

KANSAS GEOLOGICAL SURVEY OPEN-FILE REPORT 97-61

Kansas Academy of Science
Multidisciplinary Guidebook 10

Fall Field Trip in
Greenwood, Woodson, and Wilson Counties
Southeast Kansas

by

Pieter Berendsen

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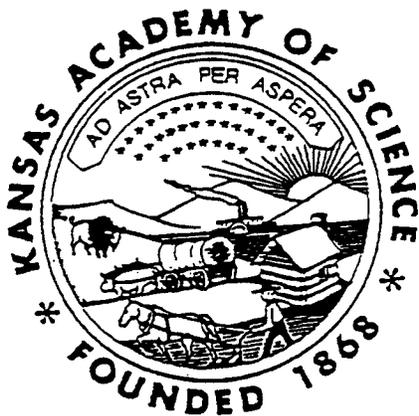
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KANSAS ACADEMY OF SCIENCE
MULTIDISCIPLINARY GUIDEBOOK 10

FALL FIELD TRIP IN
GREENWOOD, WOODSON AND WILSON COUNTIES
SOUTHEAST KANSAS

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INTRODUCTION

The North American continent is divided into a number of physiographic provinces. A physiographic province is defined as "a region of which all parts are similar in geologic structure and climate and which has consequently had a unified geomorphic history; a region whose pattern of relief or landforms differ significantly from that of adjacent regions" (Glossary of Geology, 1997). Because of this the flora and fauna that thrive in the various regions are unique and well adapted to the specific conditions that exist.

The Osage Plains, occupying all of southeast Kansas, is a subdivision of the Central Lowland physiographic province comprising all of eastern Kansas and the area of the Arkansas River valley. On our trip we will examine the flora, geomorphology, and geology that characterize the Osage Cuestas and the Chautauqua Hills, which are minor divisions of the Osage Plains (Figure 1).

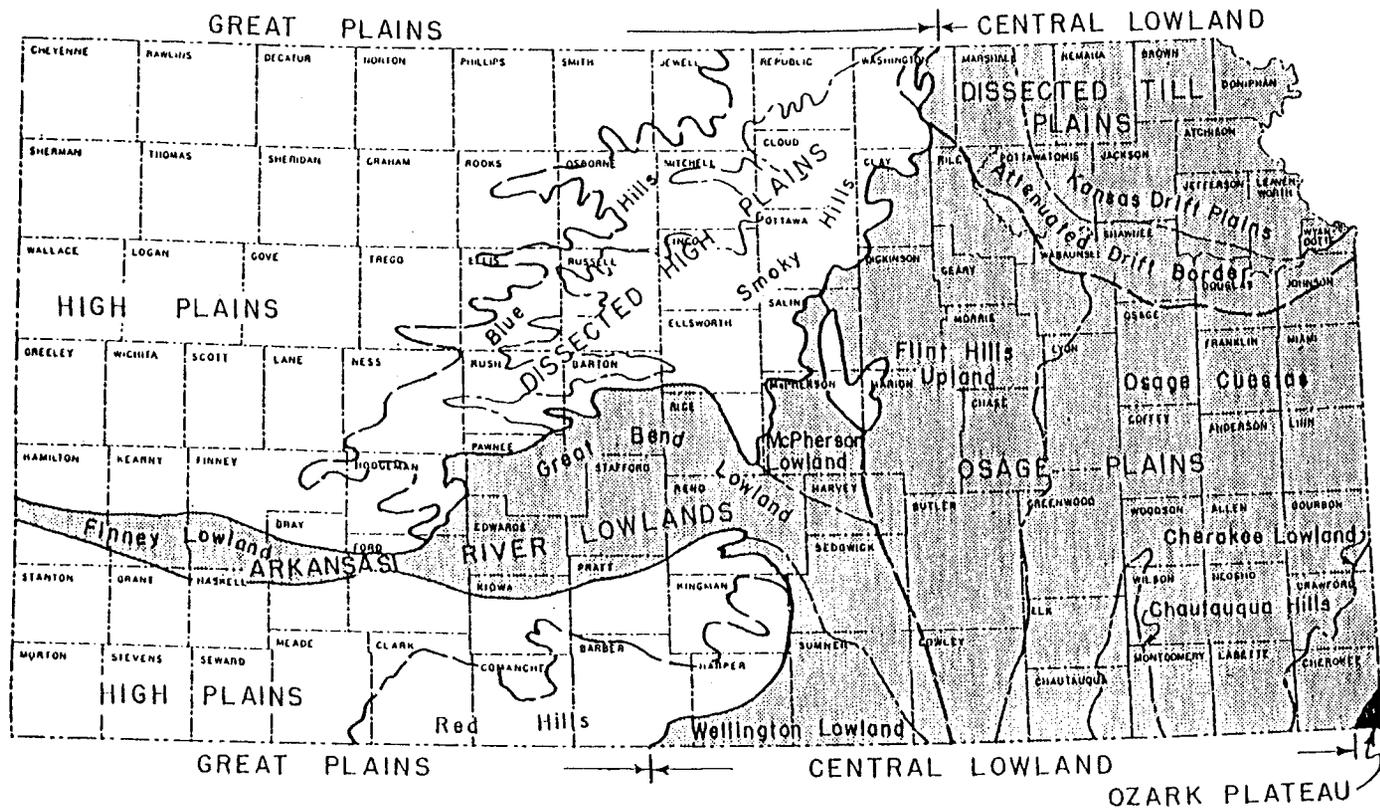
Schoewe (1949) considered the Osage Cuestas to be characterized by a series of northeast-southwest irregularly trending east-facing escarpments between which are flat to gently rolling plains. The cuestas are formed by differential erosion of alternating hard and soft westerly dipping Pennsylvanian limestones and shales. Each cuesta consists of a relatively steep east-facing escarpment and a gentler westward slope conforming to the dip of the strata. Schoewe (1949) recognized at least 18 escarpments in the Osage cuestas. We will see a good example of a cuesta in northeast Wilson County. Here the escarpment is formed by a thick sandstone of the Ireland Sandstone Member of the Lawrence Shale.

The Chautauqua Hills form a ten-mile-wide belt extending south from Yates Center in Woodson County to the Oklahoma border (Schoewe, 1949). The Chautauqua Hills are developed chiefly in the thick sandstones of the Douglas Group. Farther north the sandstone units are not as well developed and gradually change into shales. Areas underlain by these sandstones are generally easily recognized, because they sustain a healthy growth of jack-oak.

