

**Guide to Selected Industrial Mineral Producers,
Preliminary Reconnaissance Bedrock Geology
and Pennsylvanian Stratigraphy of the
St. Joseph, Missouri Area**



by
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Prepared for the

ASSOCIATION of MISSOURI GEOLOGISTS



47th Annual Meeting and Field Trip

September 29 and 30, 2000

St. Joseph, Missouri

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And Pennsylvanian Stratigraphy of the St. Joseph, Missouri Area**

by
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Missouri Department of Natural Resources
Division of Geology and Land Survey
Geological Survey Program
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Prepared for the
**Association of Missouri Geologists
47th Annual Meeting and Field Trip
September 29-30, 2000**

Schedule

Friday, September 29, 2000

11:30 a.m. to 12:30 p.m. Association of Missouri Geologists (AMG) **business meeting**
Holiday Inn Riverfront Conference Center, 102 South 3rd Street, St. Joseph, MO.

1:00 p.m. to 5:00 p.m. **Field trip**, selected St. Joseph area industrial mineral producers.
Depart from parking lot on the north side of the Holiday Inn Riverfront Conference Center, 102 South 3rd Street, St. Joseph, MO, transportation via yellow Laidlaw busses.

Stop 1 Idecker, Inc. Amazonia Quarry
Stop 2 Buildex, Inc. Haydite Plant

7:00 p.m. to 10:00 p.m. **Banquet and annual meeting**
Holiday Inn Riverfront Conference Center, 102 South 3rd Street, St. Joseph, MO.

Saturday, September 30, 2000

7:00 a.m. to 8:15 a.m. Missouri Section, American Institute of Professional Geologists **breakfast meeting** adjacent to the Holiday Inn Riverfront Conference Center restaurant. Please fill your plates from the buffet prior to 7:00 a.m.

8:30 a.m. to 2:30 p.m. **Field trip**, stratigraphy of the northern St. Joseph area
Depart from parking lot on the north side of the Holiday Inn Riverfront Conference Center, 102 South 3rd Street, St. Joseph, MO, transportation via yellow Laidlaw busses.

Stop 1 Iatan Limestone
Stop 2 Lawrence Formation
Stop 3 Oread Formation
View of North St. Joseph Pre-Glacial Channel
Stop 4 Kanwaka Formation
Stop 5 Lecompton Formation
Stop 6 Deer Creek Formation

Acknowledgements

Jennifer Walker, Sales Manager, and Charlotte Danbury, Catering Manager, Holiday Inn St. Joseph Conference Center, 102 South 3rd Street, St. Joseph, MO 64501, 816-279-8000 arranged the accommodations, meeting rooms, and banquet for the September 29-30, 2000 AMG annual meeting and field trip. Transportation was arranged by Janice Samples, Laidlaw Transit, Inc., 4713 St. Joseph Ave., St. Joseph, MO 64501, 816-232-2833. A substantial portion of Saturday's lunch was provided by Marsha Rosenthal, The Deli Gourmet Food & Wine, 2316 North Belt, St. Joseph, MO 64506, 816-279-3354. The kind assistance of these ladies made planning this meeting a very pleasant experience.

Kenneth Ideker, Ideker Construction, Inc., P. O. Box 7140, St. Joseph, MO 64507, 816-364-3970, kindly granted permission to visit their Amazonia Quarry. Junior Hayes, Quarry Superintendent, 816-475-4606, cheerfully allowed access to measure stratigraphic sections. Wayne Barnett, Vice President of Production, Buildex, Inc., 22105 Highway 371, Dearborn, MO 64439, 816-992-3317 also gave permission to measure stratigraphic sections and visit their Weston Shale pit and expanded lightweight aggregate plant. Hardhats and safety glasses are required to enter the pit and tour the plant. Steve Crawford, 573-387-1050, owner of Pony Express Warehouse, 11th Street, St. Joseph, MO graciously gave permission to visit the Iatan Limestone exposure behind his warehouse.

Kenneth Markwell, District 1 Geologist, Missouri Department of Transportation, 3602 North Belt Highway, P. O. Box 287, St. Joseph, MO 64502-0287, 816-387-2441, has been a constant source of encouragement, provided three excellent pictures of the Amazonia Quarry, and arranged the strategic placement of porta johns during the field trips.

Virginia Ragan, AMG President, and George Kastler, AMG Treasurer, provided valuable advice. George took responsibility for registration, guidebook sales, and reporting the number of participants to the St. Joseph Holiday Inn. He also purchased refreshments and part of Saturday's lunch. We owe them our gratitude for their faithful service.

Karen Loveland and James R. Palmer, Division of Geology and Land Survey (DGLS), P. O. Box 250, Rolla, MO 65401, 573-368-2100 prepared the figures. Generous assistance was provided by Jerry Bixler, Phillip Streamer, Susan Dunn, Terry Sheffield, and Dolly Howard toward completing this guidebook. Sandy Miller's typing and proof reading skills made this document. I am indebted to DGLS staff for their encouragement and to DGLS management for the opportunity to serve the citizens of Missouri. The work summarized in this guidebook is dedicated to the people of Platte, Buchanan, and Andrew Counties. My hope is that understanding the succession of rock units and their distribution will be a significant contribution to the health and financial success of each person living in the region.

Friday, September 29, 2000 Field Trip

The AMG Friday, September 29, 2000, field trip will depart at 1:00 p.m. from the parking lot north of the Holiday Inn Riverfront Conference Center, 102 South 3rd Street, St. Joseph, MO. Transportation will be by yellow Laidlaw busses. The trip will visit two important industrial mineral producers in the St. Joseph area. The Ideker, Inc. Amazonia Quarry and the Buildex, Inc. Haydite Plant directly contribute raw materials and value added products to construction and maintenance of roads, bridges, and buildings which underpin the region's quality of life. A map showing the route and locations of each stop is provided in Figure 1. An itinerary and road log follows:

Mileage	Point of Departure
Itinerary	
0.0	1:00 p.m. depart Holiday Inn parking lot northwest of 3 rd and Edmond Streets
	proceed west on Francis Street, take I-229 North
5.0	turn left on Highway K
9.1	turn right on Highway T in Amazonia just past Strasser Auto Body at Schneider Orchard sign
10.4	cross under I-29, lower part of Oread Formation is visible on left on north side of I-29
11.4	turn left into the Ideker, Inc. Amazonia Quarry, Stop 1 estimated travel time: 15 min.
1:15 p.m. to 2:40 p.m. examine pit, porta john rest stop	
0.0	depart Ideker, Inc. Amazonia Quarry
	turn right on Highway T
2.3	turn left on Highway K
6.2	turn right on I-229 South
17.6	turn right on I-29 South
27.0	Haskell Limestone Member, Stranger Formation is exposed on the east side of I-29
30.5	turn right on Highway H at Dearborn-New Market exit
31.3	turn left on Highway 371
32.8	turn left into southern most entrance to Buildex, Inc. Haydite plant, Stop 2 estimated travel time: 35 min.
3:15 p.m. to 4:30 p.m. examine pit and tour plant, restrooms available at office	
0.0	depart Buildex, Inc. Haydite plant
	turn right on Highway 371
1.5	turn right on Highway H
2.3	turn left on I-29 North
5.8	Haskell Limestone Member, Stranger Formation is exposed on the east side of I-29
12.1	Lower Unnamed Shale Member, Lawrence Formation is exposed in pit east of I-29
15.1	turn right on I-229 North
21.3	turn right on Exit 6A, Edmond Street
21.6	turn left on South 3 rd Street
21.7	turn left into Holiday Inn parking lot estimated travel time: 23 min.
5:00 p.m. field trip ends	

The approximate distance covered during the Friday field trip is 67 miles. Total travel time is estimated to be 1 hr. 13 min.

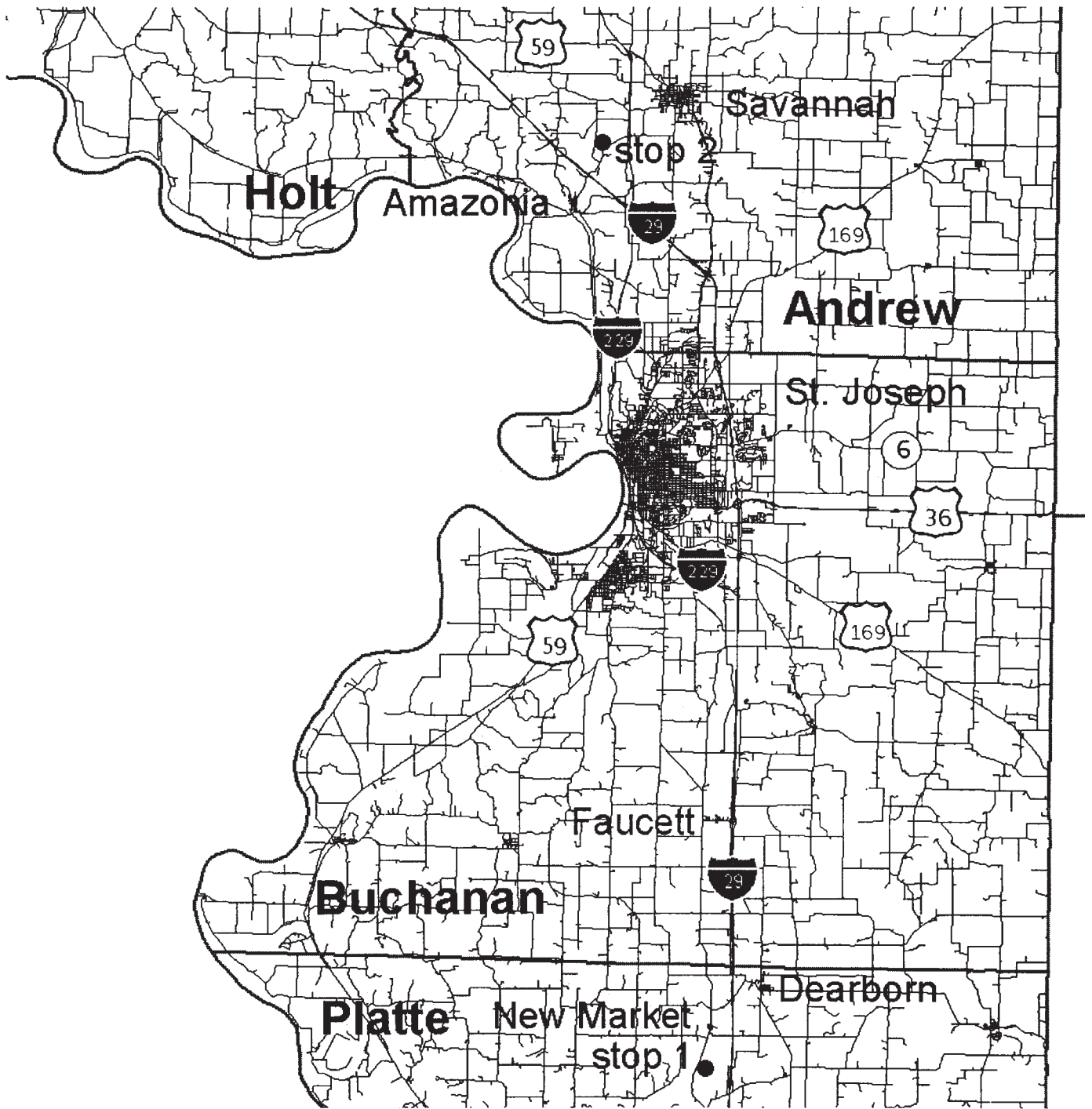


Figure 1. Map of Friday, September 29, 2000 field trip route.

Stop 1 Ideker, Inc. Amazonia Quarry

Ideker Construction, Inc. is an integrated industrial mineral producer and paving contractor. Ideker operates the New Point Quarry in Holt County and the Amazonia Quarry in Andrew County. The Amazonia Quarry produces crushed stone with a wide variety of uses. The Plattsmouth and Kereford Limestone Members of the Oread Formation are the primary beds quarried and crushed. A measured stratigraphic section follows. Figure 2 summarizes bedrock stratigraphy and unit thickness at the Amazonia Quarry. Plates 1 through 3 illustrate quarrying operations in the Plattsmouth and Kereford limestones and stratigraphy of the overburden.

Measured stratigraphic section at Stop 1, Ideker, Inc. Amazonia Quarry.

Andrew County, Missouri

Savannah 7.5 Minute Quadrangle

Top: Center, SE ¼, SE ¼, SE ¼, SW ¼, Sec. 18, T. 59 N., R. 35 W.

Base: NW ¼, NW ¼, NW ¼, SE ¼, NW ¼, Sec. 19, T. 59 N., R. 35 W.

Elevation on top of the Avoca estimated from topographic map.

Measured by David C. Smith, July 21, 2000.

Description of units 1 through 8 supplemented by information supplied Ken Markwell, District 1 Geologist, Missouri Department of Transportation dated March 23, 2000.

Correlation

Unit No.	Description	Elevation	Thickness
	Quaternary System:	1041 ft. 6 in.	
40.	Loess, exposed on inaccessible central portion of southeast highwall, thickness varies from an estimated 6 to 15 ft.		from an estimated 6 ft. 0 in.
		1035 ft. 6 in.	
39.	Glacial drift, exposed on inaccessible central portion of southeast highwall, thickness varies from an estimated 6 to 8 ft.		8 ft. 0 in.
	Pennsylvanian System, Virgilian Series, Shawnee Group:		
	Lecompton Formation: 35 ft. 2 in. thick		
	Avoca Limestone Member:	1027 ft. 6 in.	
30.	Limestone, weathered, present as one bed of weathering boulders separated by clay-filled joints, exposed on inaccessible central portion of southeast highwall, estimated thickness.		1 ft. 0 in.
	King Hill Shale Member:	1026 ft. 6 in.	
29.	Shale, weathered, exposed on inaccessible central portion of southeast highwall, sharp upper contact, estimated thickness.		6 ft. 0 in.
	Beil Limestone Member:	1020 ft. 6 in.	
28.	Limestone, yellowish gray (5Y7/2), weathers very pale orange (10YR8/2) to grayish orange (10YR7/4), finely crystalline, mudstone to packstone, contains abundant algal material and broken fossil fragments, massive, dense, hard.		1 ft. 2 in.
		1019 ft. 4 in.	
27.	Limestone interbedded with minor shale; limestone is yellowish gray (5Y7/2), weathers grayish orange (10YR7/4), finely crystalline, mudstone to packstone, earthy, poorly bedded to nodular; shale weathers yellowish gray (5Y7/2), slightly silty, sharp contact with above unit.		7 in.
		1018 ft. 9 in.	
26.	Limestone, yellowish gray (5Y7/2), weathers very pale orange (10YR8/2) to grayish orange (10YR7/4), finely crystalline, packstone at base grading upward to mudstone, earthy, fossiliferous, contains fusulinids.		1 ft. 0 in.
		1017 ft. 9 in.	
25.	Limestone interbedded with minor shale; limestone is yellowish gray (5Y7/2) to light olive gray (5Y6/1), finely crystalline, dense, hard.		1 ft. 1 in.
		1016 ft. 8 in.	

Measured stratigraphic section at Stop 1, continued.

