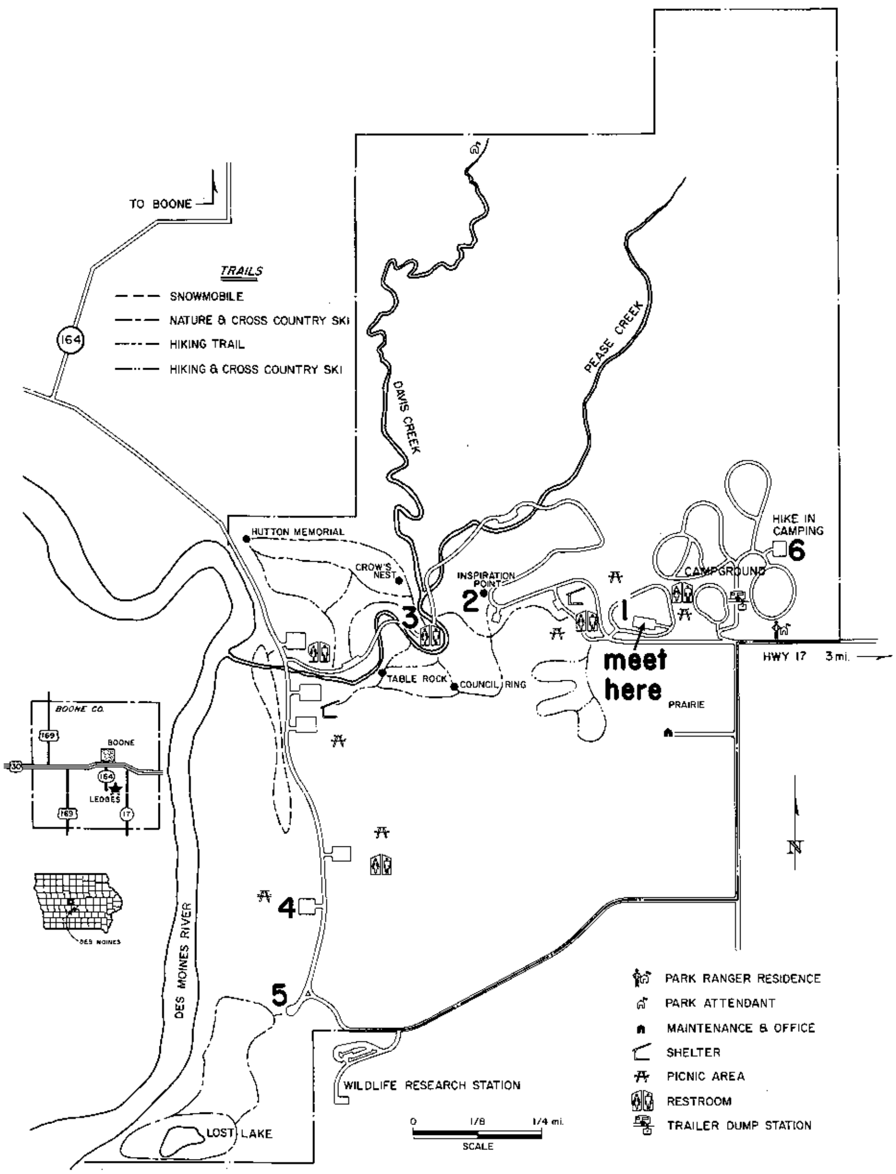
NATURAL HISTORY of LEDGES STATE PARK
and the Des Moines Valley in Boone County



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NATURAL HISTORY OF LEDGES STATE PARK AND THE DES MOINES VALLEY IN BOONE COUNTY

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PART 1. LEDGES STATE PARK

INTRODUCTION

Project Background and Area History

In 1921, 644 acres of rugged and wooded land along Pea's Creek, a tributary stream of the Des Moines River in Boone County, was acquired by the State of Iowa. The site, known as the "Ledges" because of its outstanding sandstone formations, was purchased for the purposes of preserving the area's splendid beauty and unique features as well as providing open space and recreation opportunities for a growing central Iowa population. Dedicated as a state park in 1924, Ledges is one of Iowa's original and oldest state parks. By 1945, Ledges State Park had been expanded to 860 acres, and recent lands transferred to the State of Iowa by the U. S. Army Corps of Engineers as mitigation for lands periodically flooded by the Saylorville Reservoir have increased the area to 1,117 acres.

The cultural and natural resources of the park offer a diversity of attractions. These include wooded slopes, restored native prairie, rare flora, abundant wildlife, significant geological formations, active landslides, archaeological and historical features, outstanding scenic qualities, and a diversity of aquatic features ranging from the Des Moines River and tributary stream environments to a small lake and marshy areas.

Popular recreation activities at Ledges are hiking, stream wading, picnicking, nature study, sightseeing, camping, winter sports, and other nature-oriented activities. Facility development at the park occurred primarily during the 1930's through the Work Progress Administration and Civilian Conservation Corps depression era programs. The CCC facilities constructed at the Ledges include shelters, latrines, entry and gate structures, trails, bridges, cabins, roads, and parking lots. Many of these fine facilities, which were constructed of fieldstone and native timber, are still standing and used today. Since the 1930's, few physical improvements or additions have been made to the area. Modern day pressures and Saylorville-related flooding impacts have made redevelopment of Ledges State Park a high priority.

Redevelopment planning for the park began in 1972 with a study by graduate students and staff of the Department of Landscape Architecture at Iowa State University. Richard Pohl, a graduate student, was principal author of a subsequent report and plan for redeveloping the park. In hindsight, the planning process utilized in the 1972 plan lacked adequate Commission staff and public input and review. The plan contained features which required further analysis; and, as a result, was not implemented. The current master plan study, begun in 1977, expands and modifies the concepts outlined in 1972. The nearly ten-year period occurring since initiating redevelopment planning in 1972 has resulted in a thorough analysis of the area, its current problems, and needs for the future. It has also allowed for ample staff and public involvement of in development sufficient well-thought design detail to ensure successful implementation.

Below is a chronology of events relating to Ledges State Park since 1971:

1971	Conceptual Master Plan for Ledges State Park (ISU Department of Landscape Architecture).
October, 1972	Commission approves the Redevelopment Master Plan for Ledges State Park (Richard Pohl)
December, 1972	A lawsuit is filed by local environmental groups to stop construction of the Saylorville Dam until an environmental impact statement is completed.
January, 1973	An out-of-court settlement is reached allowing for continued construction of the dam, but mandating the preparation of an impact statement.
September, 1973	Army Corps of Engineers sponsors public hearing.
May, 1974	Flash flood occurs and the Canyon road in Ledges State Park is closed.
May, 1974	Army Corps of Engineers releases final environmental impact statement.
August, 1974	Governor Ray announces a compromise plan which will provide protection for Ledges. Endorsements gained from state agencies but not from environmentalists or the Army Corps of Engineers.
November, 1974	Legislation introduced in Iowa legislature which would require construction of a barrier dike to protect the Ledges.
Spring, 1975	Legislation defeated.
May, 1975	New shuttle bus service to the Canyon area is provided.
June, 1975	Iowa State Inter-Agency Resource Council holds public hearing on the operation of Saylorville Dam.
June, 1975	Army Corps endorses Governor Ray's compromise plan.
September, 1975	Saylorville Dam completed but could not begin operation until Congress endorsed plan to protect Ledges and provide appropriate funds.
October, 1976	Needed congressional approval and authorization obtained.
December, 1976	Conservation Commission and Army Corps of Engineers reach a settlement. Commissioners direct ICC staff to prepare an update of the 1972 Master Plan according to the Commission's formal Master Planning Process.
February, 1977	Conservation Commission Task Force for Ledges State Park holds first meeting as part of Master Planning Process.
April, 1977	Commission approves a plan for opening of the Canyon road to intermittant traffic.

April, 1977	Saylorville Dam floodgates are closed.
October, 1977	Commission approves the revised master Plan Redevelopment Concepts formulated by Planning Task Force.
March, 1978	Conservation Commission holds public listening meeting in Boone, Iowa.
May, 1979	A professional consultant is hired to prepare the Interpretation Center Program and Facility Plan for Ledges State Park (Harland Bartholomew and Associates, North Brook, Illinois).
February, 1980	Public Review Meeting--Des Moines, Iowa--Good level of public support expressed for Revised Master Plan and Interpretive Proposals.
March, 1980	Commissioners approve Final Master Plan and Interpretive Plan for redevelopment. They also approve a ban on rappelling.

Purpose of the Master Plan and Planning Process

The purpose of this Master Plan is to provide the Iowa Conservation Commission with a detailed plan for park programs including facility development, recreation interpretation, and land management. The plan is based on a comprehensive study of Commission goals, objectives, and responsibilities; site characteristics, suitabilities, and limitations; and local and regional needs and desires. In addition to defining specific use areas, interpretation programs, facility development details, and land management programs, the plan also provides a logical implementation schedule with cost estimates for use by Commission administrators in preparing the Commission's biennial budget request.

The planning process, as structured by the Iowa Conservation Commission, seeks sound conservation recreation planning through a rational process. This process assures that those who have a reason to be involved or concerned with the project are given an opportunity to participate in a constructive manner. This includes staff, general public, affected local interest groups, and the Commissioners of the Conservation Commission. Public meetings are held to hear citizens' ideas and for their review of conceptual plans. A staff task force, composed of Commission staff members representing the Commission's various divisions and sections, supervises the preparation of the plan. The staff task force members provide technical data, recommendations, and periodic review of the plan.

* Project Goals:

The following goals guided the development of this plan:

-- To protect and conserve the unique natural and cultural resources of Ledges State Park. Additionally--to restore and enhance certain features with the majority of the site maintained in an undisturbed or "wild" state.

-- To provide recreation developments to serve as support amenities for visitors primarily interested in experiencing the area's natural and cultural resources. Development features will occur only when they do not conflict with or affect the integrity of the site's significant resources.

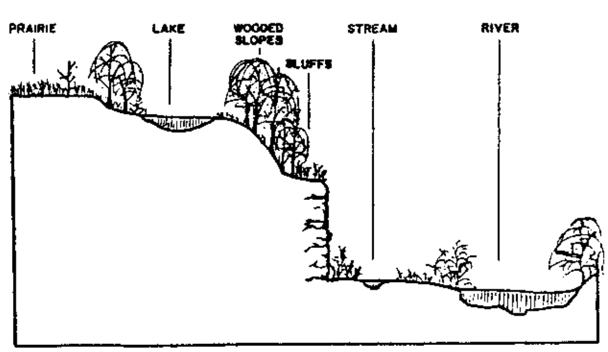
-- To develop an education program emphasizing interpretation of natural and cultural features in order to promote the recognition and understanding of natural systems. Intent of this program is to instill public awareness of the significance of our resource heritage and to promote public concern for the care and protection of these resources.

-- To improve and modernize the park's utility system, ranger residences, and maintenance center for more efficient park management and operation.

Area Theme

> "Humanized environments give us confidence because nature has been reduced to the human scale, but wildness, in whatever form, almost compels us to measure ourselves against the cosmos. It makes us realize how insignificant we are as biological creatures and invites us to escape from daily life into the realms of eternity and infinity . . ." (The Wooing of Earth by Rene DuBois)

Rediscovery is the theme for the redevelopment plan for Ledges State Park. With the great technological advancements and urbanization over the last century, more and more people have lost touch with natural systems. The rediscovery theme attempts to establish an understanding of and sympathy for the complexities of nature in order to develop an appreciation of these resources. Whether it be a discovery or a rediscovery, it is important to experience nature, to be awed by its wonders, and to feel a reverence for the natural laws which link human kind to the rest of creation.



OVERVIEW OF THE GEOLOGY OF LEDGES STATE PARK

by
Art Bettis

Pennsylvanian Strata

Ledges State Park derives it's name from the picturesque exposures of Pennsylvanian-age sandstone found in several areas within the park. This thick, lenticular, channel sandstone is flanked on the north and south by interbedded siltstones, shales, thin sandstones, and coals. The Ledges sandstone reaches about 30 meters in thickness within the park, and pinches out to the north and south. On the northern park boundary the sandstone is 10.6m thick and it is 7.6m thick on the southern end (Osolin, 1983). The lateral extent of the Ledges sandstone body is about 3.2km.

Osolin (1983) described the outcrops of Pennsylvanian-age rocks in the park. He recognized two major lithofacies; a friable, cross-stratified sandstone facies, and a well-indurated cross-stratified sandstone facies. Large-scale planar and trough cross-bedded sets are the dominant primary structures in these lithofacies. Calcium carbonate (microcrystaline calcite) is the primary bonding agent in these rocks. Often, the lower few meters of the exposures are reddish brown. These reddish brown sandstones, all of the friable facies, are characterized by the replacement of the calcium carbonate cement with iron oxides, which imparts the reddish brown color. Carbonized plant fragments are often found in these reddish brown sandstones.

The well-indurated facies is more erosionally resistant because of a greater abundance of calcium carbonate cement. As a result of it's resistant nature, this lithofacies crops out in many places in the park, and forms the overhanging ledges from which the park derives it's name. Usually this lithofacies overlies the friable sandstone lithofacies suggesting that the cement was precipitated from meteoric water (water of atmospheric origin). This hypothesis does not explain the spherical and lensoid shapes of the well-indurated lithofacies that commonly occur within the friable sandstone. These isolated, well-indurated sandstones probably result from some type of concretionary process which produced localized concentrations of calcium carbonate. Stratification passes across the boundary between the isolated, well-indurated sandstones and the adjacent friable sandstone indicating that the carbonate cement is epigenetic (of later origin than the enclosing rock). To the casual observer, many of the isolated occurrences of the well-indurated sandstones facies look like logs lying nearly horizontal within the friable sandstone.

Minor, fine-grained lithofacies also occur within the Ledges sandstone (Osolin, 1983). These rocks occupy a very small portion of the channel's volume and were deposited in lower energy environments than the sandstone lithofacies. These units are less resistant than the sandstone and are usually covered with slump.

Sedimentary structures in the sandstone, the geometry of the sandstone body, and interfingering relationships between the sandstone and adjacent fine-grained rocks indicate that the exposures in Ledges Park represent a series of vertically-stacked fluvial channels flanked by floodbasin deposits. Paleodirection data (maximum dip of the forset beds of the planar and trough cross-stratified units) indicate that flow was in a southwesterly direction (Osolin, 1983). The Ledges sandstone was deposited in a distributary channel of a prograding delta.

Studies of the Madrid and Boone coal fields, south and north of the Ledges respectively, concluded that the Cherokee section represents a shift from a lower to an upper delta plain environment (Reese, 1975; Mason, 1980). This shift was in response to a marine transgression, probably produced by a eustatic rise in sea level.

The stratigraphic position of the Ledges sandstone within the Cherokee Group is debatable. On the basis of inferred relationships with the Ardmore Limestone (Swede Hollow Formation) and the upper coal at Boone, Osolin (1983) concluded that the Ledges sandstone is Upper Cherokee in age and probably within the Swede Hollow Formation. Regionally, however, thick channel sandstones seem to be associated with the Floris Formation, stratigraphically below the Swede Hollow Formation (Ravn et al., 1984). Figure 1.1 shows the stratigraphic nomenclature of Pennsylvanian strata in Iowa and the suggested positions of the Ledges sandstone within the Cherokee Group.

Quaternary Geology

Exposures along some of the small valleys in Ledges State Park provide glimpses of the Quaternary deposits that underlie the Des Moines Lobe landform region of central Iowa. These exposures are usually produced by slumping of the Quaternary materials and are relatively short-lived.

The oldest Quaternary deposits in the park are Pre-Illinoian tills and related deposits. Their distribution and properties are poorly understood because of the limited exposures. These deposits rest unconformably on Pennsylvanian-age sandstone and are overlain by late Wisconsinan-age deposits. The unconformity separating the Quaternary and Pennsylvanian rocks at Ledges State Park represents about 300 million years. Where exposed in the park, Pre-Illinoian-age till is jointed, mottled, and oxidized or reduced. Thick accumulations of iron occur along the joints. Investigations of this till sequence elsewhere in Iowa indicate that the last Pre-Illinoian glaciation in the state occurred about 500,000 years ago (Hallberg, 1986).

Stratigraphic Nomenclature – This Report				
Western Interior Basin			Eastern Interior Basin, Scott & Muscatine Counties	
GROUP	FORMATION	Named Member	FORMATION	Named Member
MARMATON	"LOST BRANCH"	Cooper Creek Ls. unnamed Sh. Sni Mills Ls.		
	UNNAMED SH.			
	LENAPAH LS			
	NOWATA SH.			
	ALTAMONT	Worland Ls. Lake Neosho Sh. Amoret Ls.		
	BANDERA SH.			
	PAWNEE	Coal City Ls. Mine Creek Sh. Myrick Sta. Ls. Anna Sh.		
	LABETTE SH.	Mystic Coal Marshall Coal		
	STEPHENS FOREST	Higginsville Ls. unnamed sh. Houx Ls. Little Osage Sh.		
	MORGAN SCHOOL SH	Summit Coal		
	MOUSE CREEK	Blackjack Creek Ls. Excello Sh.		
CHEROKEE	SWEDE HOLLOW	Mulky Coal Bevier Coal Wheeler Coal Ardmore Ls. Oakley Sh. Whitebreast Coal		
	FLORIS	Carruthers Coal unnamed coal Laddsdale	? "SPOON" ?	
	KALO	Cliffland Coal Blackoak Coal		
	KILBOURN	unnamed coals		
			CASEYVILLE	Wyoming Hill Coal Wildcat Den Coal

Figure 1.1. Stratigraphic nomenclature for the Marmaton and Cherokee Groups in Iowa. Suggested positions of the Ledges sandstone in the Pennsylvanian sequence are indicated with bold arrows. Adapted from Ravn et al., 1984.