The thick sandstone formations and the development of cuestas give rise to a landscape that for Kansas shows quite a bit of relief. The escarpments commonly show elevation differences ranging from 50 to 200 feet, while the relief associated with the sandstone formations may reach 250 feet (Schoewe, 1949). The whole area is underlain by Pennsylvanian rocks about 300 million years old. Limestones, shales, and to some extent sandstones are the main rock types. Based upon the characteristics of the individual rock units, including their composition and fossil content, the rocks can be divided into formations that in many instances can be traced from Oklahoma in a north-northeasterly direction through Kansas and Missouri into Iowa.

STRATIGRAPHY

Except for a few miles south and east of Emporia our trip takes us through country where the bedrock has been assigned to the Lansing, Douglas, and Shawnee Groups of rocks (Table 1). General descriptions of the units present can be found in Merriam (1963) and Zeller (1968). The oldest rocks, assigned to the Lansing Group, consist of two prominent limestone formations and an



The Kansas Academy of Science

Figure 1 Kansas Physiographic Provinces

Classification of rocks in Kansas

ERA	PERIOD	SERIES	GROUP/FORMATION			
CENOZOIC	Quaternary					
	Tertiary					
MESOZOIC	Cretaceous	Upper				
		Lower				
	Jurassic					
	Triassic					
PALEOZOIC	Permian	Leonardian	Sumner Group Chase Group Council Grove Group			
		Wolfcampian	Admiral Group			
	Pennsylvanian	Virgilian	Wabaunsee Group Shawnee Group Douglas Group			
		Missourian	Lansing Group Kansas City Group Pleasanton Group			
		Desmoinesian	Marmaton Group Cherokee Group			
		Atokan				
		Morrowan	Basal Penn. Cgl.			
	Mississippian	Chesterian	Mississippian Limestones			
		Meramecian				
		Osganlian				
		Kinderhookian				
	Devonian		Chattanooga Shale, Misener Sandstone			
			Upper "Hunton" Group			
Silurian		Lower "Hunton" Group				
Ordovician	Upper	Maquoketa Shale				
	Middle	Viola Limestone				
	Lower	Simpson Group Arbuckle Group				
Cambrian	Upper	Reagan, Lamotte Ss.				
	Middle					
	Lower					
PRECAMBRIAN			Fractured Basement Rocks			

Virgilian Stage

- Topeka Limestone: Coal Creek Ls. Mbr., Holt Sh. Mbr., Du Bois Ls. Mbr., Turner Creek Sh. Mbr., Sheldon Ls. Mbr., Jones Point Sh. Mbr., Curzon Ls. Mbr., Iowa Point Sh. Mbr., Hartford Ls. Mbr.
- Calpoun Shale
- Deer Creek Limestone: Edna Creek Ls. Mbr., Lamb & Burdick Sh. Mbr., Rock Bluff Ls. Mbr., Okatoosa Sh. Mbr., Ozawie Ls. Mbr.
- Tecumseh Shale
- Lecompton Limestone: Avoca Ls. Mbr., King Hill Sh. Mbr., Bell Ls. Mbr., Queen Hill Sh. Mbr., Big Springs Ls. Mbr., Donighan Sh. Mbr., Spring Branch Ls. Mbr., Skull Sh. Mbr., Clay Creek Ls. Mbr.
- Kanwaka Shale: Jackson Park Sh. Mbr., Kerford Ls. Mbr., Heumader Sh. Mbr., Pattenough Ls. Mbr., Heebner Sh. Mbr., Leavenworth Ls. Mbr., Snyderville Sh. Mbr., Toronto Ls. Mbr.
- Oread Limestone

Upper Pennsylvanian Series

- Lawrence Formation: Amazonia Ls. Mbr., Ireland Sh. Mbr., Robbins Sh. Mbr., Haskell Ls. Mbr., Vinland Sh. Mbr., Westphalia Ls. Mbr., Torganoole Ss. Mbr., Islan Ls. Mbr., Weston Sh. Mbr.
- Stranger Formation
- Stanton Limestone: South Bend Ls. Mbr., Rock Lake Sh. Mbr., Soper Ls. Mbr., Eudora Sh. Mbr., Captain Creek Ls. Mbr.
- Vilas Shale
- Platsburg Limestone: Spring Hill Ls. Mbr., Hickory Creek Sh. Mbr., Merriam Ls. Mbr.
- Bonner Springs Sh.
- Wyandotte Limestone: Farley Ls. Mbr., Island Creek Sh. Mbr., Argenta Ls. Mbr.

Missourian Stage

Table 1

intervening shale. The thickness of the group is about 85 feet. The two limestone formations form escarpments that are readily traced for long distances. Locally, prominent marine algal limestone build-ups lead to considerable thickening of the limestone formations.

To the west of, and overlying rocks belonging to the Lansing Group, are a series of younger, alternating shales and sandstones with minor limestone that are assigned to the Douglas Group. The average thickness of the group is about 325 feet. The Douglas Group is divided into two formations and several more members. Individual members may be difficult to identify, because of a lack of distinguishing characteristics. Two thin, economically insignificant coal beds, the Upper Sibley and the Williamsburg, have been identified in the Douglas Group.

The youngest group of rocks, the Shawnee Group, consists of four limestone and three shale formations. The shale is commonly sandy in places and also contains some coaly intervals. In this area the whole group is about 400 feet thick. The Shawnee Group is characterized by rock units that exhibit cyclic sequences or cyclothems. A cyclothem is a systematic repetition of bedrock lithology and fossils in the stratigraphic column. Studies by Moore (1964), and many since that time, have made the Kansas cyclothems world famous. The cyclothem model includes six units; they were described in the Kansas Academy of Science Fall Field Guidebook by Aber and Finck (1995).

FIELD TRIP

Leave Emporia State University campus and proceed south on Highway 57 for about 31 miles to the Hamilton Quarry, located 2.5 miles east of the small settlement of Hamilton in secs. 5, 8, and 17, T24S, R12E.

Stop 1

HAMILTON QUARRY: A BRIEF OVERVIEW

Michael Morales
Emporia State University

Hamilton Quarry is an abandoned rock quarry near the town of Hamilton, in Greenwood County, eastern Kansas. It is known throughout the world as a rich fossil site that has yielded a diverse assemblage of extremely well-preserved plant, invertebrate, and vertebrate fossils of late Pennsylvanian age, about 290 million years old. Hamilton Quarry qualifies as one of the world's Fossil-Lagerstätte, relatively rare sites that produce fossil specimens of unusually high quality and in large quantities.

