

GEOLOGY AND FOSSILS OF NORTHEASTERN KANSAS:  
A Field Trip for the 7<sup>th</sup> International Conference on  
Coelenterate Biology

9 July 2003

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Kansas Geological Survey

Open-file Report 2003-39



Route of today's field trip, showing Stops 1-5.

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Today's field trip focuses on the geology and invertebrate fossils of eastern Kansas. All our stops will be in rocks of Late Pennsylvanian age, deposited in shallow seas during the Coal Age, about 300 million years ago. The northeastern corner of Kansas was covered by ice sheets during a glaciation that occurred about 600,000 years ago; we'll see this much younger glacial material that lies atop the considerably older Pennsylvanian bedrock.

Our trip starts in Lawrence, then makes a stop just west of town that will serve as an introduction to the rock types and environments of deposition that are common in eastern Kansas and much of the midcontinent, primarily interbedded limestones and mudrocks deposited in or near shallow seas. This stop is not a particularly good place to collect fossils, but it will provide you with an orientation for better things to come during the rest of the day. We'll then move to a roadcut east of Topeka where we will see the well-preserved remains of numerous invertebrates that lived in these Pennsylvanian seas (crinoids, bryozoans, fusulinids, foraminifers, bivalves, brachiopods, corals, sponges, echinoderms, gastropods, maybe even a stray trilobite). From Topeka we will head south to a roadcut along Interstate 35 where you can collect cornucopia-shaped horn (or rugose) corals. After lunch we'll make a quick stop at a slightly younger outcrop to examine and collect tabulate corals.

Our final stop will be at a quarry that contains a range of nicely preserved invertebrates. See figure 1 for examples of fossils we will encounter today.

Four of these stops are along roads. **At the I-35 stop, in particular, you need to stay off the highway and watch for traffic at all times.** The final stop is in a privately owned quarry. While we have permission to visit this site, please remember that we are here through the courtesy of the landowner. You can collect fossils at any of these stops, but be careful about turning over rocks, especially at the quarry. Snakes are rare and mostly harmless, but they are around. Because fossils have weathered out of the surrounding material, you won't need a rock hammer to help you collect. Climbing isn't really required to collect fossils at any of these stops. But if you do get on top of an outcrop or roadcut, stay away from the edge and be aware of people below you. Please, be careful out there.

The authors express their appreciation to the Kansas Department of Transportation for providing access at Stop 3; to Ken Nelson, for permission to visit the quarry at Stop 5; and to Marla Adkins-Heljeson and Jennifer Sims for their assistance in preparing this guidebook. Also, some of the material in this guidebook is from McCauley et al., 2000, and Maples and Buchanan, 1993.