Between about 500,000 and 30,000 years ago, the central Iowa landscape evolved through several episodes of drainage development and accompanying slope erosion. Soils developed on this old landscape during periods of relative stability, and are known today as the Yarmouth-Sangamon and Late-Sangamon soils (Ruhe et al, 1967; Bettis et al, 1984). These soils have not been recognized in the park, but this may be a result of limited exposure, as opposed to an absence of the paleosols.

Studies in the central Des Moines Valley (DMV) indicate that the DMV above Saylorville Dam was not in existence before about 13,000 B.P. (Bettis and Hoyer, 1986; Bettis et al, 1985). Prior to that time the DMV above Des Moines trended northwest to southeast in a large, now partially buried valley occupied, in part, by Beaver Creek (Bain, 1897; Lees, 1916; Bettis and Hoyer, 1986).

Loess (windblown silt) began to accumulate on all stable landscape positions in the central Iowa landscape about 20,000 years ago. The loess consists of silt and clay blown from the floodplains of major valleys that carried meltwater from continental glaciers advancing into north-central Iowa. This loess, and the deposits laid down by the associated glacier(s) have been referred to as "Tazewell" in the literature (Ruhe, 1969; Black and Reed, 1965). Radiocarbon dates from the "Tazewell" till in north-central and northwest Iowa range between 29,000 and 21,000 B.P. (Ruhe, 1969; Hallberg et al, 1981).

Organic materials within the loess have also been radiocarbon dated. In central Iowa the dates range from about 17,000 B.P. in the lower part of the loess, to about 14,000 B.P. in the top of the loess and the base of the overlying Des Moines Lobe till (Ruhe, 1969; Kemmis et al, 1981). A radiocarbon date of 15,775±145 B.P. (Beta-4807) on spruce wood collected within the loess beneath Des Moines Lobe till in a small valley in the eastern part of Ledges State Park is in agreement with other dates collected from the loess.

Studies of plant macrofossils, pollen, and small mammal fossils in deposits dating between 25,000 and 13,500 B.P. suggest that the period from about 21,000 to 16,500 B.P. was the coldest period during the middle and late Wisconsinan (Baker et al, 1986). During that time arctic and subarctic conditions prevailed in north-central Iowa. After about 16,500 B.P. climatic conditions ameliorated, and boreal species became dominant.

The Des Moines Lobe glacier surged into north central Iowa and reached its terminus (at the present city of Des Moines) between 14,000 and 13,500 B.P. As the glacier advanced, it buried the loess-mantled landscape, including the ancestral Des Moines Valley above Saylorville Dam.

Glacial deposits associated with the Des Moines Lobe in Iowa are included in the Dows Formation (Kemmis et al, 1981). The Dows Formation has distinctive properties of texture and mineralogy. Three of these properties, shale-clast abundance and composition, clay mineralogy, and carbonate mineralogy, distinguish the Dows Formation from other Quaternary units in Iowa.

The mineralogy of the Dows Formation is related to the provenance (source area) of the deposits. As the Des Moines Lobe ice traversed southern Canada, the Dakotas, and entered Minnesota, it passed over large areas of Upper Cretaceous shales and mudstones. A conspicuous element of the Des Moines Lobe deposits is the abundance of Cretaceous (Pierre-type) shale fragments in the cobble, pebble, and sand size fractions (Wright, 1972; Matsch, 1972; Kemmis et al, 1981). These lithoclasts distinguish Des Moines Lobe deposits from older, underlying Pre-Illinoian tills. The Cretaceous deposits have also strongly influenced the clay mineralogy which, in fact, is nearly identical to the Cretaceous lithoclasts.

These characteristics of the Dows Formation distinguish it from the Pre-Illinoian tills that underlie the Des Moines Lobe, and form the surficial tills outside of the Des Moines Lobe landform region. The tills of the Pre-Illinoian Wolf Creek Formation are also high in expandable clay minerals, but unlike the Dows Formation, these older tills always exhibit higher kaolinite than illite percentages (Hallberg, 1980). Pre-Illinoian tills also have very little or no Cretaceous shale in the sand (or pebble) fraction in this region (Hallberg, 1980), or in northwest Iowa and adjacent Minnesota (Van Zant, 1974).

Another contrast between the Dows Formation and Pre-Illinoian tills is in the matrix carbonate data (as analyzed by the Chittick method). The Dows Formation exhibits a much higher dolomite content and a lower calcite/dolomite ratio (Hallberg, 1980). The only till in Iowa known to have lithologic properties similar to the Dows Formation is the previously mentioned "Tazewell" till of northwest and north-central Iowa.

Today deposits of the Dows Formation are the surficial materials over much of the Des Moines Lobe. These deposits accumulated beneath the Des Moines Lobe glacier as well as during melting of the glacial ice. Dows Formation deposits form the upper part of the upland sequence in Ledges Park, and average about 10 to 15 meters in thickness (Osolin, 1983). Upper portions of the Dows Formation are oxidized and exhibit brown matrix colors. At depth the deposits are unoxidized and are grayish brown to gray in color. Typically the Dows Formation deposits are calcareous, but upper portions of the unit, within the modern soil profile, may be leached of primary carbonates.

Two facies, formally defined as members of the Dows Formation, are evident in the exposures in Ledges Park. The Alden Member consists of till deposited at the glacier's base (Kemmis et al, 1981). This member has a very uniform texture, and a high bulk density, averaging 1.89 g/cc (see Figure 12 in Kemmis et al, 1981). Occasionally, inclusions of underlying materials, or lenses of sand and gravel originally deposited in englacial channels, occur in the lower portions of the Alden Member. The Morgan Member, in contrast, is quite variable texturally, often includes lenses of sand and occasional graded beds, and has a lower bulk density than the Alden Member (averaging 1.62 g/cc).

This member was deposited supraglacially as debris melted out of the glacial ice. This process can be very complex and the reader is referred to Boulton (1972; 1976), Lawson (1979; 1982), Kemmis (1981) and Sugden and John (1976) for discussions of sedimentation in the supraglacial environment.

The late Wisconsinan history of the central Des Moines Valley (DMV) is relatively short, but complex. The valley pattern and location as well as many of its striking features, such as the deep entrenchment and high outwash terraces and benches, originated during wastage of the Des Moines Lobe glacier between about 14,000 and 11,000 years ago (see Part 2 of this guidebook).

After reaching its terminus the Des Moines Lobe glacier stagnated and rapid wastage began. Around 13,500 B.P. the active glacier front was at the position of the Altamont Moraine just north of Boone and Ames (Figure 1.2). At that time meltwater was carried from the glacier front by Beaver Creek and the Skunk River. Available evidence suggests that the Des Moines River was not carrying outwash when the glacier was building the Altamont Moraine (Bettis and Hoyer, 1986).

Exposures in several tributaries of the central DMV shed some light on the origin of the DMV in the southern portion of the Des Moines Lobe. From the base up these exposures reveal: Pennsylvanian-age or Pre-Illinoian-age deposits overlain by late Wisconsinan loess that is buried, and in most cases, angularly truncated by calcareous sand and pebbly sand. The sands are abruptly, but conformably, overlain by Des Moines Lobe glacial till. Sedimentary structures within the sands, such as trough crossbeds, indicate that they are fluvial deposits. The sands range from 2 to 4 meters in thickness, and appear to thicken toward the DMV. We interpret these deposits as subglacial or englacial Des Moines Lobe deposits. Originally these deposits may have occurred as a large lenticular body in a subglacial or englacial channel complex at the base of, or within the Des Moines Lobe glacier. Between about 13,500 and 12,600 B.P. the glacier stagnated and a sag developed along what was to become the central DMV. Water from the melting glacier and precipitation events was channeled toward the sag and a valley began to develop. As time passed, the valley cut down through the stagnant ice and into the sandy and gravelly fill of the former englacial or subglacial channel complex.

Exposures of the sub-Des Moines Lobe sands are present in tributary valleys in Ledges Park (Osolin, 1983). In the Ledges area the sands are faulted and the sand body has an inverted channel shape. These observations support a sub-glacial origin for the sands.

About 12,300 B.P. the Des Moines Lobe glacier readvanced to the position of the Algona Moraine (Figure 1.2). By that time the DMV was acting as a meltwater channel carrying large volumes

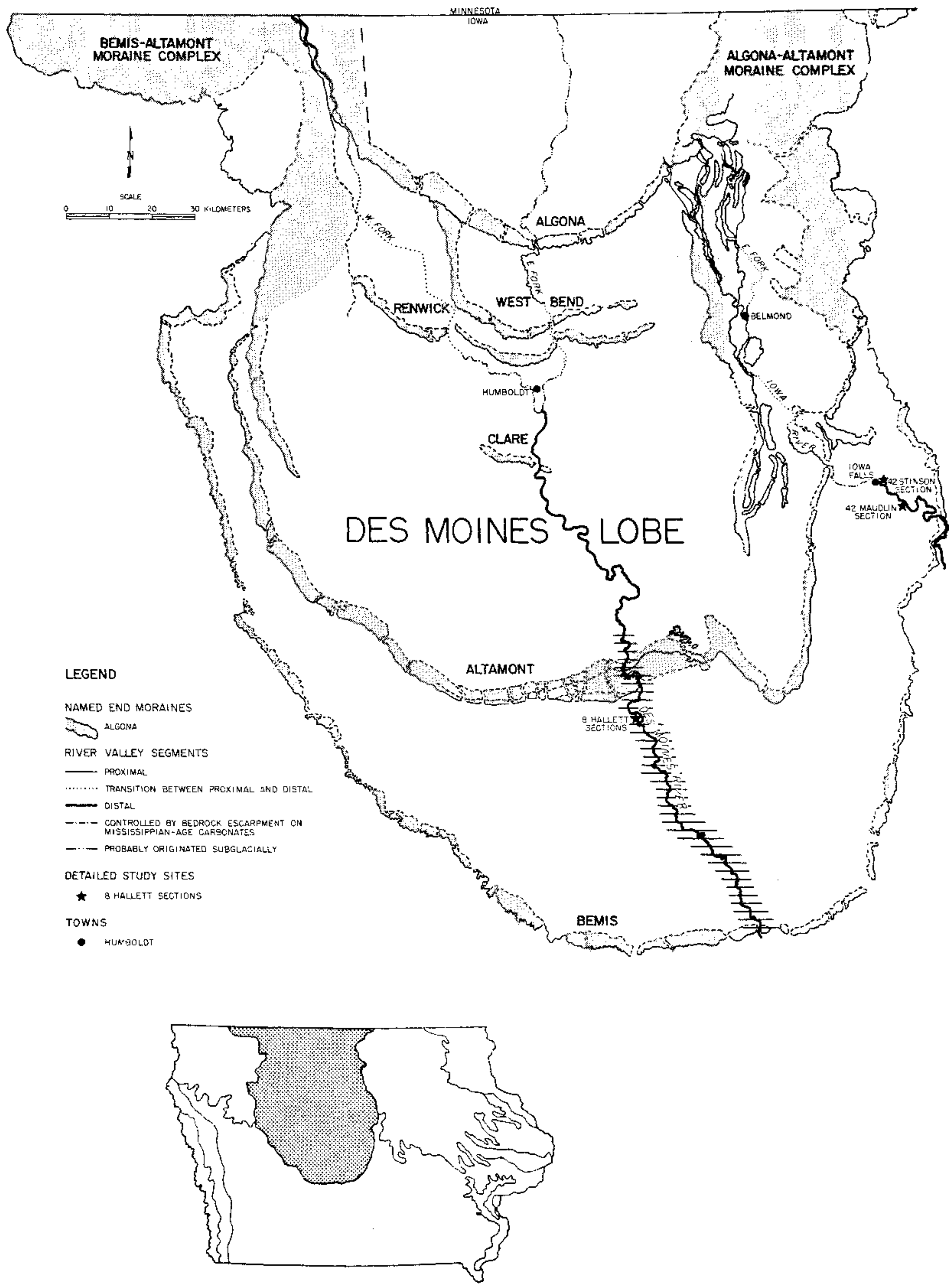


Figure 1.2. Map of the Des Moines Lobe showing the location of end moraines. The central Des Moines Valley is indicated by the horizontal ruling.

of meltwater and outwash from the glacier front. From 12,300 to 11,000 B.P. the central DMV cut down episodically and produced a series of terraces and benches in Webster, Boone, Dallas, and Polk counties. As used here benches are erosional features cut into underlying deposits and are mantled with less than 2 meters of alluvium. Terraces, on the other hand, are constructional landforms, and have more than 2m of alluvium burying a cut surface. The benches and terraces are generally unpaired, developed on glacial till or Pennsylvanian-age rock, and are separated by prominent scarps. Benches are common and are found at both low and high elevations, while outwash terraces are less common and are restricted to the lower elevations. The origin and sedimentology of these outwash features are discussed in detail in Part 2 of this guidebook.

Tributary valleys also underwent rapid evolution during the late Wisconsinan in response to downcutting of the DMV. Most of the larger tributaries, such as Peas and Davis creeks in Ledges Park, probably originated as subglacial or englacial channels related to the larger englacial channel that was to become the DMV. As the DMV cut down episodically between 12,300 and 11,000 B.P. the major tributaries incised and eroded headward.

By 11,000 B.P. the DMV was cut down to approximately its present level and the Des Moines River no longer carried outwash (Bettis and Hoyer, 1986). The valley walls were very steep and tributaries had much steeper gradients than at present. From this time until about 4,000 B.P. large amounts of sediment were stored in the DMV. These deposits make up what Bettis and Benn (1984) refer to as the High Terrace, and also are present in alluvial fans and colluvial slopes along the valley walls (Bettis and Hoyer, 1986). Deposits accumulating in the DMV during this period of time were derived from widening, lengthening, and downcutting of the tributary valleys. Alluvial fans accumulated at the junction of small and moderate-sized tributary valleys with the DMV. These landforms were constructed in several short pulses separated by longer periods of relative stability and soil formation. Alluvial fan deposits interfinger with the High Terrace deposits in the DMV. Surface soils on the High Terrace and alluvial fans tend to be thick, and moderately to strongly developed.

About 4,000 B.P. the Des Moines River downcut slightly and began constructing a new floodplain below the level of the High Terrace. These younger deposits are collectively referred to as the Intermediate Terrace (Bettis and Benn, 1984; Bettis and Hoyer, 1986). Intermediate Terrace deposits are derived primarily from reworking of older Holocene alluvium in the tributaries and in the DMV. The Intermediate Terrace was flooded during large floods prior to construction of Saylorville Dam. Weakly to moderately developed surface soils are present on the Intermediate Terrace.

The youngest alluvium in the DMV is contained within the active channel belt, referred to as the Low Terrace by Bettis and Benn (1984; Bettis and Hoyer, 1986). Deposits in this area are less than 750 years old. The Low Terrace, actually the active floodplain, parallels the modern channel, is slightly lower in elevation than the Intermediate Terrace, and has very slight soil development.

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OVERVIEW OF THE VEGETATION OF LEDGES STATE PARK

by
John Pearson

The vegetation of Ledges State Park has been studied by several workers, probably beginning with Pammel (1895). Most of the studies however, included "the Ledges" as part of a larger geographical or ecological summary (Pammel 1903, Diehl 1915, Aikman 1934, Kucera 1952, Bach 1982). The most recent and comprehensive studies of the park vegetation are by Johnson-Groh (1983, 1985) and Johnson Groh and Farrar (1985). These latest studies contained detailed descriptions of the flora and plant communities, including a large-scale (1:3600) map. A special feature of the dry and dry-mesic forest in Ledges is the presence of numerous old white oak trees with ages of 200 to 350 years (Duvick and Blasing 1981, 1983; Blasing and Duvick 1984). Brief descriptions of the natural vegetation communities and old trees follow.

Dry upland forests.

Forests on higher parts of the park landscape are dominated by mixtures of white oak (*Quercus alba*), northern red oak (*Q.rubra [= Q. borealis]*), and chinquapin oak (*Q. muhlenbergii*). In his classic monograph on Wisconsin vegetation, Curtis (1959) classified such communities as "southern dry forests." Johnson-Groh (1985) recognized three community-types within this broad unit: *Quercus alba* (QA), *Quercus alba-Quercus rubra* (QAR), and Slump Forest (QARS). The QA type is primarily restricted to flat upland areas. The QAR type occurs widely on steep slopes. The QARS type occurs on steep slopes which have slumped (see geological section); dominance of this community-type is shared among at least four tree species: chinquapin oak, white oak, shagbark hickory, and red oak. A unique feature of the Slump Forest type is the presence of vernal ponds in small, perched basins created by uneven downslope movement of soil. Although the dry upland forests in Ledges State Park are currently dominated by the dry oak, the future composition of their canopy in uncertain. Most of the saplings (of tall-growing tree species) observed by Johnsin-Groh (1985) were non-oak speices, including ash (*Fraxinus* spp.), basswood (*Tilia americana*), and black maple (*Acer nigrum*).

Dry-mesic upland forests.

Communities variously dominated by northern red oak and basswood were called "southern dry-mesic forest" by Curtis

(1959). As with the dry upland forests, Johnson-Groh (1985) recognized three community-types in this broad unit at Ledges State Park: Quercus rubra (QR), Quercus Rubra-Tilia americana (QRTA), and Tilia americana (TA). All three occur extensively on steep slopes in the park. Johnson-Groh (1985) felt that succession in dry-mesic forests in Ledges was toward a more mesophytic maple-basswood composition, involving a gradual loss of red oak dominance. As with the dry upland forests, ash was the most abundant sapling species.

Mesic upland forests.