Correlation Unit No.	Description	Elevation	Thickness
		1016 ft. 8 in.	
24.	Shale, yellowish gray (5Y7/2) to grayish orange (10YR7/4), calcareous, contains small limestone concretions, hard, tough, gradational upper contact.		4 in.
		1016 ft. 4 in.	
23.	Limestone, yellowish gray (5Y7/2), occasionally stained pale yellowish orange (10YR8/6) to grayish orange (10YR7/4), finely crystalline, mudstone to wackestone, slightly abrasive to touch, sharp upper contact.		4 in.
	Queen Hill Shale Member:	1016 ft. 0 in.	
22.	Shale, dark gray (N3) and olive gray (5Y4/1) at base grading upward to light olive gray (5Y6/1) at top, weathers medium light gray (N6), blocky to subparallel horizontal stratification, slightly silty, sharp upper contact.		1 ft. 5 in.
		1014 ft. 7 in.	
21.	Shale, black (N1) to olive black (5Y2/1), weathers medium gray (N5), fissile, parallel horizontal stratification, silty, gradational upper contact.		2 ft. 2 in.
		1012 ft. 5 in.	
20.	Shale, light olive gray (5Y5/2), weathers light gray (N7), calcareous, contains abundant fossil fragments, crinoid stems, and fusulinids, sharp upper contact.		3 in.
	Big Springs Limestone Member:	1012 ft. 2 in.	
19.	Limestone, very pale orange (10YR8/2) to pale yellowish brown (10YR6/2), weathers yellowish gray (5Y7/2) to very pale orange (10YR8/2), finely crystalline, packstone at base, grades upward to mudstone, fossiliferous, contains abundant fusulinids, lowest 1 ft. in one bed, thin limestone beds alternate with shale in upper 3 in., irregular upper and lower surfaces, sharp upper contact.		1 ft. 3 in.
	Doniphan Shale Member:	1010 ft. 11 in.	
18.	Claystone, deeply weathered moderate yellowish brown (10YR5/4) to dark yellowish orange (10YR6/6), silty, sharp upper contact.		9 in.
		1010 ft. 2 in.	
17.	Siltstone, grayish orange (10YR7/4), weathers very light gray (N8) to white (N9), very fine grained, massive, occasionally laminated, contains 2 in. thick shale bed 9 in. above base and 0.5 in. shale bed 4.5 in. above base, spalls from curved surfaces sub-parallel to face, poorly exposed upper contact.		8 ft. 0 in.
		1002 ft. 2 in.	
16.	Shale, yellowish gray (5Y7/2), weathers medium light gray (N6), silty, parallel horizontal bedding, sharp upper contact.		6 in.
		1001 ft. 8 in.	
15.	Claystone, olive gray (5Y3/2) to dark greenish gray (5GY4/1), blocky with curved nonparallel stratification, slightly silty, damp, irregular upper surface, unit varies from 16 to 24 in. thick, sharp upper contact.		2 ft. 0 in.
		999 ft. 8 in.	
14.	Limestone interbedded with shale; limestone is light yellowish gray (5Y7/2) to light olive gray (5Y5/2), weathers yellowish gray (5Y7/2) to very light gray (N8), very finely crystalline, mudstone, irregularly bedded to nodular; shale is light olive gray (5Y6/1), slightly silty, occurs in thin beds separating limestone beds and nodules, parallel horizontal stratification, unit has sharp upper contact. In southeast Holt County, this unit is a calcareous shale containing abundant limestone nodules.		2 ft. 6 in.
	Spring Branch Limestone Member:	997 ft. 2 in.	
13.	Limestone, very light gray (N8) to yellowish gray (5Y7/2), weathers pale yellowish orange (10YR6/6) to grayish orange (10YR7/4), finely crystalline, wackestone to packstone, silty abrasive feel, present in two to three beds, lowest bed is occasionally massive and resistant to weathering, dominant joint set N 45° W, subordinate joint set N 50° E, curved plates spall sub-parallel to face, sharp upper contact.		4 ft. 10 in.
	Kanwaka Formation:	41 ft. 0 in. thick	
	Stull Shale Member:	992 ft. 4 in.	
12.	Shale, light olive gray (5Y5/2) to dusky yellowish green (5GY5/2), sandy calcareous, micaceous, sharp upper contact.		9 in.

Measured stratigraphic section at Stop 1, continued.

Correlation Unit No.	Description	Elevation	Thickness
		991 ft. 7 in.	
	11. Shale, medium gray (N5) to dark gray (N3), occasionally laminated medium light gray (N6), silty, micaceous, thin parallel horizontal stratification is present throughout most of unit, becomes blocky in upper 1 or 2 ft., a 1 ft. 3 in. zone of interbedded sandstone and shale occurs about 7 ft. below top; sandstone is medium light gray (N6), very fine grained, micaceous, calcareous, other thin beds of sandstone and/or siltstone occur in the uppermost 12 ft., sharp upper contact.		28 ft. 3 in.
	Clay Creek Limestone Member:	963 ft. 4 in.	
	10. Limestone, medium light gray (N6), weathers light gray (N7), finely crystalline, mudstone to wackestone, slightly abrasive to touch, massive, present as one bed, dominant joint set N 55° E, sharp upper contact.		2 ft. 10 in.
	Jackson Park Shale Member:	960 ft. 6 in.	
	9. Shale laminated medium gray (N5) and light gray (N7), silty, micaceous, sub-parallel stratification, sharp upper contact.		9 ft. 2 in.
	Oread Formation:		
	Kereford Limestone Member:	951 ft. 4 in.	
	8. Limestone, medium gray (N5), weathers buff, wackestone to packstone, finely crystalline, medium grained, bedding thickness from bottom to top is 10, 10, 6, 7, 9, and 5 in., tabular set bedding planes dip southeast, fossiliferous, occasional black calcite seams and vugs and thin shale seams, very hard, sharp upper contact, thickness increases to southeast, 8 ft. 1 in. was exposed on 03/30/2000.		3 ft. 11 in.
	Heumader Shale Member:	947 ft. 5 in.	
	7. Shale, medium gray (N5) to medium dark gray (N4), parallel horizontal stratification, hard, tough, sharp upper contact, thickness decreases to southeast, 2 ft. was exposed on 03/30/2000.		5 ft. 6 in.
	Plattsmouth Limestone Member:	941 ft. 11 in.	
	6. Limestone, light gray (N7) to yellowish gray (5Y7/2) to pinkish gray (5YR8/1), fine to medium crystalline, mudstone to wackestone, dense, fossiliferous, thin to thick irregular beds, thickness varies from 5 ft. 5 in. to 7 ft. 4 in.		7 ft. 4 in.
		934 ft. 7 in.	
	5. Shale, black (N1).		5 in.
		934 ft. 2 in.	
	4. Limestone, light gray (N7) to medium gray (N5), finely crystalline, mudstone to wackestone, thin to medium irregular beds, fossiliferous, contains fusulinids near top, contains occasional dark gray (N3) chert nodules and thin black (N1) shale partings, thickness varies from 5 ft. 11 in. to 7 ft.		7 ft. 0 in.
		927 ft. 2 in.	
	3. Shale, black (N1).		4 in.
		926 ft. 10 in.	
	2. Limestone, brownish gray, (5YR4/1), finely crystalline, mudstone to wackestone, thin to medium slightly irregular beds, contains occasional dark gray (N3) chert nodules and thin black (N1) shale partings, thickness varies from 7 ft. 4 in to 7 ft. 6 in.		7 ft. 4 in.
		919 ft. 6 in.	
	1. Limestone, covered, serves as quarry floor.		1 ft. 8 in.
		917 ft. 10 in.	
	Heebner Shale Member: not exposed		
	Total Thickness		123 ft. 8 in.

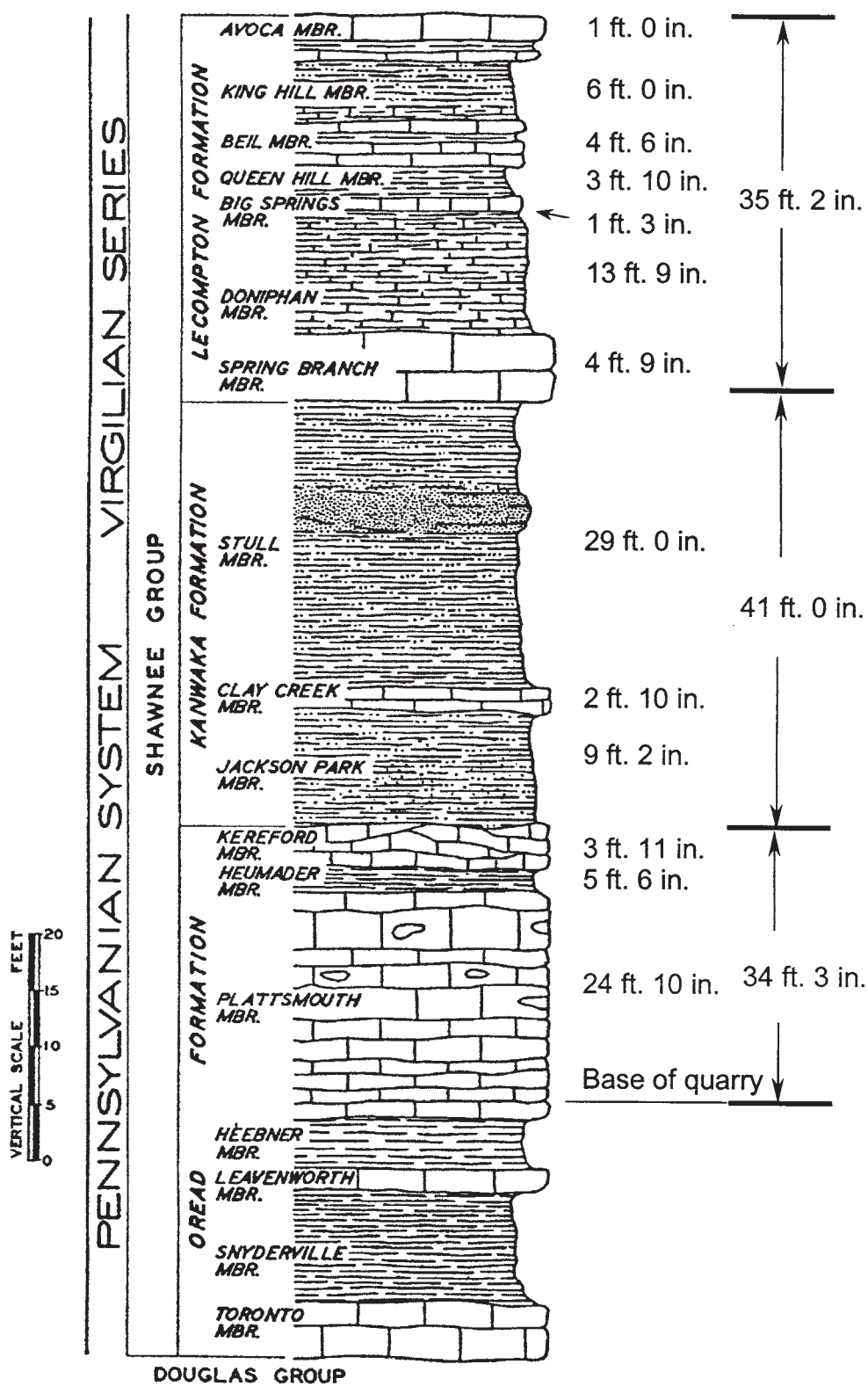


Figure 2. Stratigraphy at the Ideker, Inc. Amazonia Quarry (from Howe, 1961, figure 22, p.112).



Plate 1. Drilling and loading operations in the upper Plattsmouth limestone at the Ideker Amazonia Quarry. An extensive bench is developed on top of the Kereford limestone behind the track drill. The Kereford face is identified by a red "K" on the right side of the photograph. Photograph courtesy of the Missouri Department of Transportation.



Plate 2. Benches in the Plattsmouth and Kereford limestones, southeast highwall, Ideker Amazonia Quarry. This view is to the right of Plate 1. Approximately 22 ft. of Plattsmouth is exposed above the waterline in the central portion of the picture. The upper most 4 to 5 ft. of Plattsmouth has been removed on the left foreground. Approximately 2 ft. of Heumader shale and 10 ft. of Kereford limestone form the bench above the Plattsmouth. About 41 ft. of the Kanwaka Formation is present between the top of the Kereford and the sharp demarcation between gray and yellow on the right of the photograph. The Beil limestone is the youngest resistant ledge in the upper left portion of the photograph. It is overlain by till and loess. Photograph courtesy of Missouri Department of Transportation.

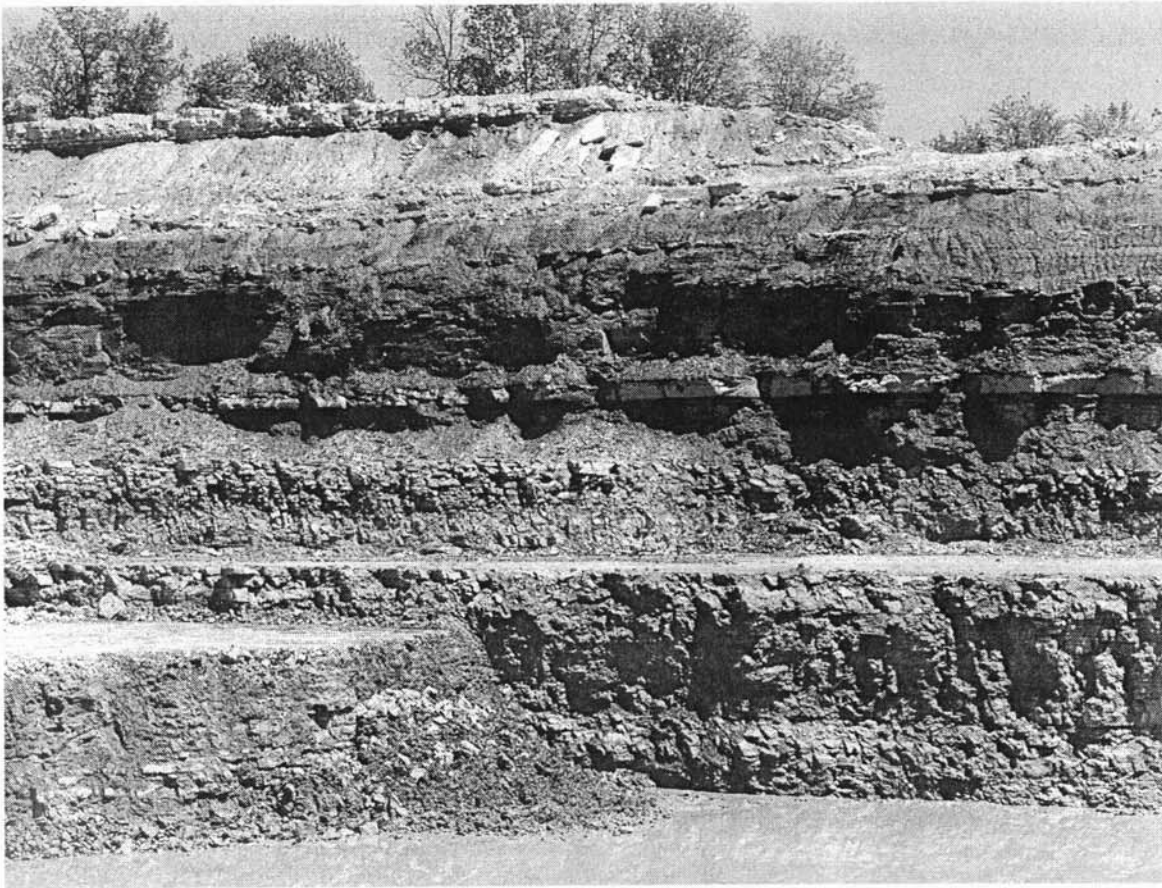


Plate 3. Close up of the southeast highwall at the Idecker Amazonia Quarry. The Plattsmouth is exposed above the waterline in the center and right portion of the picture. Three divisions of the Plattsmouth are distinctly visible in the face. Dark gray beds in the middle separate lighter gray upper and lower beds. Approximately 8 ft. of Kereford is visible above the bench on top of the Plattsmouth. A 2 ft. Heumader shale separates the Kereford and Plattsmouth limestones. The 9 ft. Jackson Park shale overlies the Kereford. The 3 ft. massive Clay Creek limestone is distinctly visible above the Jackson Park. The Stull shale comprises the remaining 29 ft. of gray strata. About 15 in. of sandstone is present 7 ft. below the top of the Stull. Yellow and orange strata above the Stull include the Spring Branch limestone, Doniphan shale, Big Spring limestone, and Queen Hill shale. All of these units are poorly exposed. The 5 ft. Beil limestone is the youngest resistant bed.

Stop 2 Buildex, Inc. Haydite Plant

Buildex, Inc. produces a lightweight aggregate from expanded shale using a patented rotary kiln process. The Buildex, Inc. Haydite Plant at New Market is one of three plants serving 15 Midwest and Rocky Mountain states with a total annual production capacity exceeding 750,000 cubic yards. Other Buildex plants are located in Ottawa and Marquette, Kansas. Their chemically stable lightweight aggregate offers low density, high strength, high insulation, and excellent fire resistance for a wide range of applications. Typical uses of Haydite lightweight aggregate include lightweight concrete masonry, lightweight structural concrete, refractory concrete, insulating concrete, asphaltic chip-seal, aggregate fill, soil conditioner, decorative ground cover, and traction aid.