History

In 1964, Walter Lockard found a very well preserved fossil fish in an old abandoned quarry near his home in the vicinity of Hamilton, Kansas. For many years he had collected invertebrate fossils from local marine limestones, but he had never found anything like this before. In 1969, Dr. Thomas Bridge from Emporia State Teachers College (now Emporia State University) met Lockard, identified the specimen as an acanthodian fish similar to *Acanthodes*, and

visited Hamilton Quarry. Bridge later met with the land's owner, Author Lyke, discussed his desire to conduct research at the quarry, and received permission to collect there. During 1969 and 1970, Bridge and graduate students made several trips to the quarry to collect fossils and study the stratigraphy and environment of deposition. These visits, and additional ones by others, resulted in the collection of a large assemblage of fossils from the site (Bridge and Mapes, 1988).

Through the 1970 and 1980 many professional, amateur, and commercial researchers and collectors visited Hamilton Quarry, and many technical and popular papers have been written about the site and its fossil biota (see Mapes and Mapes, 1988, for the most complete summary, and Cunningham, 1993, for the most recent review). Today, Hamilton Quarry is known by paleontologists and geologists throughout the world as one of the best single fossil localities ever discovered. It is also re-created in a diorama at the Denver Natural History Museum.

Stratigraphy and Depositional Environment

The rocks that make up the quarry are paleochannel deposits that were laid down on underlying Pennsylvanian formations: (in descending order) the Topeka Limestone, Calhoun Shale, Deer Creek Limestone, and possibly the Tecumseh Shale. It is not clear whether the paleochannel actually cut down into these formations, or simply deposited its sediments on a surface that had previously eroded down to these strata. Furthermore, the degree of marine influence during the time of deposition of the quarry's sediments is disputed (Mapes and Mapes, 1988). Some researchers believe there was mainly freshwater deposition in the paleochannels

with little marine influence, whereas others think that estuarine or lagoonal influences were more important. In any case, the main fossiliferous part of Hamilton Quarry is a carbonate unit approximately four meters thick made up primarily of wackestones and mudstones with interbedded limey conglomerates.

Fossil Biota

The Hamilton Quarry Lagerstätte includes an extremely well preserved terrestrial flora and fauna that is rather diverse, and a less diverse freshwater to brackish water fauna. Many of the fossil specimens show indications of soft body parts through impressions, compressions, and organic stains in the rock. This allows us to know these ancient animals and plants not only from their preserved hard parts (bones, teeth, shells, etc.) but from their soft parts as well. Very few fossil localities around the world have yielded specimens of high enough quality to reveal such soft tissues.

Vertebrate fossils from the quarry include sharks, spiny finned fish (acanthodians), lobe-finned fish (lungfish and coelacanths), ray-finned fish (palaeoniscids), amphibians, and reptiles. The marine or brackish water invertebrates are brachiopods, bryozoans, bivalves, crinoids, and annelid worms. The non-marine (i.e., terrestrial or freshwater) invertebrates include bivalves, crustaceans, eurypterids, arachnids, millipedes, and insects. Plants specimens from the site come in two forms: large body fossils (twigs, leaves, fronds, etc.) and palynomorphs (spores and pollen). The plants include lycopods, seed ferns, and gymnosperms, but no tree ferns. The flora suggests an upland habitat somewhat removed from typical Pennsylvanian coal forest environments (Leisman et. al, 1988).

REFERENCES

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- Leisman, G. A., W. H. Gillespie, and G. Mapes, 1988. Plant megafossils from the Hartford Limestone. Kansas Geological Survey Guidebook Series, p. 203-212.
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Return to Hamilton and proceed south on Highway 57 for 10 miles to the intersection with Highway 54. Turn east for about 17 miles. At Batesville turn south on gravel road for 2 miles and east for 1 mile to reach the west entrance of Woodson State Fishing Lake, also known as Lake Fagan.

Stop 2.

WOODSON STATE FISHING LAKE AND WILDLIFE AREA

Woodson State Fishing Lake and Wildlife Area was constructed in the 1930's by the Civilian Conservation Corps. It includes a 180-acre lake and 2,400 acre-wildlife area. The lake was drained in 1992 for rehabilitation, during which operation rough fish were removed and sportfish restocked. The wildlife area is a mixture of native grassland and hardwood timber. Game species in the area include bobwhite quail, prairie chicken, waterfowl, rabbits, squirrels, furbearers, white-tailed deer, and turkey. The sandstone outcroppings of the Tonganoxie Sandstone Member of the Stranger Formation near the lake are especially good places to find frogs, salamanders, lizards, and other cold-blooded critters.

Several oil wells that produce from the Big Sandy oil field can be seen between this and the next stop at Silver City Dome.

Big Sandy Oil Field. Produces oil and gas from the "Bartlesville Sand" at a depth of about 1,230 feet. The top of the Mississippian limestone rocks is at about 1,400 feet below the surface in the area. The composition of the sands and the physical shape of the long and relatively narrow sand bodies indicate that they originated as offshore sand bars (Bass,

1936). This particular oil field trends in a northeasterly direction. Closer to the north rim of Silver City Dome we pass over another oil field, the Silver City oil field, that produces from the same rock unit, except that this field trends in a northwesterly direction.

The Big Sandy oil field has 32 productive leases and produces 5,023 barrels of oil per month from 37 wells. Total cumulative production of the field since 1970 is 1,186,374 barrels of oil. Little gas is produced from the field.