Communities dominated by sugar maple (Acer saccharum) or by a mixture of sugar maple and basswood were classified as "southern mesic forest" by Curtis (1959). In central Iowa, black maple (A. nigrum) can be viewed as the ecological equivalent of sugar maple (A. saccharrum); in fact, some taxonomists treat black maple as merely a variety of sugar maple. Johnson-Groh (1985) mapped mesic forests in Ledges as the Tilia americana-Acer nigrum (TAN) type, but merged it with the TA type in her written discussion. It is restricted to the most sheltered, shaded habitats in the park such a narrow ravines and east-facing slopes. Unlike more xerophytic forest types, the mesic upland forests appear to be fairly stable in species composition, i.e., a "climax" forest in which the overstory and understory trees are largely of the same species. A caveat with this view is (again) the abundance in the understory of ash saplings, which outnumber the combined representation of maple and basswood saplings by a ratio of nearly two to one (Johnson-Groh 1985).

Wet-mesic bottomland forests.

Communities dominated by American elm (Ulmus americana), ashes (Fraxina pennsylvanica and f. nigra), maple and other tree species on floodplains were classified by Curtis (1959) as "southern wet-mesic forest." Johnson-Groh (1985) recognized the extensive walnut (Juglans nigra) - dominated communities along undeveloped reaches of Pease Creek and Davis Creek as Bottomland Forest (JN). Due to past disurbance, this community-type is undergoing continued succession. Maple and ash are the most abundant species in the sapling statum.

Prairies.

Only five natural prairie sites were mapped by Johnson-Groh (1985) in Ledges State Park, mostly on very steep west-facing slopes on shallow or unstable soils. All are very small (each approximately 0.05 hectare [0.1 acre]) and harbor a depauperate flora consisting mainly of the grasses big bluestem (Andropogon gerardii), little bluestem (Schizachyrium [= Andropogon] *scoparius*), sideoats grama (*Bouteloua curtipendula*), and Indiangrass (*Sorghastrum nutans*). They are heavily invaded by ironwood (*Ostrya virginiana*). Manual control (hand-cutting) of invading trees and shrubs has been initiated.

Two larger areas of prairie in the park are anthropogenic in origin. The large prairie by the east entrance was planted, beginning in 1949 and continuing with current efforts to convert old fields located further south. When finished, planted prairie will occupy a major part of the southeastern side of the park. A second area of prairie can be found in an old field undergoing invasion by big bluestem (and woody species) near Lost Lake in the southwestern part of the park.

Old trees.

As part of a larger dendrochronological study of white oaks in Iowa and the eastern United States, Duvick and Blasing (1981, 1983) and Blasing and Duvick (1984) cored over 100 trees in Ledges State Park. Fifty-one of the cored trees were older than 200 years and fifteen were older than 300 years. The oldest living individual was approximately 350 years old. Of seventeen Iowa sites sampled by Duvick and Blasing, only one other locality (Pammel State Park near Winterset) yielded a greater number of old trees. The old trees in Ledges were instrumental in documenting a sereis of 20-year precipitation cycles in eastern North America between 1680 and 1980.

Most of the old trees in Ledges State Park are scattered along the long, narrow, tortuous "rim" between the steep slopes of the canyon and the flat uplands, but local clumping of old trees is evident in Walking Fern Hollow, a large ravine in the southern part of the park. Most of the old trees are located in remote, undeveloped parts of the park, but some are easily viewed in the picnic area and campground near the east entrance.

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TRAILS - A SENSE OF PLACE

by
Mark Edwards

"The job of recreational engineering is not one of building trails into lovely country, but of building receptivity into the yet unloving mind."

- Aldo Leopold

We each have our area of expertise and interest which has brought us to this area today. As we walk through the landscape, looking at the natural world, we must consider our affect on it. We are connected to this scene and our presence on the path makes us liable for its condition.

Each of us who spends time on the trail should understand why it is there, how fragile it is, and how much work goes into its care and feeding. Only then will we respect it properly. And perhaps only then will we be willing to work to save that endangered species - the trail.

What is the purpose of trail building??? Most of us would guess - to provide access to the area. Primarily, it is to protect and minimize our effect on the features that drew us to the area in the first place. When trail building is perceived from this direction, it takes on a whole new dimension. All land area has an inherent and variable ability to sustain use without suffering damage to soils, vegetation, and water. This ability is quite low, especially with steep slopes, abundant water runnoff, and heavy use. To increase the land's ability to withstand hiking use without resource damage, trail management programs must be introduced.

A few years ago, the DNR had the foresight to recognize this and made an investment in protecting and restoring this area. The trails in the park have historically been a focal point of the recreation experience. Numerous trails link the unique features, scenic areas, and recreation facilities of the park. Hiking demand over the years has exceeded the carrying capacity of the Ledges trail system. Overuse and resource damage has resulted. Rehabilitation of existing trails will enhance hiking as a recreational activity and provide a necessary support facility for interpretive programs.

Historically, this area has always been a unique and sacred space for people. The Native Americans found this valley to be bountiful in the riches of nature. This relationship, or sense of place, was expressed in physical form still evident today by the construction of earthen mounds and trails. The unique colonies of plants for food and medicine drew them to specific areas for collection, while the geological features provided altars and amphitheaters. This valley lies on one of the main interstates of trade and travel routes connecting the areas of

Minnesota and the Dakotas to the Mississippi valley and Gulf of Mexico.

With the recent advent of the "white man," many major changes began to affect this valley. First, the harvest of timber took place. This is best illustrated by a picture in the archives showing the valley completely clear-cut with only a few scrub trees still on the side slopes. The timber was also removed from the Des Moines River flood plain. The channel, which originally resided on the western side, moved eastward and has remained there skirting the rock walls around Katina Falls. Next came heavy grazing of livestock and a number of families moved into the valley. These intrusions of mining, farming, logging, and stagecoach roads for people and horses, began to accelerate the erosion patterns.

As early as 1914 this valley was proposed as a park, and in the 1930s limited development took place through the Work Progress Administration and Civilian Conservation Corps depression era programs. From this period we find the major trail systems established and constructed to protect and preserve this area from erosion. The CCC's craftsmanship and concern have been unmatched since. We are now trying to restore and maintain this original concept.

Park attendance has steadily been increasing over the years. in 1946 the annual attendance was over 117,000, and the all time high of over 500,000 was reached in the late 60s and early 70s. While this increase in park usage was occurring, few associated physical or pragmatic improvements or additions to the park were being made. "People were literally swarming all over the park" and "loving it to death."

This past usage and abuse has led to trail surfaces dropping up to twenty feet of soil into the water channels below. The force that moves this soil we call erosion. Most of us fail to see it except when the damage has already been done and is quite severe. The way to comprehend this force is to set on one of these trails in a heavy rainstorm. Down comes the driving drops at about 20 mph. Increase this two to three times with a wind and you will see these little bombs are moving dirt two to three feet up into the air and as far as five feet downhill. This force must be the primary concern of trail construction, especially when you realize this will further be compounded by hiker compaction. Research has shown that water flows up to fifteen times faster on compacted soils. The yardstick for putting all this into perspective is - it takes about thirty years to form one inch of topsoil.

Trail conditions have caused severe erosion, affecting adjacent slopes, disrupting natural drainage patterns, and destroying vegetation. In some areas, the erosion has caused irreparable damage to the resources of the site, not to mention the diminishing of scenic values important to trail recreation. In studying the existing conditions of the trails, it is important to understand the soils upon which the trails have been located. Most of the trails have been established on soils classified as Hyden-Storden Loam or Hayden Loam. According to the U. S. Department of Agriculture Soil Conservation Service, these soils have slight limitations for trails on slopes fourteen percent and less. However, a majority of the Ledges Trail System exists on slopes with much steeper gradients. It is when the gradient increases that the limitations for trails increase due primarily to the susceptibility to erosion. This means that good management, careful design, and sound construction of trail structures are extremely important, in order to mitigate or minimize environmental impacts and ensure user safety.

Corrective measures for these areas include: grade reestablishment; slope stabilization; and revegetation. As a general rule, grades of 7% or less are ideal for trails. Grades over 7% require step construction, landings, water diversions, and retaining walls. Many of the Ledges trails approach 50%, which is the maximum slope for trails. The main problem to be faced here at the Ledges and elsewhere, is to educate people of the importance of staying on the trails that have stabilized. The area is riddled with numerous impromptu trails. These will continue to erode and develop into major problems in the years to come.

The popularity of the sandstone ledges have created some special overuse problems in the canyon area. The glacial till overlying the sandstone formation is rapidly eroding. The structure of these formations limit the type of protective trail surfacing needed for protection from heavy use. Great care is being taken to protect this unique feature of the park. Rappelling and rock climbing--once a popular activity in the park--has been banned as a Destructive Act. According to Dr. Robert Palmquist, formerly of the ISU Geology Department, "The sandstone ledges are more fragile than normally realized. The sandstone is poorly cemented and thus weak and easily broken. The face of most cliffs is 'case hardened.' Case hardening is the strengthening of the surface layer of rock from the addition of calcite cement. Groundwater, as it flows through the sandstone, dissolves the calcite cement which holds the sand grains together. When the groundwater reaches the cliff face, it evaporates. The dissolved calcite crystallizes from the water to add cement and strength to the cliff face. The outer quarter-inch to two-inch layers of cliff face is stronger than the interior rock. Concern is that continued rappelling will break through the case to expose the soft interior to rapid erosion. Small scale examples of natural case breaching are the niches developed in some of the cliffs along Pea's Creek and also in the Katina Falls area. The problem is that once the case is breached and enlargement begins, it is to late to stop the process. Prevention is thus required." Also because of this unique case hardening, we have a severe problem with defacement from graffiti and the carving of names.

Some discussions of possible solutions have lead to constructing six foot high chain link fence to force people to stay on the trail. What a deplorable answer, but many areas are already so far gone that even this approach is too late. What will it take for people to see that they are destroying the very thing that attracts them to this area? We can learn something from the animals that use the park. They make trails that tend to follow the contour lines of elevation. They rarely proceed straight up and down the slopes. They meander along, slowly changing elevation to transverse the side slopes. We all must learn to "walk gently on Mother Earth."

The Ledges Trail System is an important educational tool for illustrating the design and function of trail building. It is already being used as a model for state, county, and city trail design and will continue to serve as a statement of concern for fragile slopes, while providing safe and easy access to a place of unique beauty and magic.

FIELD TRIP STOPS

by
Art Bettis, John Pearson, David Gradwohl, and Nancy Osborn

Stop #1

A grove of old white oak trees is located immediately west of the westernmost parking lot in the picnic ground near the east entrance. The ages of these trees range from 200 to 300 years. One individual near the edge of the upland was selected by the Iowa Urban Foresters to commemorate the 200th anniversary of the signing of the U.S. Constitution.

Stop #2

Inspiration Point--- At this stop we are standing on the edge of the upland underlain by Des Moines Lobe glacial deposits. You traversed this low relief landscape on your way from Ames to Ledges Park. Surface soils on the Des Moines Lobe till plain are developed in glacial deposits as well as local alluvium derived from the glacial deposits. Subtle topographic changes produce major differences in internal drainage of the soils developed on the upland area.

The drainage network of the upper Des Moines Basin is incised into the Des Moines Lobe glacial deposits, and in close proximity to the Des Moines Valley, through older underlying glacial deposits and into Pennsylvanian-age rocks. This drainage network has developed entirely within the last 12,600 years and has many youthful characteristics. This youthfulness is well expressed in Ledges Park where the Des Moines River tributaries are relatively short and have steep gradients. Many are actively eroding headward into the upland area. Slopes along the drainages are very steep and unstable as a result of the deep entrenchment and active undercutting by the tributary streams. In fact, the landscape in Ledges Park may be one of the most unstable in the State.

Slopes in the park area contain abundant slumps, debris flows, and evidence of creep. The slump blocks produce localized soil microclimates; poorly drained areas behind the rotated slump block, and better drained areas on the crest of the rotated block. While driving into the canyon after the stop at Inspiration Point, note the abundant slumps and debris flows along both sides of the road. Also look for tilted trees and trees with bent trunks, indicating areas undergoing active creep.

All of the natural vegetation visible from Inspiration Point is a complex of dry and dry-mesic upland forest. En route to Stop #3, we will pass through a large area of Slump Forest dominated by basswood on a north-facing slope. The opposite, south-facing slope is also a Slump Forest, but is dominated by a mixture of white oak, red oak, chinquapin oak, and shagbark hickory.

STOP #3

Peas Creek Canyon--- Just before crossing the first bridge across Peas Creek at the base of the canyon road, notice the outcrop of Pennsylvanian-age sandstone on the left side of the road. In this exposure lenticular bodies of well-indurated sandstone are enclosed in friable sandstone. Primary sedimentary structures in the sandstone extend across the friable/well indurated boundary, indicating that the induration is epigenetic (developed after the sequence of rocks was deposited).

As we drive to stop 3 note several other occurrences of the well-indurated sandstone facies enclosed in the friable sandstone facies. Also note that the well-indurated facies crops out high in the bluff where it forms a resistant ledge holding up the valley wall. The bonding agent in these sandstone exposures is calcite.

At stop 3 we can take a close look at the friable sandstone facies. Note that overall the deposit is planar cross-stratified, with the lower boundary of one set truncating the subjacent set. Large-scale trough cross-bedding is also found in the friable sandstone lithofacies.

The lower 10 to 15 feet of the exposure is stained reddish brown. These sandstones are characterized by the replacement of the calcium carbonate cement with iron oxides (Osolin, 1983). Plant macrofossils are occasionally found in this portion of the sandstone.

Reconstructed trails in this area will guide us through a variety of dry and dry-mesic upland forest communities. To the south is Reindeer Ridge (probably named for the abundant reindeer lichen here), on which small prairie openings were reported by Ada Hayden in the 1940s; no prairies can be found here today due probably to uncontrolled natural succession to forest. To the north, the present condition of the trail crossing the top of the "amphitheater" wall is a graphic demonstration of the "before" and "after" effects of trail reconstruction; the unreconstructed east end of this trail still exhibits severe erosion problems. A savanna-like dry forest of white oak trees and some prairie species can also be seen near the east end of this trail.

The Beulah Home

Today visitors to Ledges State Park may observe the remains of a stone and mortar pillar which stands just north of the roadway and about 100 ft. from a parking lot within the upper canyon; this is apparently the last vestige of the Beulah Home. The Beulah Home was built by Mrs. Emma Main Fowler as a Christian recreation center for children from Des Moines. This facility was probably built in 1904 or 1905 on the basis of information found within land transfer records. Mrs. Fowler was a self-proclaimed "childrens' evangelist." She is said to have brought both boys and girls to the Ledges for fresh air and spiritual uplifting. The Fowlers turned the home over to the Boone Biblical College in 1912, and it served for a time as a recreation spot for students and staff persons at the school. The following year, however, the land was sold into private hands. This remnant of the Beulah Home can serve as a reminder of one of the varied uses made of the beautiful Ledges canyon.

Archaeological Site 13BN268 -- The McGaw Cabin and Homestead

In the summer of 1983, during the course of an archaeolcgical survey along the transect of a waterline under construction, a anomalous concentration of daylillies within a stand of red cedar trees was noted amidst the heavy lowland vegetation along the left bank of Pea's Creek upstream from the main Ledges canyon. Further surface investigation resulted in the discovery of foundation bricks, broken porcelain and china tableware, glass bottle fragments, and other historic domestic detritus. Nearby was located a deep depression within which was still more historic debris. In 1925 Carl Fritz Henning, a long-time custodian in the park, made reference to "...the old McGaw homestead, a tumble-down shack, around which early history clings..." Archival records show that one "S.M. McGaw & S. B. Watkins and husb." transferred five acres within the NE 1/4 of the NW 1/4 on the SE 1/4 of Section 16 to Rachel J. McGaw on 16 May in 1879. Obviously the McGaw family had acquired interest in this parcel sometime prior to 1879, but the records show no earlier entry of transfer. No entries are noted for this portion of the section until 1867, and on this basis it is suggested that the "old McGaw home" is likely to have been built no earlier than the late 1860s or early 1870s.

Further archaeological and archival work is recommended to document this site and to provide information for future interpretive programs at the Ledges. Ironically, potential utilization of the McGaw cabin as part of the park's facilities may be found in recommendations date as early as 1925. In an early development plan provided to the Iowa Conservation Commission regarding Ledges State Park, John R. Fitzsimmons, a landscape architect at Iowa State College recommended under "future developments" that the commission consider "...the reconstruction of the old McGaw house to serve as a shelter at the Picnic Grade."

Immediately east and northeast of the cabin ruins, during archaeological monitoring of the tree clearing for the waterline, prehistoric artifacts were recovered from the ground surface. Some limited archaeological tests into the subsurface showed that this bench position is also the locus of a prehistoric settlement spanning the late Archaic to late Woodland cultural periods (possibly as old as 2000 BC to AD 900). More extensive archaeological excavation would be necessary to provide interpretation of this earliest-known occupation of the Pea's Creek valley.

Centennial Mill

Early industry within the Pea's Creek valley is known to have included at least one mill. By 1853 James Hull, along with W. D. Parker, is said to have built a sawmill on the creek, although its exact location is not known. On the Andreas map of 1875 a "mill" is indicated generally along the upper reaches of the creek; it may be that of Hull and Parker. However, it is also possible that by that time Hull and Parker's lumber mill had been converted to the grist mill that came to be known as the Centennial Mill.

Although the former location of the mill has not been found, tangible evidence for its existence has been recovered. In 1981, while dismantling the former assistant park ranger's residence in the lower Ledges, Kenneth Lansing salvaged the large sandstone backdoor step. Upon turning it over he discovered that chiseled into its surface was the following inscription:

CENTENNIAL MILL
1876
SELLHORN & WALSER

According to Boone County's land transfer records, a Martin Sellhorn had purchased a tract of land within the W 1/2 of the NE 1/4 of Section 16 in April of 1884; this parcel was still in his possession in 1896, but in 1901 he and his wife sold the property. A portion of Pea's Creek flows through the southern portion of this tract and it is probable that somewhere along this segment Sellhorn and his presumed partner operated their mill. Coincidentally, it is in this same general area through which a road is shown to pass on a 1918 plat map.

