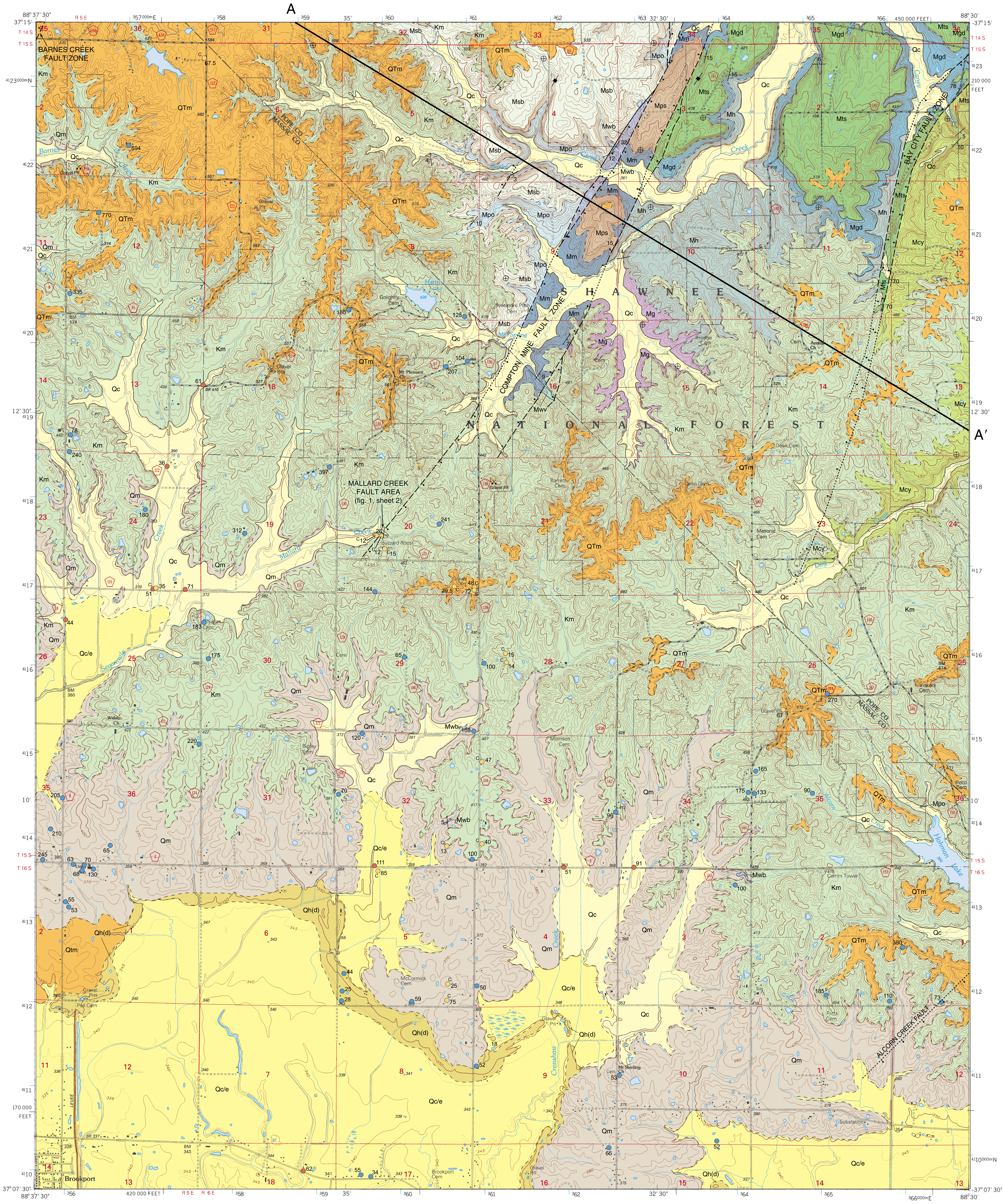
Illinois Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
William W. Shilts, Chief

