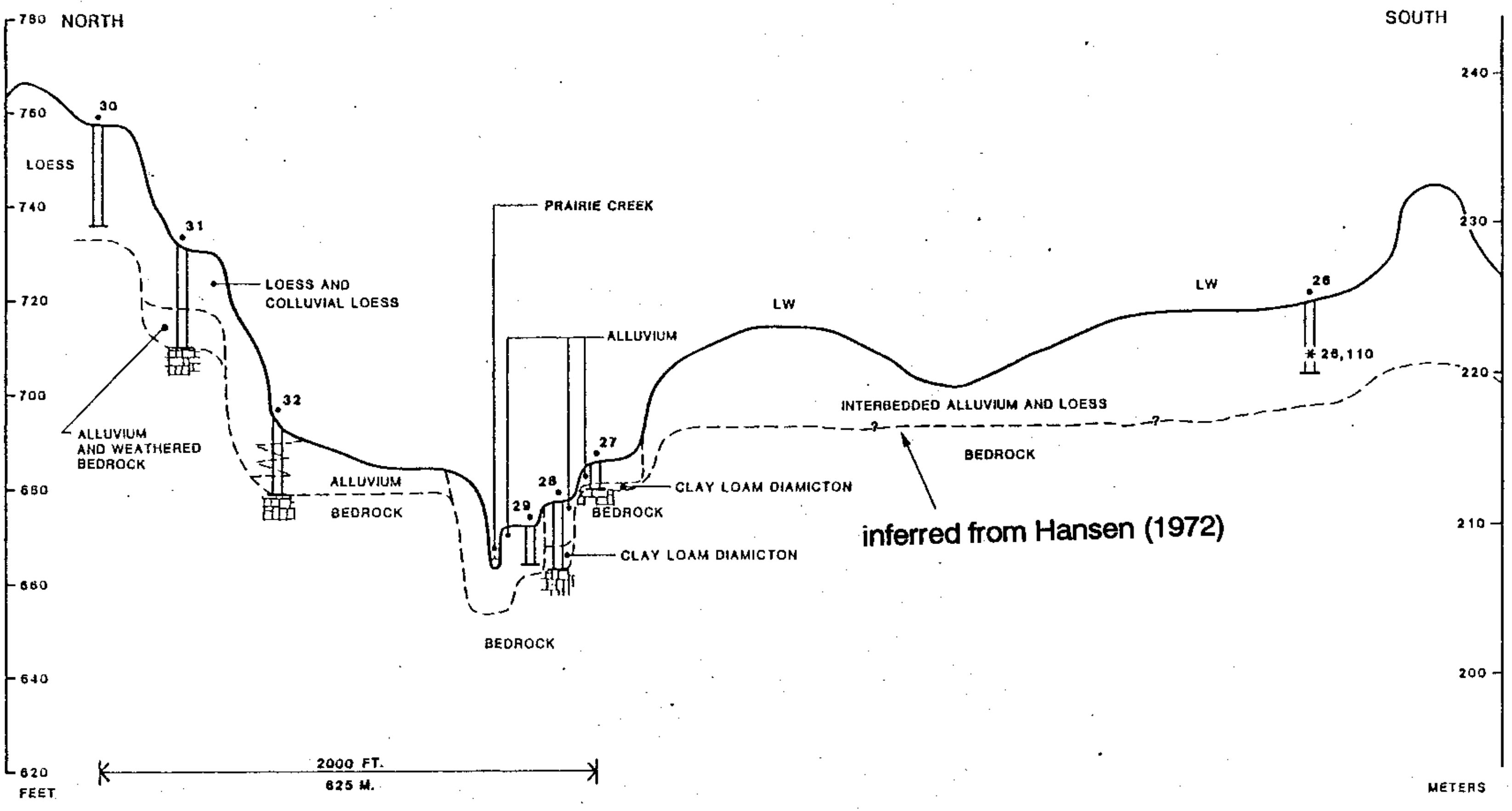

Figure 5. Prairie Creek cross-valley profile. See Figure 2 for legend. See Figure 1 for location.

STOP 2: INVESTIGATIONS NEAR FULTON: IS THE NORTH FORK MAQUOKETA RIVER VALLEY AN EXHUMED PRE-ILLINOIAN VALLEY?

Early geological investigators were aware of the presence of abandoned drainageways in Jackson County. Savage (1906) discussed the general significance of the Goose Lake Channel (which we will visit this afternoon). Swenson et al. (1941) mapped the Goose Lake Channel in detail, and also mapped the southeastward trending paleovalley encompassing the towns of Monmouth, Baldwin, and Nashville (Fig. 1), and a possibly related north-south trending paleovalley underlying the City of Maquoketa.

A problem is posed by the low-relief lowland area in the paleovalley encompassing the City of Maquoketa and the area to its immediate south. This roughly north-south trending lowland area bisects narrow, steep-walled portions of the Maquoketa River Valley upstream (west) and downstream that are deeply incised into bedrock uplands. Municipal wells in Maquoketa show that this lowland area is characterized by deep bedrock, more than 100 feet below the surface (Fig. 1). Quaternary sequences filling this paleovalley include pre-Illinoian(?) tills overlying gravels. Widely scattered drillhole information along the Monmouth-Baldwin-Nashville paleovalley also show relatively deep bedrock, with sequences of pre-Illinoian till overlying gravels. These ancient valleys literally abut geological terranes with deeply dissected bedrock to the immediate north.

Where are the headwaters areas of these paleovalleys? Do they abruptly terminate west of Monmouth and north of Maquoketa, or can they be traced into the dissected bedrock landscapes? Some possible answers were suggested during the compilation of bedrock exposures for the purposes of bedrock topographic mapping as a component of the mapping of groundwater vulnerability regions of the state of Iowa (Hoyer and Hallberg, 1991). The lower more southerly trending reaches of the North Fork Maquoketa River Valley alternate between narrow, steep-walled segments cutting through Silurian bedrock, and wider segments with more gently-sloping walls that lack bedrock exposures (Fig. 6). This observation led to the hypothesis that the gently-sloping valley walls are eroding remants of the sedimentary fill in a partially exhumed northern extension of the paleovalley underlying the City of Maquoketa. A corollary to this hypothesis is that these paleovalley segments contain deeper sedimentary fills than the more modern bedrock-walled valley segments, since they putatively are portions of the same deeply incised valley system (Hypothesis 1 of Fig. 7).

Figure 1 shows the positions of abandoned drainageways in stippled patterns. Segments with gently-sloping valley walls in the lower reaches of the North Fork Maquoketa Valley conform to meander loops that are either: 1) former pathways of a partially exhumed, more deeply incised paleovalley (Hypothesis 1, Fig. 7), or 2) remnants of former courses of the North Fork Maquoketa River during earlier stages of downcutting (Hypothesis 2, Fig. 7). Under hypothesis 1 (Fig. 7), the meandering ancient drainageways upstream from Fulton were proposed to be remnants of a once contiguous pre-Illinoian paleovalley that drained towards Hurstville, where it supposedly connected with the paleovalley beneath the City of Maquoketa. The narrow bedrock-walled valley of the North Fork Maquoketa to the east of the U.S. Highway 61 bridge is floored by bedrock rapids (Fig. 6), and cannot have been part of the hypothesized paleovalley system. A hypothetical paleovalley segment (queried in Fig. 1) was proposed to extend through an upland area lacking bedrock exposures, thus connecting ancient valley segments in the Fulton and Hurstville areas, and suggesting that the paleovalley bifurcated near Fulton just as the modern North Fork Maquoketa River joins in confluence with Farmers Creek at Fulton.

We decided to test these competing hypotheses by drilling in several reaches of ancient drainageways in the North Fork Maquoketa River Valley. The presence of bedrock rapids along the North Fork Maquoketa River just to the east of the U.S. Highway 61 bridge south of Fulton adds an important constraint to the test, because this observation indicates that deep alluvial fills are not present beneath the floor of the modern floodplain. If the ancient drainageways along the North Fork Maquoketa are exhumed pre-Illinoian paleovalleys as outlined above, drilling with a Giddings rig would definitely not be able to penetrate the bedrock surface, and might be expected to penetrate sections of pre-Illinoian tills (Hypothesis 1, Fig. 7). Alternatively, if the ancient drainageways are only remnants of earlier stages of downcutting by the North Fork Maquoketa River, drilling sites near their intersections with the modern floodplain would probably be able to reach the bedrock surface with a Giddings rig (Hypothesis 2, Fig. 7).

In order to examine the sequence of deposits in the presumed paleovalley we drilled hole 49GL-1 in the road ditch near the center of the inferred channel, and examined the remaining sequence to the land surface in the road cut west of the road. From the land surface down the sequence encountered was:

Depth (ft)	Description
0-15	Peoria Loess with surface soil developed in its upper part.
15-16.5	Farmdale Soil developed in Pisgah Fm. pedisediment.
16.5-29.5	Sangamon Soil developed in clay loam grading downward to silty clay loam alluvium/colluvium.
24.0	modern surface in road ditch; cored below this level
29.5-34.5	gray (2.5Y hue) stratified clay loam and medium to coarse pebbly sand alluvium/colluvium with occasional clasts up to 3 inches in diameter. Many of the clasts are igneous and metamorphic rocks. Pebble band at base.
34.5-36.0	brown and reddish brown (7.5YR and 5YR hue) silty clay grading downward to loam. This zone is an eroded paleosol developed in weathered dolostone and grades into harder weathered dolostone.

This sequence of deposits accumulated in a former course of the North Fork Maquoketa Valley. The bedrock floor of the former valley was at about the same level, or slightly above that of the present North Fork, and therefore was not part of a deeply entrenched paleovalley system. The presence of the Sangamon Soil developed in the upper part of the valley fill sediments suggests a early or pre-Wisconsinan age for this abandoned valley segment.

Drilling in the abandoned valley segment to the immediate northwest of Fulton revealed a different sequence of Quaternary deposits. At that location 29 feet of fine to medium sand grading downward to pebbly sand overlay Silurian bedrock. The upper 19 feet of the deposits are interpreted as interbedded local alluvium and eolian sand, while the basal 10 feet are alluvium. The absence of buried paleosols and major changes in materials indicates that the entire sequence is related in time and is probably late Wisconsinan in age.

This abandoned valley segment is also not a part of a deeply entrenched ancient drainage system. Elevation of the rock surface beneath this site is approximately the same as beneath the modern North Fork Maquoketa immediately to the south.