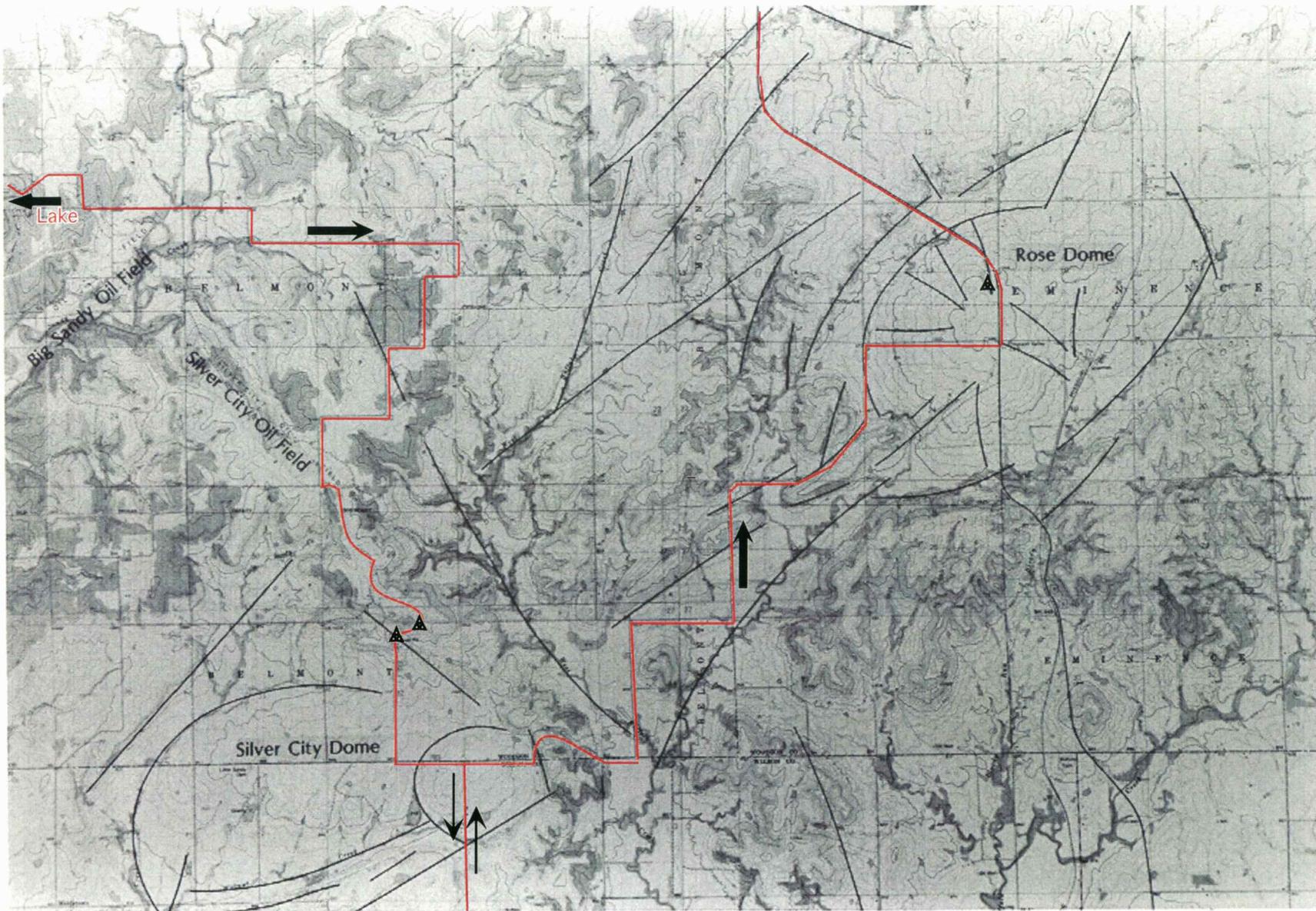
From the east entrance of the lake proceed in an easterly direction for about three miles, than proceed on the gravel road, making several 90-degree turns, in a southeasterly direction for about 2 miles. Here we enter private property, heading south for about a mile to get to the north rim of Silver City Dome (Figure 2).

Stop 3.

SILVER CITY DOME

The name Silver City Dome implies that one expects to see a circular hill or other positive feature dominating the local landscape. Instead, Silver City Dome appears as a topographic, northeast-trending, elliptical depression, about 2.5 miles long by 1.5 miles wide. The dome is on all sides surrounded by a set of hills, about 60-feet high, that form a rim around the depression. The dome is drained through Little Sandy Creek, which breaches the rim in the southwest corner. A subtle topographic high occurs roughly in the center of the dome.

In the late 1870's, erroneous reports that silver occurred, drew prospectors to the area,



Silver City and Rose domes

▲ Stops

— linear and curvilinear structures

Figure 2

resulting in a short burst of mining activity. A small settlement, appropriately named Silver City, existed at this site for a short while. The area later attracted more attention because of the occurrence of an unusual rock, now called lamproite, exposed for a short distance along the northern rim of the dome. In the 1940's attention was drawn again to the lamproite as a possible source for vermiculite, bauxite, chromite, and road ballast. In 1961 a mining operation was started to produce insulating material. The venture only lasted about five years. Between 1966 and 1982 the lamproite was intermittently mined and the material was marketed as a complete fertilizer. The present-day mining operation by Micro-Lite LLC started in 1982. The company has been mining the soft, olive-brown, weathered lamproite. Most of the material (98%) is used as a feed additive for cattle and pellet binder. The remainder is utilized in the area of specialty applications. During 1996, about 70,000 tons of lamproite was mined.

Originally, lamproite was believed to be a slightly metamorphosed sedimentary rock (Mudge, 1881), but not long thereafter the igneous nature of the rock was recognized. The intrusives were recognized at Silver City Dome and Rose Dome (Figure 2) and are apparently restricted to the two northeast-trending elliptical depressions.

Briefly, the lamproites are porphyritic and contain up to 34% anhedral pseudomorphs after olivine, up to 25% euhedral to subhedral reddish-brown phlogopite, up to 5% euhedral to subhedral diopside, and lesser amounts of chrome spinel and potassic richterite as the main minerals set in a mostly serpentized groundmass. The chemistry and petrogenesis of the lamproites in Woodson County were described in detail by Cullers and others (1985). Volumetrically, lamproites are insignificant, but once it was realized that they

are chemically closely related to kimberlites, they are now well-known as important source rocks for diamonds. As a matter of fact, the world's richest diamond mine at Argyle in northwestern Australia, occurs in lamproite. The diamond-bearing rock at Prairie Creek in Arkansas is also a lamproite.

Lamproite magma evolves at depths below 100 miles and is intruded into the existing country rocks at temperatures in the neighborhood of 8000 °C and pressures ranging from 225 to 300 bars (Franks and others, 1971). The lamproite magma is charged with a lot of gas and rises quickly to the surface. According to Wagner (1954), the sedimentary rocks at Silver City Dome have been metamorphosed for a distance of up to 1000 feet from the contact with the intrusion. Of course, this distance depends upon the thickness of the intrusive unit. Isotopic age determinations of phlogopite mica show that the lamproite was intruded about 90 million years ago during the late Cretaceous. Fresh lamproite is black to dark gray-green and weathers to olive-brown at depths of about 35 feet when exposed at the surface.