Kenneth Lansing donated the chiseled stone, which probably had served as a lintel or cornerstone for the mill structure, to the Iowa Conservation Commission. Restoration of this stone is highly recommended so that it might serve as a focal point for discussing with park visitors the 19th-century industrial history within the Ledges. Further archaeological reconnaissance along Pea's Creek could provide additional information as to the exact location of the former mill.

STOP #4

Des Moines River terraces and alluvial fans--- At this stop we can see two of the Holocene-age landform/sediment assemblages found in the central Des Moines River valley. A series of small, coalescing alluvial fans form the upper surface where we parked our cars at this stop. The deposits in these alluvial fans were derived from the small tributaries along the eastern valley wall. The fans were constructed episodically between about 11,000 and 2,500 years ago during periods of instability and erosion in the small tributary valleys. During periods of stability in the tributary valleys sedimentation on the fans was much reduced, and soils formed on the fan surface. The western and northern border of the fans is formed by a short, steep scarp descending to the Intermediate Terrace level. This terrace is actually an upper floodplain of the Des Moines River. Deposits making up this terrace accumulated between about 4,000 and 750 years ago during overbank flooding.

Prehistoric Archaeological Sites 13BN6, 13BN201, and 13BN263

The riverine terraces and alluvial fans within the lower Ledges are known to be the loci of prehistoric archaeological sites spanning the Archaic to Middle Woodland cultural periods (roughly 5000 BC to AD 650). Three of these sites investigated by archaeologists from Iowa State University in 1968 and in 1982 lie on either side of the road which presently traverses the lower Ledges. Local artifact collectors were said to have gathered "Havana-like rims (of ceramic vessels), corner-notched projectile points, and grooved axes" here over the years, and these reports were corroborated by similar materials excavated from the surface to a depth of 3.5 ft. by the archaeologist. These sites are interpreted to have been prehistoric Native American encampments and chert knapping areas and, as such, are indicative of the earliest documented human habitation and use of the Ledges area. Such information is vital in providing a perspective of land use over time to present-day park visitors.

STOP #5

Lost Lake--- On the Lost Lake hike we will walk through a dissected portion of the upland. Several interesting landscape features are present in this area. The parking lot is located on a late Wisconsin-age bench cut into Pennsylvanian-age sandstone. The first part of the hike follows a narrow channel associated with the bench. Note the large glacial erratics along the side of the path. These were left on the bench/channel as an erosional lag during high magnitude late glacial floods that formed these features.

About midway to Lost Lake we cross a limestone dam constructed by the CCC in the 1930's. This dam was constructed at the top of a waterfall held up by the well-indurated facies of the Ledges sandstone. You can get a good look at the Pennsylvanian-age rocks here by walking to the overlook southwest of the dam.

Lost Lake is located adjacent to the Des Moines Valley on the southern park boundary. Osolin (1983) concluded that the basin occupied by the lake originated during melting of the Des Moines Lobe glacier, and that this was an ice stagnation feature. We suggest that his interpretation is incorrect and that Lost Lake was created by damming of a small Des Moines River tributary, possibly sometime around the turn of the century. Several lines of evidence support this contention. First, it seems unlikely that a closed depression formed during the late Wisconsin Episode has survived this close to the Des Moines Valley. To our knowledge, no other closed depressions remain this close to the valley in this portion of the Des Moines Lobe. Secondly, Lost Lake does not appear on the original land survey map of this area. Usually, these maps are quite good at recording these sort of features. Finally, there is a low earthen dam on the northeast end of Lost Lake. Records on file at Ledges Park suggest that this dam was constructed prior to 1920. It seems likely that the present Lost Lake basin was constructed by borrowing selected areas around a series of short drainageways, and damming the larger drainage they formed after joining.

Dry-mesic forest communities variously dominated by basswood and red oak are found along the Des Moines River bluffs. Bryophyte communities are also well-developed on rock outcrops. An old field north of Lost Lake (a boggy pond) resembles a prairie due to the invasion of big bluestem. En route to Stop #6, watch for the prairie planting project currently underway in the southeast corner of the park; this will complement the prairie by the east entrance which was planted in 1949.

STOP #6

Campground, east side of Ledges Park

Numerous 200-300 year-old white oak trees are clearly visible along the western edge of the campground near this stop. A short hike northward will take us through a dry upland forest dominated by white oak. A small natural prairie remnant can also be seen on the steep west-facing slope bordering this upland.

Historic Archaeological Site 13BN269 -- Fowler Homestead Ruins

In November of 1982 archaeologists from Iowa State University met in the Ledges with Iowa Conservation Commission personnel to examine some building ruins and a large stone chimney located in the eastern part of Section 16 within a newly-acquired portion of the park. Since these ruins lay near the route of a proposed backpacking trail, Kenneth W. Smith of the Commission's Planning Section had solicited advice on how these ruins might be incorporated into the development plan.

Initial examination showed the ruins to include a poured concrete foundation of fairly large extent plus concrete piers outlining the former porch along the east side of the house. The northern wall of the house foundation is dominated by an extant two-story-high field stone chimney with a ground-level fireplace. Immediately to the north and west of the house site was noted a concrete toilet vault and the remains of a wooden outhouse which probably had covered it. Beyond this was a poured concrete wall foundation for a larger outbuilding such as a garage or storage shed. Large-diameter ceramic pipes and a riveted metal pressure tank were noted in this area. Nonstructural artifacts observed within the main house structure included some metal bed frames, a metal cook stove, and the cast iron leg of a school desk or chair. None of these items was removed from its context so that the specific provenience of each item could be piece-plotted within the site at a future date. To the south of the house foundations was noted the presence of a large-diameter ceramic pipe that probably marks the position of a well. Also observed in the immediate environs of the house exterior were obvious plantings of various shrubs and perennial flowering plants such as honeysuckle, barberry, iris, and daylillies.

In the spring following the initial visit, the archaeologists were accompanied to the site by Robert Dyas, distinguished professor of Landscape Architecture at Iowa State University, and one of his graduate students. A quick inventory of the plant species observable in the spring was made, and Dr. Dyas noted which of these he felt were introduced ornamental species probably planted by the former residents of the site. The graduate student and Kenneth Smith then mapped the house foundations and landscaping vegetation immediately around the house.

For the purpose of potential future historical archaeological investigation and public interpretation, the house foundations and associated outbuilding ruins and plantings were designated as archaeological site 13BN269. The homestead covers an area of less than 2 acres. Specific historic and archival references to this residence are, as yet, obscure. The house was evidently occupied for a time by Elmer E. Fowler, the husband of Emma Main (or Mary E.) Fowler who is known to have operated the Beulah Home sometime between 1905 and 1911 a short distance away in the Ledges canyon. A plat map of 1918 shows that 20 acres of this vicinity were owned by E. E. Fowler at that time. Local legend says that Fowler, a food faddist, operated a sanitarium here in the late 1920s. Some evidence to corroborate this legend may be found in land transfer records for Boone County.

Given the presence of these ruins, and particularly the strong focal point created by the stone chimney, it is recommended that interpretation of this site be incorporated into the development plan for the backpacking trail. The ruins can provide a dramatic "document" of past land use within the park area and can show how botany, archival records, oral history studies, and archaeology can all play a cumulative role in historical sites interpretation. Continued oral historical and archaeological work, however, will be necessary to accurately develop this interpretation.

PART 2. HALLETT GRAVEL PITS

by

Tim Kemmis
Deb Quade
Art Bettis

SUMMARY

Geological study of the Des Moines River valley attempts to answer several different questions: When and how did the valley form? What river processes were involved, and did they change with time? What physical features make up the valley landscape, and what are the properties of the deposits and soils within the valley? Recent detailed studies give good clues to the answers of these questions.

From a geological standpoint, the Des Moines River valley is a young landscape feature, formed by the erosional and depositional processes of the Des Moines River. The valley history has been dynamic, featuring major differences in river processes and landscape changes between the Wisconsin (glacial) and Holocene (post-glacial) Episodes.

The valley was initiated during the Wisconsin Episode by the downcutting of glacial meltwaters beginning around 12,600 radiocarbon years ago. Meltwater discharge fluctuated greatly between low-flow conditions during winter freeze-up and major floods in the summer melt season. Infrequent, high-magnitude meltwater floods (jökulhlaups) deposited coarse gravel and sand, and downcut the valley rapidly and deeply. In the vicinity of Boone, Iowa, the river downcut a total of nearly 65 m (220 ft) during the Wisconsin Episode. A series of discontinuous terraces, separated by scarps several meters high, indicate that Wisconsin downcutting was episodic, rather than continuous and gradual. The meltwater deposits comprising Wisconsin-age terraces consist predominantly of coarse in-channel deposits, rather than fine-grained overbank sediments. Very poorly sorted cobble gravels near the top of each terrace, here termed "middle-increment" deposits, indicate major meltwater flooding. Glacial ice of the Des Moines Lobe no longer existed in the Des Moines River basin by about 11,000 radiocarbon years before present.

Since the beginning of the post-glacial Holocene Episode, the river's discharge has been dependent solely on seasonal rainfall and snowmelt within the basin. As a consequence, Holocene processes and environments differ dramatically from those of the Wisconsin Episode: peak flood discharges are significantly lower, and annual discharge fluctuations are less. Since the beginning of the Holocene Episode, the river has been characterized by an actively moving meander belt, and river downcutting has been reduced: in the Boone area, the uppermost Holocene terrace lies less than 5 m (15 ft) above the present river. The Holocene deposits form a series of three low, discontinuous terrace complexes with scarps ranging in height from less than a meter to at most a few meters (10 ft). The preserved depositional sequences are dominated by thick, fine-grained overbank deposits, while active channel areas consist predominantly of sands and pebbly sands.

The differing Wisconsin- and Holocene-age terrace stratigraphies provide generally differing environments for plant growth. Wisconsin-age terraces tend to be droughty because there is just a thin veneer of fine-grained deposits over rapidly draining gravels and sands, and because water tables tend to be deep. Benched substrate materials (glacial deposits or bedrock) beneath the terrace deposits tend to have lower hydraulic conductivity than the overlying gravels and sands, promoting perched water tables at the base of the terrace sand-and-gravel sequence. Lateral flow of this perched water causes seepage spots on the lower part of terrace edges (scarps) that provide locally different habitats. These seepage spots are generally formed in various valley-wall materials (fine-grained glacial deposits and Pennsylvanian-age bedrock) because the benched-terrace sands and gravels rarely extend down to the next terrace level.

Holocene-age terraces tend to be less droughty than Wisconsin-age benches. The water table is shallower, and the thicker fine-grained deposits can provide significantly better moisture retention. The high-terrace complex (never flooded) and the intermediate-terrace complex (occasionally flooded only by present low-frequency, high-magnitude floods) provide reasonably stable environments for plant growth. In contrast, the low-terrace complex is frequently flooded, does not provide a stable environment for plant growth, and beneath the woodland canopy the vegetation consists of disturbance plants.

INTRODUCTION

Origin and Age

To geologists, the upper Des Moines River valley (above the city of Des Moines) is a relatively young landscape feature, originating as a drainageway for meltwaters from the Des Moines Lobe during the last glaciation of the State. In fact, current geological evidence strongly suggests that the present upper Des Moines River valley was not established until the Algona End Moraine (Fig. 2-1) was formed by the last glacial advance into the state:

1. Radiocarbon dates on wood associated with the Algona advance and with Algona outwash (12,600 to 12,000 years before present) are the same as that found in the highest terrace downvalley near Saylorville Dam, just north of Des Moines (Table 2-1).
2. The area of the Algona advance forms the headwaters for both the East and West Forks of the Des Moines River. Proglacial drainages along the frontal portion of the Algona Moraine are all tributaries to the Des Moines River. In Emmet County, where the West Fork of the Des Moines River is ice-marginal to the Algona End Moraine, the highest (oldest) terrace in the valley is kettled, and therefore, contemporaneous with moraine formation.
3. The Des Moines River is abruptly incised into, and thus younger than, the various glacial landforms on the Des Moines Lobe older than those of the Algona advance.
4. There is no indication that older end moraines (Bemis, Altamont, etc.) had major drainages to the present Des Moines River valley area. In the Boone vicinity, for instance, the geological evidence shows that drainage of the nearest ice-marginal position, the Altamont End Moraine, was to Beaver Creek, the Skunk River, and their tributaries, rather than to the present Des Moines River valley; high terraces in the Des Moines River are inset well below the Altamont End Moraine and extend through it toward younger sources to the north (Fig. 2-2). Glacial meltwaters from the Algona ice-margin surely flowed preferentially along pre-existing, probably small drainageways, but there is no evidence that these drainageways would have been major drainageways from older ice-marginal end-moraine positions.

There is also no evidence that bedrock influenced the original river location. However, where the river has locally downcut to or into bedrock, bedrock has importantly affected local river base level and downstream gravel composition.

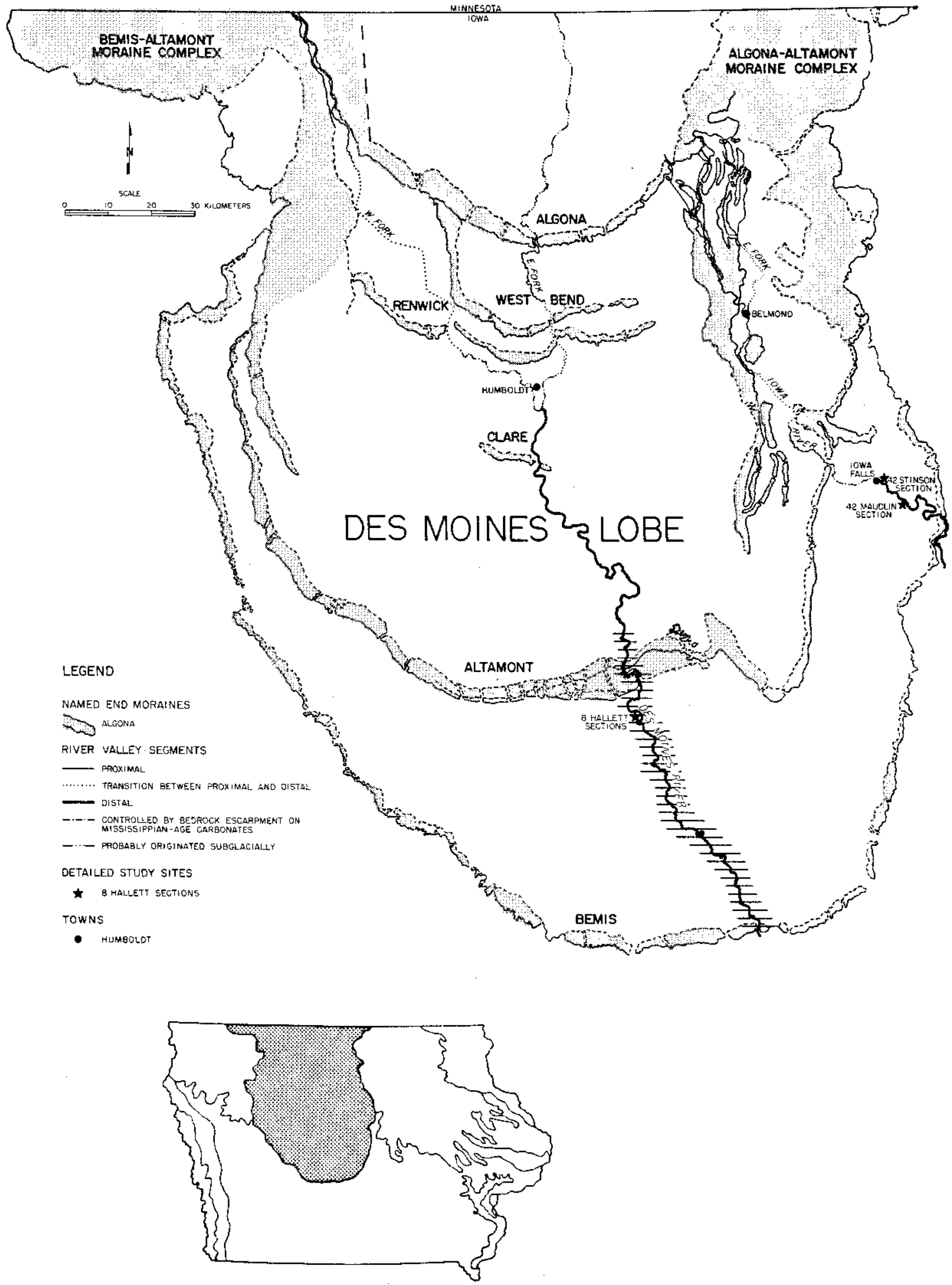


Figure 2-1. Map of Wisconsin-age Des Moines Lobe showing former ice-marginal positions (end moraines), different valley segments along the Des Moines River, and the location of the Hallett Sections west of Boone.

TABLE 2-1. Selected radiocarbon dates.