Two requirements for haydite production include large reserves of suitable shale and a stable supply of natural gas to fire the rotary kiln. The proper shale feedstock should expand to a cellular mass when heated above 1000° C. Two simultaneous reactions occur: evolution of a gas from dissociation of non-clay minerals and formation of a melt by clay minerals viscous enough to trap the evolved gas. Sudden cooling produces a slag-like material, which is screened to produce expanded lightweight aggregate (Bates, 1969, p. 127). Portions of the Bonner Springs Formation, Weston Shale, Lower Unnamed Shale Member of the Lawrence Formation, and Jackson Park Shale Member of the Kanwaka Formation are suitable for production of lightweight aggregate (Rueff, 1972, p. 4).

Figure 3 summarizes bedrock stratigraphy and unit thickness at Buildex, Inc. The Tonganoxie Sandstone Member of the Stranger Formation shown in Figure 3 is rarely present above the Iatan Limestone in the St. Joseph area. A measured stratigraphic section follows Figure 3.

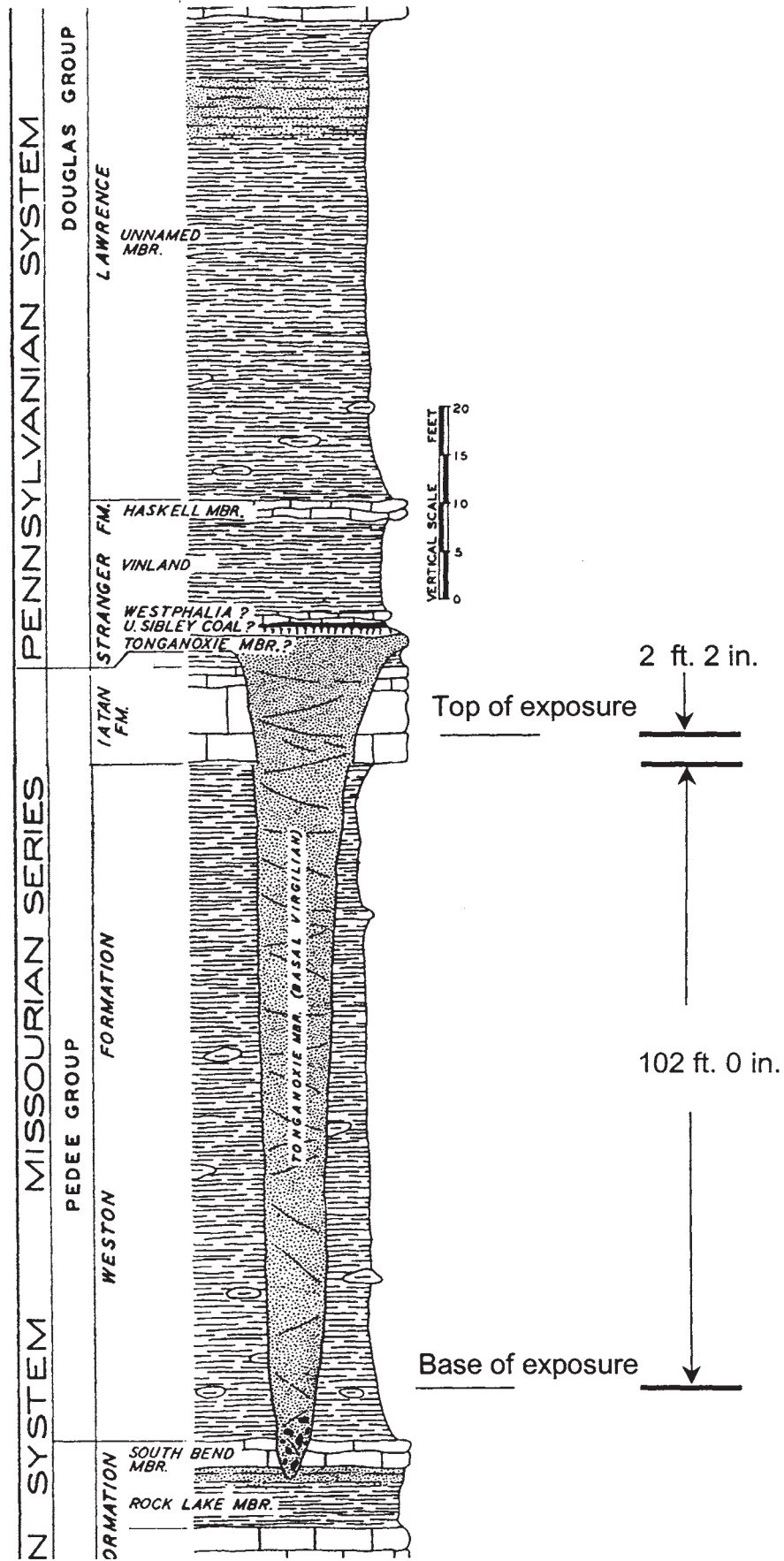


Figure 3. Stratigraphy at the Buildex, Inc. Haydite Plant (after Howe, 1961, figure 21, p. 107).

Measured stratigraphic section at the Buildex, Inc. Haydite Plant.

Platte County, Missouri

Tracy 7.5 Minute Quadrangle

E ½, NE ¼, NW ¼, SW ¼ and NW ¼, NE ¼, SW ¼, Sec. 14, T. 54 N., R. 35 W.

Elevation on top of Weston estimated from topographic map.

Measured by David C. Smith, September 6, 2000.

Correlation

Unit No.	Description	Elevation	Thickness
Pennsylvanian System:			
Missourian Series:			
Pedee Group:			
	Iatan Formation:	882 ft. 2 in.	
8.	Limestone, pale yellowish brown (10YR6/2) to grayish orange (10YR7/4), weathers grayish orange (10YR7/4) to dark yellowish orange (10YR6/6), finely crystalline, mudstone to wackestone, present as one massive bed with thin to medium stratification emphasized by algal material and fossil fragments in relief on weathered surfaces, poorly exposed, several large blocks have been gathered near the lower contact, incomplete thickness.		2 ft. 2 in.
	Weston Formation:	880 ft. 0 in.	
7.	Shale, weathered light olive gray (5Y6/1) to medium light gray (N6), occasional light brown (5YR6/4) clay ironstone-rich lamina, silty, finely micaceous, very thin to thickly laminated, wavy parallel to curved non-parallel stratification. This unit comprises the slope above the pit.		7 ft. 0 in.
		873 ft. 0 in.	
6.	Shale, medium light gray (N5), weathers light gray (N7) to yellowish gray (5Y8/1), silty, slightly finely micaceous, thinly laminated to thinly bedded, parallel to curved non-parallel stratification, this interval is characterized by pseudo-flower structures developed in yellowish gray (5Y8/1) shale that end in a silt-rich bed, approximately 1 ft thick, at the base. A 3 in. thick discontinuous ferruginous siltstone occurs above the basal silt-rich bed, it is dark yellowish brown (10YR4/2) when fresh and weathers pale yellowish brown (10YR6/2). This unit comprises the weathered part of the upper pit.		23 ft. 0 in.
		850 ft. 0 in.	
5.	Shale, medium gray (N5) to medium light gray (N6) to light olive gray (5Y6/1), weathers light gray (N7) to greenish gray (5GY6/1), silty, finely micaceous, medium laminated to thinly bedded, stratification varies from concentric lumps to curved non-parallel bedding planes. This unit comprises the unweathered part of the upper pit.		37 ft. 0 in.
		813 ft. 0 in.	
4.	Shale, poorly exposed, interval above the lower pit to the base of the working upper pit face, estimated thickness.		6 ft. 8 in.
		806 ft. 4 in.	
3.	Shale, medium light gray (N6) with some light olive gray (5Y6/1), weathers light olive gray (5Y6/1) to greenish gray (5GY6/1), silty, finely micaceous, thickly laminated to very thinly bedded, concentric lumps to curved non-parallel to wavy parallel stratification. This interval comprises the upper part of the lower pit.		17 ft. 0 in.
		789 ft. 4 in.	
2.	Shale, medium gray (N5), weathers medium light gray (N6), silty, finely micaceous, thickly laminated to very thinly bedded, wavy parallel stratification, hard, no reaction with dilute HCl. This interval contains a horizon, about 3 ft. 4 in. above the base and 9 ft. above the water line, occupied by an occasional clay ironstone concretion, 14 in. long by 4 in. tall, moderate brown (5YR4/4) on the surface, dark yellowish orange (10YR6/6) internally with very thin, finely crystalline, grayish orange (10YR7/4) calcite veins occupying the open space between concoidal fracture planes.		5 ft. 8 in.
		783 ft. 8 in.	
1.	Shale, medium light gray (N6), weathers light bluish gray (5B7/1), silty, very finely micaceous, medium laminated, curved non-parallel stratification, soft, to water level in sump in lower pit.		5 ft. 8 in.
		778 ft. 0 in.	
Total Thickness			104 ft. 2 in.

Preliminary Reconnaissance Bedrock Geologic Map of the St. Joseph Area

Map Area

Reconnaissance bedrock geologic mapping was conducted in the northern part of Platte County, Buchanan County, and the southern two thirds of Andrew County. Eighteen complete or partial 7.5 minute quadrangles were mapped within this area (see Figure 4). A preliminary edition of the St. Joseph area bedrock geologic map is included in the guidebook. Some contours on top of bedrock will be edited to better portray the shape of buried pre-glacial channels. Additional editing is also required to join crop lines at several quadrangle boundaries.

Mapping Method

The mapping method used to produce the St. Joseph area bedrock geologic map included compiling and field checking existing information, searching for additional bedrock exposures on each 7.5 minute quadrangle, and displaying all available information on an outcrop and drill hole location map for each quadrangle.

Compilation of existing information included collecting published geological literature and copying drill hole logs, measured stratigraphic sections, geologic maps, and unpublished geological literature available at DGLS. Table 1 lists several DGLS collections which materially assist geologic mapping. Emphasis was placed on collecting and field checking drill hole logs and stratigraphic sections.

Field work had three objectives: verify the location, elevation, and correlation of drill holes and stratigraphic sections, find additional bedrock exposures, and identify rock units. Water wells were verified by visiting farms and homes for which there were drill hole records. When no one was home, or knew about a well, or when the well was poorly located, county plat books were used to estimate location and elevation. Once the well location was verified or estimated and the strata correlated, a data point with stratigraphic information was plotted on a 7.5 minute quadrangle labeled "outcrop and drill hole location map." The same was done with stratigraphic sections.

Considerable walking was done early in the project to recognize and map older rock units in the southeast part of the map area. Additional walking late in the project mapped the distribution of younger units in the northwest map area. The map is reconnaissance in nature, as there are large areas with limited outcrop and drill hole control and only the roads were driven for most of the area.

Top of Bedrock

Bedrock in the St. Joseph area is usually covered by glacial drift, loess, or alluvium. This cover prevents examination of bedrock units, hampers correlation of isolated exposures, and frustrates traditional geologic mapping methods. These problems force new approaches to bedrock geologic mapping in glaciated terrain.

The first approach was to mentally classify bedrock into habitats roughly based on geomorphic landforms and processes. Bedrock occurs in four different habitats in the St. Joseph area. The habitats are: dissected bedrock is overlain by upland glacial drift and loess; bedrock covered by thick glacial drift and loess; bedrock eroded by modern rivers whose channels are now filled with alluvium; and bedrock eroded by pre-glacial drainage channels and later covered by glacial drift. The second approach was to develop a method to contour top of bedrock in each of the four bedrock habitats. A 20 ft. interval was selected to contour top of bedrock in the St. Joseph area.

Where dissected bedrock is overlain by upland glacial drift and loess, structural contours drawn on top of the uppermost rock unit represent top of bedrock.

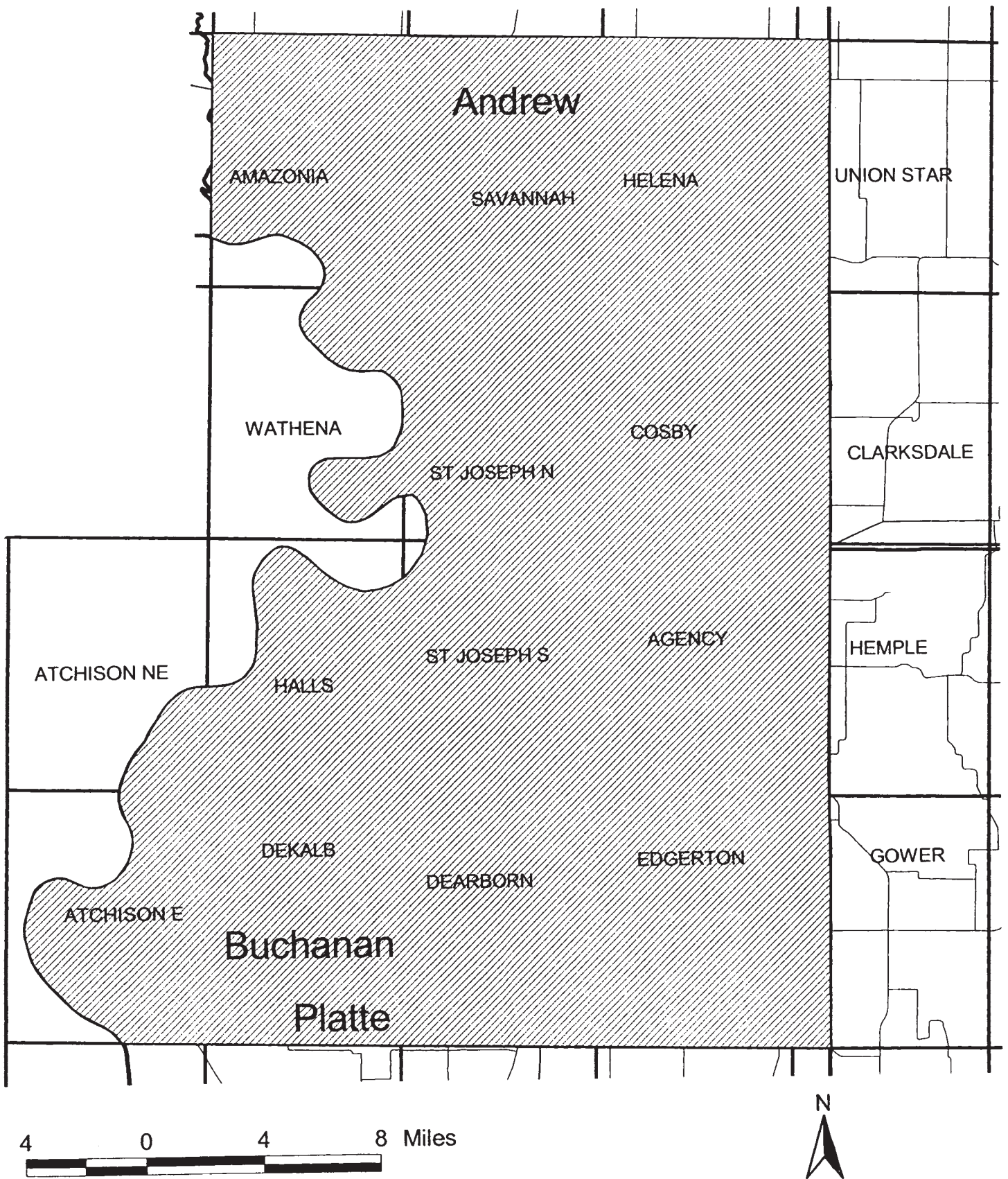


Figure 4. Area covered by bedrock geologic map.

Table 1. Major DGLS databases that support geologic mapping.

