

**FIELD TRIP GUIDEBOOK**



**SITE CHARACTERIZATION AND ANALYSIS PENETROMETER (SCAPS)  
DEMONSTRATION  
AND  
GEOLOGY OF WESTERN CASS COUNTY, MISSOURI**

**ANNUAL MEETING  
September 27-28, 2002**

GUIDEBOOK TO FIELD TRIP:  
SITE CHARACTERIZATION AND ANALYSIS PENETROMETER (SCAPS)  
DEMONSTRATION  
AND  
GEOLOGY OF WESTERN CASS COUNTY, MISSOURI

ASSOCIATION  
OF  
MISSOURI GEOLOGISTS

49<sup>TH</sup> ANNUAL MEETING

SEPTEMBER 27-28, 2002  
KANSAS CITY, MISSOURI

Andrew S. Gosnell  
U.S. Army Corps of Engineers  
Kansas City District  
Kansas City, Missouri 64106

Association of Missouri Geologist  
49<sup>th</sup> Annual Meeting and Field Trip

September 27 – 28, 2002

EXECUTIVE COMMITTEE

President	Robert C. Beste
President-elect	Andrew S. Gosnell
Past President	David C. Smith
Secretary	Thomas G. Plymate
Treasurer	George A. Kastler
Member at Large	Carl Priesendorf

FIELD TRIP COMMITTEE

Andrew S. Gosnell  
Richard J. Gentile  
Kathleen Older

GUIDEBOK EDITOR

Andrew S. Gosnell  
Richard J. Gentile

BANQUET AND MEETING

George A. Kastler

HOSTS

U.S. Army Corps of Engineers – Kansas City District  
Mr. and Mrs. Warren Moss  
Martin Marietta Peculiar Quarry

## TABLE OF CONTENTS

Introduction .....	1
Acknowledgements .....	3
Field Trip Itinerary – Day 1, Friday, September 27 .....	4
Stop No.    1    Smithville Reservoir – SCAPS Demonstration.....	7
Field Trip Itinerary – Day 2, Saturday, September 28 .....	13
Stop No.    1    Martin Marietta Peculiar Quarry .....	16
2    Fossils in Block Limestone .....	22
3 <i>Chaetetes</i> Mounds in Coal City Limestone .....	25
4    South Grand River Outcrop near Archie, MO .....	29
The U.S. Army Corps of Engineers Site Characterization and Analysis Penetrometer System (SCAPS).....	36
References .....	44

## LIST OF FIGURES

Figure 1: Guide to field trip stop – Day 1.....	6
Figure 2: SCAPS loading on U.S. Air Force C-5 Galaxy for deployment at overseas installations.....	7
Figure 3: Generalized SCAPS LIF sensor and detection system.....	8
Figure 4: SCAPS panel plot showing sensor data vs. depth.....	9
Figure 5: Guide to field trip stops - Day 2.....	15
Figure 6: Exposure in working highwall at the Peculiar quarry .....	16
Figure 7: Stratigraphy of the Martin Marietta Peculiar Quarry.....	21
Figure 8: Exposure of Block Limestone along Highway 2.....	22
Figure 9: Stratigraphy of Block Limestone along highway 2, near intersection with county road D.....	24
Figure 10: <i>Chaetetes</i> mound, Coal City Limestone.....	25
Figure 11: Individual <i>Chaetetes</i> corallites .....	25
Figure 12: Coal City Limestone exposed along South Grand River channel cut...	26
Figure 13: Stratigraphy of exposed Marmaton Group rocks along South Grand River channel cut near Everett, MO.....	28
Figure 14: Large septarian nodule from the "Lost Branch" Formation near Archie, Mo.....	30
Figure 15: Cone-in-cone shown under large concretion at South Grand River channel cut near Archie, Missouri.....	31
Figure 16: Stratigraphy of the South Grand River outcrop near Archie, MO.....	35
Figure 17: Kansas City District Corps of Engineers SCAPS drilling rig.....	38
Figure 18: SCAPS data acquisition room.....	39
Figure 19: SCAPS rod handling room.....	39

## INTRODUCTION

This field trip is designed to give participants an overview of a) state-of-the-art hazardous waste site characterization techniques using innovative direct-push drilling technology, and b) an overview of the stratigraphy of Cass County.

The U.S. Army Corps of Engineers (USACE) developed the Site Characterization and Analysis Penetrometer System (SCAPS) to provide the Department of Defense (DoD) with a rapid and cost-effective means to characterize soil conditions at DoD sites undergoing installation restoration (cleanup). The use of SCAPS reduces the time and cost of site characterization and restoration monitoring by providing rapid on-site real-time data acquisition/processing (i.e., in situ sample analysis) and on-site 3-dimensional visualization of subsurface soil stratigraphy and regions of potential contamination.

SCAPS is its relatively non-intrusive and minimal environmental impact operation. SCAPS prevents cross layer contamination by grouting through the penetrometer probe during rod retraction. Rods are automatically decontaminated during the retraction process, thus only clean tools are stored in the vehicle. Decontamination fluids are stored on board for subsequent disposal.

Direct push technologies presently utilized by the Kansas City SCAPS crew include: Laser Induced Fluorescence (LIF) Petroleum, Oil, and Lubricant (POL) Sensors; Explosives Sensors; Thermal Desorption Volatile Organic Compound (VOC) Samples; the Hydrosparge VOC Sensing System; Multiport Sampling systems and Membrane Interphase (MIP) Probes.

Three SCAPS are presently operated by the USACE Kansas City, Savannah, and Tulsa Districts for operational site characterization and monitoring field investigations at government facilities. The Air Force conducts SCAPS work via contract to the COE and private contractors.

Exposed rocks in the field trip area in western Cass County measure approximately 145 ft (44 m), measured from the bottom of the lowest valley to the top of the highest hill. All exposed rocks are sedimentary in origin, and belong to the Pennsylvanian

System, Desmoinesian and Missourian Series, and include rocks of the Kansas City, Pleasanton, and Marmaton Groups. Good exposures of Pennsylvanian Strata can be examined in road cuts along highways and county roads, and creek and river channels where rocks have been exposed due to erosion.

Exposed rocks consist predominately of limestone and shale, with minor amounts of sandstone, coal, and conglomerate. Strata is arranged in a cyclical fashion throughout most of the section, commonly referred to as “cyclothem.”

The most economically important rock type within the field trip area is limestone, especially the Bethany Falls, which is used commercially for aggregate, cement products and, to a lesser extent, rip-rap material. The Bethany falls is extensively mined in Jackson County, located immediately south of Cass County, and mining has created over one square mile of commercially developed underground space utilized for warehouses, manufacturing, offices, and service related activities (Gentile, 1994).

Overlying the Pennsylvanian rocks is surficial deposits, predominately Holocene in age, including soil and alluvium. Pennsylvanian rocks are underlain in the subsurface by, in descending order, rocks of the Mississippian, Ordovician, Devonian and Cambrian Systems. These rocks are predominately limestone and dolomite, and have a combined thickness of approximately 1,800 – 2000 feet in adjacent areas (Gentile, 1976, Gosnell, 1996).

## **ACKNOWLEDGEMENTS**

The Association of Missouri Geologist acknowledges the following individuals and organizations for providing it's members with exposure to modern hazardous waste site characterization technology, and the opportunity to visit features of geologic and commercial interest in Cass County Missouri. The cooperation of each is greatly appreciated: Ms. Kathleen Older, Mr. James Campbell, Mr. Theodore Thompson, and Mr. Bruce Clark, U.S. Army Corps of Engineers for presenting the SCAPS technology; Mr. Charley Reed, Martin Marietta Corporation for allowing access to the Peculiar Quarry, and to Mr. and Mrs. Warren Moss, for graciously allowing access across their property to view Upper Marmaton Group stratigraphy.

FIELD TRIP ITENERARY

DAY 1

FRIDAY, SEPTEMBER 27

## Itinerary - Day 1 - 27 September, 2002

<u>Route</u>	<u>Mileage</u>
- 08:00 Depart Holiday Inn Parking Lot; Proceed West on I-70 to I-435	1
- Proceed North on I-435 to US 169 North	21
- Proceed North on US 169 to County Road DD (Smithville)	5.5
- Proceed East on DD to Mt. Olivet Rd.	0.25
- Proceed South on Mt. Olivet Road...Take first right (400 ft) through yellow gate onto gravel road. Proceed straight about _ mile to dead end.	