BEDROCK GEOLOGY OF PADUCAH NE QUADRANGLE
MASSAC AND POPE COUNTIES, ILLINOIS

F. Brett Denny and W. John Nelson
2005

Illinois Geologic Quadrangle Map
IGQ Paducah NE-BG



EXPLANATION

Quaternary		Qc	Cahokia Formation	Holocene
		Qc/e	Cahokia overlying Equality Formation	Holocene
			Unconformity	
		Qh(d)	Henry Formation Dolton Member	Pleistocene
			Unconformity	
		Qm	Metropolis Formation	Pleistocene
			Unconformity	
Tertiary		QTm	Mounds Gravel	Pliocene
			Unconformity	
Cretaceous		Km	McNairy Formation	Upper Cretaceous
			Unconformity	
Mississippian		Mps	Palestine Sandstone	Chesterian
			Unconformity	
		Mm	Menard Limestone	Chesterian
		Mwv	Waltersburg Formation and Vienna Limestone	Chesterian
		Mts	Tar Springs Sandstone	Chesterian
		Mgd	Glen Dean Limestone	Chesterian
		Mh	Hardinsburg Sandstone	Chesterian
		Mg	Golconda Formation	Chesterian
	Mwb (West Baden)	Mcy	Cypress Sandstone	Chesterian
			Unconformity	
	Mwb (West Baden)	Mr	Ridenhower Formation (cross section only)	Chesterian
	Mwb (West Baden)	Msb	Sample and Bethel Sandstones	Chesterian
			Disconformity	
		Mpo	Paoli Limestone	Chesterian
		Msg	Ste. Genevieve Limestone and Aux Vases Sandstone (cross section only)	Chesterian

Symbols

- 40 — Strike and dip of bedding; number indicates degree of dip
- Horizontal bedding
- Vertical joints
- Gravel pits

Drill Holes
numbers indicate total depth of boring in feet

- 35 — Stratigraphic boring
- S 67 — Stratigraphic boring with samples
- C 15 — Stratigraphic boring with core description
- 210 — Water well
- S 70 — Water well with samples
- 75 — Engineering boring

Line Symbols
dashed where inferred, dotted where concealed

- Contact
- Normal fault; bar and ball on downthrown side
- A—A′ Line of cross section

Base map compiled by Illinois State Geological Survey from digital data provided by the United States Geological Survey. Topography compiled 1956. Planimetry derived from imagery taken 1993. Partial field check 1996.

North American Datum of 1927 (NAD 27)
Projection: Transverse Mercator
10,000-foot ticks: Illinois State Plane Coordinate system, east zone (Transverse Mercator)
1,000-meter ticks: Universal Transverse Mercator grid system, zone 16

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SCALE 1:24 000
1 — 1/2 — 0 — 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER

BASE MAP CONTOUR INTERVAL 10 FEET
SUPPLEMENTARY CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Released by the authority of the State of Illinois: 2005

Geology based on field work by F. Brett Denny and W. John Nelson, 1995 and 1996.

Digital cartography by L. Verhelst and J. Domier, Illinois State Geological Survey.

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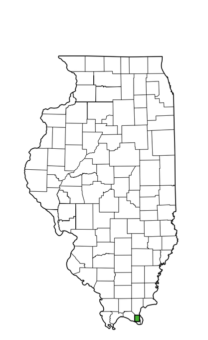
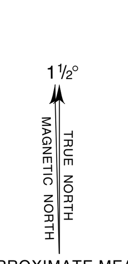


1	2	3
4	■	5
6	7	8

ADJOINING QUADRANGLES
1 Reevesville
2 Brownfield
3 Golconda
4 Metropolis
5 Smithland
6 Paducah West
7 Paducah East
8 Little Cypress



APPROXIMATE MEAN DECLINATION, 2005

ROAD CLASSIFICATION

- Primary highway, hard surface
- Secondary highway, hard surface
- Light-duty road, hard or improved surface
- Light-duty road, dirt
- Unimproved road
- County Route

Introduction

The Paducah NE 7.5-minute Quadrangle is located in Massac and Pope Counties in southeastern Illinois, approximately 5 miles north of Paducah, Kentucky. Ross (1964) published a 1:62,500-scale geologic map of this region. Amos (1966) mapped the Kentucky portion of the Smithland Quadrangle to the east and the Golconda Quadrangle to the northeast (1967). Nelson et al. (2002) mapped the Metropolis Quadrangle to the west and W.J. Nelson (unpublished) mapped the Brownfield Quadrangle to the north. This is the first 1:24,000-scale bedrock map of the Paducah NE 7.5-minute Quadrangle.