Data Base	File Name	Type	Custodian Organization	Telephone Number Electronic or Digital Products
Drill Hole Log Files			Rex Bohm	573-368-2192
	Sample log file	paper	county	tops in "Logmain," scanned images
	Drillers log file	paper	county	none
	Written log file	microfiche	county	none
Well Information Management System (WIMS)			Sharon Beistel	573-368-2168
	Water well logs	paper	reference no.	WIMS, for holes after 1987
	Monitoring well logs	paper	reference no.	WIMS, for holes after 1987
	Heat pump well logs	paper	reference no.	WIMS, for holes after 1987
Underground Injection Control (UIC), Oil & Gas			Sherri Stoner	573-368-2195
	Oil & gas well list	paper	county	Data Manager, for holes after 1966
	Some drillers logs	paper	county	none
	Geophysical logs	paper	county	none
County Stratigraphic Section Notebooks			Thomas L. Thompson	573-368-2140
	Stratigraphic sections	paper	county	Outcrop
	Field notebooks	paper	ascending no.	none
Geologic Map Repository			Mark Middendorf	573-368-2147
	Geologic maps	paper	1x2° quadrangle	
	Outcrop maps	paper	1x2° quadrangle	
Coal Files & National Coal Resources Data System (NCRDS)			David C. Smith	573-368-2183
	Sample logs	paper	county	NCRDS, USGS, in progress
	Drillers logs	paper	county	NCRDS, USGS, in progress
	Stratigraphic sections	paper	county	NCRDS, USGS, in progress
	Geophysical logs	paper	county	NCRDS, USGS, in progress
	Some old geologic maps	paper	county	
	Outcrop maps	paper	county	NCRDS, USGS, in progress
	Ug. coal mine maps	paper	county	scanned images
	Mine entry location	paper	7.5' quad	NCRDS, USGS, in progress
Library, Archives, and Publication Sales			Terry Sheffield	573-368-2125
	1 st & 2 nd Series Volumes, Reports of Investigations, Miscellaneous Publications, Information Circulars, Open File Reports, and Open File Maps			

In the case where bedrock is covered by thick glacial drift and loess, gentle slopes were contoured on top of bedrock guided by available drill hole control. Care was taken not to allow a top of bedrock contour to intersect a topographic contour of the same value. Top of bedrock contours end at topographic contours of the same elevation where bedrock, no longer covered by unconsolidated material, is exposed.

Contouring bedrock channels presents a unique set of challenges. At least five variables guide contour placement: location of the channel, width of the channel, gradient of the channel, shape of the channel in cross section, and depth of the channel. Where bedrock was eroded by modern rivers and the channel is now filled with alluvium, the location and width of the channel are obvious from topography. Channel gradient, shape, and depth are inferred from drill hole data. For example, consider contouring the top of bedrock beneath the Missouri River channel. A gradient can be estimated from comparing the elevation of the bottom of the channel in Kansas City to the elevation of the bottom of the channel north of St. Joseph. Once the distance along the river between drill holes is known and the elevation is known, a gradient can be deduced. Drill hole records suggest that top of bedrock beneath the Missouri River channel is usually steeply inclined near the sides for about two-thirds of the channel's depth and then the channel slopes gently to its maximum depth.

In the case where bedrock was eroded by pre-glacial drainage channels and then filled by glacial drift, the same variables are addressed. Heim and Howe (1962) published a map showing locations and widths of buried pre-glacial channels in northwestern Missouri at a scale of 1:315,000. Their channel location and width are a useful starting point. The shape can be assumed to be similar to that of the Missouri River channel. The gradient and depth are inferred from drill hole data. Heim and Howe's work was honored when drill hole control allowed alternative interpretations during contouring.

Two pre-glacial channels are present in the vicinity of St. Joseph. The south channel runs approximately east-west through south St. Joseph then curves to the north. The north channel cuts through the Missouri River bluffs south of Amazonia. From there the channel continues east southeast to where the two buried channels join east of St. Joseph (see Figure 5). The Platte River crosses the buried pre-glacial channel on the Cosby 7.5 Minute Quadrangle (see Figure 6). Contouring top of bedrock on the Cosby Quadrangle was done with a high degree of uncertainty.

The third approach was to develop a method to map stratigraphic horizons in the four bedrock habitats. The solution is to intersect structural contours drawn on top of the horizon to be mapped with either topographic contours or contours drawn on top of buried bedrock to produce a cropline. The four habitats can be grouped into two cases of bedrock occurrence: bedrock is either exposed on hill sides or concealed beneath unconsolidated materials.

In the situation where dissected bedrock is overlain by upland glacial drift and loess, bedrock is exposed on the hill sides. In this case, structural contours drawn on top of bedrock are used to draw the crop line between top of bedrock and the base of glacial drift. Structural contours drawn on top of each mapping horizon are intersected with the topography until all the crop lines are drawn. In situations where bedrock is covered, structural contours drawn on top of the mapping horizon are intersected with contours drawn on top of bedrock to generate sub-crop lines.

Bedrock Stratigraphy

Pennsylvanian-age strata assigned to the Missourian and Virgilian Series is present as top of bedrock throughout the map area (see Figure 7). The oldest exposed rocks are shale and sandstone of the Bonner Springs Formation, Kansas City Group, which crop out along Grove Creek southwest of Edgerton in northeast Platte County. The youngest exposed unit is the Ervine Creek Limestone Member, Deer Creek Formation, Shawnee Group, which crops out north of Amazonia and west of Savannah in Andrew County. A few feet of Calhoun shale overlies the Ervine Creek beneath glacial drift northwest of Savannah.

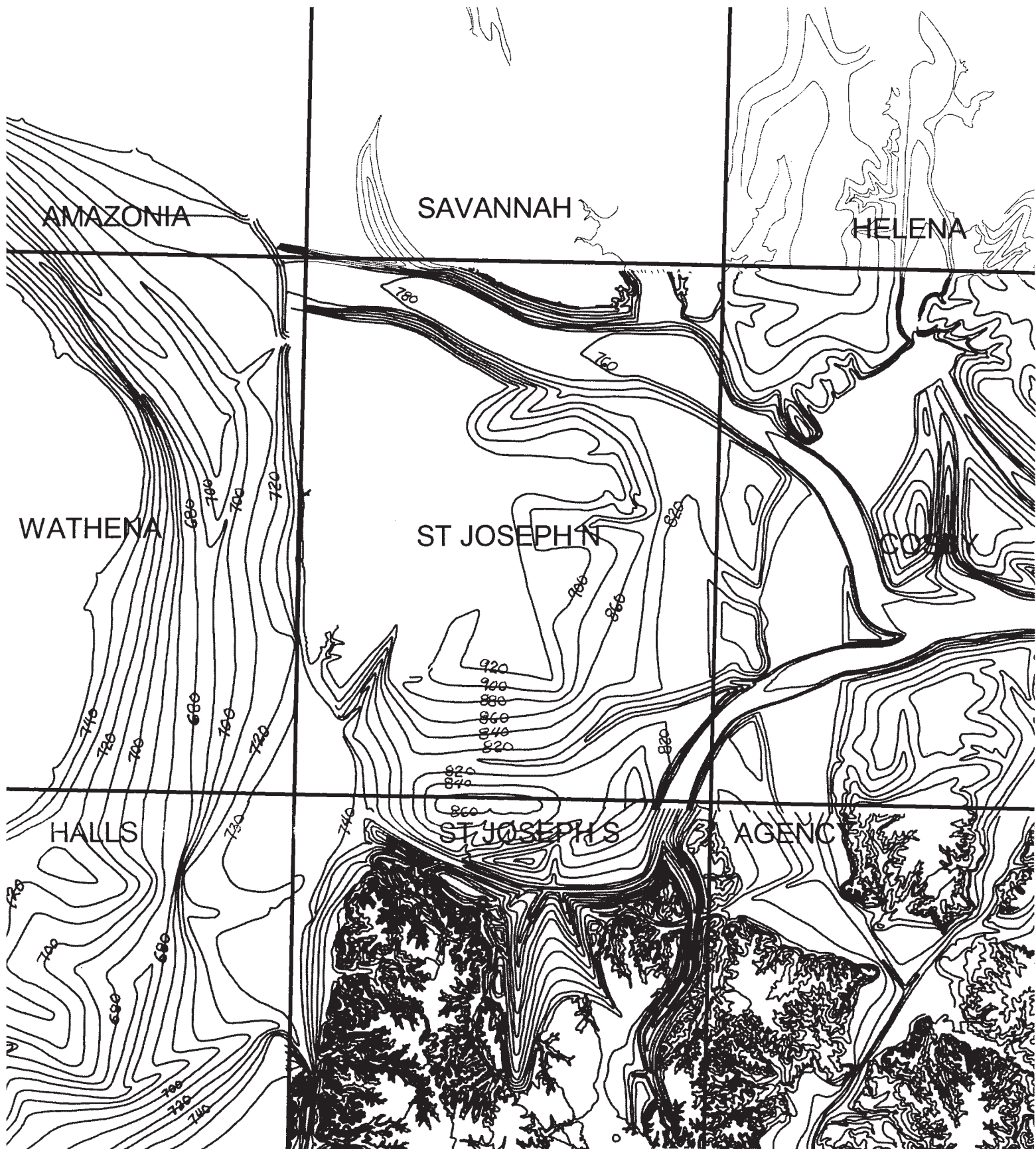


Figure 5. Bedrock topography near St. Joseph.



Figure 6. Top of Bedrock on the Cosby 7.5 Minute Quadrangle.

Above the Kansas City Group, the Plattsburg, Vilas, and Stanton Formations comprise the Lansing Group. The Plattsburg Formation is 15 to 25 ft. thick and consists of two limestone and one shale member. The uppermost Spring Hill Limestone Member varies from 10 to 20 ft. thick and often contains dark gray chert. The Vilas Formation contains 5 to 20 ft. of shale. The 35 ft. thick Stanton Formation is composed of three limestone and two shale members. The Eudora Shale Member, in part a black, fissile shale, is a distinct marker bed. The Stoner Limestone Member varies from 10 to 15 ft. thick (Howe, 1961, p. 105-106). The South Bend Limestone Member, which occurs at the top of the Lansing Group, is also an important marker bed. The Stoner is quarried south of St. Joseph. Both the Spring Hill and Stoner contain important limestone resources.

The overlying Pedee Group includes the Weston Shale and Iatan Limestone. The Weston is typically about 100 ft. thick, and is the thickest shale in the St. Joseph area. It is used to manufacture expanded lightweight aggregate. The Iatan Limestone varies from less than 5 ft. thick near St. Joseph to about 15 ft. thick in the southern part of the map area (Howe, 1961, p. 108). It was formerly quarried several places within the map area.

Above the Pedee is the Douglas Group. It includes the Stranger and Lawrence Formations. The Vinland Shale and Haskell Limestone Members are present in the St. Joseph area. Together they average about 25 ft. thick. The Tonganoxie Sandstone Member, Upper Sibley coal, and Westphalia Limestone are rarely present in this part of Missouri. The Lawrence Formation is divided into a lower unnamed shale member, Amazonia Limestone Member, and upper unnamed shale member. The lower shale thins from 75 to 80 ft. thick north and south of St. Joseph to about 50 ft. thick near the city. The Amazonia thickens northward from about 2 ft. in the south part of the map area to about 15 ft. north of St. Joseph. The upper shale member thins from about 50 ft. in the south part of the map area to about 20 ft. in southern Andrew County (Howe, 1961, p. 110). These changes in thickness allow the Amazonia to be quarried in tandem with the Plattsmouth north of St. Joseph in Andrew County.

Above the Douglas is the Shawnee Group. The Oread, Kanwaka, Lecompton, Tecumseh, Deer Creek, and lower part of the Calhoun Formations are present in the map area. The Oread consists of seven alternating limestone and shale members and is about 50 ft. thick. The Leavenworth Limestone and Heebner Shale members are important marker beds. The Leavenworth's two or more beds are a useful diagnostic tool in distinguishing between the Oread and Deer Creek Formations. The Heebner contains black fissile shale in its lower part, which makes it a reliable marker bed for geophysical logging. The Plattsmouth and Kereford Limestone Members are important sources of crushed stone in the St. Joseph area. The wavy-bedded Plattsmouth is commonly 20 ft. thick and slightly cherty, while the Kereford varies from 2 to 10 ft. thick (Howe, 1961, 111). The Kanwaka Formation is 30 to 40 ft. thick, consists mostly of micaceous shale with the 2 ft. Clay Creek Limestone Member 10 to 15 ft. above the base (Howe, 1961, 113). The 35 ft. thick Lecompton Formation contains seven members of alternating limestone and shale, a core shale underlain by thin limestone, but lacks thick limestone at the Beil horizon (Howe, 1961, p. 113-114). The Tecumseh Formation consists of 40 to 50 ft. of shale. The Ost Limestone Member is usually less than 1 ft. thick and occurs about 4 to 6 ft. above the base of the Tecumseh (Howe, 1961, p. 114). Like the Oread and Lecompton, the Deer Creek Formation consists of seven alternating members of limestone and shale. It is about 40 ft. thick and contains a core shale underlain by a single massive bed of limestone. The wavy-bedded Ervine Creek Limestone Member varies from 15 to 20 ft. thick and is slightly cherty (Howe, 1961, p. 114). The Calhoun shale consists of about 10 ft. of gray shale (Howe, 1961, p. 114-115).

Distribution of Bedrock Units

Crop lines were drawn on top of the Kansas City Group, Lansing Group, Pedee Group, Amazonia Limestone Member, Oread Formation, Lecompton Formation, and Deer Creek Formation. Contacts were generated by intersecting structural contours drawn on top of each horizon with topography in areas where bedrock is exposed. Where bedrock is covered, sub-crop lines were generated by intersecting structural contours drawn on each mapping horizon with contours drawn on top of bedrock. The resulting reconnaissance bedrock geologic map of the St. Joseph area is shown in Figure 8.

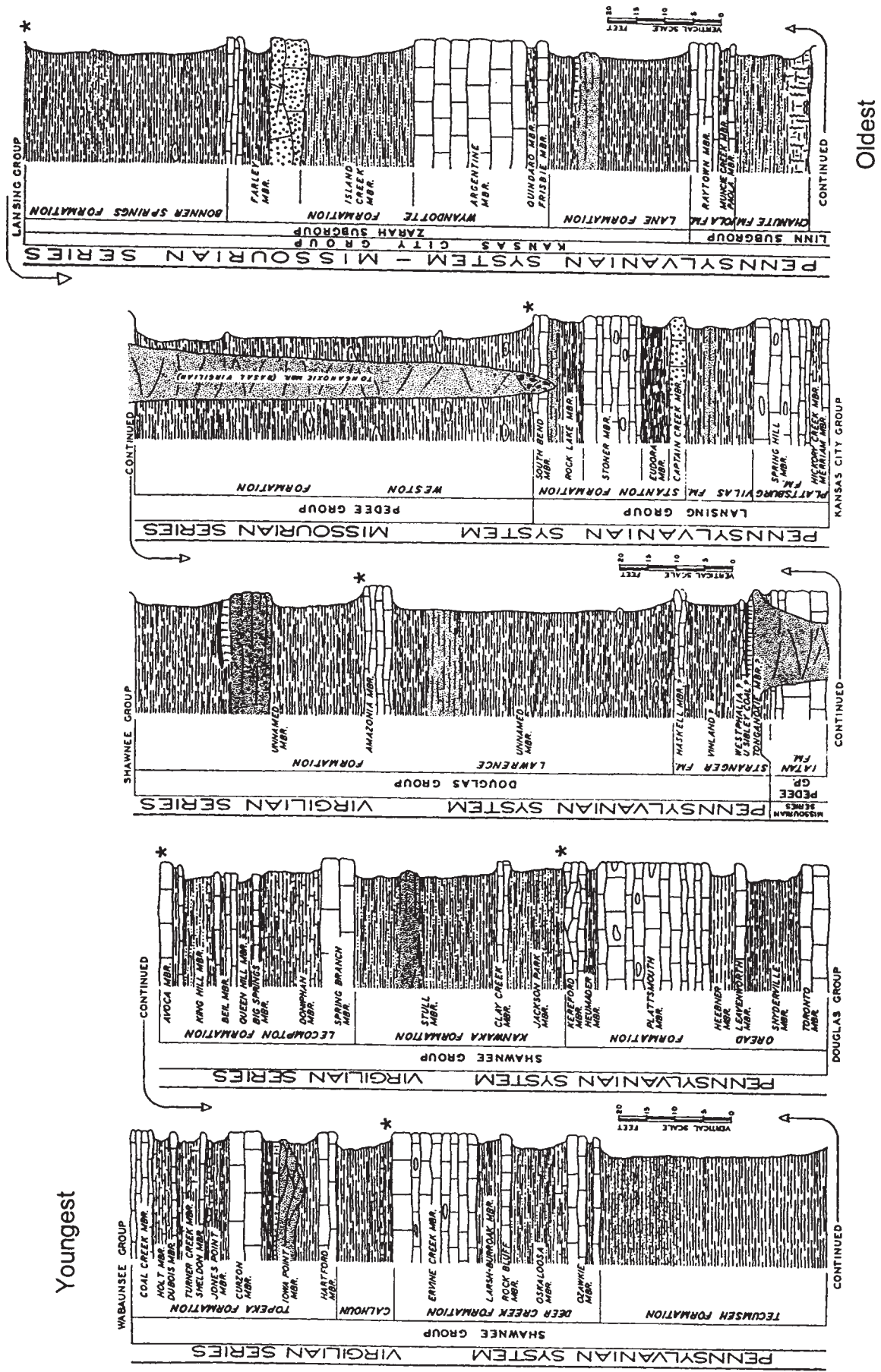


Figure 7. Stratigraphy of the St. Joseph area (after Howe, 1961, figure 20, p. 101, figure 21, p. 107, Figure 22, p. 112). An asterisk indicates mapping horizon.