Estimated Travel Time: 40 - 50 Minutes

**2:00 – 4:00 Examine SCAPS in Groups – Shuttle to Large Glacial Erratic for Discussion hosted by Dr. R.J. Gentile**

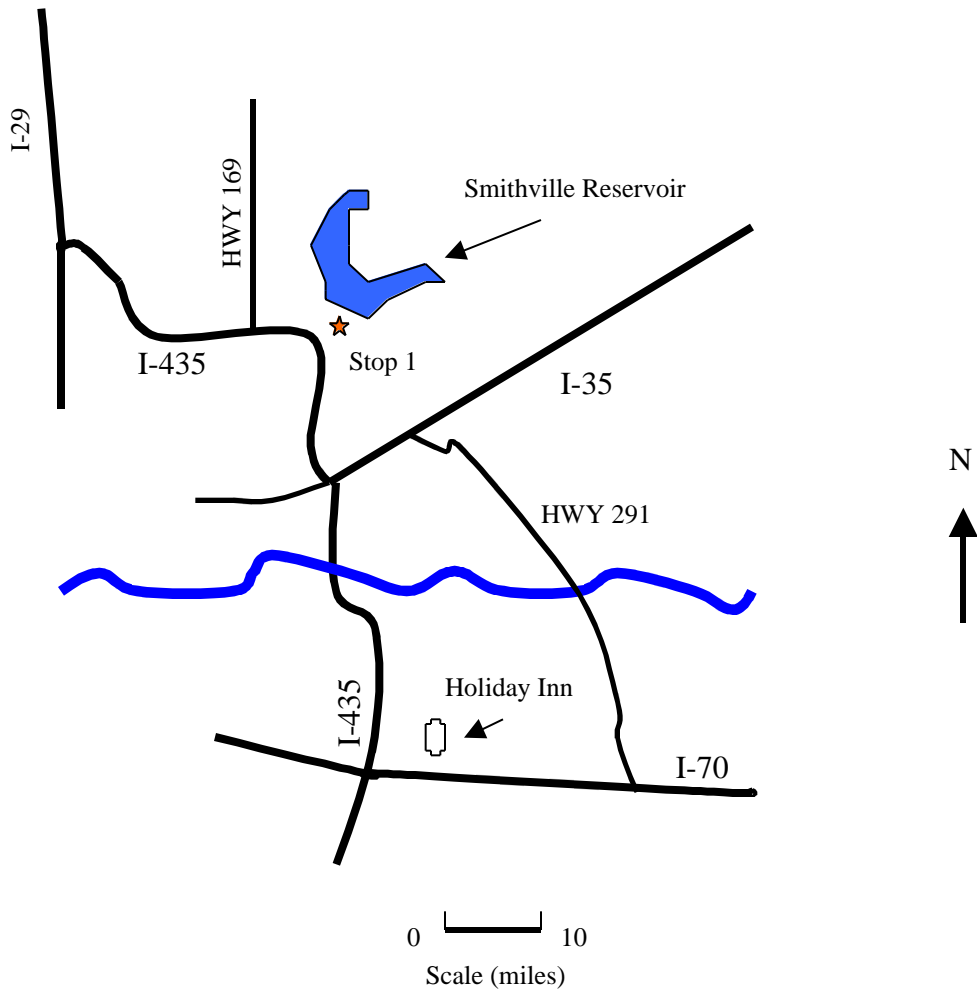


Figure 1: Guide to field trip stop – Day 1

**Stop No. 1: Corps of Engineers Site Characterization and Analysis Penetrometer System Demonstration – Smithville Lake**



Figure 2: SCAPS loading on U.S. Air Force C-5 Galaxy for deployment at overseas Installations (Photo courtesy of US Army Corps of Engineers)

Defining the location and extent of chemical contamination in the subsurface is difficult at best. Typical site investigations require monitor well installation, physical sampling and laboratory analysis. The Site Characterization and Analysis Penetrometer System (SCAPS) provides a rapid and cost effective method of screening a contaminated site. This demonstration is designed to give the participant an overview of current technologies used for rapid characterization of hazardous waste sites, and a demonstration of the SCAPS capabilities in the field.

### DESCRIPTION

SCAPS utilizes existing cone penetrometer technology to determine soil physical properties, while simultaneously measuring chemical properties, in-situ. SCAPS can also be used to install small diameter ground water sampling points, and to obtain soil and ground water samples.

Currently, SCAPS has three in-situ sensing capabilities: defining soil stratigraphy, determining the presence of petroleum, oil, and lubricant (POL) contamination, and profiling electrical resistivity. The ability to determine the presence of POL by Laser induced Fluorescence (LIF) can rapidly define the extent of such contamination.

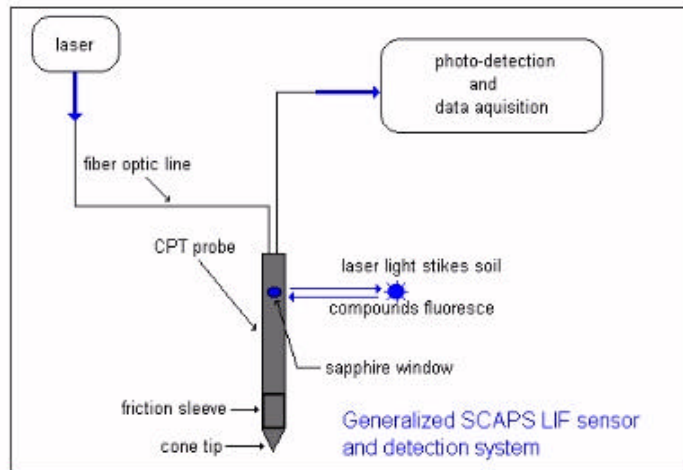
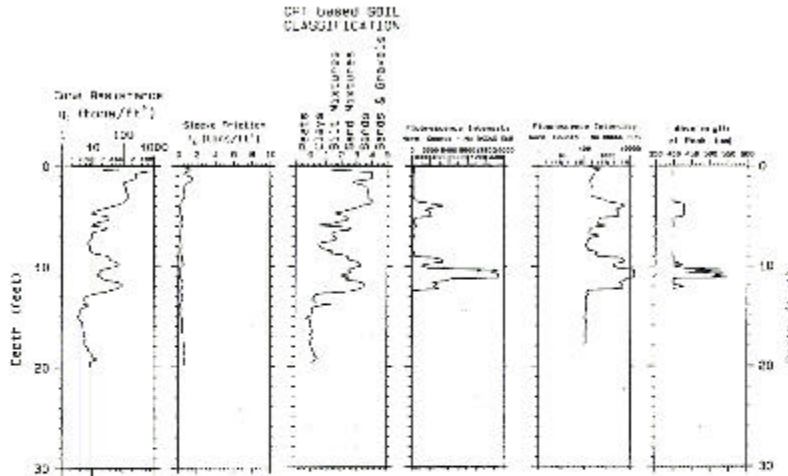


Figure 3: Generalized SCAPS LIF sensor and detection system

### *Laser Induced Fluorescence*

The laser signal is transmitted to the subsurface by a fiber optic cable. The laser light excites polynuclear aromatics contained in the POL. The return fluorescence is transmitted back via a return fiber optic cable to be collected and analyzed by an on-board data acquisition system. The data are then plotted to show sensor information vs. depth, and soil classification. These real-time plots provide information on contaminant thickness, location, and relative concentration.



SCAPS generated panel plot showing sensor data vs. depth

Figure 4: SCAPS panel plot showing sensor data vs. depth

The use of SCAPS can define the extent of POL contamination, reduce the need for monitor wells and lab analysis, and optimize well placement and sampling. Another sensor probe becoming widely used is the membrane interface probe, made by GeoProbe Inc. The membrane interface probe is used to detect chlorinated solvents in either soil or water. On-going research will develop new sensors for other contaminants and improve upon current capabilities.

### ***ABILITIES***

- Pushes easily in clayey to sandy soils, and fine gravels
- Capable of working in rolling terrain free of overhead obstructions
- All Weather
- Maximum push depth of 80 feet
- Sensors provide a continuous measurement
- Measured strength properties (tip penetration resistance and skin friction) are used to determine soil properties

- No drilling fluids or cuttings to dispose
- Sealing and grouting of sensor hole as penetrometer is withdrawn
- Push rods are cleaned and decontaminated when retracted
- Collect and field screen subsurface soil samples
- Collect and field screen groundwater samples
- Minimal exposure to contamination

A 3-dimensional rendering of subsurface contamination can also be generated as a post processing operation, currently available through the Kansas City District.

The Kansas City District has utilized the SCAPS successfully in numerous military installations across the United States and Europe to delineate subsurface contamination rapidly and efficiently.

### SPECIFICATIONS

#### **TRUCK**

MAKE	Kenworth Model C-5008, 350 hp Chassis, with limited slip differentials in both rear axles, offset drive shaft to accommodate penetrometer
WEIGHT	21,319 kg (47,000 lb)
POWER	261 kW (350 hp) turbocharged Caterpillar Diesel
LENGTH	10.52 m (34.5 ft)
WIDTH	2.6 m (8.5 ft)
HEIGHT	4.14 m (13.5 ft)
VAN BODY	Two compartments, each 2.29 m (7.5 ft) wide by 2.74 m (9 ft) long by 2.13 m (7 ft) high, all stainless steel inside and out
AUXILIARY EQUIPMENT	Pto-driven hydraulic pump 56.88 l/min (15 gpm) at 13.8 MPa (2,000 psi) Hydraulic-driven 25 kW, 3-phase generator for electrical power (110 v, 220 v) Shock and vibration damped floor for instrumentation compartment Electronic governor for the main engine

#### **PENETROMETER SYSTEM**

MAKE	Hogentogler, Inc.
RAMS	Twin hydraulic with hydraulic chuck, 122 cm (48 in) stroke
FORCE OUTPUT	177,930 N (40,000 lb) push, 299,890 N (60,000 lb) retract @ 13.8 Mpa (2,000 psi)
SPEED	2 cm/sec (regulated) during push, up to 12 cm/sec retract
CONTROLS	Hydraulic manifold, manual lever valves, pressure regulated, solenoid operat emergency pressure dump valve

SUBFRAME	Heavy wall 20.3 cm (8 in) square steel members with extension, anchor, jack mounts, fluid reservoir, and piping bolted to truck chassis
LIFTING/LEVELING	Four hydraulic jacks, independently controlled, two each fore and aft of van body, removable transverse connector pad between each pair, fore and aft

