Field Trip Guidebook

Recent mapping of Pennsylvanian bedrock southeast of Kansas City by the Geologic Mapping Unit at the Missouri Geological Survey

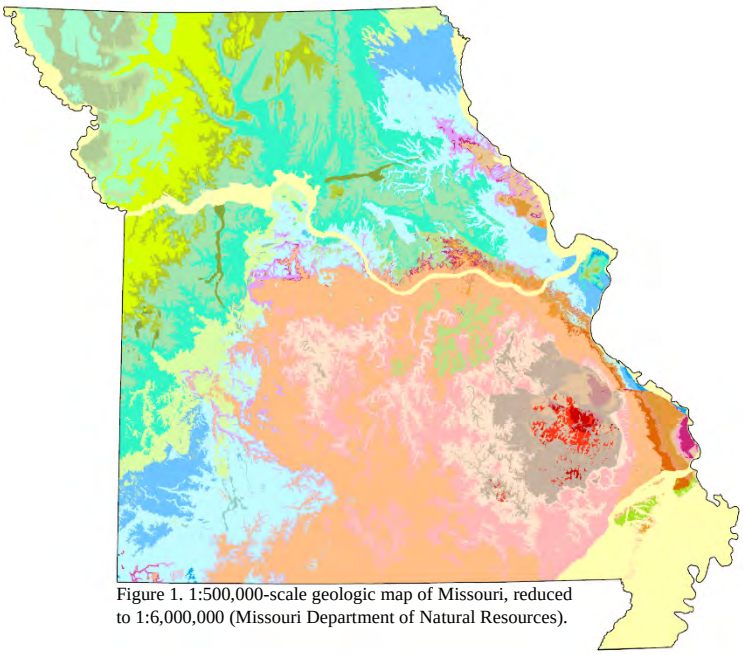

Figure 1. 1:500,000-scale geologic map of Missouri, reduced to 1:6,000,000 (Missouri Department of Natural Resources).

Prepared for the

Association of Missouri Geologists

71st Annual Meeting

October 11-12, 2024

Warrensburg, MO

by

Missouri Department of Natural Resources
Missouri Geological Survey
Rolla, Missouri
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Association of Missouri Geologists

71st Annual Meeting and Field Trips

October 11-12, 2024

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Introduction

Pennsylvanian bedrock southeast of Kansas City consists of cyclic successions of limestones, shales, claystones, and sandstones, known as midcontinent cyclothems (Wanless and Shepard, 1936; Heckel, 1984, 1986), deposited in marine to coastal to terrestrial environments during repeated marine transgressions (i.e., sea level rise) and regressions (i.e., sea level fall). Other constituent rock types, including conglomerates and coals, are interspersed within these successions. As seawater transgressed, terrestrial deposits were overlain with transitional deposits that were then overlain by marine deposits, and the opposite occurred during marine regressions. Lateral discontinuity of coastal environments is also preserved in the bedrock record, reflecting depositional environments such as deltas and fluvial channels. Mapping Pennsylvanian bedrock, therefore, presents unique challenges because many of the units are very thin, lack lateral continuity, weather easily, and can be mistaken for similar units in other cyclothems. Additionally, some cyclothems do not represent complete cycles of transgression and regression, and therefore present an atypical sequence of rock types. A further challenge comes with identifying and defining structural features, such as low-amplitude folds and associated faults, often observed while mapping these units.

Generations of geologists at the Missouri Geological Survey (MGS) have laid a strong foundation in Pennsylvanian bedrock mapping, spending hours studying drill cores and covering thousands of miles on foot to describe outcrops in the field. MGS has archived the body of work conducted by these earlier geologists, which has become a valuable resource for current mapping projects. One of the most comprehensive of these resources for Pennsylvanian strata is “Paleozoic succession in Missouri part 5: Pennsylvanian Subsystem of Carboniferous System” by Gentile and Thompson (2004). This reference includes information on nomenclature changes of the lithostratigraphic units through time, locations of type sections and reference sections, and descriptions of typical characteristics of the units. A stratigraphic section for generalized Pennsylvanian strata in Missouri was published alongside this document, and the portion of that section that will be viewed during this field trip is provided in Figure 2. In addition, MGS archives include many reconnaissance field maps, field notebooks, borehole logs, measured sections, etc, that are invaluable references for current mappers. Geophysical tools have become an important supplement to these resources, especially in areas of thick surficial cover.

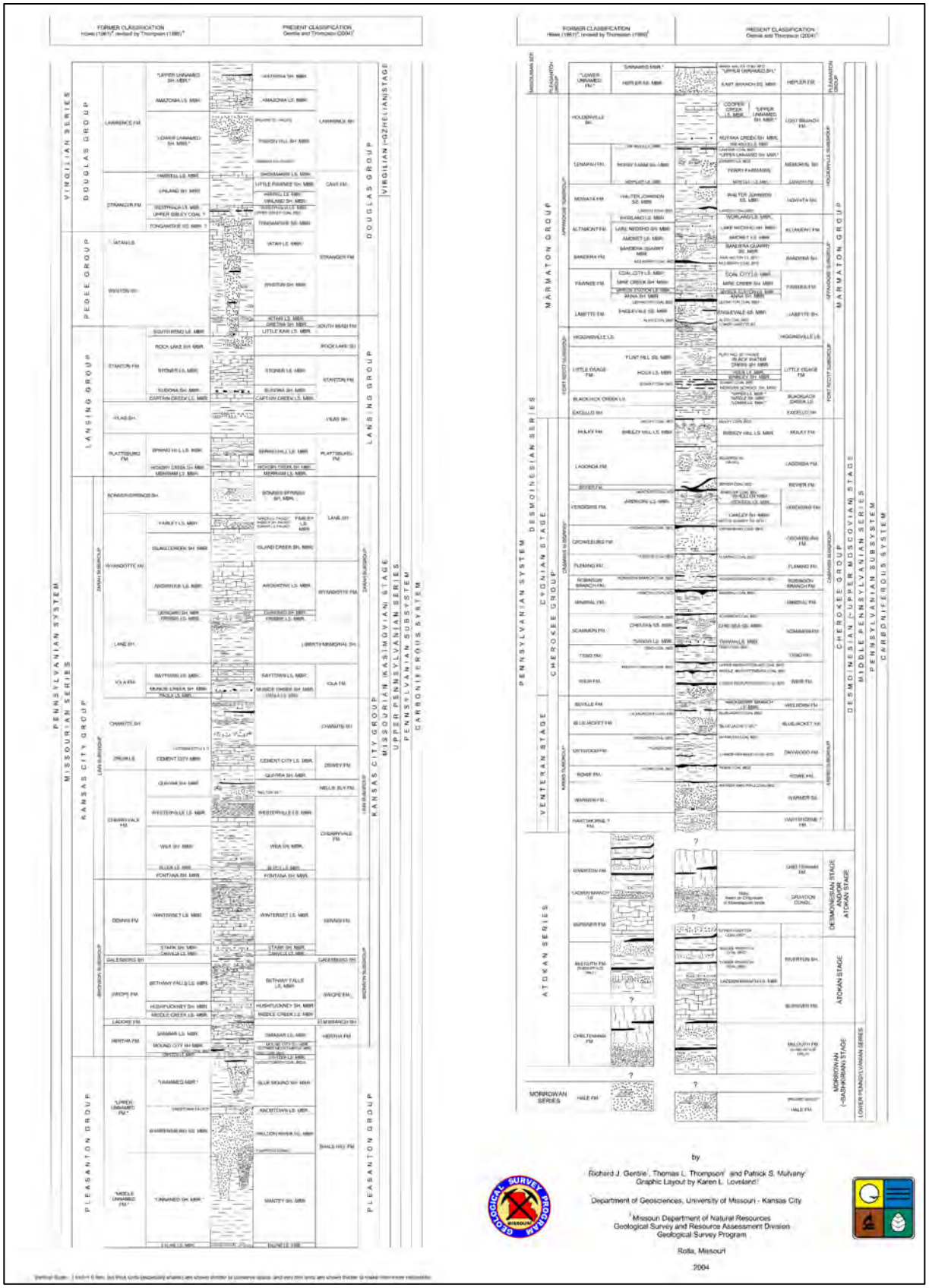

Figure 2. Truncated stratigraphic column for the Pennsylvanian Stratigraphy of Missouri (Gentile and Thompson, 2004).

The bedrock mapping showcased on this field trip was conducted as part of an ongoing, multiyear project to map the corridor along Interstate 70 from St. Louis to Kansas City, which will come to completion in 2025. Statewide geologic mapping coverage exists at a scale of 1:500,000 but current mapping is much higher in resolution, at a scale of 1:24,000, and does not include surficial materials. Generally, within the Kansas City area, each mapper produces bedrock geologic maps of two 7.5′ quadrangles per year, at a scale of 1:24,000, and those products are then compiled into a 1:100,000-scale map of a larger 30′ x 60′ quadrangle. Standards have been established for data distribution required at different scales, which includes field mapping of outcrops, well log interpretation, incorporation of mine and quarry data, etc. Coverage at these higher resolutions is increasing, but there is still much work to be done. The improvement in resolution from 1:500,000- to 1:24,000-scale is demonstrated in Figure 3.

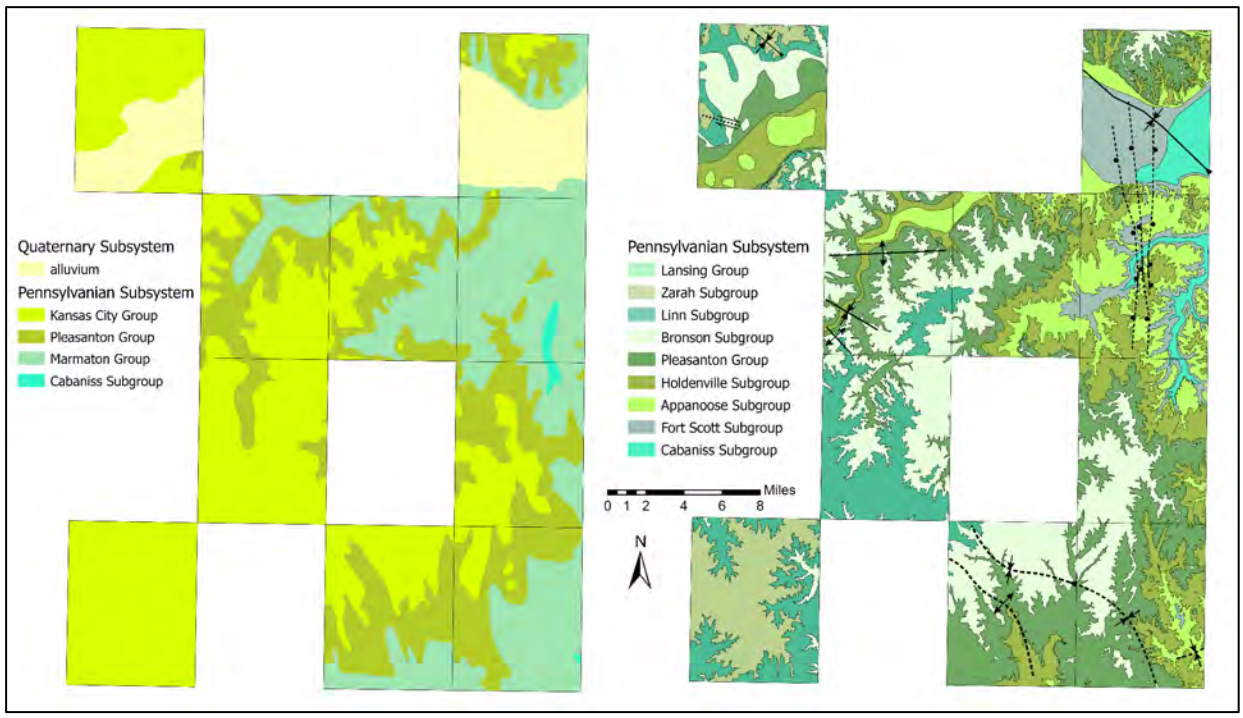

Figure 3. 1:500,000-scale geologic map (left) compared to 1:24,000-scale bedrock geologic map (right) of the same area.

Project proposals are driven and supported by a State Mapping Advisory Committee that includes stakeholders from industry, academia, government, etc. This group meets once a year to review past projects, consider factors such as planned expansion of transportation corridors and population growth, among others, and to vote on future mapping priorities. All of the work

included in this field trip guide was partially funded by the United States Geological Survey (USGS), National Cooperative Geologic Mapping Program (NCGMP) STATEMAP component, and these funds are matched by the state of Missouri. Additional mapping is being completed at the survey by other teams through various state and national programs, including the USGS Earth Mapping Resources Initiative (Earth MRI).

The outcrops featured in this field trip are excellent exposures of the typical successions of conformable strata in the section of Pennsylvanian bedrock that occurs southeast of Kansas City, along with some notable unconformable channel sands. Many of these units have been important resources for Missouri communities, both historically and currently. Most of these outcrops are accessible in public access areas or easements, and those on private property are identified in the text. The figures presented for each of the stops come from bedrock geologic maps published by members of the Geologic Mapping Unit at MGS, which are referenced throughout the guidebook. These maps can be accessed on the MGS Map Index, and associated digital coverages can be viewed on GeoSTRAT, a public Geographic Information System (GIS) repository for the electronic data housed at MGS, including bedrock geologic map coverages, borehole data, and many other topics of geologic interest.

Now let's go look at some rocks. We're looking forward to sharing some of our favorite Pennsylvanian outcrops and hope you enjoy them as much as we do.

Geologic Mapping Unit
Geologic Resources Section
Geological Survey Program
Missouri Geological Survey
Department of Natural Resources

MISSOURI
DEPARTMENT OF
NATURAL RESOURCES

Field Trip #1

Friday October 11, 2024

Base Pennsylvanian Subsystem through Fort Scott Subgroup of the Marmaton Group, and Weldon River Sandstone Member of the Pleasanton Group

(Johnson and Pettis counties)

Geologic Mapping Unit
Missouri Department of Natural Resources
Missouri Geological Survey
Rolla, MO

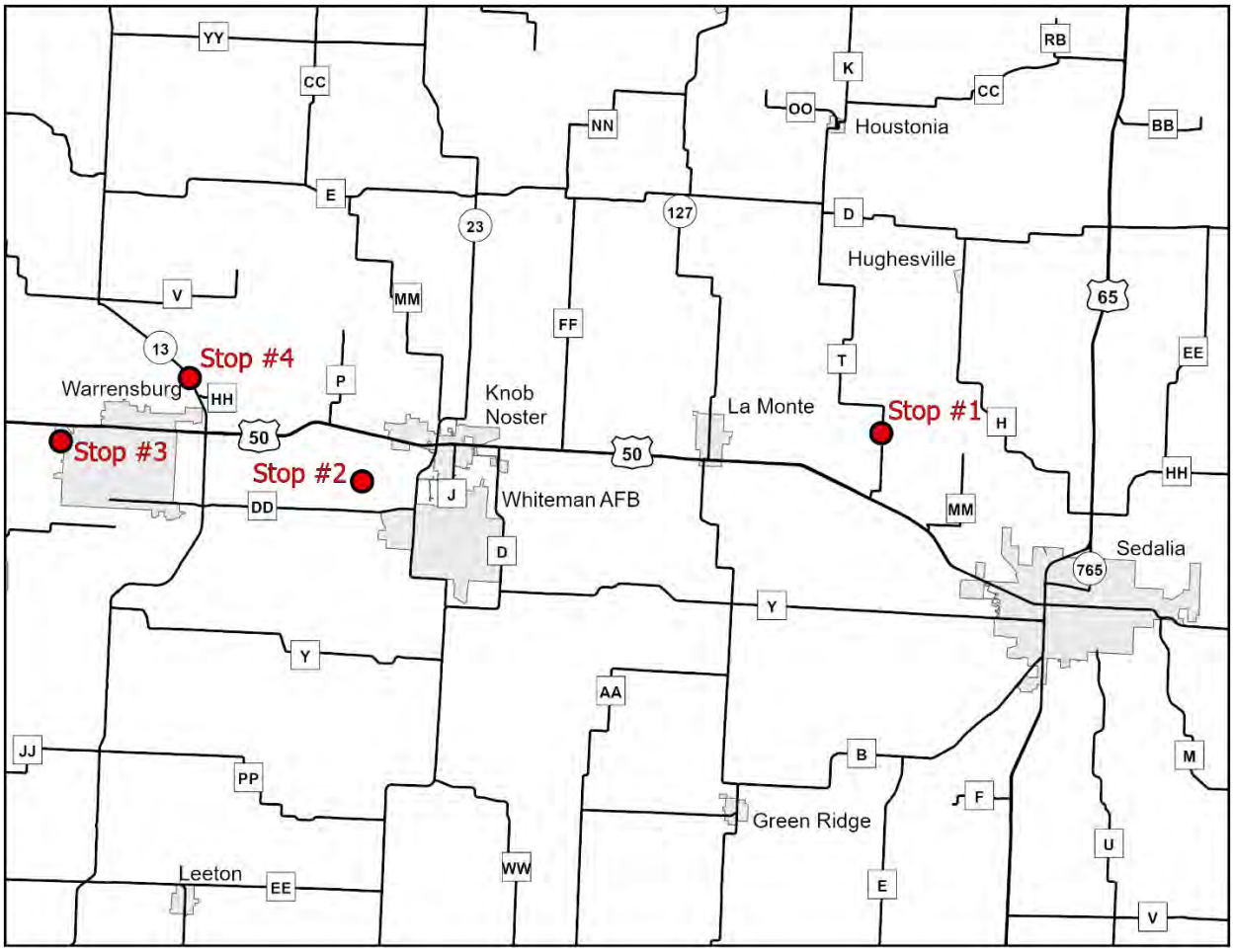

Figure 4. Map showing four stops for Field Trip #1. Field trip route begins and ends at Quality Inn in Warrensburg.