At Silver City Dome, the lamproite sill that initially attracted attention to the area occurs at the surface as a 70-foot thick, elongate body about one mile long and 750 feet wide (Figure 3). The sill is cut-off by the northwest-trending fault that defines the northern perimeter of Silver City Dome (Figure 3). The sill dips at a low angle in a northerly direction as shown in boreholes M-1 and 7 in the south-to-north cross-section A-A' (Figure 4). The location of the boreholes drilled in the area to date is shown in Figure 5. The contact with the underlying siltstone and shale of the Weston Shale Member of the Stranger Formation of the Douglas Group (Table 1) and the fault contact are well-exposed in the open-pit mine. The fault

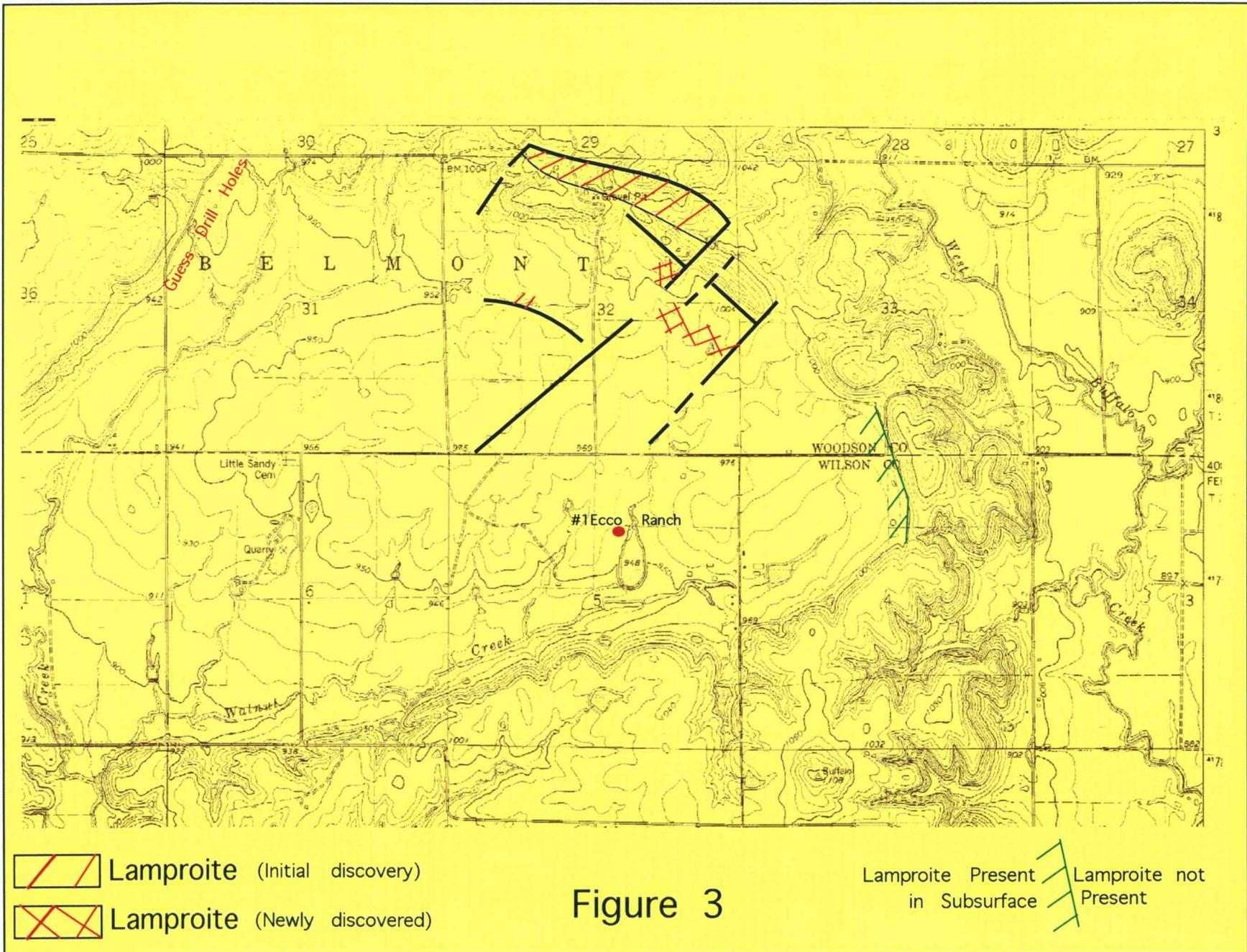


Figure 3

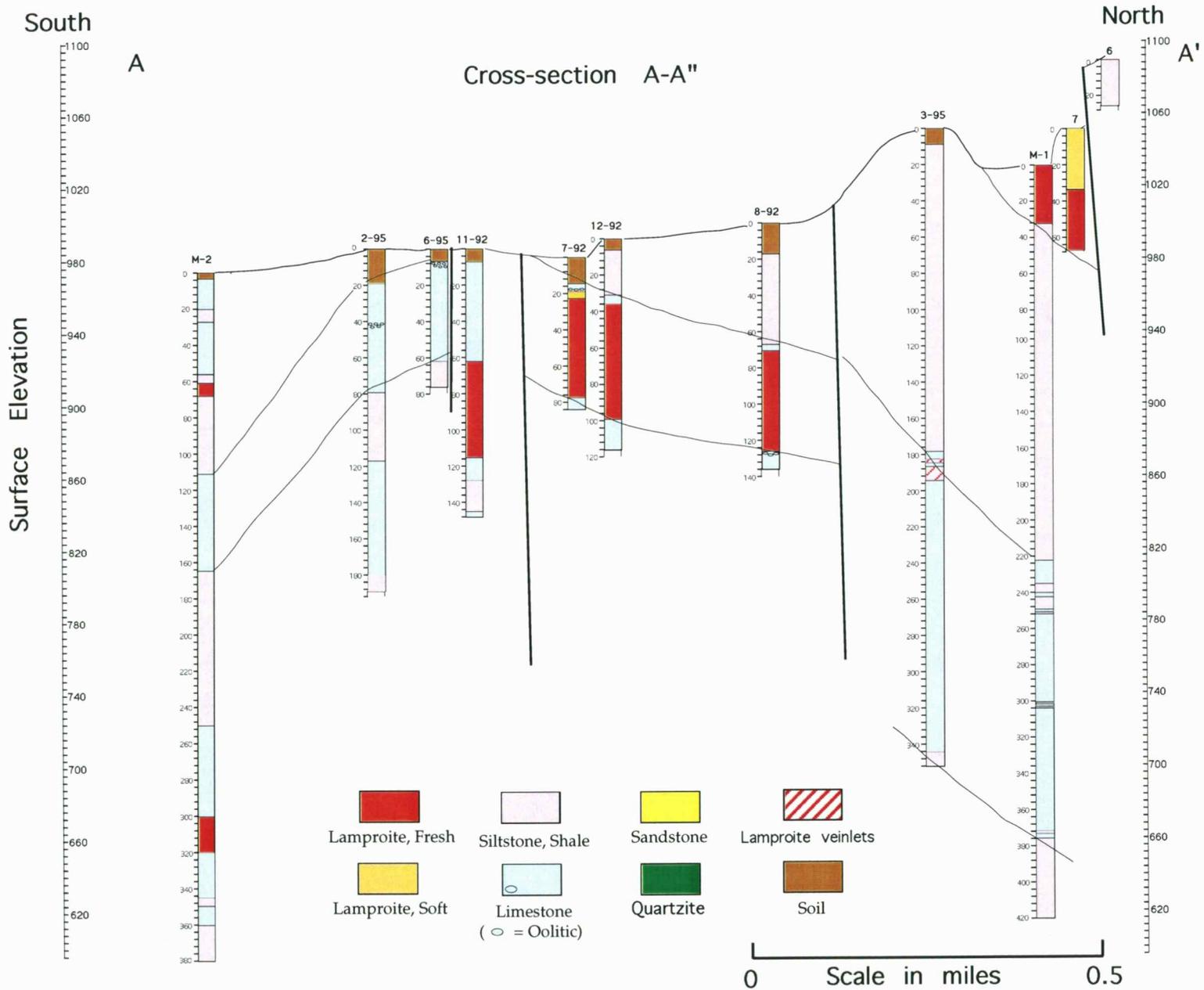
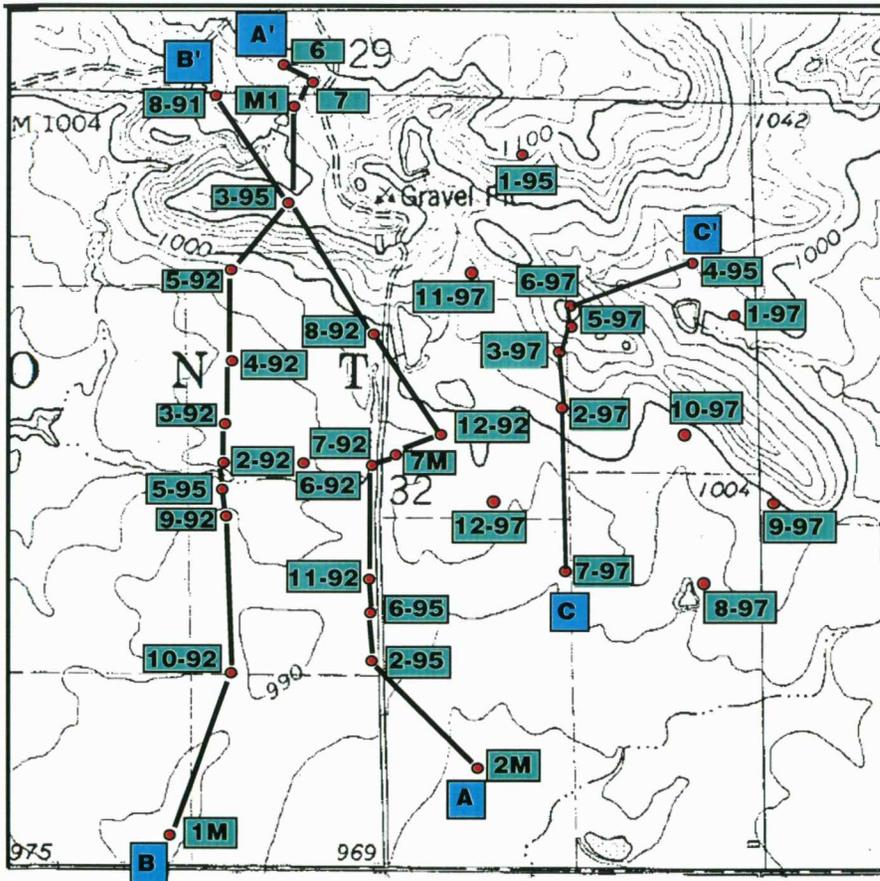


Figure 4



- Borehole Location
- 8-92 Bore hole Number
- Cross-section Line

Figure 5

dips at a high angle (700-850) to the north. Several tens of feet of the siltstone of the Weston Shale Member below the lamproite and of the overlying sandstone of the Tonganoxie Sandstone Member were subjected to the high heat of the intruding lamproite magma. As a result, the rocks underwent a chemical and physical alteration, which in this case gave rise to substantial hardening and color change of the rocks adjacent to the contact. This process is known as contact metamorphism, and the area affected is known as the contact metamorphic zone.