Paleozoic bedrock of the Mississippian System is exposed in the northeast and eastern portions of the quadrangle. Weakly lithified to non-lithified Cretaceous sediments overlap the Paleozoic rocks, and Tertiary and younger sediments overlap these Cretaceous sediments. Where unaffected by faulting, the Paleozoic rocks dip gently to the northeast, and the Cretaceous sediments dip gently to the south, producing a Paleozoic-Mesozoic angular unconformity. Several Tertiary units are known to be present in adjacent quadrangles to the west. The Wilcox Formation (Eocene) and the Porters Creek Formation (Paleocene) may be locally present, preserved in fault slices. Additionally, well-rounded, light-gray and black chert gravel, the Post Creek Formation (Harrison and Litwin 1997), may be locally present underlying the McNairy Formation (Maastrichtian). The Post Creek Formation (Campanian) was formerly named the Tuscaloosa Formation (Willman et al. 1975).

Structural Geology

The quadrangle is traversed by a series of northeast-southwest–trending fault zones. From west to east they are the Barnes Creek Fault Zone, Compton Mine Fault Zone, Bay City Fault Zone, and the Alcorn Creek Fault Zone. These faults are southwestern extensions of the Fluorspar Area Fault Complex (FAFC), a series of horsts and grabens that strike northeast-southwest directly toward the New Madrid Seismic Zone. These faults have been traced to the northeast along the Ohio River through Kentucky and into Hardin County, Illinois. W.J. Nelson (unpublished) has mapped northeastern extensions of the fault zones, and Amos (1966) has mapped a series of northeast-trending faults in the Golconda Quadrangle that coincide with the FAFC. The FAFC has been active from as early as the Cambrian. Although most of the tectonic activity occurred during the Paleozoic and Mesozoic, neotectonic studies have documented Quaternary tectonic activity in this area (Nelson et al. 1997, 1999).

Barnes Creek Fault Zone

The Barnes Creek Fault Zone crosses the extreme northwest corner of the quadrangle but is not exposed at the surface. Where the fault zone is exposed to the north in the adjacent Brownfield Quadrangle, it is composed of several parallel normal faults trending N20°E to N50°E that bound a central graben. Vertical displacements of up to 300 feet are recorded in Paleozoic rocks in the Brownfield Quadrangle. The fault zone has probably undergone several periods of movement, most of which was dip-slip or normal, but Quaternary faulting may have involved strike-slip motion (Nelson et al. 1997).

An unnamed normal fault was mapped in the southwest corner of Sec. 4, T15S, R6E. This fault was not well exposed and was inferred from the abrupt termination of the McNairy sand. The fault is probably small with no more than 30 feet of vertical offset.

Compton Mine Fault Zone

The Compton Mine Fault Zone, which generally trends N30°E, is composed of several high-angle, normal faults that outline a central graben. The width of the graben varies from about 1,000 to 2,000 feet, and the bedding within it is nearly horizontal. The graben has vertical displacements of up to 850 feet relative to adjacent strata to the west; it is flanked on both the east and west sides by smaller normal faults. Altogether, strata east of the fault zone are downthrown approximately 500 feet (see cross section). This graben is along strike with and is the southernmost surficial expression of the Rock Creek Graben (Nelson 1995).

Along Mallard Creek north of Buzzard Roost Cemetery (SW 1/4, Sec. 20, T15S, R6E), the McNairy Formation has been displaced (fig. 1). A compressional anticline trending N30°E was observed at this location. The rocks are fairly well lithified for the McNairy and are moderately fractured. Several shallow borings were drilled, and trenches were dug along the floodplain of Mallard Creek. Trenches along Mallard Creek exposed faults that displace not only the McNairy Formation, but also the Pleistocene Metropolis Formation and younger gravel. The younger gravel is downthrown into a small graben and contains features typical of the Sangamon Geosol (Nelson et al. 1999). An uppermost gravel layer and surficial silt, presumably of Holocene age, are not faulted. The trench thus displays evidence for at least two episodes of faulting. The first was post-Cretaceous as shown by faults that offset the McNairy but not the younger gravel. The second episode, displacing the younger gravel, probably took place during the Wisconsin Episode between approximately 10,000 and 75,000 years ago (Nelson et al. 1999).

To the north, in the Brownfield Quadrangle, this fault zone is mineralized with fluorite and lead, which were mined underground. Most Mississippi Valley Type mineralization in the Illinois-Kentucky Fluorspar District is related to igneous mafic dikes and sills, which were dated by Zartman et al. (1967) as early Permian age. Therefore, most of the movement on this fault zone was post-Mississippian, with sporadic post-Cretaceous and Quaternary movement. No movement more recent than Wisconsinan has been documented in the quadrangle.

