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Geomorphic History of the Rock River, South-Central Wisconsin, Northwestern Illinois

Richard C. Anderson
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Illinois Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
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Front Cover: *Photo of Blackhawk statue, Oregon, Illinois, with the Rock River in the foreground. (Photo by Dennis R. Kolata.)*

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Abstract

As is true of most rivers in the glaciated north-central United States, the course of the Rock River, which flows through south-central Wisconsin and northwestern Illinois, is the result of a fascinating and complex interplay of bedrock geology, bedrock topography, glaciation, and fluvial processes. In the case of the Rock River, these factors have produced a valley that displays five distinctive reaches: (1) the headwaters that lie within the area once covered by the Green Bay Lobe of the continental glacier in Wisconsin; (2) an outwash-filled bedrock valley that extends from the Johnstown Moraine to the mouth of the Kishwaukee River; (3) a bedrock gorge that extends downstream to Dixon, Illinois; (4) a reach that skirts the northwestern edge of the Bloomington outwash plain in the Green River Lowland; and (5) a lower reach that has been shared at various times with the Mississippi River. Outwash terraces related to meltwater discharge from the Green Bay glacial lobe occur downstream as far as Prophetstown, Illinois. Below Prophetstown, these terraces were removed by late glacial floods along the Mississippi River.

Introduction

The Rock River has been the focus of many geological studies during the past century, but no integrated study exists, perhaps because researchers focused only on the Wisconsin or Illinois portions of the river or because the variety of distinctive, picturesque landscapes led to the specialized, detailed study of each landscape type. The complex interplay of bedrock geology, bedrock topography, glaciation, and fluvial processes produced a drainage basin with great variety and interest, especially when viewed in its entirety. This guide attempts to put these pieces together.[1]

The Rock River is the major stream of south-central Wisconsin and north-central and northwestern Illinois. The river originates at the confluence of its east and west branches in Horicon Marsh in east-central Wisconsin (fig. 1). The headwaters of the west branch lie about 15 mi (24 km) north-northwest of Beaver Dam, Wisconsin, and those of the east branch lie about 10 mi (16 km) southeast of Mayville, Wisconsin. The river then flows generally south and west past the towns of Watertown, Jefferson, Fort Atkinson, Janesville, and Beloit in Wisconsin and past Rockford in Illinois. From Rockford, the river flows generally southwest past Oregon, Dixon, and Sterling-Rock Falls, joining the Mississippi River at Rock Island. The distance is 298 mi (480 km) from the river's origin at Horicon Marsh to its mouth at Rock Island. River elevation declines more than 300 ft (91 m) over this distance, from an elevation of 857 ft (261 m) above mean sea level at Horicon Marsh to 545 ft (166 m) at Rock Island.

Although the Rock River valley has served as a line of communication since pre-settlement times, the river itself has not been an avenue for commercial transport. The rapids at the river's mouth effectively prohibit water traffic to or from the Mississippi River (Salisbury and Barrows 1918), and there are no locks associated with the numerous dams along the river. These dams produce modest amounts of hydroelectric power, particularly those at Rock Island and Dixon. The upper dam at Rock Falls provides water to the Hennepin Canal via the Hennepin Feeder Canal (fig. 1). The river and its associated terraces are an important source of sand and gravel. Dolomite, limestone, and sandstone are quarried at many places along the length of the river. The river and its valley are also an important recreational resource. Many municipal and state parks and other recreational developments can be found along its banks.

Previous Studies

Previous investigations concentrated on particular portions of the valley or focused on specific types of information, such as local relationships to the glacial and bedrock geology, hydrogeology, and sand and gravel resources. Leverett (1899) described the Illinois portion of the Rock River, in particular how that portion was related to bedrock valleys and outwash deposits. Carman (1909) mapped the several now streamless channels that link the valleys of the Mississippi and Rock Rivers below Prophetstown, Illinois. Alden (1918) described in detail the glacial landscapes and history of southeastern Wisconsin, including the relationship of the Rock River to the underlying bedrock valleys and to the outwash deposits in front of the Johnstown and Darien Moraines. The geology, geography, and history of the area around Rockford were described by Salisbury and Barrows (1918). Savage and Udden (1921) described the geology of the area surrounding the mouth of the river. These early reports served as starting points for subsequent studies of the Rock River.

Quadrangle reports by Bretz (1923) and Knappen (1926) describe the Bedrock Gorge reach of the river between the mouth of the Kishwaukee River and Dixon, Illinois. Horberg (1950) described the relationship of the Rock River valley in Illinois to the underlying bedrock topography. The stratigraphy of the Pleistocene deposits near Rockford and their groundwater potential was described by Hackett (1960). Kempton (1963) described the Pleistocene stratigraphy of an area in north-central Illinois. Anderson (1967) mapped the terraces along the Illinois portion of the river and evaluated them as sources of sand and gravel, and Anderson (1980) described the geology of Rock Island County. Berg et al. (1984) described the geology of the Rockford area, including the stratigraphy of the deposits in the Rock River valley. Larson et al. (1995) described the hydrogeology of the Green River

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[1] Although the drainage basin of the Rock River covers two states, for consistency and simplicity the author and editors have used Illinois State Geological Survey nomenclature; the Wisconsin Geological and Natural History Survey may use slightly different nomenclature for features.

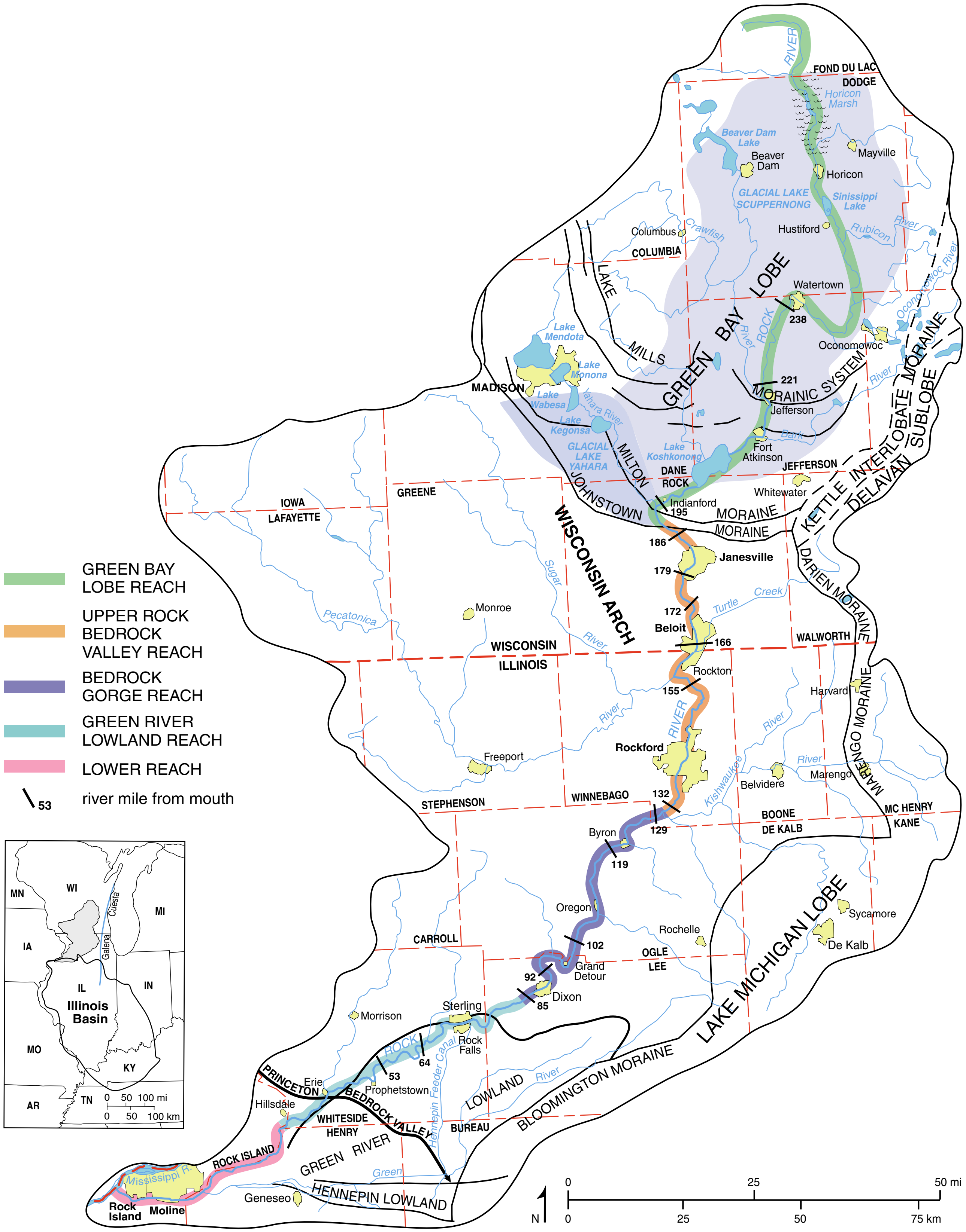


Figure 1 Drainage basin of the Rock River (U.S. Geological Survey 1999). The locations of the cross profiles shown in Figure 12 are indicated by short, numbered lines crossing the river. Municipalities are shown in yellow.

Lowland. The extent and significance of glacial Lakes Yahara and Scuppernong in the Green Bay Lobe portion of the valley were described by Clayton and Attig (1997a, 1997b) and Clayton (2001).

Bedrock Relationships

Bedrock Geology and Structure

The location of the present river, the valley features seen today, and the nature of the preserved sediment record are related directly or indirectly to the underlying bedrock structure, topography, and lithology. The Rock River drainage basin lies along the axis of the Wisconsin Arch, a broad anticline that plunges southward from the area of Precambrian outcrop in north-central Wisconsin. Dips are exceedingly gentle, less than 1 degree in most places, and the structure is so broad that the anticline's axis cannot be precisely located. Outcrop patterns show that the axis of the arch trends southward to the Baraboo Range and then turns south-southeast, passing into Illinois somewhere between the Rock and Sugar Rivers, eventually linking up with the Kankakee Arch in north-central Illinois. The width of outcrop bands (Mudrey et al. 1982) and the configuration of the top of the buried Precambrian (Thwaites 1931) suggest that the Wisconsin Arch is slightly asymmetrical; dips on the east are steeper than those to the southwest.

Like the Wisconsin Arch, the Rock River drainage basin is also asymmetrical; the longer tributaries enter from the north and west (figs. 2–6). The main stem of the river heads in Horicon Marsh, part of an extensive lowland located on the eastern flank of the Wisconsin Arch. This lowland was formed by the erosion of the weak Ordovician Maquoketa Shale from the surface of the underlying, east-dipping Ordovician Galena dolomite (Martin 1916, p. 205) (fig. 6). The lowland is bounded on the east by the Ordovician Galena cuesta (buried bedrock escarpment) and on the east by the Silurian Niagaran Escarpment. These bedrock features, although almost completely obscured by a cover of glacial drift, have nevertheless strongly influenced both the location of the Rock River above Watertown, Wisconsin, as well as the limits of the Green Bay and Lake Michigan glacial ice lobes. (Alden 1918, plate II). The Rock River flows southward among the drumlins in this lowland as far as the mouth of the Oconomowoc River (fig. 1), a tributary that heads on the west side of the Niagara Escarpment. Here the river turns to the northwest for about 10 miles. At Watertown, Wisconsin, it again turns to the south-southwest, crossing a bedrock high, the cuesta of the Galena dolomite (Martin 1916, p. 198). Downstream from Watertown, as the southwestward course of the river takes it closer to the axis of the Wisconsin Arch, the river flows over progressively older rocks. Cambrian age rocks, although deeply buried beneath glacial deposits, first occur along the course of the river between Watertown and Jefferson. From here downstream to a point a few miles below the mouth of the Yahara River, the Rock River crosses the bulky ridges of the Green Bay Lobe terminal moraine, and its course is largely independent of the underlying bedrock geology. From the mouth of the Yahara River to the mouth of the Kishwaukee River south of Rockford, Illinois, the river flows essentially along the axis of the Wisconsin Arch. At the mouth of the Kishwaukee River, the Rock River takes a southwestward course, transverse to the regional bedrock structure, through the Bedrock Gorge segment of the river (Bretz 1923). The Platteville and Galena Groups make up the valley floor and bluffs throughout this reach, except between Oregon and Grand Detour where the northwest-trending Sandwich Fault Zone and the Ashton Anticline (Kolata et al. 1978, Nelson 1995) bring St. Peter Sandstone to the surface (figs. 6 and 7). The lower end of the Bedrock Gorge is at Dixon, Illinois, although Silurian dolomite occurs on the northern bluffs of the river as far downstream as Sterling. Below Sterling, the course of the river continues on Silurian dolomite, although the latter is deeply buried in the Princeton Bedrock Valley (fig. 8), which was the southeast-trending course of the ancient Mississippi River (Horberg 1950). Downstream from Hillsdale, the river flows directly on successively younger bedrock, first Silurian dolomite, then Devonian limestone, and finally, at its mouth, on Pennsylvanian shale at the northern edge of the Illinois Basin.

Bedrock Topography

Alden (1918) mapped the bedrock topography of southeastern Wisconsin; he used a contour interval of 100 ft. Horberg (1950) produced a similar map for Illinois using a 50-ft contour interval, and Herzog et al. (1994) mapped the bedrock surface of Illinois using a 10-foot contour interval. These maps reveal a stream-carved surface that on a regional scale broadly reflects the underlying geology, but on a more local scale displays many anomalies that are the result of a preglacial drainage network repeatedly modified by glacial ice and glacial meltwater and affected by the subtle and largely unknown effects of glacial isostasy. Consequently, attempts to define an earlier course of a trunk stream such as the Rock River may actually result in stringing together disparate valley segments unrelated by time or space (Melhorn and Kempton 1991).