Stop #1: Graydon Conglomerate (Pennsylvanian Subsystem) resting on Burlington Limestone (Mississippian Subsystem) in the Hughesville 7.5′ quadrangle, Pettis County (38.7741421°N, 93.3348347°W)

Recent mapping of the Hughesville 7.5′ quadrangle conducted by Jeffrey Crews with partial funding under STATEMAP award number G18CS00293, 2018. **Map unit descriptions, stratigraphic column, and bedrock geologic map from Crews, J. (2019).**

Notes: outcrop is in the bank of a creek just above water level. Muck boots or other waterproof footwear are recommended for closer access to outcrop.

Mileage 0.0: Starting point for the field trip. Meet in front parking lot of Quality Inn at 626 East Russell Ave, Warrensburg, MO, 64093. Turn right out of parking lot onto East Russell Avenue and proceed to intersection of East Russell Avenue and PCA Road. Turn right onto PCA Road and procced to intersection of PCA Road and East Young Avenue/US Route 50 Business. Turn left onto East Young Avenue/US Route 50 Business and proceed to intersection of East Young Avenue/US Route 50 Business and US Route 50. Turn right onto US Route 50 and proceed east for 20.5 miles to intersection of US Route 50 and State Route T. Turn left onto State Route T and proceed north for 2 miles to intersection of State Route T and Richey Road. Turn left onto Richey Road.

Mileage 23.1: Stop #1, Graydon Conglomerate (base of Pennsylvanian Subsystem at this location) along bank of Little Muddy Creek, lying unconformably on Burlington Limestone (top of Mississippian Subsystem at this location). **NOTE: Richey Road is a privately owned road and landowner permission was obtained for access to this stop.**

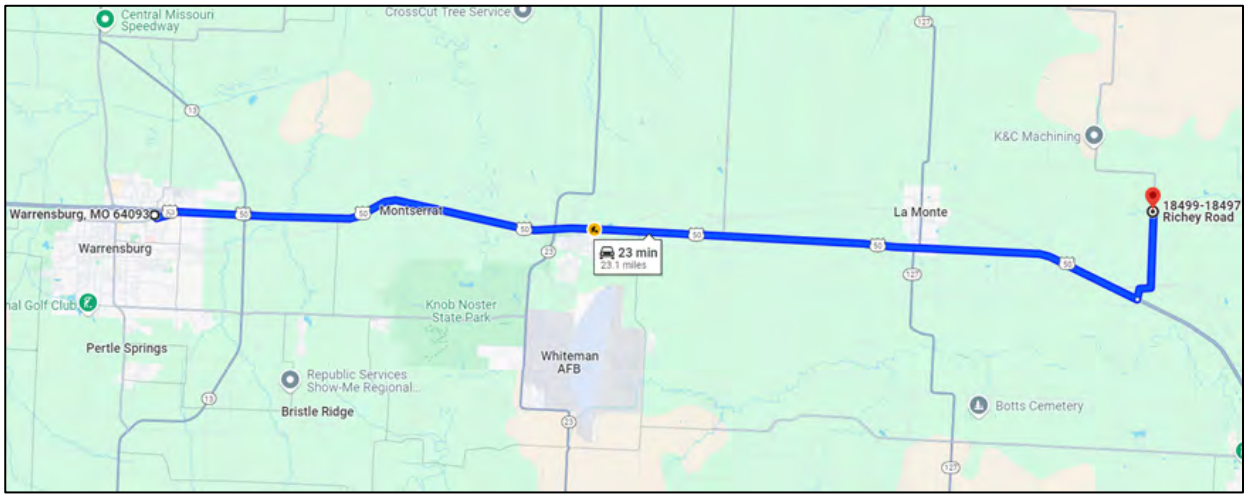

Figure 5. Map of field trip route from starting point to Stop #1 (Google Maps).

Figure 6. Annotated photograph of outcrop at Stop #1 (photograph by R. Daniels).

Pk

KREBS SUBGROUP (PENNSYLVANIAN SUBSYSTEM, DESMOINESIAN STAGE, CHEROKEE GROUP) – The Krebs Subgroup includes the Cheltenham Formation, the Warner Sandstone and the Graydon Conglomerate. The subgroup ranges between 0 and 30 feet in thickness.

Cheltonham Formation – This highly variable unit is composed of red, gray and brown clays, coal smuts and gray shales.

Warner Sandstone – Fine- to medium-grained, iron- and silica-cemented sandstone that occurs as paleao channel fills within the underlying Mississppian strata, on top of and within Cheltenham Formation and Graydon Conglomerate.

Samples of Warner Sandstone were analyzed petrographically. SM2018010 was collected from a filled paleo channel. The sample is a bimodal fine- to medium-grained sandstone composed of predominantly quartz grains. The medium sized quartz grains are well rounded and the finer grains are angular to subangluar. Slight quartz overgrowths of the sand grains cement the unit together. SM2018013 was collected from a channel sand interbedded with the Cheltenham Formation. The sample is a bimodal fine- to medium-grained sandstone composed of predominantly quartz grains. The medium sized quartz grains are well rounded and the finer grains are angular to subangluar. Slight quartz overgrowths of the sand grains and hematite cement the unit together. Porosity was estimated at 10 to 15%.

Graydon Conglomerate – Often the basal layer, a well-rounded to brecciated chert conglomerate composed of cobble-to boulder-sized clasts. It is often clast supported with an infiltration matrix that is clay or sand rich. The chert clasts were weathered from Osagean limestone and Ordovician dolomites.

Mb

BURLINGTON LIMESTONE (MISSISSIPPIAN SUBSYSTEM, OSAGEAN STAGE) – The Burlington Limestone is light-gray or brown, medium- to coarse-crystalline fossiliferous limestone with nodular gray chert. Crinoid columnals are the dominant fossil and are often the dominant constituent of the rock. Brachiopods, rugose corals and bryozoans also are common throughout the unit. While chert content of the unit can approach 30 percent or more in small areas, chert free areas are common.

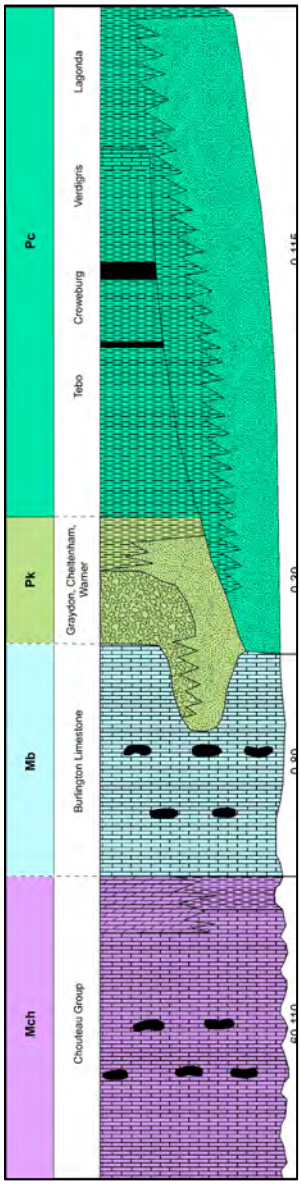

Figure 7. Stratigraphic column for Hughesville 7.5′ quadrangle.

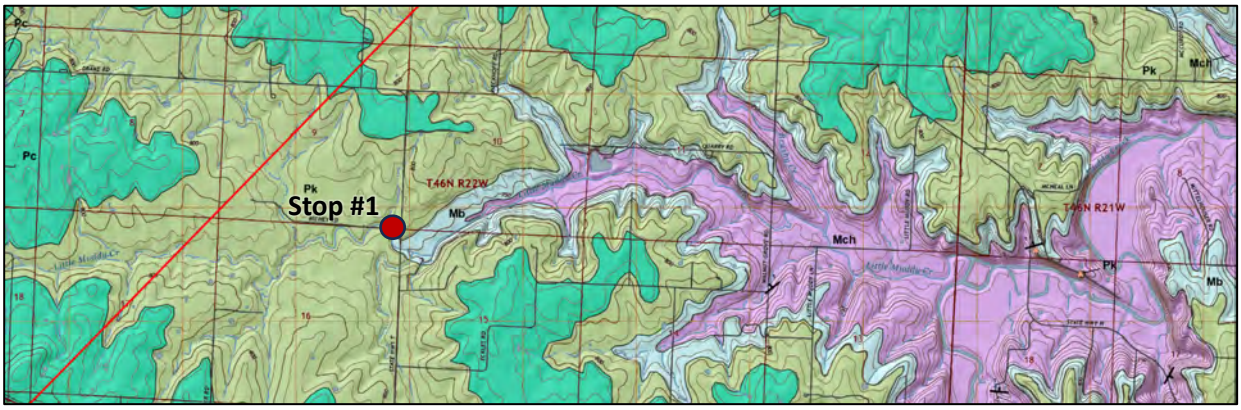

Figure 8. 1:24,000-scale bedrock geologic map of area surrounding Stop #1. Size is reduced.

Stop #2: Croweburg Formation through Verdigris Formation (Cherokee Group, Cabaniss Subgroup) in the Knob Noster 7.5′ quadrangle, Johnson County (38.7536040°N, 93.6035424°W)

Recent mapping of the Knob Noster 7.5′ quadrangle conducted by Trevor Ellis with partial funding under STATEMAP award number G19AC00312, 2019. **Map unit descriptions, stratigraphic column, and bedrock geologic map from Ellis, T. (2020).** Note: map unit description for Cabaniss Subgroup truncated below Croweburg Formation.

Notes: outcrop is accessed from Opossum Hollow Trail. Length of the hike round trip from parking area is approximately 1 mile and difficulty level is easy to moderate. The trail is a dirt path with some short ascents and descents of gentle to moderate grade.

Mileage 23.1: Starting from Stop #1, at intersection of Richey Road and State Route T, turn right onto State Route T and proceed south for 2 miles to the intersection of State Route T and US Route 50. Turn right onto US Route 50 and proceed west for 12 miles to exit ramp for State Route 23. Take exit ramp then turn left onto State Route 23 and proceed south for 2 miles to State Route DD. Turn right onto State Route DD and proceed west for 1.5 miles to intersection of State Route DD and Northeast 751st Road. Turn right onto Northeast 751st Road and proceed north for 0.8 miles to Opossum Trail parking area.

Mileage 41.9: Stop #2, Croweburg and Verdigris formations in spillway of Sullivan Lake in Knob Noster State Park, accessed from Opossum Hollow Trail. **NOTE: Opossum Hollow Trail is within Knob Noster State Park, sampling of rocks is NOT permitted.**

Figure 9. Map of field trip route from Stop #1 to Stop #2 (Google Maps).

Figure 10. Outcrop of Verdigris Fm at Stop #2 (photograph by R. Daniels).

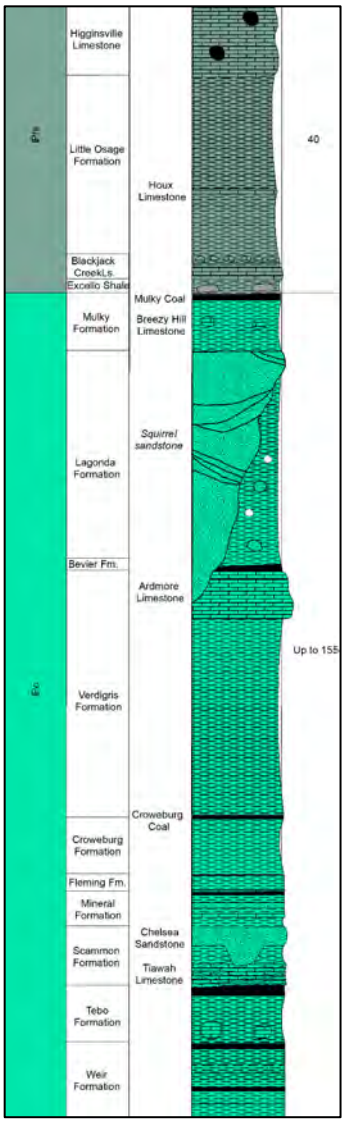

Figure 11. Stratigraphic column for Knob Noster 7.5′ quadrangle.

IPc

CABANISS SUBGROUP (PENNSYLVANIAN SUBSYSTEM, DESMOINESIAN STAGE, CHEROKEE GROUP) - The Cabaniss subgroup underlies most of the quadrangle. The subgroup is composed of siliclastics, coals, and thin carbonates, and generally forms poor outcrops. The Cabaniss Subgroup is composed of the Mulky, Lagonda, Verdigris, Croweburg, Fleming, Mineral, Scammon, Tebo, and Weir formations. The subgroup reaches a maximum thickness of 155 feet as seen in well logs (Missouri Department of Natural Resources, 2020). Formations below the Ardmore Limestone tend to crop out poorly.

Mulky Formation - The Mulky Formation is exposed in limited locations on the quadrangle. At UTM 15 S 0447037m 4289048m the Mulky is present as a blocky blue-gray clay. Petrified wood was identified at this location as well. Possible Breezy Hill was located at UTM 15 S 0446803m 4291076m. The Breezy Hill is a dark gray, lithographic limestone.

Lagonda Formation - The Lagonda Formation accounts for most of the Cabaniss outcrops on the quadrangle. The formation is generally a thinly bedded, gray to tan shale. The formation contains a significant silt and sand component. The Lagonda is typically micaceous and often contain limonite concretions. Woody plant remains are often found in the formation. The **Squirrel sandstone facies** is present across the quadrangle. The Squirrel is generally a medium grained, subangular, moderately cemented, micaceous sandstone. Bedding is variable, ranging from thin to massive. Cross-bedding, iron concretions, and limonite casts are common throughout.

Verdigris Formation - The Verdigris Formation is composed of the Oakley Shale Member and the Ardmore Limestone Member, an important marker bed across the quadrangle. The **Oakley Shale** is a gray, noncalcareous shale. The shale contains little silt, mica, or fossils. The Oakley Shale is generally 20 feet thick. The **Ardmore Limestone Member** is a mottled gray limestone with rough, uneven bedding. The Ardmore is generally three to four feet thick and well exposed at UTM 15 S 0447077m 4289378m.

Croweburg Formation - The Croweburg Formation is composed of the **Croweburg Coal** and underlying shale. The Formation is about 15 feet thick and well exposed at UTM 15 S 0454690m 4292262m. The shale is thinly bedded, dark gray, and micaceous. Claystone and ironstone are present locally.