This exercise illustrates the importance of using multiple working hypotheses in geological research. The distribution of bedrock outcrops north of Maquoketa, and well log data from the Maquoketa area suggested the presence of an ancient, deeply entrenched, south-trending drainage system (Hypothesis 1). The alternative hypothesis (# 2) is that the abandoned valley segments north of Maquoketa are not genetically related to the buried bedrock valley, but are simply remnants of earlier stages in the downcutting history of the present drainage network. Selection of the drill hole locations was facilitated by having both hypotheses to work with; we chose the center of abandoned valley segments upstream of the deeply entrenched, buried channel at Maquoketa. The absence of deeply entrenched buried valley segments at the two locations chosen also eliminates the possibility of parts of the deeply entrenched buried valley system farther up the North Fork Maquoketa system.

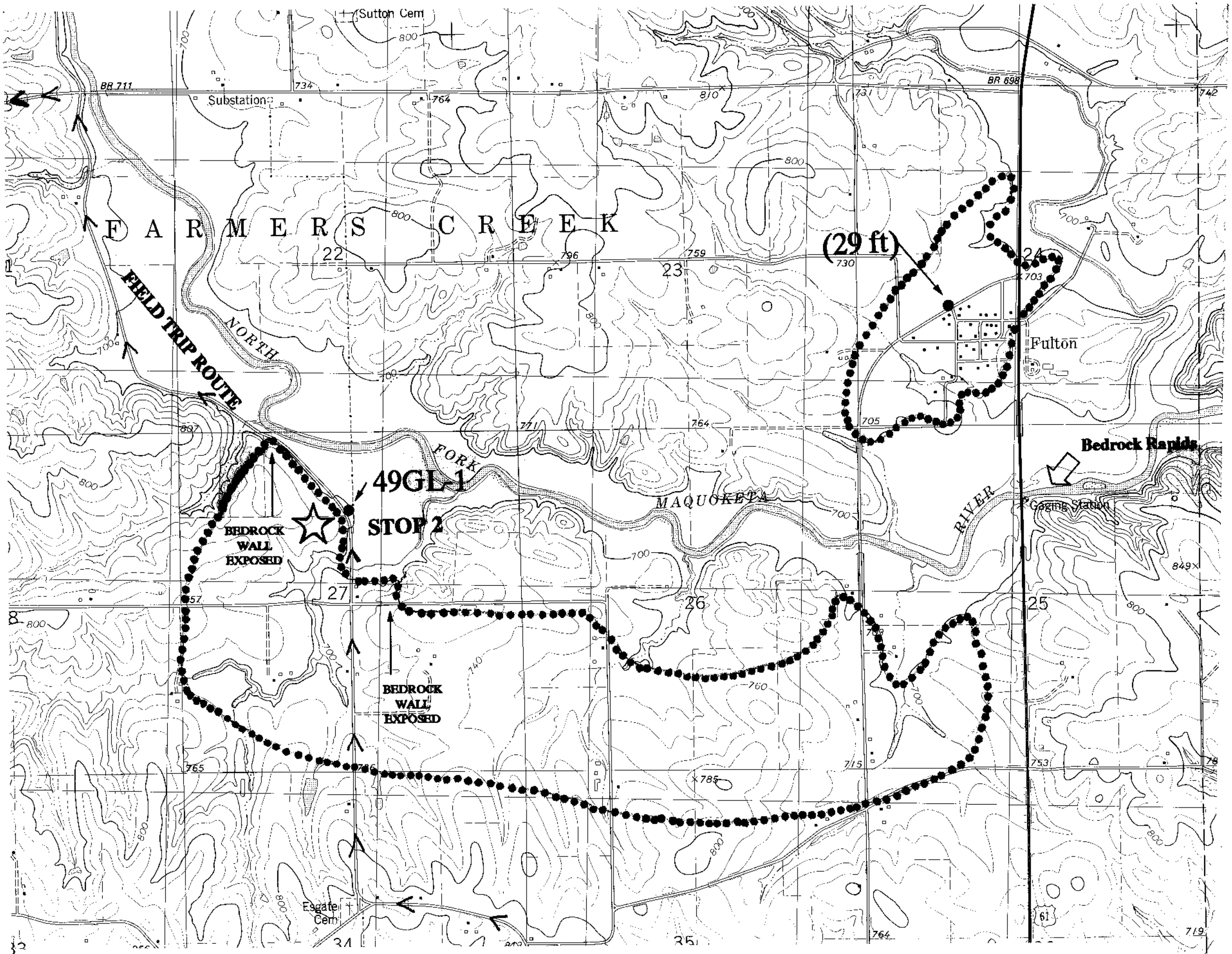

Figure 6. Topographic map of STOP 2 and environs in the Fulton area along the North Fork Maquoketa River. The dotted areas denote abandoned valley segments. From the Fulton 7.5 minute quadrangle (1:24,000), 20 foot contour interval.

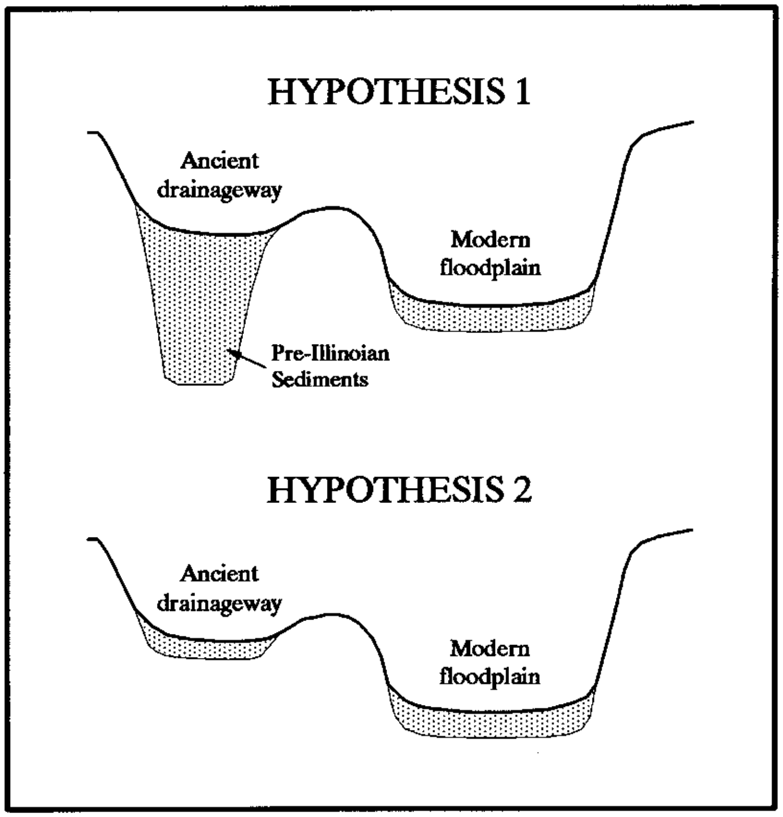

Figure 7. Schematic diagrams of alternative hypotheses for the origin of abandoned valley segments in the North Fork Maquoketa River. Drilling results support hypothesis 2.

STOP 3. MONMOUTH-BALDWIN-NASHVILLE PALEOVALLEY

This stop is an overview of a west-east trending paleovalley between Monmouth and Maquoketa in southwestern Jackson County (Figs. 1 and 8). Several modern drainage lines cut northward across the trend of the paleovalley on their way to the South Fork Maquoketa. Logs of wells in the paleovalley northeast of Nashville and along the paleovalley's margin north of the Maquoketa airport show 85 to 75 feet of Quaternary deposits overlying Silurian dolomite (IDNR-GSB file information). From the surface downward the well northeast of Nashville (well W-10856) encountered 45 feet of alluvium and slopewash, 15 feet of pre-Illinoian glacial till, and 25 feet of sandy alluvium beneath the till. North of the Maquoketa airport (well W-12101) the sequence was 55 feet of pre-Illinoian till overlying 20 feet of sandy and gravelly alluvium. This paleovalley contains alluvium buried by pre-Illinoian glacial deposits, and is therefore pre-Illinoian in age. Mineralogy of the clay fraction of samples from the glacial till in this paleovalley near the Maquoketa airport indicate that this is Alburnett Formation till, deposited by some of the earliest pre-Illinoian glaciers to cover eastern Iowa (George Hallberg, personal communication). Tills of the younger pre-Illinoian Wolf Creek Formation are usually found as remnants on uplands higher in the landscape (Hallberg, 1980).

The elevation of the bedrock surface in the Monmouth-Baldwin-Nashville paleovalley is significantly higher than that in the north-south trending paleovalley at Maquoketa (IDNR-GSB file information), suggesting that the two paleovalleys are not part of an integrated drainage network. This is in line with other observations indicating that the bedrock surface of eastern Iowa is multi-generation in origin, recording several episodes of drainage entrenchment into bedrock, and subsequent removal of parts of the record by glacial and subaerial erosion (Hallberg et al., 1985).

Shallow subsurface investigations across the Monmouth-Baldwin-Nashville paleovalley in the vicinity of the Maquoketa airport showed that significant slope erosion (pedimentation) occurred on the slopes of the paleovalley during the Wisconsinan (George Hallberg, personal communication). In many areas Peoria Loess buries Silurian bedrock with no intervening Quaternary deposits. Downslope thick sequences of slopewash materials are present along the axis of the exhumed paleovalley. These stratigraphic relationships are similar to those observed by Hudak in Prairie Creek to the east (see STOP 1 discussion).

Many issues regarding the origin and process(es) of exhumation of this paleovalley remain unresolved. We do know that the valley is exhumed, pre-Illinoian in age, and not related to the modern drainage network. The period, or more likely, periods during which the valley became exhumed, the exhumation processes, and the reasons why the modern drainage system cross cuts the paleovalley are interesting questions that need further study.

This concludes the morning field trip stops. Follow the field trip leaders into Maquoketa for a lunch break, and then reassemble for the afternoon portion of the field trip.