### SENSOR SYSTEM

SOIL STRENGTH	Built-in strain gauge load cells for tip and sleeve loads
ELECTRICAL RESISTIVITY	Bi-polar DC, 5 cm depth of investigation
SOIL FLUOROMETER	Fiber optic based, laser induced, soil fluorescence unit, nitrogen laser excitation (337.1 nm) EG&G Optical Multichannel Analyzer III with light intensifier

### TRAILER GROUTING SYSTEM

MAKE	Single ChemGrout CG-550 grout pump/mixer (5 gpm @ 225 psi) non-pulsing positive displacement three-sack mixer, with a WES designed thru the push-rod grouting system (single 3/8 in Teflon tubing to expendable tip)
GROUT MIXTURE	Minimum 1:1 Portland cement/water
WATER TANK CAPACITY	300 gallons (1.14 cu. m) potable water
SUSPENSION	Torsion Bar, twin axles
LOAD CAPACITY	7500 lb (33,362 N)
FRAME	Heavy wall 4 inch square tubing

## **DATA ACQUISITION / PROCESSING**

<b>SIGNAL CONDITIONING</b>	Custom designed and built for SCAPS, 8 channel
<b>DATA PROCESSING HARDWARE</b>	Data Translation DT2801-A card and National Instruments GPIB to interface with fluorometer optical multichannel analyzer (OMA). Additional monitor and keyboard installed in push room for auxiliary control.
<b>TRUCK SOFTWARE</b>	Custom acquisition processing and graphics code (30,000 lines) for real-time display of data during push. Display tip penetration resistance, sleeve friction resistance, soil classification, and either soil resistivity or spectral fluorescence measurements
<b>DATA VISUALIZATION</b>	3-D visualization using Silicon Graphics Personal Iris computer and custom modified Dynamics Graphics software

## **SAMPLERS**

<b>SOIL</b>	Vertek Soil Sampler. Soil sample require a penetrometer push and are typically smaller than drilling samples
<b>FLUID</b>	Power Punch Water Sampler, Geo Insight Inc.

## ***ADVANTAGES***

- Rapid and cost effective screening method
- Decreased time to characterize a site
- Advanced penetrometer, sensors, and data processing
- 3-Dimensional imaging
- Reduced drilling, sampling, and analytical costs
- Optimum placement of monitoring wells

## ***DISSADVANTAGES***

Because the SCAPS system is truck mounted, especially rough or uneven terrain may require preliminary site preparation. Also, the penetrometer system cannot be used in formations consisting of dense, well compacted or rocky material.

FIELD TRIP ITENERARY  
DAY 2  
SATURDAY, SEPTEMBER 27

Itinerary - Day 2 - 28 September, 2002

<u>Route</u>	<u>Mileage</u>
- 08:00 Depart Holiday Inn Parking Lot; Proceed West on I-70 to I-435	1
- Proceed South on I-435 to US 71 South	8
- Proceed South on US 71 to South C Exit (Peculiar, MO)	13
- Take a right after exit, Proceed to Intersection County Rd. YY	0.25
- Proceed East on Road YY to Peculiar Quarry	2.8
Estimated Travel Time: 50 Minutes	
<b>09:00-09:45 - Examine Quarry</b>	
- Proceed From Quarry East on Road YY to Road Y	1.0
- Proceed North on Road Y to Road D	5.9
- Proceed South on Road D to Mo. Hwy 2	3.0
- Proceed East on Hwy 2 to Outcrop	~1
Estimated Travel Time: 15 Minutes	
<b>10:00-10:30 - Examine Block Limestone</b>	
- Continue East on Hwy 2, thru Freeman, Mo, Proceed 1.5 Miles Past the Intersection of Road C to Grand River Road	7.7
- Proceed South on Grand River Road until Terminus at T-intersection	2.7
Estimated Travel Time: 15 Minutes	
<b>10:45 - 11:15 Examines <i>Chaetetes</i> Mounds</b>	
- Proceed West from T-intersection to Zellmer Rd	0.6
- Proceed South to 299th street	0.6
- Take Left at 299th street, Follow Road to Stop Sign (Int. Rd. W)	1.3
- Proceed Straight (South) on Rd. W To Amarugia Wildlife Area	1.2
Estimated Travel Time: 10 Minutes	
<b>11:30 - 12:00 Lunch and Restroom Break</b>	
- Proceed South on Rd. W to Rd. A	3.9
- Proceed East on Rd. A to Butcher Rd.	3.5
- Proceed South to Moss Residence	1.3
Estimated Travel Time: 10 Minutes	
<b>12:10 - 13:00 Examine Marmaton/Pleasanton Group</b>	
-Return to Rd. A, Proceed East to US 71	
-Return To hotel via US 71 / I-435	

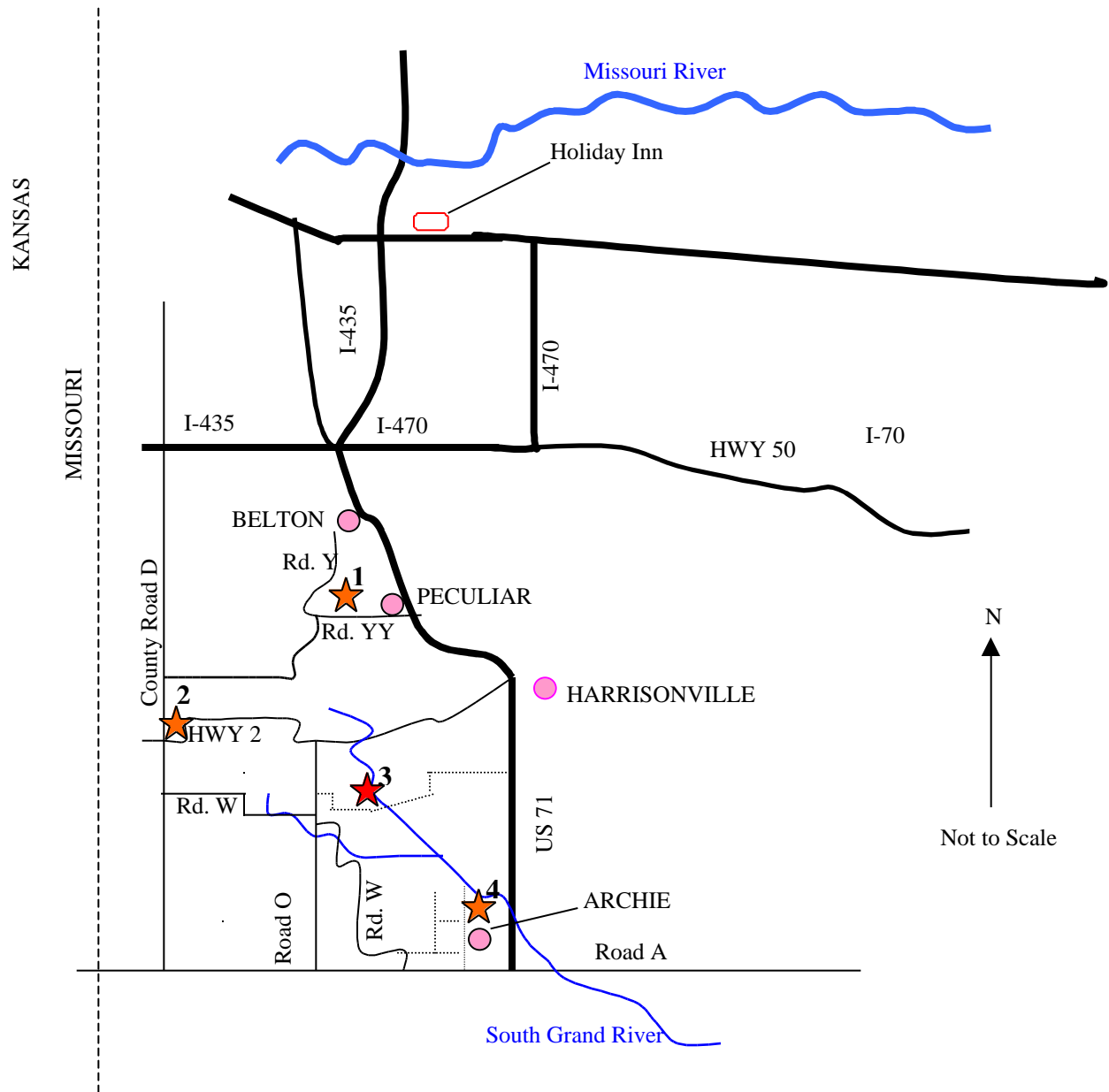


Figure 5: Guide to field trip stops - Day 2

### **Stop No. 1: Martin Marietta Quarry**

The Martin Marietta quarry, located on county road YY in western Cass County, produces aggregate and calcium carbonate for use in cement production from a Bethany Falls “ledge” which occupies the lower portion of the quarried areas. The Winterset Limestone is also utilized for aggregate. The quarry has been in operation for approximately 35 years. Approximately 300 acres has been quarried to date, with about 40 acres remaining on the present property, located 2 miles west of Peculiar, Missouri.

The exposure in the working high wall (figure 6) at the quarry offers an excellent opportunity to view Kansas City Group stratigraphy. The Kansas City Group is the uppermost Group of Pennsylvanian rocks exposed at the surface within western Cass County, and outcrops in higher elevations, typically in the western area of the county, and is generally absent in the southeastern portion of the county. Locally at high elevations, isolated “mounds” occur sporadically that are capped by the rocks of the Kansas City Group.



Figure 6: Exposure in working highwall at the Peculiar quarry (Photo by R.J. Gentile)

The following is a described stratigraphic section for the quarry, and figure 7 illustrates the described units.