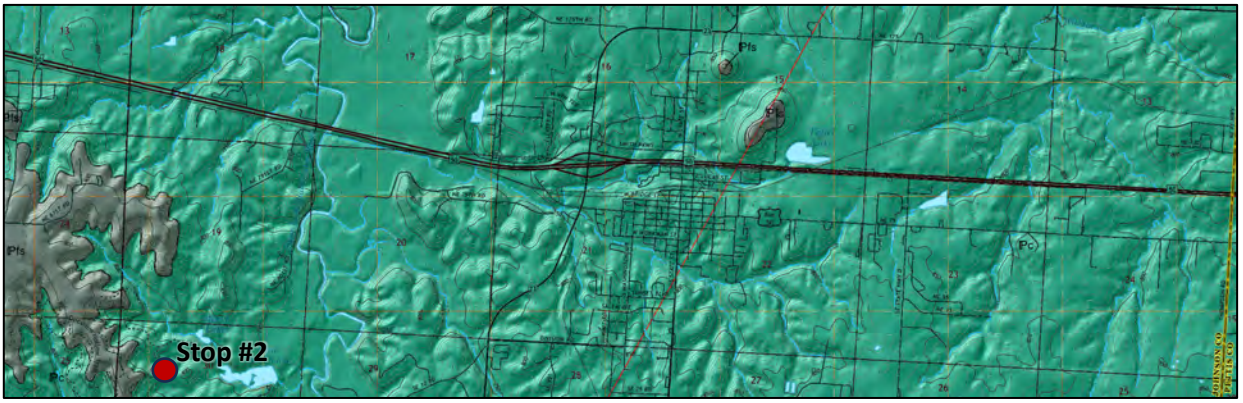

Figure12. 1:24,000-scale bedrock geologic map of area surrounding Stop #2. Size is reduced.

Stop #3: Verdigris Formation through Lagonda Formation (Cherokee Group, Cabaniss Subgroup) and Weldon River Sandstone Member of the Shale Hill Formation (Pleasanton Group) in the Warrensburg West 7.5′ quadrangle, Johnson County (38.7691237°N, 93.7610946°W)

Recent mapping of the Warrensburg West 7.5′ quadrangle conducted by Robyn L. Daniels with partial funding under STATEMAP award number G21AC10872, 2021. **Map unit descriptions, stratigraphic column, and bedrock geologic map from Daniels, R.L. (2022).**

Notes: outcrop of Weldon River Sandstone Member is accessed from park trail. Length of the hike round trip from parking area is approximately half of a mile and difficulty level is easy. The trail is paved with a flat to gentle grade.

Mileage 41.9: Starting from Stop #2, proceed south for 0.8 miles on Northeast 751st Road to intersection of Northeast 751st Road and State Route DD. Turn right onto State Route DD and proceed west for 4.4 miles to traffic circle at intersection of State Route DD and State Route 13. Take first exit from traffic circle onto State Route 13 and proceed north for 2 miles to traffic circle at intersection of State Route 13 and US Route 50. Take second exit from traffic circle and proceed west on US Route 50 for 2.3 miles to exit ramp for North Maguire Street/State Route 13 Business. Take exit and turn left onto North Maguire Street/State Route 13 Business and proceed south to intersection of North Maguire Street/State Route 13 Business and East Young Street/US Route 50 Business. Turn right onto East Young Street/US Route 50 Business and proceed west to intersection of West Young Street/US Route 50 Business and North Warren Street. Turn left onto North Warren Street and proceed south to intersection of North Warren Street and West Gay Street. Turn right onto West Gay Street and proceed west for 0.8 miles to entrance of Cave Hollow Park, on right side of road. Turn right into parking lot of Cave Hollow Park.

Mileage 54.4: Stop #3, Verdigris and Lagonda formations near parking area in Cave Hollow Park and Weldon River Sandstone Member of the Shale Hill Formation, accessed from park trail. **NOTE: Outcrops are within Cave Hollow Park of the city of Warrensburg, sampling of rocks is NOT permitted.**

Figure 13. Map of field trip route from Stop #2 to Stop #3 (Google Maps).

Figure 14. Outcrops of Verdigris Fm (left and center) and Lagonda Fm (right) at Stop #3 (photographs by R. Daniels).

IPc **CABANISS SUBGROUP (PENNSYLVANIAN SUBSYSTEM, DESMOINESIAN STAGE, CHEROKEE GROUP) –** The Cabaniss Subgroup is present across a large portion of the quadrangle in the lowland areas surrounding the Blackwater River and its tributaries, and was also observed at higher elevations along the hinge lines of anticlines that trend from southeast to northwest within the quadrangle. It comprises a very thick package of shales intermittently interbedded with sand, coal, and limestone. Drill logs show the total thickness of the subgroup to be as much as 250 feet within the quadrangle. Observed in outcrop during this survey were the units above, and including, the Ardmore Limestone Member of the Verdigris Formation, with the exception of the Bevier Formation.

Mulky Formation – Mulky Formation comprises the Mulky Coal, its underclay, a grey to brown shale, and the Breezy Hill Limestone Member, where present. A thin smut of the coal was found underlying the Excello Shale in a single location. The Breezy Hill Limestone was not observed.

Lagonda Formation – Lagonda Formation consists of 50 to 90 feet of shale that coarsens upward from a transitional grey shale to tan, silty, sandy shales and intermittent sandstones of the Squirrel sandstone facies. Terrestrial plant fossils and siderite concretions are commonly found in the formation. The Squirrel sandstone was observed to be fine- to medium-grained, moderately- to well-sorted, micaceous, and weathered tan to brown. Outcrops of the Lagonda Formation are abundant along the banks of the Blackwater River and its tributaries. The thickness of the formation within the quadrangle is most commonly 55 to 70 feet.

Verdigris Formation – Wheeler Member consists of the Wheeler Coal and its underclay. The Wheeler Coal was observed with a thickness of approximately one foot in the southeast section of the quadrangle. Overlying the coal at this location is a thin transgressive limestone "caprock" that is abundantly fossiliferous with several species of brachiopods and numerous crinoid ossicles. Ardmore Limestone Member is the oldest unit that was observed in outcrop during the course of this survey. It is a dark grey, nodular, argillaceous wackestone that weathers buff to tan or grey as shown in Photo 1.

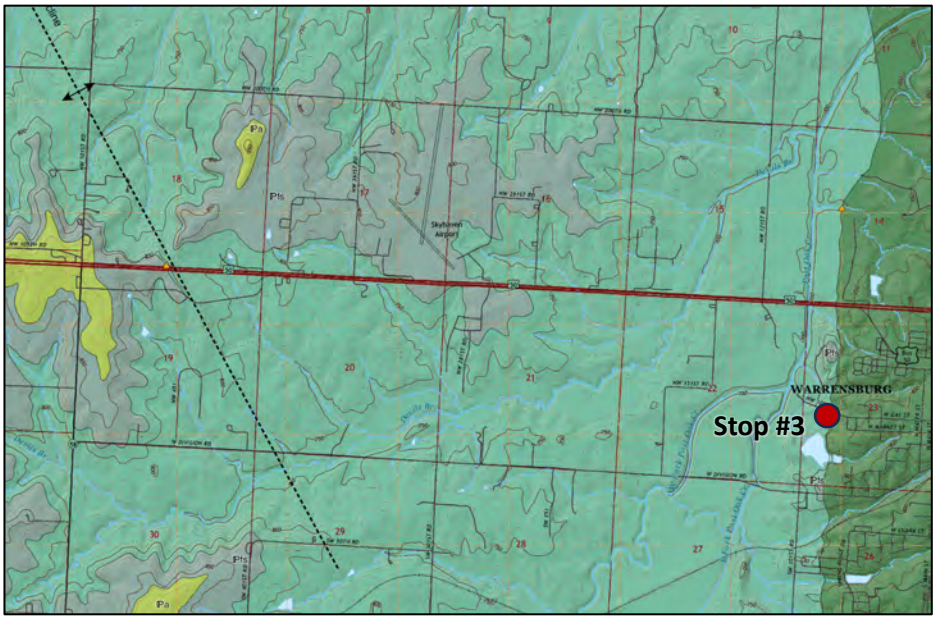

Figure 16. 1:24,000-scale bedrock geologic map of area surrounding Stop #3. Size is reduced.

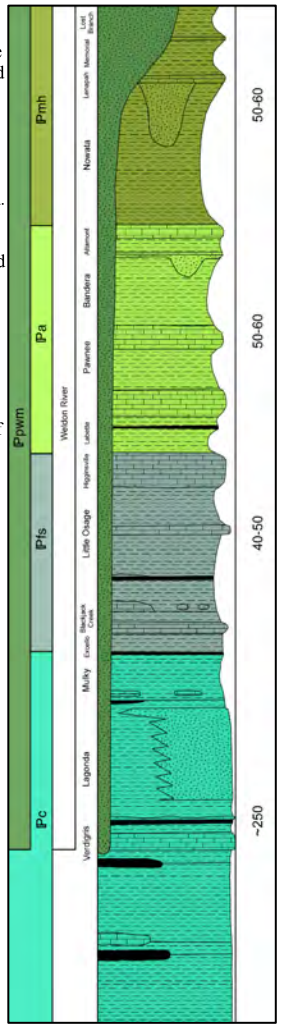

Figure 15. Stratigraphic column for Warrensburg West 7.5′ quadrangle.

Figure 17. Outcrop of Weldon River Sandstone Mbr of Shale Hill Fm at Stop #3 (photograph by B. Zalneraitis).

IPpwm

SHALE HILL FORMATION (PENNSYLVANIAN SUBSYSTEM, MISSOURIAN STAGE, PLEASANTON GROUP) – The Weldon River Sandstone Member of the Shale Hill Formation is present along the eastern boundary of the quadrangle where a north-south paleochannel filled with sediment after downcutting through antecedent Pennsylvanian rocks. The sandstone is generally fine- to medium-grained, moderately sorted, micaceous, weathers tan to brown, and often exhibits iron staining. Beds are variable in thickness with cross-beds that can be observed at east- or west-facing outcrops. Cross-bedding indicates a southerly paleo-flow direction. The outcrop shown in Photo 5 is south-facing and does not exhibit cross-bedding. The base of the channel was observed west of the city of Warrensburg in the bank of a tributary to Post Oak Creek where thin beds of sandstone and coal stringers overlie a conglomerate that, in turn, overlies Cabaniss Subgroup shales of the Cherokee Group. Large outcrops at Cave Hollow Park in Warrensburg, as well as borehole logs, indicate a total thickness of at least 60 feet within the quadrangle.

Figure 18. Weldon River Sandstone Mbr of Shale Hill Fm. Photo 5 of description (left) and close up of cross-bedding (right) (photographs by R. Daniels).

Stop #4 : Mulky Formation (Cherokee Group, Cabaniss Subgroup) through Little Osage Formation (Marmaton Group, Fort Scott Subgroup) in the Warrensburg East 7.5′ quadrangle, Johnson County (38.7957925°N, 93.6944826°W)

Recent mapping of the Warrensburg East 7.5′ quadrangle conducted by Kyle Ganz with partial funding under STATEMAP award number G21AC10872, 2021. **Map unit descriptions, stratigraphic column, and bedrock geologic map from Ganz, K. (2022).**

Notes: outcrops are on both sides of a busy highway and crossing will be required to view entire section. Exercise extreme caution when crossing. A high visibility vest is strongly recommended.

Mileage 54.4: Starting from Stop #3, turn left out of Cave Hollow Park parking area onto West Gay Street and proceed east to intersection of West Gay Street and North Warren Street. Turn left onto North Warren Street and proceed north to intersection of North Warren Street and West Young Street/US Route 50 Business. Turn right onto West Young Street/US Route 50 Business and proceed east to intersection of East Young Street/US Route 50 Business and North Maguire Street/State Route 13 Business. Turn left onto North Maguire Street/State Route 13 Business and proceed for 3.8 miles to traffic circle at intersection of North Maguire Street/State Route 13 Business and State Route 13. Take first exit from traffic circle onto State Route 13 and proceed southeast for 3 miles to Stop #4.

Mileage 63.3: Stop #4, Mulky Coal, Excello Shale, Blackjack Creek Limestone, and Morgan School Shale outcrops along State Route 13.

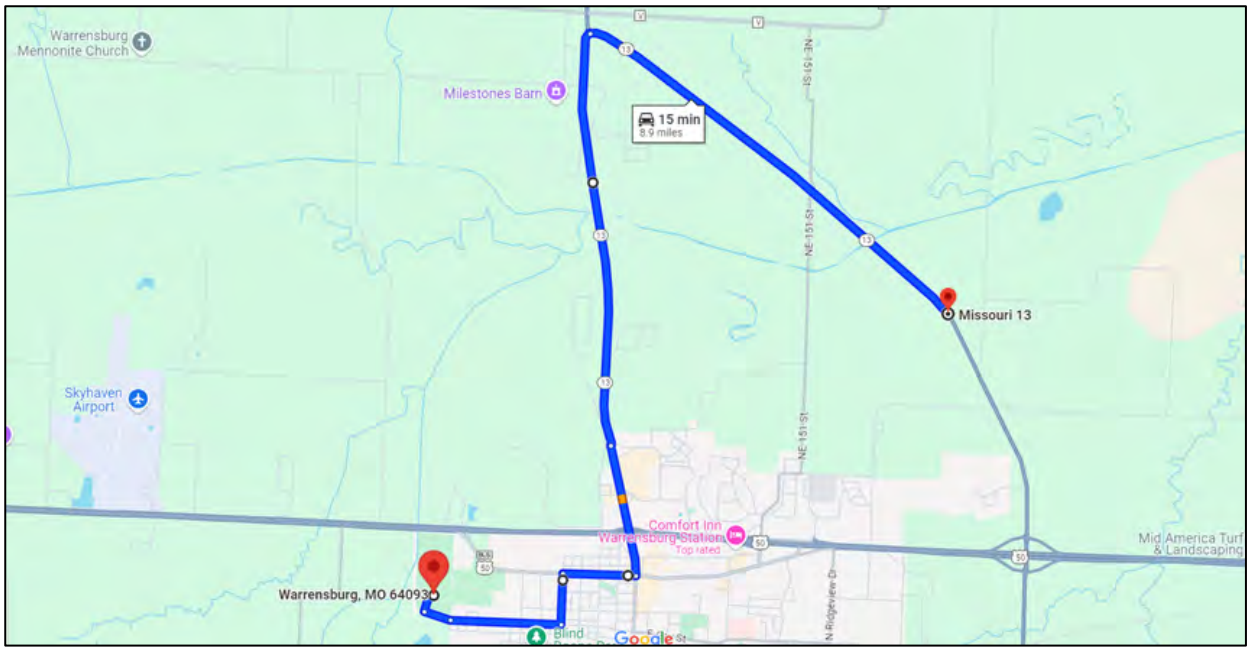

Figure 19. Map of field trip route from Stop #3 to Stop #4 (Google Maps).

Figure 20. Outcrop of Blackjack Creek Ls and Little Osage Fm at Stop #4 (photographs above and below by B. Zalneraitis).

Figure 22. Annotated photograph of outcrops at Stop #4.

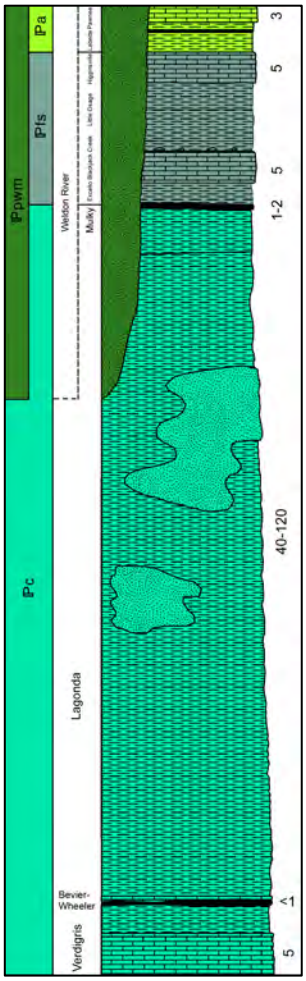

Figure 21. Stratigraphic column for Warrensburg East 7.5′ quadrangle.