Regional dip should control the overall outcrop pattern. Bedrock is expected to dip gently to the northwest in response to an estimated less than 1 degree regional dip. Older rocks should be exposed toward the east, while younger rocks should be exposed to the west.

Rocks assigned to the Kansas City Group are present as top of bedrock in the buried pre-glacial channel east and southeast of St. Joseph. Kansas City strata extend up the south fork of the buried channel into southeast St. Joseph. The Kansas City Group is exposed along Grove Creek southwest of Edgerton. It is present beneath Platte River alluvium south of Agency. It is also present beneath alluvium in Castile Creek between Edgerton and Gower.

The Lansing Group is present as top of bedrock in the buried pre-glacial channel east, northeast, and south of St. Joseph. Lansing strata extend up the south fork of the buried channel through south St. Joseph to the Missouri River Channel. The Lansing Group is exposed beneath the Missouri River channel from just south of Amazonia to just north of Halls. The window of older rocks surrounded by younger rocks suggests uplift. The Lansing is exposed along the Platte River from Agency to the southern boundary of the map area. Lansing is also exposed along Jenkins, Wolfpen, and Castile creeks from Gower to Castile Creek's confluence with the Platte River. A large area of the South Bend and Stoner Limestone Members is present as top of bedrock beneath glacial drift southwest of Gower along both sides of Castile Creek and the Platte River to the southeastern boundary of the map area. The Lansing Group is present beneath Platte River and Muddy Creek alluvium from near Cosby south to Agency.

The Pedee Group occupies upland surrounding the buried pre-glacial channel east of St. Joseph. It occupies lower ground along the south branch of the buried channel and is low in the western end of the north branch of the buried channel. The Pedee is present as top of bedrock in the Missouri River channel south of Halls. It surrounds the uplifted Lansing Group between Halls and Amazonia. It dips below the Douglas Group south of Nodaway beneath Burr Oak Bottom. The Pedee Group occupies the uplands east of the Platte River and between the Platte and the Third Fork. The Iatan dips below the Platte River at Rochester Falls and below the Douglas along Muddy Creek east of Rochester. The Iatan is top of bedrock on much of the Agency, Hemple, and Edgerton Quadrangles. The Pedee is overlain by Douglas near the western boundaries of the Edgerton and Agency Quadrangles. The Pedee Group is exposed along Bee Creek and its tributaries and is overlain by the Douglas near Faucett. It is exposed for a short distance up Jordan Branch south of Wallace. It is present below alluvium for about a third of the distance up Contrary Creek south of St. Joseph. The Iatan is exposed just above alluvium or under shallow cover along the east side of the Missouri River from the south boundary of the map to Amazonia.

The Amazonia Limestone Member of the Lawrence Formation is exposed or under shallow cover along the Missouri River Bluffs from the south boundary of the map to about midway between Amazonia and Nodaway. It is exposed along the 102 River on the Savannah Quadrangle. It is also exposed along each side of Bee Creek and is present as top of bedrock over a large area east of Faucett. An exceptionally thick Amazonia outlier is present in the highlands east of Agency and north of Highway H.

The Plattsmouth or Kereford Limestone Member of the Oread Formation is present as top of bedrock over a large area in the uplands east of the Missouri River from the south map boundary to the south side of St. Joseph. It is also top of bedrock for much of the area between the south and north forks of the pre-glacial channel and east side of the Missouri River channel in the central and north part of St. Joseph. The Plattsmouth is present in the uplands as top of bedrock east of Union Star and over much of the Helena Quadrangle. The Plattsmouth dips westward until it is 20 feet above road level at Nodaway and then dips below the level of the Nodaway River south of I-29.

The Avoca Limestone Member of the Lecompton Formation is present as top of bedrock along the northern part of the boundary between the Savannah and Helena Quadrangles. It is also top of bedrock in the uplands west of the 102 River and east of Savannah.

The Ervine Creek Limestone Member of the Deer Creek Formation is present as top of bedrock in the uplands in a portion of the northwest Savannah Quadrangle and throughout the Amazonia Quadrangle.

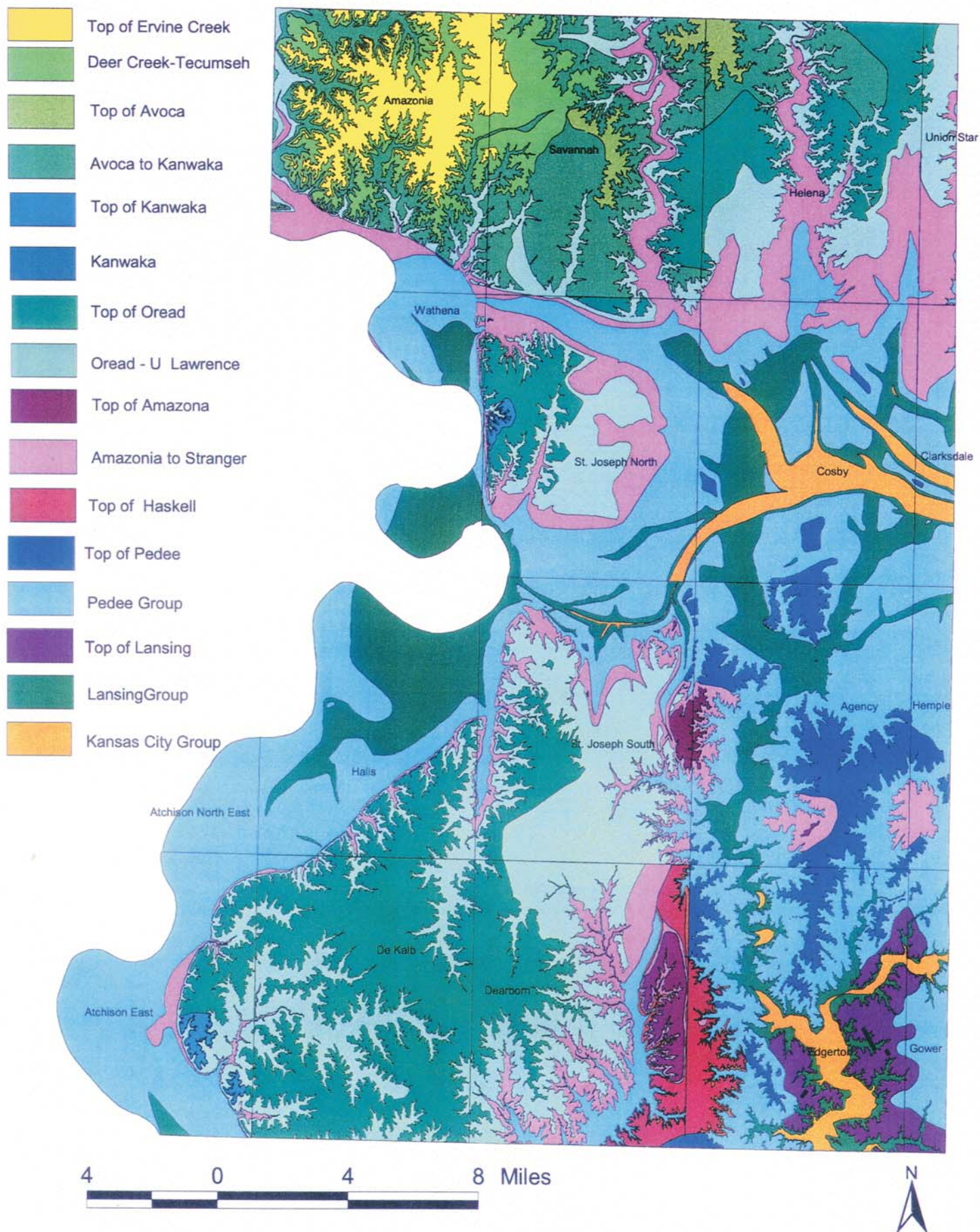


Figure 8. Preliminary reconnaissance bedrock geologic map of the St. Joseph area.

Saturday, September 30, 2000 Field Trip

The AMG Saturday, September 30, 2000, field trip will depart at 8:30 a.m. from the parking lot north of the Holiday Inn Riverfront Conference Center, 102 South 3rd Street, St. Joseph, MO. Transportation will be by yellow Laidlaw busses. This trip will examine Pennsylvanian-age bedrock stratigraphy in the northern St. Joseph area. Stops include exposures of Iatan Limestone, Lawrence, Oread, Kanwaka, Lecompton, and Deer Creek Formations. These units, along with the Tecumseh Formation, comprise the bedrock exposed or directly beneath Quaternary glacial drift and loess in northern Buchanan County and Andrew County. We will also see the north St. Joseph pre-glacial channel in cross section south of Amazonia. An itinerary and road log follows. Figure 9 shows the location of each stop.

Mileage	Point of Departure
Itinerary	
0.0	8:30 a.m. depart Holiday Inn parking lot northwest of 3 rd and Edmond Streets
	proceed south on 3 rd Street
0.1	turn left on Edmond Street
0.5	turn right on 9 th Street
2.0	turn left on Garfield
2.1	turn right on 10 th Street
2.3	turn right on Belle Street
2.4	turn left at chain link fence, proceed behind Pony Express warehouse to Stop 1 estimated travel time: 10 min.

8:40 a.m. to 9:15 a.m. examine **Iatan Limestone**

0.0	depart Stop 1, turn right on Belle Street
0.1	turn left on 10 th Street
0.2	turn left on Atchison Street
0.5	turn right on 6 th Street, turn right onto ramp, take I-229 North
11.3	turn around at I-29 and take I-229 South
14.0	pull off to the shoulder of I-229 at Stop 2 estimated travel time: 20 min.

9:35 a.m. to 10:00 a.m. examine part of the **Lawrence Formation**

14.0	depart Stop 2, continue south on I-229
14.4	Pull off to the shoulder of I-229 at Stop 3 estimated travel time: 5 min.

10:05 a.m. to 10:50 a.m. examine the **Oread Formation**, porta john rest stop

14.4	depart Stop 3, continue south on I-229
15.1	turn right on Highway K
18.6	north St. Joseph pre-glacial channel along the east side of Highway K
19.3	turn left on Highway T at Amazonia
23.7	Highway T becomes County Road 402
23.9	turn left on County Road 400
24.9	park to the right opposite farm road railroad crossing to the left at Stop 4 estimated travel time: 20 min.

11:10 a.m. to 11:45 a.m. examine the **Kanwaka Formation**

24.9	depart Stop 4, continue west on County Road 400
25.6	turn right onto Department of Conservation parking area at Stop 5 estimated travel time: 5 min.

Mileage Point of Departure, continued

11:50 a.m. to 12:45 p.m. lunch and porta-john rest stop
12:45 p.m. to 1:30 p.m. examine **Lecompton Formation**

0.0 depart Stop 5, go east on County Road 400
1.7 turn right on County Road 402
1.8 continue straight on Highway T
6.3 turn left on Highway K
6.9 **Plattsmouth Limestone Member, Oread Formation** exposed on the right
8.9 turn left on I-29 North
9.3 park off of the pavement along I-29 on ramp at **Stop 6**
 estimated travel time: 20 min.

1:50 p.m. to 2:30 p.m. examine **Deer Creek Formation**

0.0 depart Stop 6, continue on I-29 North
 Deer Creek Formation is exposed along this part of I-29
13.8 turn around at Fillmore exit, Exit 65, take I-29 South
20.1 **Avoca Limestone Member, Lecompton Formation** exposed on northeast side of I-29
22.2 turn right on I-229 South
30.7 turn left on Exit 6A, Felix Street
30.9 turn left on South 3rd Street
31.1 turn left into Holiday Inn parking lot
 estimated travel time: 20 min.

3:00 p.m. field trip ends

The approximate distance covered during the Saturday field trip is 60 miles. Total travel time is estimated to be 1 hr. 40 min.

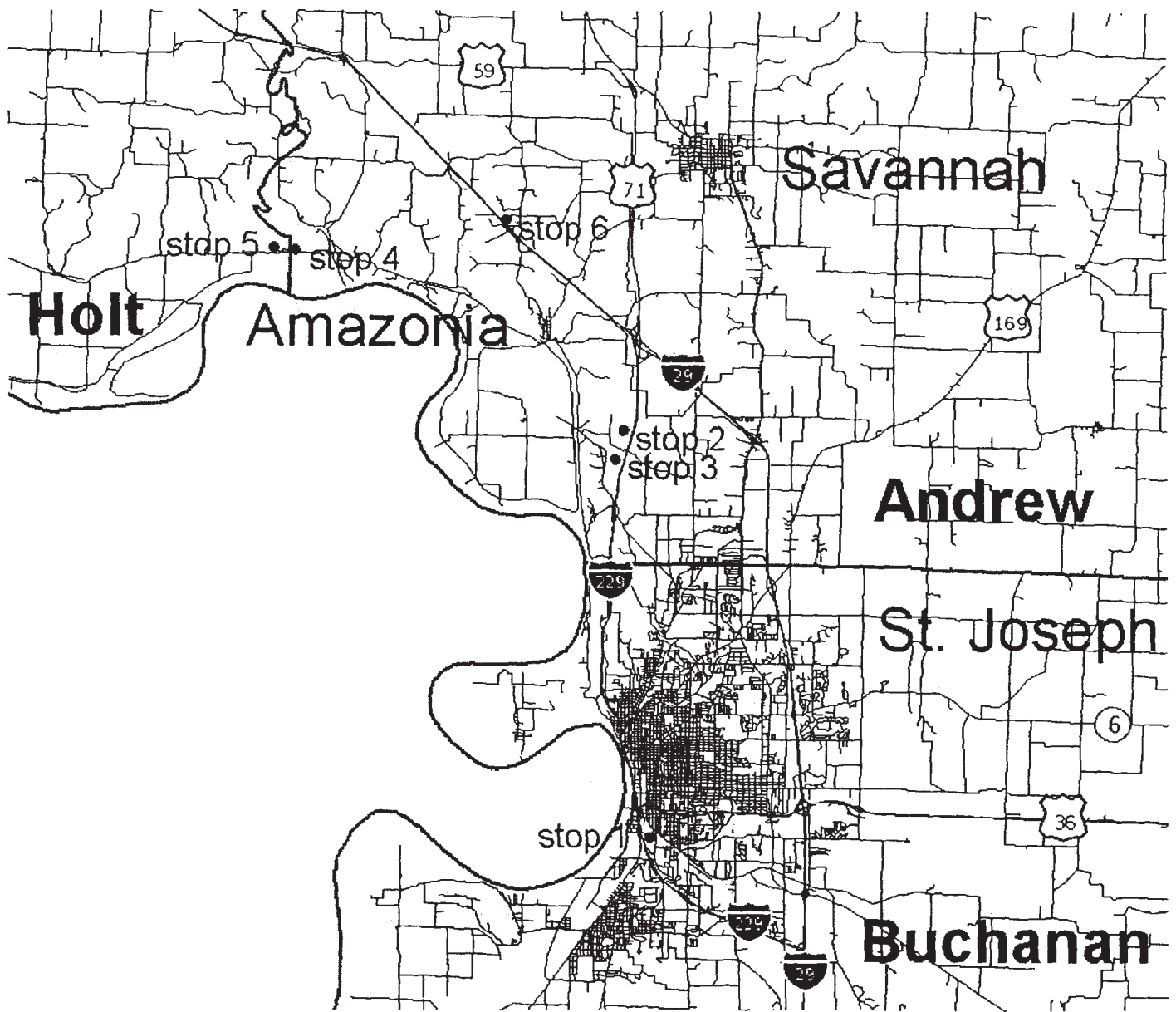


Figure 9. Map of Saturday, September 30, 2000 field trip route.

Stop 1 Iatan Limestone

This is the best of four exposures of the Iatan Limestone within the city of St. Joseph, and the only place in the city where its full thickness is observed. This exposure is on the south bank of a buried pre-glacial channel that lies beneath south St. Joseph. Figure 10 shows the stratigraphic position of the Iatan. It is recognized by its position above an approximately 100 ft. thick Weston shale and below the 50 to 80 ft. thick lower unnamed shale and 2 to 15 ft. thick Amazonia Limestone, both of the Lawrence Formation. Figure 11 shows the position of the pre-glacial channel in south St. Joseph.

