Cover Photo: Route MM at Sycamore Springs, Jefferson County Missouri
ASSOCIATION OF MISSOURI GEOLOGISTS

58TH ANNUAL MEETING
SEPTEMBER 30 – OCTOBER 1, 2011
FESTUS, MISSOURI

GUIDEBOOK TO FIELD TRIPS
Ordovician Geology in Recent Road Cuts of Jefferson County Missouri

2011

Phil Ruffus, Editor
Missouri Department of Transportation
St. Louis Metro District
Chesterfield, Missouri
Association of Missouri Geologists

58th Annual Meeting and Field Trips

September 30 – October 1, 2011
Best Western Shalimar Plaza Hotel and Conference Center
Festus, Missouri

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ACKNOWLEDGEMENTS

Special thanks to Bob Berri. Bob’s assistance and experience in leading field trips was invaluable. Without him, this trip would not have been possible.

IN MEMORIAM: Anne Peery (1946-2011)
Anne was the first person I met at AMG. It was her enthusiasm and kindness that inspired an unemployed geology student to become who I am professionally. She was a great friend and I will miss my seatmate of the last fourteen years.
Area Map Showing Field Trip Stops

Day 1:

1) Mississippi Sand Company
   St. Peter Sandstone
2) Route 61 @ I-55
   St. Peter SS and Joachim Dolomite
3) I-55 @ Route TT
   Cotter/Powell Dolomite
4) I-55 roadcut
   Everton Formation

Day 2:

1) Route 21 @ Route BB
   Plattin Fm. Crystal Zone
2) Route 21
   Kimmswick Ls and Karst
3) Route MM @ Sycamore Springs
   Plattin Fm., Decorah Gr., and Kimmswick Ls.
4) Route MM @ Route 21
   Unnamed Osagean/Fern Glen
5) Route M
   Fern Glen, Bushburg, Kimmswick, Decorah and Plattin Groups.
6) Mastodon State Park
   (If Time Permits)
## Generalized Stratigraphic Column of Southern Jefferson County

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General Overview of Jefferson County

Jefferson County Missouri is bounded clockwise from the north by St. Louis County, the Mississippi River, Ste. Genevieve, St. Francois, Washington and Franklin counties. It contains an area of about 664 square miles, with a population of 218,733. Hillsboro (2,062) is the county seat.

Overall, Jefferson County is very hilly. There is general ridge, running roughly southwest through the center of the county, that forms a watershed between Big and the Mississippi Rivers.

In the northern and western portions of the county, the ridges are very narrow at their summits, and are separated from each other by deep ravines. The hills bounding the valleys of the larger streams are also frequently marked with deep declivities, but sometimes they rise by a succession of gentle slopes or terraces to the general level of the table-lands.

East of the central ridge, the county is drained by the Meramec River, Little Rock, Glaize, Sandy, Joachim, Muddy, Isle au Bois Creeks, which flow into the Mississippi.

The western part of the county is drained by Big River, which flows in a tortuous route from the southern to the northern boundary of the county, where it empties into the Meramec. The principal tributaries of Big River are Dry Fork, Belew, Head and Jones Creeks. A part of the northern portion of the county is drained by Saline, Sugar, Mill and Labarque Creeks, which also empty into the Meramec.

There are a great many springs in Jefferson County with a large amount associated with the Kimmswick Limestone. Outside of the cities and towns, people obtain drinking water from shallow to moderately deep wells that penetrate the St. Peter Sandstone.
The mineral resources of Jefferson County have only been partially developed. Iron and zinc and lead have been mined since before the county was organized in 1818. While there has been some limestone and dolostone quarrying, lead has been the predominant mineral product in the county's history, and the only one that had been developed to any considerable extent. Schoolcraft's 1818 list of mines in Southeast Missouri refers to two mines that were then worked in what is now Jefferson County: Gray's mine, on Big River, and McKane's mine, on Dry Creek.

The following is an excerpt from George C. Swallow's First and Second Annual Reports of the Geological Survey of Missouri regarding lead mines:

_Sandy Mines_ extend over a line nearly one mile in length, the course of which is a little east of north and west of south. The ground is covered with clay from fourteen to thirty feet deep. By one who was working for the present lessee I was informed that during the present year (1855) about 30,000 pounds of mineral had been obtained; and from Mr. Coolidge I learned that in 1842 and 1843 several thousand pounds of mineral were raised, and in 1846 and 1847 some 300,000 pounds. The ore is sulphuret, with small quantities of carbonate, and sometimes accompanied by yellow iron pyrites and zinc blende.

_Mammoth Mine._—This mine was discovered by Mr. Higgins in 1843, and, being on Government land, it was entered by Boldur & Higginbotham. It lies in a hill, the height of which is not over 150 feet, and the entrance to it is on the northwest side. The hill is covered with a reddish clay, varying in depth, having a thickness of nineteen feet in the main shaft. Below this is the magnesian limestone, and through which one shaft has been sunk sixty-two feet. The lead here was deposited in a series of irregular caves varying in size from four to nine feet in height, and in width from four to twelve feet. *** The reported amount of mineral obtained here is almost incredible. From the best information obtainable from different parties engaged at different times in working this mine, I estimated, in 1852, the total amount obtained at 5,000,000 pounds of ore. In 1851 and 1852 Col. J. N. Reed, president of the former company, reported that 21,692 pounds had been obtained in tracing out some lateral arms from the caves. Belonging to the same company as the Mammoth, and six miles north of it, is the Eding lead. It is near a branch of Cedar Creek, and on the side of a hill that is covered with clay, the average depth of which is twelve feet, while below is the magnesian limestone. The lead is found here in vertical fissures, the course of which is nearly north and south, and the width usually varying from eighteen inches to two and a half feet.
"Tarpley Mines* are covered with a red, ferruginous clay, the average thickness being forty feet; beneath is a solid magnesian limestone, passing through which the mineral is found. The mineral obtained here is very pure, massive galena, and the mines have been quite productive. This mine yielded from 1845 to 1854 inclusive, 1,463,538 pounds.

In that report, Dr. A. Litton also says that in 1855, there were three lead furnaces in Jefferson County: Sandy Mine, Mammoth Mines, and the other at the Valles Mines. The lead smelted at the furnace at Valles Mines came principally from across the line in St. Francois County. Lead was actively mined there until the late 1890s.

Numerous small deposits have been discovered, opened and worked all around the county. Among those worth mentioning were: the extensive Frumet Mines located seven miles west of De Soto; The Plattin Mines, on Plattin Creek, east of De Soto; Howe’s Mine, east of that location; the Old Ditch Mines near the Washington County line, Hart's Mines, near the Franklin and Washington County line; and the McCormack Zinc Mine, near Plattin Missouri.

Today limestone and dolomite mining are predominant in Jefferson County. Limestone and dolostone from the Fern Glen Formation, Kimmswick Limestone, Plattin Group, Joachim, Cotter and Jefferson City Dolomite are mined in no less than seven quarries. Central Stone Quarries and Fred Weber Incorporated (now owned by Summit Materials of Texas) operate the three largest of these quarries providing materials for construction from driveways to airports and everything in between.

The St. Peter Sandstone is mined commercially in two locations in the county. It is used for manufacture of glass, filters, and abrasives. Within the last eight years, Mississippi Sand LLC in Festus has been supplying cement manufacturers with high silica sand from the St. Peter.