IPfs **FORT SCOTT SUBGROUP (PENNSYLVANIAN SUBSYSTEM, DESMOINESIAN STAGE, MARMATON GROUP)** – Fort Scott Subgroup caps ridgetops across the quadrangle with limestone ledges prominently visible.

Higginsville Limestone – Higginsville Limestone contains *Chaetetes* fragments but they are less abundant than fusulinids, which are more commonly found. Limestone is irregularly thin bedded, light gray to gray and crystalline.

Little Osage Formation – Little Osage Formation is represented on the quadrangle as a covered interval between the Blackjack Creek and the Higginsville. The formation contains gray shale, black fissile shale and limestone, however, it is not exposed and covers an interval of 20 to 40 feet in some places.

Blackjack Creek Limestone – Limestone is finely crystalline, medium bedded and dark gray to dark brown. *Chaetetes* are abundant along with brachiopods, crinoids and ostracods. Thickness varies from four to six feet. The formation develops a tan to buff weathered rind. The lower limestone member is present in the mapping area, with limestone clasts in the above adjacent shale that are part of the middle and upper limestone members.

Excello Shale – Excello Shale is light gray to dark gray and in places three to seven feet thick where exposed. Best exposures are found directly beneath the Blackjack Creek Limestone or above the Mulky Coal in the Cabaniss Subgroup. An exposure can be found at SE ¼ NW ¼ Sec. 8, T. 46 N., R. 25 W. (Photo #3) which shows the contact between the Marmaton and the Cabaniss.

IPc **CABANISS SUBGROUP (PENNSYLVANIAN SUBSYSTEM, DESMOINESIAN STAGE, CHEROKEE GROUP)** – The Cabaniss Subgroup is primarily exposed in the southern portion of the Warrensburg East 7.5' quadrangle. Light to dark brown shales, coal and a fine-grained brown to red-brown sandstone with lithic fragments and specks of mica are present. Exposures in creeks and along roads consist of gray to brown shale with thin sandstone partings. Shale present is from the Lagonda Formation and the sandstone is the Squirrel sandstone facies of the Lagonda Formation. The coal seams present are likely from the Bevier Coal of the Bevier Formation. The Ardmore Limestone Member of the Verdigris Formation is the lowest unit found on the quadrangle. Ardmore is buff to tan to gray, nodular, argillaceous limestone. Exposure can be found at SE ¼ NE ¼ Sec. 15, T. 47 N., R. 25 W. (Photo #1).

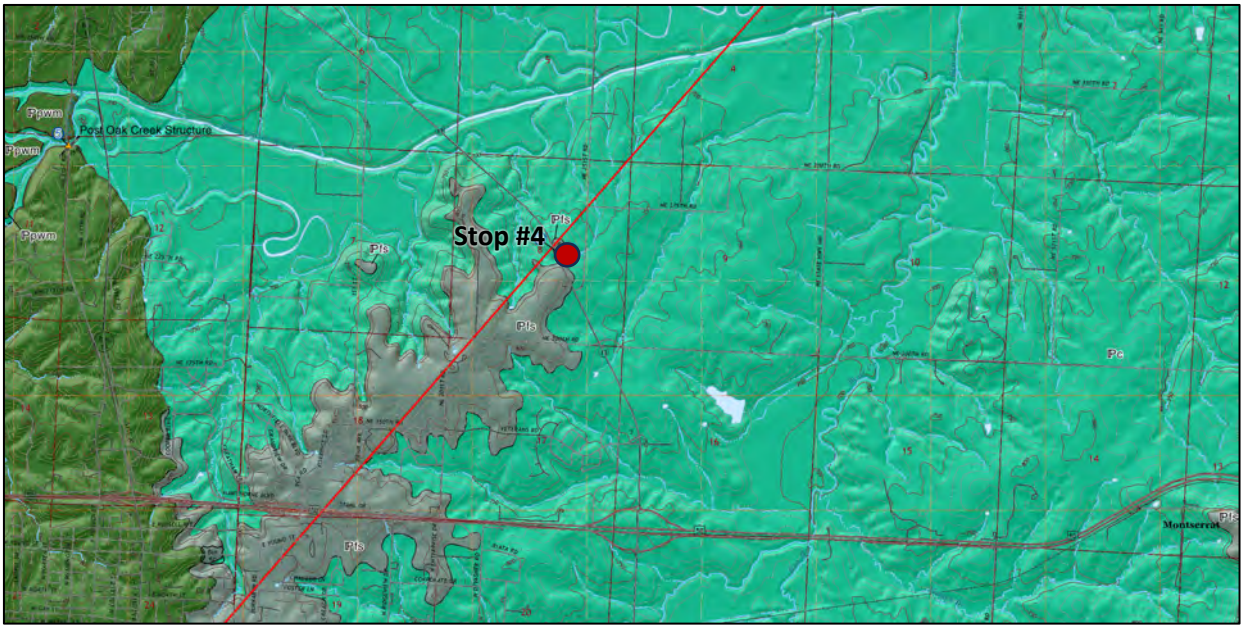

Figure 23. 1:24,000-scale bedrock geologic map of area surrounding Stop #4. Size is reduced.

Mileage 63.3: Starting from Stop #4, proceed southeast on State Route 13 to traffic circle at intersection of State Route 13 and US Route 50. Take first exit from traffic circle onto US Route 50 and proceed west for 1 mile to exit ramp for US Route 50 Business/Stahl Drive. Continue on Stahl Drive to intersection of Stahl Drive and PCA Road. Turn left onto PCA Road and proceed south to intersection of PCA Road and East Russell Avenue. Turn right onto East Russell Avenue and then turn left into parking lot of Quality Inn at 626 East Russell Ave, Warrensburg, MO, 64093

Mileage 67.0: End point of field trip at Quality Inn in Warrensburg.

Field Trip #2

Saturday October 12, 2024

Fort Scott Subgroup of the Marmaton Group through Bronson Subgroup of the Kansas City Group

(Jackson and Lafayette counties)

Geologic Mapping Unit
Missouri Department of Natural Resources
Missouri Geological Survey
Rolla, MO

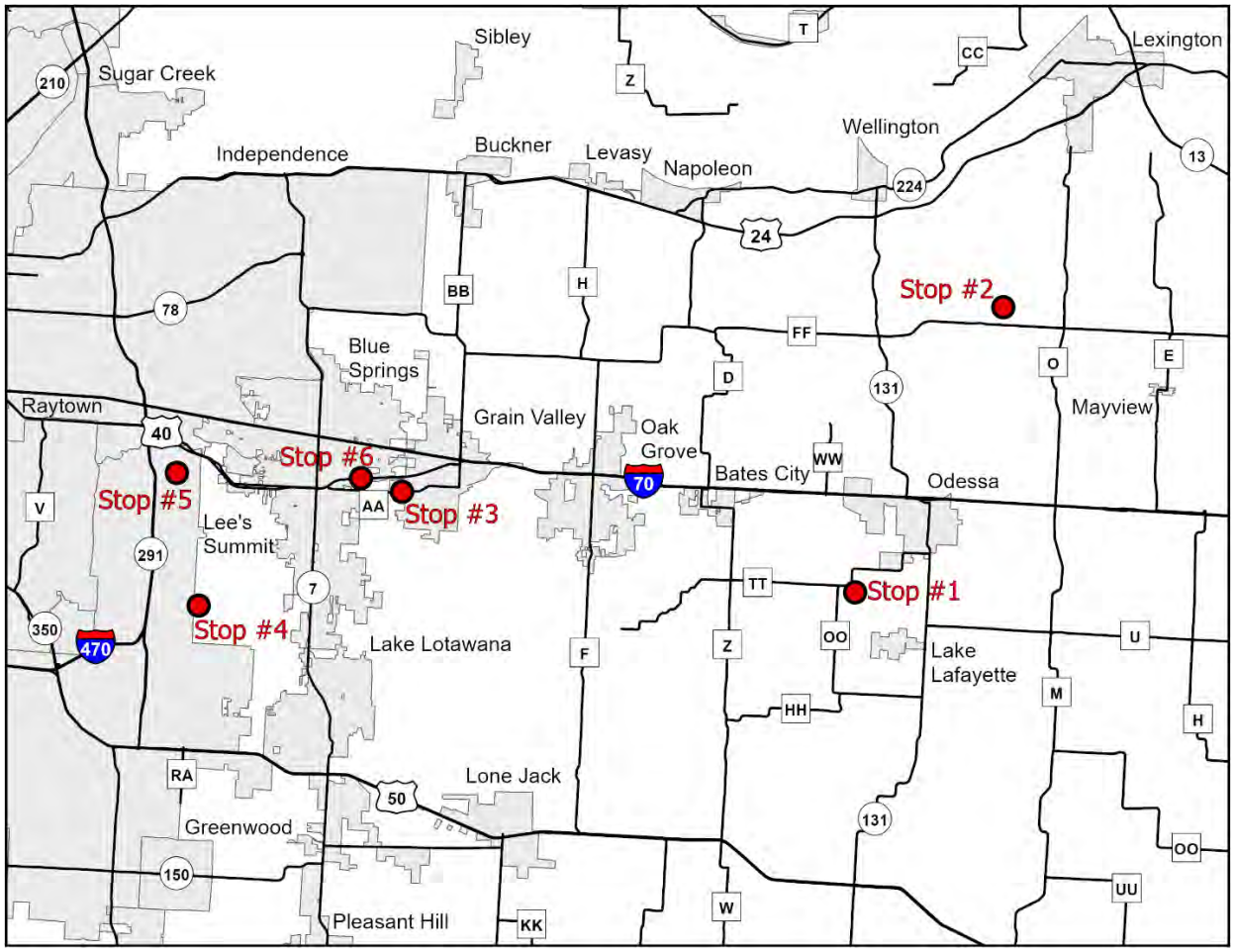

Figure 24. Map showing six stops for Field Trip #2. Field trip route begins and ends at Quality Inn in Warrensburg.

Stop #1: Little Osage Formation (Marmaton Group, Fort Scott Subgroup) through Bandera Shale (Marmaton Group, Appanoose Subgroup) in the Odessa South 7.5′ quadrangle, Lafayette County (38.9726461°N, 93.9903609°W)

Recent mapping of the Odessa South 7.5′ quadrangle conducted by Nicholas M. Umholtz with partial funding under STATEMAP award number G21AC10872, 2021. **Map unit descriptions, stratigraphic column, and bedrock geologic map from Umholtz, N.M. (2022).**

Notes: outcrop is in spillway across the dam from parking area. The hike round trip from parking area is approximately half of a mile and difficulty level is easy. The dam is flat with grass cover. The outcrop can be viewed from the dam, but closer access requires descending dam slope to spillway. Difficulty level for this leg is moderate to difficult with uneven terrain and steep grade.

Mileage 0.0: Starting point for the field trip. Meet in front parking lot of Quality Inn at 626 East Russell Ave, Warrensburg, MO, 64093. Turn right out of parking lot onto East Russell Avenue and proceed to intersection of East Russell Avenue and PCA Road. Turn left onto PCA Road and proceed to entrance ramp at intersection of PCA Road and US Route 50. Turn left onto entrance ramp and proceed northwest on US Route 50 for 16.4 miles to intersection of US Route 50 and State Route 131. Turn right onto State Route 131 and proceed north for 6.5 miles to intersection of State Route 131 and State Route HH. Turn left onto State Route HH and proceed west to intersection of State Route HH and State Route OO. Turn right onto State Route OO and procced north then east to intersection of State Route OO and Odessa Lake Road. Take slight right onto Odessa Lake Road and proceed to parking area.

Mileage 29.4: Stop #1, Outcrops of Fort Scott and Appanoose subgroups in spillway and shoreline slopes of Odessa Lake.

Figure 25. Map of field trip route from starting point to Stop #1 (Google Maps).

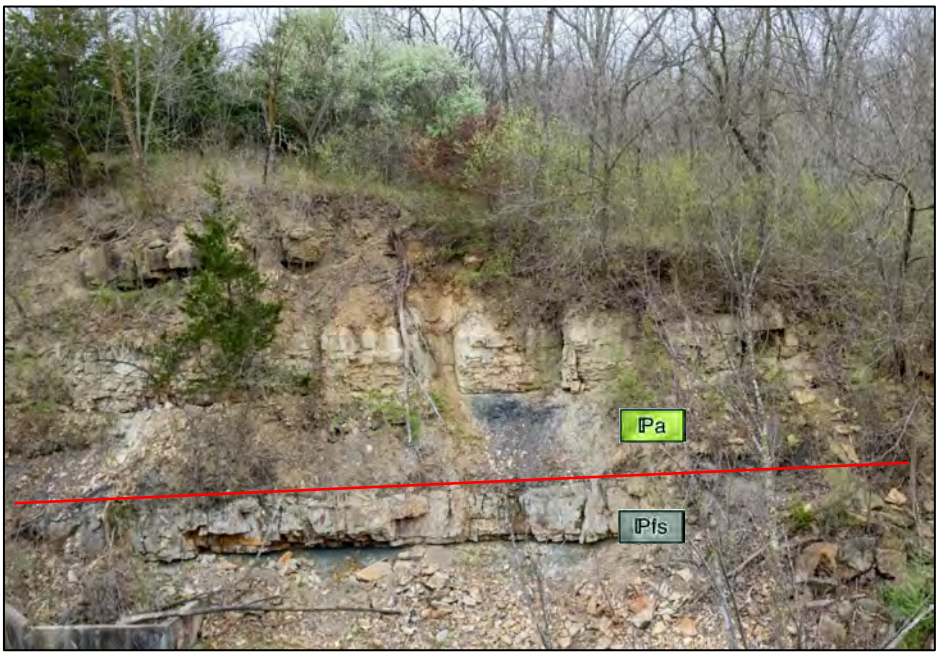

Figure 26. Annotated photograph of spillway outcrop at Stop #1 (photograph by B. Zalneraitis).

IPa

APPANOOSE SUBGROUP (PENNSYLVANIAN SUBSYSTEM, DESMOINESIAN STAGE, MARMATON GROUP) — The Appanoose Subgroup of the Marmaton Group on the Odessa South 7.5' quadrangle is comprised of the Labette Shale, Pawnee Formation, Bandera Shale, and Altamont Formation.

The **Altamont Formation** consists of the Worland Limestone Member, Lake Neosho Shale Member, and Amoret Limestone Member. The Amoret Limestone Member is a dark gray nodular carbonate wackestone. The Lake Neosho Shale Member was not observed in outcrop during this survey but is present in well logs and is described by Gentile (1976) as a dark-gray to black shale having large spheroidal phosphatic concretions. The Worland Limestone Member is a light-gray carbonate wackestone which is observed to be massive and more fossiliferous near the base and becomes wavier and more thinly bedded upwards.

The **Bandera Shale** is a green to gray micaceous, calcite-cemented shale with silty interbeds. The Bandera Shale also consists of the Mulberry coal bed and Bandera Quarry Sandstone Member. The Mulberry coal bed is a few inches thick to a smut locally. The Bandera Quarry Sandstone Member is a tan to orange, fine-grained, well-sorted, calcite-cemented, micaceous sandstone that is commonly cross bedded, and observed to be up to 20 feet thick.

The **Pawnee Formation** consists of the Anna Shale Member, Myrick Station Limestone Member, Mine Creek Shale Member, and Coal City Limestone Member. The Anna Shale Member is a black fissile shale with abundant spheroidal phosphate nodules. The Myrick Station Limestone Member is a light gray carbonate wackestone with tan interbeds and increasing fossil debris as beds thin upwards. The Mine Creek Shale Member is a gray shale with buff colored interbedded carbonate wackestone. The Coal City Limestone Member is an orange to brown carbonate mudstone to wackestone with *Chaetetes* mounds, brachiopods and fusulinids.

The **Labette Formation** consists of a black fissile shale, tan siltstones, and the Lexington coal bed which was observed up to six inches thick during this survey and is historically reported to be up to 14 inches thick on the quadrangle.