RADIOCARBON DATE IN RCYBP	LOCATION	LAB. NO.	DATE SUBMITTED	MATERIAL DATED	NOTES
DATE FROM HIGHEST WISCONSIN-AGE TERRACE NEAR SAYLORVILLE DAM					
12,160±80	Wood within gravels of highest Wisconsin-age Des Moines River terrace near Saylorville Lake, Polk Co.	Beta-2632	1981	Wood	
DATES FROM WOOD IN TILL OF THE ALGONA MORAINE					
11,740±100	Log from basal till at depth of 10 m, in exposure in Algona, Kossuth Co.	Dic-1361	1978	Spruce Wood	Date from same log as ISGS-641. In till of Algona Moraine.
12,610±250	Same log as Dic-1361	ISGS-641	1978	Spruce Wood	Date from same log as Dic-1361.
DATES FROM OUTWASH ASSOCIATED WITH THE ALGONA MORAINE					
12,000±105	Log from peat and forest bed within outwash near Whittemore, Kossuth Co.	Dic-1362	1978	Spruce Wood	Same site as I-8768.
12,020±170	Tree stump, rooted in peat within outwash, near Whittemore, Kossuth Co.	I-8768	1975	Wood	Same site as Dic-1362.
12,970±250	Tree stump, rooted in place, in outwash near Britt, Hancock Co.	W-626	1957	Larch Wood	Site is tributary to the Iowa River.
13,030±250	Peat from buried soil in outwash below W-626, near Britt, Hancock Co.	W-625	1957	Peat	Site is tributary to the Iowa River.
DATES FROM TILL ASSOCIATED WITH THE ALTAMONT MORAINE					
13,400±130	Log from basal till at depth of 10 m (0.7 m above base of till), from quarry near Dows, Franklin Co.	Dic-1651	1979	Spruce Wood	Date from same horizone as Beta-1076.
13,525±95	Log from same site and stratigraphic position as Dic-1651.	Beta-1076	1980	Spruce Wood	Date is average of two analyses: 13,485±145 and 13,565±130.
DATES FROM TILL ASSOCIATED WITH THE BEMIS ADVANCE					
14,380±180	Log from contact of basal till and weak paleosol in top of underlying loess, Weaver Quarry, near Alden, Hardin Co.	I-9765	1976	Larch Wood	
14,470±400	Wood from top of loess at contact with basal till, near Scranton, Greene Co.	W-512	1956	Spruce Wood	

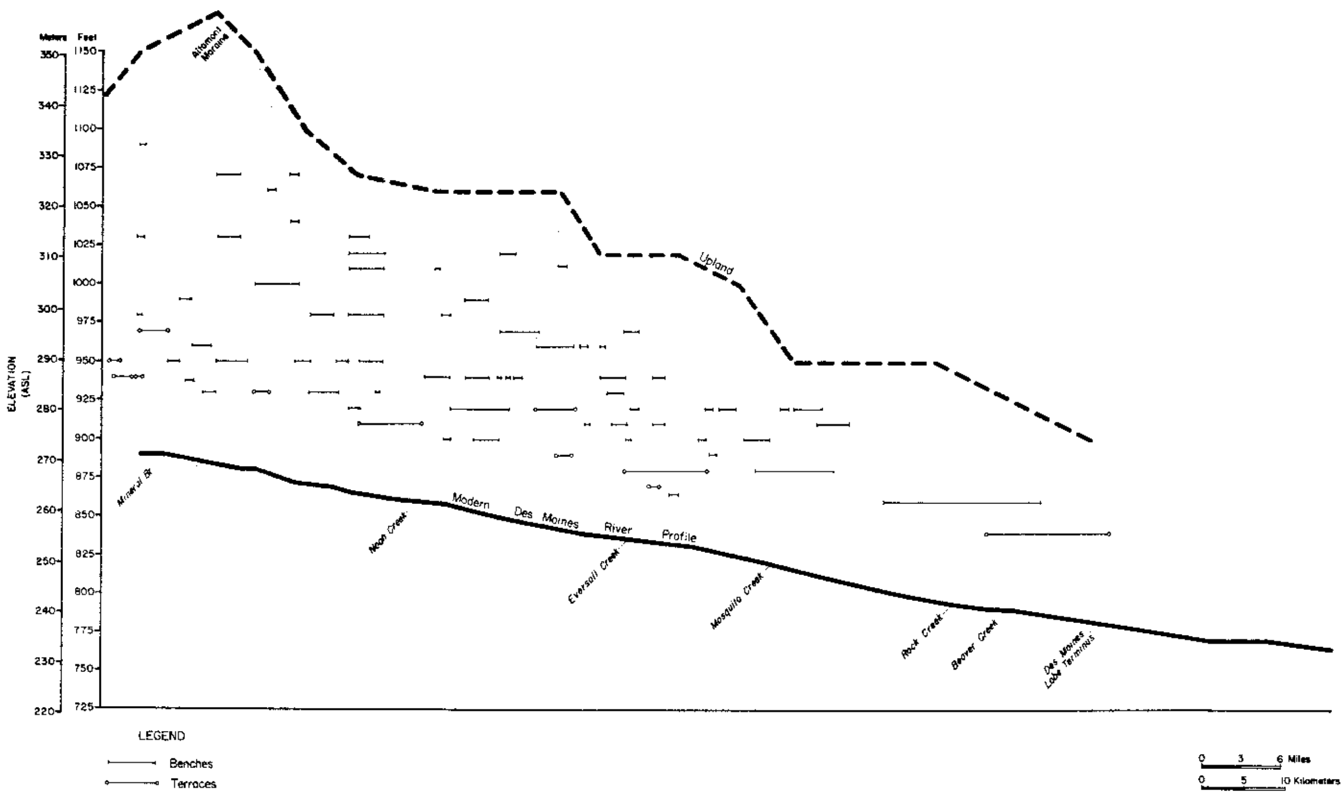


Figure 2-2. Wisconsin-age bench and terrace levels in a portion of the distal reach of the upper Des Moines River. The Hallett sites are located in benches and terraces near Noah Creek.

Changing Features in Different Reaches of the Valley

Like any major river valley, the Des Moines valley changes character along its course. On the Des Moines Lobe, four generalized segments or types of reaches can be identified (Fig. 2-1). **Proximal reaches** are adjacent to the former ice-marginal source, the Algona End Moraine. These reaches are characterized by a landscape of low-relief terraces in broad, shallow valleys. In Humboldt County, **bedrock-controlled reaches** of the East and West Forks of the Des Moines River are incised down onto an escarpment developed on Mississippian-age carbonate rocks. Here the valley is broad and shallow with little significant terrace development, and thin alluvium veneers the bedrock surface. **Transitional reaches** link the proximal and bedrock-controlled reaches. Transitional reaches consist of broad valleys with few, if any, terraces. The alluvium varies in thickness, but tends to be significantly thicker than in the bedrock-controlled reaches. The **distal reach** occurs downvalley of the bedrock-controlled reaches in Humboldt County. After coming off the bedrock escarpment of Mississippian-age carbonate rocks, the Des Moines River enters the long reach extending through the field-trip area to the Des Moines Lobe margin in which thicker Quaternary-age deposits overlie a Pennsylvanian-age bedrock sequence that is erosionally less resistant than the Mississippian-age carbonates upstream. This distal reach is distinctive, characterized by a sinuous, deeply entrenched gorge with numerous Wisconsin-age terrace levels separated by scarps several meters in height. Only a few major tributaries are present. Most of the drainage network, even with the deep entrenchment of the main valley, consists of numerous short, steep tributaries and wooded ravines that extend only 1 to 2 km (0.5 to 1.5 miles) from the main valley.

Wisconsin-age terraces along the Des Moines River are unpaired and discontinuous downvalley. Three different kinds of terraces can be recognized (Fig. 2-3): a longitudinal type, which parallels straight reaches of the valley; a point type, which occurs on the inside of valley meanders; and a cut-off type, that meanders into the valley wall. The exposures we have studied at this stop are all in point-type terraces.

Holocene-age terraces occur low in the valley, within 5 m (15 ft) above the present river. Three terrace complexes, here termed high, intermediate, and low terraces, are present. Each terrace complex is composed of several different terraces occurring over a limited range of elevations above the present river, and each complex has its own distinctive stratigraphy.

The stratigraphy and sedimentology of Wisconsin- and Holocene-age terraces differs between the four different reach or segment types on the Des Moines Lobe and to a lesser degree between different terrace types and levels. This stop on the field trip occurs in the distal reach of the upper Des Moines River.

Changing Environments Through Time

Two major environments have successively affected the Des

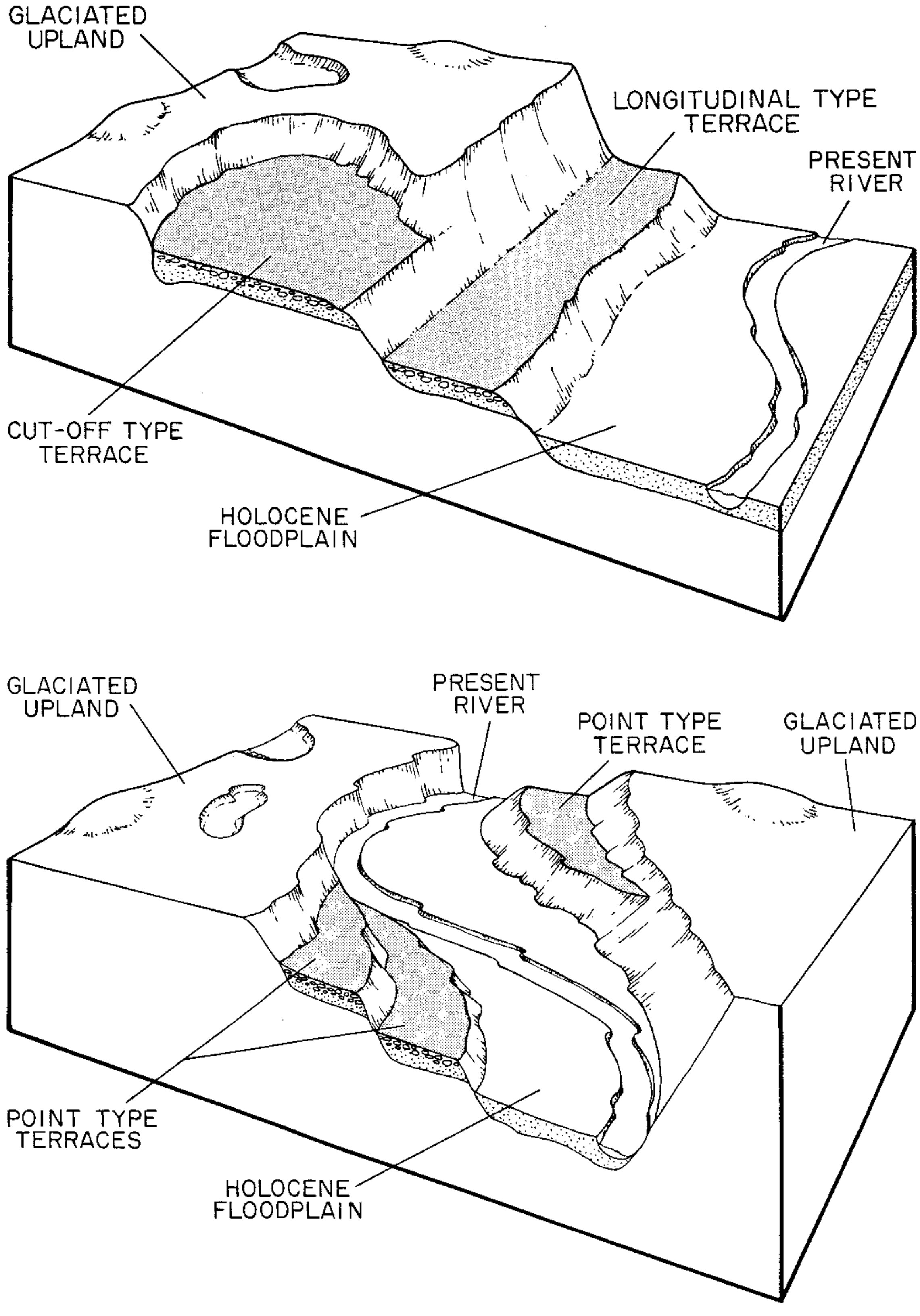


Figure 2-3. Types of Wisconsin-age terraces along the Des Moines River. The Hallett Sections are located on point-type terraces. Holocene terraces are not depicted.

Moines River on the Des Moines Lobe. During the Wisconsin Episode, glacial ice was in the basin contributing large, seasonal discharges of glacial meltwater. Since the beginning of the Holocene Episode, only precipitation has contributed to river discharge, and the river has had both lower magnitude flood peaks and less fluctuation in discharge. The following sections will discuss the geological record of the river's history in the Boone area during these two different episodes.

WISCONSIN EPISODE

A major point of the previous section was that the Des Moines River valley was initiated by glacial meltwater drainage related to the Algona advance. How long were these meltwaters active in the Des Moines River basin? Radiocarbon dates indicate that the Des Moines River was initiated sometime between 12,600 and 12,000 years before present (Table 2-1). Organics in core 17 (8AB17) near the base of the Holocene-age sequence in the highest (oldest) Holocene-age terrace near Boone (Fig. 2-4) were radiocarbon dated at 11,000±290 years before present (Benn and Bettis, 1985; Bettis and Hoyer, 1986). Thus, meltwater drainage into the Des Moines River basin ceased sometime prior to 11,000 years before present.

What effect did this meltwater drainage have? One major effect was the deep incision of the valley. In the Boone area, the present river lies over 65 m (220 ft) below the adjacent upland; in most areas, even the various Holocene-age alluvium and the present river appear to be on Wisconsin-age outwash (meltwater deposits). Thus, meltwater drainage, resulting in over 65 m (220 ft) of valley deepening, occurred over a surprisingly short period of only 1,000 to 1,600 years (between 12,600 and 11,000 years before present).

Was the deep entrenchment a gradual, continuous process or did it occur episodically, in steps? The Wisconsin-age terraces are "benched" terraces. That is, the alluvium on these benched terraces does not extend all the way to the present floodplain (Fig. 2-3); instead, thin outwash, generally thinner than 6 m (20 ft), overlies an erosion surface developed on valley-wall materials. These benched Wisconsin-age terraces, each capped by deposits indicating a major meltwater flood, indicate that the valley was episodically downcut by high-magnitude glacial meltwater floods. At different elevations down the valley side various valley-wall materials underlie the benched deposits. Uppermost terraces may be cut onto Des Moines Lobe glacial deposits, while lower terraces may be cut progressively onto pre-Illinoian-age glacial deposits and then Pennsylvanian-age bedrock. At the studied exposures west of Boone (Fig. 2-4), the Wisconsin-age terrace deposits are cut below the Des Moines Lobe

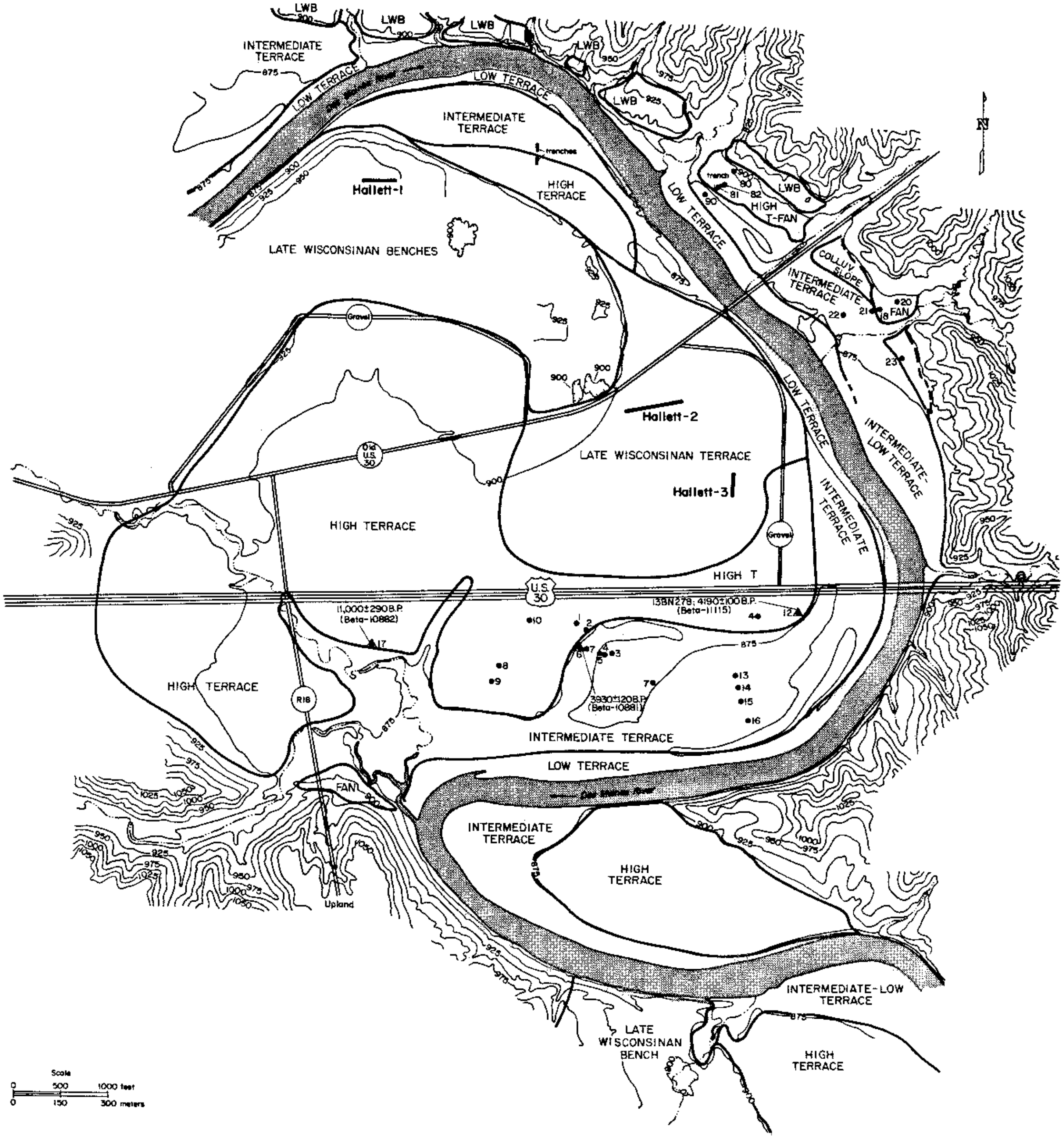


Figure 2-4. Map of a portion of the Des Moines River valley west of Boone, Iowa, showing the location of the Hallett study sites in Wisconsin-age terraces, and the location of Holocene-age terraces and alluvial fans. Core locations are numbered.

deposits and benched on pre-Illinoian-age glacial deposits.