For example, the Rock River upstream from Watertown, Wisconsin, follows the broad lowland on the stripped surface of the Galena dolomite; south from Watertown, three parallel bedrock valleys join a few miles east of Jefferson, Wisconsin (Alden 1918, plate II). From there, a well-defined bedrock valley can be traced southwestward to Lake Koshkonong and then directly south to Rockford, Illinois (fig. 8). Even though the modern Rock River deviates from the bedrock valley between Lake Koshkonong and Janesville, the upper Rock Bedrock Valley most certainly marks the course of an earlier Rock River. A major bedrock valley, the Yahara, joins the upper Rock River valley from the northwest at Janesville. The Yahara Bedrock Valley is now occupied by the modern Yahara River and by the modern Rock River below the Rock River's junction with the Yahara River. The upper Rock Bedrock Valley continues south from Rockford and eventually joins the Princeton Bedrock Valley far to the south (fig. 8). The present Rock River leaves

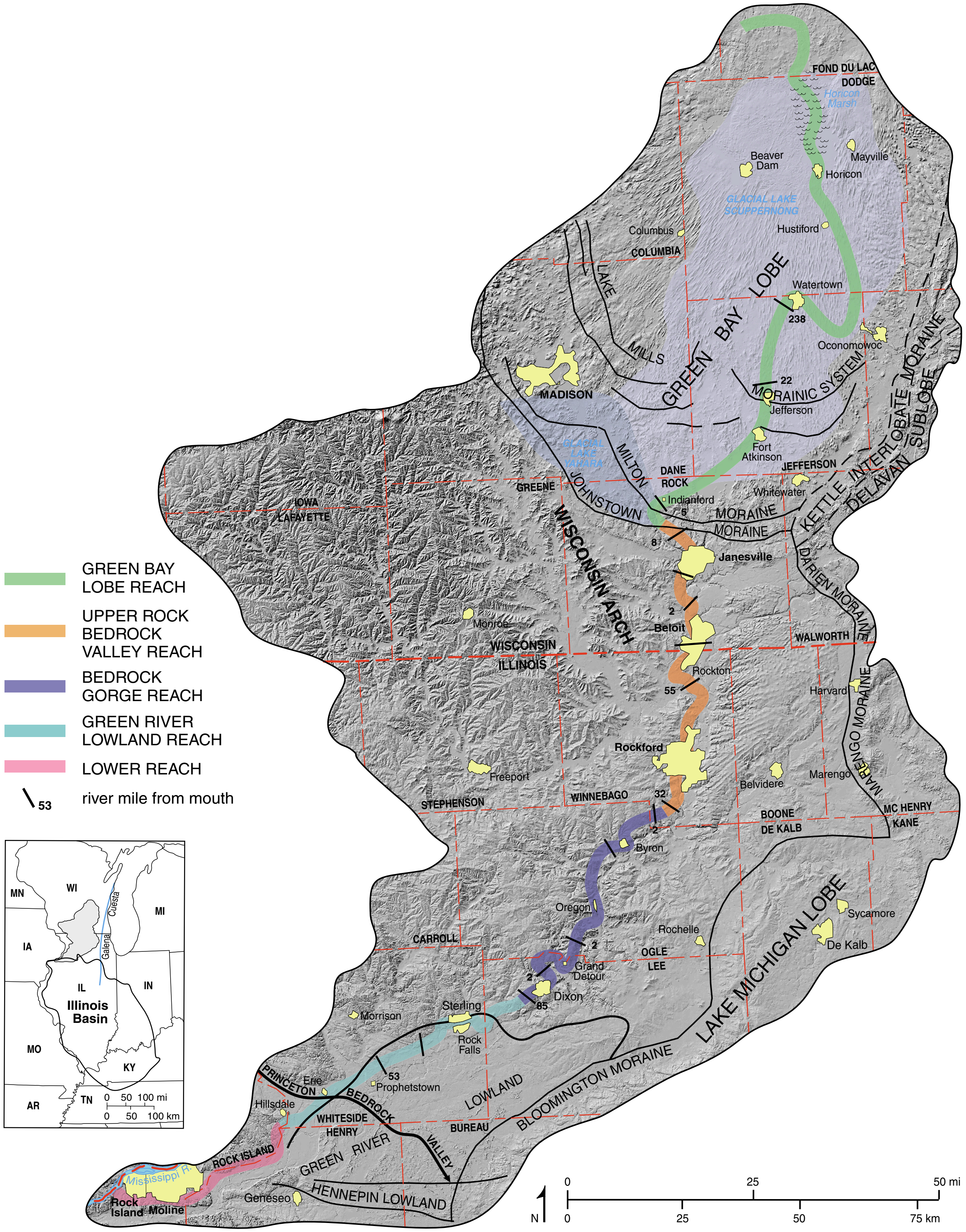


Figure 2 Digital elevation model showing the surface topography of the Rock River drainage basin (U.S. Geological Survey 2004).

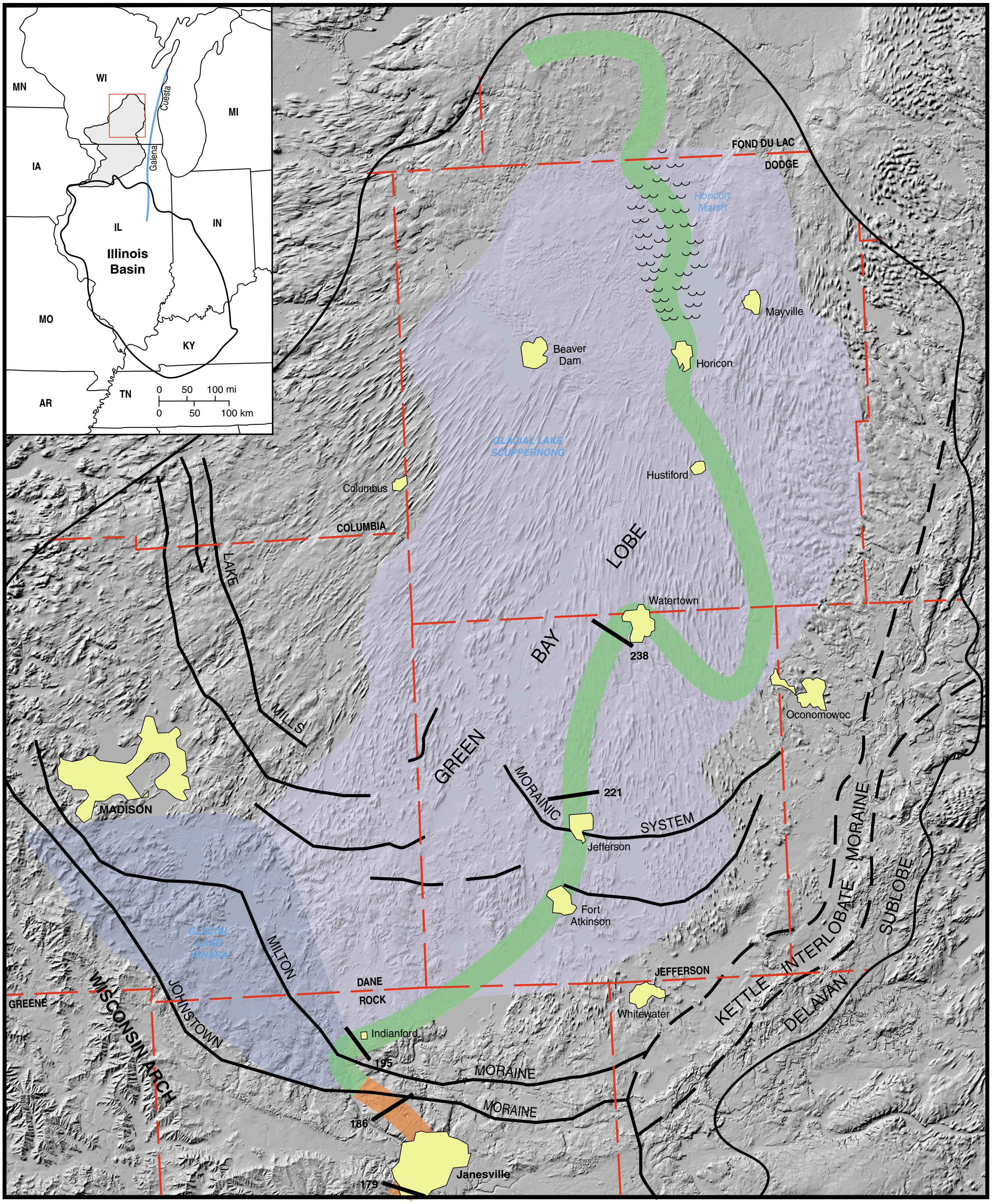
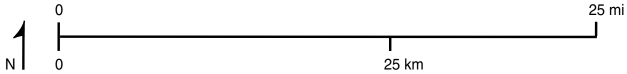


Figure 3 Digital elevation model showing the surface topography of the northern section of the Rock River drainage basin (U.S. Geological Survey 2004).



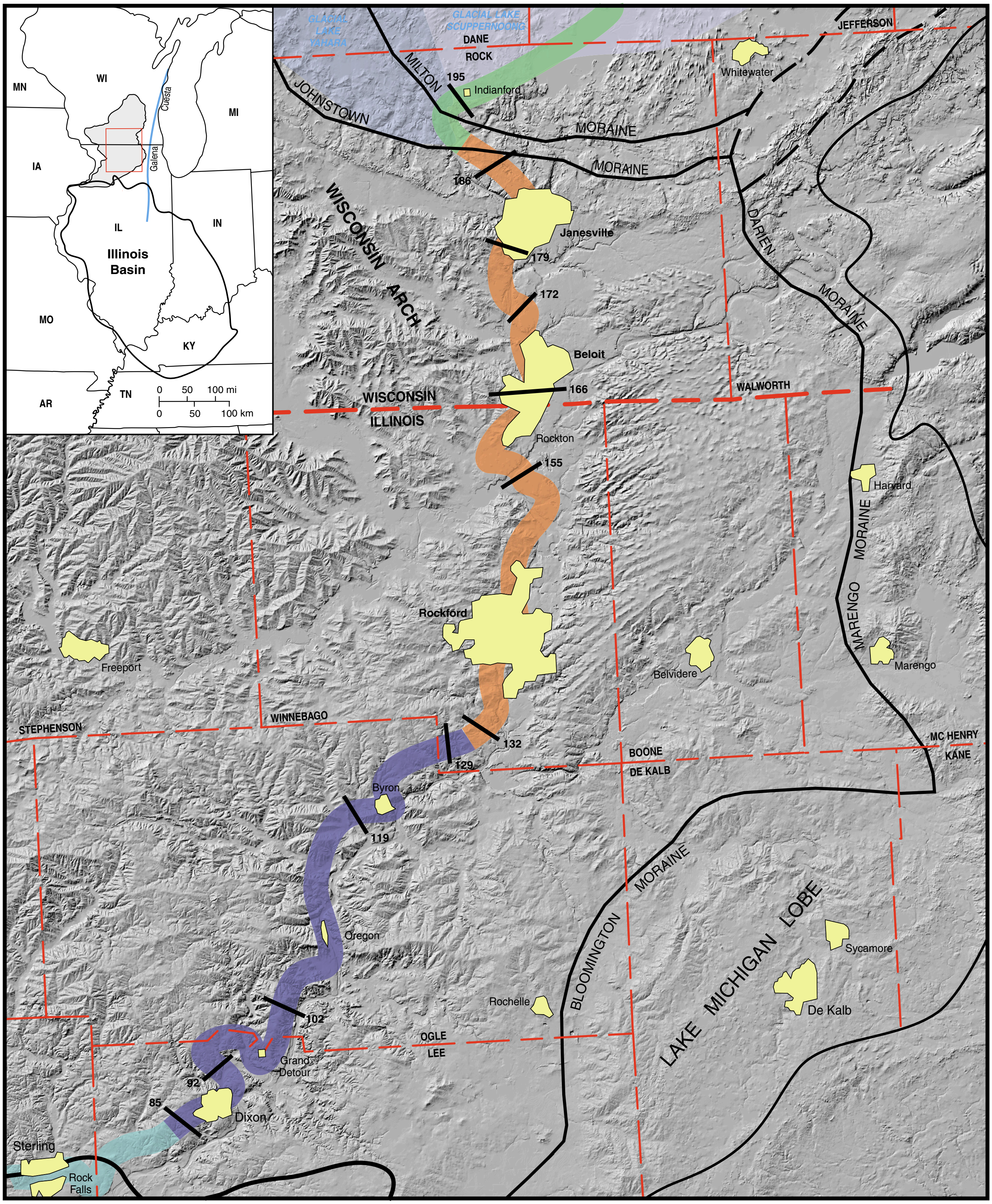


Figure 4 Digital elevation model showing the surface topography of the central section of the Rock River drainage basin (U.S. Geological Survey 2004).

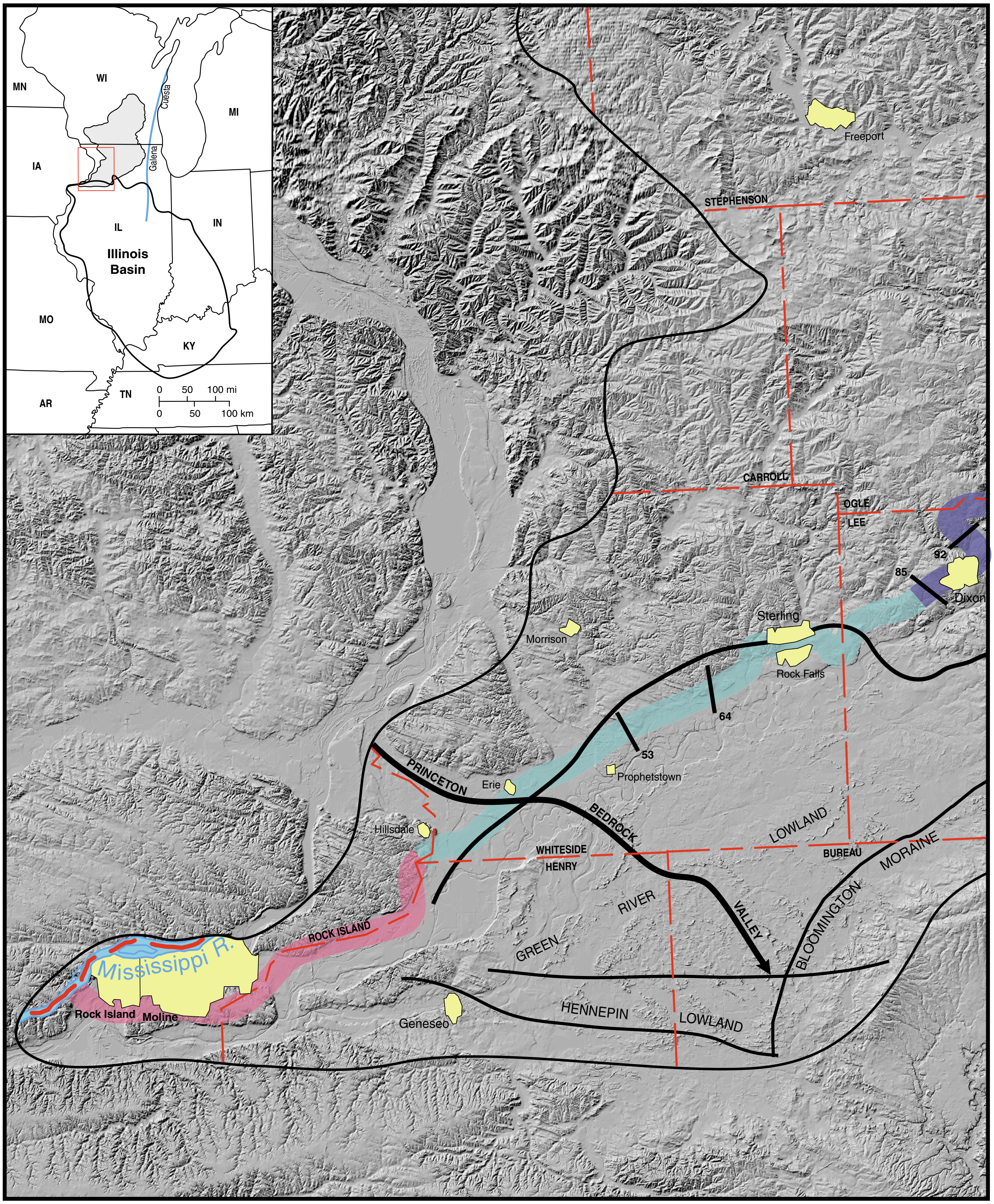
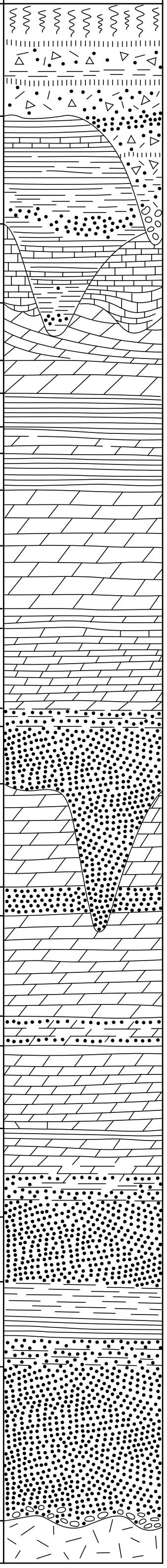


Figure 5 Digital elevation model showing the surface topography of the southern section of the Rock River drainage basin (U.S. Geological Survey 2004).