IPfs

FORT SCOTT SUBGROUP (PENNSYLVANIAN SUBSYSTEM, DESMOINESIAN STAGE, MARMATON GROUP) — The Fort Scott Subgroup of the Marmaton Group on the Odessa South 7.5' quadrangle is comprised of the Excello Shale, Blackjack Creek Limestone, Little Osage Formation, and Higginsville Limestone.

The **Higginsville Limestone** is a tan to grey, jointed, carbonate wackestone/packstone to grainstone/boundstone. In some horizons it is nearly a fusulinid packstone. *Chaetetes* are abundant. Chert rip-up clasts are occasionally found.

The **Little Osage Formation** consists of the Morgan School Shale Member, Summit coal bed, Binkley Shale Member, Houx Limestone Member, and Blackwater Creek Shale Member. The Morgan School Shale Member is a dark gray, calcareous shale overlain by the Summit coal bed, which was observed as a few inches thick to a smut. The Binkley Shale Member is a black fissile shale with phosphatic nodules and sometimes lenses or interbeds, often jointed with the overlying Houx Limestone Member. The Houx Limestone Member is a dark gray to maroon, jointed, carbonate wackestone which was observed to be less than two feet thick and occasionally present as two discrete but continuous sub-foot beds separated by shale. The Blackwater Creek Shale is a gray, occasionally maroon or olive, claystone.

The **Blackjack Creek Limestone** is a gray, carbonate wackestone with abundant crinoid columnals and brachiopod fragments. It is regularly jointed and weathers brownish-red, forming a deep oxidation rind along joint planes. It is observed as a single bed less than two feet thick on the Odessa South quadrangle.

The **Excello Shale** is a black, fissile shale containing phosphates typically as lenses along bedding planes.

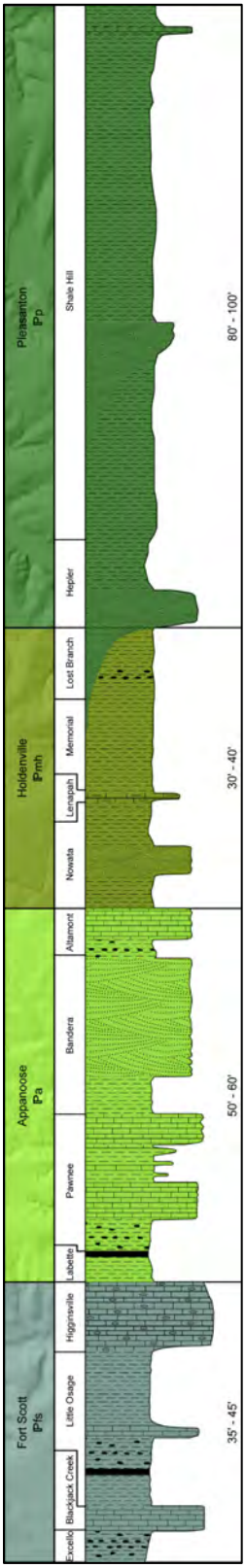

Figure 27. Stratigraphic column for Odessa South 7.5′ quadrangle (truncated).

Figure 28. Outcrop of Bandera Quarry Sandstone Mbr at Stop #1 (photograph by B. Zalneraitis).

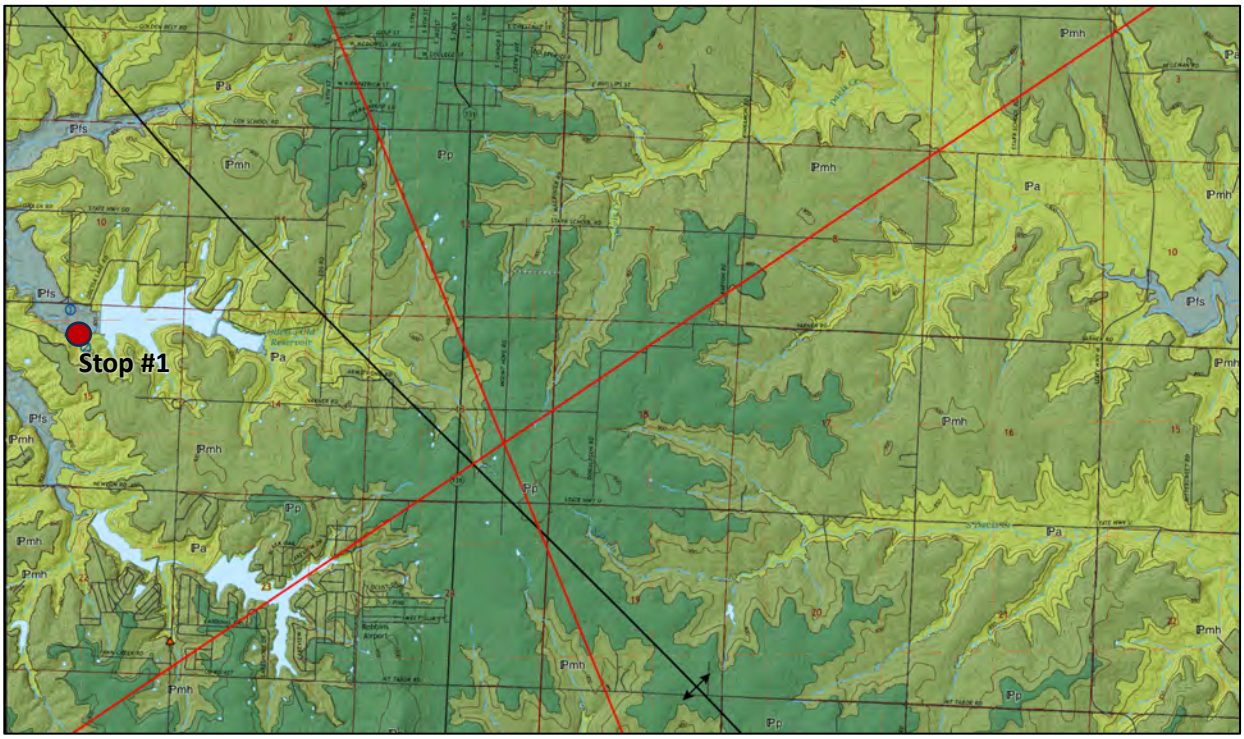

Figure 29. 1:24,000-scale bedrock geologic map of area surrounding Stop #1. Size is reduced.

Stop #2: Bandera Quarry Sandstone Member of Bandera Shale (Marmaton Group, Appanoose Subgroup) in the Odessa North 7.5′ quadrangle, Lafayette County (39.0861321°N, 93.9159812°W)

Recent mapping of the Odessa North 7.5′ quadrangle conducted by Benjamin Zalneraitis with partial funding under STATEMAP award number G21AC10872, 2021. **Map unit descriptions, stratigraphic column, and bedrock geologic map from Zalneraitis, B. (2022).**

Notes: outcrop is in the bed and bank of a small creek. Bedrock surfaces may be slick. Muck boots or other waterproof footwear are recommended for closer access to outcrop.

Mileage 29.4: Starting from Stop #1, turn left out of parking area onto Odessa Lake Road and proceed to triangle at intersection of Odessa Lake Road and Vanhorn Road. Turn right at triangle onto Vanhorn Road and proceed to intersection of Vanhorn Road and State Route OO (northbound). Continue straight onto State Route OO and proceed north and east for 3.1 miles to intersection of State Route OO and State Route 131. Turn left onto State Route 131 and proceed north to fork at intersection of State Route 131/South 2nd Street and South 1st Street. Take slight right at fork onto South 1st Street and proceed to intersection of South 1st Street and East Phillips Road. Turn right onto East Phillips Road and proceed east to intersection of East Phillips Road and Johnson Road. Turn left onto Johnson Road and proceed north for 1.2 miles to intersection of Johnson Road and Old Highway 40. Turn right onto Old Highway 40 and proceed east for 2.0 miles to intersection of Old Highway 40 and State Route M. Turn left onto State Route M then continue straight onto State Route O and proceed for 5 miles to the intersection of State Route O and State Route FF. Turn left onto State Route FF and proceed for 1.7 miles to Linn Grove Road. Turn right onto Linn Grove Road and proceed to intersection of Linn Grove Road and Ponderosa Trail.

Mileage 45.3: Stop #2, Outcrop of Bandera Quarry Sandstone in tributary of Little Sni-A-Bar Creek. **NOTE: outcrop is on private property and landowner permission was obtained for access to this stop.**

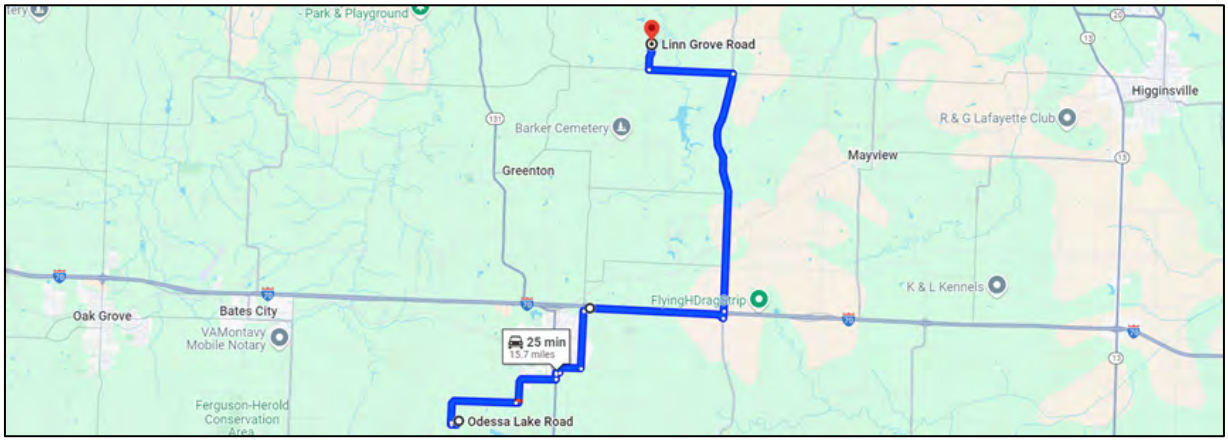

Figure 30. Map of field trip route from Stop #1 to Stop #2 (Google Maps).

Figure 31. Outcrop of Bandera Quarry Sandstone Mbr at Stop #2 (photograph by R. Daniels).

Pa **APPANOOSE SUBGROUP (PENNSYLVANIAN SUBSYSTEM, DESMOINESIAN STAGE, MARMATON GROUP)** – The Appanoose Subgroup of the Marmaton Group on the Odessa North Quadrangle is composed of the Pawnee Formation, Bandera Shale, and Altamont Formation.

The **Altamont Formation** consists of the Amoret Limestone Member, Lake Neosho Shale Member, and Worland Limestone Member. The **Amoret Limestone Member** was not seen in outcrop, but was seen occasionally in geophysical logs. According to Gentile and Thompson (2004), it occurs in nodular limestone beds embedded in a conformable claystone layer with the top of the Bandera Shale. The **Lake Neosho Shale Member** was only seen in construction debris, but is a fissile, gray to black mudstone, and appears consistently as a positive gamma excursion in geophysical logs. The **Worland Limestone Member** is a grayish orange (10 YR 7/4) to moderate brown (5 YR 4/4) carbonate wackestone with numerous invertebrate fossils, including one-inch crinoid columnals and brachiopods.

The **Bandera Shale** is a medium gray (N 5) to yellowish gray (5 Y 7/2), micaceous, variably calcite-cemented shale with occasional flattened calcareous concretions, interlaminated near the top with calcite-cemented sandstone beds. It can contain the Mulberry coal bed and the Bandera Quarry Sandstone Member. The **Mulberry coal bed** occurs near the bottom of the Bandera Shale, but only one to two feet is seen occasionally in subsurface logs. Near the center of the quadrangle, past surveys and geophysical logs indicate that the coal bed overlies a thin, unnamed limestone bed. The **Bandera Quarry Sandstone Member** is very pale orange (10 YR 8/2) to light brown (5 YR 5/6), medium-grained, variably calcite-cemented, micaceous sandstone, occurring in beds from four to ten feet thick.

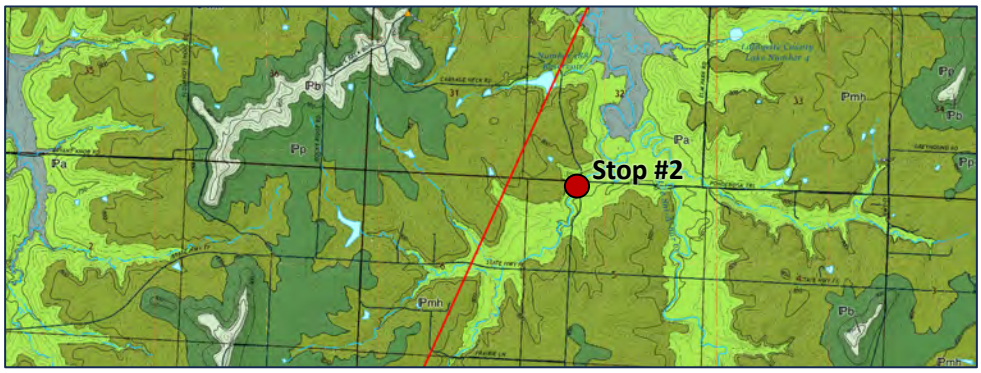

Figure 33. 1:24,000-scale bedrock geologic map of area surrounding Stop #2. Size is reduced.

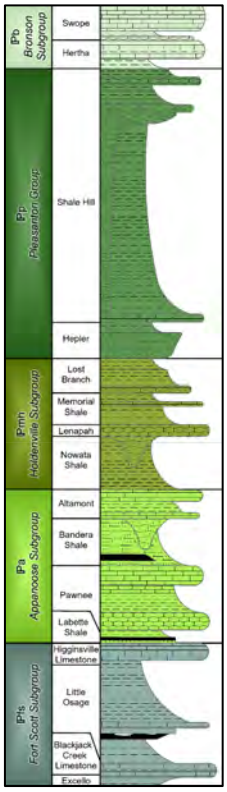

Figure 32. Stratigraphic column for Odessa North 7.5′ quadrangle (truncated).

Stop #3: Shale Hill Formation (Pleasanton Group) through Swope Formation (Kansas City Group, Bronson Subgroup) in the Oak Grove 7.5′ quadrangle, Jackson County (39.0085860°N, 94.2274107°W)

Recent mapping of the Oak Grove 7.5′ quadrangle conducted by Benjamin N. Zalneraitis with partial funding under STATEMAP award number G22AC00576, 2022. **Map unit descriptions, stratigraphic columns, and geologic bedrock map from Zalneraitis, B.N. (2023).**

Notes: outcrop is on a benched hillside with a steep face. When viewing highest part of outcrop from bench, exercise extreme caution and do not approach cliff edge.

Mileage 45.3: Starting from Stop #2, head south on Linn Grove Road to intersection of Linn Grove Road and State Route FF. Turn left onto State Route FF and proceed east for 1.7 miles to intersection of State Route FF and State Route O. Turn right onto State Route O and proceed south for 5 miles to entrance ramp at intersection of State Route O and US Interstate 70. Turn right onto entrance ramp and merge onto US Interstate 70 then proceed west for 16.4 miles to exit ramp for US Route 40/State Route BB. Turn left onto State Route AA/North Main Street and proceed south to intersection of State Route AA/North Main Street and US Route 40. Turn right onto US Route 40 and proceed west to intersection of US Route 40 and East Kirby Road. Turn left onto East Kirby Road and proceed south to intersection of East Kirby Road and Southwest Eagles Parkway/State Route AA. Turn right onto SW Eagles Parkway/State Route AA and proceed to Stop #3.

Mileage 73.7: Stop #3, Outcrop of Pleasanton Group and Bronson Subgroup of the Kansas City Group along State Route AA. **NOTE: outcrop is on private property and landowner permission was obtained for access to this stop.**

Figure 34. Map of field trip route from Stop #2 to Stop #3 (Google Maps).

Figure 35. Outcrop of the Pleasanton Group and the Bronson Subgroup of the Kansas City Group at Stop #3 (photograph by R. Daniels).