A less common economic use of the St. Peter Sandstone is utilizing the old mine works as underground storage in the Festus/Crystal City area.

Jefferson County is crisscrossed by numerous major highways including but not limited to I-55, Missouri Routes 21, 30, 141, and M. During the last 10 years, MoDOT has relocated two of these routes (21, M), and the work on these highways has provided the spectacular outcrops seen on these field trips.
Friday Field Trip

Road Log

0.0-1.0 Leave Best Western Shalimar and travel east on Missouri Route A towards Festus.

1.0-1.6 Turn right onto US 61/67 south. Cotter Dolomite exposed behind the Aldi supermarket.

1.6-1.7 Turn left on St. Pius Drive and then turn left at the stop sign on VFW Drive.

1.7-2.2 Travel on VFW Drive and arrive at Stop 1, Mississippi Sand LLC @ Fred Weber Festus Quarry.


2.8-7.1 Take ramp onto I-55 South towards Cape Girardeau. Cotter Dolomite is along ramps. Everton and Cotter in road cuts intermittently on both sides of highway.

7.1-7.4 Take exit 170 for US Route 61. Turn left at bottom of ramp and cross under highway. Arrive at Stop 2, Bank of Bloomsdale site.

7.4-7.7 Return to I-55 and head south towards Cape Girardeau.

7.7-8.0 Immediately south of US Route 61 is an exposure of the entire St. Peter Sandstone along with the underlying Everton and overlying Joachim Dolomite.

8.0-10.3 “Lower and Middle” Everton Formation in road cuts on both sides of highway.

10.3-13.0 Cotter Dolomite on both sides of highway.

13.0-13.3 Take exit 165 Missouri Route TT. Arrive at Stop 3, Cotter Dolomite roadcut.

13.3-19.9 Return to I-55 and head north towards Festus. Arrive at Stop 4, I-55 undulating Everton.

19.9-22.0 Continue north of I-55 to exit 175 Route A. Turn right and return to hotel.
Stop 1, Mississippi Sand LLC, Weber Festus Quarry. (NE¼, Sec 17, T40N, R6E)

For years Fred Weber #3 Festus Quarry (Buck Knob Qy.) mined the Joachim Dolomite and Plattin Formation here for roadway aggregate. Large vertical bluffs remain along the northern and eastern edges of the pit. There are still some intermittent limestone production runs, but the majority of mining is concentrated in the St. Peter Sandstone.

A large block of St. Peter Sandstone stood exposed in the center of the quarry and was largely ignored until the early 2000s. That outcrop, seen below, was at a higher elevation than the Joachim Dolomite seen today in the quarry wall behind the asphalt plant. This suggests faulting in the area, likely related to the Crystal Escarpment and also possibly influencing the present alignment of nearby Plattin Creek.

Since 2003, the St. Peter Sandstone has been mined to an average depth of 67 feet by Mississippi Sand, LLC. Though covered today, a white limestone/dolostone underlies the St. Peter’s undulating lower contact between 65 and 72 feet.

With significant reserves that meet all API specifications for proppant sand, Mississippi Sand LLC provides material exclusively for the natural gas industry for use as Frac Sand.

This state of the art facility has the capability to safely produce year round, 24 hours a day, and the ability to utilize a multi-modal distribution network.
Stop 2: Bank of Bloomsdale future development site. (NE¼, NW¼, NW¼, Sec 33, T40N, R6E)

From the 1930s to 1968, the interchange with I-55 (then Route CC) and US 61 remained unchanged. Then came construction of the new I-55, along with a full interchange at US 61. Later improvements were made to accommodate the new River City Cement plant (now Buzzi Unicem) that was being built near Selma on the banks of the Mississippi River.

Unfortunately for geologists, the original beautiful outcrops in three out of the four quadrants here were subsequently removed and utilized as fill in other areas of I-55. The remaining and relatively untouched St. Peter Sandstone on the southeast quadrant remained undeveloped until 2005.

Now owned by the Bank of Bloomsdale, this parcel has passed through several sets of hands until finally a developer broke ground on a 100+ residential development. In 2008, the project went into foreclosure after a majority of the blasting and grading had been completed.

Fortunately for geologists, the partially completed site allows up-close access to the same outcrops located immediately to the south on I-55 that Joseph Thacker and Ira Satterfield described as, “…one of the most beautiful exposures of middle Ordovician strata occurring along I-55.”

The Joachim Dolomite in Jefferson County is typically a brown to grayish brown argillaceous dolostone that is highly absorptive with abundant brown to black shale partings. The Joachim grows from around 95 feet in northern Arkansas to more than 150 feet in East Central Missouri. A 140-foot section is exposed in nearby Fred Weber #3 Quarry in Festus. There the Joachim takes on the more familiar argillaceous dolostone with undulating shale partings. Accordingly, the Joachim stone is only mined for base rock material in road construction.

Missing in Jefferson County, however, is the “lower Joachim Dolomite” as described by Thompson. (Thompson 1991) Here, the Defiance Member and at times the Matson Member lie unconformably on the St. Peter Sandstone.

Present at Stop 1, the Defiance Member of the Joachim Dolomite is present with a 7” brecciated layer between it and the underlying St. Peter. Large bioherms are present in the spoil pile to the west of the existing face. Also, abundant secondary free calcite can been seen in the fractures near the base.
The St. Peter Sandstone is typically a well sorted, medium grained, frosted quartz sandstone. The final deposition environment was likely a high energy shallow marine platform. (Amaral & Pryor, 1977) The fresh sandstone is extremely friable, but long term weathering ‘case-hardens’ the stone, giving it a tough, durable patina where the originally pure white stone turns yellow, then brown, and eventually to gray. This patina ensures the sandstone’s well indurated form seen in the sheer bluff immediately to the south on I-55.

In general terms, the St. Peter Sandstone in Jefferson County only consists of the Tonti Member. Both the basal Kress and barrier bar Starved Rock Members appear to be absent. It is mined extensively in Unimin Quarry (Stop 4) and the above mentioned Fred Weber #3 Quarry with the latter’s exposure fault related.

The Tonti Member exposed in Stop 1 is chiefly a coarse grained quartz arenite with various weak cementatious agents including glauconite. Upon closer inspection, the grains are indeed frosted and rounded as described by Thompson in the referenced section of Paleozoic Succession in Missouri Part 2. However, the massive bedding seen in that section thins upward as it approaches the unconformity with the Joachim.