Based on available field evidence at the time, it had been proposed by Wagner (1954) that the sill came up from depth along the northwest-trending fault paralleling the northern rim of the dome. A 430-foot deep drill hole (M-1) completed by Berendsen in 1989 in the open-pit close to the fault contact demonstrated that the sill is an isolated body underlain by 190 feet of shale belonging to the Weston Shale Member of the Stranger Formation (Figure 4). Thus the conduit along which the lamproite migrated to the surface is not located along the fault plane, but must be sought elsewhere in the dome.

In the course of drilling for oil, and drilling conducted by the Kansas Geological Survey, it has become obvious that quite a number of lamproite sills of varying thickness have intruded between the layers of alternating limestone and shales with minor sandstone belonging to the Upper and Middle Pennsylvanian. In the 820 feet deep #1 Ecco Ranch drill hole completed in 1988 by Berendsen in the southern part of the dome, seven lamproite sills were identified (Figures 3 and 6). Thick lamproite sills were also encountered in two oil exploration holes (Guess #2 and #3) in the sandstone and shale of the Cherokee Group of rocks (Table 1) at

about 900 feet in depth in the northwestern part of the dome (Figure 3). Quite a number of oil exploration drill holes are located in and near the eastern part of the dome. Available records in the form of electric logs and sample description by geologists indicate that lamproite sills commonly are encountered in those holes that are located inside the high rim of the dome. The 1,000-foot elevation contour line on the topographic map appears to be the boundary line separating rocks inside the dome from those outside the dome. Few drill holes have penetrated any of the deeper rocks, so that we have no knowledge of possible lamproite occurrences below the Pennsylvanian, which is on the order of 1,400 feet thick in this area. All the sills so far encountered are isolated from their source.