Bay City Fault Zone

The Bay City Fault Zone is composed of two parallel faults, which probably merge southward into a single fault. Faults appear to juxtapose the McNairy Formation with Mississippian bedrock in Secs. 11, 14, and 23. The Mounds Gravel and younger sediments are not visibly affected; however, the area is extensively mantled in loess and vegetation, and no trenching has been undertaken. The fault zone is well exposed in the northern part of the quadrangle, but no displacements were observed in the Cretaceous or younger sediments to the south. The fault zone is sinuous and trends N10°E to N60°E. Compressional features are evident in the adjacent Smithland Quadrangle, where the fault is well exposed (Sec. 36, T14S, R6E). The first period of movement along this fault zone was compressional, followed by a later extension that produced a central graben. Vertical displacement is nearly 400 feet.

Alcorn Creek Fault Zone

The Alcorn Creek Fault Zone is projected into the map area from the Smithland Quadrangle, where it is exposed. An asymmetrical syncline with an axial trend of N45°E parallels faults that define the graben (Devera unpublished). The Alcorn Creek structure appears to be essentially a Paleozoic structure that did not affect Cretaceous or younger units.

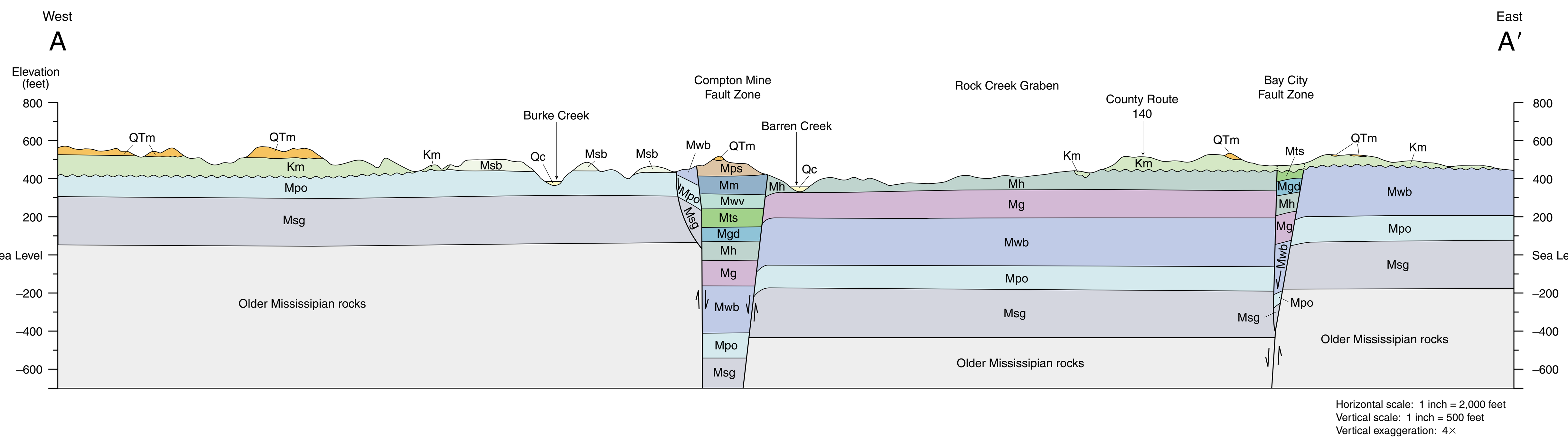
Conclusions

The structural and tectonic character of the quadrangle suggests that the area was subjected to a general southeast-northwest compressional stress, followed by later extension, which produced a series of normal faults. The major displacements appear to be dominantly normal, producing a series of grabens. Evidence in the Barnes Creek area suggests that a more recent period of strike-slip movement may have occurred (Nelson et al. 1999, 2002). Faulting has occured as recently as the Wisconsinan along the Compton Mine Fault Zone at Mallard Creek (fig. 1).

Economic Geology

Sand and Gravel

The Mounds Gravel is quarried at several pits in the quadrangle. Most of the pits provide a local supply of aggregate for driveways and, in some cases, county roads. These gravel pits generally cover only a few acres and operate intermittently. The gravel is typically located above 500 feet in elevation, generally on the tops of ridges or hills; therefore, water infilling the pits is not a significant problem. Currently no mining operation separates the sand from the chert gravel. The sand fraction of the Mounds is fairly clean quartz and could be utilized for a variety of applications.