AGE-ROCK UNITS			ROCK UNITS			
MILLION YEARS AGO	SYSTEM	SERIES	GROUP	FORMATION	THICKNESS ft (m)	DESCRIPTION
1.8	QUATER-NARY	Pleistocene			0–250 (76)	Loess, glacial till, silt, clay, sand and gravel
290	PENNSYL-VANIAN	Desmoines-ian	RACCOON CREEK	Tradewater	0–200 (61)	Shale and sandstone with thin coals and limestone
		Atokan				
323		Morrowan		Caseyville		
380	DEVON-IAN			Cedar Valley	0–140 (43)	Limestone, dolomite
				Wapsipinicon	0–60 (18)	
417	SILUR-IAN	Niagaran		Racine	300 (91)	Dolomite
				Marcus	40 (12)	
		Alexandrian		Sweeney	45–65 (14–20)	Dolomite
				Blanding	35–50 (11–15)	
443	ORDOVICIAN	Cincinnatian	MAQUOKETA	Brainard	75–90 (23–27)	Shale
				Fort Atkinson	15–20 (4.5–6)	Dolomite, shale
				Scales	120 (37)	Shale
		Champlainian	GALENA	Wise Lake	110 (34)	Dolomite
				Dunleith	130 (40)	Dolomite, cherty
				Guttenberg	20 (6)	Dolomite, shale
			PLATTEVILLE		85–130 (26–40)	Limestone, dolomite
			ANCELL	Glenwood	5 (1.5)	Sandstone, silty
				St. Peter	70–160 (21–49)	Sandstone
480		Canadian	PRAIRIE DU CHIEN	Shakopee	207 (63)	Dolomite
				New Richmond	50 (15)	Sandstone
				Oneota	100 (33)	Dolomite
490	CAMBRIAN	St. Croixan		Eminence	60 (18)	Dolomite, sandy
				Potosi	166 (51)	Dolomite
				Franconia	180 (55)	Sandstone, siltstone, shale
				Ironton-Galesville	130 (40)	Sandstone
				Eau Claire	300 (91)	Sandstone, siltstone, shale
				Mt. Simon	1,250 (381)	Sandstone
543	PRECAMBRIAN					Igneous (granite)

Figure 6 Stratigraphic column for the Rock River drainage basin (modified from Anderson 1980).

Figure 7 Fold in St. Peter Sandstone near Grand Detour, Illinois (SW¼SE¼NW¼, Sec. 14, T22N, R9E).

this bedrock valley near the mouth of the Kishwaukee River and follows a southwesterly course through a series of bedrock gorges. The relationship of those bedrock gorges to bedrock topography was discussed in detail by Horberg (1950, p. 66).

In the Princeton Bedrock Valley and its tributaries below Sterling, Illinois, bedrock is deeply buried by glacial outwash, lacustrine silt and clay, and till through a major part of the Green River Lowland (Leighton et al. 1948) (fig. 1). From Hillsdale, Illinois, to the river's mouth at Rock Island, the Rock River follows the shallow bedrock valleys of Duck Creek and the Green River, former east-flowing tributaries of the Princeton Bedrock Valley (Horberg 1950) (fig. 8).

Distinctive Subdivisions of the Rock River Valley

The Green Bay Lobe Reach

The Green Bay Lobe reach extends from the river's headwaters in Fond du Lac County, Wisconsin, to the outer margin of the lobe northwest of Janesville. Along this reach, the river flows through a varied glacial landscape that includes elongate, streamlined hills called drumlins; broad, nearly flat former glacial lake basins; and ridges called end moraines (or simply moraines) that formed at former ice margins. The river also flows along this reach through present-day lakes and marshes, including Horicon Marsh, Sinissippi Lake, and Lake Koshkonong. Variations in river valley features, such as the river's gradient, the width of its floodplain, and the presence or absence of terraces formed at former Rock River levels are to a large extent determined by these varied glacial landscapes.

The Rock River heads near the center of the Green Bay Lobe (fig. 1). The Rock River's uppermost reach flows through an extensive drumlin field (Alden 1918) that was partially submerged by a widespread but short-lived glacial lake, Lake Scuppernong (Clayton and Attig 1997 a, 1997b; Clayton 2001). Glacial Lake Scuppernong formed when glacial meltwater was temporarily impounded behind the Milton and Johnstown moraine ridges near the margin of the Green Bay Lobe (fig. 1). The river eventually cut a channel through the moraines and entered the next reach of the valley, which extends from the Johnstown moraine to the Kishwaukee River in north-central Illinois.

Gradients of the Rock River within the Green Bay Lobe are low, averaging 0.7 ft·mi^{-1} (0.12 m·km^{-1}) (table 1 and fig. 9), but vary greatly. An extremely low gradient of 0.1 ft·mi^{-1} occurs where the

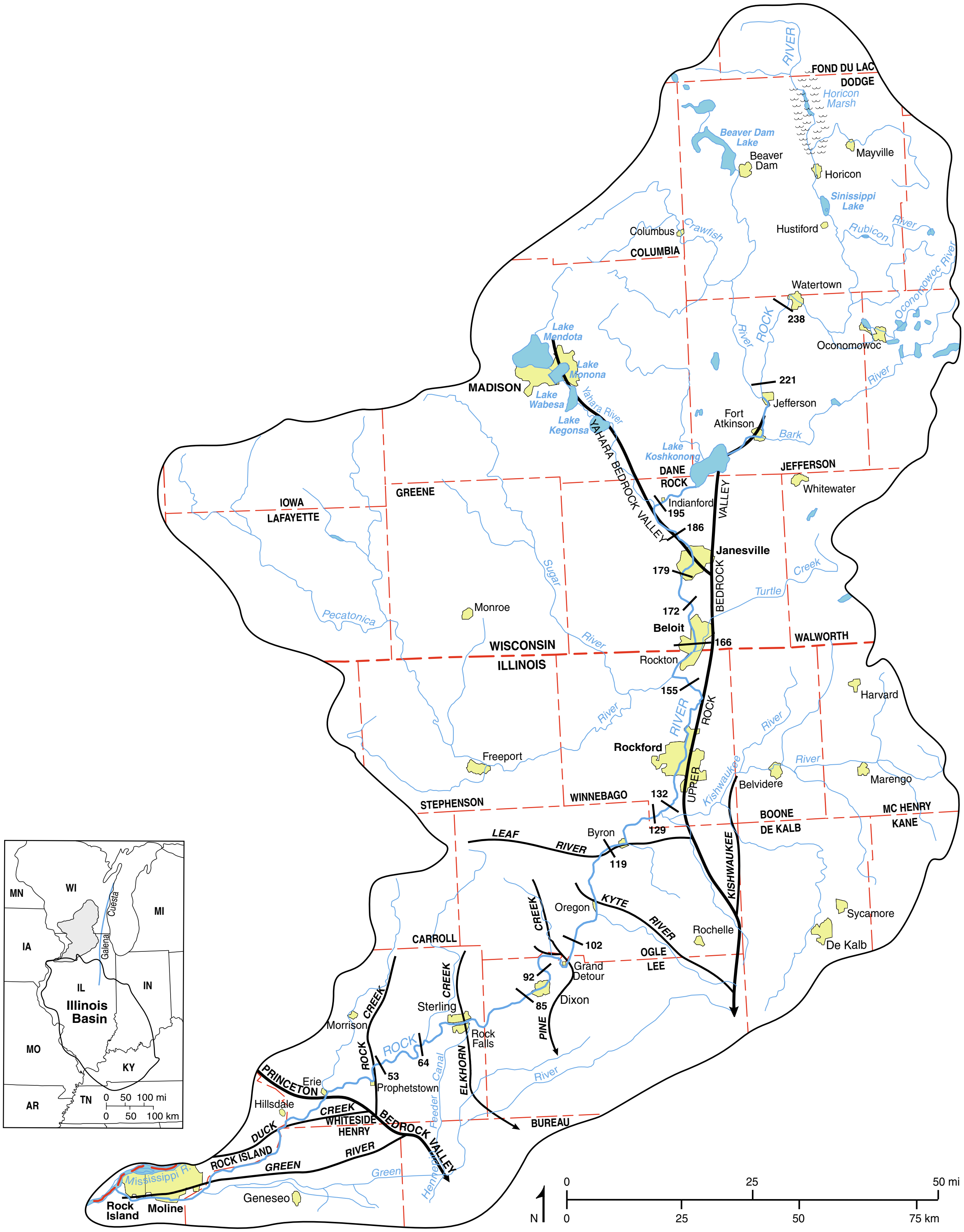


Figure 8 Bedrock valleys in the Rock River basin (Alden 1918, Horberg 1950, U.S. Geological Survey 1999).

Table 1 Gradients of the Rock River and its outwash terraces.

	Reach									
	Green Bay Lobe		Johnstown Moraine to Kishwaukee River		Bedrock Gorge		Green River Lowland		Lower	
	(ft)	(m)	(ft)	(m)	(ft)	(m)	(ft)	(m)	(ft)	(m)
Rock River										
River Mile										
From	298	480	188	303	131	211	83	134	31	50
To	188	303	131	211	83	134	31	50	0	0
Elevation										
Up	857	261.2	785	239.3	680	207.3	635	193.6	573	174.7
Down	785	239.3	680	207.3	635	193.6	573	174.7	545	166.1
Gradient										
$\text{ft}\cdot\text{mi}^{-1}$	0.7		1.8		0.9		1.2		0.9	
$\text{m}\cdot\text{km}^{-1}$	0.12		0.35		0.18		0.23		0.17	
Johnstown Terrace										
River Mile										
From			188	303						
To			166	267						
Elevation										
Up			880	268.2						
Down			805	245.4						
Gradient										
$\text{ft}\cdot\text{mi}^{-1}$			3.4							
$\text{m}\cdot\text{km}^{-1}$			0.65							
Milton Terrace										
River Mile										
From	197	317	188	303	131	211	84	135		
To	188	303	131	211	84	135	80	129		
Elevation										
Up	835	254.5	825	251.5	720	219.5	664.4	202.5		
Down	825	251.5	720	219.5	669.3	204	659.4	201		
Gradient										
$\text{ft}\cdot\text{mi}^{-1}$	1.1		1.8		1.1		1.2			
$\text{m}\cdot\text{km}^{-1}$	0.21		0.35		0.20		0.23			
Watertown Terrace										
River Mile										
From	238	383	188	303	131	211	84	135		
To	191	307	131	211	84	135	53	85		
Elevation										
Up	810	246.9	785	239.3	700	213.4	650	198.0		
Down	790	240.8	700	213.4	649.6	198.0	620	189.0		
Gradient										
$\text{ft}\cdot\text{mi}^{-1}$	0.4		1.5		1.1		1.0			
$\text{m}\cdot\text{km}^{-1}$	0.08		0.28		0.20		0.18			

river flows across the floor of former glacial Lake Scuppernong in the 10-mile stretch between Horicon Marsh and Sinissippi Lake. The steepest gradient is 7 $\text{ft}\cdot\text{mi}^{-1}$ near Watertown where the river flows on thin glacial deposits mantling a cuesta developed on Galena Group bedrock.

In the headwaters area, the Rock River consists of two branches. The west branch originates 20 miles west of Fond du Lac, and the east branch originates 10 miles southeast of Mayville. Their confluence within the 32,000-acre Horicon Marsh marks the beginning of the Rock River (fig. 1). The water level of Horicon Marsh, 857 ft (261 m), is controlled by a low dam at the marsh's outlet at the town of Horicon. From that outlet, the Rock River meanders south 10 mi (16 km) to Sinissippi Lake, an expansion of the river. Sinissippi Lake is less than 10 ft deep in most places, and its surface elevation of 856 ft (261 m) is maintained by a low dam at Hustisford. From Sinissippi Lake, the river continues to meander south among drumlins and across the floor of glacial Lake Scuppernong. The Rubicon River flows in from the east a few miles south of Sinissippi Lake, and, still farther south, the Rock River is joined by the Oconomowoc River. Both of these rivers flow generally west from the Kettle Interlobate Moraine, which forms the eastern boundary of the Green Bay Lobe.