FUSULINIDS

*Triticites*



TRILOBITES

*Ditomopyge*



MOLLUSCS

Clams

Snails

*Aviculopecten*



*Allorisma*



*Amphiscapha*



*Bellerophon*



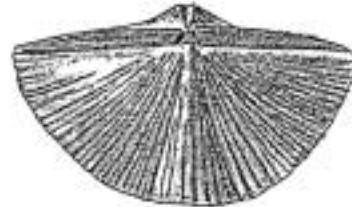
BRACHIOPODS



*Echinaria*



*Antiquatonia*



*Neospirifer*



*Punctospirifer*



*Linoproductus*



*Derbyia*



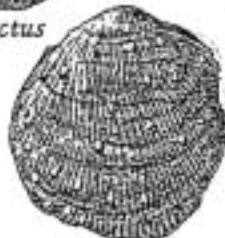
*Composita*



*Dielasma*



*Juresania*



*Cancrinella*



*Neochonetes*



*Hustedia*



*Meekella*

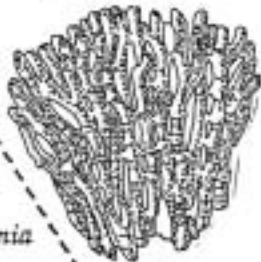
CORALS

colonial

solitary



*Caninia*



*Syringopora*

BRYOZOANS

stick



fenestrate



CRINOIDS

column



crown

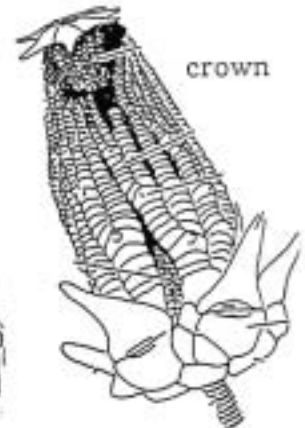


Figure 1. Examples of the types of fossils we can expect to see in the rocks encountered on this field trip.

## STOP 1

The spillway at Clinton Lake provides an excellent introduction to the geology of eastern Kansas. The dam here was constructed on the Wakarusa River, a tributary of the Kansas River, in the late 1970s. The spillway is a means by which water can move out of the lake during times of extremely high water levels (though the water has never been that high). The bike path along the floor of the spillway was added in the 1990s.

The spillway is a good place to view a vertical sequence of the rock layers that are typical of this area. These interbedded limestones and mudrocks were deposited late in the Pennsylvanian Period of geologic history (also known as the Coal Age or Upper Carboniferous), about 300 million years ago. At that time, Kansas was near the equator, the climate was warmer, and a shallow sea advanced and retreated repeatedly across eastern Kansas as glaciers waxed and waned in the southern continents (figs. 2 and 3). Life flourished in the clear, warm water, producing abundant carbonate sediments that later consolidated into limestone.

At other times, mud was deposited by sluggish rivers; these muds eventually formed shales and mudrocks, the softer, thinly layered rocks between the limestones. Occasionally, this area was at or slightly above sea level and sands (now sandstone) were deposited in the channels, estuaries, and deltas of rivers.

Although each rock layer here is only a few feet thick, these formations extend vast distances across Kansas and adjacent states. Geologists have given each of these rock layers a name, based on the location where it was first described (fig. 4). The limestones and shales/mudrocks here are part of two formations, the Oread Limestone (the upper unit) and the Lawrence Formation. The Oread Limestone is named after nearby Mount Oread, home of the University of Kansas (KU), where the formation was first described by geologist Erasmus Haworth in 1894. In spite of its name, the Oread Limestone, like many other formations, contains about as much shale as limestone. The Lawrence Formation, which lies below the Oread (and is thus older) consists of a variety of mudrocks as well as some sandstone, thin limestones, and very thin coals. This unit is named for the city of Lawrence.

Geologists have divided the rock layers in the Oread and the Lawrence into smaller units called members, much the way that biologists divide a genus into smaller groups of species. The rock layer at the bottom of the spillway is called the Amazonia Limestone Member, named for the small town of Amazonia, north of St. Joseph in Andrew County, Missouri. Above the Amazonia are mudrocks of the 'Wathena' member of the Lawrence Formation. This part of the Lawrence Formation includes one or two thin coal layers called the Williamsburg coal, named for the small town of