Measured stratigraphic section at Stop 1.

Buchanan County, Missouri

St. Joseph South 7.5 Minute Quadrangle

SW ¼, SE ¼, SE ¼, NW ¼, SE ¼, Sec. 20, T. 57 N., R. 35 W.

Elevation of base of section (track level) estimated from topographic map.

Measured from exposures on the southwest cut bank of Whitehead Creek just southwest of Pony Express warehouse by David C. Smith, February 25, 1996.

Correlation

Unit No.	Description	Elevation	Thickness
Quaternary System:			
5.	Loess, to top of hill.		
Pennsylvanian System, Missourian Series, Pedee Group			
	Iatan Formation: 3 ft. 7 in.	856 ft. 3 in.	
4.	Limestone, pale yellowish brown (10YR6/2) mottled yellowish gray (5Y7/2), weathers light olive gray (5Y5/2), finely crystalline, mudstone, massive, poorly developed stratification, hard, weathers into irregular plates.	854 ft. 11 in.	1 ft. 4 in.
3.	Limestone, yellowish gray (5Y7/2) mottled light olive gray ((5Y5/2), finely crystalline, mudstone, argillaceous, poorly developed stratification, weathers into irregular plates.	854 ft. 1 in.	10 in.
2.	Limestone, deeply weathered moderate brown (5Y4/4) to moderate yellowish brown (105Y4/4) to moderate yellowish brown (105/4), finely crystalline, mudstone, massive, poorly developed stratification, hard.		1 ft. 5 in.
	Weston Formation:	852 ft. 8 in.	
1.	Shale, covered to track level.		12 ft. 8 in.
		840 ft. 0 in.	
	Total Thickness		16 ft. 3 in.

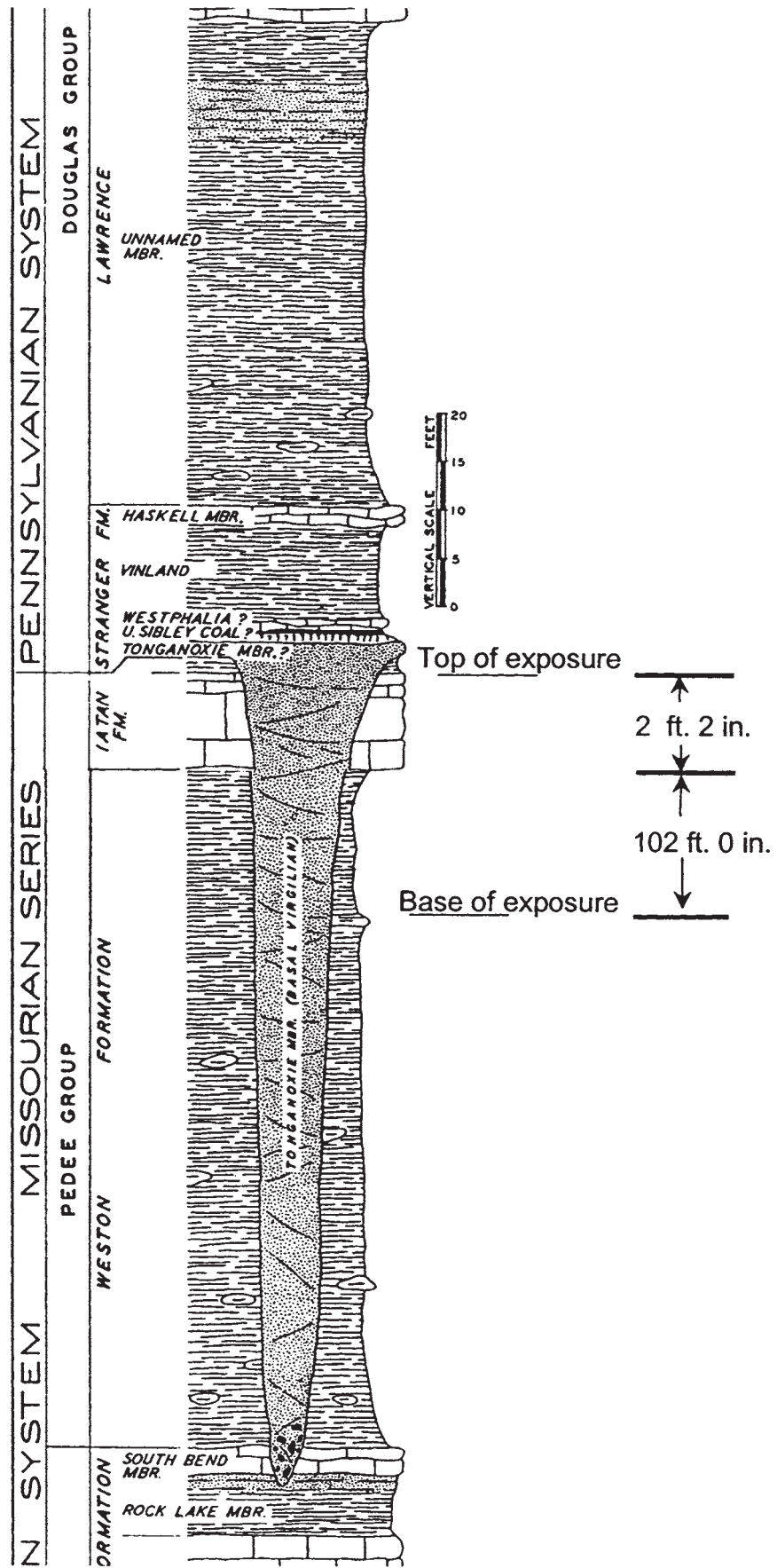


Figure 10. Iatan Limestone in south St. Joseph (after Howe, 1961, figure 21, p. 107).

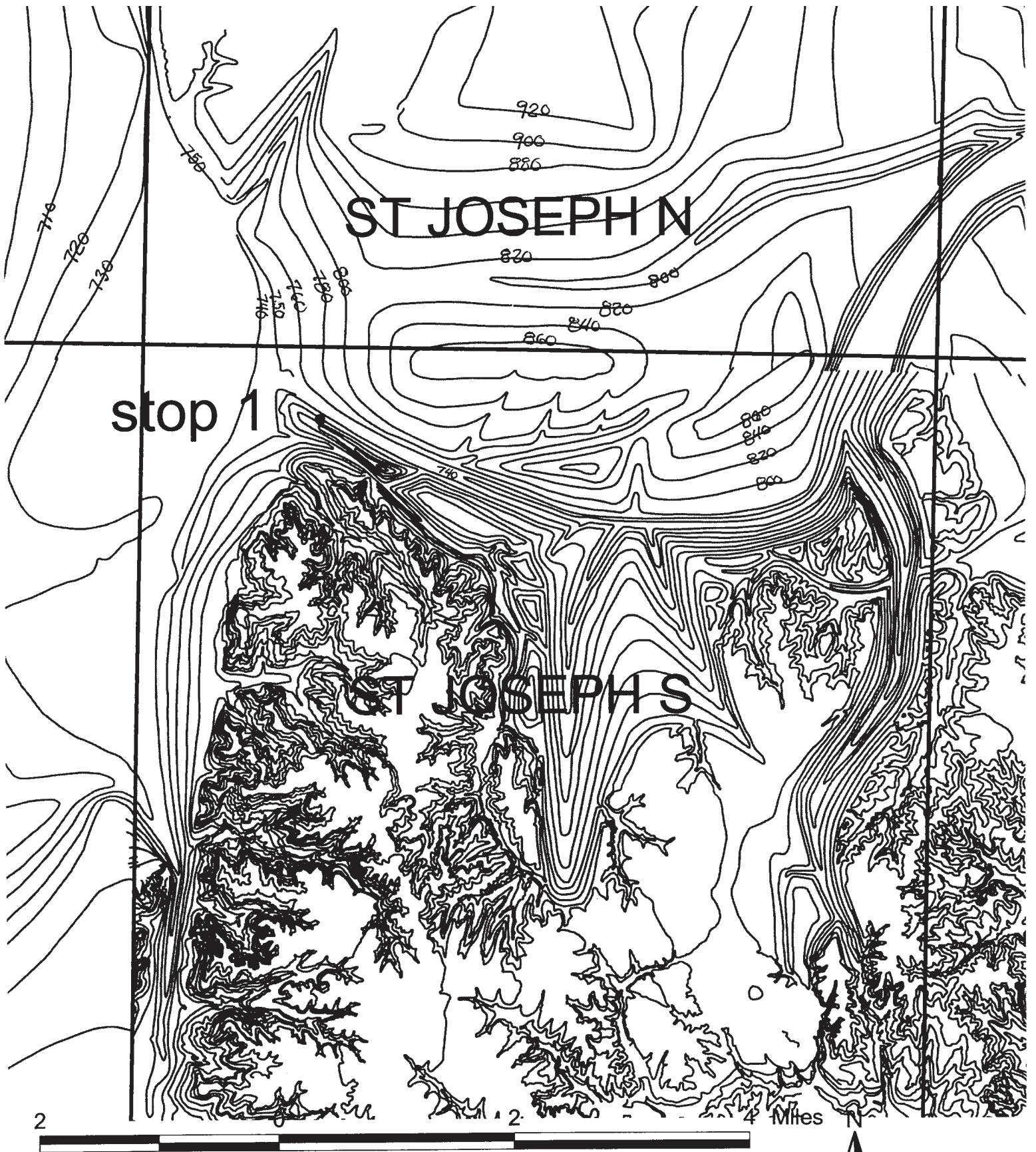


Figure 11. Pre-glacial channel south of St. Joseph.

Stop 2 Amazonia Limestone

This is the best and most accessible exposure of the Amazonia Limestone Member of the Lawrence Formation in Missouri. Figure 12 provides an overview of the succession and thickness of units at Stops 2 and 3. A stratigraphic section of the units exposed at Stops 2 and 3 follows Figure 12.

The Amazonia is distinguished from other limestone in the St. Joseph area by its stratigraphic position, thickness, internal brecciated texture, and iron content. Regionally, the Amazonia thins to about 2 ft. in southwest Buchanan County. An 18 ft. thick limestone outlier correlated with the Amazonia is exposed along Highway H east of Agency in southeast Buchanan County.

Historically the Amazonia has been an important source of crushed limestone and concrete aggregate. The upper Lawrence shale thins in the St. Joseph area and northward into southern Andrew County. This allows the Amazonia and Plattsmouth limestones to be quarried in tandem in the area lying between St. Joseph, Amazonia, and Savannah.

This exposure is located on the south bank of the buried pre-glacial channel that drains east southeast. A spectacular view of cropland to the north suggests there is an incongruity between the tree-covered slopes on the south side of Dillon Creek. The southern edge of the buried pre-glacial channel corresponds to the bed of Dillon Creek at this location. The position of the pre-glacial channel is shown in Figure 13.

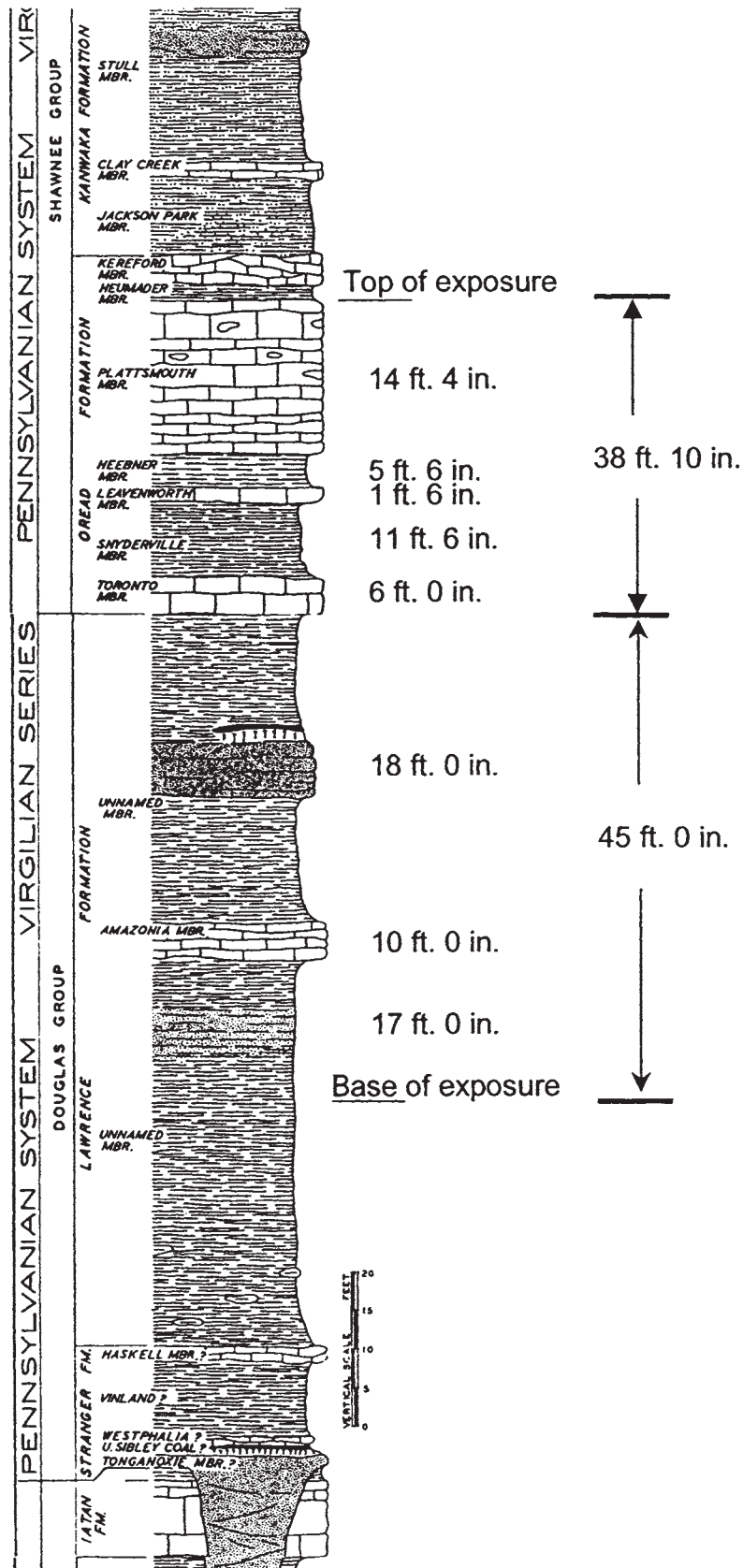


Figure 12. Lawrence and Oread Formations north of St. Joseph (after Howe, 1961, figure 21, p. 107 and figure 22, p. 112).

Measured stratigraphic section at Stops 2 and 3.

Andrew County, Missouri

St. Joseph North 7.5 Minute Quadrangle

Top: SW ¼, SW ¼, SW ¼, Sec. 8, T. 58 N., R. 35 W.

Base: NE ¼, NE ¼, SW ¼, NW ¼, SW ¼, Sec. 8, T. 58 N., R. 35 W.

Elevation on top of Amazonia Limestone Member, Lawrence Formation estimated from topographic map.

Measured from exposures on west side of I-229, south of Dillon Creek by David C. Smith, June 19, 1996.

Correlation

Unit No.	Description	Elevation	Thickness
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Quaternary System:

Loess, poorly exposed, extends to top of hill.

Pennsylvanian System, Virgilian Series, Shawnee Group

Oread Formation:

Plattsmouth Limestone Member: 976 ft. 10 in.

17. Limestone, weathered grayish orange (10YR7/4) to moderate yellowish brown (10YR5/4), finely crystalline, mudstone, massive, present as single bed, very hard, fossiliferous, brachiopod fragments are common. 1 ft. 10 in.

975 ft. 0 in.

16. Limestone, light gray (N7) to light olive gray (5Y6/1), deeply weathered yellowish gray (5Y7/2), finely crystalline, mudstone to wackestone, wavy bedded, 2 to 17 in. bed thickness, 5.5 in. average bed thickness, contains numerous ½ to 3 in. thick grayish orange (10YR7/4) calcareous shale partings between limestone beds, partings often contain flattened limestone concretions, shale is about 8 % of the unit's total volume, contains about 3% chert, mottled medium light gray (N6) and medium dark gray (N4), fossiliferous, brachiopod fragments and fusulinids are common. 6 ft. 4 in.

968 ft. 8 in.