The Rock River makes a sharp turn to the west a few miles above the mouth of the Oconomowoc River and turns northwest at the confluence of the Oconomowoc River. Flowing northwest, the river obliquely crosses the eastward-dipping dolomite bedrock of the Galena Group, which here has only a thin cover of glacial deposits. In this area, the river flows among drumlins and displays no floodplain or other characteristic fluvial feature (fig. 10). At Watertown, the river changes character

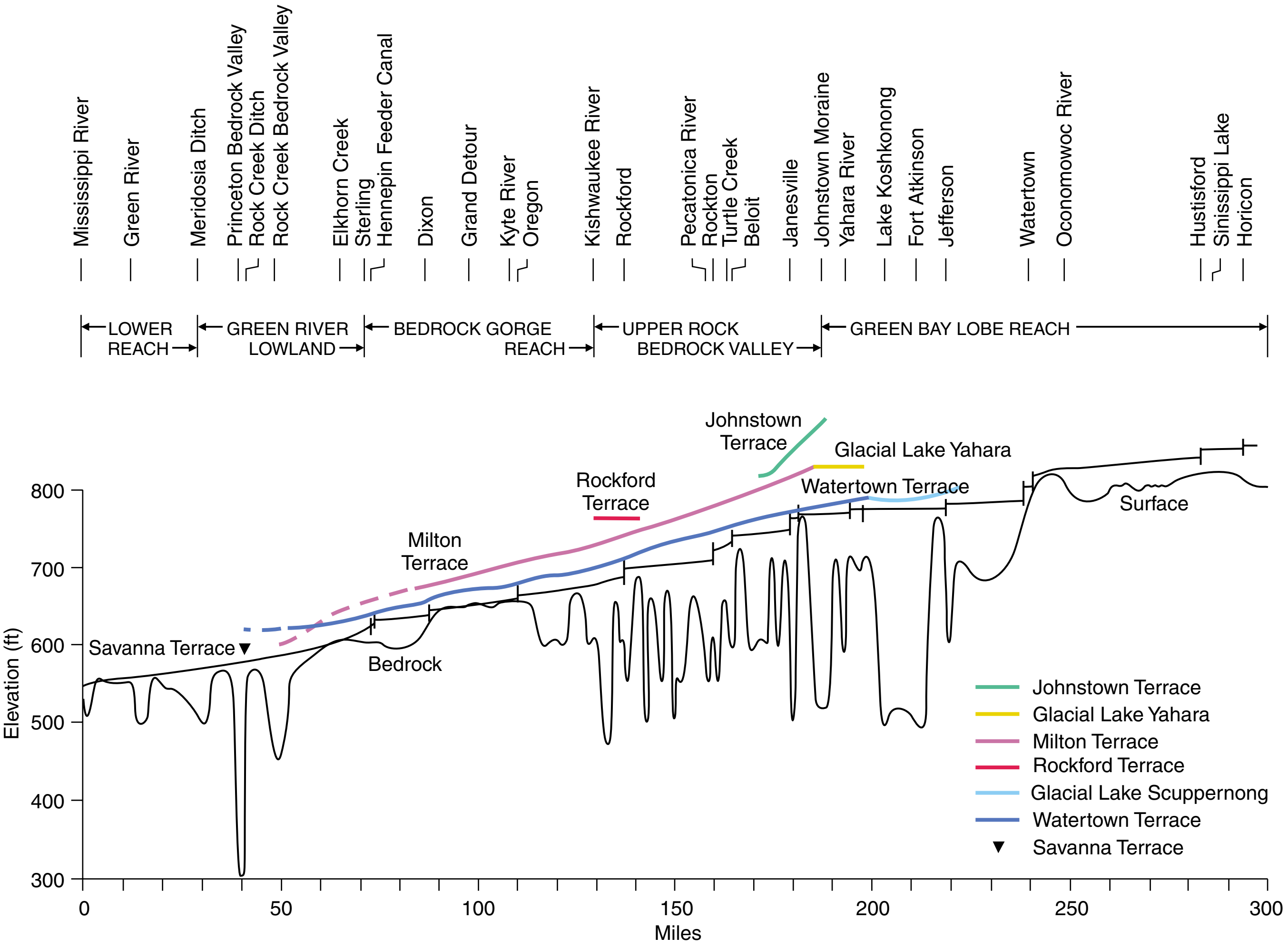


Figure 9 Longitudinal profile of the Rock River showing valley train terraces and bedrock topography.

Figure 10 The Rock River viewed to the northwest from a point about 6 mi (10 km) southeast of Watertown, Wisconsin (Sec. 32, T8N, R16E). Note the absence of a floodplain. All of the hills in view are drumlins.

dramatically. The river turns abruptly back to the south (fig. 1), crossing an area of thin glacial deposits covering the cuesta that developed on the resistant bedrock of the Galena Group. The steepest gradient on the river occurs here as the river descends the buried bedrock cuesta ridge (fig. 9). Further evidence of the effect of the Galena cuesta is the course of Johnson Creek; its headwaters are only a quarter of a mile (402 m) from the Rock River. Johnson Creek, however, flows southward away from the Rock River and parallel to the crest of the Galena cuesta for more than 10 miles before turning back to the north and finally joining the Rock River a few miles north of Jefferson (fig. 11). Johnson Creek makes a sharp, almost 180-degree turn as it crosses the crest of the Galena cuesta.

At Watertown, the Rock River not only displays striking changes in direction and gradient, but it also displays the first occurrence of a terrace that marks a former, higher level of the river. This terrace is named the Watertown Terrace in this guide. The Watertown Airport is built on this surface (fig. 12, profile 238). The terrace has a well-defined scarp descending to the river, but the terrace's limits away from the river are indistinct; the terrace merges with the very flat lacustrine lowlands present between the numerous drumlins in this area (fig. 12, profile 221). Discontinuous remnants of this terrace extend down valley all the way to Prophetstown, Illinois (figs. 1 and 9). The Watertown Terrace is the youngest of the Rock River's terraces. Farther downstream, the Watertown Terrace occurs at elevations below older terraces (fig. 9). At its head, the Watertown Terrace occurs at an elevation of 810 ft (247 m), 25 ft (8 m) above the present river. Gradients of the terrace (table 1) range from 0.4 to 1.5 $\text{ft}\cdot\text{mi}^{-1}$ (0.08 to 0.28 $\text{m}\cdot\text{km}^{-1}$). The terrace is typically composed of sand and gravel constituting the Mackinaw facies of the Henry Formation (Hansel and Johnson 1996), but within the Green Bay Lobe the terrace is composed mostly of silt overlying sand, which are deposits of glacial Lake Scuppernong.

The river crosses the Lake Mills Morainic System (mapped by Alden 1918) between Jefferson and Fort Atkinson (fig. 1). The Bark River enters from the east at Fort Atkinson, and, as the Oconomowoc and Rubicon Rivers upstream, also heads in the Kettle Moraine along the southeastern margin of the Green Bay Lobe. South of Fort Atkinson, the river valley overlies a bedrock valley called the upper Rock Bedrock Valley (fig. 8), and 6 mi downstream from Fort Atkinson, the river flows into one of southern Wisconsin's largest lakes, the 10,460-acre Lake Koshkonong. The lake's scalloped shoreline suggests that coalescing glacial ice-block depressions formed the lake.

The river crosses a bedrock high below Lake Koshkonong and then crosses the Milton Moraine (Alden 1918). The Milton Terrace, named in this guide for its close association with the Milton Moraine, is older and higher than the Watertown Terrace and originates at the front of the Milton Moraine. The Milton Terrace can be traced downstream as far as Dixon, Illinois (figs. 9 and 12; profile 195). This terrace is composed of outwash deposited when the Green Bay Lobe formed the Milton Moraine. At its head adjacent to the moraine, the Milton Terrace occurs at an elevation of 850 ft (259 m). Gradients of the Milton Terrace are steeper than those of the Watertown Terrace, ranging from 1.1 to 1.8 $\text{ft}\cdot\text{mi}^{-1}$ (0.20 to 0.35 $\text{m}\cdot\text{km}^{-1}$) (table 1). The Milton Terrace is buried by later Watertown Terrace deposits farther downstream (fig. 9).

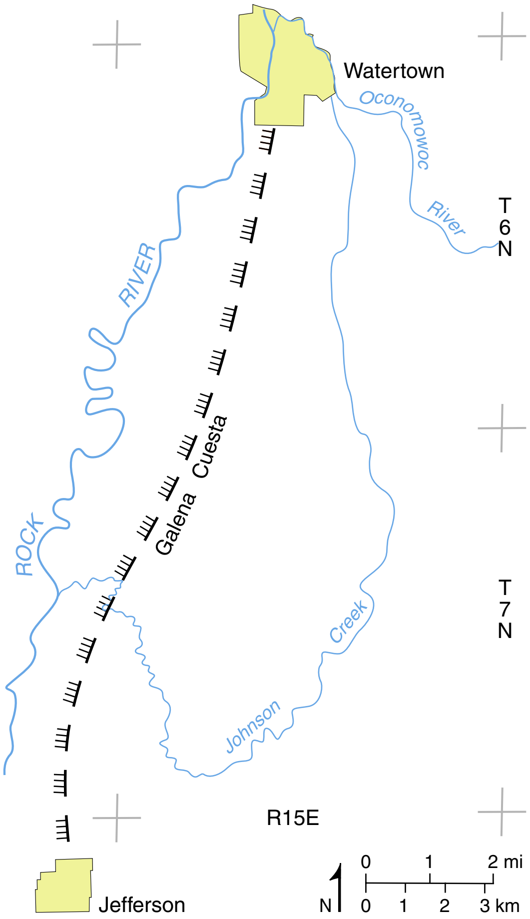


Figure 11 The course of Johnson Creek, Jefferson County, Wisconsin.

Along the front of the Milton Moraine near Indianford, Wisconsin, the Rock River is joined from the northwest by the Yahara River, which is the outlet for the lakes in the Madison area. The valley of the Yahara River trends southeast and overlies a bedrock valley (fig. 8). The bedrock valley was the site of glacial Lake Yahara, which was impounded behind the Johnstown Moraine, and its outlet coincided with the present course of the Rock River through the Johnstown Moraine (Clayton and Attig 1997b). Five miles below the mouth of the Yahara River, the Rock River crosses the Johnstown Moraine, the moraine that forms the margin of the Green Bay Lobe and marks the lower end of the Green Bay Lobe reach of the Rock River.

The Reach from the Margin of the Green Bay Lobe to the Mouth of the Kishwaukee River

After crossing the Johnstown Moraine, the Rock River enters a reach distinctive in its greater width, broad river terraces, scattered bedrock outcrops, and mid-sized towns such as Janesville and Beloit in Wisconsin and Rockford in Illinois. At the front of the Johnstown

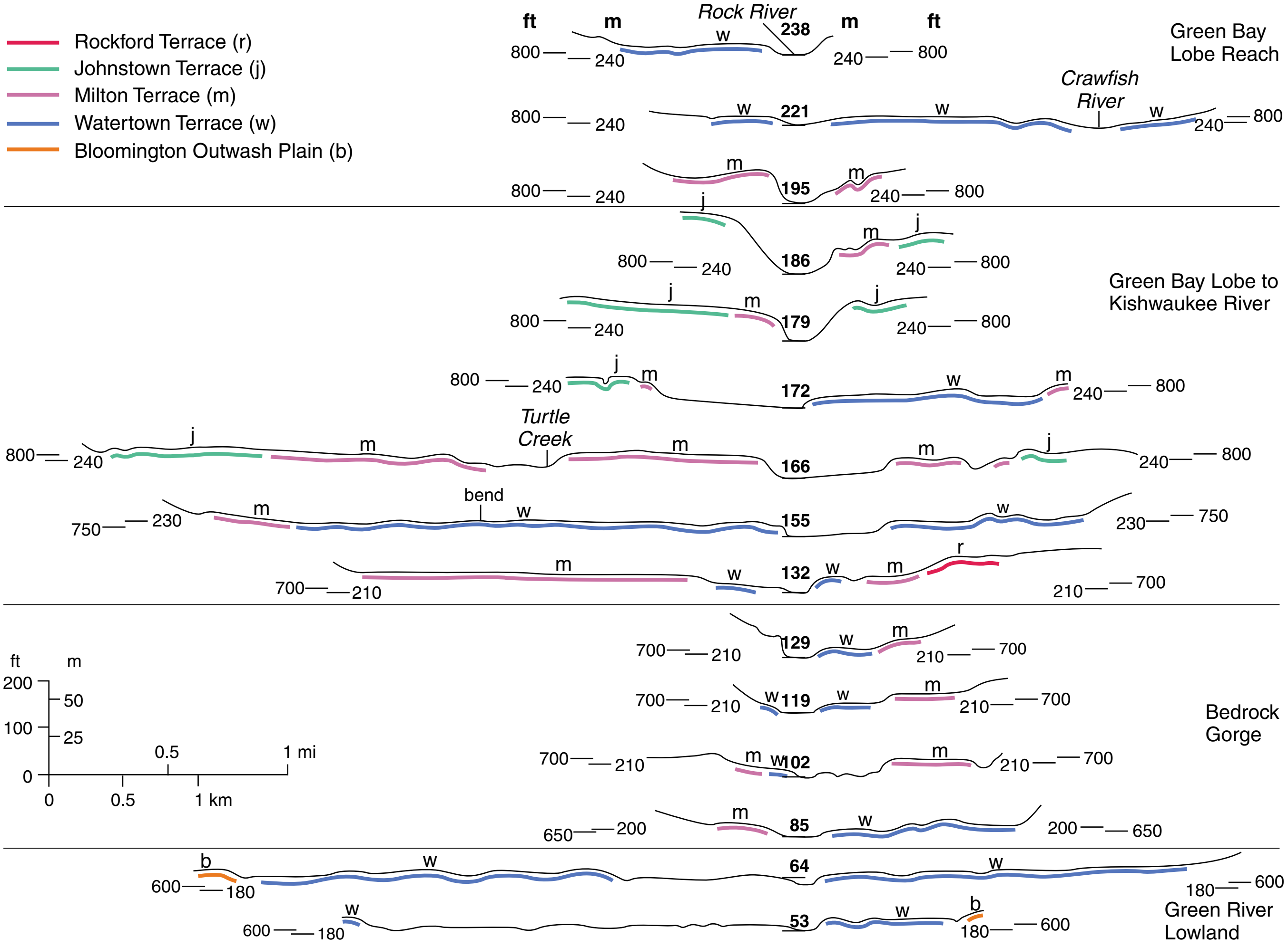


Figure 12 Cross profiles of the Rock River valley identified by numbers in miles above the mouth of the river in figure 1. All profiles reflect the view looking in the downstream direction.

Moraine, another, higher and older terrace occurs and extends down valley as far as Beloit, Wisconsin. This terrace is named the Johnstown Terrace in this guide (fig. 9). The Johnstown Terrace formed as the Green Bay Lobe built the Johnstown Moraine. The valley train terraces have been extensively exploited as sources of sand and gravel. Throughout this reach, the course of the Rock River coincides with that of the upper Rock Bedrock Valley that contains Quaternary sediment that in places is more than 350 ft (107 m) thick (Hackett 1960, Berg et al. 1984). This material is largely sand and gravel, but fine-grained sediments also occur that may record periods when the valley was blocked by glacial ice, forming short-lived, ice-dammed lakes (Hackett 1960). Along this reach, the Rock River tends to flow along the western side of its bedrock valley, displaced by the flux of outwash from the east. The river is thus superimposed across a series of bedrock spurs (Chamberlin and Salisbury 1885; Alden 1918, p. 310; Workman 1937, p. 36; Hackett 1960) (fig. 9). This is best illustrated at Janesville, where the Rock River makes a very sharp turn, flowing first southeast and then turning abruptly to the west, a result of the lateral migration of the river down a bedrock spur. In doing so, the river captured Blackhawk Creek at a point about 5 mi (8 km) above the creek's former mouth (fig. 13). This interpretation of the relationship between the Rock River and Blackhawk Creek differs from that of Chamberlin and Salisbury (1885), who considered the abandoned lower course of Blackhawk Creek to be a former course of the Rock River. This bedrock spur is considered by Clayton and Attig (1997b) to be the sill that ultimately controlled the level of the Yahara and Scuppernong glacial lakes. The Rock River also flows against bedrock at the base of its west bluffs near the mouth of the Pecatonica River at Rockton, Illinois. An isolated bedrock knob occurs on the western side of the valley about 4 mi downstream from the mouth of the Pecatonica River (NW¼NE¼, Sec. 31, T46N, R2E). The river crosses another bedrock spur on the western side of the valley at Blackhawk Park in Rockford (Sec. 34, T44N, R1E) (Bretz 1923, p. 292).