The sills so far identified in the northern portion of the dome all dip at a low angle to the north (Figures 4 and 7). Whether the sills in other parts of the dome dip outward from the center of the dome towards the rim is not known at this moment. Generally, each sill is terminated by a fault contact (Figures 4 and 7). All the faults so far mapped are high-angle faults. Two kinds of faults are common: faults that are concentric with the outline of the dome and radial faults, resembling spokes in a wheel.

Based on 1) the geomorphological character of Silver City Dome and Rose Dome; 2) the internal structure of the dome; and 3) the nature of the lamproite magma, I have tentatively concluded that both domes are ancient small volcanoes that erupted in Cretaceous time. Of course one has to realize that much of the record and physical evidence has been destroyed by erosion. One can make some estimates of the amount of rock that was present at the time of the eruption and has since been eroded away. The thickness of younger Pennsylvanian rocks assigned to the

STRIP LOG
 #1 ECCO RANCH
 Kansas Geological Survey Strat Test
 July, 1988
 SW NW NE
 Section 5, T27S - R15E
 WOODSON COUNTY, KANSAS

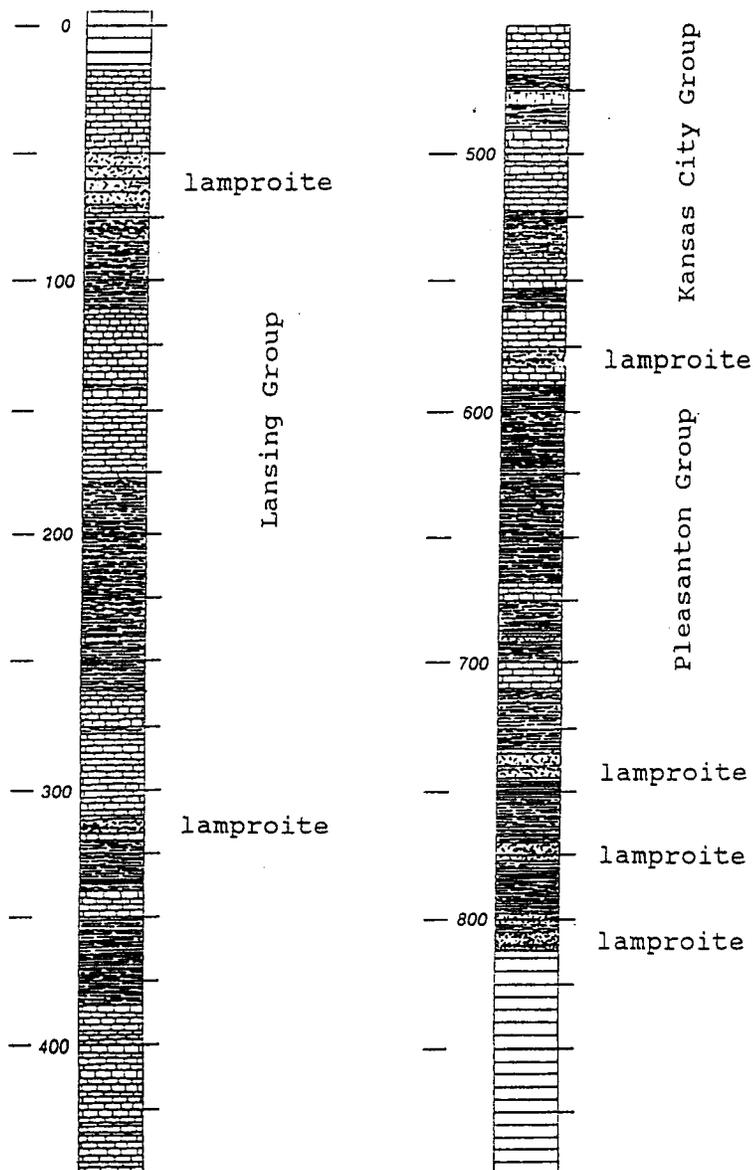


Figure 6

Virgilian Series is at least 1,000 feet, the thickness of the overlying rocks of Permian age is about 2,700 feet (Table 1). It is not well established if, and to what extent, Triassic and Jurassic rocks covered the area, but certainly Cretaceous rocks were deposited. Based on this information it is thus likely that several thousands of feet of sediment were eroded since Cretaceous time.

The lamproite magma was highly charged with gas. As the magma moved slowly from great depth nearer to the surface into lower pressure regions, the gas wants to expand, but was prevented from doing so by the overlying rocks. Eventually the gas pressure became so great that it started to open up existing faults and/or fractures present in the overlying rocks. As the magma moved higher and higher, this process became more intense, until finally the pressure was so great that it literally lifted the overlying rock column and exploded to the surface along pre-existing pathways. Once the pressure was released the uplifted rocks settled back and developed the radial and concentric faults that we can map today. The slight positive areas in the middle of the domes are likely the place where magma came up; in other words, the vent of the now-eroded volcano probably occurs somewhere near the center of the dome. The mineralogical make-up of the lamproite rock is such that it contains no minerals that survive on earth for a long time. Therefore we do not expect to find any evidence of this eruption in rocks in the vicinity of the dome.

From the mine site proceed to the small town of Buffalo for lunch. On the outskirts of Buffalo by the railroad crossing we pass the processing plant operated by Micro-Lite LLC. Here the material is processed into various forms and packaged for delivery to customers.

We will return to Silver city Dome and proceed via gravel road to Rose Dome (Figure 2). On the way to Rose Dome you will note several northeast-trending straight linear ridges that are up to 100 feet higher than the surrounding countryside. These ridges are bounded by southwest- to northeast-trending faults as indicated by a shallow seismic survey (Berendsen, Personal Communication). We believe that they are indications of major basement faults having the same orientation that have undergone reactivation throughout geologic time.

Stop 4.

ROSE DOME

Rose Dome is located about four miles northeast of Silver City Dome and 7 miles south of Yates Center. U.S. Highway 75 passes through the middle of Rose Dome. The geomorphology of Rose Dome is identical to that of Silver City Dome. Except for the northeast side, Rose Dome is surrounded on three sides by a set of hills, forming, in effect, a rim around the dome. The center of the dome is at the same elevation as the surrounding hills. Radial drainages from the center of the dome flow into two creeks that flow just inside the rim of the dome and breach the dome in the southwest corner. No lamproite has been found on the surface at Rose Dome, but drilling by the State Geological Survey in 1964 confirmed the presence of lamproite (then referred to as peridotite) in the shallow subsurface in the center of the dome (Franks, 1971) in several boreholes (Figure 8). Lamproite was also encountered at depths greater than 1,150 feet in the course of oil and gas exploration drilling (Twenhofel and Bremer, 1928).