Although blasting finished only two years ago, the existing face is still fresh enough to see these bedding planes, including some small cross bedding in the upper 12 feet of the exposure.
Stop 1: Bank of Bloomsdale Development Site
<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
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<tbody>
<tr>
<td>7</td>
<td>Dolostone, gray, very fine grained, medium bedded, weathers tan to Orange tan, with grayish green shale partings. (1 ft)</td>
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<tr>
<td>6</td>
<td>Dolostone, light gray, fine grained, thick bedded, with calcite filled fractures at base and trace bioherms throughout. (5 ft)</td>
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<td>5</td>
<td>Sandy Dolostone, light gray, fine to medium grained, medium bedded, with angular dolomite fragments. (1/2 ft)</td>
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<td>4</td>
<td>Quartz sandstone, white, medium frosted and rounded grained, medium to thick bedded, friable, weathers tan, with trace crossbeds. (6 ft)</td>
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<td>3</td>
<td>Quartz sandstone, white, medium frosted and rounded grained, very thick bedded, friable, with elongate cylindrical structures that have been interpreted as reed molds. (5 ft)</td>
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<td>2</td>
<td>Quartz sandstone, white, fine frosted and rounded grained, medium bedded, friable. (1 ft)</td>
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<tr>
<td>1</td>
<td>Quartz sandstone, white, medium frosted well rounded grained, massive bedded, weathers tan to brown, trace glauconite nodules, with glauconitic cement. (29 1/2 ft)</td>
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**ORDOVICIAN SYSTEM – MOHAWKIAN SERIES**  
**Joachim Dolomite**

7. Dolostone, gray, very fine grained, medium bedded, weathers tan to Orange tan, with grayish green shale partings. (1 ft)  
6. Dolostone, light gray, fine grained, thick bedded, with calcite filled fractures at base and trace bioherms throughout. (5 ft)  
5. Sandy Dolostone, light gray, fine to medium grained, medium bedded, with angular dolomite fragments. (1/2 ft)  

**St. Peter Sandstone**

4. Quartz sandstone, white, medium frosted and rounded grained, medium to thick bedded, friable, weathers tan, with trace crossbeds. (6 ft)  
3. Quartz sandstone, white, medium frosted and rounded grained, very thick bedded, friable, with elongate cylindrical structures that have been interpreted as reed molds. (5 ft)  
2. Quartz sandstone, white, fine frosted and rounded grained, medium bedded, friable. (1 ft)  
1. Quartz sandstone, white, medium frosted well rounded grained, massive bedded, weathers tan to brown, trace glauconite nodules, with glauconitic cement. (29 1/2 ft)
Stop 2 Bonus: US 61 Unbonded Concrete Overlay

With the ever increasing commercial development in southern Jefferson and northern Ste. Genevieve counties, the region’s transportation infrastructure was becoming vastly outdated. When Holcim announced plans to construct a cement plant somewhere near the Jefferson/Ste. Genevieve county line, MoDOT anticipated traffic on US 61 would go from 4,000 cars a day to a projected 7,000 (2012).

Originally built in 1940, US 61 had served as a major north/south artery in the region, but it was worn out. Maintenance crews worked often to repair the asphalt roadway.

MoDOT’s geotechnical section in St. Louis investigated the stretch of US 61 from I-55 to Route OO. Based on the findings from that investigation, it was determined that a simple “mill and fill” wouldn’t be the best use of taxpayer money. Therefore, an innovative approach was taken by Pavement Engineer John Donahue to try something outside of the box.

An unbonded concrete overlay is essentially a new concrete pavement constructed over an existing pavement. A flexible interlayer, typically constructed of hot-mix asphalt (HMA), separates the concrete layers, as shown in Figure 1. The flexible interlayer acts as a shear zone, allowing the concrete layers to move independently of each other, and preventing reflective cracking in the concrete overlay. For this reason, the term “unbonded” is used, although the layers do bond in the sense of adhering together. In this case, MoDOT used the existing roadway as the flexible interlayer.
2. If there are elevation restrictions, the existing wearing course should be milled to the required depth to a maximum of 4 inches and either of the following two options should be selected:
   a. Hot Mix Asphalt
   b. PCC option – replace base widening to milled surface elevation with 4” PCC, and then place 4” ultrathin whitetopping with 4-foot joint spacing across the entire surface.
2' HMA base widening

6.5’ x 6.5’ joint spacing

6.5’ x 6.5’ joint spacing

5’ - 6” HMA

6/10HN

10’

13’

10’

13’

2' HMA base widening

6/10HN

5’ - 6” HMA

6/10HN

6/10HN

10’

13’

10’

13’
Grid pattern established in final product for a design life of more than 30 years.

Stop 1

New 5” unbonded concrete overlay

Old remaining asphalt and concrete
Stop 3: Route TT and I-55 interchange. (NE¼, SW¼, Sec 18, T39N, R7E,)

During the early 1990s, Switzerland-based Holcim Inc. began to seriously look for sites to develop a cement plant. After numerous meetings and after careful consideration of numerous cost benefit / trade off options, a site was chosen along the Jefferson and Ste. Genevieve County line.

Holcim originally approached MoDOT with a cost share proposal to build a diamond interchange at I-55 and Route TT to facilitate a direct access to the interstate system nearest the proposed plant site. Finally, in late 2007, MoDOT decided to go it alone and build a half diamond interchange as negotiations with Holcim ended.

Now exposed along the newly constructed ramps are fresh rock cuts of dolostone. Originally identified as the Powell, (Thacker and Satterfield 1977) it is more likely the upper Cotter Dolomite due to its similarity with identified units seen in Dry Creek Quarry (now Central Stone #60) in northwestern Jefferson County, and exposures along the new Route 100 in Franklin County.

The Cotter Dolomite in Stop 2 is principally a brownish gray to tan dolostone that is finely crystalline, contains thin to medium bedding, and weathers to a coarse pitted surface. In addition, the Cotter in this area contains horizontal fractures, solution joints, and is argillaceous at times. Located in the bottom bench, however, is a undulating siliceous or calcareous layer that contains numerous calcite filled vugs and some overlying “bulls eye” chert.

Several challenges occurred while developing the slopes. Due to the varying degrees of weathering and fracturing encountered in the geotechnical investigation, a 10 foot flat bottom ditch was recommended to add to the factor of safety. This extra-wide ditch will allow the anticipated weathered boulders to safety land and rest away from the travelled way. In addition, another 10-foot wide bench was called for at the proposed soil/rock interface. The additional 10 feet at the top, along with the associated Right of Way, allowed the contractor to lay the slope back when a clay filled joint was encountered in the bench.
Stop 2: I-55 exit ramp to Route TT

Station 11+00

Station 12+00
ORDOVICIAN SYSTEM – CANADIAN SERIES

Cotter Dolomite

10. Dolostone, brownish gray, fine grained, medium bedded, with scattered dendritic pyrolusite, weathers tan. (6 to 8 ft)

9. Dolostone, grayish brown, fine grained, medium bedded, argillaceous, highly weathered, with pockets of bioherms associated with chalcedony filled vugs. Upper contact is erosional. (4 to 6 ft)

8. Dolostone, gray to brownish gray, fine to medium grained, thin to medium bedded, with scattered free calcite and “bulls eye” chert. (2½ ft)

7. Dolostone, brownish gray, fine grained, medium bedded, with trace iron stained concretions. (1½ ft)

6. Dolostone, brownish gray, very fine grained, thin bedded. (6 ft)

5. Dolostone, brownish gray, fine grained, thin bedded, with banded chert in lower 2 foot. (6 ft)

4. Dolostone, tan to yellowish tan, fine grained, medium bedded. (1 ft)

3. Dolostone, brownish gray to medium gray, fine grained, medium to thick bedded, worm burrowed, undulating top and bottom contacts. (8 ft)

2. Dolostone, medium gray, fine grained, thick bedded, with predominant calcite filled vugs layer in upper 2 foot. Green shaley dolomite seam at base. (4½ ft)

1. Dolostone, dark gray becoming brownish gray, fine grained, very thick bedded, with abundant mineral filled vugs in upper 2 foot. (5½ ft)
MEMORANDUM  
Missouri Department of Transportation  
Materials and Construction  
District 6

TO:  
Michael Fritz -cm

CC:  
Michael Fritz -cm (2)  
David Wyman -pm10  
Construction -cm6 (2)

FROM:  
Phil Ruffus  
Senior Geotechnical Specialist

DATE:  
January 18, 2008

SUBJECT:  
Preliminary Geotechnical Report  
Job No. J611416  
Route I-55, Jefferson County

This report amends the previous report dated November 5, 2007.