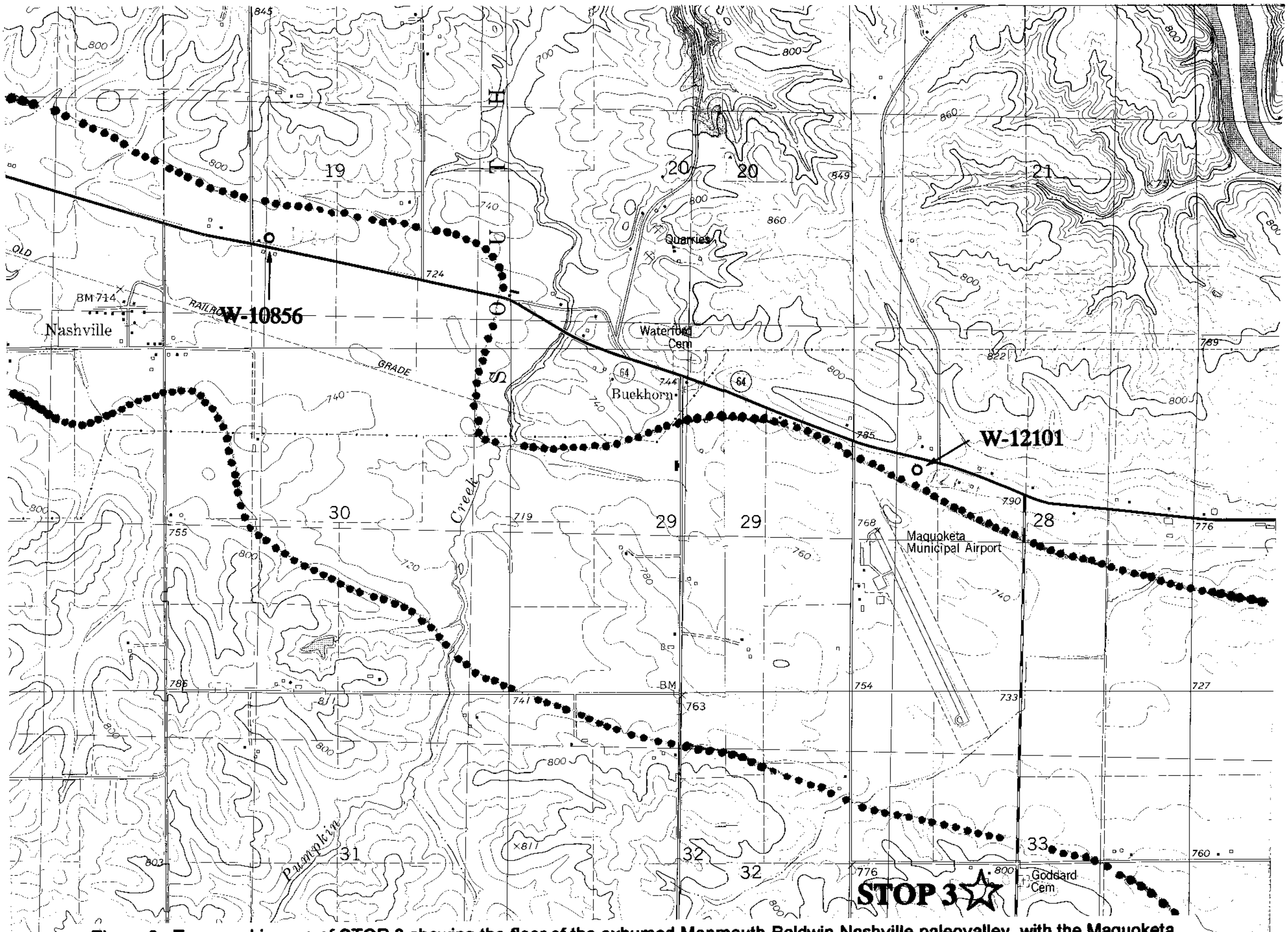

Figure 8. Topographic map of STOP 3 showing the floor of the exhumed Monmouth-Baldwin-Nashville paleovalley, with the Maquoketa Municipal Airport (MA in Fig. 1) at its eastern end. The exhumed palevalley is bounded by upland elevations greater than 840 feet above sea level, with valley floor elevations below 740 feet where cross cut by northward draining tributaries to the South Fork Maquoketa River. From Baldwin and Maquoketa 7.5 minute quadrangles (1:24,000), 20 foot contour interval.

INTRODUCTION TO AFTERNOON STOPS

The afternoon portion of the field trip will examine and discuss younger aspects of the drainage history that are related to the Mississippi Valley. The drainage lines discussed this afternoon are Illinoian and younger in age, and not buried by glacial till. As during the morning stops, we will present a mixture of past and present studies, and interpretations ranging from best guesses to well-documented scenarios.

STOP 4. GOOSE LAKE CHANNEL OVERVIEW.

This brief stop is along the western margin of the Goose Lake Channel west of Preston, and provides a good view of the wide, north-south trending valley that has been interpreted as an Illinoian-age diversion channel of the Mississippi River (Carman, 1909; Leverett, 1921; Anderson, 1968). Below us lies Deep Creek, flowing northward to its confluence with the Maquoketa River near Spragueville (Fig. 9). Goose Lake, the wetland from which the channel derives its name, is located in the abandoned valley about 5.5 miles to the south on the divide between Deep Creek and Brophy's Creek, which flows southward through the Goose Lake Channel to the Wapsipinicon River.

A prominent, paired loess-mantled terrace covers most of the floor of the Goose Lake Channel, and the Holocene alluvial fill of Deep and Brophy's creeks is inset below it. As we drive to the next stop, note that a 10 to 15 foot high scarp separates the loess-mantled terrace from the Deep Creek floodplain.

Uplands in this area are typical of the Southern Iowa Drift Plain in eastern Iowa, and consist of multiple stepped surfaces developed on eroded pre-Illinoian till, and in a few cases, such as along the Plum River Fault Zone, bedrock. A variable thickness of late Wisconsinan loess mantles all but the lowest stepped surfaces. The greatest loess thickness, on upland divide areas, is about 22 feet.

As we proceed to the next stop at Spragueville note that the Goose Lake Channel narrows and the scarp separating the loess-mantled terrace from Deep Creek's floodplain heightens. At Spragueville, on the northern end of the Goose Lake Channel, the west side of the channel is a bedrock bench (strath) mantled with a thin veneer of alluvium and loess, and the more deeply entrenched part of the Goose Lake Channel (now occupied by the floodplain of Deep Creek) is very narrow.

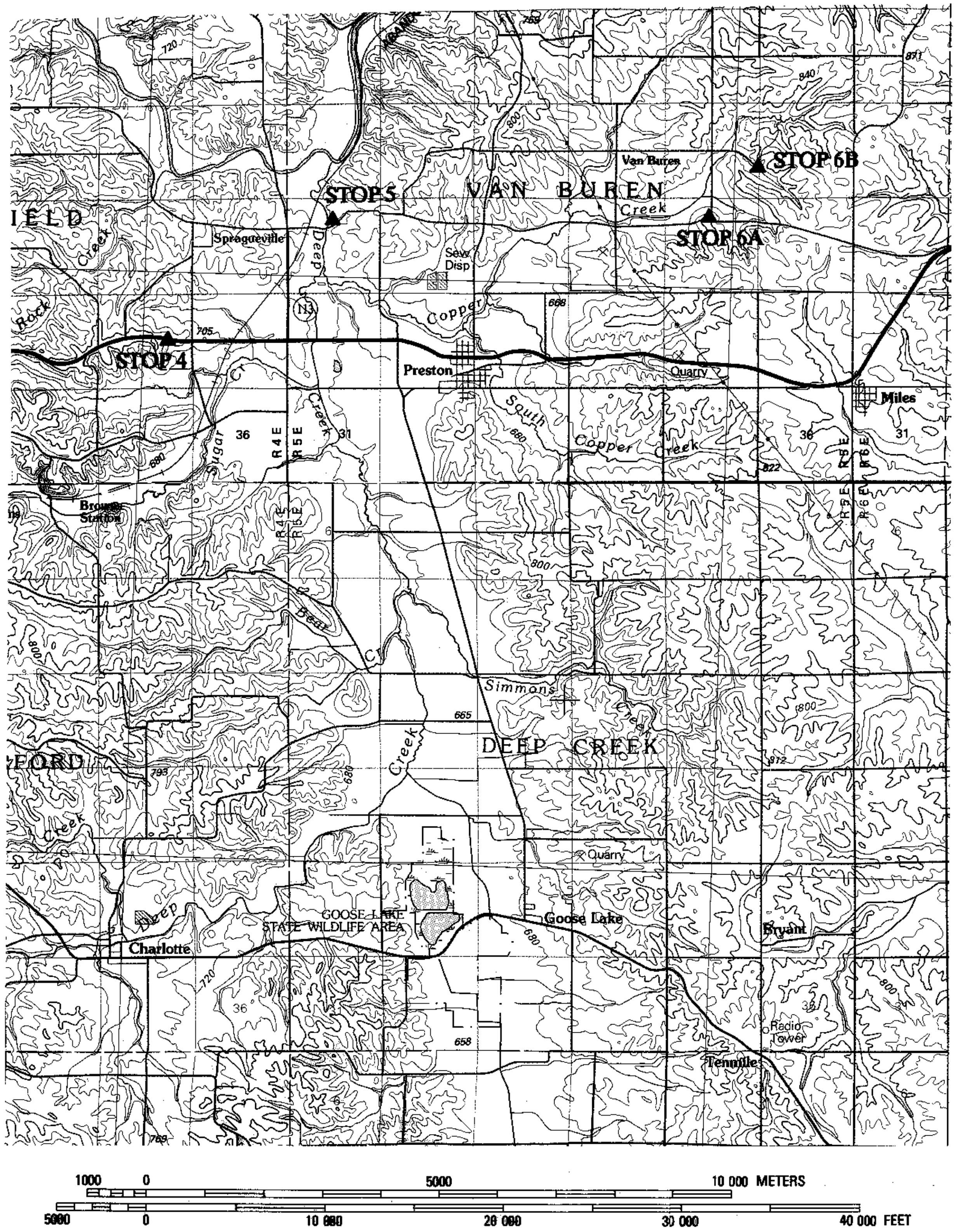

Figure 9. Topographic map of the Goose Lake Channel area, showing locations for field trip STOPS 4, 5, 6A, and 6B. From the Jackson and Clinton County 1:100,000-scale topographic maps, 40 foot contour interval.

STOP 5. QUATERNARY STRATIGRAPHY AND HISTORY OF THE GOOSE LAKE CHANNEL.