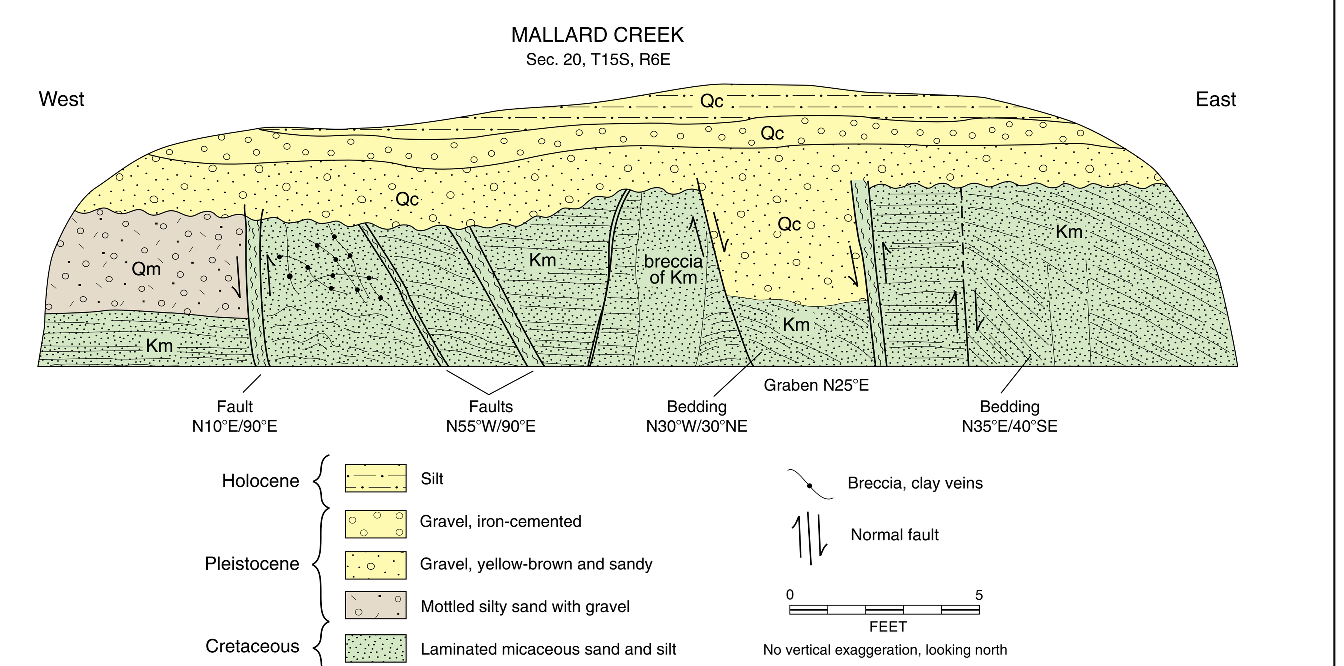
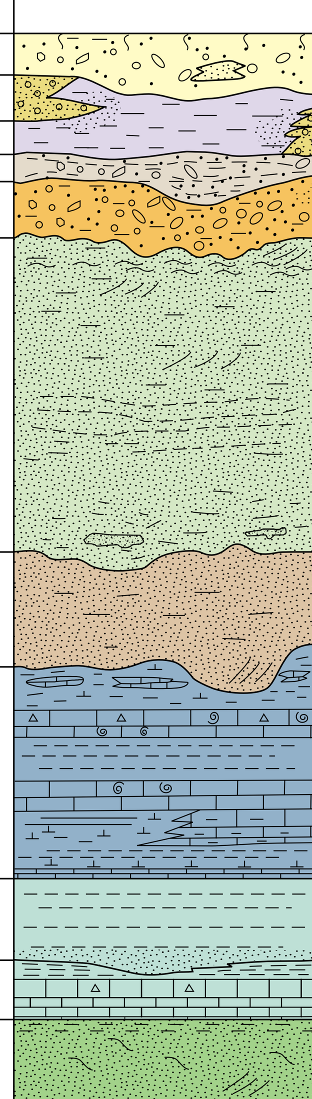


Figure 1 Sketch of north bank of Mallard Creek showing fault zone (modified from Nelson et al. 1999).