The preliminary geotechnical report for the above job has been completed. This 0.62-mile length of road on I-55 extends from south of Route AA, Sta. 1421+75, to north of the Ste. Genevieve county line, Sta. 1461+63. Additional work will be done on Route TT from Sta. 462+75 to Sta. 492+76 on both the east and west sides of I-55. The proposed improvements include a new partial diamond interchange at I-55 and Route TT along with associated entrance/exit ramps and acceleration/deceleration lanes. Also, Route TT will be widened with new shoulders.

This preliminary geotechnical report was prepared in accordance with the conceptual plans and cross sections furnished on August 10, 2007.

Logs of subsurface information are attached along with a preliminary geotechnical report summary sheet showing descriptions and typical properties of the materials encountered.

Soil Types and Geologic Formations:

Soils to be encountered from east to west are the Freeburg, Goss, and Sonsac series. The Freeburg series consists of very deep, poorly drained, moderately permeable soil. They are formed in silty alluvium and are lean clay (CL) by ASTM classification. The Freeburg will be encountered in the ditches along Route TT east of I-55. The Goss series are very deep, well drained, moderately permeable soils found on uplands. The B-horizon consists of modified silty loess that is low plastic clay (CL). The C-horizon is highly to moderately plastic clay (CH) formed in residuum. The Goss will be encountered in cuts and fills along both the acceleration and deceleration ramps. The Sonsac series consists of moderately deep, well-drained, moderately permeable soils. They are low to moderately plastic clay (CL) formed in gravelly colluvium over clayey residuum (CL) that has weathered from cherty dolostone. The Sonsac series soils are found in cuts along the deceleration ramp and along Route TT west of I-55.

The Powell and Cotter Dolomites comprise the bedrock in this area. At the time of this report, it is unclear whether the uppermost dolostones are in fact the Powell, or another similar unit, perhaps the Smithville Dolomite. Additional insoluble residue testing, and conodont identification will be performed to confirm the unit's identity. For the purpose of this report, the uppermost stratigraphic dolostones encountered will be referred to as the Powell. The Powell Dolomite, where present, overlies the Cotter and is a medium grained dolostone that contains several zones of chert. The Cotter is principally a light brown to yellowish gray dolostone that is finely crystalline, contains thin to medium bedding and weathers to a coarsely pitted surface. In addition, the Cotter contains horizontal cracks, solution joints, heavily weathered areas, and is argillaceous at times. These solution joints are often filled with highly plastic, essentially rock-free heavy clays. Several areas of solution activity have been identified within the project limits along I-55 between Sta. 1434+10 and 1436+27 both left and right of centerline. However, additional solution activity is possible, and is not necessarily limited to these identified areas.

Slope and Grading Recommendations:

CL soils of the Sonsac, and to a lesser extent the Goss series, are the predominant soil in the proposed cuts. Based on these soils being the most prevalent and likely utilized in the project area, back slopes and fill side slopes should be no steeper than 2.5:1. However, where encountered, the reddish brown, highly plastic, essentially rock-free, fat clay-filled solution cavity material should be thoroughly mixed with rock fill available on the job prior to placement in cuts and fills, or wasted.

Class C excavation will be encountered along both sides of I-55 from Sta. 1428+00 to Sta. 1438+00 with a maximum cut in rock of thirty-four feet. Class C excavation will also be encountered above grade along the entrance ramp from Sta. 8+75 to Sta. 12+22 with a maximum cut in rock of twenty-two feet, and along the exit ramp from Sta. 0+00 to Sta. 4+00 and Sta. 8+00 to Sta. 12+25 with a maximum cut in rock of forty-four feet. Finally, Class C excavation will occur along Route TT from Sta. 467+67 to Sta. 474+75. This section will have a maximum cut in rock of fifteen feet. Existing thirty feet vertical slopes in the Cotter/Powell are stable. Accordingly, vertical slopes up to thirty feet in height in the Cotter/Powell and Smithville are adequate. However, due to the variability of rock quality encountered during drilling, it is also recommended that a fifteen foot bench be constructed along the proposed exit ramp from Sta. 9+00 to Sta. 12+50 at elevation 488'. The RQD percentages ranged in this area from 0 to 50.

Due to varying degrees of weathering, and fracturing, it is recommended that an additional 10-foot bench be constructed at the soil/rock contact. A 10-foot flat bottom ditch is recommended throughout the rock cut sections to retain the anticipated rockfall from weathering.

As mentioned above, the Cotter/Powell exhibits several areas of solution activity in the project limits. Additional areas of solution activity were also encountered during drilling along the proposed new ramps. Therefore, it is recommended that right of way be bought on a 1.5:1 in cut sections along the proposed exit ramp from Station 9+00 to Sta.12+50 where vertical slopes are
proposed. This should allow for possible remedial work if any solution enlarged joints are encountered in the side slopes and also allow for related slope flattening or adjustments during construction.

Since a large amount of the excavation will be in rock, fill slopes can be as steep as 2:1 if rock fill is selectively placed in the embankments and compacted according to standard specifications.

Dolostone of the Cotter/Powell of sufficient quality and quantity should be available to permit construction of an eighteen-inch layer of rock fill base for the entire length of the job.

Foundations:

There are no structures proposed for this job that require foundation information.

Drainage and Erosion Control:

Standard ditches, with the above-mentioned exception, necessary to handle normal drainage will be adequate.

A fertility sample was taken and submitted to the laboratory for seeding and mulching information.

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>FROM</th>
<th>TO</th>
<th>RUN</th>
<th>RECOVERY</th>
<th>LOSS</th>
<th>RQD%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sta. 3+00</td>
<td>1.6'</td>
<td>6.6'</td>
<td>5.0'</td>
<td>4.5'</td>
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<tr>
<td>BL</td>
<td>EL: 490.2'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sta. 9+00</td>
<td>0.0-5.9'</td>
<td>Brown lean clay, dry.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>50' LT</td>
<td></td>
<td>5.9-7.5'</td>
<td>Tan lean clay, moist, with sparse gravel.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL: 493.3'</td>
<td></td>
<td>7.5-8.5'</td>
<td>Rock, hard, cuts with moderate difficulty.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sta. 9+00</td>
<td>0.0-4.0'</td>
<td>Brown lean clay, dry.</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>50' RT</td>
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<td>4.0-6.5'</td>
<td>Brown lean clay, moist, with scattered gravel.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL: 504.3'</td>
<td></td>
<td>6.5-9.0'</td>
<td>Tan lean clay, moist.</td>
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</tr>
<tr>
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<td>9.0-9.3'</td>
<td>Rock, hard, cuts with moderate difficulty.</td>
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<tr>
<td>BL</td>
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<td>5.2-7.3'</td>
<td>Brown lean clay, moist, with sparse gravel.</td>
<td></td>
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</tr>
<tr>
<td>EL: 505.6'</td>
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<td>7.3-7.5'</td>
<td>Rock, hard, cuts with moderate difficulty.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Depth</td>
<td>LL</td>
<td>PI</td>
<td>AASHTO</td>
<td>ASTM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0-5.0'</td>
<td>46</td>
<td>29</td>
<td>CL</td>
<td>A-7-6 (13)</td>
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<td>Sta. 10+00</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>50' RT</td>
<td></td>
<td>4.6-5.8'</td>
<td>Dolostone, cut with rock bit.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL: 514.2'</td>
<td></td>
<td>5.8-6.2'</td>
<td>Dolostone, yellowish gray, fine grained, medium bedded, heavily fractured.</td>
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<td></td>
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</tr>
<tr>
<td>Driller Hole #:</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>B-07-82</td>
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<td></td>
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<td></td>
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<tr>
<td>Operator:</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Overby</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.2-7.8'</td>
<td>Clay seam.</td>
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<tr>
<td>7.8-12.1'</td>
<td>Dolostone, yellowish gray, fine grained, medium bedded, with sandstone seam at 10.4-10.6'.</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>12.1-16.8'</td>
<td>Dolostone, yellowish gray, fine to medium grained, medium bedded, with bullseye chert and vugs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.8-21.0'</td>
<td>Dolostone, gray, fine grained, thick bedded.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>21.0-28.9'</td>
<td>Dolostone, light gray, fine grained, thin bedded, with intermittent shale partings.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>28.9-29.6'</td>
<td>Dolomitic sandstone, white, coarse grained, medium bedded, with green shale partings.</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