The Goose Lake Channel has long been recognized as a former course of the Mississippi River, yet very little study of the abandoned valley's stratigraphy has occurred (Leverett, 1899; Udden, 1899; Norton, 1899; Carman, 1909; Anderson, 1968). The general idea is that the Mississippi Valley was blocked in the vicinity of Savanna, Illinois during advance of the Illinoian glacier that deposited the Kellerville Till Member of the Glasford Formation. The blocked waters ponded up the Maquoketa Valley and eventually spilled over a low divide in the vicinity of Spragueville (or Preston), whereupon the Goose Lake Channel was formed. The Goose Lake Channel carried the Mississippi's flow southward along the ice margin to the Wapsipinicon Valley and into another ice-marginal diversion channel, the Cleona Channel (Fig. 10). With the retreat of Illinoian ice, the Mississippi re-occupied its former bedrock channel south of Savanna and Goose Lake Channel was abandoned.

This was a nice, tidy story until Richard Updegraff undertook a study of the shallow stratigraphy of the Goose Lake Channel as part of his M.S. degree at the University of Iowa in the late 1970's and early 1980's (Updegraff, 1981). He found that the alluvial fill of the loess-mantled terrace graded upward into late Wisconsinan Peoria Loess. No evidence of weathering or erosion separated the alluvial fill from the overlying loess, and therefore the two were closely related in time. The loess was thinner on the terrace than on adjacent upland summits (terrace average-12 feet; upland summit average-22 feet) and the terrace lacked an older Wisconsinan loess, the Roxana Silt (Pisgah Formation) that was present on the upland. In addition, the Farmdale Soil, found developed in the upper part of the Roxana on upland divides was not present beneath the Peoria Loess on the terrace's alluvial fill. These lines of evidence indicated that the upper part of the alluvial fill was younger than the Farmdalian (approximately 25,000-21,000 B.P.) but older than the upper part of the Peoria Loess (minimum age about 12,500 B.P.). The minimum age of the terrace fill was further constrained by a radiocarbon age of 11,010±110 B.P. (Beta-1140) obtained from peat beneath Goose Lake, overlying the loess mantle of the alluvial fill. On the basis of these relationships we estimate the age of the top of the alluvial fill beneath the loess mantled terrace at about 15,000 to 16,000 B.P.

Similar stratigraphic relationships have been documented for the Late Phase High Terrace in the Iowa-Cedar Valley (Esling, 1984), and in the Cleona Channel to the south (Autin and Bettis, 1991; 1992). The alluvial fill beneath the Late Phase High Terrace accumulated from at least the Farmdalian through the late Wisconsinan and was derived in large part from extensive upland erosion during development of the Iowan Erosion Surface. Figure 11 shows that the surface of the alluvial fill beneath the loess-mantled terrace in the Goose Lake Channel slopes northward to the Maquoketa Valley north of Goose Lake, and southward toward the Wapsipinicon Valley south of Goose Lake. This indicates that the upper part of the Goose Lake Channel's alluvial fill was deposited by two drainage systems; one draining north to the Maquoketa Valley and another southward to the Wapsipinicon Valley.

Unfortunately, the upper part of the alluvial fill doesn't necessarily tell us the whole story. Logs of several water wells drilled in the Goose Lake Channel between Preston and Goose Lake show that the valley contains at least 120 feet of alluvial fill. Some wells encountered "gray clay" between sand and gravel, possibly suggesting multiple upward-fining sequences in the valley. Although it seems certain that the upper part of the alluvial fill is late Wisconsinan in age and deposited by local drainage systems, rather than the Mississippi River, we can't assume that is the case for the entire alluvial fill in the valley. In the case of the Iowa and Cedar valleys, as well as the Cleona Channel, pre-Wisconsinan (post-Kellerville) alluvium lies beneath the Early Phase High Terrace. The surface of that terrace is elevated above the loess-mantled late Wisconsinan terrace (Late Phase High Terrace) in those valleys. Why no equivalent older terrace exists in the Goose Lake Channel is problematic if it shares a common Illinoian history with the Cleona Channel to the south.

Our STOP 5 parking area at the Spragueville County trail head is located along the narrowest portion of the Goose Lake Channel. The east wall of the deeply incised channel exposes Silurian dolostones at the east edge of the Deep Creek floodplain, and the west wall exposes Silurian dolostone on the eastern-facing scarp of the Spragueville strath (Fig. 12). At this locality, the total width of this deeply incised channel (containing more than 100 feet of fill?) is about 1000 feet. This segment of the channel presents a dramatic contrast with the channel morphology 0.5 miles to the south, where lowland drainages into the channel extend for approximately 6 miles in an east-west direction. The abrupt change in valley morphology results from changes in the shallow bedrock resulting from vertical displacements along the Plum River Fault Zone. Ludvigson (1988; Fig. 12) mapped the geology of this area, and showed that the broad lowlands of the Goose Lake Channel to the south of the Plum River Fault Zone are underlain by the Brainard Shale of the Ordovician Maquoketa Group, whereas the narrow bedrock-confined segment of the Goose Lake Channel east of the Spragueville strath cuts through Silurian dolostones.

The differing geomorphic expressions for these two fault-juxtaposed rock sequences is believed to be related to differential rates of slope retreat, with more rapid erosion of Brainard Shale slopes leading to more gentle slopes and a wider valley segment. Northward-facing slopes forming the south wall of the valley of Copper Creek, the westward flowing tributary to the Goose Lake Channel along the Plum River Fault Zone, clearly illustrate these bedrock controls on valley morphology, and will be the subject of the next stop.

In the mid-1980's, when geologic mapping was underway, exposures of the Farmers Creek Member of the Hopkinton Formation, containing the important index fossil *Cyclocrinites* (a calcareous green algae) were found at the bedrock scarp of the Spragueville strath, and in natural exposures to the south of the county highway passing east out of Spragueville. Natural exposures and overgrown railroad cuts along the abandoned Chicago, Milwaukee, and St. Paul railroad right-of-way to the north of the county road showed exposures of abundantly fossil-moldic dolostones with echinoderm debris, gastropods, and rare pentamerid brachiopods. Ludvigson (1988) erroneously interpreted these rocks to be portions of the Welton Member of the Scotch Grove Formation, and thus interpreted the Hopkinton strata exposed at Spragueville to be contained within a narrow horst (Fig. 12). New roadcuts along the more recently completed county trail also expose *Cyclocrinites*, and clearly show that the exposures to the north of the county road are part of the Hopkinton Formation.

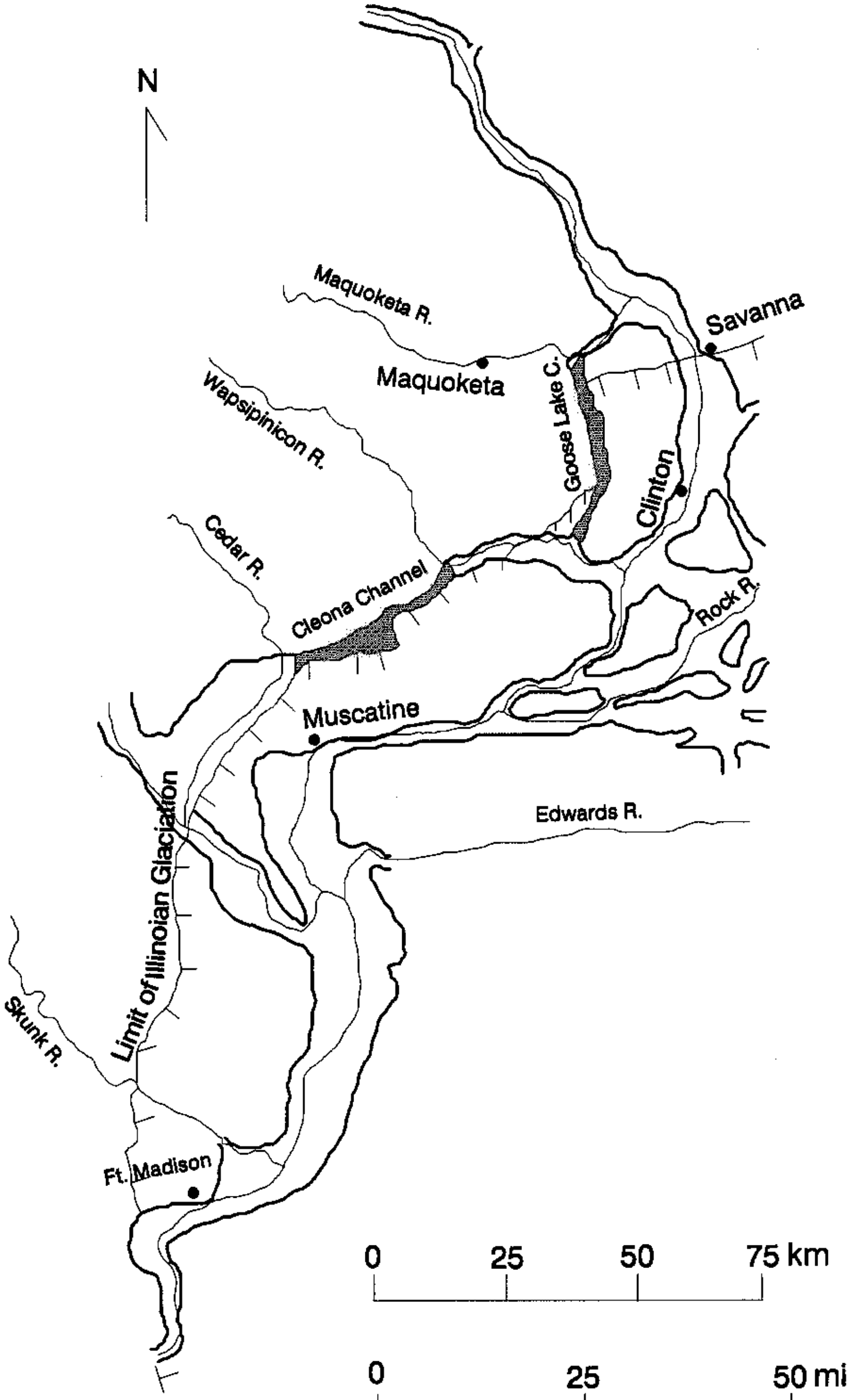

Figure 10. Map showing regional relationships among the early Illinoian glacial limit, Mississippi River diversion channels, and modern river valleys in the field trip area.