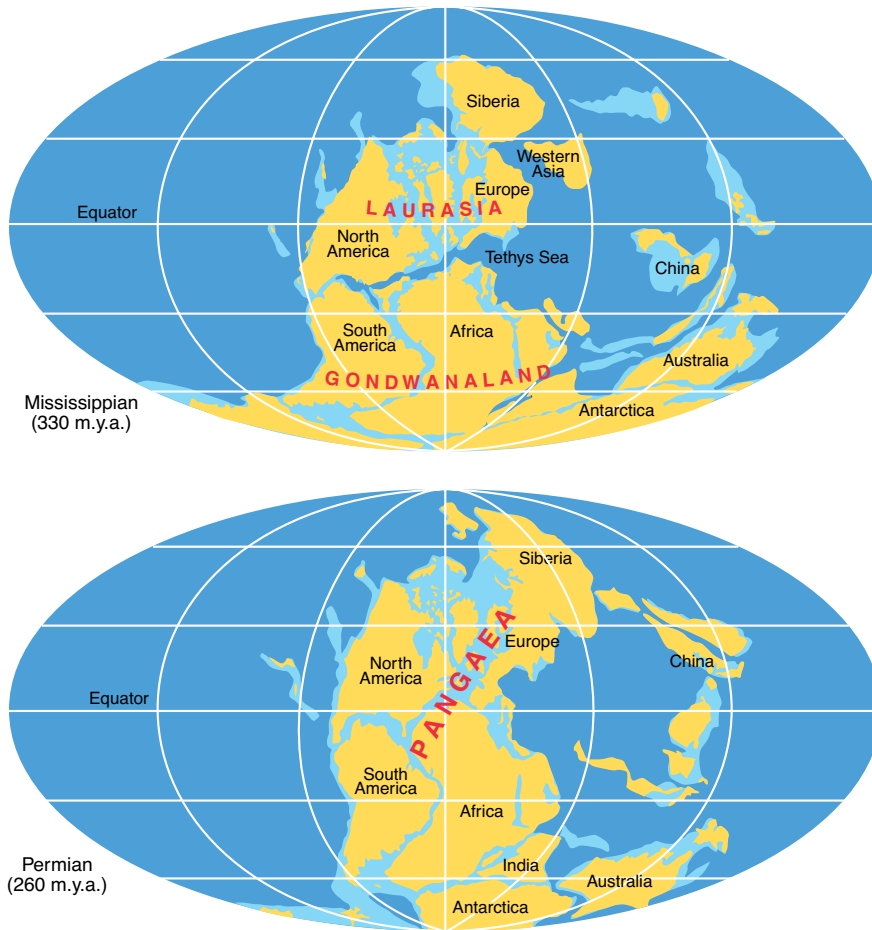
Williamsburg, Kansas, southwest of here. Locally, carbonized tree stumps have been found in the Williamsburg. Small brittle-star fossils are also sometimes found here in the sandy mudrocks of the Lawrence. This part of the Lawrence Formation may have been deposited on the plain of an ancient delta, where local swamps had formed (see fig. 5).

Above the Lawrence Formation is the Toronto Limestone Member of the Oread Limestone (see fig. 6 for a depiction of the depositional environment). It is named for the town of Toronto, Kansas, and not the more famous (and slightly larger) city in Ontario, Canada. The Toronto is a thick, light-gray limestone that weathers rusty brown; it contains a few fossils. Above the Toronto is the Snyderville Shale Member, which is unfossiliferous gray clay, and above that is the Leavenworth Limestone Member. The Leavenworth is a thin layer of gray to brown limestone that was first described from exposures northeast of here, near the town of Leavenworth, Kansas (home of the federal penitentiary and Fort Leavenworth, site of the Army Command and General Staff College).

The next unit up is the Heebner Shale Member, one of the most distinctive rock layers in the spillway. The Heebner is very different from the Snyderville Shale Member and mudrocks in the Lawrence Formation. The Heebner is black, brittle, and bedded in layers so thin that they resemble pages in a book. Fossils include abundant conodonts (microscopic tooth or jaw-like fossils of uncertain biological affinity) and rare inarticulate brachiopods and fish fragments. The Heebner also contains phosphate nodules, pebble-sized spheroids that are high in phosphate and contain about 170 parts per million of uranium, making them slightly radioactive. When studying rocks in the subsurface, geologists use logs that measure various rock properties. These higher levels of radioactivity make the Heebner easier to recognize on logs that measure gamma radiation, so that the Heebner serves as a "marker" bed, helping geologists orient themselves stratigraphically when working with subsurface data. Geologists agree that the Heebner was deposited on a stinking, anoxic sea bottom, but disagree about the origin of these conditions. Some regard it as representing deposition when the Pennsylvanian sea was at its deepest, perhaps 200 meters. Others argue for a shallow lagoon.