MISSOURI DEPARTMENT OF TRANSPORTATION CONSTRUCTION AND MATERIALS GEOTECHNICAL SECTOR
Subsurface Logs for Preliminary Geotechnical Report

County: Jefferson Route: 1-55 Exit Ramp Job No.: J611416
Logged by: Ruffus Date Work Performed: 10/1/07-10/13/07

LOCATION LOG OF MATERIALS CLASSIFIED BY
Sta. 3+00 From To Run Recovery Loss RQD%
BL EL: 490.2' 1.6' 6.6' 5.0' 4.5' 0.5' 28

Versadriil 4000 TR2 with 6" hollow stem augers and NX core

Sta. 9+00 0.0-5.9' Brown lean clay, dry.
50' LT 5.9-7.5' Tan lean clay, moist, with sparse gravel.
EL: 493.3' 7.5-8.5' Rock, hard, cuts with moderate difficulty.

B-31 Mobile Drill with 3" augers

Sta. 9+00 0.0-4.0' Brown lean clay, dry.
50' RT 4.0-6.5' Brown lean clay, moist, with scattered gravel.
EL: 504.3' 6.5-9.0' Tan lean clay, moist.
| Sta. 9+50 | 9.0-9.3' Rock, hard, cuts with moderate difficulty. |
| BL | 0.0-5.2' Brown lean clay, dry. |
| EL: 505.6' | 5.2-7.3' Brown lean clay, moist, with sparse gravel. |
| | | 7.3-7.5' Rock, hard, cuts with moderate difficulty. |

Sta. 10+00 0.0-4.6' Brown lean clay, dry.
50' RT 4.6-5.8' Dolostone, cut with rock bit.
EL: 514.2' 5.8-6.2' Dolostone, yellowish gray, fine grained, medium bedded, heavily fractured.
Driller Hole #: B-07-82
Operator: Overby

Versadriil 4000 TR2 with 6" hollow stem augers and NX core
### LOCATION

| Sta. 10+00 | 50' RT | 35.8-35.9' | Dolostone, gray, fined graded, medium to thick bedded, with sparse shale partings. |
| Sta. 11+00 | 50' LT | 35.8-35.9' | Dolostone, gray, fined graded, medium to thick bedded, with sparse shale partings. |

### LOG OF MATERIALS

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Run</th>
<th>Recovery</th>
<th>Loss</th>
<th>RQD%</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.8'</td>
<td>10.8'</td>
<td>5.0'</td>
<td>3.6'</td>
<td>1.4'</td>
<td>38</td>
</tr>
<tr>
<td>10.8'</td>
<td>15.8'</td>
<td>5.0'</td>
<td>5.0'</td>
<td>0.0'</td>
<td>40</td>
</tr>
<tr>
<td>15.8'</td>
<td>20.8'</td>
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<td>5.0'</td>
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<td>76</td>
</tr>
<tr>
<td>20.8'</td>
<td>25.8'</td>
<td>5.0'</td>
<td>5.0'</td>
<td>0.0'</td>
<td>10</td>
</tr>
<tr>
<td>25.8'</td>
<td>30.8'</td>
<td>5.0'</td>
<td>5.0'</td>
<td>0.0'</td>
<td>20</td>
</tr>
<tr>
<td>30.8'</td>
<td>35.0'</td>
<td>4.2'</td>
<td>4.2'</td>
<td>0.0'</td>
<td>50</td>
</tr>
<tr>
<td>35.0'</td>
<td>40.0'</td>
<td>5.0'</td>
<td>4.0'</td>
<td>1.0'</td>
<td>0</td>
</tr>
<tr>
<td>40.0'</td>
<td>41.8'</td>
<td>1.2'</td>
<td>1.2'</td>
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<td>0</td>
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<tr>
<td>41.2'</td>
<td>45.8'</td>
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<td>4.6'</td>
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<tr>
<td>45.8'</td>
<td>50.0'</td>
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<td>3.6'</td>
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### LOGGED BY

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<tr>
<th>Date Work Performed</th>
<th>Log Notes</th>
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<tr>
<td>10/1/07-10/17/07</td>
<td>Log Continued</td>
</tr>
<tr>
<td></td>
<td>Versadrill 4000 TR2 with 6' hollow stem augers and NX core</td>
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</table>

### CLASSIFIED BY

<table>
<thead>
<tr>
<th>Location</th>
<th>Log Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sta. 11+50</td>
<td>0.0-3.5' Brown lean clay, dry, with scattered gravel.</td>
</tr>
<tr>
<td>BL</td>
<td>3.5-3.8' Weathered rock.</td>
</tr>
<tr>
<td>EL: 500.2'</td>
<td>3.8-4.1' Dolostone, cut with rock bit.</td>
</tr>
<tr>
<td>Driller Hole #: B-07-83</td>
<td>4.1-8.8' Dolostone, light gray, fine graded, medium to thick bedded.</td>
</tr>
<tr>
<td>Operator: Snyder</td>
<td>8.8-15.4' Dolostone, yellowish gray, fine graded, medium to thick bedded, with sparse shale partings.</td>
</tr>
<tr>
<td>15.4-16.5'</td>
<td>Brown clay layer.</td>
</tr>
<tr>
<td>16.5-17.4'</td>
<td>Dolostone, light gray, stained brown, fine graded, thin bedded.</td>
</tr>
<tr>
<td>17.4-17.7'</td>
<td>Dolomitic sandstone, white, coarse graded, thin bedded, with green shale partings.</td>
</tr>
<tr>
<td>17.7-21.5'</td>
<td>Dolostone, yellowish gray, fine graded, thin to medium bedded, with bullseye chert nodules.</td>
</tr>
<tr>
<td>21.5-22.8'</td>
<td>Dolostone, light gray, medium graded, medium bedded.</td>
</tr>
<tr>
<td>22.8-29.1'</td>
<td>Dolostone, gray, medium graded, medium bedded, weathered.</td>
</tr>
<tr>
<td>29.1-35.8'</td>
<td>Dolostone, light gray, coarse graded, medium to thick bedded with small vugs, becomes fractured at 33.2'.</td>
</tr>
<tr>
<td>35.8-39.9'</td>
<td>Dolostone, gray, fined graded, medium to thick bedded, heavily fractured at times.</td>
</tr>
<tr>
<td>39.9-44.1'</td>
<td>Dolostone, yellowish gray, fine graded, thin bedded, with green shale partings.</td>
</tr>
</tbody>
</table>