Figure 36. Stratigraphic column for Oak Grove 7.5′ quadrangle (truncated).

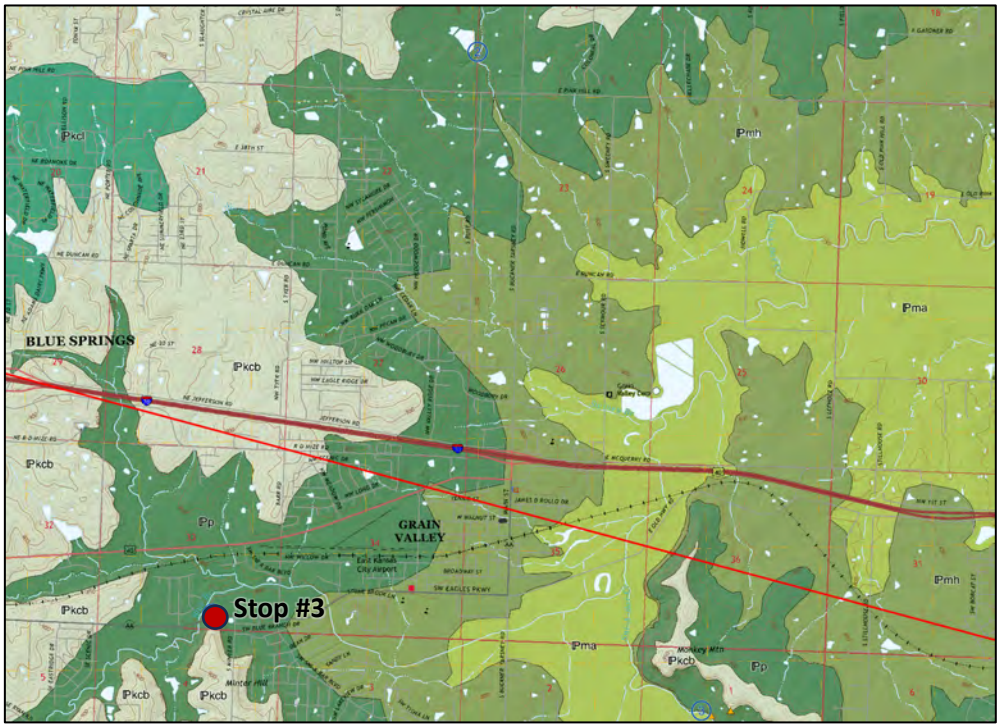

Figure 37. 1:24,000-scale bedrock geologic map of area surrounding Stop #3. Size is reduced.

IPkcb

BRONSON SUBGROUP (PENNSYLVANIAN SUBSYSTEM, MISSOURIAN STAGE, KANSAS CITY GROUP) — The Bronson Subgroup of the Kansas City Group on the Oak Grove quadrangle is composed of the Hertha Formation, Elm Branch Shale, Swope Formation, Galesburg Shale and Dennis Formation.

The **Dennis Formation** is composed of the Canville Limestone, Stark Shale and Winterset Limestone members. The formation reaches a thickness of nearly 25 feet, but the upper boundary was not observed in outcrop or well log. The **Canville Limestone Member** is a thin, dark-colored limestone only visible in a few well logs in the mapping area. On neighboring quadrangles it ranges from a featheredge to nearly 1 foot thick. The **Stark Shale Member** is a fissile, fossiliferous, black marine shale. It contains phosphate nodules and brachiopod fossils. It only crops out in the southwest quadrant of the quadrangle, but is present in the subsurface in Bronson-supported ridges west of Buckner-Tarsney Road. The **Winterset Limestone Member** is primarily a thin- and wavy-bedded, shaley wackestone, primarily occurring in the subsurface of the western half of the mapping area. It crops out in road cuts between I-70 and U.S. 40. Just to the west of the mapping area, the lower and upper limestone units are separated by a thick shale unit. The upper unit also features beds of dark gray to black chert.

The **Galesburg Shale** is a gray marine shale beneath the Stark Shale Member and above the Bethany Falls Limestone Member. It is covered in the mapping area, as the underlying Bethany Falls usually marks the top of visible outcrops. It is 5 to 15 feet thick in well logs containing the Dennis Formation units.

The **Swope Formation** is composed of the Middle Creek Limestone Member, Hushpuckney Shale Member and Bethany Falls Limestone Member. The formation is between 20 and 30 feet thick. The **Middle Creek Limestone Member** cropped out once on the south edge of the quadrangle as about 6 inches of dark gray limestone. In well logs, the limestone was less than two feet thick. The **Hushpuckney Shale Member** is a fissile, black, phosphatic shale. It is resistant to weathering, and often crops out when more resistant layers are buried below or eroded above. It grades to a gray calcareous shale near the contact with the Bethany Falls Limestone. Conodonts are numerous and slightly visible even without magnification. The **Bethany Falls Limestone Member** is a 10- to 20-foot-thick limestone unit occurring in the western half of the quadrangle. It is an important marker bed in the region because of its consistent appearance and high resistance to weathering. The lower half is medium-bedded, gray-to-yellow mudstone with sparse fossil content and algal structures. The halves are split by a bed, less than 1 foot thick, that laterally grades from a shale parting in some outcrops to a fossil-rich packstone in other outcrops. The upper half then has progressively thinning beds with a mottled gray coloration that thins to a nodular bed of pebbles on the upper surface.

The **Elm Branch Shale** is a consistently covered, gray marine shale between the Sniabar Limestone Member and the Middle Creek Limestone Member. The shale is 3 to 5 feet thick in well logs.

The **Hertha Formation** is composed of the Mound City Shale Member and Sniabar Limestone Member. It measures between 5 and 15 feet thick. The **Mound City Shale Member** is a fissile marine shale, ranging from gray to black. It only appears in well logs, and is difficult to distinguish from the underlying Guthrie Mountain Shale Member. The **Sniabar Limestone Member** is a fossiliferous, tan to brown wackestone to packstone. It occurs in one to three beds in outcrop, with a shale parting between each. The uppermost bed can be a bioherm, drastically thickening the unit. Each bed normally ranges 1 to 3 feet thick, for a total thickness varying between 3 and 10 feet.

IPp

PLEASANTON GROUP (PENNSYLVANIAN SUBSYSTEM, DESMOINESIAN AND MISSOURIAN STAGES) — The Pleasanton Group on the Oak Grove quadrangle is composed of the Desmoinesian Stage Hepler Formation and the Missourian Stage Shale Hill Formation.

The **Shale Hill Formation** is composed of the Exline Limestone, Mantey Shale, Weldon River Sandstone, Knobtown Limestone, Blue Mound Shale, Critzer Limestone and Guthrie Mountain Shale members. The thickness varies greatly, from 60 to 110 feet, depending on units present. The **Exline Limestone Member** was previously noted on this quadrangle in a master's thesis (Howe, 1948) but was not observed on this survey. In well logs, it is approximately 1 foot thick. Just west of the quadrangle on the Lake City Army Ammunition Plant, the Exline is a lens of fossiliferous, gray to red, wavy-bedded limestone. Where it pinches out, a layer of siderite concretion chips weather out of the surrounding shales. The **Mantey Shale Member** is a gray terrestrial shale with no observed fossil content. Resistant, silty laminae were observed in outcrop, as well as resistant clastic dikes along joints. Concretionary pebbles and cobbles are present near the middle of the unit. No **Weldon River Sandstone Member** was observed in outcrop, but 10-foot-thick sand lenses were observed at its horizon in numerous well logs. The **Knobtown Limestone Member** is a fossiliferous sandstone that transitions from the Weldon River Sandstone. Where the Knobtown crops out, it is a gray to tan, 2-foot-thick bed of sandstone with numerous brachiopods, gastropods and carbonized plant impressions. Some wells note a limestone at this horizon that is than 5 feet thick. The **Blue Mound Shale Member** is a blue-green to gray, thinly bedded shale with lenses and thin beds of sand throughout. The **Critzer Limestone Member** is nodular limestone of variable appearance, even over small distances. At the south edge of the map is an outcrop about 4 inches thick, and on the other side of the hill, all that remains is pebbles of Critzer embedded in the soil just above the erosional surface. The **Guthrie Mountain Shale Member** is similar to the gray-green appearance of the Blue Mound Shale, and is undifferentiated in the absence of the Critzer Limestone Member.

Stop #4: Shale Hill Formation (Pleasanton Group) through Swope Formation (Kansas City Group, Bronson Subgroup) in the Lake Jacomo 7.5′ quadrangle, Jackson County (38.9609491°N, 94.3330752°W)

Recent mapping of the Lake Jacomo 7.5′ quadrangle conducted by Elizabeth Hall with partial funding under STATEMAP award number G22AC00576, 2022. **Map unit descriptions, stratigraphic column, and bedrock geologic map from Hall, E. (2023).**

Notes: outcrop is accessed from Bobcat Trail. Length of the hike round trip from parking area is approximately half of a mile and difficulty level is easy to moderate. The trail is a dirt path with some short ascents and descents of gentle grade. Outcrop lies at the top of a steep slope above the Lake Jacomo shoreline. The highest part of the outcrop can be viewed from the top of the slope, but access to the lower part of the section requires descending steep hill toward shoreline. When viewing lower part of the outcrop exercise extreme caution and do not approach cliff edge.

Mileage 73.7: Starting from Stop #3, head west on State Route AA/Southwest Eagles Parkway/County Road AA for 2.2 miles to intersection of County Road AA and US Route 40. Turn left onto US Route 40 and proceed west for 2.3 miles to intersection of US Route 40 and Southwest Woods Chapel Road. Turn left onto Southwest Woods Chapel Road and proceed southwest to intersection of Southwest Woods Chapel Road and Rennau Drive. Turn left onto Rennau Drive and proceed south to intersection of Rennau Drive and Beach Road. Turn right onto Beach Road and proceed for 0.9 miles to Shelter #14/trailhead of Rock Ledges Nature Trail. Turn left into driveway/parking area of Shelter #14.

Mileage 83.5: Stop #4, Outcrop of Pleasanton Group and Bronson Subgroup of the Kansas City Group above shoreline of Lake Jacomo. **NOTE: Outcrops are within Fleming Park of Jackson County, sampling of rocks is NOT permitted.**

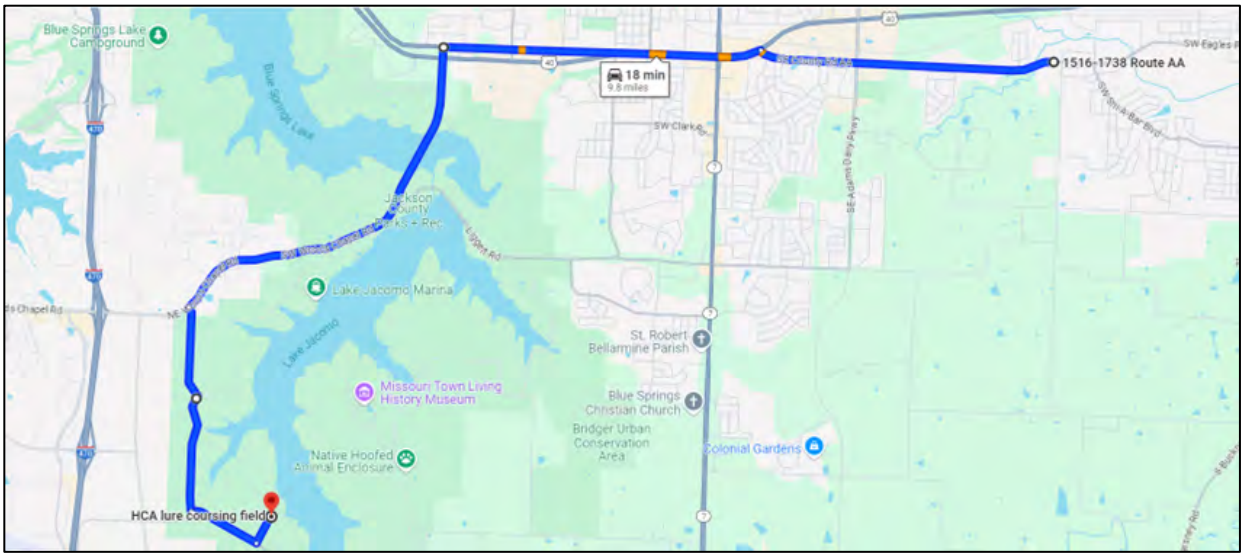

Figure 38. Map of field trip route from Stop #3 to Stop #4 (Google Maps).

Figure 39. Outcrops of Shale Hill Fm (left) and Swope Fm (right) at Stop #4 (photograph by R. Daniels).

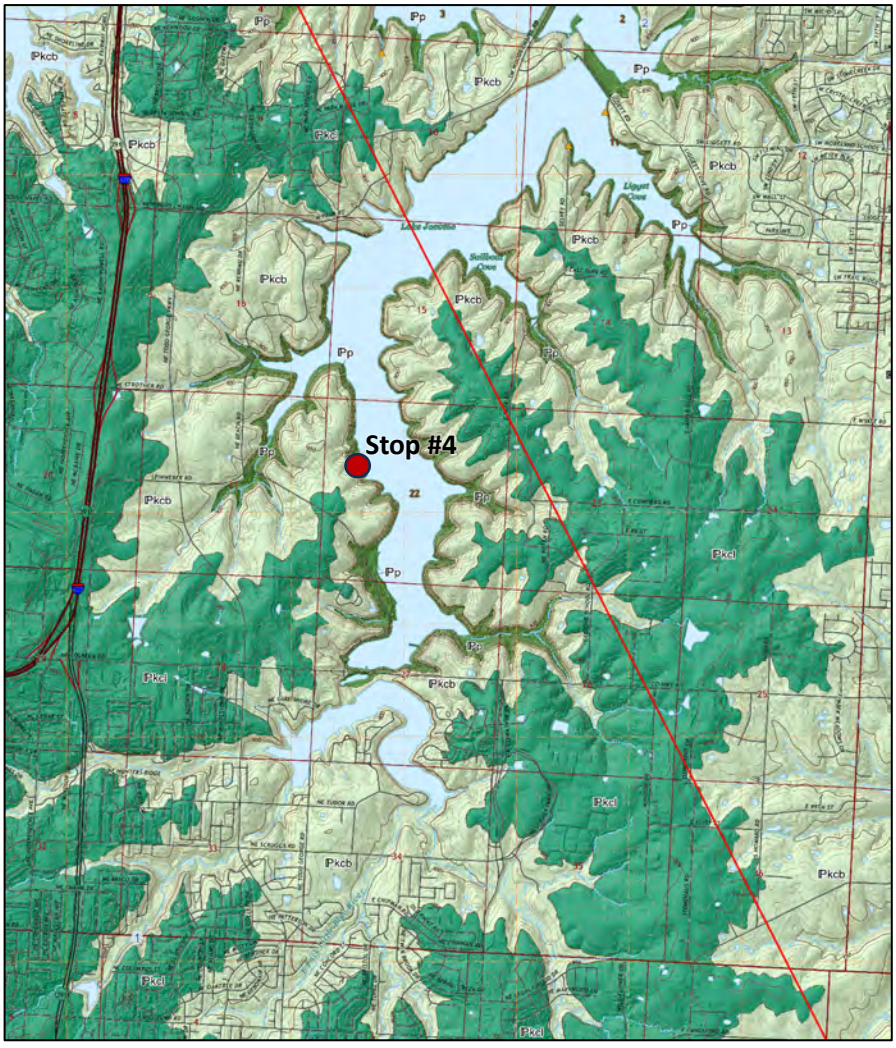

Figure 40. 1:24,000-scale bedrock geologic map of area surrounding Stop #4. Size is reduced.