Above the Heebner Shale Member is the Plattsmouth Limestone Member of the Oread Limestone. The Plattsmouth is a wavy-bedded, light-gray limestone. It contains several layers rich in chert (flint) and fossils such as crinoids, corals, and fusulinids. Remember what the Plattsmouth looks like; we will see it again throughout the trip and at our last stop.

One obvious characteristic of the rock layers exposed here at the spillway is their cyclicity. That is,



**Figure 2.** Positions of the lithospheric plates during the Mississippian and Permian periods, the two periods bracketing the Pennsylvanian Period. During the Pennsylvanian, Kansas lay near the equator (adapted from Tarbuck and Lutgens, 2000).



**Figure 3.** Paleogeographic reconstruction of North America during the Pennsylvanian (from Crouch, 1996, modified from Scotese and Golonka, 1992).

these rocks were deposited in a regular vertical sequence of limestone, mudrock, limestone, mudrock, etc. This sequence of rocks, which geologists call a “cyclothem,” is found not only in the Oread Limestone and Lawrence Formation, but is repeated in Pennsylvanian rocks above and below these formations, in Kansas and throughout the midcontinent. Geologists believe that this regular sequence of deposition is probably the result of fluctuations in sea level. As the sea levels deepened (in the range of tens of meters), mud was trapped in the shore zone and limestone was widely deposited offshore. As the seas shallowed, shoreline muds spread much further, resulting in mudrock intervals (except, perhaps, in the case of the Heebner, which represents the time when the ocean was deepest).

Geologists generally agree that the changes in Pennsylvanian sea levels were the result of the alternate shrinking and growing of continental glaciers documented in the southern hemisphere. When the glaciers melted, sea levels rose, resulting in limestone deposition. During colder times, ice caps grew, sea levels went down, and mudrock was deposited. There are other theories about the reasons behind the sea level-change. Still, it is possible to look at the rock layers in the spillway as hard evidence of sea-level fluctuations in this long-ago ocean.

These rocks also exhibit larger-scale cycles. The rock types that make up the Oread Formation are repeated with only slight variations in the same sequence in the three overlying limestone formations. The intervening shales are also similar. The upper three members of the Oread at this outcrop (the thin, dark Leavenworth Limestone Member, the black Heebner Shale Member, and the thick, wavy-bedded Plattsmouth Limestone Member) have counterparts in most of the underlying Middle Pennsylvanian limestone formations.

A name that remains widely associated with the idea of cyclic deposition—the cycles of deposition that resulted in cyclothem, or the packages of limestones and mudrocks that we’ve seen today—is R. C. Moore. Moore, a renowned paleontologist, was the director of the Kansas Geological Survey and professor of geology at KU from 1916 until 1954, and continued to be active in paleontology and geology until his death in 1973. The Kansas Geological Survey is a division of KU, and its headquarters building on west campus is named after Moore. Moore was the creator and editor of the *Treatise on Invertebrate Paleontology*, the standard reference on genera- and higher-level fossil taxa that continues to be updated and revised. He wrote textbooks on invertebrate paleontology and historical geology, and helped produce the first detailed geologic map of Kansas. Moore so vigorously defended ideas about cyclothem that they became perceived as his own and grew to be strongly identified with him (Buchanan and Maples, 1992).