SYSTEM	SERIES	GROUP	FORMATION	MEMBER	GRAPHIC COLUMN	THICKNESS (FEET)		DESCRIPTION UNIT
QUATERNARY	HOLOCENE		Cahokia			0–40		A
	PLEISTOCENE		Henry	Dolton[1]		0–40		B1
			Equality					B2
			Metropolis			0–30		C
TERT.[2]	TERT.		Mounds Gravel			0–50		D
CRETACEOUS	UPPER		McNairy			0–200		E
MISSISSIPPIAN	CHESTERIAN[3]	POPE	Palestine Sandstone			70–90		F
			Menard Limestone			90–120		G
			Waltersburg			35–50		H
			Vienna Limestone			8–35		I
			Tar Springs Sandstone			70–130		J
			Glen Dean Limestone			40–85		K
			Hardinsburg Sandstone			80–110		L
			Golconda	Haney Limestone		25–65	105–175	M
				Fraileys Shale		80–100		N
				Beech Creek Ls.		0–10		O
		WEST BADEN SANDSTONE	Cypress Sandstone	Upper		15–30	95–110	P
				Lower		70–90		
			Ridenhower			0–100		Q
			Sample Sandstone			40–125		R
			Bethel Sandstone			15–25		S
			Paoli Limestone	Downeys Bluff Limestone		25–50	120–150	T
				Yankeetown		30–45		U
				Shelterville Limestone		25–40		V
				Levias Ls.		15–20		W
			Aux Vases Ss.			15–25		X
		MAMMOTH CAVE	Ste. Genevieve Limestone			200+		Y

A Sand, clay, silt, and gravel Yellow, white, brown, or red, fine to coarse quartz sand. Gray to yellowish clay and silty clay. Gravels are white, red, black, and light-brown. The light-brown patina, indicative of the Mounds Gravel (unit D), has been abraded from most of the chert pebbles.

B Clay, sand, and gravel Unit B was previously classified as the Equality Formation divided into two members: the Carmi Member, being the silty clay portion, and the Dolton Member, being the sand and gravel portion (Willman and Frye 1970). Following Hansel and Johnson (1996), we have chosen to classify the gravel portion of this unit (B1) as a facies of the Henry Formation and to assign the silty clay portion (B2) to the Equality Formation.

B1 Gravels range from a few feet to over 30 feet thick and form local aquifers. Approximately 80% of the pebbles are coated with a distinctive brown patina; the remaining pebbles are white, gray, black, and red. Pebbles range from 1/4 to 3 inches in diameter and consist of well-rounded chert. The matrix is medium-grained, well-rounded quartz sand and in places contains a high percentage of coarse mica, probably derived from the McNairy Formation. This unit intertongues with unit B2.

B2 Sandy clay to silty clay Blue-gray, thin-bedded to laminated silty clay in the upper part. Contains sand lenses near the margin with unit B1. The unit is not well exposed, probably less than 30 feet thick, and intertongues with unit B1.

C Silt, sand, and gravel Red to brown sand and grayish silt with gravel layers. The gravels are reworked from the Mounds Gravel and are composed of chert pebbles 1/4 to 2 inches in diameter. The distinctive brown patina of the Mounds Gravel has been partially abraded. The unit is poorly sorted to indistinctly bedded, mottled and burrowed in the upper part. The unit correlates with the "Terrace Deposits" mapped by Ross (1964). The unit is interpreted as valley fill of an older paleochannel cut during the deposition of the Mounds Gravel (Nelson et al. 1999). The contact with the underlying unit was not observed but, in adjacent quadrangles, the contact is unconformable.

D Gravel and sand Exposed in several gravel pits above 500 feet elevation. Light- to medium-brown, well-rounded chert pebbles to small cobbles and very well-rounded white quartz pebbles 1/4 to 1/8 inch in diameter. Workers have described the distinctive brown color as a brown patina. The gravels are dominantly chert with an occasional pebble showing remnants of marine fossils (Pelmatozoan stems are the most common). The matrix is dominantly translucent, well-rounded to subrounded, fine- to coarse-grained quartz sand. Sand occurs as thin beds or lenses. Red-brown clays formed by weathering occur in vertical joints. Clay coatings on the pebbles are pronounced at several gravel pits. Contact with the underlying unit is unconformable.

E Sand, silt, and clay Gray, white, yellowish brown micaceous sand, silt, and clay. Sand is well-rounded to subangular, fine- to medium-grained quartz sand. The unit is thin-bedded to laminated, but some of the clay layers may be several feet thick. Abundant mica is a characteristic feature of this unit. Although generally poorly to weakly consolidated and friable, a well consolidated, medium- to very fine-grained sandstone containing root casts was observed at several locations. These sandstones were rarely observed in place but probably are in the lower or basal part of the McNairy. Contact with underlying units is unconformable.

F Sandstone, siltstone, and shale Light-gray to light-brown, fine- to medium-grained quartz arenite. Siltstone and shale are dark gray and are commonly marked with interference ripples. The lower part consists mainly of sandstone grading upward into thin-bedded siltstone or shaley sandstone. The lower contact was not observed, but the lower channel sandstone phase of this unit has probably downcut into the underlying unit.