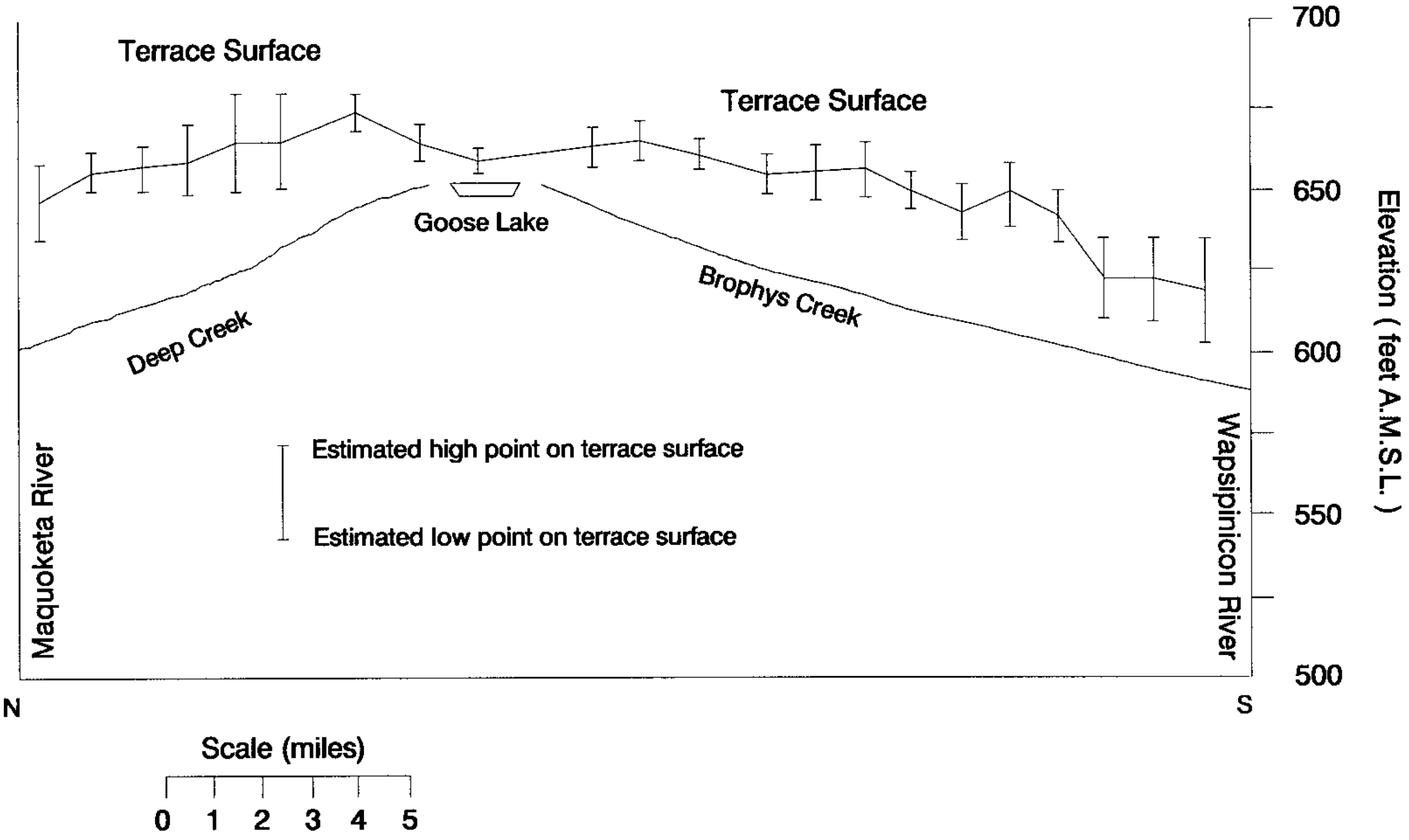

Figure 11. Profile of Deep and Brophys creeks and the loess-mantled terrace in the Goose Lake Channel. Adapted from figure 15 in Updegraff, 1981.

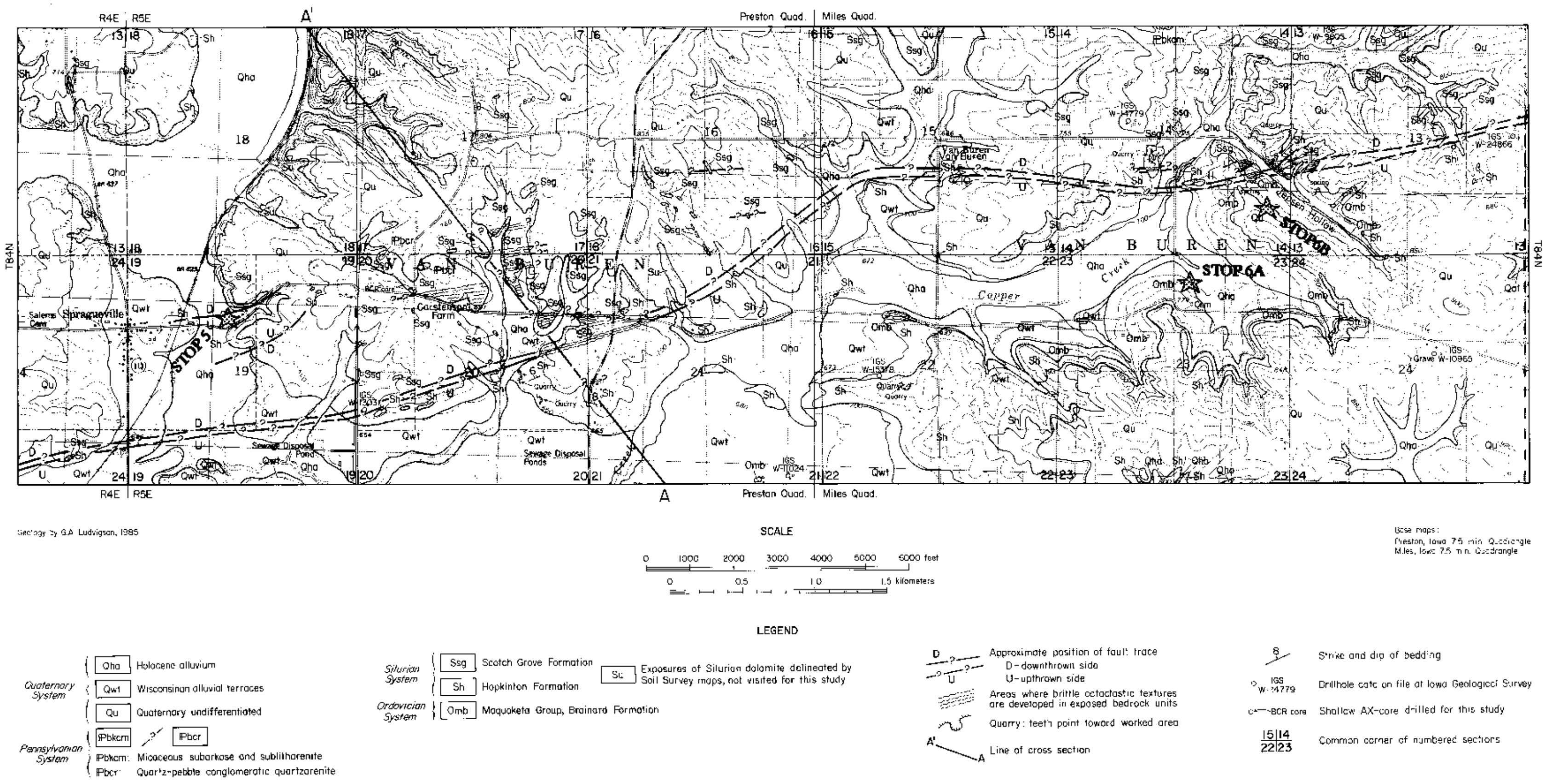

Figure 12. Geologic map of the Plum River Fault Zone of the north end of the Goose Lake Channel, showing locations of STOPS 5, 6A, and 6B, From Ludvigson (1988).

STOP 6A: COPPER CREEK VALLEY OVERLOOK

Traversing eastward from Spragueville, we have crossed the Plum River Fault Zone and passed through the broad lowlands of the Goose Lake Channel underlain by the Brainard Shale. At this T-intersection (Fig. 9; Fig. 12), we are straddling the Silurian-Ordovician contact, and can scan along the eastern, southern, and western horizons for an overview of landscapes that are typical of the Silurian escarpment in northeastern Iowa. Steeper, timbered slopes at the top of the valley wall are underlain by resistant Silurian dolostones of the Hopkinton Formation and underlying units. Beneath these steeper slopes are more gentle, densely rilled slopes characteristic of the Ordovician Brainard Shale. Routine roadwork along the ditches of this road section periodically provide fresh exposures of the Brainard.

The north valley wall exposes the Silurian Hopkinton Formation. Although these rocks lie at a lower structural position than our vantage point, they still are located to the south of the Plum River Fault Zone, denoted by the southern limits of exposure of the Silurian Scotch Grove Formation (Fig. 12). Copper Creek Valley is interpreted to have eroded into the hinge of an asymmetric eastwardly-trending anticline with a steeper northern limb that immediately bounds south wall of the Plum River Fault Zone.

STOP 6B: EXPOSURES OF THE PLUM RIVER FAULT ZONE IN JEPSEN HOLLOW

Jepsen Hollow, a northwestward-draining tributary of Copper Creek, exemplifies the landscape relationships between the Plum River Fault Zone and the Goose Lake Channel on a yet smaller scale. The northwestern mouth of the Hollow is cut through a steep-walled box canyon-like section that exposes abundantly fossil-moldic dolostones of the Silurian Scotch Grove Formation. An abrupt upstream change of valley morphology to wider, more gentle slopes corresponds to a change in the bedrock exposed in the valley walls (Fig. 12). The abrupt change in the bedrock walls of the valley denotes a fault contact juxtaposing the Silurian Scotch Grove and the Ordovician Brainard Shale (Fig. 12). Silurian exposures adjacent to the contact display evidence of cataclastic deformation (Ludvigson, 1988), and northward dips ranging from 8 to 11 degrees are noted in Silurian strata bordering and within the fault zone. Exposures of the Farmers Creek Member of the Hopkinton Formation indicate that narrow fault slices are preserved at this locality, but details of the complicated structure remain to be further studied.

STOP 7. LATE WISCONSINAN AND EARLY HOLOCENE HISTORY OF THE MISSISSIPPI VALLEY IN THE SABULA-SAVANNA AREA.

The Wisconsinan and early Holocene geomorphic and stratigraphic record of the Upper Mississippi Valley is related to both the advance and retreat of Wisconsinan glacial lobes, as well as the character, timing, duration, and frequency of glacial lake discharges.