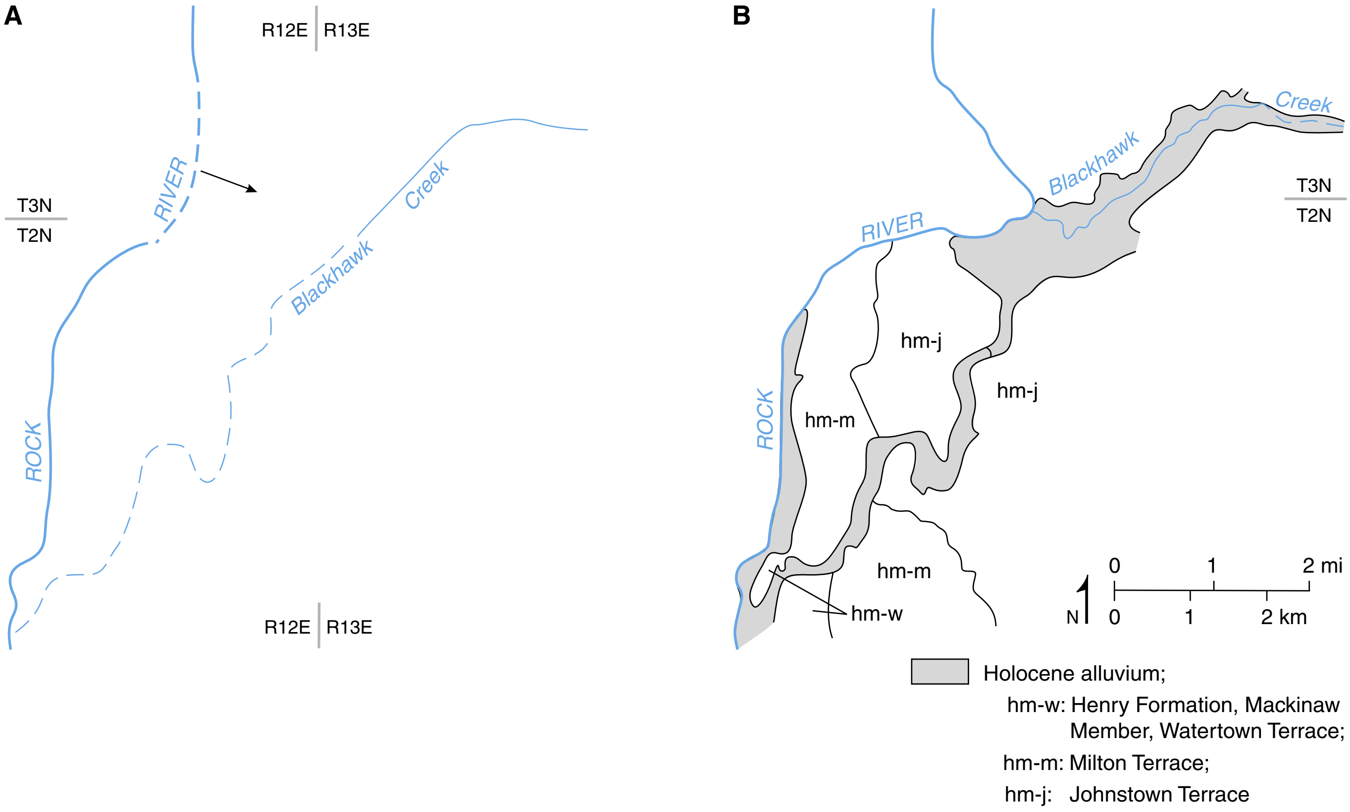


Figure 13 The capture of Blackhawk Creek at Janesville, Wisconsin. (A) Location of the Rock River and Blackhawk Creek prior to capture. Dashed lines indicate former courses; arrow indicates southeast migration of the Rock River down a bedrock nose. (B) Present-day relationship of the Rock River and Blackhawk Creek.

All three valley train terraces are present along this reach. The Johnstown Terrace, which extends downstream only as far as Beloit (fig. 9; fig. 12, profiles 186, 179, 172, and 166), descends from an elevation of 880 ft (268 m) at the front of the Johnstown Moraine to 805 ft (245 m) at Beloit, Wisconsin, where it disappears beneath the deposits of the Milton Terrace. The Johnstown Terrace was deposited by meltwater from the Green Bay Lobe at the time the large and conspicuous Johnstown Moraine was being built. The terrace's gradient, 3.4 ft·mi^{-1} (0.65 m·km^{-1}), is steeper than either the Milton or Watertown Terraces, a result of the terrace's larger caliber load and the probable isostatic uplift that followed withdrawal of the glacier from the Johnstown Moraine. The latter has been estimated to be 0.13 m·km^{-1} by Clayton and Attig (1997b).

The Milton Terrace is well expressed throughout this reach, especially in the vicinity of Beloit, where the terrace is augmented by outwash from the Delavan Sublobe of the Lake Michigan Lobe, which discharged through the valley of Turtle Creek (fig. 1; fig. 12, profile 166). The Milton Terrace descends from an elevation of 825 ft (252 m) at the front of the Johnstown Moraine to 720 ft (220 m) at the mouth of the Kishwaukee River south of Rockford, Illinois (fig. 1, table 1). The gradient along this reach is 1.8 ft·mi^{-1} (0.35 m·km^{-1}), which is steeper than the terrace gradient in any other major reach and despite the almost flat gradient just upstream from Beloit (table 1, fig. 9).

In contrast, the Watertown Terrace is absent at Beloit and has an almost flat gradient directly upstream from the zone of flat gradient that occurs on the Milton Terrace at Beloit (fig. 9). Nevertheless, as in the case of the Milton Terrace, the gradient of the Watertown Terrace is steeper in this reach than it is in any other reach. The elevation of the Watertown Terrace at the Johnstown Moraine is 785 ft (239 m) and 700 ft (213 m) at the mouth of the Kishwaukee River south of Rockford, Illinois, a gradient of 1.5 ft·m^{-1} (0.28 m·km^{-1}) (figs. 1 and 9, table 1). The terrace is broad and well expressed at and for a few miles below the mouth of the Pecatonica River, where the Watertown Terrace lies at an elevation of 750 ft (fig. 12, profile 155) and may correlate with terraces on the Blanchardville sand in the valley of the Pecatonica River (Whittecar 1979).

In the vicinity of Beloit, the Rock River and its terraces exhibit several interesting anomalies (figs. 1 and 14): (1) the Watertown Terrace is absent, (2) the river itself is unusually straight, (3) the modern floodplain is unusually narrow, (4) the river's gradient is unusually steep (fig. 9), (5) the Milton Terrace is very extensive, (6) an abandoned stream channel crosses the Milton Terrace, and (7) the Johnstown Terrace cannot be recognized downstream from this area (fig. 9). These anomalies are very likely related to the voluminous outwash from the Delavan Sublobe carried to the Rock River through the valley of Turtle Creek. This outwash is contemporaneous with the deposition of Milton outwash in the Rock River valley (Alden 1918, p. 267–269). Later, during the erosional event that followed the deposition of the Milton outwash, the Rock River reacted to this influx of coarse sediment by assuming a straight course and a steeper gradient, leading to the development of a modern floodplain that extends across the entire width of the valley below the level of the Milton Terrace (fig. 12, profile 166). This erosion apparently suppressed any development of the Watertown Terrace along this reach. The abandoned channel across the Milton Terrace clearly marks a former course of Turtle Creek, which probably was abandoned as a result of stream capture by a tributary of the Rock River that now is the lower reach of Turtle Creek (fig. 14). The capturing stream benefited from the steeper gradient of the Rock River above Beloit and thus had an advantage over the former course of Turtle Creek.

In addition to the valley train terraces, the Rock River valley in this reach contains remnants of a much older terrace, the Rockford Terrace (Anderson 1967). It occurs on the west bluffs of the river near the southern limits of the city of Rockford at elevations between 760 and 770 ft (232 and 235 m) (fig. 9; fig. 12, profile 132). The sediments in this terrace consist of up to 20 ft (6 m) of coarse to very coarse gravel with scattered small boulders overlain by 7 ft (2 m) of gray to brown leached silt. A prominent brownish red weathered zone marked by numerous silt-filled ice-wedge casts occurs in the upper 4 ft (1 m) of the gravel (fig. 15). The dolomite-rich gravel is leached to a depth of about 12 ft (4 m). The weathered zone is most likely the Sangamon Geosol, suggesting that the deposit itself dates to the Illinois glacial episode. The deposit's position high on the bluffs, above terraces of the Wisconsin glacial episode, is consistent with this interpretation. The ice-wedge casts are probably early to middle Wisconsin, and the overlying gray to brown silt is late Wisconsin loess (Peoria Silt) (table 2). Correlative sediments may occur in the buried upper Rock Bedrock Valley. The Rockford Terrace may also be related to the Illinois glacial episode that deposited the Winslow Till in the Pecatonica River valley near Freeport, Illinois (Whittecar 1979).

Bedrock Gorge Reach

At the mouth of the Kishwaukee River, south of Rockford, the Rock River turns abruptly to the southwest and enters Bedrock Gorge, a reach characterized by a relatively narrow valley eroded into the bedrock of the Galena, Platteville, and Ancell Groups. In many respects, this is the most picturesque reach of the river. Wooded bluffs rise 150 ft (46 m) or more above the valley floor, their underlying structure revealed by rock outcrops at many places. The river emerges from its gorge at Dixon, Illinois (fig. 1), having descended 45 ft (15 m) at a gradient of 0.9 $\mathrm{ft \cdot mi^{-1}}$ (0.18 $\mathrm{m \cdot km^{-1}}$) through this reach (table 1). The upper Rock Bedrock Valley, in which the Rock River flows above the mouth of the Kishwaukee River, continues south through eastern Ogle and Lee Counties and then turns to the southwest toward its junction with the Princeton Bedrock Valley (fig. 8). The bedrock gorge reach is a result of glacial diversion of the river from this former course to a course transverse to preexisting southeast-trending bedrock valleys that were tributary to the upper Rock Bedrock Valley (Leverett 1899, Bretz 1923, Knappen 1926, Horberg 1950, Herzog et al. 1994) (fig. 8).

The height of the bluffs in this reach ranges from about 170 ft (52 m) at its upper end to about 140 ft (43 m) at Dixon, and the width of the valley varies from less than 0.5 miles (.8 km) to about 1 mile (1.6 km) over the same distance. Where the river intersects pre-existing, southeast-trending valleys, such as that of the Leaf River below Byron, the Kyte River at Oregon, and Pine Creek at Grand Detour, the river's width swells to more than 2 mi (3.2 km) (fig. 8). It is at these intersections that the valley train terraces are most extensive and best preserved, although the Milton and Watertown Terraces can be traced with little difficulty throughout this reach (fig. 9; fig. 12, profiles 129, 119, 102, 85). The valley between Oregon and Grand Detour is carved into the poorly cemented St. Peter Sandstone rather than in the Platteville Limestone and Galena Dolomite that is present elsewhere. Along this segment of the Bedrock Gorge reach, the river channel is straight, but braided, possibly a reflection of the somewhat coarser bed load supplied by the easily eroded sandstone. Castle Rock, an isolated knob of St. Peter Sandstone about 4 mi (6.4 km) upstream from Grand Detour, rises from the river's edge much like Starved Rock along the Illinois River at Utica, Illinois. "Grand Detour," the twisting course of the river between the towns of Grand Detour and Dixon, is a result of the blockage of Pine Creek by Illinoian ice and the subsequent breaching of the divide between a tributary of Pine Creek and the lower Rock River (Knappen 1926, Horberg 1950) (fig. 8).

Green River Lowland Reach

A few miles below Dixon, the Rock River exits its bedrock gorge and enters the Green River Lowland, an area underlain by thick sand and gravel coincident with the Princeton Bedrock Valley and its tributaries, which are Elkhorn and Rock Creeks on the north and Duck Creek and Green River to the south (Horberg 1950) (fig. 8). The Princeton Bedrock Valley is a former course of the Mississippi River that is now filled by more than 200 ft (61 m) of outwash sand and gravel, lacustrine silt, and glacial till (Larson et al. 1995) (figs. 1, 8, and 9). Most of the surface of the 800 $\mathrm{mi^2}$ (2,070 $\mathrm{km^2}$) of the Green River Lowland is composed of the Bloomington Outwash Plain, which was deposited by meltwater from the ice front that built the Bloomington Morainic System in western Bureau County and southeastern Lee County. The Rock River flows along the northwestern edge of this sandy plain. The Rock River valley widens significantly in this reach, becoming as much as

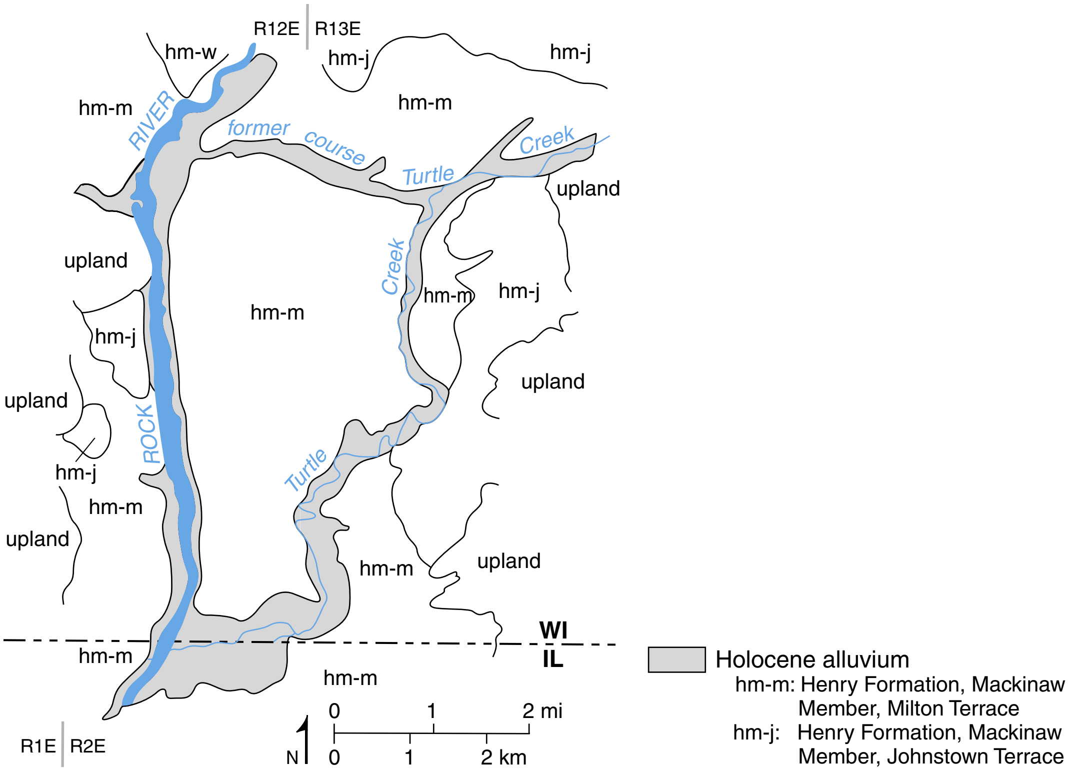


Figure 14 The Rock River valley in the vicinity of Beloit, Wisconsin. The upland areas consist of relatively thin glacial drift over bedrock.

Figure 15 Weathered zone and ice-wedge casts in Rockford Terrace, SE¼, Sec. 4, T43N, R1E. Two meters of Peoria Silt overburden have been removed. The scale in the center of the image is 1 m (3.3 ft) in length.