STRATIGRAPHIC SECTION

MARTTIN-MARIETTA PECULIAR QUARRY

Martin Marietta Corp. Quarry; NW \_ and S \_, sec. 7, T 45 N., R. 32 W.; 6 miles southeast of Belton, Missouri and 8 miles northeast of West Line, Missouri. West Line, MO-KS 7 \_ minute quadrangle. Elevation top unit 960.0 ft. Described by R.J. Gentile.

Kansas City Group

Linn Subgroup

	<b>Thickness</b>	
	<b>Feet</b>	<b>Inches</b>
Nellie Bly Formation		
31 Sandstone, brown, thin bedded, friable	5	0
29 Conglomerate, sandy; coarsely crystalline limestone matrix with fragments of shells, crinoid ossicles ammovertellids; large clay galls; cross bedded; swash marks at top	1	4
29 Sandstone, brown, fine to medium grained, friable; current ripples; carbonized plant remains; trace fossil: <i>Cruziana</i> ; interbedded in places with thin gray shale beds; hard calcite cemented sandstone concretions	8	6
28 Shale, Gray	0	6

Cherryvale Formation

Westerville Member

27 Limestone, light gray; wavy beds ~2 in. thick; phylloid algae, small brachiopods, crinoid ossicles	5	4
26 Limestone, light gray; interbedded with gray shale	0	8
25 Limestone, light gray; crinoid plates and columnals, fenestellate bryozoans, <i>Echinaria</i>	1	0
24 Limestone, bioclastic; small crinoid columnals, sparse fenestellate bryozoans, <i>Lophophyllidium</i> , <i>Neospirifer</i> <i>Echinaria</i>	0	6

Wea Member

- 23 Shale, medium gray to greenish gray at top; zone of pelecypods and productid brachiopods 2 in. at top; clay ironstone concretions 1 in. thick and 4 in. diameter isolated in shale and in persistent beds; hard, dark gray; weathers reddish brown to tan, fractures into smooth chips 14 0

Block Member

- 22 Limestone, dark gray; wavy laminae; shells; abundant ammovertellids 0 2
- 21 Limestone, dark bluish gray, weathers tan to reddish-brown; finely crystalline, resistant; breaks with smooth fractures vertically oriented hairline joints strike N75W and N10W and fracture unit into rectangular blocks; apparent dip 1-2 degrees S20E recorded on top of "pavement" of joint blocks; conspiral gastropods, crinoid columnals, small fossil fragments; bioclastic texture 1 9

Fontana Member

- 20 Shale, medium gray, calcareous; thickness increases to 4 ft. 6 in. along quarry face 3 0

Bronson Subgroup

Dennis Formation

Winterset Member

- 19 Limestone, Dark bluish-gray; thin beds at top weather to small brown chips; thick-bedded at bottom; abundant large *Composita*; lenses of dark gray to black chert weather to light brown porous ochre and comprise 20 – 40% of unit 4 4
- 18 Shale, medium gray; *Willkingia*, large productid

brachiopods	1	0
17 Limestone, medium bluish-gray; thick bedded; dark bluish-gray chert nodules; <i>Composita</i> , <i>Rhombopora</i> , crinoid columnals	3	9
16 Shale, medium gray, grades downsection into nodular crumbly, clayey limestone with impressions of <i>Calamites</i>	2	6
15 Limestone, light gray, weathers tan; thick, wavy beds; light to dark gray chert nodules and lenses to 6 in thick, some with white rinds near top. Thickness increases to 11 ft. 3 in. in lateral distance of a few hundred feet.	9	6
14 Shale, dark gray, thickness increases laterally to 6 in.	0	2
13 Limestone, light gray; thick even beds; crinoid ossicles	1	6
12 Shale, medium to dark gray; reduces laterally to 2 in. Thick	0	6
11 Limestone, light gray, clayey; bioclastic, reduces laterally to 10 in. in thickness	1	4
10 Shale, medium to dark gray	0	5
9 Limestone, light gray, clayey; 2 even beds fractured by joints	0	7
Stark Member		
8 Shale, medium to dark gray at bottom, calcareous, soft; slacking to form reentrant	1	2
7 Shale, black fissile; calcium phosphate nodules; joints strike N60E and N35W	1	10
Canville Member		
6 Shale, dark gray to black; discontinuous, pyritized <i>Crurithyris</i> and pelecypods	0	1

Galesburg Formation

5 Shale, dark gray; yellow sulfur stained	0	6
4 Claystone, medium gray, soft; red iron oxide and yellow sulfur staining	1	0

Swope Formation

Bethany Falls Member

3 Limestone, nodular; a rubble of small limestone nodules with a small percentage of light gray clay matrix; incipient stratification in upper part		
2 Limestone, oolitic, light gray; thick cross beds; discontinuous. Sharp even contact with lower unit	3	0
1 Limestone, thin to medium beds; dark gray mottles; joints strike N60E	12	0
<b>Total Thickness</b>	<b>92</b>	<b>11</b>

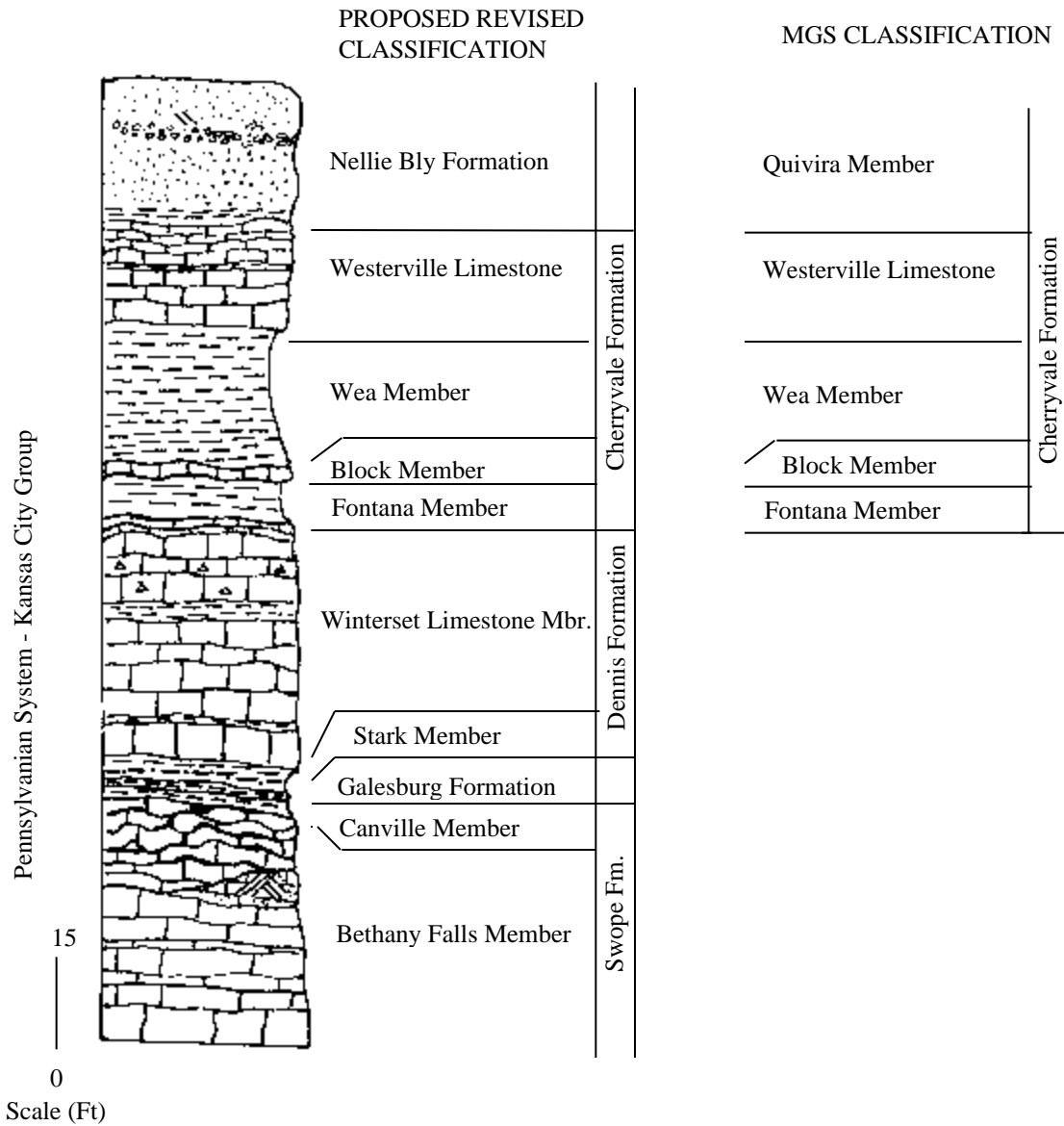


Figure 7: Stratigraphy of the Martin Marietta Peculiar Quarry. Classification shown is proposed (Gentile and Thompson, in press). Present Missouri Geological Survey classification (Howe, 1961 and Thompson, 1995) is shown for reference where classification is under revision.

## Stop 2: Fossils in Block Limestone

The Block limestone, previously examined in the high wall of the Martin Marietta quarry, is located in a road cut 10 feet above road level at this location (Figure 8). This exposure offers a good opportunity to examine Pennsylvanian invertebrate fauna, and to collect well preserved specimens. Fossils preserved within the exposure include:

*Fistulipora*, *Kozłowska*, *Hystriculina*, *Chonetina*, *Echinaria*, *Hustedia*, *Phricodothyris*, *Lophophyllidium*; small crinoid columnals and well preserved specimens of *Composita*, a productid brachiopod, that often weather completely out of the formation.