G Limestone and shale Gray to dark-gray, lime mudstone to wackestone, oolitic in places, and fossiliferous with blastoids, brachiopods, bryozoans (*Archimedes* sp.), and crinoids. The shales, interbedded with limestones, are dark gray to greenish gray and calcareous. The bedding is thin with irregular to undulatory surfaces. Contact is probably conformable with the underlying unit.

H Shale, siltstone, and sandstone This unit was identified in only one outcrop in the quadrangle, near the center of Sec. 16, T15S, R6E, where it consists of dark-gray to olive-gray pyritic siltstone, with interbedded dark-gray shale and very fine-grained sandstone. Nelson (unpublished) found the sandstone to be calcareous in some places in the Brownfield Quadrangle. Contact is locally unconformable with the underlying units.

I Limestone and shale This unit was identified in only one outcrop in the quadrangle, near the center of Sec. 16, T15S, R6E, where it consists of medium- to dark-brown, argillaceous, and cherty limestone. The limestone is a lime mudstone to wackestone. Chert weathers with a distinctive yellow-brown porous rind, contains fossil fragments of crinoids and bioclasts, and may have an oolitic appearance on fresh unweathered surfaces. The lower contact is sharp and probably conformable with the underlying unit.

J Sandstone, siltstone, and shale White to light-gray, fine-grained quartz arenite that weathers to a sugary texture. Sandstone grades upward into siltstone and shale. Sandstones are commonly cross-bedded and soft sediment deformation was prominent in an outcrop below Brasher Cave (Sec. 3, T15S, R6E). The lower part of the unit is more massive and grades upward into thinner sandstone beds containing shale rip-up clasts. The lower contact appears to be gradational.

K Limestone and shale In the upper part of the unit, limestones are light- to medium-gray crinoidal grainstone, oolitic and finely cross-bedded; the lower part is composed of dark-gray calcareous shale and argillaceous limestone. The lower portion is poorly exposed, but the contact with the underlying unit is probably conformable.

L Sandstone, siltstone, and shale Sandstone is light-brown, weathers light gray to dark brown, very fine grained, and thick to thinly-bedded or flaggy. Dark-gray to greenish gray siltstone and shales with interbedded sandstones in the upper part. Stigmarian root casts are found in the upper part of the section. Sandstones in the lower part of the section contain rip-up clasts and brachiopod casts and molds. This unit may be locally unconformable with the underlying units.

M Limestone and shale Medium- to light-gray lime mudstone with interbedded calcareous shales and crinoidal grainstone. Limestones may have a few dark-gray chert lenses. Fossils include brachiopods, crinoids, blastoids, and bryozoans. Shales are dark gray and commonly are fossiliferous and calcareous. Two large (golf ball size) blastoids (*Pentremites obesus*) were found in this unit (SE 1/4, Sec. 9, T15S, R6E). Contact with the underlying unit is gradational.

N Shale and limestone Shale is mostly dark gray but is commonly red at the top. Limestones are gray to light gray, thin-bedded, fossiliferous, and not laterally continuous. Fossils are dominantly crinoids and bryozoans. The lower part grades into a shale and calcareous shale sequence. Contact with the underlying unit is conformable.

O Limestone Varies from a dolomitic lime mudstone to argillaceous crinoidal wackestone and packstone. Brachiopods and crinoids are common. Contact with the underlying unit is conformable.

P Sandstone, siltstone, and shale Greenish gray shale, interbedded siltstones, and sandstone in upper part. Some bioturbation was noted in the upper part. Light-gray, fine-grained to very fine-grained quartz arenite in lower part. The lower part forms bluffs and ledges in outcrops and is typically well exposed. Ripple marks and cross-bedding are common in the lower part. Contact with the underlying unit is unconformable.

Q Shale, siltstone, sandstone, and limestone Exposures are too limited in this quadrangle to differentiate this unit from the underlying units. Where exposed in the Brownfield Quadrangle, the Ridenhower is composed of dark-gray fissile shale and sandy limestone to calcareous sandstone with crinoid and bryozoan fragments. The uppermost part of the unit has been eroded beneath the overlying Cypress Sandstone and may be absent in some parts of the quadrangle.

R Sandstone Light-gray, well-sorted quartz arenite. Upper part is fine- to very fine-grained and thin-bedded. Sandstone is bioturbated and finely cross-bedded. Lower part is medium- to coarse-grained and weathers to a sugary texture. Cross-bedding and ripple marks are common.