The episodic downcutting suggested by the terrace sequence is also indicated in the stratigraphy and sedimentology of the meltwater deposits (valley-train outwash) on the benched terraces. These deposits near Boone occur on the inside of a valley meander (Fig. 2-4) where five different Wisconsin-age, point-type benched terraces are preserved. We have studied three of these levels that have active sand-and-gravel operations (Fig. 2-4). Hallett-1 is located on the second terrace down from the upland, Hallett-2 is located on the fourth terrace down, and Hallett-3 is located on the fifth or lowest Wisconsin-age terrace level.

In order to better understand former river conditions, we felt that these exposures needed to be described in detail. Unfortunately, when we began our study, there was very little previous research on which to base our studies. To date there has been little research done on the stratigraphy and sedimentology of river deposits (see for example, Miall, 1985). Most studies have concentrated on specific **facies**, that is, specific sedimentary structures, rather than on the total assemblage and sequence of deposits found in river environments. Even fewer studies have been made of river deposits along any significant stretch of a river system. There have been some excellent flume (laboratory) studies of some sedimentary facies commonly found in fluvial (river) sequences, but these studies have concentrated predominantly on various sandy bedforms (ripples, dunes, sand waves, etc.). In the Midwest, very little detailed work has been done on glacial outwash deposits (Fraser and Cobb, 1982; Fraser et al., 1983; Fraser and Fishbaugh, 1985; Kehew and Lord, 1986; Lord and Kehew, 1987), and even these tend to describe single facies, rather than facies sequences which actually make up the deposits.

We began our studies by using a lithofacies code for the descriptions that had been proposed by Miall (1977), and that was suggested by Eyles et al. (1983) to be useful for all fluvial settings. It soon became apparent that more lithofacies were present in the Hallett exposures than those given in Miall's code. Consequently, we changed and expanded the code to encompass the lithofacies we encountered in the field (Table 2-2). In this revised code, general sediment type, such as sand or pebble gravel, is denoted by capital letters, while sedimentary structures are listed in parentheses using lower case letters.

For two of the sites, Hallett-1 and Hallett-3, the exposures at the time of study showed reasonably consistent lateral stratigraphy, so representative vertical profiles were described (Figs. 2-5 and 2-6, respectively). At Hallett-2 there was greater lateral diversity, so no representative vertical profile was possible. Consequently, a cross section was drawn to scale to show the lithofacies present (Fig. 2-7). Later excavations extended the Hallett-2 section to the west, and a cross section was made of this new exposure (Fig. 2-8).

TABLE 2-2. Lithofacies code used to describe the Wisconsin-age terrace deposits.

DESCRIPTIVE LITHOFACIES CODE FOR FLUVIAL DEPOSITS (PROVISIONAL)[1]

Gross Particle Size - first symbols			
BG[2]	boulder gravel	cs[5]	clast-supported
CG[2]	cobble gravel	ms[5]	matrix-supported
PG[2]	pebble gravel	cm[5]	clast-to matrix-supported
S[3]	sand		
F[4]	fines		

Bedding Structures[6] - second symbols, in parentheses	
(m)	massive.
(pl)[7]	plain-bedded; crudely horizontal; may be slightly undulatory.
(h)[7]	horizontal laminated; may be slightly undulatory.
(r)	ripple-drift cross-laminated (various types).
(t)	trough cross-bedded; size (scale) and single or multiple sets noted on log.
(w)[8]	wedge cross-bedded; size (scale) and single or multiple sets noted on log.
(p)[8]	planar cross-bedded; size (scale) and single or multiple sets noted on log.
(c)[9]	cross-bedded deposits with complex upper and lower contacts; generally large-scale, solitary sets; lower contacts commonly undulatory over irregular channel floor; upper contacts commonly undulatory, truncated by overlying bedding structures.
(la)[10]	lateral accretion deposits.
(ccf)[11]	channel cut-and-fill; massive or simple structures mimmicking the scoured channel cross-section.
(ccfc)	channel-cut-and-fill structure with complex facies changes within the fill (see Ramos and Sopeña, 1983).
(ccft)	channel cut-and fill structure with transverse fill (see Ramos and Sopeña, 1983).
(ccfms)	channel cut-and-fill structure with multi-storied fill.
(lag)	lag at base of channel or crossbed set.
(g)	normally graded.
(ig)	inversely graded.
(n-i)	normal to inversely graded.
(i-n)	inverse to normally graded.
(l)	low angle (<10°) crossbeds.
(e)	erosional scours with intraclasts.
(s)	broad shallow scours.
(sc)	laminated to massive fines.

[1] This is a descriptive code, interpretations not made here. Modified to greater or lesser extents from Miall (1977), Eyles et al. (1983), McCabe et al., (1984), Ramos and Sopeña (1983), and the authors' own work. Further additions probable. Lithofacies for diamictons are given in Eyles et al. (1983); not listed here. Deformation structures are described separately in detail.

[2] Mnemonic; first letter denotes largest particle size present: boulder, cobble, or pebble.

[3] Upper particle-size limit is 2 mm; as used here, "sand" is material which has <30% silt and clay matrix.

[4] This category includes a variety of sand-silt-clay mixtures; we further break down this category with U.S.D.A. textural classifications (Soil Survey Staff, 1975) in the descriptions; e.g., loam, silt loam, silty clay loam, etc.

[5] In gravelly deposits, particle-size grading becomes apparent and has hydrodynamic significance; hence, subdivision as cs, ms, or cm.

[6] Certain structures, such as ripple-drift cross-lamination, are generally restricted only to certain particle sizes.

[7] The distinction between plain-bedded and horizontally laminated is made on the bases of bed thickness and differences in the particle sizes involved.

[8] Differentiation as wedge or planar sets appears to be based on scale; planar sets have greater width to height ratios. Planar sets are also referred to by some authors as tabular crossbeds.

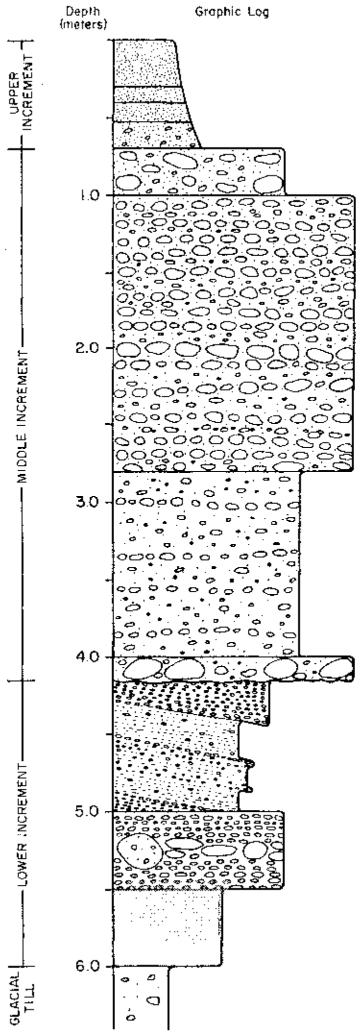
[9] Somewhat similar to gamma cross-statification of Allen (1963).

[10] In some instances, various lithofacies may occur as sets in this geometry. In such a case, this designation becomes a third symbol; e.g., S(r)(la).

[11] Occurs on a larger scale than trough cross-bedding.

DES MOINES RIVER VALLEY

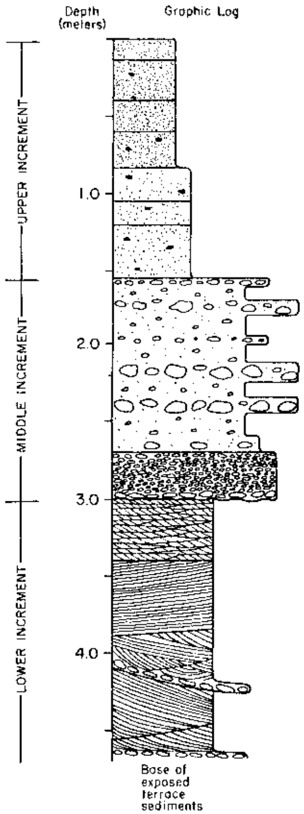
8 HALLETT-1 COMPOSITE SECTION
Location: NW 1/4, NW 1/4, Sec. 36, T.84N., R.27W., Boone Co., Iowa
Point Type Terrace



Lithofacies	Description	Notes	
F(m)	Massive loam; very dark grayish brown (10YR3/2); weak medium to fine subangular blocky soil structure; very friable; clear smooth lower boundary.	Ap horizon of modern soil profile; abundant roots; leached.	SECTION 1
	Massive loam; very dark grayish brown (10YR3/2); moderate medium subangular blocky soil structure; friable; gradual smooth lower boundary.	A1 horizon of modern soil profile; common roots; leached.	
	Massive loam; dark brown (10YR3/3); moderate medium subangular blocky soil structure; friable; gradual smooth lower boundary.	AB horizon of modern soil profile; common roots; leached.	
F(m)	Massive pebbly loam; dark brown (10YR3/3-4/3); moderate medium to coarse subangular blocky soil structure; friable; common pebbles up to 3cm in diameter; clear smooth lower boundary.	2Bt1 horizon of modern soil profile; common roots; leached.	
CGms(m)	Massive matrix-supported cobbles; dark brown (7.5YR4/3); cobbles are well-rounded, mixed lithologies, and range up to 20cm in diameter; many of the granitic cobbles are decomposed; the matrix consists of pebbly loam; secondary clay coatings on some clasts; clear smooth lower boundary.	3Bt2 horizon of modern soil profile; common roots; leached.	
CGmc(pl)	Crudely planar-bedded, sub-rounded, matrix-supported to clast-supported cobbles; cobbles are sub-rounded, mixed lithologies, typically range from 7-20cm in a-axis length, and are crudely imbricated, dipping upvalley to the NW; the matrix consists of poorly-sorted sub-rounded pebbly sands; the crudely planar beds are slightly undulatory with amplitudes of 10 to 15cm and wavelengths of 900 to 1500cm.	4C horizon of modern soil profile; oxidized, calcareous; some secondary carbonate coatings and partial secondary carbonate cementing.	SECTION 2
PGmc(pl), CGmc(pl)	Crudely planar-bedded, sub-rounded, matrix-supported to clast-supported pebbles and cobbles; cobbles are sub-rounded, mixed litholgies, up to 10cm in a-axis length, and crudely imbricated upvalley to the NW; the cobbles often occur as one clast thick lags; the matrix consists of pebbly sands; the crudely planar beds are slightly undulatory with amplitudes of 10 to 15cm and wavelengths generally of 400 to 600cm; the cobble lags, bedded every 20 to 35cm in depth, particularly help to define this bedding.	Oxidized, calcareous; some secondary iron-oxide mottling.	
CGcs(lag)	Discontinuous one-clast thick cobble lag; cobbles are sub-rounded, mixed lithologies.	Oxidized, calcareous.	
PGcs(lo), PGms(lo)	Lateral accretion sets of matrix-supported and clast-supported pebbles; set thicknesses range from 15 to 30cm and sets dip 10° to 20° to the east-southeast; occasional pebble lags at base of sets; pebbles are sub-rounded, mixed lithologies.	Oxidized, calcareous; one lateral accretion bed had a measured strike of 31°-211° and a dip to the SE at 18°; the base of individual lateral accretion sets are long, measuring over 4m.	
PGcs(pl), CGcs(lag)	Crudely planar-bedded clast-supported fine pebbles with lags of clast-supported cobbles; clasts are sub-rounded, mixed lithologies; the cobble lags are 1 to 2 clasts thick and contain diamicton balls up to 40cm in diameter.	This unit appears to be the lowest terrace deposit and to be related to incision into the underlying diamicton.	
	Covered.	Underlying diamicton has undulatory upper surface. This is the maximum depth to the underlying diamicton surface.	
Dmm	Massive, matrix-dominated diamicton; silt loam matrix texture; mottled reduced and unoxidized; calcareous.	Glacial till; mottled reduced and unleached; calcareous; Pre-Illinoian in age.	

Figure 2-5. Representative profile description of deposits at the Hallett-1 site.

DES MOINES RIVER VALLEY
8 HALLETT-3 COMPOSITE SECTION
Location: SE 1/4, SE 1/4, Sec. 36, T.84N., R.27W., Boone Co., Iowa
Point Type Terrace



Lithofacies	Description	Notes	
F(m)	Massive loam; very dark gray to very dark grayish brown (10YR3/1-3/2); weak fine granular soil structure; friable; non-effervescent; abrupt smooth lower boundary.	Ap horizon of modern soil profile; abundant roots; leached.	SECTION 1
	Massive loam; very dark gray to very dark grayish brown (10YR3/1-3/2); moderate medium to fine granular soil structure; friable; non-effervescent; few fine sub-rounded pebbles; clear smooth lower boundary.	A1 horizon of modern soil profile; common to abundant roots; leached.	
	Massive loam; very dark gray to very dark grayish brown (10YR3/1-3/2); moderate medium subangular blocky soil structure; friable; non-effervescent; clear smooth lower boundary.	A2 horizon of modern soil profile; common roots; few krotovina (infilled animal burrows); leached.	
	Massive loam; dark brown (10YR 3/3); weak fine subangular blocky soil structure; friable; non-effervescent; occasional fine sub-rounded pebbles; clear smooth lower boundary.	AB horizon of modern soil profile; common roots; abundant krotovina; leached.	
F(m)—S(m)	Massive sandy loam; dark brown to brown (10YR3/3-4/3); weak to moderate medium subangular blocky soil structure; friable; non-effervescent; occasional fine sub-rounded pebbles; gradual smooth lower boundary.	2Bw1 horizon of modern soil profile; occasional roots; common krotovina; leached.	
	Massive sandy loam; dark yellowish brown (10YR3/4); moderate medium to coarse subangular blocky soil structure; friable; non-effervescent; occasional fine sub-rounded pebbles; clear smooth lower boundary.	2Bw2 horizon of modern soil profile; occasional roots; occasional krotovina; leached.	
	Massive sandy loam; brown (7.5YR4/2-4/4); moderate coarse prismatic breaking to moderate medium subangular blocky soil structure; friable; non-effervescent; sand is coarser than above; abundant (secondary) clay bridges between sand grains; very few thin discontinuous cutans (secondary clay films) on vertical ped faces; few fine sub-rounded pebbles; abrupt smooth lower boundary.	2Bt horizon of modern soil profile; occasional roots; occasional krotovina; leached.	
PGms(pl), CGms(pl)	Stratified matrix-supported pebbles with discontinuous sheets of matrix-supported cobbles; the cobble sheets are generally one clast thick; a-axis dimensions of cobbles ranges from 10 to 20cm; cobbles and pebbles are dominated by sub-rounded igneous and metamorphic lithologies; grains and clasts are coated with secondary iron oxides which give the deposit an overall strong brown (7.5YR5/6) color; gradational lower boundary.	3C horizon of modern soil profile; oxidized; leached.	
PGcs(pl)	Clast-supported pebbles; very coarse pebble "pavement" one clast thick at base; erosional lower boundary truncating bedding in underlying sands; clasts coated with black secondary manganese oxides.	Oxidized; leached.	
S(r)	Type A ripple drift cross-laminated sand; lee-side foresets preserved in discontinuous sets 20-40cm long and up to 3-5cm thick; foreset and set boundaries marked by grain-size sorting or mineral segregation and differential secondary iron oxide accumulation; oxidized.		
S(w)	Laminated fine sand in large-scale, single wedge set; oxidized.	Laterally from the described section, exposed lower increment sediments also show various channel cut and fill structures which vary in width from 1m to a few tens of meters with preserved thicknesses of up to 1m. The channel fills are dominantly fine sands though some are as coarse as coarse sand; most channel fills are marked by one clast thick pebble lags at their base.	SECTION 2
Sw(w), Sl(w) PGcs(log)	Large-scale wedge coset of dominantly coarse sand containing small-scale wedge and trough sets; these small-scale sets are up to 10cm thick and 100cm in length; the base of the large-scale wedge coset is marked by a one clast thick cobble lag; oxidized.		
S(w)	Laminated fine sand in large-scale, single wedge set; laminations asymptotically flatten out at base; oxidized.		
S(w), PGcs(log)	Laminated fine sand in large-scale, single wedge set; laminations asymptotically flatten out at base; one clast thick cobble lag at base; oxidized.		

Figure 2-6. Representative profile description of deposits at the Hallett-3 site.