Figure 8: Exposure of Block Limestone along Highway 2 (Photo by R.J. Gentile)

The Block is over 7 feet thick at this location and includes interbedded shale. At the Martin Marietta Quarry, the Block was only 2 feet thick and consisted of a single bed. The following is a described stratigraphic section for the quarry, and figure 9 illustrates the described units.

### STRATIGRAPHIC SECTION FOSSILS IN BLOCK LIMSTONE

Road cut north side of Missouri Highway 2 from junction with dirt road eastward for a several hundred feet, South Line SE \_\_, sec 5, T. 44 N., R. 33W., \_\_ mile northeast of

Westline, Missouri, Westline, MO-KS 7 \_ ' quadrangle. Elevation bottom unit at road level 945.0 ft. Described by R.J. Gentile.

## Kansas City Group

		<b>Thickness</b>	
		<b>Feet</b>	<b>Inches</b>
Cherryvale Formation			
Wea Member			
8	Covered interval, patches of gray shale	3	0
Block Member			
7	Limestone, medium gray, thick bedded.	1	0
6	Shale, medium gray	2	0
5	Limestone, medium gray; beds 6 in. to 1 ft. at bottom to 2 in. thick at top, this shale partings; abundant phylloid algae, <i>Fistulipora</i> , <i>Composita</i> , <i>Kozlowskia</i> , <i>Hystriaculina</i> , <i>Chonetina</i> , <i>Echinaria</i> , <i>Hustedia</i> , <i>Phricodothyris</i> , <i>Lophophyllidium</i> ; abundant small crinoid columnals	4	6
Fontana Member			
4	Shale, dark gray; very fossiliferous with crinoid columnals and plates, brachial valves of productid brachiopods, algae "biscuits" (irregular bump-like encrustations of algae <i>Ottonosia</i> on shale clasts, shells, etc.) to 6 in. in longest dimension; thin beds of crinoidal limestone near top	4	0
3	Shale, dark gray, non-calcareous; 2 to 3 zones of reddish-brown clay ironstone (sideritic) concretions near the middle	10	0
2	Covered interval, patches of gray shale	5	0

## Dennis Formation

### Winterset Member

1	Limestone, medium gray with dark gray siliceous patches (incipient chert nodules), sparse, wavy dark gray clay seams $\frac{1}{8}$ in. thick; large productid brachiopods	5	0
<b>Total Thickness</b>		<b>34</b>	<b>6</b>

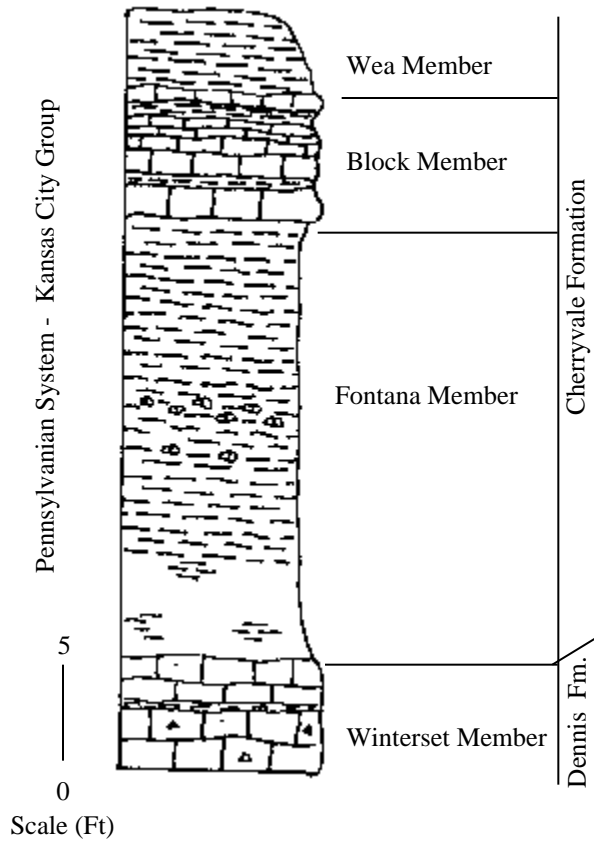


Figure 9: Outcrop of Block Limestone in road excavation along highway 2, near intersection with county road D (Classification: Howe, 1961 and Thompson, 1995).

### Stop 3: *Chaetetes* Mounds in Coal City Limestone

*Chaetetes*, shown in the photo below, is a common colonial coral in areas of Kansas and Missouri underlain by rocks of the Upper Desmoinesian Series. Its thin-walled polygonal tubes or corallites are about the size of a human hair and can be seen in specimens in the field (Figure 11). Classified among the tabulate corals, it commonly has platforms or tabulae within the tubes.



Figure 10: *Chaetetes* mound, Coal City Limestone (Photo by R.J. Gentile)

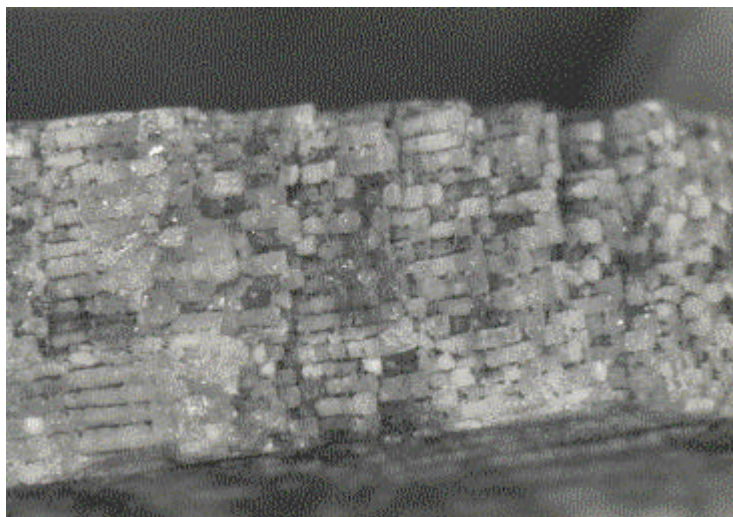


Figure 11: Individual *Chaetetes* corallites (Photo by R.J. Gentile)

In this exposure, *Chaetetes* fossils are especially abundant, and form hummocky mounds atop the Coal City limestone. The fossils are often preserved in their growth position, and are common in the upper portion of the Pawnee Formation of the Marmaton Group, especially the Coal City Limestone, throughout Cass County. Found in abundance in the Pawnee formation in the area, *Chaetetes* are an excellent “index” fossil, for identifying the Coal City Limestone for use in stratigraphic correlations between local rock units, although care must be used, as *Chaetetes* is locally found in the underlying Higginsville Limestone in Cass County. The following picture shows the Coal City Limestone outcropping along the South Grand River.



Figure 12: Coal City Limestone exposed along South Grand River channel cut  
(Photo by R.J. Gentile)

The following is a described stratigraphic section for the stop, and figure 13 illustrates the described units.

STRATIGRAPHIC SECTION  
*CHAETETES* COLONIES IN PAWNEE LIMESTONE

East cut bank of South Grand River at bridge on east-west gravel road; 300 feet west of Grand River Church; NW   , NW   , NW   , sec. 27, T. 44 N., R. 32W., 6 miles north of Everett, Missouri, Everett, MO 7   ' quadrangle. Elevation bottom unit at water line 800.0 ft. Described by R.J. Gentile.

Marmaton Group

Altamont Formation	<b>Thickness</b>	
Lake Neosho Member	<b>Feet</b>	<b>Inches</b>
9 Shale, dark gray; weathering olive gray; abundant calcium phosphate nodules, spherical to <u>  </u> in. diameter and ellipsoidal, flattened to 2 in. diameter w/ nuclei of bone, copralite, etc.	1	0
Amoret Member		
8 Limestone, large irregular shaped nodules in claystone matrix	1	0
7 Covered interval	2	0
6 Limestone, large irregular shaped nodules in claystone matrix	1	0
Altamont Formation – Bandera Formation		
5 Covered interval	8	0
Bandera Formation		
4 Shale, gray; sparse limestone nodules	2	0
Pawnee Formation		
Coal City Member		

3	Limestone weathered reddish brown; humocky upper surface; <i>Chaetetes Milleporaceous</i> colonies stand out in relief on upper surface	2	0
2	Limestone, light gray; wavy medium bedded; abundant <i>Chaetetes</i> colonies, many in growth position 1 ft. long and 6 in. thick; small productid brachiopods; joints strike N-S. Units 2 and 3 form ledge exposed for 100 feet upstream and downstream from bridge	3	0
1	Limestone, visible under waterline	2	0
<b>Total Thickness</b>		<b>22</b>	<b>0</b>

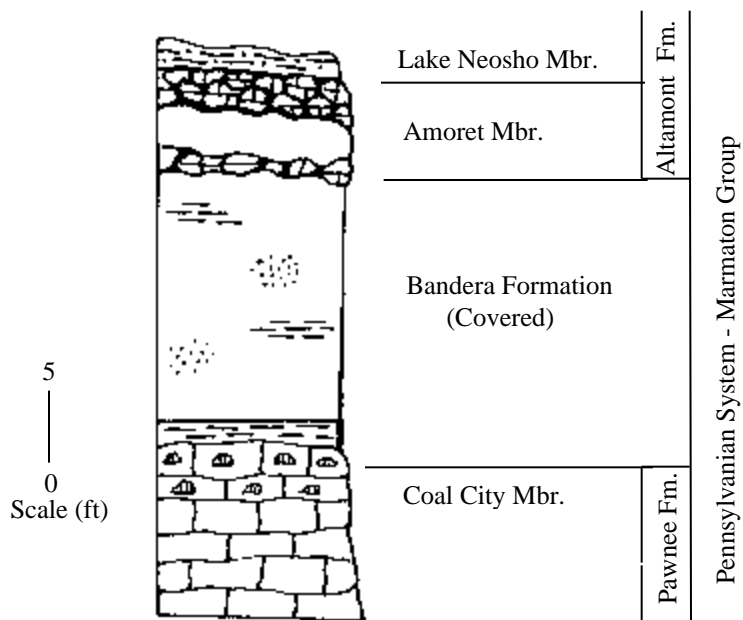


Figure 13: Stratigraphy of exposed Marmaton Group rocks along South Grand River channel cut near Everett, MO (Classification: Howe, 1961 and Thompson, 1995).