Table 2 Quaternary deposits and events in the Rock River area.

Glacial and interglacial events	Lithostratigraphy	Morphological events
Postglacial episode	Deposition of Cahokia alluvium	Formation of modern floodplain
Wisconsin Episode (late)	Deposition of sediments of the Johnstown, Milton, and Watertown Terraces	Outwash terraces formed
	Deposition of Peoria Silt	Main period of loess deposition
	Deposition of Equality Formation in the Green River Lowland	Formation of glacial Lake Milan
Wisconsin Episode	Formation of ice wedges and ice-wedge casts in sediments of the Rockford Terrace	Cryogenic processes
		Minor loess deposition
		Diversion of the Rock River into its Bedrock Gorge reach upstream from the Leaf River
Sangamon Interglacial Interval	Formation of Sangamon Soil in sediments of the Rockford Terrace	Pedogenic processes
Illinois Episode	Deposition of sediments of the Rockford Terrace	Formation of the Rockford Terrace
	Deposition of the Glasford Formation	Diversion of the Rock River into its Bedrock Gorge reach downstream from the Leaf River
	Deposition of Equality Formation in the Green River Lowland	Formation of glacial Lake Moline

5 mi (8 km) wide in places (fig. 12; profiles 64 and 53). Below Sterling, Illinois, the river flows on a broad floodplain with meanders, oxbows, natural levees, and point bars (figs. 16 and 17). At Hillsdale, Illinois, the river leaves the Green River Lowland and enters its lower reach, where the character of the river was determined by late glacial floods along the Mississippi River.

Downstream from Dixon, Illinois, the bluffs on the southeast side of the valley become less prominent and are gradually replaced by a low bluff marking the northwest edge of the Bloomington Outwash Plain (figs. 1 and 16). This outwash plain was previously mapped as the "upper" terrace (Anderson 1967). On the northwest side of the valley, the bluffs consist of (1) bedrock uplands, which are mostly Ordovician and Silurian dolomites covered by Illinois Episode till and wind-blown silt (loess); (2) a remnant of the Bloomington Outwash Plain; (3) and two wide, streamless channels, the Meredosia and Cattail, which connect the valley of the Rock River with that of the Mississippi River (fig. 16). The Meredosia Channel is the northwestern end of the Princeton Bedrock Valley. The Cattail Channel may have been formed by the diversion of the Mississippi River by a pre-Illinois episode glacier from the west (Anderson 1968).

Between Prophetstown and Lyndon, a meander belt extends westward, north of Erie, as far as the lower end of the Meredosia Channel (figs. 16 and 18). This belt is comparable in size to that of the Rock River and may indicate a former course of the Rock River to the Mississippi River through the Meredosia Channel. The meander belt does not extend through the channel to the Mississippi River, however, perhaps because it has been removed or modified by floodwaters of the Mississippi River that also coursed through the Meredosia Channel. It is more likely that this former course of the Rock River turned south before entering the Meredosia Channel and joined the present course of the Rock River in the vicinity of Hillsdale, Illinois (fig. 16). The present course of the river has the advantage of a steeper gradient, 1.2 $ft \cdot mi^{-1}$ (0.23 $m \cdot km^{-1}$), through this reach than either of these two possible former courses. The Cattail Channel (fig. 16) enters the Rock River valley near the lower end of the Green River Lowland reach, linking the valleys of the Mississippi and

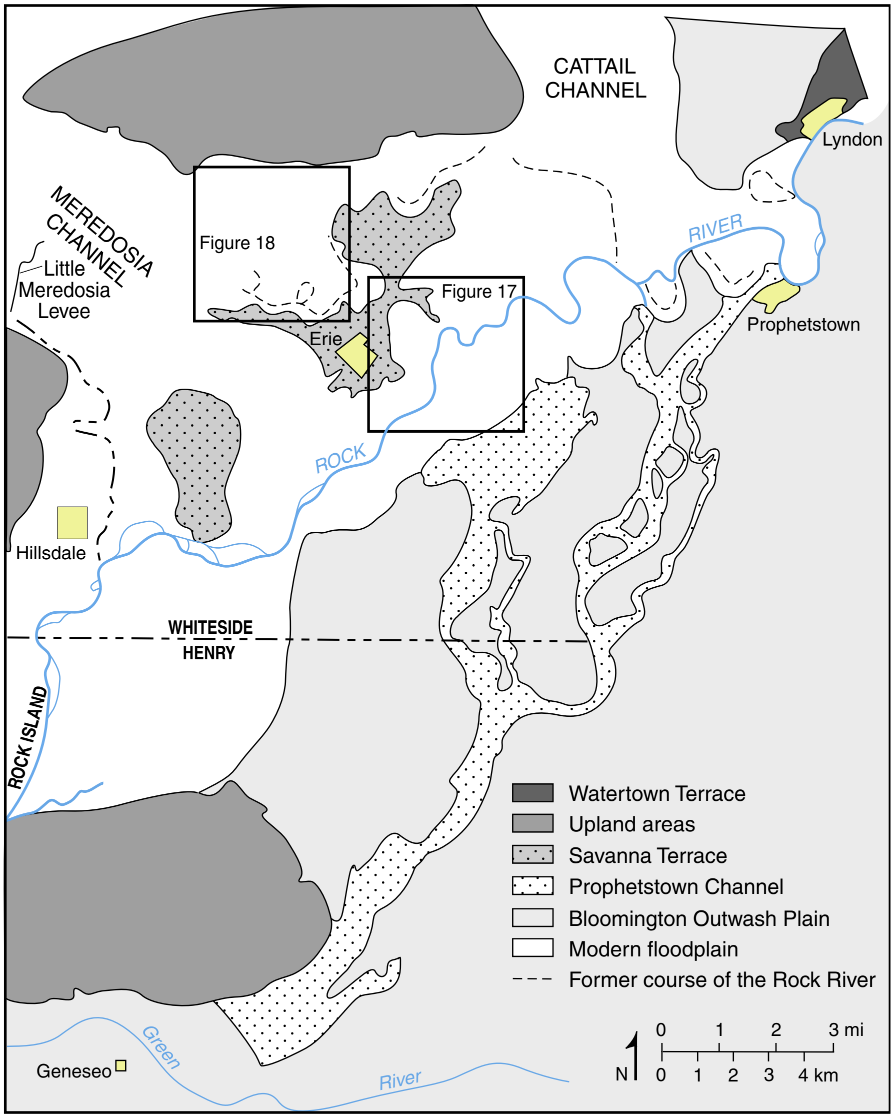


Figure 16 The Green River Lowland reach of the Rock River. Erie lies on a remnant of the Savanna Terrace. Lyndon lies on a remnant of the Watertown Terrace; Prophetstown lies on the Bloomington outwash plain and the Prophetstown Channel is developed on the Bloomington outwash plain. Upland areas occur near the southwest corner of the map, west of Hillsdale, and between the Meredosia and Cattail Channels. Dashed line represents a former course of the Rock River.

Rock Rivers. The Cattail Channel is the highest of several overflow channels (Anderson 1968) and contains more than 10 ft of peat, the base of which yielded a radiocarbon date of 10,130, ± 90 years (Kim 1982). The lowest 5 ft of the peat is interbedded with gray silt and red clay and lies on an undetermined thickness of sand, which suggests that Cattail Channel has not been subject to erosive flow for at least the last 10,000 years. Conversely, the Meredosia Channel has served as an overflow channel for floods from both the Mississippi and Rock Rivers in historic time (Shaw 1873, p. 143) (figs. 16 and 19–23).

The Rock River valley train terraces terminate within this reach. The Milton Terrace appears to merge with, or perhaps be buried by, the Watertown Terrace a few miles below Dixon, Illinois, at the upstream limit of the Green River Lowland reach (fig. 9; fig. 12, profile 85). This relationship between the two terraces is consistent with the observation that the gradient of the Milton Terrace, 1.2 ft·mi^{-1} (0.23 m·km^{-1}), is slightly steeper than that of the Watertown Terrace, 1.0 ft·mi^{-1} (0.18 m·km^{-1}) (table 1). The Watertown Terrace terminates at Lyndon, Illinois (fig. 16). Evidence of the Watertown Terrace farther downstream has apparently been eroded away by late glacial floods of the Mississippi River that swept through the Meredosia Channel and the lower reach of the Rock River.

A well-defined terrace remnant related to valley train sedimentation along the Mississippi River occurs near the lower end of the Green River Lowland reach at Erie, Illinois (fig. 16). Previously referred to as the Erie Terrace (Anderson 1967), this terrace remnant is now thought to represent the Savanna Terrace, which can be traced from the late Wisconsin terminal moraine southeast of Minneapolis, Minnesota, to southern Illinois (Flock 1983, Wright et al. 1998). At Erie, the terrace lies at an elevation of 590 ft (180 m) and has a thin cover of eolian sand dunes. The terrace is a result of deposition from sediment-laden Mississippi River meltwater produced while glacial ice still lay within the Mississippi River drainage basin prior to about 14,000 years ago (Knox 1999, Blum et al. 2000). Unlike the gravel of the Rock River terraces, the gravel fraction of the Savanna Terrace is composed primarily of basalt and rhyolite from the Lake Superior region and chert probably derived from residuum on lower Paleozoic dolomites in the Driftless Area of southwestern Wisconsin (Anderson 1967). A somewhat lower phase of the Savanna Terrace located a few miles southwest of Erie lies at an elevation of 580 ft (176 m) and appears to be an eroded remnant of the Savanna Terrace, perhaps correlative with the Bagley Terrace that occurs along the Mississippi River in southwestern Wisconsin (Knox 1999) (fig. 16). Erosion of the Savanna Terrace is related to catastrophic discharges from glacial Lakes Duluth and Agassiz, in the Lake Superior and Red River Basins, respectively, 11,000 to 12,000

Figure 17 Aerial photograph showing alluvial features of the Rock River east of Erie, Illinois. See figure 16 for location information. Arcuate point bars and abandoned channels cover most of the floodplain. A remnant of the Savanna Terrace, upon which the town of Erie is built, can be seen along the western edge of the photograph. Light-toned, eolian sand dunes on the Bloomington outwash plain are shown in the extreme southeast corner of the photo. Photo provided by U.S. Department of Agriculture.

Figure 18 Aerial photograph showing alluvial features marking a former course of the Rock River north of Erie, Illinois. See figure 16 for location information. Point bars and abandoned channels are easily recognized. Dotted lines indicate minor channels. Lighter-toned areas along the southern and eastern edges of the photo are remnants of the Savanna Terrace. Photo provided by U.S. Department of Agriculture.

Figure 19 Temporary levee built on Illinois Route 84 to protect the flooded Meredosia Channel, on the right, from Mississippi River floodwaters, on the left. The photograph was taken April 4, 1969.

Figure 20 Southeastern end of the Meredosia Channel. Wooded southern bluffs of the channel lie in the right center. The Rock River is located in the line of trees just below the distant horizon. View to the southeast taken September 28, 1967.

Figure 21 Southeastern end of the flooded Meredosia Channel. The Little Meredosia Levee stretches across the photo from left to right. The levee has been breached, allowing the Meredosia Channel (bottom part of photo) to be flooded. Rock River floodwaters cover the valley except for the remnant of the Savanna Terrace in the center distance upon which the Village of Erie lies. Photograph taken April 27, 1973.

Figure 22 Breach in the Little Meredosia Levee. This view to the southwest was taken April 4, 1973.

Figure 23 Repaired Little Meredosia Levee during the 1974 Rock River flood. This view to the southwest was photographed May 24, 1974.

years ago (Porter and Guccione 1994, Knox 1996, Brown and Kennett 1998).

The Prophetstown Channel, which crosses the western end of the Bloomington Outwash Plain and joins the valley of the Green River in the vicinity of Geneseo, is another former course of the Rock River, probably occupied during the waning stages of deposition of the outwash plain (figs. 1 and 16). Very likely the Rock River was progressively displaced to the northwest as the outwash plain prograded westward from the front of the Bloomington Moraine. Earlier channels of the Rock River that may have existed east of the Prophetstown Channel were completely obliterated by outwash deposition and the growth of sand dunes.

Lower Reach

South of Hillsdale, the character of the Rock River floodplain changes abruptly from the meandering pattern of the Green River Lowland reach to the anastomosing pattern of the lower reach. Here the river flows on generally less than 20 ft (6 m) of alluvium overlying bedrock. The river's valley is a bedrock strath, and in many places the river flows directly on bedrock. The river itself is not braided, but the floodplain is marked by numerous streamlined bars, many having a bedrock core, that are separated by elongate, poorly drained, interconnected channels (fig. 24). At Hillsdale, the river flows directly on Silurian dolomite, but a few miles downstream, Middle Devonian limestone forms the bedrock surface, and for about 2 miles (3 km) above its mouth, the river flows on Pennsylvanian shale bedrock. Outliers of this shale are present in numerous places upstream as well. Two areas of limestone and shale bedrock stand high within the floodplain: the rock-defended terrace upon which the Quad City International Airport is built, and Vandruff Island, where quarrying operations have extended downward through the Devonian limestone into Silurian dolomite (Anderson 1980). About 3 mi (5 km) above its mouth, at Big Island (fig. 25), the river intersects a buried valley filled with as much as 50 ft (15 m) of sand and gravel, but, at its mouth, both the Rock and the Mississippi Rivers flow on sand and gravel less than 20 ft (6 m) thick that overlies Pennsylvanian shale bedrock.

The change in character of the floodplain from meandering to anastomosing appears to take place where the river begins to flow on bedrock rather than on thick outwash. This change, however, may not have been produced solely by the Rock River. The character change may also represent the effects of late Pleistocene and early Holocene floods from glacial Lakes Agassiz and Duluth (Fenton et al. 1983; Dyke and Prest 1987; Knox 1996, 1999; Wright et al. 1998) that overflowed the present valley of the Mississippi River and passed through the Meredosia Channel and the lower Rock River valley, rejoining the Mississippi at what is now the mouth of the Rock River at

Figure 24 Aerial photograph showing elongate bars, generally light in tone, and channels, generally dark in tone, southwest of Hillsdale, Illinois. The northern edge of the photo is about 2 mi (3 km) southwest of Hillsdale, and the Rock River is in the extreme southeast corner. Dotted lines indicate minor channels. Photo provided by U.S. Department of Agriculture.

Rock Island. The elongate bars in the lower reach may be beds similar in form if not in size to the longitudinal grooves in bedrock produced by the more celebrated scabland floods of eastern Washington (Baker 1978) or the high-volume discharges through the spillways of glacial lakes on the Canadian prairies (Kehew and Clayton 1986). Such features are not present in the Meredosia Channel, perhaps because bedrock here lies at a depth of several hundred feet. In addition, these erosional events removed most of the Savanna Terrace.

Figure 25 Geomorphic features at the mouth of the Rock River at Rock Island, Illinois. May 9, 1958. Photo provided by U.S. Department of Agriculture.