Glaciers advanced into the Upper Mississippi Basin between 29,000 and 20,000 B.P., but after 20,000 B.P. the pattern was one of general retreat. Well-dated deposits beneath terraces in the Mississippi Valley and its tributaries span this interval, the oldest deposits being preferentially preserved in tributary valleys or re-entrants in the main valley.

Two Mississippi Valley terrace groups underlain by late Wisconsinan sediments are present in the Sabula-Savanna area (Fig. 13). The highest group, underlain by the oldest fluvial deposits, is the Savanna Terrace. This group is comprised of the highest terrace remnants in the Mississippi Valley without a significant loess cover (less than about 8 inches). In the main valley, such as at this stop, the terrace fill consists of trough-cross-bedded and planar-bedded sands and pebbly sands, grading to gravel and cobbles at depth. Overflow channels, occupied during late Wisconsinan flood events, are common on the terrace surface. These are often mantled with a thin veneer of slackwater-flood lithofacies that includes interbedded reddish-brown silty clay, gray clay, and silt. One such channel is evident on the terrace surface just west of Highway 52/67. This channel lacks the slackwater lithofacies veneer, but the veneer (about 6 feet thick) is present on the terrace in the valley re-entrant west of the overflow channel. The slackwater veneer is absent on most remnants in the main valley (most remnants of the terrace are not preserved in protected valley re-entrants). An extensive late Wisconsinan and Holocene dune system has developed on most Savanna Terrace remnants in the main valley. Colluvial slopes and alluvial fans, underlain by Holocene sediments bury the Savanna Terrace along the valley margin.

The Type Area of the Savanna Terrace is along the Plum River just east of Savanna, Illinois where its fill is a slackwater lithofacies (Flock, 1983). The slackwater facies comprises most of the fill of the Savanna Terrace in the lower reaches of tributaries to the Mississippi Valley. In tributaries the terrace exhibits a reversed gradient, and can usually only be traced a few kilometers up the tributary valley. Thinly bedded to laminated reddish-brown silty clay with a Lake Superior-Basin provenance is the hallmark of the slackwater lithofacies, yet gray silts and silty clays are more abundant. We will see an exposure of this lithofacies in a tributary valley at the next stop.

Radiocarbon dates from the alluvial fill beneath the Savanna Terrace in eastern Iowa indicate that aggradation began before 18,700 B.P. and continued until sometime after 13,000 B.P. The absence of a significant loess cover on the terrace indicates that loess deposition had ceased by the time the terrace surface stabilized. Regional accumulation of Peoria Loess ended around 12,500 B.P.

The town of Sabula, and the Evergreen Cemetery to the north, sit on a low terrace whose fill is inset below that of the Savanna Terrace (Fig. 13). This is the Kingston Terrace, usually found as streamlined remnants in the main valley. Latest Wisconsinan-age sandy and gravelly alluvial fill underlies the Kingston Terrace. Kingston Terrace remnants are associated with a Mississippi River paleochannel system where each channel was several times broader than the modern Mississippi channel (this paleochannel system has been flooded by Pool 13 in the Savanna/Sabula area). A fine braid pattern is often superimposed on the terrace surface as well as the broad paleochannel system. The alluvial fill of this terrace is very similar to that of the Savanna Terrace, but often has primary reddish brown silty clay and clay rip-up clasts associated with the sands and gravels. A thin veneer of slackwater lithofacies mantles the broad paleochannels and braid channels. The channel-and-bar morphology of the terrace surface suggests that the sediments accumulated as part of a sluiceway when the Mississippi carried moderate magnitude floods, and was later modified by a braid stream with considerably smaller discharge. The slackwater lithofacies sediments preserved in swales may be overbank deposits from early Holocene floods. Radiocarbon dates and the inset relationship with the Savanna Terrace place entrenchment forming the Savanna Terrace prior to 12,000 B.P., followed by aggradation to the level of the Kingston Terrace between 12,000 and 10,500 B.P. The downcutting episode that formed the Savanna Terrace preceded the onset of Lake Agassiz drainage down the Minnesota River by several hundred years (see Clayton, 1983), and therefore either the chronology for early Lake Agassiz drainage is incorrect or the cause-and-effect relationship between lake drainage and valley incision outlined by Wright (1987) does not apply to the Mississippi Valley downvalley of its junction with the St. Croix.

Immediately east of the Savanna Terrace remnant on the western side of the valley is a late Wisconsinan to early Holocene paleochannel of the Mississippi River (Fig. 13). The channel is filled with sand and gravel capped by a fine-grained sequence that contains a 20 inch-thick zone of laminated to massive reddish brown silty clay. This clay bed is a regional stratigraphic marker in the Mississippi Valley and has been traced from the Dubuque area southward to the junction of the Ohio River with the Mississippi in southern Illinois. The clay arrived in the Mississippi Valley when Lake Superior (at the Duluth level) discharged through the Brule Spillway just east of the southwestern tip of the modern lake, and down the St. Croix Valley (during and shortly following the Marquette Phase of the Superior Lobe?; see Clayton, 1983). Radiocarbon dates from southern Illinois to northeastern Iowa bracket the accumulation of this red clay in the Mississippi Valley between 9,800 and 9,500 B.P.

During excavation of a borrow area for bridge replacement along Illinois Highway 84 in Savanna, Illinois the zone of early Holocene, Lake Superior-source red clay was exposed in an abandoned segment of the Plum River Valley ("Savanna Site" on Fig. 13; many thanks to Julieann Van Nest for bringing this outcrop to our attention). A sketch of the eastern side of the exposure showing the location of a pollen profile and radiocarbon ages is presented in Figure 14. Alluvium in this abandoned valley segment is inset below both the Savanna and Kingston terraces, indicating that abandonment occurred during or after aggradation to the level of the Kingston Terrace in the Mississippi Valley (ca. 12,000-10,500 B.P.). Two radiocarbon ages from deposits below the red clay zone at the Savanna Site support this chronology; the lowest age (11,490±150 B.P., Beta-25839) dates the last bedload (carried by the Plum River) deposited at the site, while the upper date on peat (10,270±130 B.P., Beta-25837) indicates that the area was a peat-accumulating wetland and abandoned by that time. Peat formation was halted abruptly when reddish brown clay from the Mississippi Valley backflooded the wetland during the previously discussed Lake Superior discharge between 9,800 and 9,500 B.P. The peat beneath the red clay zone yielded a pollen and plant macrofossil record extending from 11,490 to 10,270 B.P.; across what is traditionally regarded (in terms of chronology) as the Wisconsinan-Holocene boundary in this part of the Midwest (see following discussion of pollen and plant macrofossils by Nations and Baker).

The zone of red clay overlying the peat is capped by six feet of organic silty clay (muck) that extends to the surface of the present wetland. To the south the muck interfingers with loamy and sandy loam sediment of a Holocene-age colluvial/eolian wedge coming off the Savanna Terrace (coarse facies). The red clay zone found in the wetland laps up onto stratified silt and medium sand of a Kingston Terrace remnant buried beneath the colluvial/eolian wedge. The red clay buries a weakly-expressed soil developed on the Kingston Terrace. Humates from the buried A horizon of the soil yielded a radiocarbon age of 7,750±120 B.P. (Tx-6090); an age about 2,000 years too young for its stratigraphic position beneath the red clay. Another radiocarbon age of 1,320±50 B.P.

(Tx-6089) on humates from the Ab horizon of a soil developed into the red clay zone is also significantly younger than expected from this stratigraphic position (an early or middle Holocene age would be expected). Both of these humate dates suggest that in this environment (humid temperate) the humate fraction is relatively mobile and contamination of buried soil horizons by younger humates is a likely occurrence.

POLLEN AND PLANT MACROFOSSILS FROM THE SAVANNA SITE, NORTHWEST ILLINOIS

Brenda K. Nations and Richard G. Baker

Pollen samples were collected from peat and loam sediments directly below the Superior-source red clay at location SV-2 (Fig. 14). Depths for these samples ranged from 203 cm (6'8") to 229 cm (7'6") below the modern surface. The pollen percentage diagram for this profile records conditions from 11,490 ± 150 B.P. to 10,270 ± 130 B.P. and is shown in Figure 15. During this time period there was a predominance of deciduous tree pollen. *Ulmus* (elm), *Quercus* (oak), *Betula* (birch), and *Alnus* (alder) are the most common deciduous species present, with each species comprising about 20% or more of the pollen at one time. *Salix* (willow) is present as well, amounting up to 15% towards the top of the diagram. Also present, but not as abundant, are the coniferous species *Picea* (spruce), *Pinus* (pine), and *Abies* (fir). *Picea* is the most abundant conifer species, with up to almost 15% of the arboreal (tree) pollen toward the bottom of the diagram, decreasing to 5% by 10,270 B.P.

The percentage of arboreal pollen (AP, tree species), which are plotted versus non-arboreal (NAP, shrub and herb species), are close to 90% of the total pollen. The most abundant non-arboreal pollen present are *Typha* (cattail), *Nuphar* (waterlily), and *Myriophyllum* (watermilfoil), which are aquatic species, which increase at the top of the sequence. *Artemisia* (wormwood or sagebrush) is found in dry environments, and it possibly inhabited the sandy terrace adjacent to the site.

Table 1 summarizes the plant macrofossils collected from SV-2, the same profile as shown on the pollen diagram, while Table 2 presents the plant macrofossil record from SV-2a, located closer to the margin of the basin (see Fig. 14). Numbers in Table 1 are in specimens per 200 ml sample. The macrofossils corroborate the local presence of *Picea, Betula,* and *Alnus*, and suggest that the birch was *B. papyrifera* (paper birch) and the alder was *A. rugosa* (speckled alder). Additional trees that were present include *Populus* (poplar, aspen) *Salix* (willow) and *Larix* (larch).

Other macrofossils are of predominantly aquatic and wetland plants. Submersed aquatic plants including *Naias flexilis* (naiad), *Chara* (an alga), and *Potamogeton* spp. (pondweeds) are abundant at the bottom and in the middle of the section and decrease towards the top. *Scirpus validus* or *Scirpus acutus* (bullrush), an emergent aquatic, is abundant in the middle and decreases upward. Aquatic taxa of shallow environments increase upward; these include *Nuphar* (yellow water lily), *Eleocharis palustris* s.l. (spikerush), *Myriophyllum*, *Sagittaria latifolia* (arrowhead) and *Typha*. Such wetland and bog plants as *Carex* spp., (sedge), *Leersia oryzoides* (rice cut-grass), *Larix laricina, Salix,* and *Triadenum virginicum* (St. John's-wort) also increase upward.