#### **Stop 4: South Grand River Outcrop near Archie, MO**

This exposure gives the attendee to observe some of the most unique geology in Cass County, Missouri. The South Grand River channel was re-routed and straightened between 1914 and 1919 to drain local wetland and prevent flooding in lowlands used for agriculture (Gosnell, 1996). The outcrop at this location was revealed during the channelization effort.

Rocks of the upper Marmaton Group and lower Pleasanton Group are exposed, and are separated by an unconformity, or a “gap” in the rock record. The unconformity represents a geologic boundary, which separates two time intervals within the Pennsylvanian, designated the Desmoinesian and Missourian Series’. This unconformity represents an unknown amount of time within the Pennsylvanian where rocks were either never deposited, or eroded away prior to deposition of sediments which later formed rocks of the Pleasanton Group.

Rocks belonging to the Upper Marmaton Group belong to The Holdenville Subgroup, and include the Lost Branch Formation (including rocks previously classified in the Holdenville Formation) and the Lenapah Formation. Geology of interest within the upper Marmaton Group includes large septarian nodules (Figure 14). Septarian nodules are concretions with a series of cracks that often cross one another, giving the concretions a turtle-shell appearance. These are commonly confused for fossilized turtle shells, making septarian nodules a common “pseudo” or false-fossil. These concretions form similar to other types of concretions, through cementation. Cracks form when dehydration of the sediment forming the nodule occurs. These cracks are then commonly filled with crystalline material forming the structures which we see today. Septarian nodules are often more resistant to weathering than the rocks in which they are found, and will be left behind when other rocks are eroded away through weathering.



Figure 14: Large septarian nodule from the "Lost Branch" Formation near Archie, Mo  
(Photo by R.J. Gentile)

Associated with the septarian nodules at this location are thin layers of “cone-in-cone.” Cone-in-cone (Figure 15) is a peculiar structure consisting of nests of cones, one inside another, standing vertically and arranged either in thin beds or at the edges of large concretions (KGS, 2002). Some cones are less than an inch in height, and others are as much as 10 inches high. They have a ribbed or scaly appearance. Most cone-in-cone is composed of impure calcium carbonate, but occasionally the structure has been found gypsum, siderite, and hard coal. An example of cone in cone is shown in the following figure:



Figure 15: Cone-in-cone shown under large concretion at South Grand River channel cut near Archie, Missouri (Photo by R.J. Gentile)

In addition to cone-in-cone and septarian nodules, excellent examples of ripple marks, which resulted from currents and wave action in Pennsylvanian seas, can be observed in the Lenapah Formation.

Numerous specimens of Pennsylvanian invertebrates can be found throughout the Lost Branch Formation, and some plant remains can be found in the underlying Lenapah. Sandstone of the lower Pleasanton Group can be observed along the south bank. This sandstone fills a channel eroded into the underlying Marmaton Group rocks. Plant fossils can be found sporadically near the bottom of the exposure, and include the genera *Calamites* and *Cordaites*. The following is a described stratigraphic section for the outcrop, and figure 16 illustrates the described units.

STRATIGRAPHIC SECTION

SOUTH GRAND RIVER NEAR ARCHIE MISSOURI

Section exposed for 500 feet along both banks of South Grand River drainage channel. Center W   , NW   , sec. 21, T. 43 N., R. 31W., 1 1/2 miles northwest of Archie, Austin, MO 7   ' quadrangle. Elevation Unit 1 at waterline 775 feet. Described by R.J. Gentile.

Pleasanton Group

Hepler Formation

East Branch Member

16 Sandstone, thin bedded, shaly, tan; 6 in. zone of a mesh of plant fossils, *Calamites*, *Cordaites*, fern fronds (*Neuropteris*?) near bottom. Weathered clay-ironstone concretions at bottom; fills a channel eroded into underlying shale; erosional surface dipping 45 degrees southeast

<b>Thickness</b>	
<b>Feet</b>	<b>Inches</b>
6	0

Marmaton Group

Holdenville Subgroup

Lost Branch Formation

15 Shale, tan, non calcareous; zones of concentrically banded concretions; flattened, and 1 ft. diameter; nucleus of clay with case hardened sandstone rinds; weathered to reddish-brown ochre

6	0
---	---

14 Shale, tan; sparse zones of weathered clay ironstone Concretions

4	0
---	---

13 Shale, gray, slightly calcareous; sparse calcium phosphate nodules. Zone of septaria to 6 feet in diameter and 1 foot thick, dark gray; composed of fine grained calcareous sandstone, occurrence is in discontinuous zone in a 200 foot long eroded bank; most septaria are in shale, but some are in sandstone lenses and are spaced about 25 feet

apart; septaria are underlain by 2 in zone of cone-in-cone structures. Fossil zone of chonetid brachiopods, <i>Nuculopsis</i> and other gastropods about 6 inches from bottom	2	0
12 Shale, black, soft	0	6
11 Shale, black fissile, non-calcareous; joints strike N30E. Upper surface warped where draped over septaria or concretions that form ledge along both sides of drainage ditch for a distance of 300 to 400 feet (Nuyaka Creek Shale: Units 11 & 12)	1	6

#### Sni Mills Member

10 Septaria and concretion bed; specimens are 3 ft diameter and 7 in. thick, dark gray, hard, fine-grained, pyritic, homogeneous, smooth fracture. The overlying black shale is warped over septaria or some are embedded into it (gradational); cracks in septaria filled by caramel-colored calcite; 2 in. layer of cone-in-cone structure underlies septaria. Very fossiliferous: <i>Orbiculoidea</i> , <i>Wellerella</i> , <i>Nucula</i> , <i>Glabrocingulum</i> , <i>Eoasianites</i> (?), sparse goniatite cephalopods, bellerophonids, small gastropods	0	7
---	---	---

#### Memorial Formation

9 Shale, sandy, non-calcareous; underlies black fissile shale where septaria are absent	0	3
8 Sandstone, dark gray, fine grained, hard, micaceous, flaser bedding, linguoid ripples, bioturbated, <i>Caudii galli</i> , <i>Planolites</i> . Sparse septaria to 6 in. in diameter; sandstone filled scoured out channels	1	7
7 Shale, gray, flaky; intercalated with thin beds of sandstone	5	0
6 Sandstone, reddish-brown, quartzose, micaceous; ripples, rib and furrow structures; trace fossils, carbonized plants;		

	forms ledges	0	3
5	Shale, gray, non calcareous	1	1
4	Sandstone, reddish-brown, quartzose, micaceous; ripples, rib and furrow structures; bits of carbonized plant material; forms ledges	0	3
3	Shale, gray, non calcareous	1	8
2	Sandstone, non-calcareous, micaceous, quartzose; thin bedded, linguoid ripples, rib and furrow; <i>Caudii galli</i> ; log impressions (?), <i>Calamites</i> (?), <i>Cordaites</i> (?)	0	6
1	Shale, gray, non calcareous	1	0
	<b>Total Thickness</b>	<b>40</b>	<b>2</b>