### CORING LOG

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Run</th>
<th>Recovery</th>
<th>Loss</th>
<th>RQD%</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1'</td>
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<td>5.0'</td>
<td>4.7'</td>
<td>0.3'</td>
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<tr>
<td>9.1'</td>
<td>14.1'</td>
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<td>14.1'</td>
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<td>24.1'</td>
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<td>5.0'</td>
<td>4.7'</td>
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<td>29.1'</td>
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<tr>
<td>34.1'</td>
<td>39.1'</td>
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</tr>
<tr>
<td>39.1'</td>
<td>44.1'</td>
<td>5.0'</td>
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<table>
<thead>
<tr>
<th>Depth</th>
<th>LL</th>
<th>PI</th>
<th>AASHTO</th>
<th>ASTM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0-3.5'</td>
<td>40</td>
<td>22</td>
<td>CL</td>
<td>A-6 (13)</td>
</tr>
</tbody>
</table>
Stop 4: I-55 Everton Formation. (NW¼, NE¼, Sec 29, T40N, R6E)

For the last mile and one half, the Everton has been exposed along this stretch of I-55. Although the bedding and diverse lithologies don’t usually lend themselves to good outcrops, this section of the Everton Formation has stood the test of time.

The Everton exposures along Route 21, through which the Day 2 field trip will pass, consists of tan to reddish brown dolostone and dolomitic sandstone.

Here, the Everton consists of gray to medium gray argillaceous dolostone layers interspersed with shale and sandy dolostone seams.

Of interest at this location is the overturned layers shown on right that may be caused by solution activity below during sedimentation.

The sandstone unit of the lower Everton, often times confused for the St. Peter Sandstone, is found in the road cut immediately to the south.
Saturday Field Trip

Road Log

0.0-0.5  Leave Best Western and travel west on Missouri Route A towards Hillsboro.

0.5-9.8  Cotter Dolomite are on both sides of highway. Turn left and proceed south on Missouri Route 21.

9.8-10.7 Passing through Canadian Series rock, likely Cotter. MoDOT’s District 6 Geologist wasn’t completely convinced it was the Cotter or perhaps a localized unit. During construction of Route 21 in 2009-10, the dolostone and mudstone was of such poor quality due to its argillaceous content and advanced stage of weathering that ditch cuts were widened.

10.7-11.5 Arrive at Stop 1, Route 21 north of Missouri Route B.

11.5-12.2 Proceed south on Route 21 and turn around at Missouri Route B. Proceed north on Route 21 towards Otto.

14.6  Pass under Route A.

15.0-15.8 During construction of this segment of Route 21, solution activity was so prevalent that Dr. Anderson of Missouri School of Mines was asked to perform a geophysics investigation to determine the size and extent of the sinkholes. MoDOT eventually pressure grouted a majority of these features prior to finishing the road bed.

15.9  Cross Sandy Creek.

16.7-16.9 An unusual occurrence happened here on the southbound lanes on Route 21. Desoto Maintenance Supervisor called D6 geology and mentioned that rocks were continuously being found against the inside barrier wall every night. That is a minimum distance of 60 feet. After an investigation, it was determined that the siliceous layers seen in Stop 1 were likely being heated by the sun and “popping out,” as the rocks along the barrier were the same as on the top of the bench.

19.3  Cross under Old Route 21. Notice the retaining wall on top of the rock. Normally, retaining walls under abutments are to retain the soil. In this case, this metric bridge was placed on sandstone of the St. Peter. When construction began, it was determined that the sandstone was not competent enough to function without help. Therefore, a wall was built and anchored in the underlying dolostone. Look immediately to the north and note the rocks on the top of the ridge road cut are Burlington and fault related.
**Road Log**

19.3-20.5  Arrive at **Stop 2**, Route 21 south of Klable Road.

21.2-21.4  Burlington and Fern Glen in road cuts.

22.8-23.2  High walled Burlington on both sides of highway.

23.1      Cross Heads Creek.

24.3-24.7  Take right exit to Missouri Route M/MM and turn left at bottom of ramp and proceed west on Missouri Route MM.

27.5      Arrive at **Stop 3**, Route MM at Sycamore Springs Drive.

27.5-29.9  Turn around and go east on Missouri Route MM and arrive at **Stop 4**, Unnamed Osagean/Fern Glen.

29.9-31.4  Proceed east on Missouri Route MM (Route MM becomes Route M at Route 21). Travelling further east outcrops of the Kimmswick, Decorah, and Plattin respectively are on both sides of highway.

31.5      Central Stone Antonia #56 is on the right. Kimmswick and Plattin Limestone are quarried here. There is 101’ of Plattin exposed in this quarry with Joachim Dolomite on the pit floor.

32.5      Arrive at **Stop 5**, Missouri Route M. Exposures of the Kimmswick, Bushberg and Fern Glen.

33.0-36.6  Proceed east on Missouri Route M. Outcrops along this stretch are the Kimmswick and Decorah.

36.6-38.2  Turn left onto northbound I-55 and proceed north to the Imperial/Main Street exit.

38.2-39.0  Turn left and cross I-55. Turn right on west outer road and proceed to entrance of Mastodon State Park on left. Arrive at **Stop 6**, Mastodon State Park.

39.0-51.1  Return to the hotel via the West Outer Road, I-55 and Missouri Route A.
Missouri Route 21: An Overview

In 1984, Jefferson County resident Earl Hawkins posted a gigantic sign along the side of what is now old Missouri Route 21 in northern Jefferson County. It warned:

**Danger!**
**You are driving Blood Alley Highway 21.**

Residents of this area along Route 21 believe that the vast majority of accidents along that stretch of road were due to drunk driving, inattentive driving and speeding.

Hawkins' name for the dangerous road, "Blood Alley," stuck. It went on to become the slogan for the Coalition for Highway Safety. Formed by concerned citizens, elected officials and business owners, this group originally pressed MoDOT to realign a 10-mile section of the highway from Missouri Route 141 to Schenk Road near Otto. A busload of residents went to Jefferson City to lobby the governor for help in getting the highway rebuilt.

That persistence finally led to the 3rd U.S. Congressional District Representative to earmark funds specifically for the reconstruction of that curvy roadway. However, the Coalition not only got the funding for that original section, but eventually for the entire span between Missouri 141 to Missouri Route B. That construction was completed on December 15, 2008 and Missouri Route 21 is currently freeway standard.
Stop 1: Route 21 just north of Route B near Hillsboro. (NW¼, SE¼, Sec 4, T40N, R4E)

The southern end of Missouri Route 21’s realignment poised several challenges to the design. Not least among these were the “head waters” of Belew Creek. Water from the proposed roadway had to be gathered, controlled, and responsibly released back into the watershed. With the large grade separation, this meant large areas to allow for infiltration as well as culverts at crossings of the original intermittent stream beds.