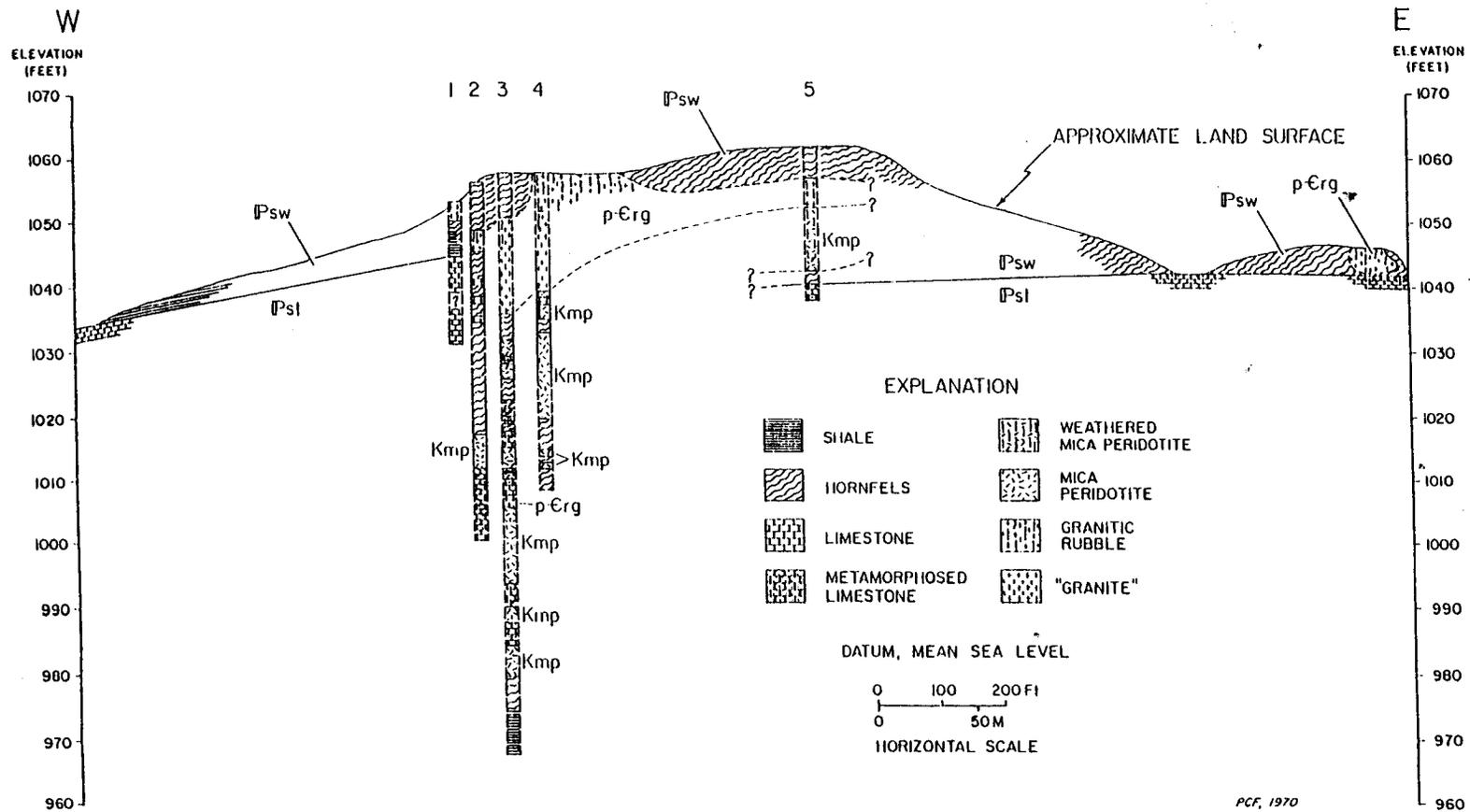


Figure 3. Cross-section W-E of igneous, metamorphic, and sedimentary rocks on Rose Dome based on drilling by State Geological Survey of Kansas. Short dashes indicate inferred geologic contacts and correlations. Dashed portions of drill holes indicate those parts of logs based on cuttings rather than core. Rock units include: Kmp, Cretaceous

mica peridotite; Psw, Weston Shale Member, Stranger Formation, Pennsylvanian; Pst, Stanton Limestone, Pennsylvanian; p-Erg, chiefly Precambrian Rose "granite" and granitic rubble but also includes admixed, weathered mica peridotite. Vertical exaggeration, X 10.

Figure 8

What initially attracted attention to Rose Dome is the occurrence of a number of large (up to about two feet in diameter), weathered, rounded granitic boulders strewn about the center of the dome. Various ideas were put forward to account for the occurrence of the boulders. Twenhofel (1917) first suggested that they were transported by Pleistocene glaciation. This was soon discounted because Pleistocene glaciers never advanced this far south. Later, an intrusive origin for the boulders was favored (Twenhofel, 1926). Other ideas involved extensive faulting (overthrusting) that brought the boulders to the surface. Another idea that still arises is that the a meteorite slammed into the earth caused the boulders to come to the surface.

The most widely held and plausible theory explains that the granite boulders were brought up by the lamproite magma. As the magma came closer to the surface and became violently explosive, it ripped pieces from the granite basement underlying the sedimentary rocks in the area. The granite pieces tumbled around as in a vortex, thus becoming rounded. As erosion took place over the next 90 million years, the large granite boulders, being much more resistant than the surrounding sedimentary rocks, collected and were preserved on the surface. Merriam (1963) first suggested that the boulders were xenoliths carried upwards by the lamproite magma.

The lamproite is dense and heavy, but contains no iron-rich magnetic minerals. An attempt by Hambleton and Merriam (1955) to detect the lamproite rock in the subsurface by detailed magnetic studies showed negative results. A structure map on top of the Mississippian rocks in the same publication clearly shows structural highs of about 100 feet coinciding with the outline of the domes on the surface.

From Rose Dome we proceed north on Highway 75 to Yates center.

Yates Center was founded in 1875 as the site for the county seat. The Courthouse Square Historic District was placed on the National Register of Historic Places in 1986. It is comprised of 41 buildings, two historic structures, and one site built between 1883 and 1928. The district is made up of a concentration of two-story sandstone and brick Italianate and one- and two-story brick early 20th Century Commercial buildings located on all four sides of the Courthouse Square. The most significant building in the historic district, the Woodson County Courthouse, constructed from 1899-1900, is a well-preserved example of the work of noted Kansas architect George P. Washburn of Ottawa, Kansas.

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