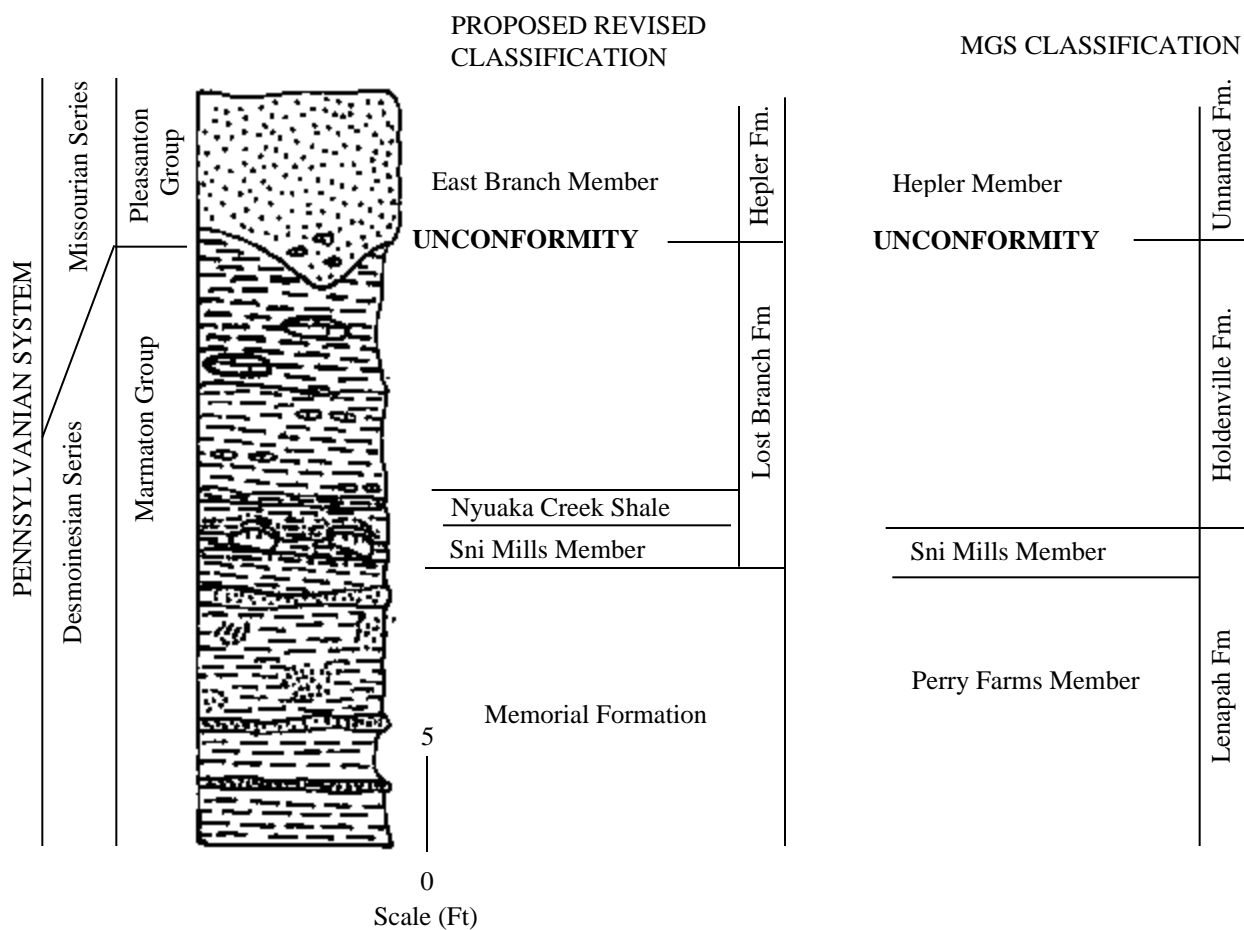


Figure 16: Stratigraphy of the outcrop along South Grand River channel cut, Archie, MO. Classification shown is proposed (Gentile and Thompson, in press). Present Missouri Geological Survey (Howe, 1961, Thompson, 1995) is shown for reference where classification is under revision.

*OVERVIEW OF THE USACE SCAPS SYSTEM*

**SITE CHARACTERIZATION AND ANALYSIS  
PENETROMETER SYSTEM (SCAPS)  
TECHNOLOGY DEVELOPMENT / APPLICATION**



**SCAPS Background**

The U.S. Army Engineer Waterways Experiment Station (WES) under the sponsorship of the U.S. Army Environmental Center (AEC) initiated the development of the Site Characterization and Analysis Penetrometer System (SCAPS) Research, Development, and Technology Demonstration Program to provide the Department of Defense (DoD) with a rapid and cost-effective means to characterize soil conditions at DoD sites undergoing installation restoration (cleanup). WES partnered with the U.S. Naval Command, Control and Ocean Surveillance Center and the U.S. Air Force Armstrong Laboratory to accelerate and coordinate the Tri-Service SCAPS technology development, demonstration, and technology transition under the sponsorship of the Strategic

Environmental Research and Development Program (SERDP). The Department of Energy has partnered with WES via an interagency agreement to receive SCAPS technology. The Environmental Protection Agency has joined with the Tri-Service SCAPS developers to conduct validation studies that will lead to regulatory acceptance of SCAPS contaminant sensing and sampling technologies.

### **SCAPS Benefits**

The use of SCAPS reduces the time and cost of site characterization and restoration monitoring by providing rapid on-site real-time data acquisition/processing (i.e., in situ sample analysis) and on-site 3-dimensional visualization of subsurface soil stratigraphy and regions of potential contamination. Another advantage of SCAPS is its relatively non-intrusive and minimal environmental impact operation. SCAPS also prevents cross layer contamination by grouting through the penetrometer probe during rod retraction. A complementary benefit is derived by determining locations that are free of contamination. Hence, cost-avoidance is derived by reducing the number of conventional monitoring wells, samples and analytical laboratory tests required to characterize and monitor cleanup activities. As regulatory acceptance of emerging SCAPS sensor and sampler technologies is obtained, site characterization and monitoring expenditures will be greatly reduced.

### **SCAPS Description**

The SCAPS platform consists of a 20-ton truck (Figure 17) equipped with vertical hydraulic rams that are used to force a cone penetrometer into the ground at a speed of 2cm/sec to depths of approximately 50m in nominally consolidated fine-grained soils when using a 100m umbilical cable (25m when using 50m umbilical cables). During a vertical push, data is continuously collected and recorded with 2cm spatial resolution. The truck consists of two separate enclosed compartments: the data acquisition/processing room (Figure 18) and the hydraulic ram/rod handling room (Figure 19). Each compartment is temperature controlled and monitored for air quality. SCAPS multisensor penetrometer probes are equipped to simultaneously measure tip and sleeve resistances to determine soil stratigraphy, layer boundaries, and soil type as well as

contaminant specific sensor data to determine the presence of pollutants in each soil strata.



Figure 17: Kansas City District Corps of Engineers SCAPS drilling rig (Photo courtesy of US Army Corps of Engineers)

The SCAPS data acquisition room contains a real-time data acquisition and processing computer system; electronic signal processing equipment; and a networked post processing computer system for 3-dimensional visualization of soil stratigraphy and contaminant plumes. A mobile laboratory truck, equipped with field portable ion trap mass spectrometer and/or gas chromatography equipment, accompanies SCAPS for near real-time analytical analysis of analyte vapor samples collected by SCAPS in situ samplers.



Figure 18: SCAPS data acquisition room (Photo courtesy of US Army Corps of Engineers)

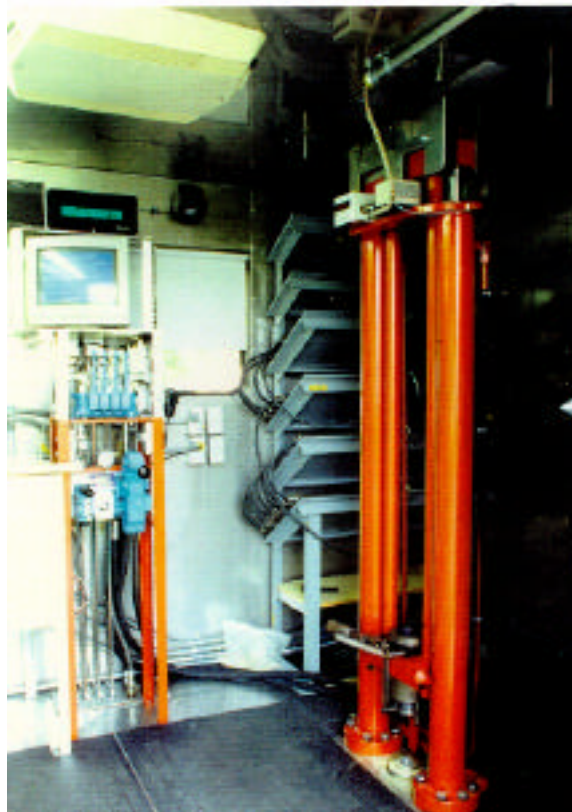


Figure 19: SCAPS rod handling room (Photo courtesy of US Army Corps of Engineers)

## **SCAPS Grout and Decontamination Systems**

A trailer mounted grout pumping system accompanies the SCAPS truck. This system is attached to a specially designed grouting system that has been incorporated into the SCAPS probe to facilitate backfilling the hole with grout as the penetrometer push rods and probe are retracted. This feature prevents subsurface cross-layer contamination. The SCAPS truck is also equipped with a specially designed steam cleaning system mounted beneath the truck rod handling room that removes soil and contaminants that may adhere to the push rods and probe during retraction. Contaminated effluent is collected for proper disposal.

## **SCAPS Technology Transition**

The Tri-Service operates four Army and three Navy SCAPS vehicles. The Army maintains the original SCAPS truck at WES for research, development, and demonstration/validation purposes. Three SCAPS are operated by the Corps of Engineers (COE) Kansas City, Savannah, and Tulsa Districts for operational site characterization and monitoring field investigations at government facilities. The Air Force conducts SCAPS work via contract to the COE and private contractors. SCAPS technologies were transitioned to the Department of Energy via a WES/DOE interagency agreement. Tri-Service SCAPS technologies have also been transitioned to the private sector via licensing agreements, cooperative research and development agreements, and technology reinvestment programs.

---

---

## **SCAPS Sensors and Samplers**

The SCAPS Program is currently conducting field verification investigations on state-of-the-art penetrometer mounted sensor and sampler systems for the real-time in situ detection of petroleum products, explosive compounds, volatile organic compounds (VOC), solvents, and gamma emitting radionuclides. A heavy metal sensing capability is under development. Improved real-time data acquisition/processing algorithms now

allow on-site three dimensional visualization of subsurface contaminant plumes, soil classification and stratigraphy.