Fortunately for geologists, these design considerations resulted in the spectacular rock cuts through the Cotter Dolomite that truly demonstrates its wide range of variability.

The Cotter Dolomite is variable in its appearance. It ranges from a tan, fine grained, thick bedded dolostone at the top of the rock cut to a medium gray, thin bedded sandy dolomite at the bottom. In between, there are numerous undulating green to brown shale partings and other oddities including at least two layers with secondary barite formation. There is also a consistent sacchoroidal dolomite filled worm-burrowed layer not previously included in any descriptions of the Cotter.

The dolomitic breccia at this location is most likely the result of an active erosional surface with minimal movement and weathering of the rock fragments. Associated with the breccia is a higher permeability that can allow greater horizontal flow than the overlying and underlying dolomite. This characteristic is responsible for directing the introduction of at least some of the barite bearing solutions.

The minerals found in the voids in this area are similar to those in Washington and southern Jefferson Counties, with the primary minerals noted at this location being: barite, drusy quartz, limonite and goethite. The goethite at this location is found both as masses and as pseudomorphs of pyrite. Given the similarity of the mineralization to the deposits further south and west, it is possible that this could be a northern extension of either the Southeast Missouri Barite District or the Valles Mines district. Since these deposits are in the Cotter, it is more likely to theorize that they are related to mineralizing fluids from the Valles Mines area, where barite bearing mineral deposits also occur in the Cotter.

The amount of mineralization present and the ratio of barite to the other mineralization suggests that this could possibly be the edge of the mineralizing fluid flow. The amount and variety of mineralization also appears to gradually diminish in a northward direction from this point, and is noted in some of the exposures further north only as zones of drusy quartz or silicified dolomite. Mineral amount and variety also decrease vertically in these exposures – the higher percentage of barite is noted in the lower breccia zone, and the silica to barite ratio increases in the higher levels of the cut.
Stop 1: SB Route 21 just north of Route B
ORDOVICIAN SYSTEM – CANADIAN SERIES

Cotter Dolomite

20. Dolostone, tan, fine grained, medium bedded with alternating layers of siliceous dolomite and shale partings. (2 ft)
19. Dolostone, tan, fine grained, thick bedded. (3½ ft)
18. Dolostone, tan, fine grained, medium bedded, with trace iron oxide filled vugs. (3½ ft)
17. Dolostone, brownish gray, fine grained, medium bedded, with predominant vugs. (1½ ft)
16. Dolostone, brownish gray, fine grained, medium bedded. (1½ ft)
15. Dolostone, brownish gray, fine grained, medium bedded, worm burrowed. (1 ft)
14. Dolostone, brownish gray, fine grained, thin to medium bedded, argillaceous, with undulating shale partings. (6½ ft)
13. Sandy Dolostone, gray to brown, coarse grained, thin bedded, with scattered undulating mudcracks. (1½ to 2½ ft)
12. Dolostone, brownish gray, fine grained, medium bedded, with trace vugs. (3 ft)
11. Dolostone, brownish gray, fine grained, thick bedded, worm burrowed. (5 ft)
10. Dolostone, tan, fine grained, thin bedded. (2 ft)
9. Dolostone, medium gray, fine grained, medium bedded, with a barite and iron oxide filled vug seam. (5 ft)
8. Dolomitic shale, greenish yellow, very fine grained, thinly laminated, undulating. (1 ft)
7. Dolostone, brownish gray, fine grained, thin to medium bedded, with orange banding and barite/goethite filled vugs. (5 ft)
Cotter Dolomite

6. Dolomitic shale, greenish tan, very fine grained, thinly laminated, undulating bottom and top contacts. (1 ft)
5. Dolostone, medium gray to brownish gray, fine grained, thin bedded, worm burrowed at top with barite filled vugs. (10 ft)
4. Dolostone, light gray, fine grained, thin to medium bedded, argillaceous, with large barite filled vugs at top. (5 ft)
3. Dolomitic breccia, medium gray, fine to coarse grained, medium bedded, with trace barite filled vugs. (1½ ft)
2. Dolomitic shale, greenish gray, very fine grained, very thinly laminated. (2½ ft)
1. Sandy dolostone, medium gray, fine to medium grained, with trace chert bands and barite filled vugs, weathers brown. (4 ft)
Stop 2: Route 21 south of Klable Road. (SW, Sec 31, R5E, T42N; SE, Sec 36, T42N, R5E)

This section of road:

Traverses the “Crystal City Escarpment”, a structure formed by the Ozark domal uplift and overlying sedimentary rock. The rock formations have a slight regional dip to the northeast, with locally steeper dips. Consequently, the roadway proposed will cross several sedimentary formations. From north to south, the Mississippian Burlington and Fern Glen limestone, the Devonian Bushberg sandstone, the Ordovician Kimmswick limestone, Decorah Group, Plattin Group, Bloomsdale Limestone, Joachim Dolomite and St. Peter Sandstone. The lithologies are extremely varied.

So described former AMG President R. J. Linebach in an Inter-Office Correspondence concerning his preliminary geotechnical report for this section of Route 21.

Drilling proved to be difficult as numerous small rock core “runs” were required to advance through the variable lithologies, especially the Decorah Group as the core barrel frequently “blocked off”. Water return was literally nonexistent.

Material removed from the cut sections was then placed as fill in the adjacent valley to account for the then nearly 250’ elevation difference between the summit and Old Route 21.

MoDOT and its contractor J.H. Berra had significant problems with this cut. The regional dips mentioned above turned out to be related to a large fault trending N50W across the northern section of the road cut. Today, a gently sloping area is all that remains of the gouge. The Kimmswick is present on the northern edge of this fault zone and has an apparent dip to the northwest. Members of the Plattin Group are encountered along the southern edge of this zone and visible slickensides are present.

The solution activity evidenced in the southern end of the road cut was so extensive that during construction, a 50 ton dump truck fell through to its axels. An investigation determined that the cavities were not interconnected and subsequently were jet grouted shut.
Fault trending N50W

Looking South
The Bloomsdale Limestone, highly weathered and full of solution joints. Fossils (including a trilobite pygidium) are plentiful in sections as well as large free calcite deposits.

Present at this road cut are the Brickeys and Establishment Shale Members of the Bloomsdale Limestone as well as the Beckett Limestone. Not present here are the Hager or Macy Limestone.
Stop 3: Route MM at Sycamore Springs Drive. (SE, NW, Sec 11, T42N, R4E; SW, NE, Sec 11, T42N, R4E)

Route MM in Jefferson County also received an infamous name of “Death Valley” after several serious accidents occurred along this major collector between Missouri Routes 21 and 30.

In 2002, MoDOT began the process of remediating the worst section of Route MM at Sycamore Springs. Going east, the road rounded a blind corner and straight into the intersection at Sycamore Springs. This caused numerous rear end collisions. Plans were drawn and District 6 Geology investigated the proposed alignment. Nearly 100 borings confirmed the presence of several formations with varying degrees of weathering. Despite that, vertical bluffs were designed originally at 20 feet, but later expanded to 30 feet in part with the help of the Colorado Rock Fall program (shown on pages 41 & 42).

Today, the various vertical bluffs contain from top to bottom: the Kimmswick Limestone, Kings Lake Limestone, Glencoe Shale, Castlewood Limestone, Macy Limestone, and at the base, parts of the Hager Limestone.