The local habitat changed from the bottom to the top of the sequence from a relatively deep open pond to a shallow pool surrounded by wetland plants.

The pollen and macrofossils indicate that the regional vegetation was changing during the period when Savanna Site sediments were deposited. The spruce forests that dominated the late-glacial landscape were being replaced by hardwoods like oak, elm, and paper birch. Yet the presence of *Picea* and *Larix* at this site indicate that these trees were relicts left behind in a few protected wetland microhabitats, because they were gone from the upland areas of Iowa and Illinois by this time (Webb et al., 1983). They are present only sporadically in sites of this age in Iowa and in the Mississippi Valley.

These findings relate well to other pollen studies that have been done nearby at similar-age sites such as Cattail Channel (Kim, 1982) and Roberts Creek (Chumbley, 1989). Cattail Channel is located in an abandoned Mississippi River overflow channel north of Rock Island, Illinois, about 25 mi south of the Savanna Site. At 10,130 B.P. the most abundant pollen at Cattail Channel are *Quercus* and *Ulmus*, with lower percentages of *Fraxinus* (ash), *Betula*, *Picea*, *Pinus*, and *Abies*. This is very similar to the findings at Savanna. At Roberts Creek in Clayton Co., Iowa the most predominant pollen found for the time period of 11,000 to 10,000 B.P. are *Picea*, *Quercus*, *Ulmus*, *Fraxinus*, and *Pinus*. The Roberts Creek site is in a different setting than the Savanna and Cattail Channel sites; it is in a small valley setting removed from the Mississippi Valley.

The time period covered by the Savanna site includes the Pleistocene-Holocene boundary (ca. 10,500 B.P.) in which regional vegetation changed from conifer-dominated to deciduous-dominated. This change was underway by 11,400 in this part of the Mississippi Valley.

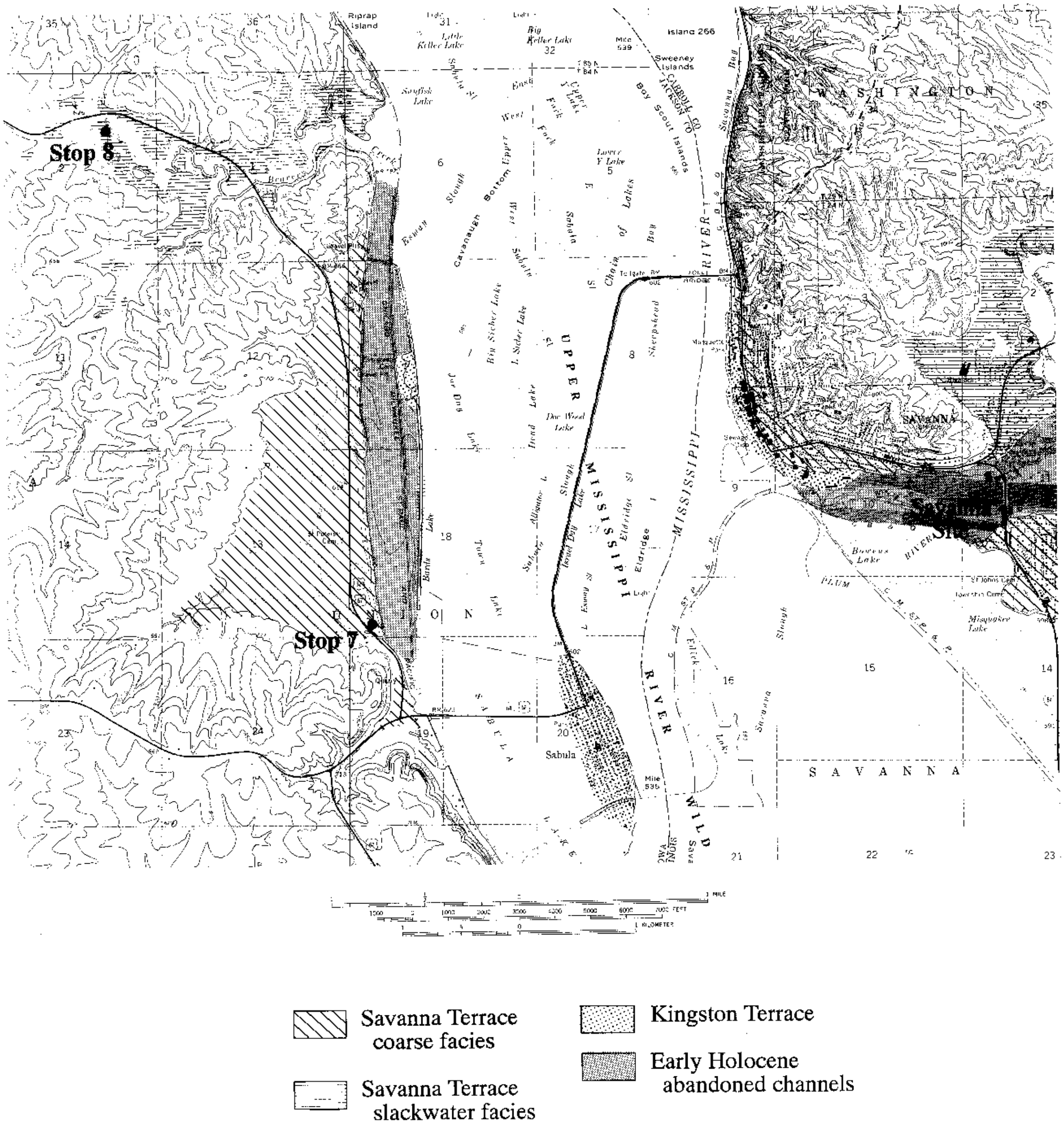

Figure 13. Surficial geology map ot the Mississippi Valley in the Sabula-Savanna area. Base is USGS Savanna, Illinios-Iowa 7.5 minute topographic map.

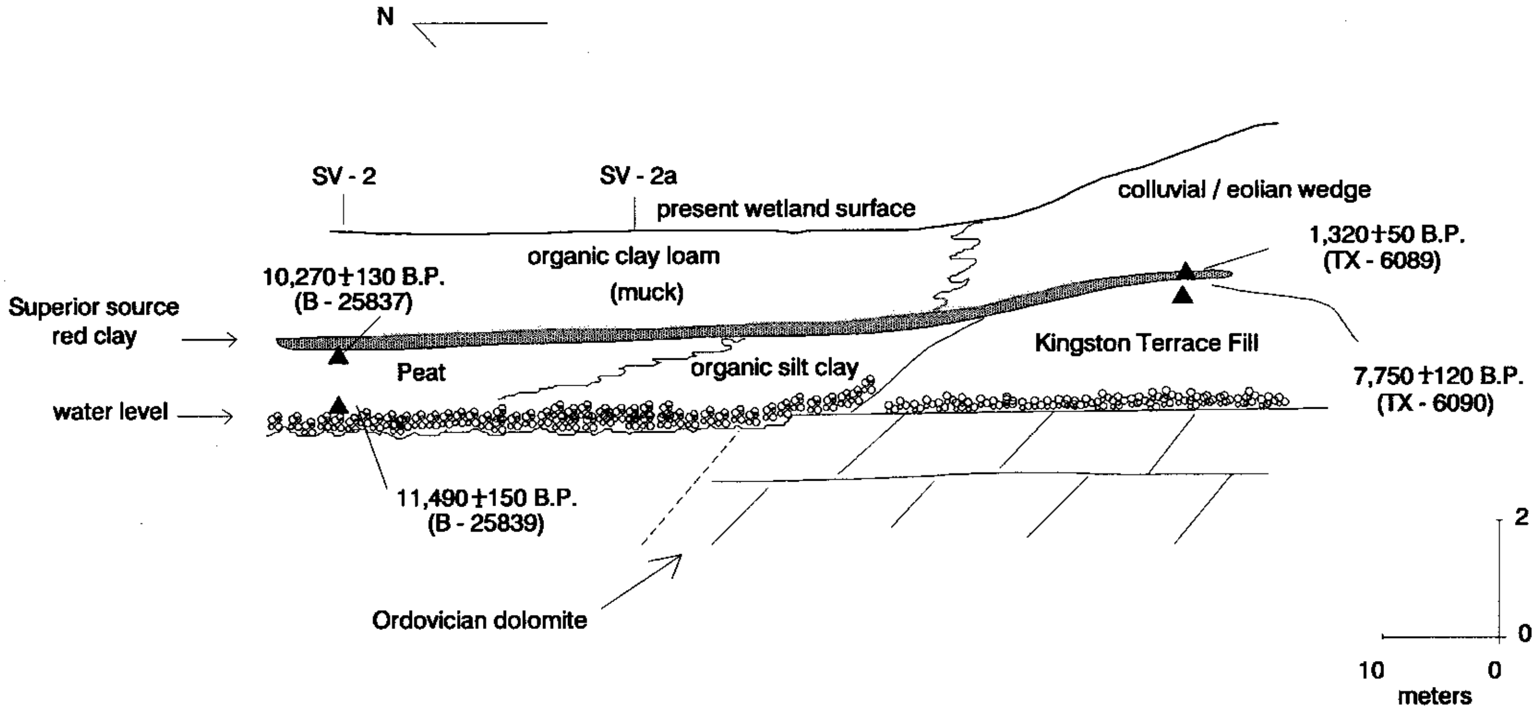

Figure 14. Cross-section of the Savanna Site, Illinois in an abandoned segment of the Plum River. Note locations of radiocarbon, pollen, and plant macrofossil samples discussed in the text.