The Rock River now flows around Big Island to the north, but in the past it flowed south of the island. This earlier course is identified by meander scars and point bars having dimensions similar to those of the Rock River where it crosses thick outwash in the Green River Lowland reach (figs. 17 and 25). The reason for this change in course is not obvious. The course change might be the result of northward displacement of the river by the growth of alluvial fans built by north-flowing tributaries that drain the upland to the south, resulting in a channel avulsion to the north side of Big Island. There are no tributaries of comparable size entering the valley from the north. Perhaps it is significant that the earlier course south of Big Island displays a meandering channel pattern, whereas the present course displays the anastomosing pattern that characterizes the floodplain throughout the lower reach.

Two facies of uneroded Savanna Terrace deposits occur along the lower reach, a sand and gravel facies at the mouth of the Rock River northeast of Turkey Island (fig. 25) and a fine sand-silt-clay facies in a large remnant that extends up the valley of the Green River as far as the vicinity of Geneseo, Illinois (fig. 1). The sand and gravel facies represents Mississippi River valley train sediments deposited when glacial ice still lay within the Mississippi River drainage basin. The fine sand-silt-clay facies represents slackwater sediments deposited in tributary valleys that were partly or completely dammed by the valley trains of the Mississippi River valley (Knox 1996). These sediments display the alternating red and gray, silty-clay laminae typical of this facies (Flock 1983).

Geomorphic History

Development of the Present Course of the Rock River

Unraveling the history of any stream in the glaciated region of the north-central United States requires consideration of the stream's preglacial course, diversion by glacial ice and meltwater, and the effects of glacio-isostasy. Preglacial drainage in Illinois and southern Wisconsin has generally been reconstructed from the pattern of bedrock valleys (Leverett 1899, Alden 1918, Horberg 1950) (fig. 8), but a variety of evidence suggests that some of these valleys may not be pre-glacial and may, in fact, be Pleistocene in age (Frye 1963, Willman and Frye 1970). Whatever the exact age, a south-flowing stream drained south-central Wisconsin and north-central Illinois prior to glaciation, and at some time that stream was incised into bedrock. The development of the bedrock valleys may have been a single event but more likely evolved over time and was affected by successive glacial advances. For the Rock River, the decipherable part of its history is more clearly discerned in Illinois than in Wisconsin and begins with the Illinois Episode (table 2).

Drift of the Illinois Episode in southern Wisconsin and northern Illinois was deposited by ice flowing south and west through the basins that are now occupied by Green Bay and Lake Michigan. In southern Wisconsin, local drainage changes can be ascribed to Illinoian ice, such as those that displaced the Pecatonica River across bedrock ridges (Whittecar 1979). In Illinois, the Rock River was diverted from its southward course in the upper Rock Bedrock Valley (fig. 8) to its southwestward flow through the Bedrock Gorge reach in two stages, first by Illinoian ice and later by pre-Bloomington, late-Wisconsin ice (Bretz 1923). The development of the Bedrock Gorge downstream from the Leaf River involved glacial diversion of southeast-flowing streams across bedrock divides (Horberg 1950). Outwash of probable Illinoian age occurs beneath Wisconsin Episode sediments in the upper Rock Bedrock Valley (Hackett 1960), in the Rockford Terrace (Anderson 1967), and in the Pecatonica River valley (Whittecar 1979).

Advances of Illinois Episode glaciers into the Green River Lowland blocked the course of the ancient Mississippi River in the Princeton Bedrock Valley and created glacial Lake Moline (Anderson 1968). As Illinois Episode ice continued to advance, a succession of lake outlets was utilized, producing the numerous channels and isolated upland tracts in eastern Rock Island County and western Whiteside County, Illinois (Anderson 1968). During the ensuing Sangamon Episode, the river downstream from Dixon flowed in its present course as far as Sterling, where it entered the Elkhorn Creek Bedrock Valley. Following this valley, the river then flowed south and east, joining the Paw Paw Bedrock Valley a few miles above its junction with the Princeton Bedrock Valley, eventually discharging into what is now the Illinois River (Horberg 1950, fig. 21 and plate 2) (figs. 8 and 26A).

The present course of the river downstream from Sterling was established as a result of the advance of Wisconsin Episode ice from Lake Michigan into the Green River Lowland. This blocked the Princeton Bedrock Valley and formed glacial Lake Milan; its outlet lay across a bedrock divide near Fairport, Iowa, about 20 mi downstream from Rock Island (Horberg 1950, Shaffer 1954, Anderson 1968) (fig. 26B). Like the Illinois Episode glacial Lake Moline, glacial Lake Milan received not only waters of the Rock River, but also those of the Mississippi River above Rock Island. The size of the lake was progressively reduced as the ice advanced westward and as outwash continued to fill the basin. In time, downcutting of the outlet completely drained glacial Lake Milan, and the Rock River was progressively shifted to the northwest by the growth of the Bloomington Outwash Plain (fig. 26C). With the deposition of the Bloomington Moraine and its outwash plain, the present course of the Rock River was established, setting the stage for the next chapter in the river's history.

Formation of the Valley Train Terraces

The Rock River served as a conduit for meltwater whenever glaciers lay within its drainage basin, but the record of all except the most recent of these events within its valley is either obscured by burial or lost to erosion. The record that remains is in stream terraces that can be traced upstream to the moraines of the Green Bay Lobe (fig. 9). The Rock River terraces are clearly the result of repeating cycles of erosion and deposition related to the timing and magnitude of the discharge of glacial meltwater (Clayton 1982) (figs. 27 and 28). Each terrace cycle appears to consist of a depositional phase followed by an erosional phase that left remnants of the depositional phase standing as a stream terrace. The sediments of the next depositional phase may either bury the terrace of the previous cycle or be deposited within the valley created by the previous erosional phase. In the case of the Rock River terraces, the depositional phases occurred when a moraine was being deposited and outwash sediment was being carried into the valley of the river. Erosional phases occurred during glacier retreat when meltwater was ponded as an ice-marginal lake between the retreating glacier and the previously formed moraine. The lake acted as a trap for the coarse outwash from the retreating glacier, and its sediment-poor discharge had the capacity for erosion beyond the lake's outlet. The Johnstown and Milton Terraces clearly illustrate this pattern. Each can be traced upstream along the Rock River to its respective moraine. Behind each moraine, lakes formed as the ice retreated (Clayton and Attig 1997b, Clayton 2001). The origin of the Watertown Terrace is not as clear. It can be traced upstream through both the Johnstown and Milton Moraines, but it does not originate at a moraine. Instead, behind the Milton Moraine, the Watertown Terrace merges with the floor of glacial Lake Scuppernong. Perhaps it originated at an obscured ice margin behind the Milton Moraine (Clayton and Attig 1997b, fig. 63) and then merged with the floor of glacial Lake Scuppernong. In general, the valley train terraces along the Rock River may have formed as follows (figs. 27 and 28):

1. The present course of the Rock River was established by fluvial erosion and glacial diversion.
2. Ice advances to form the Johnstown Moraine; Johnstown outwash is deposited.
3. Ice retreats from the Johnstown Moraine, and the Johnstown outwash is eroded by discharge from glacial Lake Yahara, which is ponded behind the Johnstown

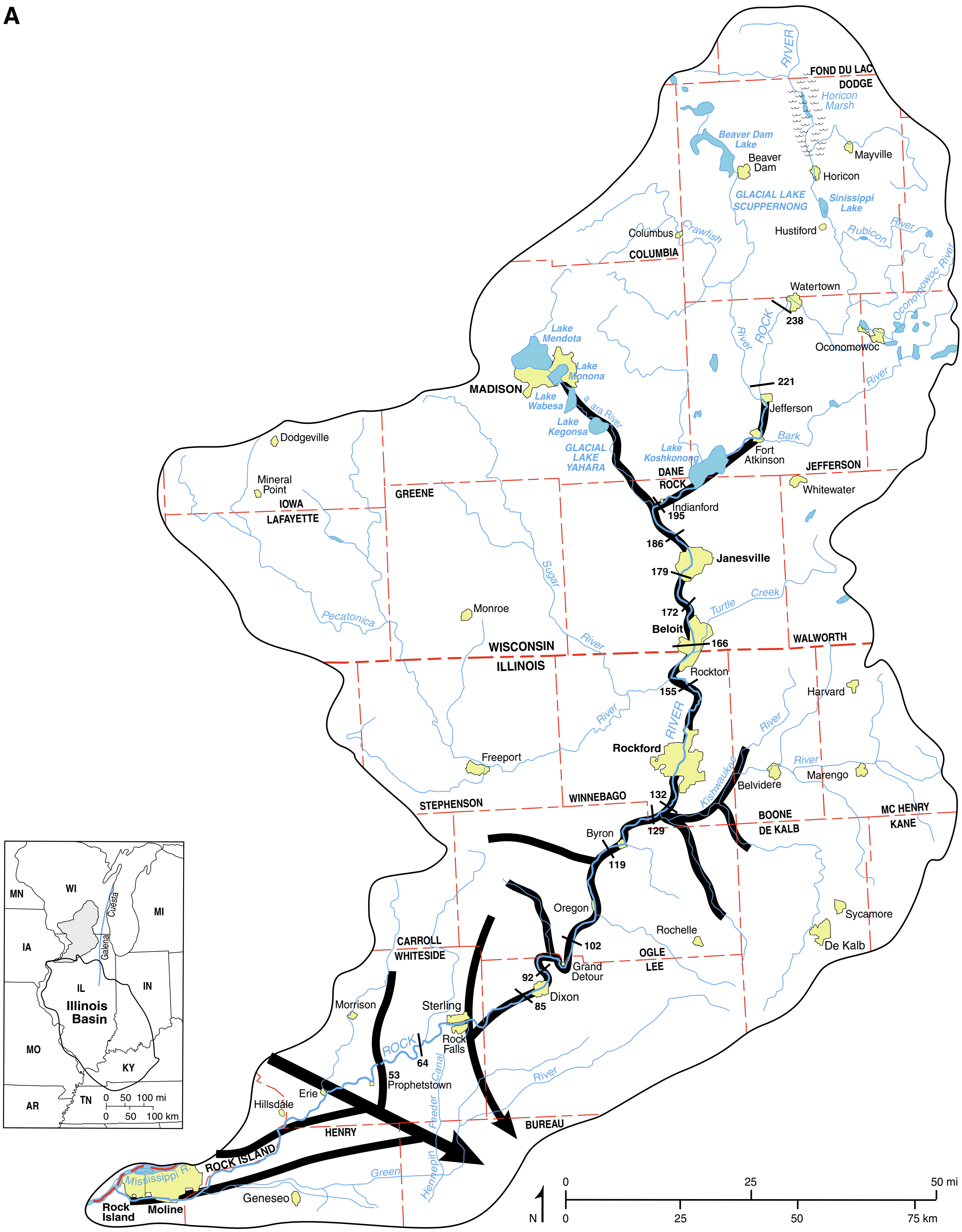
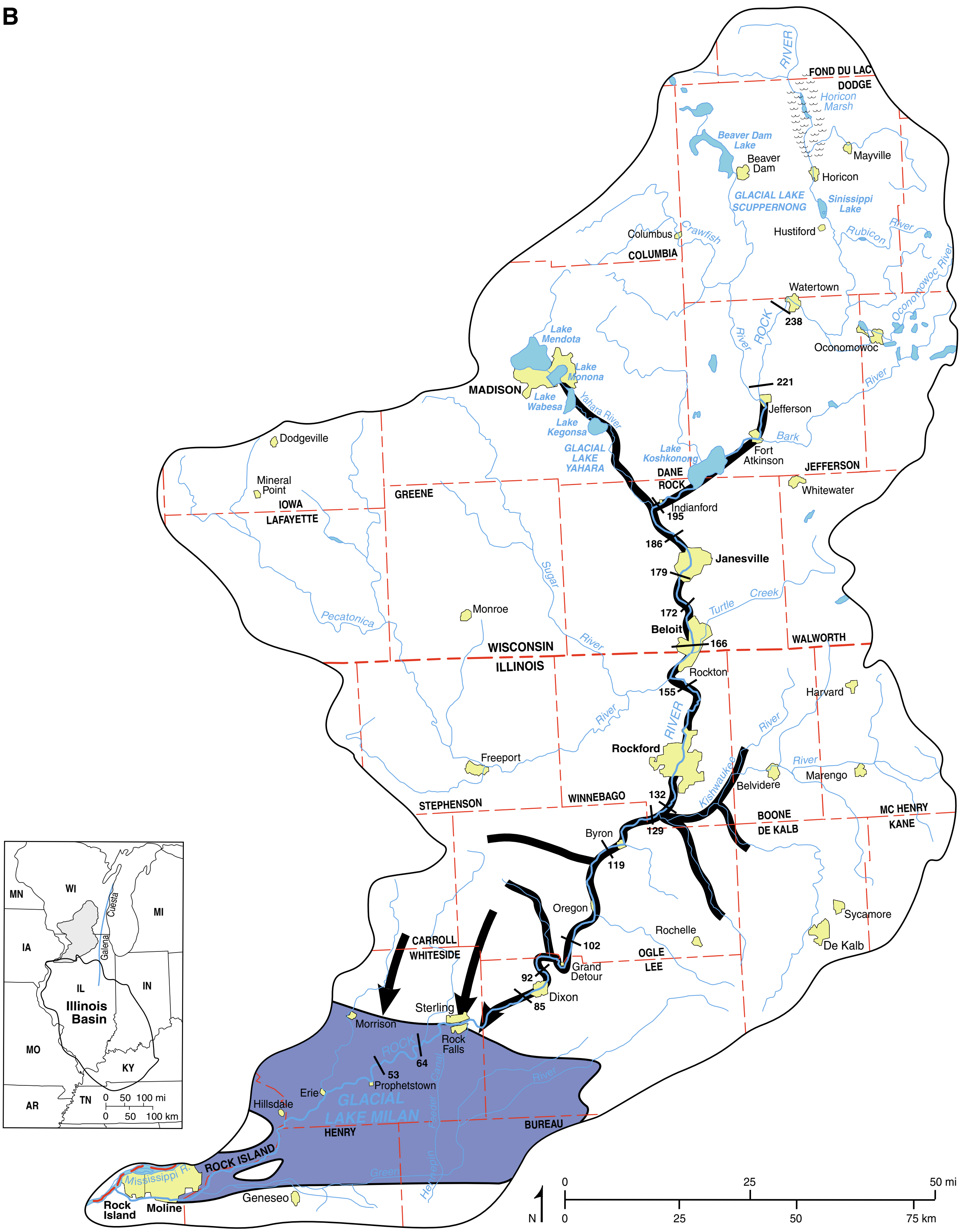


Figure 26 The course of the Rock River during (A) the Sangamon interglacial interval, (B) glacial Lake Milan, and (C) deposition of the Bloomington Moraine and outwash plain (U.S. Geological Survey 1999).