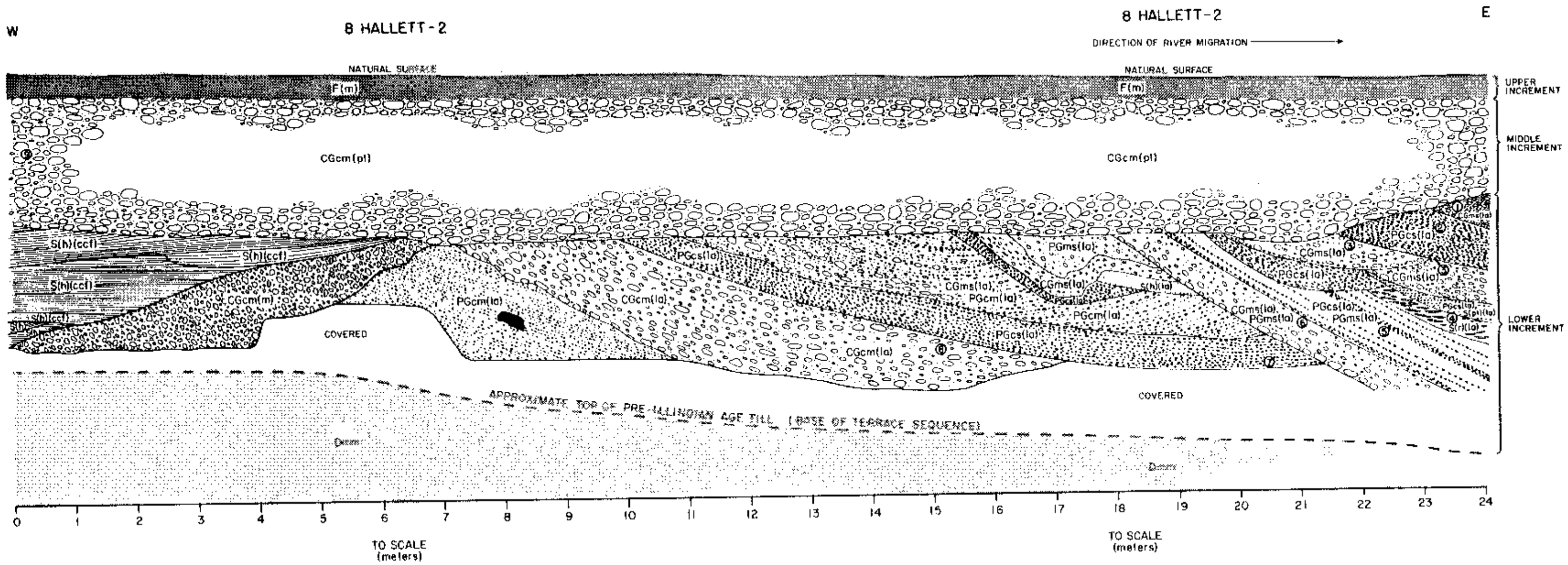


Figure 2-7. Detailed cross section of the Hallett-2 site. Lithofacies designations (sediment types and structures) use code given on Table 2.

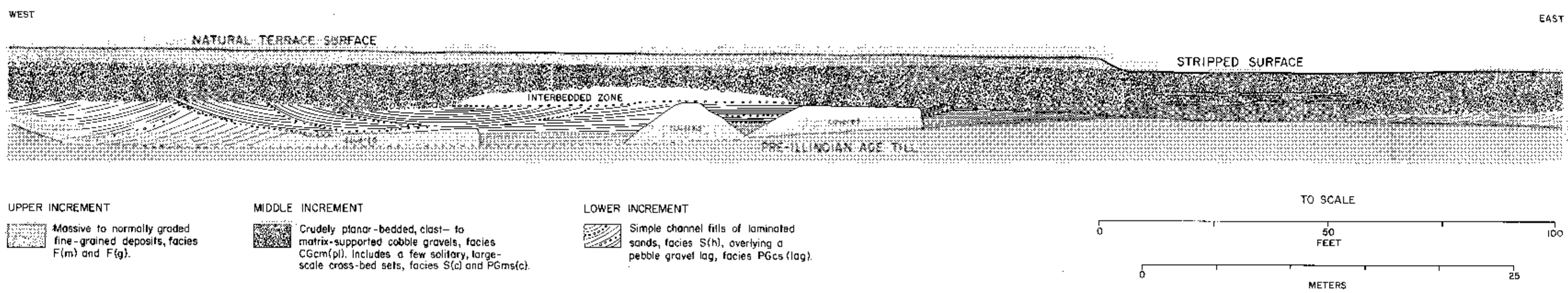


Figure 2-8. Detailed cross section of a later extension of the Hallett-2 exposure just to the west of the section shown on Figure 7.

At first glance, the cross sections and descriptions indicate one certain fact: there is an enormous diversity of sediment types and structures (lithofacies) in the different terrace levels. Yet, even with such diversity, a certain orderliness appears in the stratigraphic sequence of each terrace level. The deposits have a consistent vertical stratigraphic sequence that can be grouped into three units, here termed the lower, middle, and upper increments (Figs. 2-5 through 2-8).

What significance do these increments have? First, they indicate the nature of the Wisconsin-age depositional environments. Wisconsin-age terraces are dominated by lower- and middle-increment deposits. That is, Wisconsin-age deposits are dominated by in-channel sand-and-gravel deposits, rather than fine-grained overbank deposits. Second, and most importantly for understanding the Wisconsin history of the valley, the middle and upper increments of each terrace also suggest episodic, high-magnitude flood events.

Texturally, the lower-increment deposits include sands, pebbly sands, and less frequently, pebble gravels. These deposits occur in a wide variety of bedding structures. Typical in-channel migrating bedforms, such as various cross-bed types, are common. Medium-scale channel fills (15-50 m wide; 50-165 ft) also occur (Hallett-2, Fig. 2-8). On point-type terraces such as these, "lateral-accretion" deposits (deposits formed on the inner bank of a point bar) are also present in the lower-increment deposits (Hallett-1, Fig. 2-5; Hallett-2, Fig. 2-7). These various lower-increment lithofacies (sediment types and structures) are an assemblage of meso- and micro-forms (dunes, sand waves, ripples, etc.; Jackson, 1975) that suggest deposition related to fluctuating discharge of water and sediment. Fluctuating discharge on diurnal and seasonal scales is characteristic of glacial meltwater environments (Church and Gilbert, 1975, p. 23-30). This normal fluctuation in meltwater discharge may have resulted in the diverse lower-increment lithofacies observed.

Middle-increment deposits are significantly coarser, and overlie an abrupt unconformity on the lower-increment sediments. Middle-increment deposits are dominated by a single facies: one to two meters thick, massive to crudely planar-bedded, very poorly sorted cobble gravels. Sometimes, as at Hallett-1 (Fig. 2-5), the middle-increment sequence may include more than one bed of this massive, poorly sorted cobble-gravel facies. Large-scale, solitary cross-bed sets also occur infrequently within this increment. Middle-increment deposits indicate a significant change of scale from the meso- and micro-forms of the lower increment to large-scale, terrace-wide (valley-wide?) deposition. The very poorly sorted cobble gravels of this increment indicate a stream with very high sediment load, and simultaneous deposition of bed- and suspended-load (Harms et al., 1975, p. 133-158). Recently, sedimentologic studies have suggested a continuum between fluid-, hyper-concentrated, and debris-flow conditions (e.g., Maizels, in press; Lord and Kehew, 1987).

Unlike the deposits studied by Maizels, and Lord and Kehew, the distal terrace deposits studied here are too far removed from the meltwater sources for true hyper-concentrated flow conditions to have occurred. On the continuum of flow conditions and processes, however, middle-increment deposits probably represent very concentrated fluid-flow conditions approaching those of hyper-concentrated flow.

Thin fine-grained deposits (sandy loam to loam texture) comprise the upper increment. These deposits abruptly overlie middle-increment deposits, and tend to be either normally graded (fining upward) or massive. They mantle the middle-increment surface filling in broad, shallow channels. Usually these deposits are less than a meter (2-3 ft) thick, but in some instances they can be as thick as two meters (6 ft). These deposits appear to be waning flow and/or overbank deposits associated with middle-increment floods. The middle and upper increments of each Wisconsin-age terrace, then, are related to infrequent, very high magnitude glacial meltwater floods.

The infrequent, very high magnitude floods responsible for the middle and upper increments of distal Wisconsin-age Des Moines River terraces may be "glacier bursts" or "jökulhlaups" similar to those described by Church and Gilbert (1975), Haeberli (1983), Maizels (in press), and Sturm et al. (1987), among others. Some jökulhlaups have complex hydrographs (e.g., Sturm et al., 1987), which might explain stratigraphies such as at Hallett-1, where the middle-increment deposits appear to result from two successive flood peaks. It is unlikely that we will ever know for certain what caused these jökulhlaups in the Des Moines River basin since the ice has long since gone, and the discontinuous terrace record downstream prohibits any full historical reconstruction. There are, however, several credible possibilities, including catastrophic drainage of supraglacial, subglacial, or proglacial lakes, or perhaps even a season of extremely high melt rates.

Many jökulhlaups result from glacial lake drainage. These glacial lakes may occur in a variety of situations. Typically, modern glaciers are in mountainous areas where glacier ice dams side valleys forming lakes which subsequently drain catastrophically when a tunnel system develops in the ice. Naturally, this type of setting wasn't possible for the Des Moines Lobe. However, supraglacial ice-walled lakes (Clayton and Freers, 1967; Parizek, 1969) did occur on the Des Moines Lobe (Kemmis, 1981; in prep.; Graeff, 1986) and could have drained catastrophically. A proglacial lake, Glacial Lake Jones (Kemmis, 1981), lies just in front of the Algona Moraine in Kossuth County, and breaching of this glacial lake by the East Fork of the Des Moines River could also have resulted in a jökulhlaup.

Geomorphic and stratigraphic evidence, as well as radiocarbon dates, suggest that advances of the Des Moines Lobe were rapid, followed by general stagnation of large areas of the lobe (Kemmis, in prep.). This kind of glacial behavior is similar to that of surge-type glaciers which release large volumes of meltwater just prior to and in the early stages of surging. It is thus possible that some jökulhlaups may be related to such meltwater releases as the Des Moines Lobe surged to the Algona margin.

Finally, perhaps a season of unusual weather conditions, such as an uncommonly warm spring break-up period followed by widespread, high-magnitude rainstorm events, could have promoted unexpectedly high-magnitude summer flood events.

Our interpretation is that these infrequent jökulhlaup events are the key to understanding the Wisconsin history of the distal reaches of meltwater streams on the Des Moines Lobe (Kemmis et al., 1985; 1987; Quade, 1987). We hypothesize that besides the deposition of the middle and upper increments of the terrace sequence, these floods also caused downcutting to what later became another terrace level. The middle increment is interpreted to have been abruptly deposited on the steep rising limb of a jökulhlaup flood event where sediment discharge peaks before that of the meltwater. As the sediment load declines but meltwater discharge peaks, erosion results, causing valley widening, downcutting laterally, abandonment of this former valley floor to become a terrace, and establishment of the base of the next terrace (bench) level down. After the high-magnitude jökulhlaup event, deposition on the new, lower valley floor was controlled by normal seasonal and diurnal fluctuations in meltwater and sediment discharge, resulting in the deposition of new lower-increment deposits on this lower level. With the next jökulhlaup, new middle and upper increments are deposited before downcutting to a still lower terrace level, and so on.

The Wisconsin history of this distal valley reach, then, is interpreted to be intimately associated with high-magnitude glacial flood events originating in the headwater regions of the Algona Moraine.

Other Effects of Valley Downcutting

As the valley downcut during the Wisconsin Episode, it progressively exhumed older and older deposits which can, in certain instances, affect the provenance and apparent weathering characteristics of different terrace levels. For instance, the effect of downcutting through Pennsylvanian-age bedrock upstream has dramatically influenced the provenance and secondary weathering properties of the Wisconsin-age terraces at the Hallett sites.

The benched terrace deposits at Hallett-1 were deposited before the river had downcut into the Pennsylvanian-age bedrock sequence upstream. The gravels consist of the typical glacial mix of Precambrian-age igneous and metamorphic rocks, lower Paleozoic-age sedimentary rocks (particularly carbonate rocks), and low percentages of Cretaceous-age shale. The modern soil profile, developed primarily in upper-increment deposits, is leached, but underlying deposits are calcareous.

Lower terrace levels at Hallett-2 and Hallett-3 are below that of the Pennsylvanian-age bedrock sequence upstream. Besides the usual mix of glacially derived gravel lithologies are pebbles and cobbles of Pennsylvanian-age sandstone, coal, carbonates, and shale derived from upstream bed erosion as the river downcut. At Hallett-2, an angular block of coal with a long-axis dimension of over one meter (3 ft) was observed in the middle-increment deposits.

These Pennsylvanian lithologies commonly contain the mineral pyrite. In normal weathering, pyrite reacts with water to form sulphuric acid and release iron. The resulting acidic conditions in these lower, younger terrace levels (Hallett-2 and Hallett-3 sites) have caused the deposits to become deeply leached; carbonate gravels may be partially decomposed, and in some cases, "ghosts" or voids occur at the location of former carbonate clasts. Igneous and metamorphic clasts may also be decomposed and crumbly. Gravels on these two levels also tend to be iron stained to brown and reddish-brown colors. The apparent highly weathered nature of gravels on these terrace levels is thus related to the local mineralogy of the deposits, not to time.

HOLOCENE EPISODE

By 11,000 radiocarbon years ago, glacial ice was no longer present in the Des Moines River basin, and high-magnitude meltwater floods could no longer occur. How has the river responded to this major change in environment? What are the characteristics of Holocene-age alluvium, and how does it differ from Wisconsin-age alluvium? The river during the Holocene Episode is characterized by significant reductions in both peak flood magnitudes and discharge fluctuations compared to those during the Wisconsin Episode. It has migrated across the valley floor forming horizontal depositional sequences (Fig. 2-9; Bettis and Thompson, 1982), and little downcutting has occurred. The river's Holocene sediment load, derived from tributary and riverbank erosion, is significantly finer textured than the Wisconsin-age sediment load which included coarse glacial debris.

Four Holocene-age geomorphic (landscape) features are present in the distal reach of the valley: three terrace complexes, here termed the high, intermediate, and low terraces, and alluvial fans. The distribution of these features in the valley meander west of Boone is shown on Figure 2-4.

The Holocene-age terrace complexes occur low in the valley: all lie within 5 m (15 ft) of the present river level. Each complex (high, middle, low) is composed of multiple terraces at

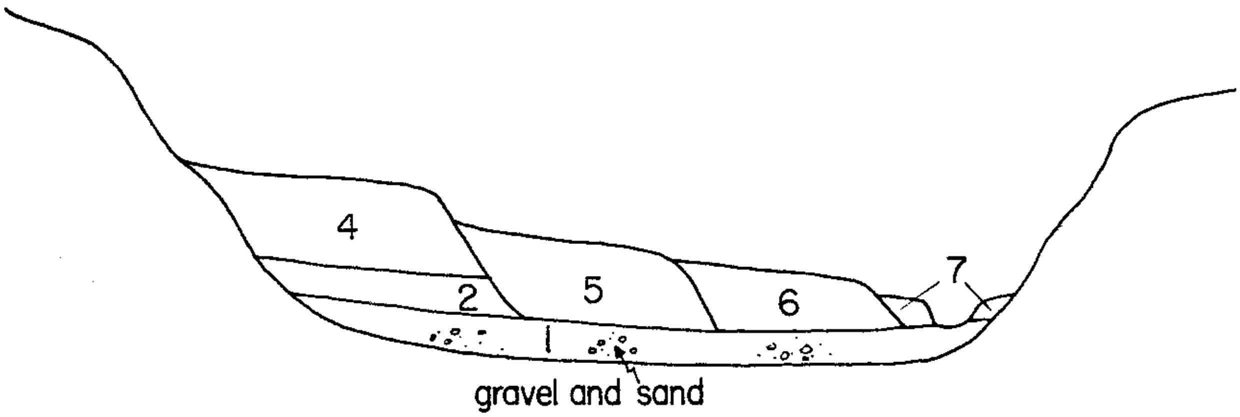


Figure 2-9. Geometry of horizontal depositional sequences found for Holocene-age deposits.

about the same level, and each complex has consistent, distinctive stratigraphy.

The high-terrace complex west of Boone forms a relatively flat, featureless level inset below the Wisconsin-age terraces. The sediments forming the high-terrace complex were deposited from about 11,000 to 4,000 radiocarbon years before present, and have several distinctive characteristics (Bettis and Hoyer, 1986). A representative core description of high-terrace deposits is given in Figure 2-10. Most high-terrace locations are underlain by fine-grained deposits, usually over 3.5 m (10 ft) thick, and as much as 8.5 m (25 ft), several times the thickness of fine-grained upper-increment deposits on Wisconsin-age terraces.

Fine-grained high-terrace deposits are dominantly overbank (vertical-accretion) deposits and are usually loam or silt loam texture, although they may also include clay loam, silty clay loam, and sandy loam textures locally. These textural differences probably reflect differing depositional conditions at various positions on the paleofloodplain surfaces.

Deposits underlying the high-terrace complex were not deposited continuously: buried soils within the sequence indicate periods of floodplain stability and soil formation between periods of floodplain deposition. A relatively widespread period of floodplain stability is indicated by a buried soil dating at around 6,000 radiocarbon years before present that is consistently found lower in the high terrace sequence (Bettis and Hoyer, 1986).

Figure 2-10. Representative description of Holocene-age high-terrace deposits; core site 17; location shown on Figure 4.

Location: 08AB17 Coal Valley; SE 1/4 NE 1/4 SW 1/4 NW 1/4 Sec. 1 T83N R27W
Landscape position: High Terrace, on edge of low scarp decending to Noah Creek
Elevation: approximately 883 feet
Parent material: alluvium
Slope: 2-5%
Vegetation: wheat
Date described: 9/26/84
Described by: E. A. Bettis III
Remarks: C-14 date on organics 552-570 cm. 11,000 ±290 B.P. (Beta-10882); the 4A1 appears to be a separate soil superimposed on the underlying soil.

Depth (cm)	Soil Horizon (weathering zone)	Description
0-30	Ap	very dark gray to very dark grayish brown (10YR 3/1-3/2) loam, cloddy, friable, noneffervescent, abrupt boundary, common roots.
30-55	A1	very dark gray to very dark grayish brown (10YR 3/1-3/2) loam, weak to moderate medium subangular blocky, friable, noneffervescent, gradual boundary, common roots.
55-69	A2	very dark grayish brown (10YR 3/2) loam, moderate medium subangular blocky, friable, noneffervescent, clear boundary, few roots.
69-88	A3	very dark grayish brown (10YR 3/2) sandy loam, moderate medium to fine subangular blocky, friable, noneffervescent, abrupt boundary, few roots.
88-107	2Bt1 (Ab?)	very dark gray to very dark grayish brown (10YR 3/1-3/2) loam with common coarse sand grains, moderate medium to fine columnar, friable, noneffervescent, clear boundary, very few roots, very few thin discontinuous very dark gray (10YR 3/1) cutans.
107-131	2Bt2	dark grayish brown (10YR 4/2) loam, moderate coarse columnar breaking to moderate medium subangular blocky, friable, noneffervescent, gradual boundary, common medium to fine light olive brown (2.5Y 5/4) mottles, common medium iron concretions, common medium iron concretions very dark grayish brown (10YR 3/2) cutans, occasional charcoal flecks.