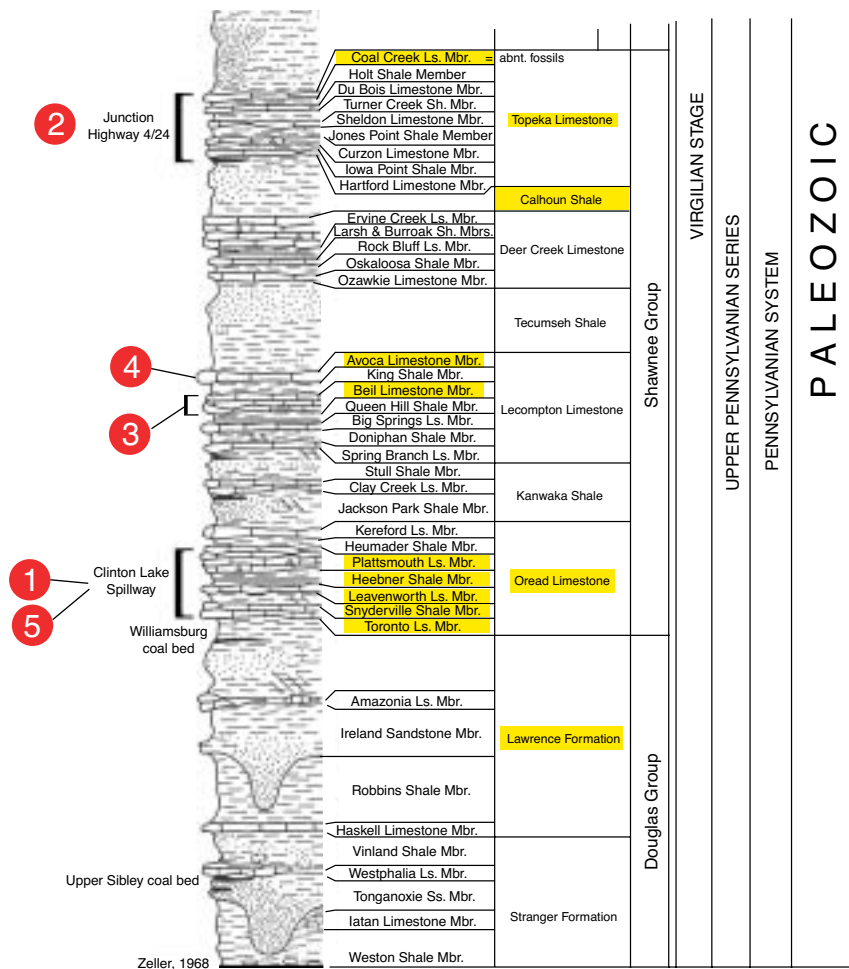
## STOP 2

We are now in Shawnee County, at Calhoun Bluffs northeast of the city of Topeka, the capital of Kansas. The interchange at the junction of Kansas Highway 4 and U.S. Highway 24 is a good place to see and collect invertebrate fossils.

Two rock units here, the Holt Shale and Coal Creek Limestone Members of the Topeka Limestone, are particularly fossiliferous. The Holt Shale Member is a dark-gray, layered siltstone, about 0.6 meters (or 2 feet) thick. Fossils of brachiopods and bryozoans are common in this member. The Coal Creek Limestone Member, which is directly above the Holt Shale Member, is a light-gray or olive, silty limestone, about 1.2 meters (or 4 feet) thick. Both of these units are about a million years younger than the rocks in the Oread Limestone and the Lawrence Formation that we saw in the Clinton Lake spillway; they are separated by two limestone and three mudrock formations. Although most of the rocks in eastern Kansas look layer-cake flat, many of them dip at slight angles. In this area, the general dip is to the west, so that rocks that are at the surface in, say, Lawrence, dip down into the subsurface as you move to the west; the rocks that we saw at Stop 1 are overlain here by more than 100 feet of younger rocks.

In addition to the fossils at this site, a thin coal is also visible here, exposed in the Calhoun Shale, the formation just below the Topeka Limestone. Pyritized wood is also found just above the coal layer in the Calhoun Shale. Although there are many coal layers in eastern Kansas, and a thriving coal industry once existed in southeastern Kansas, most are too thin or contain too much sulfur to be burned as fuel, and nearly all of the electricity generated in the state comes from burning coal from Wyoming. In the past few years, however, a number of natural-gas wells have been drilled into these coal beds in eastern Kansas to produce coal-bed methane.