### **Laser Induced Fluorescence (LIF) Petroleum, Oil, and Lubricant (POL) Sensor**

The WES/AEC patented LIF POL sensor uses ultra violet laser energy to induce fluorescence in POL contaminants. The laser, mounted in the SCAPS truck, is linked via fiber optic cables to a sampling "window" mounted on the side of a penetrometer probe. Laser energy emitted through the window causes fluorescence in adjacent POL contaminated media. The fluorescent energy is returned to the surface via fiber optic cables for real-time spectral data acquisition/processing (spectral analysis) in the SCAPS truck. The SCAPS LIF POL sensor has undergone numerous successful field investigations at various government facilities to determine soil classification/layering and POL contaminant data. The SCAPS LIF POL sensor is currently undergoing EPA demonstration/validation investigations and has been licensed to private industry for commercialization.

### **Explosives Sensor**

The SCAPS Explosive Sensor probe incorporates electrochemical sensors for the in situ measurement of explosive contamination and geophysical sensors (tip resistance and sleeve friction sensors) for determining soil classification/layering. The probe is used to collect soil classification information during the penetrometer push, and contaminant information during penetrometer retraction. The probe incorporates an external pyrolyzer system used to transform explosive compounds into electroactive vapors and a pneumatic system to transport these vapors from the soil to the electrochemical sensors inside the probe. The probe's umbilical (a) allows the chemical sensor signal to be monitored continuously at the surface, (b) ensures positive flow of clean air through the vapor sampler, supplies power to the pyrolyzer during analysis, (d) interfaces the geophysical sensors to the SCAPS computer thus providing real-time soil classification data, and (e) supplies grouting fluids to the probe's tip.

### **Thermal Desorption VOC Sampler**

The SCAPS Thermal Desorption VOC Sampler combines thermal desorption and cone penetrometer technologies to provide a means for real-time detection and mapping of solvent and hydrocarbon contamination in both the vadose and saturated zones. In operation, the thermal desorption VOC sampler is pushed to a desired depth, an interior rod retracts the penetrometer tip, and a known volume of soil is collected in a sample chamber. While in the sample chamber, heat is applied around the soil sample to purge contaminant vapors. Volatilized compounds are transferred to the surface via carrier gas where they are trapped on tenax, desorbed and analyzed using a field portable gas chromatograph and/or an ion trap mass spectrometer. The soil sample is then expelled, and the cone penetrometer pushed to a new depth where the process is repeated. Alternately, the sampler may be used as a vapor sampler in the vadose zone by applying a vacuum to the transfer line to draw soil vapors to the surface where they are trapped and analyzed.

### **Hydrosparge VOC Sensing System**

The Hydrosparge VOC sensing system consists of a direct push groundwater sampling device coupled to an in situ sparge device interfaced to an ion trap mass spectrometer. A commercially available direct push groundwater sampling tool, Hydropunch<sup>tm</sup>, is pushed to the desired depth. A temporary screen is opened and essentially a temporary monitoring well is developed to provide access to groundwater. An in-situ sparge device, developed by Oak Ridge National Laboratory, uses a helium gas flow to strip VOCs from the groundwater. The VOCs are then returned to the surface via a sampling tube and analyzed in real-time by an onboard field portable ion trap mass spectrometer or similar detection system.

### **Multiport Sampler**

The Multiport Sampler (MPS) contains vertically stacked sampling modules that are independently operated from the surface and collect multiple vapor samples during a single penetration. The MPS is advanced to the desired sampling depth, a module is

selectively opened, and analyte is drawn through a sidewall port. Sampling is conducted by either bringing the analyte/carrier gas to the surface via tubing for analysis using field portable analytical equipment or storing the analyte in probe mounted ion traps that are analyzed after the MPS is brought to the surface. In addition to the sampling modules, the MPS is capable of real-time soil layer (stratigraphy) mapping and grouting through the probe tip as the MPS is retracted to prevent cross-layer contamination. The MPS has been successfully used to sample vapors from soils contaminated with chlorinated organic solvents to determine the relative concentration of the contaminants in different soil strata. Technology Transfer: MPS technology is available via license through the USAE-WES.

**Reproduced from: USACE Waterways Experiment Station Website**

<http://www.wes.army.mil/el/scaps.html>

**For additional information concerning SCAPS, contact:**

**Mr. John Ballard, USACE Waterways Experiment Station, ATTN: CEWES-EP-J,  
3909 Halls Ferry Road, Vicksburg, MS 39180-6199, Phone (601) 634-2446, FAX  
(601) 634-2732**

## References

Gentile, R.J., 1976, *The Geology of Bates County, Missouri*, Missouri Department of Natural Resources, Division of Geology and Land Survey, Report of Investigations No. 59, 89 pages.

Gentle, R.J., 1994, *Geology and Underground Storage in Metropolitan Kansas City, Missouri*, AMG Field Trip Guidebook, 55 pages.

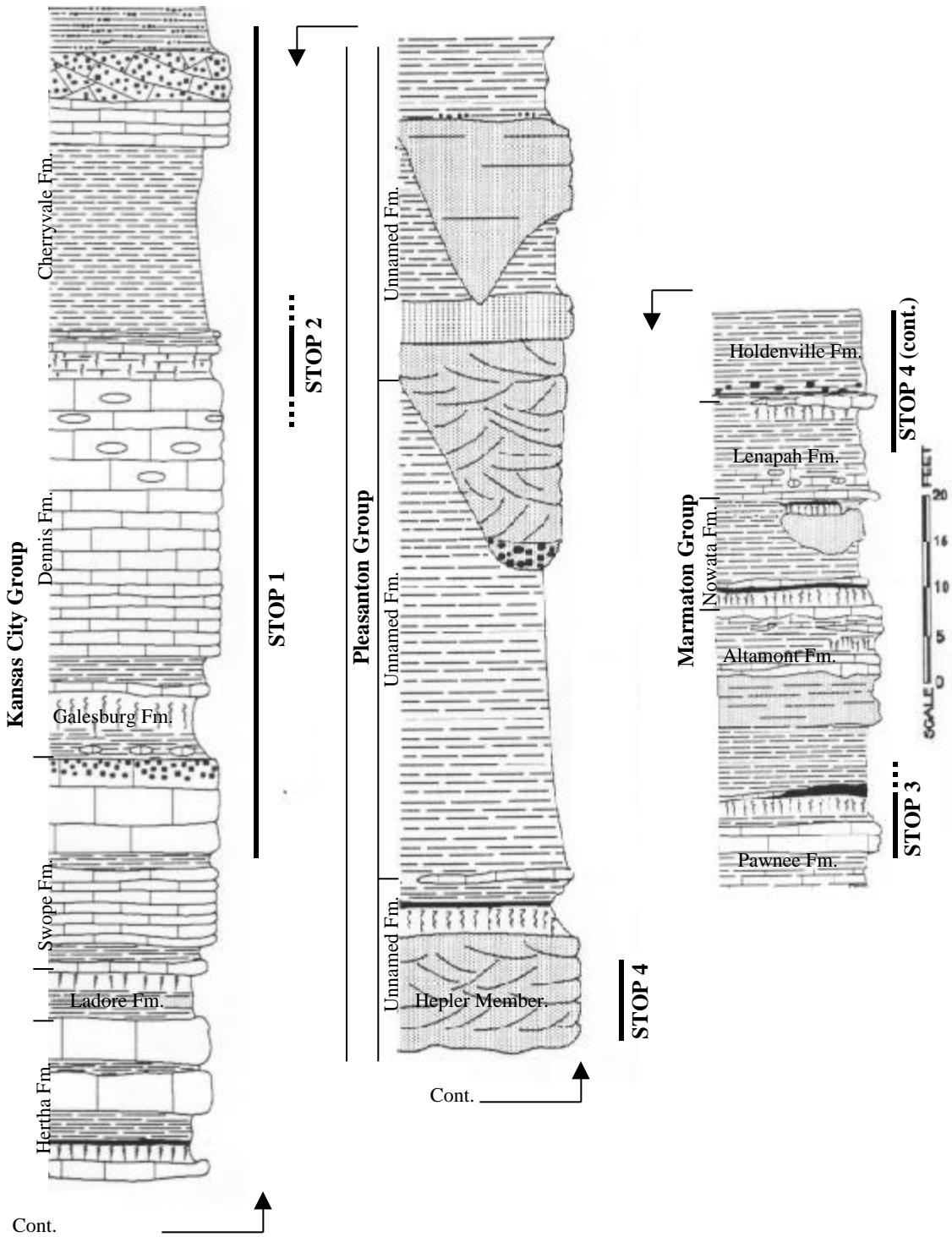
Gosnell, A.S., 1996, *The Structural Geology of South-Central Cass County, Missouri*, Unpublished Masters Thesis, University of Missouri, Kansas City, 68 pages.

Howe, W.B., 1961, *The Stratigraphic Succession in Missouri*, Missouri Department of Natural Resources, Division of Geology and Land Survey Volume 40, 185 pages.

Kansas Geological Survey, 2002, Website URL: <http://www.kgs.ukans.edu/kgs.html>

Thompson, T.L., *The Stratigraphic Succession in Missouri*, Missouri Department of Natural Resources, Division of Geology and Land Survey Volume 40 (revised), 190 pages.

U.S. Army Corps of Engineers Waterways Experiment Station, 2002, Website URL: <http://www.wes.army.mil/el/scaps.html>



Generalized Stratigraphy of Western Cass County, Missouri Showing Stratigraphic Intervals for Day 2 Field Trip Stops. Classification is based upon Howe, 1961 and Thompson, 1995.

*INCLUDED FOR REFERENCE ONLY*