S Sandstone and siltstone This unit is difficult to differentiate from the overlying Sample Sandstone. It is white to light-gray, medium- to fine-grained quartz arenite. Granule size particles may serve as a distinguishing characteristic. The unit is interbedded with gray siltstones and the lower contact is erosional upon the underlying units.

T Limestone and shale Medium-gray oolitic limestone, thin-bedded to thick-bedded; shale partings and small amounts of chert are present in some places. Orange echinoderm fragments are distinctive for this unit. The lower contact is probably conformable with the underlying units.

U Shale, limestone, and claystone Red, light green-gray, and yellowish mottled shales and claystones at the top. The lower part is composed of interbedded limestones and claystones. The limestone is light-gray and oolitic; the claystone is dark-gray. The lower contact is gradational.

V Limestone Dark greenish gray to gray, argillaceous limestone with thin shale layers in the upper part, grading into an oolitic grainstone and packstone in the lower part. The lower contact was not observed but was found to be unconformable in the Brownfield Quadrangle (Nelson unpublished).

W Limestone White to light-gray, oolitic grainstone with scattered red to pink oolites.

X Sandstone, siltstone, and limestone Sandstone is light-gray, calcareous, and fine-grained to very fine-grained. Siltstone may be present at the top of the unit, grading laterally into silty and sandy limestones.

Y Limestone, sandy limestone, and chert Light-gray, thick-bedded oolitic limestone and crinoidal grainstone. Some parts of the section are argillaceous and may be dolomitic in places. Stylolites, shale partings, and sandy limestone layers are present locally. Some of the sandy limestone layers show cross-bedding. Chert is common and is generally gray.

[1] Dolton Member, formerly a member of the Equality Formation (Willman and Frye 1970), was redefined by Hansel and Johnson (1996) as a member of the Henry Formation.
[2] Tert., Tertiary.
[3] Maples and Waters (1987) placed the Chesterian-Valmeyeran boundary at the base of the Ste. Genevieve Limestone.

The uniform light-brown color of the Mounds Gravel makes it a visually appealing landscape gravel or decorative stone. The unit is weakly to moderately lithified, but in places it can be well lithified by iron oxides. Gravel similar to the Mounds Gravel also occurs at lower elevations, between 400 and 350 feet in elevation, in the southern part of the quadrangle. These younger gravels are a result of reworking of the Tertiary age Mounds Gravel into younger units of Pleistocene and Holocene age. These gravels are unconsolidated and consist of granules, pebbles, and cobbles with a sandy clay and in some places micaceous matrix. The younger gravels at lower elevations make a good aquifer, and this unit is a local water source for many private residences in the quadrangle. The gravel pits that lie at about 350 feet in elevation at the southern end of the quadrangle are no longer in operation and are flooded. These gravels offer a good, inexpensive supply of aggregate where the gravels are located above the water table.

Fluorite, Lead, and Zinc

The Compton Mine Fault Zone is mineralized in the Brownfield Quadrangle, about 1 mile north of this map area. In the Brownfield area the ore is confined to a vein with a strike of N45°E and a dip of 60°SE. The ore is located along the western segment of the Compton Mine Fault Zone in the Brownfield Quadrangle. Although no fluorite mineralization was observed along this fault in the Paducah NE Quadrangle, the Compton Mine Fault Zone may be mineralized here. This fault zone offers the best exploration target in the quadrangle for vein type fluorite mineralization. Fluorite, lead, zinc, and barite have been produced less than 10 miles to the east in Kentucky (Amos 1966).

Limestone

Limestone resources of the quadrangle are limited because of the cover of Cretaceous sediments to the south. The Paoli Limestone is a relatively pure limestone unit that outcrops along Burke Creek (Sec. 4, T15S, R6E). A pit at this location would require the removal of up to 70 feet of sandstone.

Oil and Gas

No oil or gas has been produced from the Paducah NE quadrangle, but several horizons that produce oil elsewhere in Illinois are present in the subsurface. Potential horizons include the lower Chesterian through the Devonian. It is possible that the widespread faulting allowed oil and gas to escape at the surface during the geologic past.

Acknowledgments

Joseph A. Devera, John M. Masters, and Leon R. Follmer aided in field studies and stratigraphic correlations for this map. Dennis R. Kolata, Jonathan H. Goodwin, and Zakaria Lasemi provided editorial advice and technical review.

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