B
FOND DU LAC
DODGE
Horicon Marsh
RIVER
Beaver Dam Lake
Beaver Dam
Mayville
Horicon
GLACIAL LAKE SCUPPERNONG
Sinissippi Lake
Hustiford
Rubicon
River
Columbus
Crawfish
COLUMBIA
Watertown
238
Oconomowoc River
Oconomowoc
ROCK
River
Lake Mendota
Lake Monona
MADISON
Lake Wabesa
Yahara River
Lake Kegonsa
GLACIAL LAKE YAHARA
221
Jefferson
Bark
River
Lake Koshkonong
Fort Atkinson
DANE
ROCK
JEFFERSON
Whitewater
Indianford
195
186
Janesville
179
172
Turtle
Creek
Beloit
166
WALWORTH
Dodgeville
Mineral Point
IOWA
LAFAYETTE
GREENE
Sugar
River
Monroe
Pecatonica
WISCONSIN
ILLINOIS
Rockton
155
Harvard
River
RIVER
Rockford
Freeport
River
Kishwaukee
Belvidere
River
Marengo
STEPHENSON
WINNEBAGO
132
129
BOONE
DE KALB
MC HENRY
KANE
Byron
119
Oregon
Rochelle
Sycamore
De Kalb
CARROLL
WHITESIDE
102
OGLE
LEE
Grand Detour
92
85
Dixon
Sterling
Rock Falls
Morrison
ROCK
64
53
Prophetstown
Erie
Hillsdale
GLACIAL LAKE MILAN
Feeder Canal
River
HENRY
BUREAU
ROCK ISLAND
Mississippi R.
Green
Hennepin
Rock Island
Moline
Geneseo
0
25
50 mi
0
25
50
75 km
N
MN
WI
MI
IA
Cuesta
Galena
IL
IN
Illinois Basin
MO
KY
AR
TN
0 50 100 mi
0 50 100 km

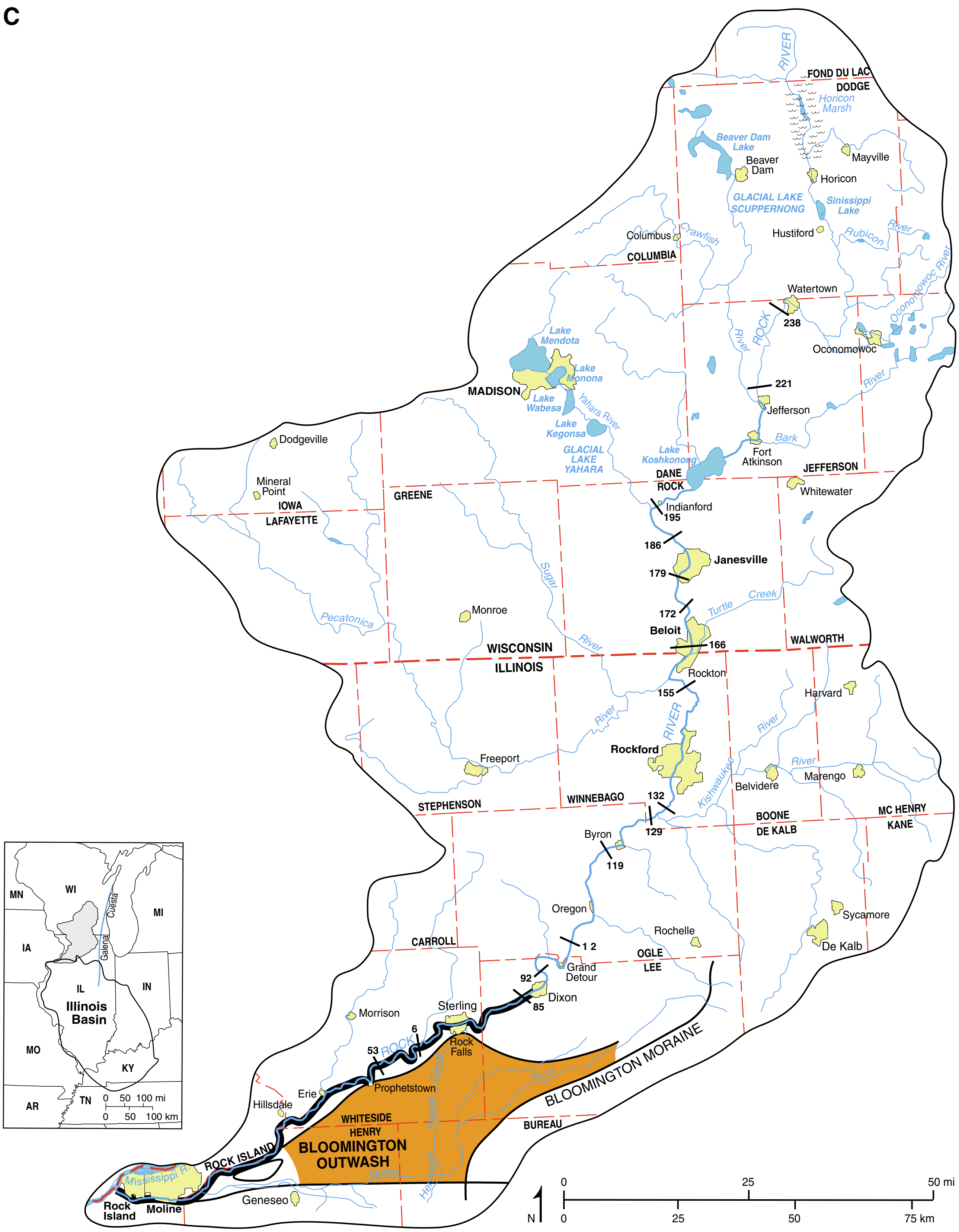
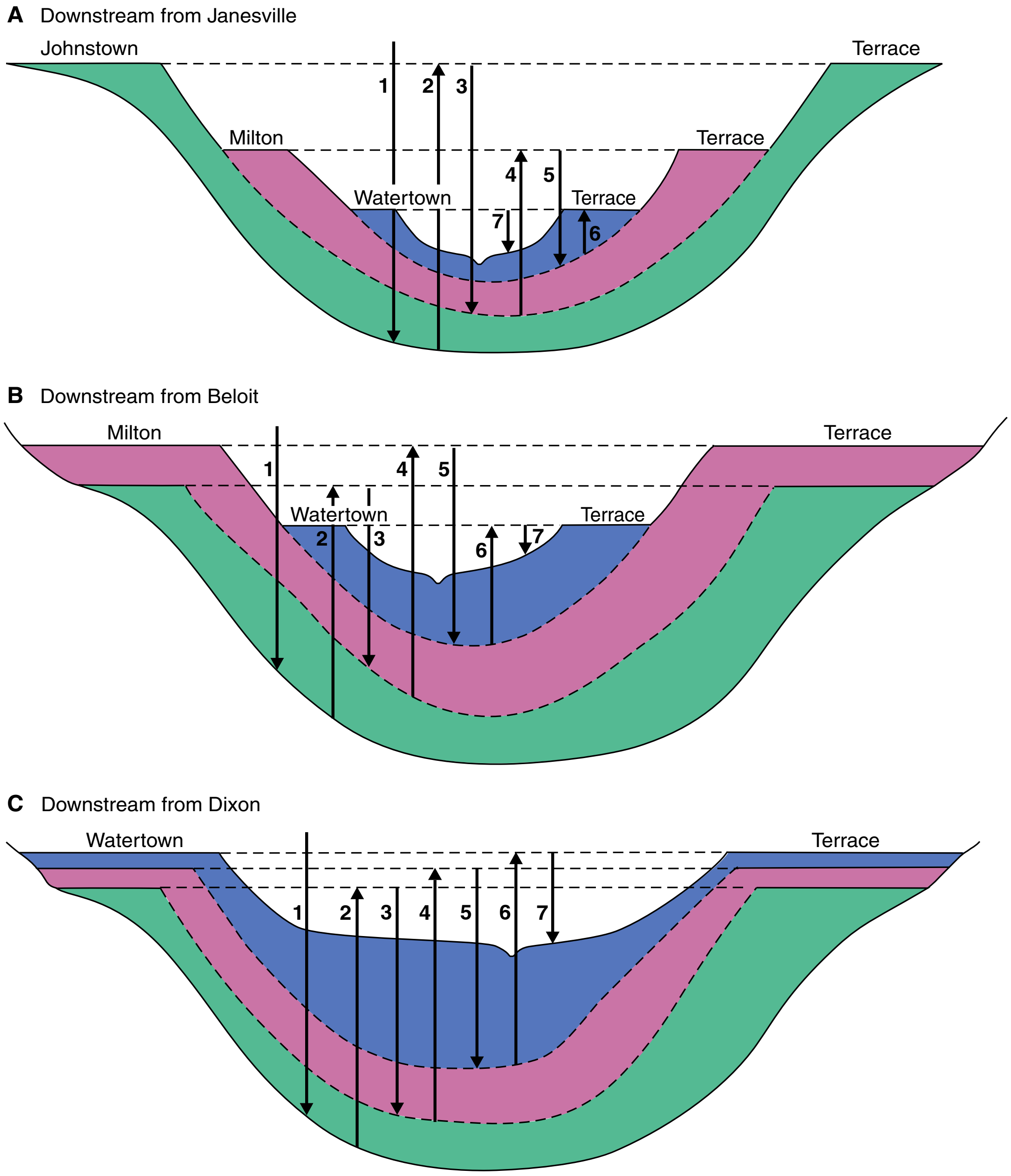


Figure 26 (continued) The course of the Rock River during (A) the Sangamon interglacial interval, (B) glacial Lake Milan, and (C) deposition of the Bloomington Moraine and outwash plain (U.S. Geological Survey 1999).



A Downstream from Janesville

B Downstream from Beloit

C Downstream from Dixon

Figure 27 Cross sectional view of selected locations showing the sequence of erosional and depositional events that formed the valley train terraces along the Rock River. Numbered lines correlate with the numbered erosional and depositional events described in the text.

Moraine, forming the Johnstown Terrace. Downcutting of the outlet lowers the level of Lake Yahara.

4. Ice advances to form the Milton Moraine; Milton outwash is deposited.
5. Ice retreats from the Milton Moraine, and the Milton (and possibly Johnstown) outwash is eroded by discharge from glacial Lake Yahara-Scuppernong, which is ponded behind the Johnstown and Milton Moraines, forming the Milton Terrace. Downcutting of the outlet lowers the level of Lake Yahara-Scuppernong.
6. Ice advances to an unrecognized location behind the Milton Moraine; outwash is deposited.
7. Ice retreats and outwash is eroded by discharge from glacial

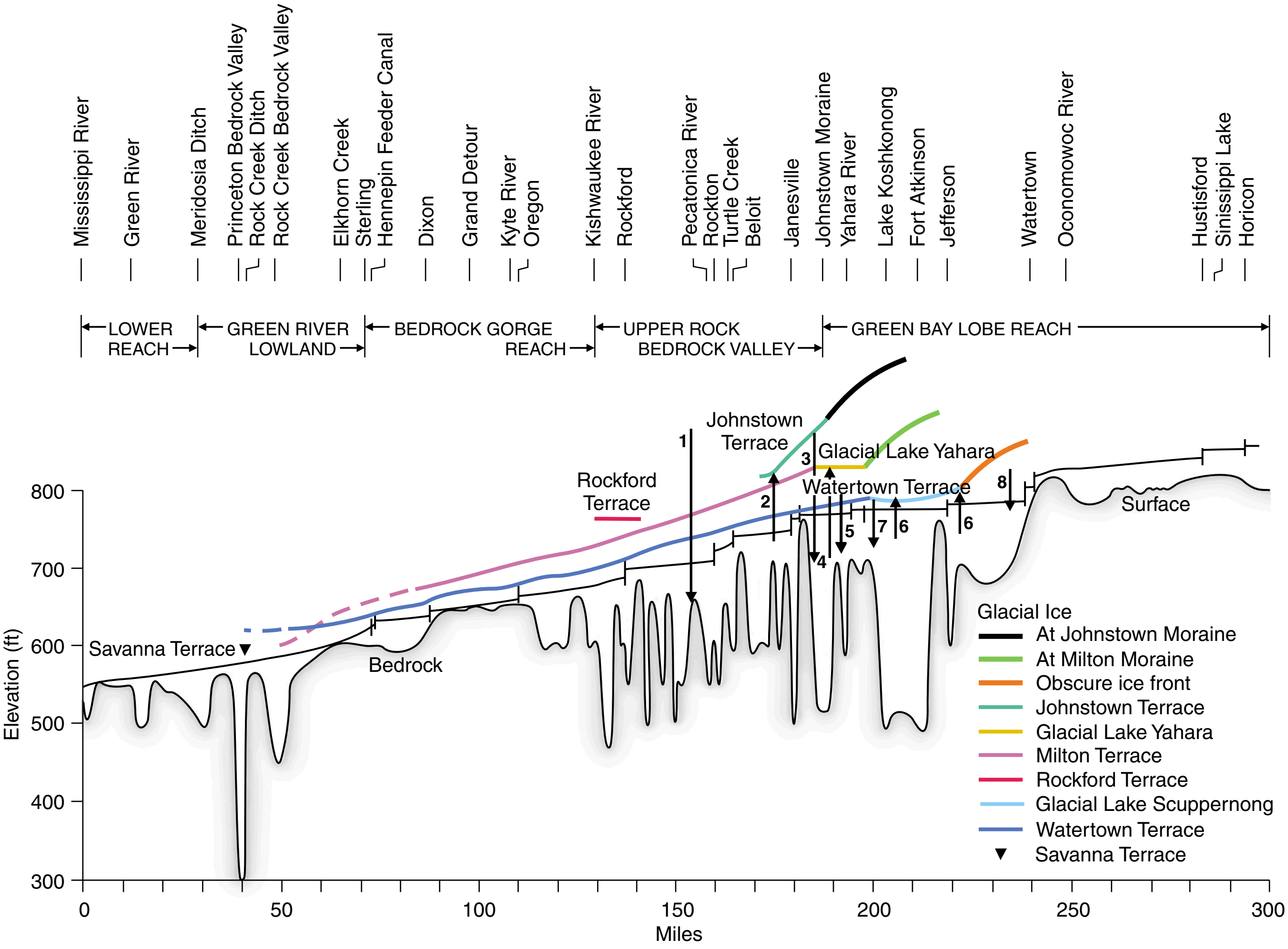


Figure 28 Longitudinal view showing the sequence of erosional and depositional events that formed the valley train terraces along the Rock River.

Lake Scuppernong, forming the Watertown Terrace.

8. The Green Bay Lobe retreats from the drainage basin of the Rock River. Continued downcutting of the outlet to Lake Scuppernong lowers the lake's level and eventually drains the lake completely. Headward erosion of the Rock River across the floor of Lake Scuppernong proceeds upstream as far as Watertown, Wisconsin (fig. 28).

Conclusions

The Rock River illustrates many of the characteristics common to the rivers of the glaciated north-central United States. In places, its course reflects strong bedrock control, but overall, the influence of bedrock geology and structure is minimal. The bedrock topography in the drainage basin reflects the influence of underlying geology, but, except for the upper Rock Bedrock Valley reach, the course of the river does not follow major bedrock valleys. The present course of the river is a result of glacial diversions, and only the most recent diversions are readily decipherable. Valley train terraces that can be related to sources in the Green Bay glacial lobe can be recognized throughout, except along the lower part of the valley where they have been removed by late glacial floods that spilled over from the Mississippi River. This geologic setting has produced a river valley of uncommon interest and potential. The Rock River valley is a source of raw materials such as sand and gravel, limestone, dolomite, and sandstone. The Rock River is also a source of groundwater and surface water for cities and industry and provides opportunities for a variety of recreational activities.

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