The hill to the north of Sycamore Springs is composed mostly of highly weathered Kimmswick overlying the Decorah Group. Both the Diecke K-bentonite and the Millbrig K-bentonite are visible in the cut with the latter less discernable in the second bench.

The Kimmswick in this location is very light gray to gray, fine to medium grained, and weathers brown. It is thick bedded for the most part and contains numerous fossils and both horizontal and vertical fractures.

Lying underneath the Kimmswick is the Kings Lake Limestone of the Decorah Group. The Kings Lake is similar to the Kimmswick, but is less weathered with intermittent shale partings and thinner bedding. The Glencoe shale is almost completely fossiliferous and contains crinoids, bryozoans and brachiopods. The Castlewood is the lowest member of the Decorah Group. These limestone beds are found between the shale of the Glencoe and the heavily burrowed Zell Member of the Plattin.

The southern hill contains mostly members of the Plattin Group with the Zell and Hook composing a majority of the cut. While encountered in drilling, the Hager Limestone lies almost exclusively in the subgrade now covered by the roadbed.

Both members of the Macy Limestone (Hook and Zell) are burrowed limestone where a majority of the worm burrowed material has weathered out.
The original slope design recommended a 1:1 slope (20’ x 20’)

Cross Sections of the hill north of Sycamore Springs
Route MM at Sycamore Springs

EL: 534'

EL: 705'
The original estimate for the project came in at $2.2 million over projected cost.

However, by using the Colorado Rockfall Simulation Program, MoDOT’s District Geologist was able to come up with additional savings by increasing the maximum vertical slopes in the Plattin. Along with other minor changes, this brought the project down to an more acceptable cost.

These savings came by the way of decreased Right of Way (ROW) that were required. On large projects, ROW can account for an average of 54% of the total funds.
By entering known values including height of the vertical slopes as well as the mass, size and angularity of the rock, reasonable assumptions can be made regarding the possibility of rockfall endangering the travelled way.

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The Kimmswick, Decorah Group: Kings Lake Limestone, Glencoe Shale, Castlewood Limestone and the Macy Limestone of the Plattin Group from right to left.
A meld of several core boxes showing the Macy Limestone from elevation 585’ to 550’. The Victory Member is encountered in the next run.
This is the Macy Limestone with weathered out fucoids.

Exposed below during construction
Members of the Decorah and Plattin Groups (right)

Kings Lake Limestone
Glencoe Shale
Castlewood Limestone
Macy Limestone

Finished eastern section (left) shows the Macy and Becket Limestones of the Plattin Group
Fresh exposures of the Decorah during construction. Note the Kings Lake and Glencoe Shale Members.
Stop 4: Route MM at Route 21, Cherty Osagean, Burlington? Fern Glen? (SW, NE, Sec 18, T42N, R5E)

When Routes M and MM were relocated to their present alignment, this problematic exposure was uncovered. The Burlington is exposed to the south on Route 21, while the Fern Glen Formation is present immediately to the east. Therefore, stratigraphically is should be the Fern Glen. However, lithologically it doesn’t conform.

An erosional zone near the base of the exposure is exhibited on the south side of Route M. Above this zone the rock character and fossils suggest Burlington.

With its abundance of fossils and chert, could this particular outcrop be the same unit as described by Thompson near Keifer Creek as unassigned Osagean? (NW, SW, SW, Sec 13, T44N, R4E)

There are several possible interpretations:

This is part of a stream channel where the Fern Glen was eroded and the Burlington was later deposited.

This is a local facies of the Fern Glen.

This is another depositional period between the Fern Glen and the Burlington.

The breccia/erosion zone is the remnant of solution activity and the overlying Burlington dropped into the same Stratigraphic elevation as the Fern Glen.
MISSISSIPPIAN SYSTEM – OSAGEAN SERIES

Unassigned Osagean

6. Limestone, medium gray, fine grained, thick bedded with trace 1" diameter “bulls eye” chert. (4½ ft)

5. Cherty (70%) Limestone, light gray, fine grained, thin to medium bedded, with undulating banded chert. (6 ft)

4. Limestone, medium gray, fine to medium grained, medium bedded, slightly fossiliferous, with two distinct shale seams in lower 5 foot. Bottom contact is uneven and contains iron oxide concretion molds. (11 ft)

3. Shale, light gray, very fined grained, thinly laminated. (2 ft)

2. Limestone, gray, fine grained, thick bedded. (2 ft)

1. Limestone, gray, fine grained, medium bedded, with abundant undulating bands of multi stage “bulls eye” chert. (5 ft)
Stop 5, Route M (SW, NW, Sec 21, T42N, R5E)

In August of 1992, MoDOT completed a nearly year long preliminary geotechnical investigation on Route M from Missouri Route 21 to I-55 in Jefferson County. Like a growing number of lettered routes in the county, existing Route M was a windy road with no shoulders and could no longer handle the growing traffic between Route 21 and Barnhart Missouri. The new proposed four lane divided highway would act like an “outer belt” connecting southern Jefferson County with a high speed corridor.

This 7.3 mile length of road takes us through the remainder of the rocks of southern Jefferson County starting in the lower Mississippian, through the Ordovician, and back again.

At this rock outcrop just east of Central Stone Quarry #56, the Fern Glen Formation and Bushberg Sandstone are exposed on top of the Kimmswick Limestone seen earlier in Stops 2 and 3.

The Fern Glen displays its variability in this cut. Along I-55 north of the Route M interchange, the Fern Glen is a red limestone with little chert. Here, less then five miles away, that red bioclastic limestone is missing. Instead the limestone is likely a less developed Meppen Member. The brownish gray limestone consists of a relatively chert free lower half that is fossiliferous at times.

The Bushburg Sandstone forms the gentle slope between the Fern Glen and Kimmswick. Similar in texture to the St. Peter Sandstone, it is a tan to yellowish brown, fine to medium grained, friable quartz sandstone. The unit is comprised of a single very thick bed lying directly on the Kimmswick, the Maquoketa Shale being absent. In some areas, it weathers to red brown and is loosely cemented.

The Kimmswick Limestone here is light gray, medium bedded and fossiliferous. As in Stop 3, its upper surface is extensively eroded in some places, and deep clay filled solution cavities are rare.
Stop 6, Mastodon State Park and Historic Site (NW, SE, Sec 7, T42N, R6E)

Mastodon State Park and Historic Site contains an important archeological site: the Kimmswick Bone Bed. Bones of the mastodons and other now extinct animals were first found there in the early 1800s.

Archaeological history was made at the site in 1979 when Dr. Russell Graham of the Illinois State Museum discovered stone spear points made by hunters of the Clovis culture (14,000 - 10,000 years ago) in direct contact with mastodon bones. This was the first solid evidence of the coexistence of people and these giant prehistoric beasts.

Today, the 425-acre (1.7 km²) property preserves this National Register of Historic Places site and provides recreational opportunities. An onsite museum tells the natural and cultural story of the oldest publically accessible American Indian site in Missouri. A full-size replica of a mastodon skeleton highlights the exhibits. A picnic area, several trails and a special-use campground offer chances to explore the land where the lives of Native Americans and mastodons once intertwined.

The site was originally a quarry where the Kimmswick Limestone was mined. In 1966, the property was acquired by the State Highway Department (now MoDOT) for construction of I-55. Ten years later, the surplus acreage was purchased and turned over to the Missouri Division of Natural Resources for a state park.
Selected Bibliography