Location: 08AB17 Coal Valley
CONTINUED

Depth (cm)	Soil Horizon (weathering zone)	Description
131-164	2Bt3	dark gray (10YR 4/1) silty clay loam, moderate coarse columnar breaking to moderate medium subangular blocky, friable, noneffervescent, clear boundary, common fine oxides, few fine iron concretions, common thick continuous very dark gray to very dark grayish brown (10YR 3/1-3/2) cutans.
164-200	2BC	dark grayish brown (10YR 4/2) loam with common coarse sand grains and fine pebbles, weak coarse subangular blocky, very friable, moderate effervescence, abrupt boundary, common medium grayish brown and light olive brown (2.5Y 5/2 and 5/4) mottles, oxides, and iron concretions as above, occasional gastropod shells.
200-224	3Ab	dark gray (10YR 4/1) loam with common coarse sand grains, very weak medium to fine subangular blocky, friable, moderate effervescence, clear boundary, oxides and iron concretions as above.
224-243	3C1	dark grayish brown (10YR 4/2) sandy loam, massive friable, moderate effervescence, abrupt boundary, common medium olive brown (2.5Y 4/4) mottles, occasional gastropod shells.
243-257	3C2	dark grayish brown (10YR 4/2) sandy loam, single grain, loose, moderate effervescence, abrupt boundary, mottles and gastropod shells as above.
257-288	3C3	dark grayish brown (10YR 4/2) silt loam, massive friable, moderate effervescence, abrupt boundary, mottles and gastropod shells as above.
288-318	4A1b	dark gray to dark grayish brown (10YR 4/1-4/2) silt loam, very weak medium subangular blocky to massive, friable, moderate to violent effervescence, clear boundary, common dark gray (10YR 3/1) coatings in pores.
318-340	4A2b	very dark gray to dark gray (10YR 3/1-4/1) silt loam, weak medium to fine subangular blocky, friable, weak effervescence, clear boundary.

Figure 2-10. Continued.

Location: 08AB17 Coal Valley
CONTINUED

Depth (cm)	Soil Horizon (weathering zone)	Description
340-364	4Bg1b	olive gray (5Y 1/2) silt loam, weak medium to fine subangular blocky, friable, weak effervesence, gradual boundary, abundant medium olive (5Y 4/6) mottles, very few fine soft carbonate concretions.
364-381	4Bg2b	dark greenish gray to greenish gray (5GY 4/1-5/1) silty clay loam, moderate fine angular blocky, friable, weak effervescence, gradual boundary, abundant medium to coarse olive (5Y 4/6) mottles, carbonate concretions as above.
381-415	4Bg3b	dark greenish gray to greenish gray (5GY 4/1-5/1) silt loam, weak medium to fine subangular blocky, friable, very weak effervescence, gradual boundary, mottles and carbonate concretions as above.
415-427	4C1	greenish gray (5GY 5/1) silt loam, massive, friable, very weak effervescence, clear boundary, mottles and carbonate concretions as above.
427-510	4C2	greenish gray (5GY 5/1) silt loam,massive, slightly sticky nonplastic, noneffervescent, gradual boundary, common medium olive (5Y 4/4) mottles.
510-base (600)	4C3	greenish gray to gray (5GY 5/1- 5Y 5/1) stratified silt loam and fine to medium sand, massive, nonsticky nonplastic, noneffervescent, common organics 552-570 cm, C-14 date on organics 11,000 ±290 B.P. (Beta-10882).

The high-terrace complex differs from the lower complexes in that the deposits are usually oxidized and the surface soils tend to be thick mollisols (classification of Soil Survey Staff, 1975), that is, prairie soils, with A-Bt-C soil horizon sequences (Bt horizons are subsurface horizons with coatings of translocated clay on soil ped surfaces).

The intermediate-terrace complex is generally inset 2-3 m (6-10 ft) below the high-terrace complex. It occupies the highest areas of the present floodplain, and usually has an undulating, low-relief upper surface marked by subtle natural levees, chutes, and abandoned channels. Sediments underlying the intermediate-terrace complex were deposited primarily between 4,000 and 750 radiocarbon years before present, and have several distinctive characteristics (Bettis and Hoyer, 1986). A representative core description of intermediate-terrace deposits is given in Figure 2-11. Intermediate-terrace deposits are dominated by thick, fine-grained overbank deposits overlying 1-2 m (3-6 ft) of sandy in-channel deposits. The fine-grained overbank deposits have the same textural diversity as those comprising the high-terrace complex, but stratification is more evident.

Like high-terrace sequences, intermediate-terrace deposits include buried soils that indicate periods of floodplain stability and soil formation between periods of floodplain deposition. These buried soils are entisols (classification of Soil Survey Staff, 1975), A-C soil profiles, which suggest that these periods of floodplain stability were short. Unlike high-terrace deposits, intermediate-terrace deposits tend to be dark colored and not oxidized.

Surface soils developed in intermediate-terrace deposits tend to be deep, dark-colored inceptisols, soils with incipient soil development, and mollisols (prairie soils) with A-Bw-C soil horizon sequences (soil classification of Soil Survey Staff, 1975). These soils do not have the structural development and clay translocation (Bt horizon) of those on the high-terrace complex.

The low-terrace complex occurs in narrow strips bordering the present river channel. It is usually wooded, inset 1-2 m (3-5 ft) below the intermediate-terrace complex, and has formed during the last 750 years (Bettis and Hoyer, 1986). It includes the lower portion of the present floodplain, and unlike the other Holocene-age terrace levels, has a very uneven surface. Large-scale "ridge-and-swale topography," related to scour and deposition around tree trunks on this terrace level, extends across much of this surface, while natural levees, flood chutes, and abandoned meanders occupy the remaining areas.

Unlike higher Holocene-age terrace complexes, the low terrace tends to have an insignificant veneer of overbank deposits. The depositional sequence is stratified, and dominated by in-channel deposits of sands and pebbly sands. Typical textures include pebbly sand, pebbly loamy sand, loamy sand,

Figure 2-11. Representative description of Holocene-age intermediate-terrace deposits; core site 15; location shown on Figure 4.

Location: 08AB15 Coal Valley; NW 1/4 SE 1/4 SE 1/4 NE 1/4 Sec. 1 T83N R27W; 13BN124
Landscape position: Intermediate Terrace
Elevation: approximately 862 feet
Parent material: alluvium
Slope: 2-5%
Vegetation: fallow field
Date described: 9/24/84
Described by: E. A. Bettis III
Remarks: the + material is 1984 flood deposits

Depth (cm)	Soil Horizon (weathering zone)	Description
0-16	+	black (10YR 2/1) clay loam, massive, firm, violent effervescence, abrupt boundary, common plant fragments, organic mat at base.
16-48	Ap	very dark gray to very dark grayish brown (10YR 3/1-3/2) loam, cloddy, friable, noneffervescent, abrupt boundary, common roots.
48-70	A1	very dark grayish brown to very dark gray (10YR 3/2-3/1) loam, weak to moderate medium to coarse subangular blocky, friable, noneffervescent, clear boundary, few roots.
70-91	A2	very dark grayish brown (10YR 3/2) loam, moderate fine subangular blocky, friable, noneffervescent, clear boundary, few roots.
91-120	Bw	very dark grayish brown to dark brown (10YR 3/2-3/3) sandy loam, weak medium subangular blocky, very friable, weak to moderate effervescence, gradual boundary, very few roots.
120-140	BC	brown (10YR 5/3) fine sand, single grain, loose, weak effervescence, abrupt boundary.
140-147	C1	brown (10YR 5/3) fine sand, single grain, loose, weak effervescence, abrupt boundary.
147-164	C2	dark brown (10YR 3/3) sandy loam, massive, friable, moderate to strong effervescence, abrupt boundary.
164-210	C3	pale brown (10YR 6/3) fine to medium sand, single grain, loose, weak effervescence, abrupt boundary.
210-260	C4	dark brown (10YR 3/3) loamy sand, massive, very friable, moderate effervescence, abrupt boundary.

Location: 08AB15
CONTINUED

Depth (cm)	Soil Horizon (weathering zone)	Description
260-284	C5	dark brown to dark grayish brown (10YR 3/3-4/2) fine to medium sand, single grain, loose, moderate effervescence, abrupt boundary.
284-base (290)	2C	oxidized coarse sand and fine subrounded pebbles of mixed lithology, single grain, loose, strong effervescence.

sandy loam, and loam. These Holocene-age in-channel deposits are significantly finer-textured than those of Wisconsin-age. Either no soil profile or only a poorly expressed entisol, A-C soil profile, has developed in these deposits, since the low-terrace surface is still subject to frequent flooding, causing localized erosion and deposition.

The last Holocene-age valley features to be discussed are alluvial fans. These have formed where short, steep tributaries enter the main valley and deposit their sediment load. The bulk of the alluvial-fan deposits grade into and interfinger with high-terrace deposits (Fig. 2-12), indicating that they are of similar age. Like high-terrace deposits, fan sediments are fine-grained and oxidized; they were also deposited episodically, and buried soils within the sequence have radiocarbon dates similar to those in high-terrace sequences (Bettis and Hoyer, 1986).

The fine-grained deposits in alluvial-fan sequences include both alluvial and colluvial (mass-movement) deposits. Surface soils developed in the alluvial-fan deposits are thick mollisols (prairie soils) with A-Bt-C soil horizon sequences like those developed in adjacent high-terrace surfaces.

CONCLUSIONS AND SIGNIFICANCE

The geological record provides considerable insight into the history of the Des Moines River valley with respect to its formation and changing environments through time. The origin of the distal valley near Boone is related to glacial meltwater drainage during the Wisconsin Episode. This drainage originated at the Algona End Moraine in the northern part of the State, however, rather than at earlier ice-marginal positions in the immediate area (the Bemis and Altamont end moraines).

During the Wisconsin Episode deep valley entrenchment was caused by episodic downcutting related to infrequent, high-magnitude glacial meltwater flood events (jökulhlaups). Several "terraces," benched on the valley wall, are related to these infrequent jökulhlaups. Each benched terrace has a thin veneer (about 6 m or 20 ft thick) of meltwater deposits overlying an erosion surface cut on valley-wall deposits. (From top to bottom in this reach of the valley, the valley-wall deposits successively include Wisconsin-age Des Moines Lobe glacial deposits, pre-Illinoian-age glacial deposits, and Pennsylvanian-age bedrock.) The uppermost meltwater deposits of each benched terrace (middle and upper increments) were deposited during the early stages of a jökulhlaup flood event, while valley widening and deepening to the next bench/terrace level were accomplished later during the same flood. Following entrenchment to the next bench/terrace level and cessation of the jökulhlaup

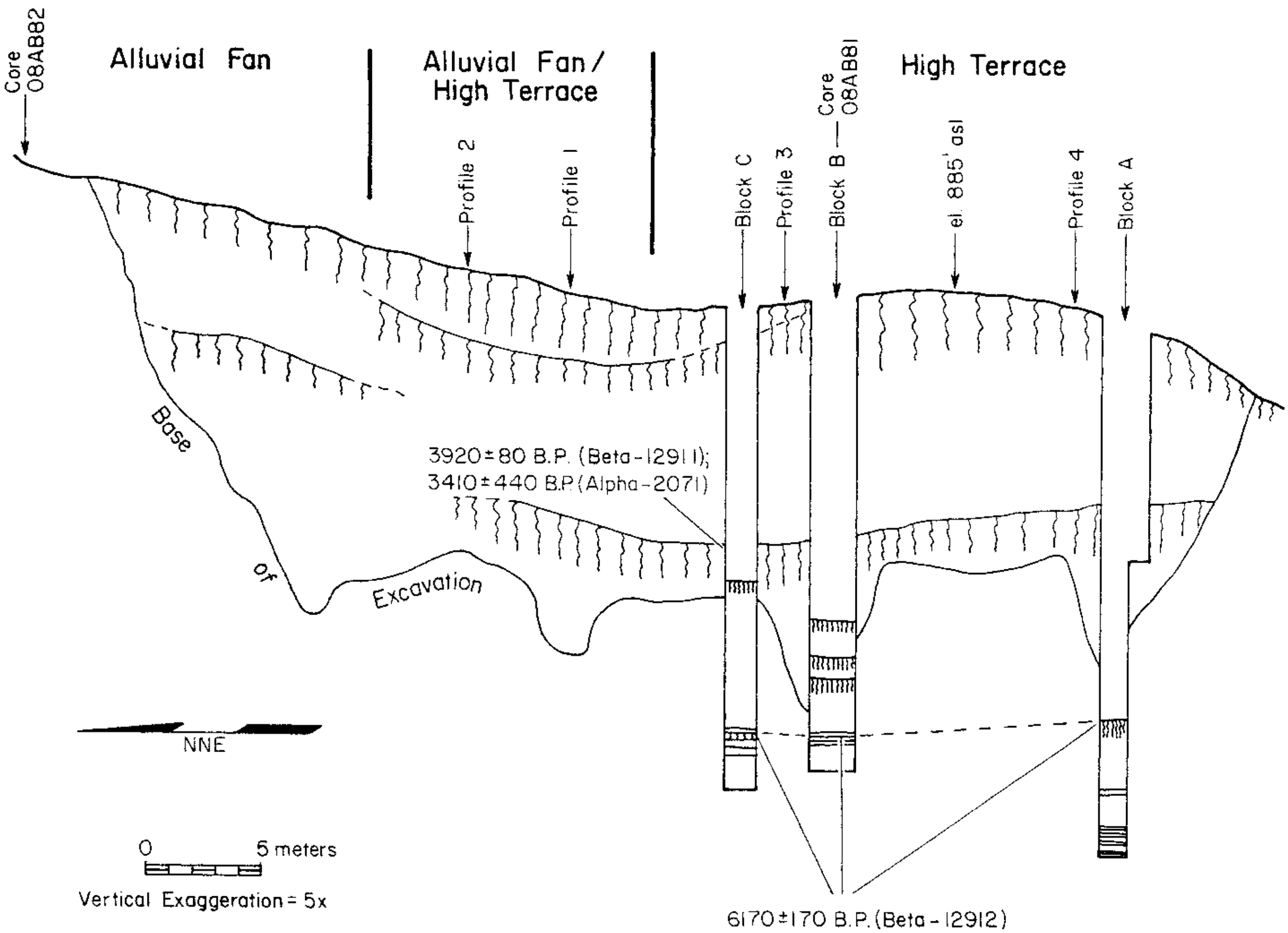


Figure 2-12. Cross section of south wall of backhoe trench showing interbedded Holocene-age alluvial-fan and high-terrace complex deposits; by core site 81; location shown on Figure 4.

event, normal fluctuating meltwater discharge deposited lower-increment sediments until whenever the next jökulhlaup event occurred. Total valley entrenchment in the Boone area, nearly 65 m (220 ft) occurred over a geologically short span of time, 1,000 to 1,600 years, based on limiting radiocarbon dates for the age of the meltwater deposits.

During the post-glacial Holocene Episode, the river's environment has been significantly different. Glacial meltwater floods can no longer occur, and river discharge has been related solely to precipitation. The geological record indicates dominant lateral movement of the river, rather than downcutting. Three terrace complexes can be recognized in which each is progressively inset 1-3m (3-10 ft) below the next oldest, and each has its own distinctive stratigraphy. The low-terrace complex generally lies in a narrow belt along the present river valley and forms the lower portion of the present floodplain. The intermediate- and high-terrace complexes form most of the valley floor, and the stratigraphy underlying both is complex. In each, the preserved depositional sequence is dominated by fine-grained overbank deposits, and buried soils indicate terrace accumulation was occasionally interrupted by floodplain stability and soil formation.

Following incision of the main valley, short, steep tributaries formed. Where these tributaries join the valley, alluvial-fan deposits grade to and interfinger with Holocene-age high-terrace deposits, indicating contemporaneous formation of short tributaries, alluvial fans, and high-terrace deposits 11,000 to 4,000 years before present.

The differing Wisconsin- and Holocene-age terrace stratigraphies provide generally differing environments for plant growth. Wisconsin-age terraces tend to be droughty because there is just a thin veneer of fine-grained deposits over rapidly draining gravels and sands, and because water tables tend to be deep. Benched substrate materials (glacial deposits or bedrock) beneath the terrace deposits tend to have lower hydraulic conductivity than the overlying gravels and sands, promoting perched water tables at the base of the terrace sand-and-gravel sequence. Lateral flow of this perched water causes seepage spots on the lower part of terrace edges (scarps) that provide locally different habitats. These seepage spots are generally formed in various valley-wall materials (fine-grained glacial deposits and Pennsylvanian-age bedrock) because the benched-terrace sands and gravels rarely extend down to the next terrace level.

Holocene-age terraces tend to be less droughty than Wisconsin-age benches. The water table is shallower, and the thicker fine-grained deposits can provide significantly better moisture retention. The high-terrace complex (never flooded) and the intermediate-terrace complex (occasionally flooded only by present low-frequency, high-magnitude floods) provide reasonably stable environments for plant growth. In contrast, the low-terrace complex is frequently flooded, does not provide a stable environment for plant growth, and beneath the woodland canopy the vegetation consists of disturbance plants.

The geological record, then, indicates that river environments during the Wisconsin and Holocene Episodes were strikingly different. The resulting coarser-grained Wisconsin-age and finer-grained Holocene-age deposits provide significantly different plant habitats.

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