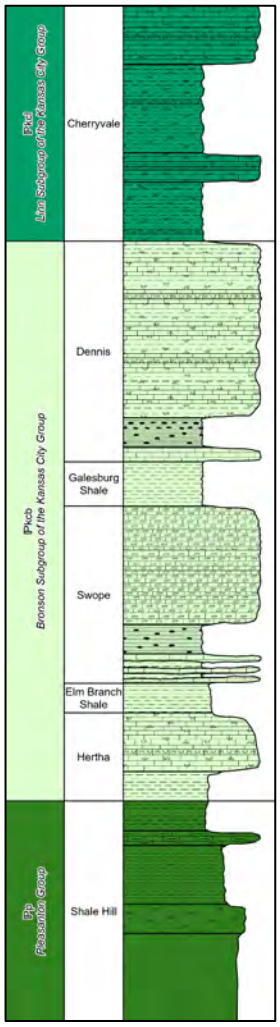

Figure 41. Stratigraphic column for Lake Jacomo 7.5′ quadrangle.

IPkcb

BRONSON SUBGROUP (PENNSYLVANIAN SUBSYSTEM, MISSOURIAN STAGE, KANSAS CITY GROUP) – All the lithostratigraphic units of the **Bronson Subgroup** are present in the Lake Jacomo quadrangle, from the base to the top – Hertha Formation, Elm Branch Shale, Swope Formation, Galesburg Shale and Dennis Formation.

The **Dennis Formation** is composed of three member units – the basal Canville Limestone, Stark Shale, and the Winterset Limestone at the top. The **Canville Limestone Member** is a very thin to thin-bedded tabular dark gray bioclastic wackestone. It may or may not be present in between the Galesburg Shale and the Stark Shale. Observed thickness along a cutbank in Banner Park, Sec. 4, T. 48 N., R. 31 W. is from 1 to 6 inches. **The Stark Shale Member** is a 1- to 3-foot-thick, black, platy shale that grades toward the top into dark gray shale. It has phosphatic concretions and conodonts as documented in measured section E0919 (Missouri Department of Natural Resources, 2023d) of Lake Jacomo Spillway, Sec. 2 and Sec. 11, T. 48 N., R. 31. W. Unlike the underlying Galesburg Shale, its platy section is more resistant and ledge-forming. The **Winterset Limestone Member** caps the Dennis Formation of the Bronson Subgroup. It is typically bioclastic packstone to wackestone, thick- to medium-bedded in the lower sections and medium- to thin-bedded in the upper sections. It can have shale partings and thick shale to rippled sandstone interbeds. It is dark tan to reddish brown on weathered surfaces, and cream to light gray on fresh surfaces. It is fossiliferous, bioturbated, and contains cobble-sized chert nodules towards the top. Its thickness in the Lake Jacomo quadrangle ranges from more than 10 feet to almost 50 feet.

Below the Canville Limestone of the Dennis Formation and above the Bethany Falls Limestone of the Swope Formation is the **Galesburg Shale**. It is a gray clay that grades upwards into black shale. The black shale contains a thin layer of coal smut. It can be distinguished from the Stark Shale of the Dennis Formation by its friable nature. Its thickness based on well data and outcrop is from 2.5 to 5 feet.

The **Swope Formation** consists of three members, from the base to the top – Middle Creek Limestone, Hushpuckney Shale, and Bethany Falls Limestone. The **Middle Creek Limestone Member** occurs as three thin beds of brown-gray wackestone interbedded by two dark gray shales, with about 1 foot of total thickness. Bioclasts identified in the Middle Creek Limestone in measured section E0919 (Department of Natural Resources, 2023d) of Lake Jacomo Spillway are brachiopods (e.g., *Neospirifer* sp., *Crurithyris*, productid spines), bryozoa (e.g., *Rhombopora*), ammovertellids, ostracodes, and crinoid fragments. The **Hushpuckney Shale Member** is a black, platy shale, containing phosphatic concretions that grades upward into gray to brown clay. Its thickness ranges from 3 to 5 feet. The Hushpuckney Shale and Middle Creek Limestone are usually covered by aprons of soil and rock debris from the more resistant and towering Bethany Falls above. The **Bethany Falls Limestone Member** is well-exposed in the Fleming Park that surrounds the Lake Jacomo Reservoir. Here, it outcrops as greenish gray ledges and bluffs, over 10 feet high. The Bethany Falls Limestone is a hard, brittle mudstone to wackestone, light gray to cream colored on fresh surface. The lower part is medium-bedded, wavy, bearing occasional crinoid fragments, and sparse chert nodules as described in measured section E0920 (Missouri Department of Natural Resources, 2023d) of Prairie Lee Lake, Sec. 27, T. 48 N., R. 31 W. The middle part is mottled where bioturbations are common. The upper part is generally thin-bedded, bioturbated, and can be nodular. The thickness of the Bethany Falls in the Lake Jacomo quadrangle derived from well logs is from 15 to 30 feet.

The **Elm Branch Shale** stratigraphically sits below the Middle Creek Limestone of the Swope Formation and above Sniabar Limestone of the Hertha Formation. It is a brown-gray gritty clay, 2- to 5-foot thick in well logs. It contains abundant *Derbyia* at the Prairie Lee Lake outcrop of measured section E0920 (Missouri Department of Natural Resources, 2023d). It is poorly exposed in the Lake Jacomo quadrangle, often covered by soil and fragments from the overlying rock units.

The **Hertha Formation** is the basal formation of the Kansas City Group. It includes two member units, the lower Mound City Shale and the upper Sniabar Limestone. In Lake Jacomo, the **Mound City Shale Member** occurs as a 2- to 3-foot-thick, very weathered, tan to gray crumbly mudstone underneath the Sniabar Limestone and above the Guthrie Mountain Shale of the Pleasanton Group. The **Sniabar Limestone Member** is thin- to medium-bedded, gray to dark brown on weathered surfaces, cream on fresh surfaces, bioclastic packstone to wackestone. Its thickness is from 5 to 12 feet and is often used in well logs as a marker bed that indicates boundary between the Pleasanton Group and the Kansas City Group.

IPp

PLEASANTON GROUP (PENNSYLVANIAN SUBSYSTEM, DESMOINESIAN AND MISSOURIAN STAGES) – Below the shale-carbonate sequences of the Kansas City Group is the predominantly clastic sediment package of the **Pleasanton Group**. The group is comprised of the lower Hepler Formation of Desmoinesian Stage, and the upper Shale Hill Formation of Missourian Stage. The upper sections of the Shale Hill Formation constitute the Pleasanton Group bedrock in the Lake Jacomo quadrangle.

The **Shale Hill Formation** is represented by member units, in ascending order – Weldon River Sandstone, Knobtown Limestone, Blue Mound Shale, Critzer Limestone, and Guthrie Mountain Shale. The **Weldon River Sandstone Member** is the stratigraphic floor in the Lake Jacomo quadrangle. It is greenish gray, tan to dark brown, cross-laminated to thin cross-bedded, sandstones, siltstones, and mudrock that outcrops mostly around the reservoir areas of Lake Jacomo and southern Blue Springs. It is variably weakly calcareous to non-calcareous, friable, and may on occasion have calcite concretions and fossil fragments. Its base was not observed but it makes cliff walls that rise from the lake surface to more than 10 feet high. Its contact with the overlying Knobtown Limestone is gradational. The **Knobtown Limestone Member** is a 2- to 4-foot-thick tabular, tan to dark brown, cross-bedded, and calcareous to non-calcareous siltstone and sandstone. It contains numerous macrofossils and forms a resistant ledge above the Weldon River Sandstone. The **Blue Mound Shale Member** is a gray to tan silty shale, with laminations that are generally thinner compared to the Weldon River Sandstone. Its gross thickness at Coon's Cove is about 10 feet. The **Critzer Limestone Member** is a yellowish tan, irregularly bedded argillaceous limestone. It appears as a thin calcarenitic crust, about 3 to 6 inches thick, that separates the Guthrie Mountain Shale above and the Blue Mound Shale below. The **Guthrie Mountain Shale Member** is a gray to reddish brown shale, about 3.5 feet thick at a lakeshore outcrop in sec. 11 T. 48 N. R. 31W. The **Ovid coal bed** is absent where Guthrie Mountain outcrops were observed in Lake Jacomo quadrangle during this survey. However, a 1/8-inch coal smut attributed to the Ovid coal bed, underlying a 6-inch clay with root impressions was documented in measured section E0919 (Missouri Department of Natural Resources, 2023d) in the Lake Jacomo Spillway at about 806-foot elevation, lower than the current elevation of the spillway.

Stop #5: Hertha Formation through Dennis Formation (Kansas City Group, Bronson Subgroup) in the Blue Springs 7.5′ quadrangle, Jackson County (39.0145602°N, 94.3452442°W)

Recent mapping of the Blue Springs 7.5′ quadrangle conducted by Marissa Schorr with partial funding under STATEMAP award number G22AC00576, 2022. **Map unit descriptions, stratigraphic column, and bedrock geologic map from Schorr, M. (2023).**

Notes: access to outcrop requires crossing a busy park road. Exercise caution when crossing. A high visibility vest is strongly recommended.

Mileage 83.5: Starting from Stop #4, turn right out of parking lot of Shelter #14 onto Beach Road and proceed northwest to triangle at Beach Road and Leinweber Road. Continue onto Leinweber Road and proceed to intersection of Leinweber Road and Northeast Todd George Parkway. Turn right onto Northeast Todd George Parkway and continue north for 1.5 miles to intersection of Northeast Todd George Parkway and Northeast Woods Chapel Road. Travel straight through intersection onto Northeast Lakewood Way and proceed northwest and north for 1.7 miles to intersection of Northeast Lakewood Way and Bowlin Road. Turn right onto Bowlin Road and proceed to intersection of Bowlin Road and Northeast Campground Road. Turn left onto Northeast Campground Road and proceed to intersection of Northeast Campground Road and Lake Ridge Road. Turn left onto Lake Ridge Road and proceed for 0.8 miles to parking area at Blue Springs Lake boat ramp.

Mileage 89.2: Stop #5, Outcrop of Bronson Subgroup of the Kansas City Group in Blue Springs Lake spillway. **NOTE: Outcrops are within Fleming Park of Jackson County, sampling of rocks is NOT permitted.**

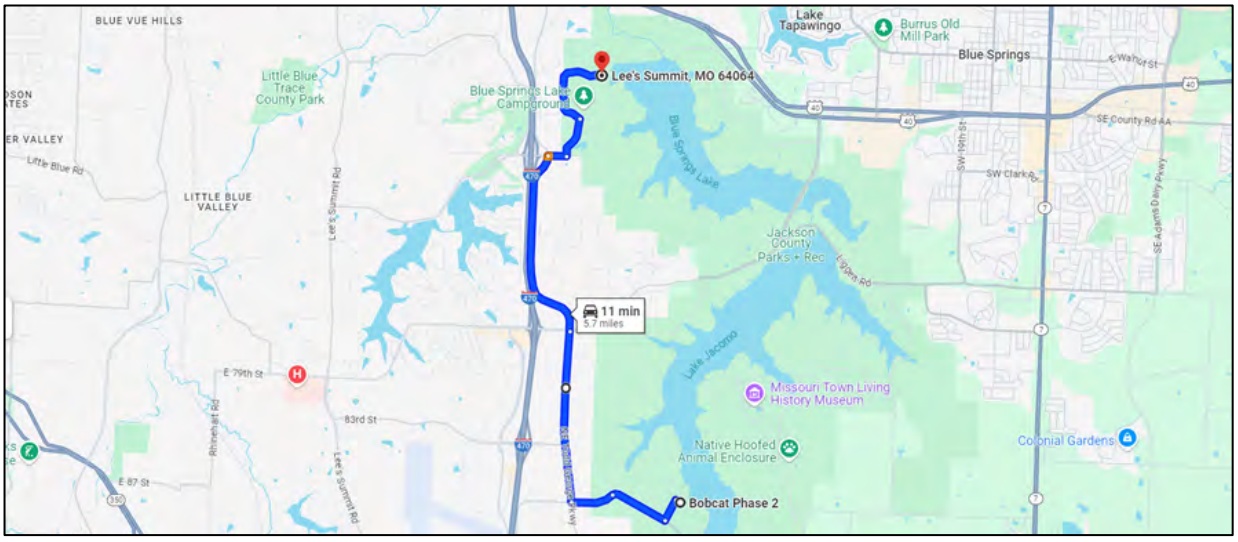

Figure 41. Map of field trip route from Stop #4 to Stop #5 (Google Maps).

Figure 42. Outcrop of Hertha and Swope formations at Stop #5 (photograph by M. Schorr).

Pkcb

BRONSON SUBGROUP (PENNSYLVANIAN SUBSYSTEM, MISSOURIAN STAGE) – The Bronson Subgroup on the Blue Springs quadrangle is comprised of the Hertha Formation, Elm Branch Shale, Swope Formation, Galesburg Shale, and Dennis Formation.

The **Dennis Formation** is composed of the Canville Limestone Member, Stark Shale Member, and Winterset Limestone Member. The **Canville Limestone Member** was not observed in the current study, but has been previously described from one locality on the Blue Springs quadrangle. Gentile (1981) described the Canville Limestone Member from the Jackson County No. 2 quarry (sec. 2, T. 48 N., R. 31 W.) as a 1-inch-thick, discontinuous limestone bed with the brachiopod *Derbyia*, bivalvia of the genus *Aviculopecten*, and bryozoans. The **Stark Shale Member** is a black, platy, fissile shale that is typically 2 to 4 feet thick. It is organic rich and locally contains *Orbiculoidea* fossils and small phosphatic concretions. The **Winterset Limestone Member** on the Blue Springs quadrangle ranges from 25 to 35 feet in thickness and is composed of alternating beds of micritic limestone and dark shale. The lower 10 to 20 feet of the Winterset Limestone is mostly micritic, fossiliferous limestone with two to three prominent 6- to 8-inch-thick, dark grey shale beds between the limestone beds. In the upper 10 to 15 feet, calcareous shale becomes dominant and is interspersed with beds of massive, nodular, dark grey, unfossiliferous limestone and black chert. The calcareous shale in the upper part is laminated and often contains brachiopod fossils, thin sandy beds or lenses, and *Cordaites* plant fossils.

The **Galesburg Shale** is covered in most outcrops on the Blue Springs quadrangle, but where it is observable, it is a 3- to 4-foot-thick, grey, silty to clayey shale.

The **Swope Formation** is composed of the Middle Creek Limestone Member, Hushpuckney Shale Member, and Bethany Falls Limestone Member. The **Middle Creek Limestone Member** ranges in thickness from 3 to 8 inches across the Blue Springs quadrangle. It is a medium grey, micritic to finely crystalline limestone that contains fragments of brachiopod and crinoid fossils as well as pinpoint pyrite. Above the Middle Creek Limestone Member is the **Hushpuckney Shale Member** which is a black, platy, fissile shale very similar to the Stark Shale Member of the Dennis Formation. The Hushpuckney shale is about 2 to 4 feet thick and can contain phosphate nodules. The upper portion of the Hushpuckney shale is often light grey and calcareous where it is in contact with the overlying Bethany Falls Limestone Member. The **Bethany Falls Limestone Member** is a reliable marker bed across the Blue Springs quadrangle. It is a hard, micritic limestone that forms a resistant, 15- to 20-foot-tall cliff in many hillsides and roadcuts. The lower portion of the Bethany Falls Limestone is wavy-bedded and can contain some brachiopod and crinoid fossils. The middle and upper portions have a distinct dark and light grey mottling that is characteristic of the unit. The middle and upper portions have fewer fossils and tend to be more massively bedded. The uppermost 1 to 2 feet of the Bethany Falls Limestone are composed of nodular limestone interbedded with thinner, shalcy layers that grade up into the overlying Galesburg Shale.

The **Elm Branch Shale** is comprised of 3 to 5 feet of grey, clay-rich shale. It weathers easily and is often covered in talus from the overlying Middle Creek and Hushpuckney members of the Swope Formation.

The **Hertha Formation** is composed of the Mound City Shale Member and the Sniabar Limestone Member. The **Mound City Shale Member** is defined as a black fissile shale below the overlying Sniabar Limestone Member. It was not observed on the Blue Springs quadrangle, but is usually about 2 feet thick. The **Sniabar Limestone Member** is typically 4 to 8 feet thick and is comprised of one to three beds of massive, fossiliferous limestone separated by 2- to 6-inch-thick grey shale beds. Fossils typical of the Sniabar Limestone include colonial corals, crinoids, and brachiopods. The Sniabar Limestone is typically grey in color, but often weathers orange or chocolate brown.