15. Shale, weathered grayish orange (10YR7/4), silty, calcareous, contains flattened limestone concretions, persistent parting. 2 in.

968 ft. 6 in.

14. Limestone, pale yellowish brown (10YR6/2), occasionally mottled pinkish gray (5YR8/1), lowest 6 in. is light olive gray (5Y5/2) to medium light gray (N6) which may represent typical unweathered colors of this unit, deeply weathered grayish orange (10YR7/4), finely crystalline, mudstone to wackestone, wavy bedded, 2 to 11 in. bed thickness, 6 in. average bed thickness, contains numerous ½ to 2 in. thick grayish orange (10YR7/4) calcareous shale partings between limestone beds, shale is about 3 % of the unit's total volume, fossiliferous, crinoid fragments are common, chert free. 6 ft. 0 in.

Heebner Shale Member: 962 ft. 6 in.

13. Shale, olive gray (5Y3/2) at base grading upward to medium dark gray (N4) near top, weathers olive gray (5Y3/2), medium gray (N5), and light gray (N7), upper 6 in. stained dark yellowish orange (10YR6/6), silty, thickly laminated to thinly bedded, becomes somewhat blocky near top, parallel horizontal stratification. 2 ft. 6 in.

960 ft. 0 in.

12. Shale, black (N1), weathers medium dark gray (N4) to medium gray (N5), fissile in part, parallel horizontal stratification, carbonaceous, contains phosphatic nodules, soft. 3 ft. 0 in.

Leavenworth Limestone Member: 957 ft. 0 in.

11. Limestone, light brownish gray (5YR6/1) to brownish gray (5YR4/1), weathers medium light gray (N6), very finely crystalline, mudstone, present in one bed (?), poorly exposed, typically covered with talus, base not exposed. 1 ft. 6 in.

Snyderville Shale Member: 955 ft. 6 in.

10. Shale, dark gray (N3), weathers light gray (N7), silty, parallel horizontal stratification, abundant myalinid clam and brachiopod fragments occur at the top, this unit is at the top of the first bench of the upper road cut. 11 ft. 6 in.

Measured stratigraphic section at Stops 2 and 3, continued.

Correlation Unit No.	Description	Elevation	Thickness
Toronto Limestone Member:		944 ft. 0 in.	
9.	Limestone, weathered pale yellowish orange (10YR8/6), finely crystalline, mudstone to wackestone, silty, irregularly bedded, parallel to subparallel stratification, very permeable.	941 ft. 6 in.	2 ft. 6 in.
8.	Limestone, medium dark gray (N4), weathers medium gray (N5), mudstone to wackestone, argillaceous, calcareous shale content increases laterally, irregularly bedded.	941 ft. 0 in.	6 in.
7.	Limestone, grayish orange (10YR7/4) and dark yellowish orange (10YR6/6), wackestone to packstone, finely crystalline, one bed, fossil fragments stand in relief above weathered surface.	939 ft. 4 in.	1 ft. 8 in.
6.	Limestone, grayish orange (10YR7/4) and dark yellowish orange (10YR6/6), weathers pale yellowish orange (10YR8/6), grayish orange (10YR7/4), and dark yellowish orange (10YR6/6), mudstone to wackestone, finely crystalline, argillaceous, irregularly bedded.	938 ft. 9 in.	7 in.
5.	Limestone, grayish orange (10YR7/4) and dark yellowish orange (10YR6/6), weathers pale yellowish orange (10YR8/6), grayish orange (10YR7/4), and dark yellowish orange (10YR6/6), wackestone to packstone, finely crystalline, occasionally medium crystalline, one bed, fossil fragments stand in relief on weathered surface.		9 in.
Douglas Group:			
Lawrence Formation:			
Upper Unnamed Shale Member:		938 ft. 0 in.	
4.	Shale, olive gray (5Y3/2), weathers medium light gray (N6), stained moderate yellowish brown (10YR5/4), silty, thickly laminated, parallel horizontal to subparallel stratification, poorly exposed, this unit is at the base of the upper road cut south of the Amazonia exposure.	932 ft. 4 in.	5 ft. 8 in.
3.	Shale, covered, approximate thickness.		12 ft. 4 in.
Amazonia Limestone Member:		920 ft. 0 in.	
2.	Limestone, light gray (N7), very light gray (N8), and yellowish gray (5Y7/2), weathers pale yellowish brown (10YR6/2) and light olive gray (5Y5/2), predominantly mudstone, some wackestone and packstone, finely crystalline, occasionally medium crystalline, dense, hard, massive, parts of exposure show stratification of algal material and fossil fragments, other portions have a brecciated texture often accompanied by secondary calcite, goethite (?), and rarely rhodochrosite (?) mineralization, dominant joint set N 17° W, subordinate joint set N 70° E.		10 ft. 0 in.
Lower Unnamed Shale Member:		910 ft. 0 in.	
1.	Shale, medium gray (N5) with olive gray (5Y3/2) and yellowish gray (5Y7/2) laminae, weathers medium light gray (N6) to brownish gray (5YR4/1), silty, thinly laminated to thinly bedded, parallel horizontal stratification, contains occasional thin yellowish gray (5Y7/2) micaceous siltstone beds and pods, and occasional clay ironstone concretions moderate brown (5R3/4) to dark reddish brown (10R3/4) on the outside and olive gray (5Y4/1) on the inside, base not exposed.	893 ft. 0 in.	17 ft. 0 in.
Total Thickness			83 ft. 10 in.

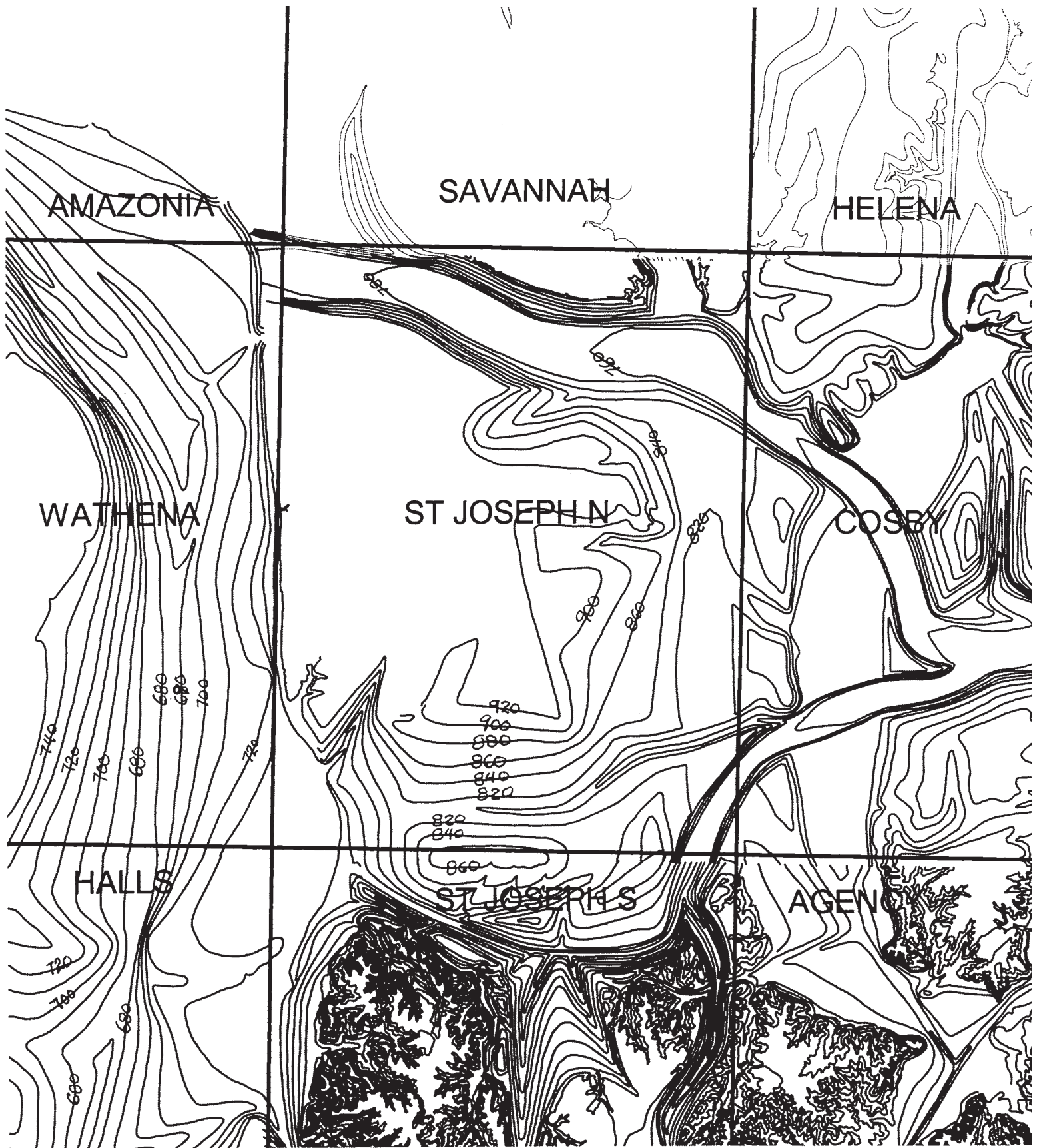


Figure 13. Pre-glacial channel north of St. Joseph.

Stop 3 Oread Formation

This is the most accessible exposure of the Oread Formation in Missouri. Figure 12 provides an overview of the succession and thickness of units at Stop 3. A stratigraphic section follows Figure 12.

The Oread Formation is distinguished by two or more beds present in the Leavenworth and by the presence of the Kereford limestone above the Plattsmouth.

View of North St. Joseph Pre-Glacial Channel

A cross section of the north St. Joseph buried pre-glacial channel can be observed along Highway K south of Amazonia. See Figure 13 for a plan view of this channel.

Stop 4 Kanwaka Formation

Figure 14 shows the rock succession of rocks and thickness of units at Stop 4 and 5. A measured stratigraphic section at Stop 4 follows Figure 14.

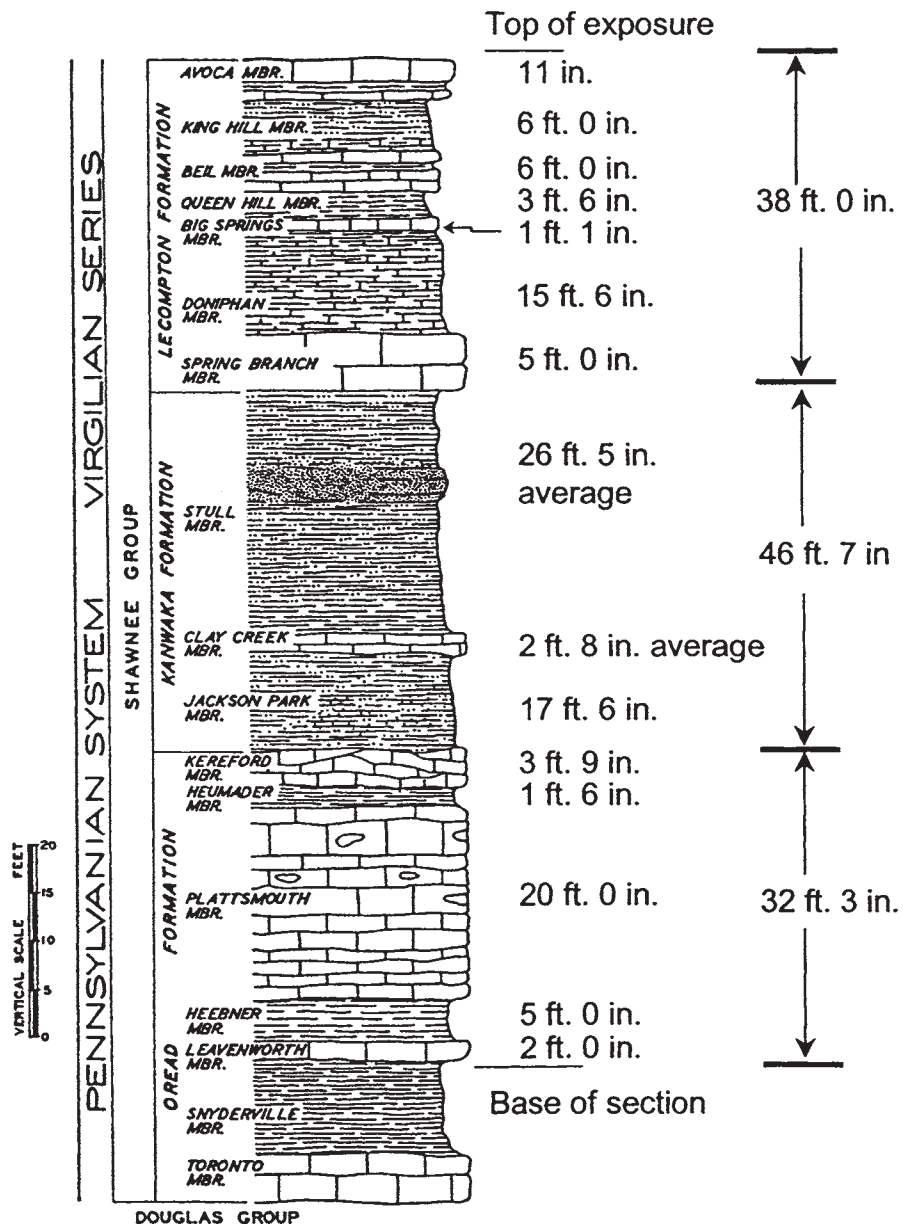


Figure 14. Oread, Kanwaka, and Lecompton Formations near the mouth of the Nodaway River (after Howe, 1961, figure 22, p. 112).

Measured stratigraphic section at Stop 4.

Andrew County

Amazonia 7.5 Minute Quadrangle

N ½, S ½, SE ¼, SW ¼, SW ¼, Sec. 19, T. 59 N., R. 36 W.

Elevation on top of Jackson Park Shale Member estimated from topographic map.

Exposures on east hill side west of the Nodaway River along north side of County Road 400 and north side of railroad tracks.

Units 5-19 measured by David C. Smith, March 20, 1996.

Units 1-9 from Hinds and Greene, 1914, p. 181.

Correlation

Unit No.	Description	Elevation	Thickness
Pennsylvanian System, Virgilian Series, Shawnee Group			
Lecompton Formation:			
Spring Branch Limestone Member:			
		936 ft. 4 in.	
22.	Limestone, mottled dark yellowish brown (10YR4/2) and moderate yellowish brown (10YR5/4), weathers grayish orange (10YR7/4), finely crystalline, mudstone, weathers into plates.		2 ft. 0 in.
		934 ft. 4 in.	
21.	Limestone, mottled grayish orange (10YR7/4) and pale yellowish orange (10YR8/6), weathers grayish orange (10YR7/4), finely crystalline, wackestone.		1 ft. 5 in.
		932 ft. 11 in.	
20.	Limestone, dark yellowish brown (10YR4/2), weathers very pale orange (10YR8/2), finely crystalline, wackestone with mudstone clasts.		1 ft. 7 in.
Kanwaka Formation:			
Stull Shale Member:			
		931 ft. 4 in.	
19.	Clay stone, weathers moderate yellowish brown (10YR5/4), slightly silty, blocky.		2 ft. 6 in.
		928 ft. 10 in.	
18.	Clay shale, medium light gray (N6), slightly silty.		2 ft. 6 in.
		926 ft. 4 in.	
17.	Shale interbedded with siltstone, weathers grayish orange (10YR7/4).		2 ft. 0 in.
		924 ft. 4 in.	
16.	Shale, medium light gray (N6) at top, light olive gray (5Y5/2) at base, slightly silty.		21 ft. 3 in.
		903 ft. 1 in.	
15.	Shale, medium gray (N5) to medium dark gray (N4), slightly silty.		0 ft. 3 in.
Clay Creek Limestone member:			
		902 ft. 10 in.	
14.	Limestone, mottled grayish orange (10YR7/4) and yellowish gray (5Y7/2) with some light brown (5YR5/6), weathers yellowish gray (5Y7/2), finely crystalline, with scattered medium crystalline grains, mudstone to packstone.		1 ft. 3 in.
		901 ft. 7 in.	
13.	Limestone, mottled grayish orange (10YR7/4) and yellowish gray (5Y7/2), weathers yellowish gray (5Y7/2), finely crystalline, mudstone, argillaceous, irregularly bedded with parallel to subparallel stratification.		1 ft. 7 in.
Jackson Park Shale Member:			
		900 ft. 0 in.	
12.	Shale, light olive gray (5Y5/2), weathers yellowish gray (5Y7/2), slightly silty, a silt-rich zone is present from 3 to 4 ft. below top, parallel to subparallel stratification.		17 ft. 6 in.
Oread Formation:			
Kereford Limestone Member:			
		882 ft. 6 in.	
11.	Limestone, pale yellowish brown (10YR6/2), deeply weathered grayish orange (10YR7/4) with abundant light brown (5R5/6) fossil casts, finely crystalline, wackestone, massive, dripstone deposited on joint planes, with thin shale parting at base.		1 ft. 3 in.
		881 ft. 3 in.	