From here we return south, crossing the Kansas River. The Kansas River is generally regarded as the southern boundary of glaciation in Kansas. In fact, the original Kansas (or Kaw) River was probably created as a meltwater stream from those glaciers, which got this far south and as far west as the Big Blue River near Manhattan. Hence, the Kansas River valley is much larger than befits the present modest-sized river and has a very thick fill of sand and gravel. These glaciers were massive sheets of ice; one geologist estimated that ice would have been as much as 500 feet thick at Mount Oread (Wakefield Dort, personal communication, 2001). Some of the most visible pieces of evidence for glaciation are large red boulders of quartzite, a billion-year-old metamorphic rock that was originally in place around Sioux Falls, South Dakota. These glacial erratics were carried here, then left behind, by the glaciers about 600,000 years ago. Because that glaciation occurred so



**Figure 4.** Stratigraphic classification of Upper Pennsylvanian rocks in Kansas (adapted from Zeller, 1968). The numbers indicate the rocks taht will be encountered during that stop.

long ago, erosion has since erased most other glacial features in Kansas (such as moraines). This is particularly true relative to areas north of here, such as Wisconsin, where evidence of much more recent glaciation (in the past 15,000 years) is still apparent.

### STOP 3

This is a roadcut in the Beil Limestone Member of the Lecompton Limestone. The Beil (pronounced to rhyme with “peel”) is named after the Beil farm in Cass County, Nebraska, where it also crops out and where it was first described. In general, rock units are named after locations, such as towns, and not people (although the story has long been told that R. C. Moore, while director of the Kansas Geological Survey, named the Aarde Shale Member after a farm, the owner of which just happened to be a member of the Kansas Legislature). The Lecompton Limestone, of which the Beil is a member, is named for a

small town between Lawrence and Topeka that was a pro-slavery capital of territorial Kansas. The Beil is slightly younger than the Oread Limestone (one shale formation separates them), which we saw in Lawrence, and slightly older than the units we saw at the last stop in Topeka (by two shales and one limestone formation). The Beil is an extremely fossiliferous unit, and at this location it contains many cornucopia-shaped rugose corals. These are tetracorals with skeletons of calcite, in contrast to the modern hexacorals or scleractinians with skeletons of aragonite, a less stable form of calcium carbonate.

We are now in Osage County and in the Osage Cuestas physiographic region of Kansas. This region occupies nearly all of eastern Kansas south of the Kansas River and is characterized by a series of east-facing ridges (or escarpments), between which are flat to gently rolling plains. Cuesta, Spanish for hill or cliff, is the term geologists use to describe ridges with steep faces on one side and gentle slopes on the other. In the Osage Cuestas, the underlying strata are Pennsylvanian limestones and





*Figure 5. Restoration of the ecosystem associated with the time of the deposition of the Lawrence Formation. Drawn by R. C. Moore (1964), the original caption says that this is a “view looking west from site of Douglas County courthouse in Lawrence.”*



*Figure 6. From a paper by R. C. Moore (1964), this illustration includes a caption that reads “Seascape at Lawrence, Kansas, in early Oread time, defective as a paleoecologic illustration in that depth of water, nature of salinity, and type of bottom sediment cannot be shown.”*

mudrocks that dip gently to the west and northwest. Each cuesta consists of a striking east-facing ridge or escarpment and a gently inclined surface that slopes in the direction of the dip of the strata. Each escarpment is capped by the more-resistant limestone, while the gentle slopes are underlain by the thick layers of mudrock.