Figure 44. 1:24,000-scale bedrock geologic map of area surrounding Stop #5. Size is reduced.

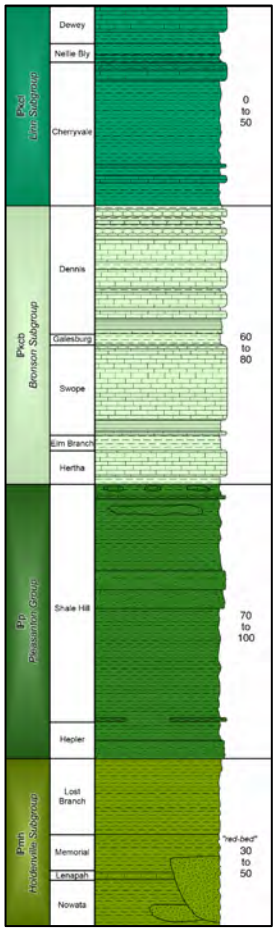

Figure 43. Stratigraphic column for Blue Springs 7.5′ quadrangle (truncated).

Stop #6: Swope Formation through Dennis Formation (Kansas City Group, Bronson Subgroup) in the Oak Grove 7.5′ quadrangle, Jackson County (39.0134861°N, 94.2495274°W)

Recent mapping of the Oak Grove 7.5′ quadrangle conducted by Benjamin N. Zalneraitis with partial funding under STATEMAP award number G22AC00576, 2022. **Map unit descriptions, stratigraphic columns, and geologic bedrock map from Zalneraitis, B.N. (2023).**

Notes: outcrop is along a busy city highway. Exercise caution around roadway traffic. A high visibility vest is strongly recommended.

Mileage 89.2: Starting from Stop #5, head north then east on Lake Ridge Road to intersection of Lake Ridge Road and Turkey Hollow Road/Southwest Tapawingo Lane. Turn left onto Turkey Hollow Road/Southwest Tapawingo Lane and proceed to intersection of Turkey Hollow Road/Southwest Tapawingo Lane and US Route 40. Turn right onto US Route 40 and proceed southeast and east for 3.3 miles to intersection of US Route 40 and County Road AA. Turn right onto County Road AA and continue on State RouteAA/Southwest Eagles Parkway for 2.5 miles to intersection of State Route AA/Southwest Eagles Parkway and Barr Road. Turn left onto Barr Road/Northwest Sni-A-Bar Parkway and proceed north to intersection of Barr Road/Northwest Sni-A-Bar Parkway and Northwest Sni-A-Bar Drive. Turn left onto Northwest Sni-A-Bar Drive and proceed northwest to intersection of Northwest Sni-A-Bar Drive and US Route 40. Turn left onto US Route 40 and proceed west for 1.4 miles to Stop #6.

Mileage 98.3: Stop #6, Outcrop of Bronson Subgroup of the Kansas City Group along US Route 40.

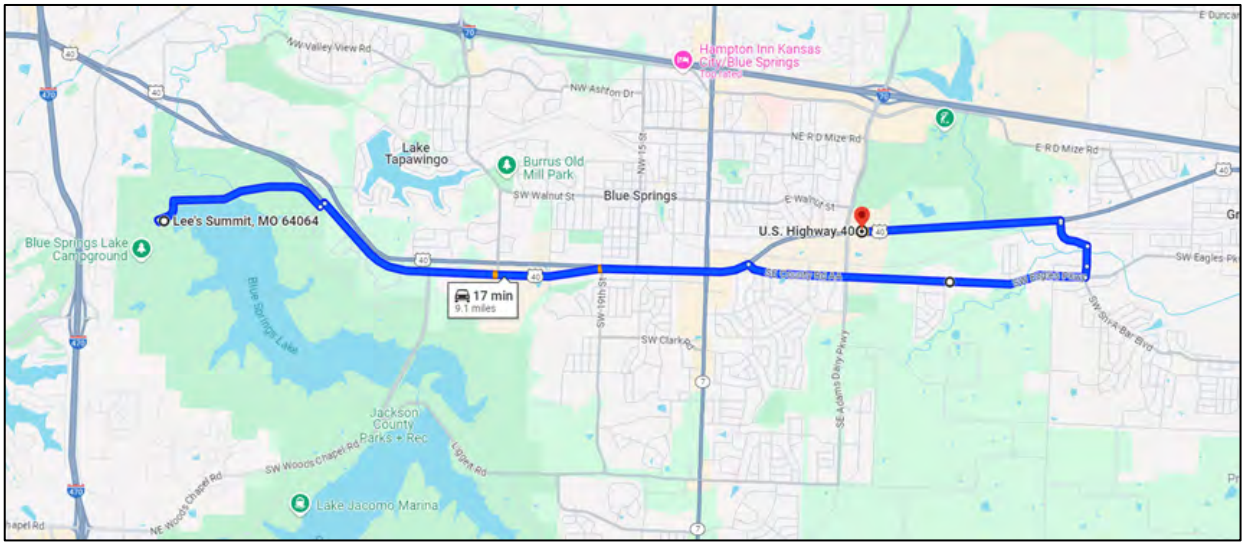

Figure 45. Map of field trip route from Stop #5 to Stop #6 (Google Maps).

Figure 46. Outcrops of Swope Fm (left) and Dennis Fm (right) at Stop #6 (photographs by R. Daniels).
Refer to Stop #3 for map unit descriptions and stratigraphic column.

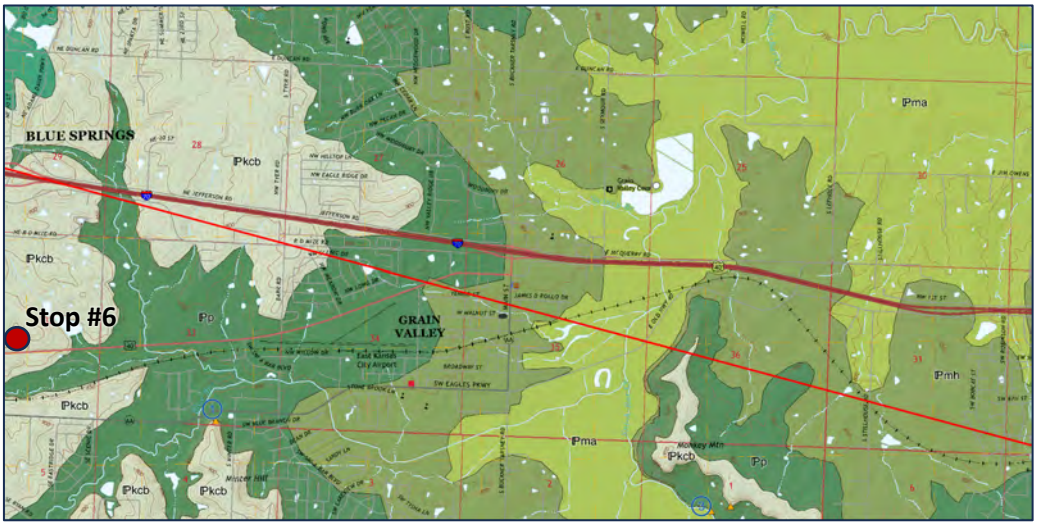

Figure 47. 1:24,000-scale bedrock geologic map of area surrounding Stop #6. Size is reduced.

Mileage 98.3: Starting from Stop #6, head west on US Route 40 to intersection of US Route 40 and Southeast Adams Dairy Parkway. Turn right onto Southeast Adams Dairy Parkway and proceed north for 1 mile to eastbound entrance ramp at intersection of Southeast Adams Dairy Parkway and US Interstate 70. Turn right onto entrance ramp then merge onto US Interstate 70 and proceed east for 27.3 miles to exit ramp for State Route 13. Turn right onto State Route 13 and proceed south for 12.1 miles to traffic circle at intersection of State Route 13 and State Route 13 Business. Take third exit from traffic circle and proceed southeast on State Route 13 for 1.9 miles to intersection of State Route 13 and Northeast 151st Street. Turn right onto Northeast 151st Street and proceed south to intersection of Northeast 151st Street and Northeast 150th Road/Veterans Road. Turn right onto Northeast 150th Road/Veterans Road and proceed west, then continue south on PCA Road to intersection of PCA Road and East Russell Avenue. Turn right onto East Russell Avenue then turn left into parking lot of Quality Inn at 626 East Russell Ave, Warrensburg, MO, 64093.

Mileage 146.6: End point of field trip at Quality Inn in Warrensburg.

References and Suggested Readings

Clair, J.R., 1943, The Oil and gas resources of Cass and Jackson counties, MO; Missouri Geological Survey and Water Resources, Volume 27, 2nd Series, 208 p., 7 pls.

Crews, J., 2019, Bedrock geologic map of the Hughesville 7.5′ quadrangle, Pettis County, Missouri; Missouri Department of Natural Resources, Missouri Geological Survey, Open-file Map OFM-2019-697-GS, 1:24,000-scale, 1 sheet.

Daniels, R.L., 2022, Bedrock geologic map of the Warrensburg West 7.5′ quadrangle, Johnson County, Missouri; Missouri Department of Natural Resources, Missouri Geological Survey, Open-file Map OFM-2022-727-GS, 1:24,000-scale, 1 sheet.

Doty, R.W. and Hubert, J.F., 1962, Petrology and paleogeography of the Warrensburg Channel Sandstone, western Missouri; Sedimentology, Volume 1, 1st Issue, p. 7-39.

Ellis, T., 2020, Bedrock geologic map of the Knob Noster 7.5′ quadrangle, Johnson and Pettis counties, Missouri; Missouri Department of Natural Resources, Missouri Geological Survey, Open-file Map OFM-2020-707-GS, 1:24,000-scale, 1 sheet.

Emerson, J.W. and Nold, J.L., 2001, Valley anticline associated with the Warrensburg Sandstone in Missouri; Missouri Academy of Science Transactions, Volume 35, p. 25-37.

Federal Geographic Data Committee [prepared for the Federal Geographic Data Committee by the U.S. Geological Survey], 2006, FGDC Digital Cartographic Standard for Geologic Map Symbolization; Reston, Va., Federal Geographic Data Committee Document Number FGDC-STD-013-2006, 290 p., 2 pls.

Ganz, K., 2022, Bedrock geologic map of the Warrensburg East 7.5′ quadrangle, Johnson County, Missouri; Missouri Department of Natural Resources, Missouri Geological Survey, Open-file Map OFM-2022-728-GS, 1:24,000-scale, 1 sheet.

Gentile, R.J., 2015, Rocks and fossils of the central United States with special emphasis on the greater Kansas City area, 2nd ed; University of Kansas, Department of Geology and Paleontological Institute, Special Publication 8, vi + 217 p.

Gentile, R.J. and Thompson, T.L., 2004, Paleozoic succession in Missouri part 5: Pennsylvanian Subsystem of Carboniferous System; Missouri Department of Natural Resources, Geological Survey and Resource Assessment Division, Report of Investigations 70 part 5, 1225 p., 1 pl.

Hall, E., 2023, Bedrock geologic map of the Lake Jacomo 7.5′ quadrangle, Jackson County, Missouri; Missouri Department of Natural Resources, Missouri Geological Survey, Open-file Map OFM-2023-738-GS, 1:24,000-scale, 1 sheet.

Heckel, P.H., 1984, Changing concepts of Midcontinent Pennsylvanian cyclothems, North America, *in* Congres International de Stratigraphie et de Geologie du Carbonifere, 9th edition, Compte Rendu, Volume 3, pt. 3: Carbondale, Southern Illinois University Press, p. 535-553.

Heckel, P.H., 1986, Sea-level curve for Pennsylvanian eustatic marine transgressive-regressive depositional cycles along midcontinent outcrop belt, North America; Geology, Volume 14, Issue 4, p. 330-334.

Hinds, H. and Greene, F.C., 1915, The stratigraphy of the Pennsylvanian series in Missouri; Missouri Bureau of Geology and Mines, Volume 13, 2nd Series, 407 p., 32 pls.

Howe, W.B., 1948; Geology of the Oak Grove quadrangle: unpublished Master's thesis; University of Missouri-Columbia, Missouri, v + 78 p.

Howe, W.B., 1982, Stratigraphy of the Pleasanton Group Pennsylvanian System in Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Report OFR-82-10-GI, 81 p.

Jeffries, N.W., 1958, Stratigraphy of the lower Marmaton rocks of Missouri; University of Missouri, Doctoral Dissertation, Columbia, Missouri, 331 p., 28 pls.

Jewett, J.M., 1941, Classification of the Marmaton group, Pennsylvanian, in Kansas; Kansas Geological Survey Bulletin 38, pt. 2, p. 285-344

Lamb, R.E., 1989, The environmental geology of the southern half of the Blue Springs quadrangle, Missouri; Unpublished M.S. Thesis, University of Missouri – Kansas City, 64 p., 2 app., 2 pl.

Missouri Department of Natural Resources, 2006, Well logs; in Missouri Geological Survey Geosciences Technical Resource Assessment Tool (GeoSTRAT), Missouri Department of Natural Resources, Missouri Geological Survey, http://dnr.mo.gov/geostrat/.

Missouri Department of Natural Resources, 2014, Inventory of mines, occurrences and prospects (IMOP); in Missouri Geological Survey Geosciences Technical Resource Assessment Tool (GeoSTRAT), Missouri Department of Natural Resources, Missouri Geological Survey, http://dnr.mo.gov/geostrat/.

Missouri Department of Natural Resources, 2019, Well cuttings; in Missouri Geological Survey Geosciences Technical Resource Assessment Tool (GeoSTRAT), Missouri Department of Natural Resources, Missouri Geological Survey, http://dnr.mo.gov/geostrat/.

Robertson, C.E., 1971, Evaluation of Missouri’s coal resources: Missouri Geological Survey and Water Resources, Report of Investigations 48, 100 p., 9 pls.

Robertson, C.E. and Smith, David C., 1981, Coal resources and reserves of Missouri; Missouri Department of Natural Resources, Division of Geology and Land Survey, Report of Investigations 66, 49 p.

Schorr, M., 2023, Bedrock geologic map of the Blue Springs 7.5′ quadrangle, Jackson County, Missouri; Missouri Department of Natural Resources, Missouri Geological Survey, Open-file Map OFM-2023-735-GS, 1:24,000-scale, 1 sheet.

Searight, W.V., and Howe, W.B., 1961 Pennsylvanian deposits of the Forest City Basin, Missouri (abstract); Geological Society of America Bulletin, v. 70, p. 1673.

Thompson, T.L., 1995, The stratigraphic succession in Missouri (revised); Missouri Department of Natural Resources, Division of Geology and Land Survey, Volume 40, 2nd Series, 188 p.

Umholtz, N.M., 2022, Bedrock geologic map of the Odessa South 7.5′ quadrangle, Johnson and Lafayette counties, Missouri; Missouri Department of Natural Resources, Missouri Geological Survey, Open-file Map OFM-2022-723-GS, 1:24,000-scale, 1 sheet.

Wanless, H.R. and Shepard, F.P., 1936, Sea level and climatic changes related to late Paleozoic cycles: Geological Society of America Bulletin, v. 47, p. 1177-1206.

Watney, W.L., French, John, and Franseen, E.K., 1989, Sequence stratigraphic interpretations and modeling of cyclothems in the Upper Pennsylvanian (Missourian) Lansing and Kansas City groups in eastern Kansas; Kansas Geological Society 41st Annual Field Trip, 211 p.

Zalneraitis, B., 2022, Bedrock geologic map of the Odessa North 7.5′ quadrangle, Lafayette County, Missouri; Missouri Department of Natural Resources, Missouri Geological Survey, Open-file Map OFM-2022-720-GS, 1:24,000-scale, 1 sheet.

Zalneraitis, B.N., 2023, Bedrock geologic map of the Oak Grove 7.5′ quadrangle, Jackson County, Missouri; Missouri Department of Natural Resources, Missouri Geological Survey, Open-file Map OFM-2023-736-GS, 1:24,000-scale, 1 sheet.