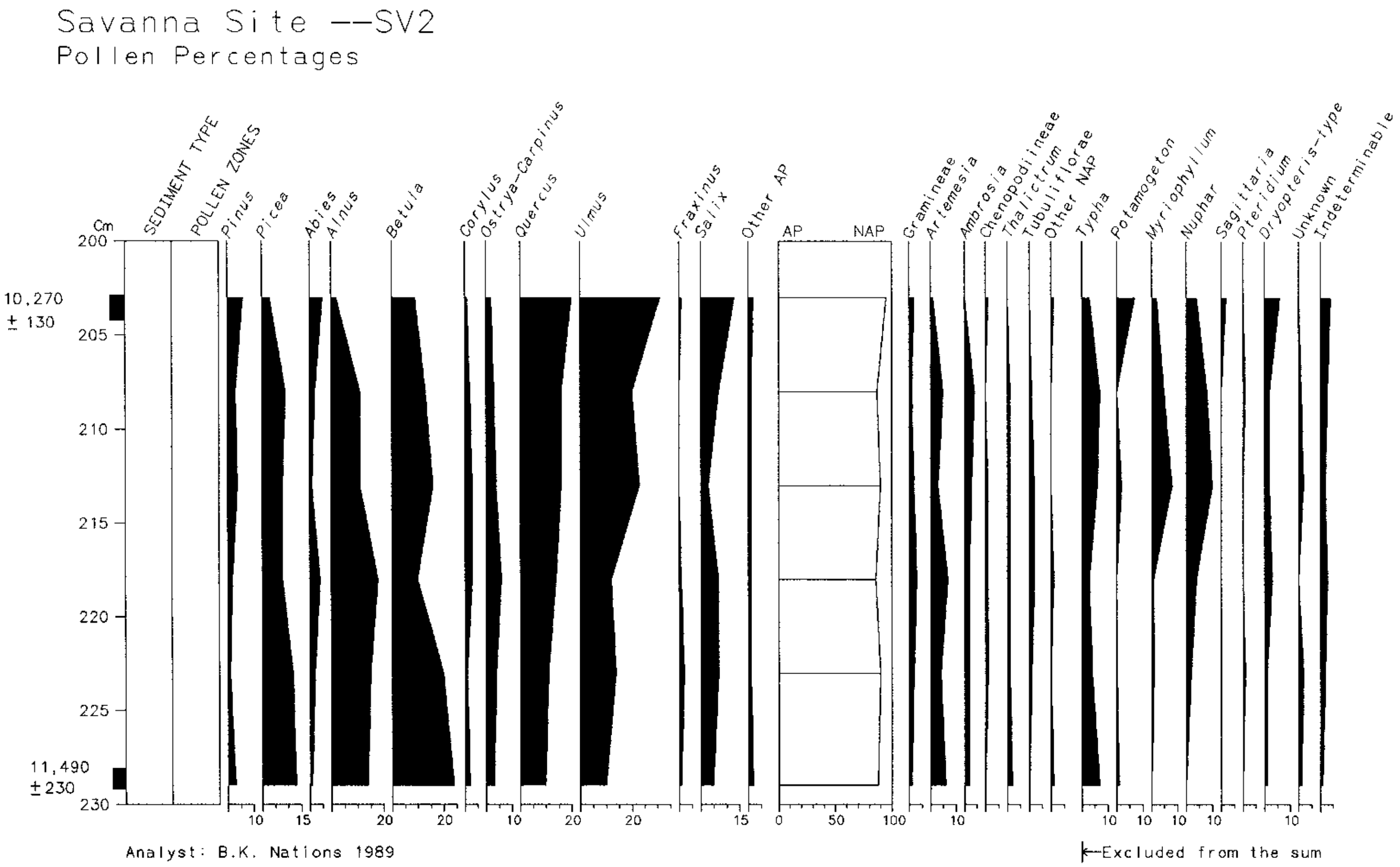

Figure 15. Pollen diagram of location SV-2 at the Savanna Site, Illinois. Location of the pollen profile is shown on figure 14.

Table 1. Plant macrofossils from Savanna Site SV-2. The pollen diagram presented in Figure 15 is also from the location.

Savanna Site					
Depth (cm)	201-205	205-211	211-216	216-221	226-231
Alismataceae	1	2	0	0	0
Amaranthus	0	2	0	0	0
Alnus	0	0	0	0	1
Alnus rugosa type	0	0	0	1	0
Betula	0	2	1	2	1
Betula cf. papyrifera	0	0	1	0	0
Nuphar	24	22	15	9	1
Carex (biconvex)	2	14	1	3	0
Carex (trigonous)	80	37	6	8	0
Chara	88	256	393	66	107
Eleocharis palustris s.l.	10	1	0	0	0
Larix	0	4	0	0	0
Leersia oryzoides	2	0	0	0	0
Lycopus americanus	0	1	0	0	0
Myriophyllum	26	24	21	1	1
Myriophyllum cf. pinnatum	33	2	0	0	0
Najas flexilis	86	288	487	456	160
Potamogeton filiformis	1	17	12	23	3
Potamogeton (large)	3	2	6	13	35
Potamogeton (small)	11	16	62	126	8
Ranunculus aquatilis	0	1	0	0	1
Sagittaria latifolia	6	1	0	0	0
Sagittaria sp.	9	3	2	0	1
Scirpus validus/acutus	17	134	124	3	0
Sparganium	2	2	1	0	0
Sium suave	1	0	0	0	0
Typha	11	1	2	0	0
Triadenum virginicum	1	2	0	0	0
conifer seed wing	0	0	1	0	0
Grass	6	0	0	0	0
Larix needle fragments	153	118	99	80	23
Picea needle fragments	0	3	2	0	0
Populus budscales	0	0	0	1	0
unknowns	6	0	0	3	0
mosses	p	0	p	0	p
beetles	p	0	p	0	0

Table 2. Plant macrofossils from Savanna Site SV-2a. This site is closer to the margin of the wetland than site SV-2.

Savanna Site A			
Depth (cm)	188-193	198-203	221-226
Alismataceae	16	3	0
Alnus rugosa type	0	3	0
Betula	1	0	0
Betula cf. papyrifera	0	11	0
Nuphar	0	22	4
Carex (biconvex)	19	11	2
Carex (trigonous)	76	13	3
Chara	0	27	410
Ceratophyllum	0	1	0
Larix	1	10	0
Myriophyllum	0	2	0
Najas flexilis	0	568	857
Potamogeton filiformis	0	13	15
Potamogeton (large)	0	8	63
Potamogeton (small)	0	46	9
Rubus (charred)	0	1	0
Sagittaria latifolia	2	0	0
Sagittaria sp.	14	13	1
Scirpus validus/acutus	0	16	2
Typha	14	18	0
conifer seed wing	0	3	0
Larix cones	0	2	0
Larix short shoot	0	1	0
Larix needle fragments	24	502	22
Picea needle fragments	0	49	2
Salix budscales	2	2	0
Populus budscales	0	0	0
unknowns	2	0	0
mosses	p	p	0
beetles	p	p	0

STOP 8. SLACKWATER LITHOFACIES OF THE SAVANNA TERRACE IN BEAVER CREEK VALLEY

At this stop we are 1.5 miles above the junction of Beaver Creek with the Mississippi Valley (Fig. 13). The Savanna Terrace forms a prominent, flat surface about 30 feet above the floodplain where we first enter Beaver Creek Valley, and decreases in height relative to the floodplain up the valley. The section we will examine has had approximately 11-15 feet of its upper part removed by erosion of an ephemeral tributary. Sedimentary and soft-sediment deformation structures, and the stratigraphic succession of bedding types exposed in this section are typical for the slackwater facies of the Savanna Terrace.

The lower 31 inches of the exposure (zone 1) consists of dark grayish brown laminated silt loam that contains a few laminae of organic materials. A radiocarbon age of 18,790±390 B.P. (Beta-31883) was obtained on wood collected from this zone at about creek level. A leaf of *Vaccinium uliginosum* var. *alpinum* (barren ground blueberry; R. G. Baker, personal communication, 1989) was also recovered from this zone. This basal zone is deformed into low-amplitude folds and contains common secondary stains of manganese oxides. From 31 to 59 inches (zone 2) the deposits consist of grayish brown and brown planar-bedded silt loam with a few pods and lenses of brown (7.5YR hue) silty clay that contain gastropod shells. Bedding in this zone is deformed into higher-amplitude folds than those of the basal zone. An abrupt erosional contact separates zone 2 from the overlying zone 3 which consists of a basal 1.5 to 4 inch-thick lag of coarse sand, pebbles, and transported carbonate concretions, giving way upward to 83 inches of planar-bedded dark grayish brown silt loam with brown (7.5YR hue) silty clay beds (Superior-source "red clay"). The silty clay beds contain abundant, fine, rounded, grayish brown silty clay rip-up clasts. Gray to grayish brown silty clay and silt loam beds increase in abundance upward. There are a few continuous beds in this zone, but most are lenses or associated with shallow troughs. A few medium to coarse, hard secondary accumulations of carbonate are also present in this zone. The upper 37 inches of the section (zone 4) consists of pale yellow silt loam beds draped with thin brown to dark brown (7.5YR hue) silty clay beds ("red clay"). Sinusoidal passing to type B ripple drift lamination is present in the silt loam (these sedimentary structures form under conditions of high sediment load and rapid sedimentation). Abundant medium to fine carbonate concretions are present in this zone. The modern surface soil is developed in the upper 24 inches of zone 4.

The sedimentology of this deposit suggests the following scenario: Zone 1 consists of fine-grained tributary deposits that are derived, in large part, from freshly fallen loess washed off the surrounding landscape. These deposits are low in sand and clay content and high in silt, especially coarse silt. Clay mineralogy of these deposits is indistinguishable from that of Peoria Loess. The overlying zone 2 that contains brown ("red") silty clay beds records initial back-flooding of the tributary during Mississippi River floods produced by overflow from Lake Superior. Deposits in zone 2 are dominantly tributary basin in origin, except for the brown silty clays. Zone 3, with a basal erosional contact and containing common troughs, records shifting of the tributary channel as a result of fluctuations in flow conditions and direction during back-flood events, as well as in response to decreased gradient in the tributary as a sediment dam was being constructed at its junction with the Mississippi Valley. The uppermost zone (4), consists of planar-bedded deposits, some of which contain ripple drift cross-lamination. This zone records an episode when the lower tributary was probably flooded. Deposits coming down the tributary may have passed into its lower reaches as density currents. When Mississippi River floods topped the sediment dam at the tributary's mouth, sediment was dumped into the ponded tributary and deposited in planar beds with ripple drift, and as silty clay drapes. The contacts between zones are probably diachronous within the tributary since the gradient decrease resulting from sediment damming would have prograded up the tributary as time progressed.

This concludes the field trip and we will drive northward to Potter's Mill in Bellevue for the social hour and banquet. We hope you have enjoyed the trip and have gained an appreciation for the value of integrating surficial and subsurface geologic studies when attempting to work out the geologic history of an area. Most of all, we hope that some of the issues raised during the trip will stimulate additional work by others.

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FIELD TRIP ROUTE