With both Melvern Lake and nearby Pomona Lake, Osage County is the only county in the nation with two federally constructed reservoirs. The U.S. Army Corps of Engineers and the Bureau of Reclamation operate 24 reservoirs in Kansas, constructed from 1948 to 1981. Many of those reservoirs, such as Clinton Lake, are on branches of the Kansas River, and many of them were built for flood control. A major (“100-year”) flood inundated much of the Kansas River valley in 1951, and when heavy flooding occurred again in 1993, the dams were given credit for reducing damage.

## LUNCH

We will eat lunch at a shelterhouse at John Redmond Reservoir, an artificial lake that is operated by the Tulsa District of the U.S. Army Corps of Engineers. John Redmond was constructed on the Neosho River, a northwest-to-southeast-trending stream that heads in the Flint Hills to the northwest of here and eventually empties into the Arkansas River in Oklahoma. The lake was primarily created for flood control and recreation. Construction was started on the dam in 1959 and it was completed in 1963. The lake was named after a local newspaper editor who was active in efforts to bring flood control to the Neosho River valley.

We are now in Coffey County, named after Asbury M. Coffey, a member of the first Kansas territorial legislature. Coffey was a native of Kentucky, in favor of slavery, and later a colonel in the Confederate army. Many Kansas counties were originally named for southern sympathizers, but later changed their name. A few, such as Coffey and Atchison County in northeastern Kansas, retained their original name in spite of the political leanings of their namesake.

## STOP 4

This is an excellent place to see and collect corals in the Avoca Limestone Member of the Lecompton Limestone. The Avoca is named after a small town in Nebraska, about 30 miles east of Lincoln. The outcrop belt of many of these limestone and mudrock units runs

generally from north-northeast to south-southwest across eastern Kansas. Thus, many of them extend into southeastern Nebraska or Iowa and, like the Plattsmouth, Avoca, and Beil Limestone Members, are named for localities there. The Avoca is locally up to 6 meters (20 feet) thick in Kansas, but is generally much thinner and good outcrops are rare. In addition to tabulate (syringopoid) corals, it contains fusulinids and gastropods in most locations. Here, the corals occur in patches and are in the same position that they occurred in life; in some respects, you are now walking on the top of an ancient, coral patch reef. Also visible here are joints, or narrow cracks in the bedding surface of the limestone. Rainwater is funneled into these cracks, leading to erosion by dissolution along these joints and breaking off limestone chunks in a linear fashion. Ultimately, such dissolution can form small caves. Kansas has many small caves, most of them in the slightly younger Permian limestones in the Flint Hills to the west of here. Some of these caves extend several thousand feet, but most are small because the limestones are so thin.

## STOP 5

This quarry is privately operated and provides crushed rock that is used by the county on gravel roads. It is in the Plattsmouth Limestone Member of the Oread Limestone. The Plattsmouth is the thickest of the limestones in the Oread, and is generally from 5 to 10 meters (15 to 30 feet) thick. The Plattsmouth, named for a small town in Cass County, Nebraska, just across the Platte River from Omaha, is the same unit that we saw toward the top of the spillway at Clinton Lake at our first stop. Here it contains abundant, well-preserved fossils, including bryozoans, gastropods, echinoids, brachiopods, crinoids, fusulinids, sponges, algae, trilobites, and trace fossils—the tracks, trails, and burrows of animals that lived on this soft seafloor (Crouch, 1996; see also Mangano et al., 2002, for a detailed discussion of trace fossils in a slightly younger limestone at a location a few miles southwest of here). Many of these fossils are from the same animals that we saw at the second stop northeast of Topeka. As a result, this location gives a good sense of the association of animals that lived in these Pennsylvanian seas. Also the recurrences of similar biota, even to the species level, provide another demonstration of the cyclic nature of these rocks. In addition, this site has a few rugose corals and many good specimens of the tabulate corals that we saw in the previous stop in the Avoca Limestone Member.

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## APPENDICES

(following)

Generalized Physiographic Map of Kansas  
Generalized Geologic Map of Kansas  
Kansas Geologic Timetable