Measured stratigraphic section at Stop 4, continued.

Correlation Unit No.	Description	Elevation	Thickness
10.	Limestone, pale yellowish brown (10YR6/2), finely crystalline, wackestone, irregularly bedded, with thin shale parting at base.	880 ft. 0 in.	1 ft. 3 in.
9.	Limestone, mottled light olive gray (5Y5/2) and light olive gray (5Y6/1), finely crystalline, mudstone, nodular.	878 ft. 9 in.	1 ft. 3 in.
	Heumader Shale Member:		
8.	Shale, weathered moderate yellowish brown (10YR5/4), silty, poorly exposed.	877 ft. 3 in.	1 ft. 6 in.
	Plattsmouth Limestone Member:		
7.	Limestone, light olive gray (5Y6/1) and yellowish gray (5Y7/2) at top to light olive gray (5Y6/1) and light gray (N7) at base, weathers yellowish gray (5Y7/2), contains abundant light brown (5YR5/6) oxidized fossil casts in upper 1 ft. 4 in., finely crystalline, mudstone to wackestone, irregularly to wavy bedded, bed thickness from base to top is 22, 19, 14, 5, and 9 in.	871 ft. 3 in.	6 ft. 0 in.
6.	Limestone, thin wavy beds with shale partings, covered along east-west gravel road, exposed on north side of railroad track.	859 ft. 9 in.	11 ft. 6 in.
5.	Limestone, light gray (N7) to yellowish gray (5Y8/1), weathers pale yellowish brown (10YR6/2) to grayish orange (10YR7/4), finely crystalline, mudstone to wackestone, present as one massive resistant bed in road.	858 ft. 9 in.	1 ft. 0 in.
4.	Limestone, thin wavy beds with shale partings, covered along east-west gravel road, exposed along north side of railroad track.		1 ft. 6 in.
	Heebner Shale Member:	857 ft. 3 in.	
3.	Shale, blue or gray, argillaceous, not observed by Smith.	855 ft. 3 in.	2 ft. 0 in.
2.	Shale, black, bituminous, slaty, not observed by Smith.		3 ft. 0 in.
	Leavenworth Limestone Member:	852 ft. 3 in.	
1.	Limestone, gray, compact, in two layers, not observed by Smith.		2 ft. 0 in.
		850 ft. 3 in.	
	Total Thickness		86 ft. 1 in.

Stop 5 Lecompton Formation

This is one of the most spectacular bedrock exposures in Missouri. The view of the Missouri River and Burr Oak Bottom is unsurpassed anywhere. Couple this with the constant passage of coal trains to the south and empties to the north and you get a sense of commerce in the middle of a serene view.

Figure 14 shows the rock succession of rocks and thickness of units at Stops 4 and 5. A measured stratigraphic section at Stop 5 follows.

Measured stratigraphic section at Stop 5.

Holt County, Missouri

Forbes and Amazonia 7.5 Minute Quadrangles

Top: NW ¼, SW ¼, SE ¼, SW ¼, SE ¼, Sec. 24, T. 59 N., R. 37 W. Amazonia Quadrangle

Base: N ½, S ½, SW ¼, SW ¼, SE ¼, Sec. 24, T. 59 N., R. 37 W. Forbes Quadrangle

Elevation at base of Jackson Park Shale Member estimated from topographic map.

Exposures in road cut along north side of east-west county road.

Measured by David C. Smith, March 20, 1996.

Correlation

Unit No.	Description	Elevation	Thickness
Pennsylvanian System, Virgilian Series, Shawnee Group			
	Tecumseh Formation:	943 ft. 1 in.	
	20. Shale residuum, approximate thickness.		3 ft. 0 in.
Lecompton Formation:			
	Avoca Limestone Member:	940 ft. 1 in.	
	19. Limestone, deeply weathered yellowish gray (5Y7/2), finely crystalline, mudstone, irregularly bedded, weathers into plates.		11 in.
	King Hill Shale Member:	939 ft. 2 in.	
	18. Shale, olive gray (5Y4/1), weathers yellowish gray (5Y7/2), silty, contains nodular limestone in lowest 24 in. and 18 to 24 in. below top, poorly exposed.		6 ft. 0 in.
	Beil Limestone Member:	933 ft. 2 in.	
	17. Limestone, interbedded with calcareous shale; limestone is yellowish gray (5Y7/2) to very light gray (N8), weathers grayish orange (10YR7/4), finely crystalline, wackestone; shale typically weathers yellowish gray (5Y7/2), slightly silty.		6 ft. 0 in.
	Queen Hill Shale Member:	927 ft. 2 in.	
	16. Shale, light olive gray (5Y5/2), weathers yellowish gray (5Y7/2), slightly silty, thinly laminated, subparallel stratification.		1 ft. 5 in.
		925 ft. 9 in.	
	15. Shale, black (N1), weathers olive gray (5Y4/1) to dark yellowish brown (10YR4/2), bituminous, fissile, slightly silty, thinly laminated, parallel horizontal stratification at base grading upward to subparallel stratification at top.		2 ft. 1 in.
	Big Springs Limestone Member:	923 ft. 8 in.	
	15. Limestone, light gray (N7) to very pale orange (10YR5/2) matrix with light brown (5YR5/6) fossil clasts, weathers grayish orange (10YR7/4), finely crystalline, packstone, one bed.		1 ft. 1 in.
	Doniphan Shale Member:	922 ft. 7 in.	
	14. Shale, dark yellowish orange (10YR6/6), thinly laminated, parallel stratification, silty.		2 in.
		922 ft. 5 in.	
	13. Siltstone, grayish orange (10YR7/4), weathers yellowish gray (5Y7/2) to pale yellowish orange (10YR8/6), calcareous in part, mica is rare, basal 1 ft. 0 in. is shaly, well laminated in lowest 4 ft., nearly structureless in upper 4 ft. 10 in., previous Missouri Geological Survey geologists called this interval "cotton rock" because of its resemblance to Canadian Series dolomite.		8 ft. 10 in.
		913 ft. 7 in.	

Measured stratigraphic section at Stop 5, continued.

Correlation Unit No.	Description	Elevation	Thickness
12.	Shale, medium light gray (N6), weathers dark yellowish orange (10YR6/6), blocky in upper 5 in., thinly laminated in middle 10 in., irregular nonparallel stratification in lower 3 in., the upper 5 in. of this interval resembles a paleosol.		1 ft. 6 in.
		912 ft. 1 in.	
11.	Shale, deeply weathered grayish orange (10YR7/4), silty, calcareous, contains abundant limestone nodules, limestone nodules are irregular in shape and usually smaller than 1 in. x 2 in. x 3 in. in size, finely crystalline, mudstone, thickness of unit varies from 4 ft. 2 in. to 5 ft. 2 in.		5 ft. 0 in.
	Spring Branch Limestone Member:	907 ft. 1 in.	
10.	Limestone, grayish orange (10YR7/4), finely crystalline, mudstone to wackestone, massive, present as one bed, dripstone commonly encrusts joint surfaces.		3 ft. 5 in.
		903 ft. 8 in.	
9.	Limestone, light olive gray (5Y6/1), deeply weathered pale yellowish brown (10YR6/2), occasionally stained light brown (5YR5/6), finely crystalline, wackestone to packstone, one bed.		1 ft. 7 in.
	Kanwaka Formation:		
	Stull Shale Member:	902 ft. 1 in.	
8.	Shale, weathered yellowish gray (5Y7/2) to light gray (N7), slightly silty.		2 ft. 6 in.
		899 ft. 7 in.	
7.	Shale, dark gray (N3), slightly silty.		3 in.
		899 ft. 4 in.	
6.	Shale, light olive gray (5Y5/2), weathers light olive gray (5Y6/1), slightly silty, becomes very silty in lowest 2 ft.		4 ft. 0 in.
		895 ft. 4 in.	
5.	Shale, light olive gray (5Y5/2), weathers yellowish gray (5Y7/2) to light gray (N7), occasionally stained pale brown (5YR5/2), slightly silty.		12 ft. 7 in.
		882 ft. 9 in.	
4.	Shale, poorly exposed.		5 ft. 0 in.
	Clay Creek Limestone Member:	877 ft. 9 in.	
3.	Limestone, weathers yellowish gray (5Y7/2), occasionally stained grayish orange (10YR7/4), finely crystalline, mudstone to wackestone, less argillaceous and irregularly bedded than below.		1 ft. 4 in.
		876 ft. 5 in.	
2.	Limestone, mottled yellowish gray (5Y7/2) and light olive gray (5Y6/1), weathers yellowish gray (5Y7/2), finely crystalline, mudstone to wackestone, argillaceous, irregularly bedded.		1 ft. 2 in.
	Jackson Park Shale Member:	875 ft. 3 in.	
1.	Shale, light olive gray (5Y5/2), weathers yellowish gray (5Y7/2), slightly silty, interval is poorly exposed, base of unit is covered.		15 ft. 3 in.
		860 ft. 0 in.	
Total Thickness			83 ft. 1 in.

Stop 6 Deer Creek Formation

The Deer Creek is exposed extensively throughout this part of Andrew County. The Deer Creek is distinguished from the Oread by the massive Rock Bluff limestone and by the absence of a 2 to 10 ft limestone a few feet above the top of the Ervine Creek. Figure 15 summarizes the succession and thickness of strata at stop 6.

Measured stratigraphic section at Stop 6.

Andrew County, Missouri

Amazonia 7.5 Minute Quadrangle

SW ¼, NE ¼, NW ¼, NE ¼, NW ¼, Sec. 23, T. 59 N., R. 36 W.

Elevation on top of Ervine Creek Limestone Member estimated from topographic map.

Exposures in road cut along north side of I-29 at end of west-bound on ramp.

Measured by David C. Smith, June 17, 1996.

Correlation

Unit No.	Description	Elevation	Thickness
Pennsylvanian System, Virgilian Series, Shawnee Group			
Deer Creek Formation:			
	Ervine Creek Limestone Member:	1045 ft. 0 in.	
9.	Limestone, grayish orange (10YR7/4), weathers very pale orange (10YR8/2), pale yellowish orange (10YR8/6), and dark yellowish orange (10YR6/6), finely crystalline, mudstone to wackestone to packstone, contains some calcite-filled vugs, fossiliferous, thinly bedded in lowest 3 ft. 5 in., wavy, thin, or irregularly bedded in upper 8 ft. 7 in.		12 ft 0 in.
	Larsh-Burroak Shale Member:	1033 ft. 0 in.	
8.	Shale, deeply weathered dark yellowish orange (10YR6/6), silty, thin to medium laminated, parallel horizontal stratification, poorly exposed.		2 ft. 0 in.
		1031 ft. 0 in.	
7.	Shale, light olive gray (5Y5/2), olive gray (5Y3/2), weathers light olive gray (5Y5/2) and dark yellowish orange (10YR6/6), silty, medium laminated, parallel and subparallel stratification.		1 ft. 0 in.
		1030 ft. 0 in.	
6.	Shale, black (N1), weathers dark gray (N3), bituminous, silty, fissile, parallel horizontal stratification, dull on broken surface.		1 ft. 2 in.
		1028 ft. 10 in.	
5.	Shale, light olive gray (5Y5/2), weathers light olive brown (5Y5/6) to dark yellowish orange (10YR6/6), silty, soft.		2 in.
	Rock Bluff Limestone Member:	1028 ft. 8 in.	
4.	Limestone, medium gray (N5) to medium light gray (N6) with some light olive gray (5Y5/2) and yellowish gray (5Y7/2) mottling, finely crystalline, mudstone to wackestone, massive, present as one bed, 21 to 24 in. thick.		2 ft. 0 in.
	Oskaloosa Shale Member:	1026 ft 8 in.	
3.	Shale, light olive gray (5Y5/2), weathers yellowish gray (5Y7/2), silty, thin to medium laminated, parallel horizontal stratification, poorly exposed.		10 ft. 4 in.
	Ozawkie Limestone Member:	1016 ft. 4 in.	
2.	Limestone, grayish orange (10YR7/4), very pale orange (10YR8/2), laminated in part moderate yellowish brown (10YR5/4) and dark yellowish orange (10YR6/6), weathers pale yellowish orange (10YR8/6) and dark yellowish orange (10YR6/6), finely crystalline, mudstone, wackestone, packstone, silty, slightly abrasive to touch, massive to irregularly bedded in lower 2 ft. 9 in., thinly bedded in upper 3 ft. 0 in.		5 ft. 9 in.
		1010 ft. 7 in.	
Total Thickness			34 ft. 5 in.

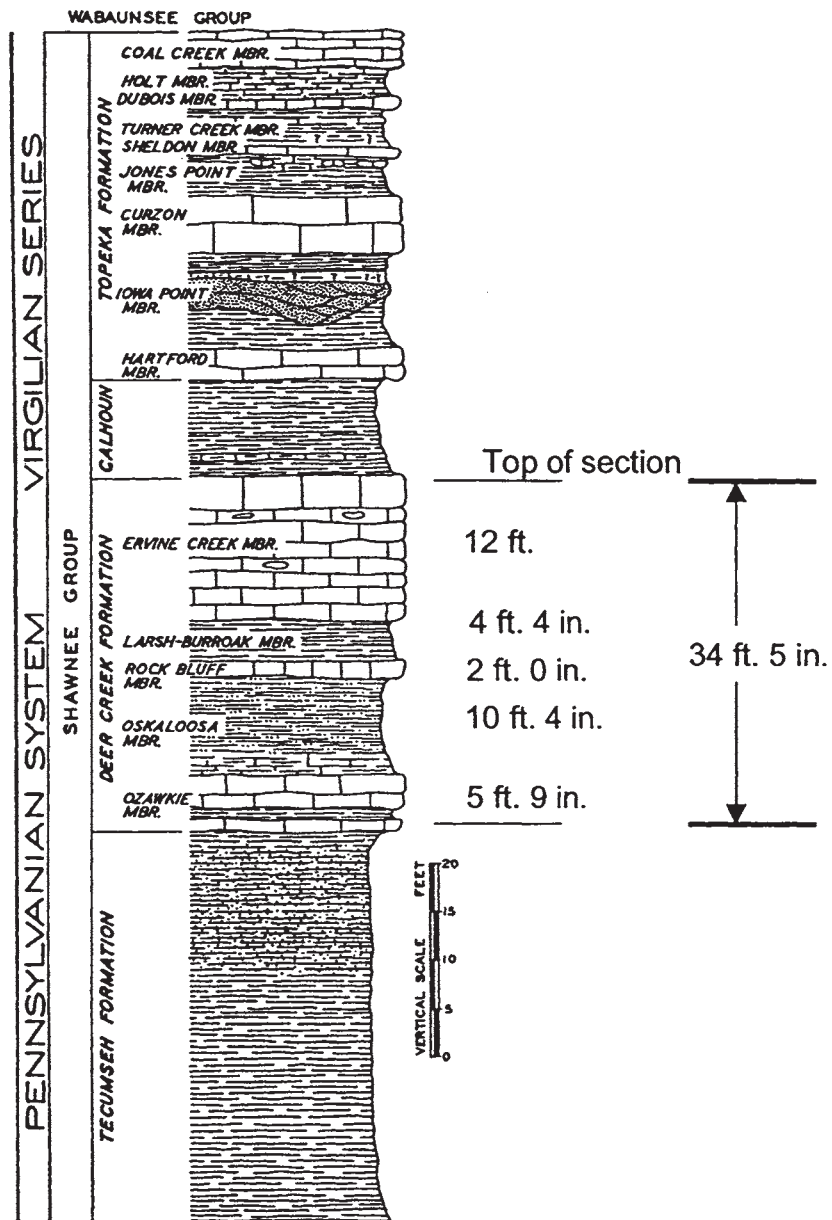


Figure 15. Deer Creek Formation north of Amazonia (after Howe, 1961, figure 22, p. 112).

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