

UPPER ORDOVICIAN ROCKS IN THE VICINITY OF MAYSVILLE, KENTUCKY: A FIELD TEACHING LABORATORY FOR HISTORICAL GEOLOGY STUDENTS

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ABSTRACT

The rocks in and around Maysville, Kentucky are known for their abundant, diverse, and well preserved fossils. During Late Ordovician time (about 450 million years ago), the region was covered by a shallow epicontinental sea that was teeming with marine invertebrates, such as bryozoans, brachiopods, trilobites, cephalopods, bivalves, gastropods, crinoids, corals, etc.

This geologic setting is a wonderful field laboratory for students of historical geology. For many years Marietta College and West Virginia University at Parkersburg, separately, have been escorting students to study the Upper Ordovician limestones and shales outcropping there. The students may be both geology majors and non-majors. Maysville, Kentucky is about a three hour drive from the Marietta-Parkersburg area and the students are typically transported in vans to the locality. The trip can be completed in one long day, but sometimes students and professors spend the night in a motel in the area and continue to study the outcrops and collect fossils the following day.

During Late Ordovician time the Taconic Orogeny forming the Taconic Mountains to the east of this area (due to plate tectonic activity) resulted in periodic episodes of clastic sedimentation with fine clay transported to this area to form muddy bottoms that would form shales alternating with times of low clastic input that would result in limestones. The resulting thick sequence of alternating fossiliferous limestones and shales (about 75 meters represented by the Kope, Fairview, and Grant Lake formations at the Ohio River suspension bridge locality on Kentucky Route 3071) impresses upon students the time span that would be necessary for these deposits to accumulate. Other principles and concepts of historical geology that may be discussed during these field trips include superposition, lateral continuity, fossil succession, index fossils, correlation, paleoecology, paleogeography, paleoenvironmental analysis, relative geologic time, and absolute geologic time. Primary sedimentary structures such as ripple marks and trace fossils are also common in these deposits. Some unique features that may be found in these rocks are shingled brachiopod shells deposited during severe storms and ball and pillow structures that may be related to regional earthquake activity.

INTRODUCTION, GEOLOGIC SETTING AND STRATIGRAPHY

The Ordovician rocks in and around Maysville, Kentucky are part of the classic Cincinnati region Upper Ordovician (Cincinnatian Series) stratigraphic section. These rocks are known world-wide for their abundant, diverse, and well preserved Upper Ordovician fossils. During Late Ordovician time (Cincinnatian Epoch – from about 450 to 440 million years ago), the region surrounding Cincinnati, Ohio (northern Kentucky, southwestern Ohio, and southeastern Indiana) was covered by a shallow epicontinental (epeiric) sea that was teeming with marine invertebrates, including bryozoans, brachiopods, trilobites, cephalopods, bivalves (clams), gastropods (snails), crinoids, and corals. The Upper Ordovician rocks of the Cincinnati region represent deposits of limestone and shale that formed atop the positive structural feature referred to as the Cincinnati Arch (Figure 1).



Figure 1. Map showing tectonic structural features of the midwest. Slightly modified from Indiana Geological Survey.

The Upper Ordovician (Cincinnatian Series) rock exposures may be used to emphasize to students the three major themes of historical geology (see Wicander and Monroe, 2012): plate tectonics, the vastness of geologic time, and biologic evolution. Fauna of the Ordovician Period represents one of greatest biodiversity radiations of all time culminating in one of the largest mass extinction events in the history of life. During Late Ordovician time the Taconic Orogeny was forming the Taconic Highlands to the east of this area (due to plate tectonic activity) that resulted in periodic episodes of clastic sedimentation prograding into the Appalachian foreland basin. In the Maysville area, fine silt and clay was transported onto the Cincinnati Arch during times of high clastic input to form muddy bottoms that would form calcareous siltstones and shales (much more dominate than siltstones) alternating with times of low clastic input that would result in limestones. The thick sequence of alternating fossiliferous limestones and shales near Maysville, Kentucky (about 75 meters or 250 feet along Kentucky Route 3071 and Kentucky Route 11) impresses upon students the immense time span that would be necessary to deposit this accumulation of rocks. Other principles and concepts of historical geology that may be discussed during these field trips include superposition, lateral continuity, fossil succession, biostratigraphic correlation, index fossils, paleoecology, paleogeography, paleoenvironmental analysis, relative geologic time, and absolute geologic time. Primary sedimentary structures (such as ripple marks and mudcracks) and trace fossils (see Osgood, 1970) are also common in these deposits. Some unique features that may be found in these rocks are tempestites (storm beds, often consisting of shingled brachiopod shells) and seismites (earthquake formed features resulting in soft sediment deformation and ball and pillow structures).

Of the five formations representative of Late Ordovician time in north central Kentucky (Figure 2), students sample the following four formations that outcrop in the Maysville area: the Kope Formation, Fairview Formation, Grant Lake Limestone, and the Bull Fork Formation (formation names used by the Kentucky Geological Survey and the United States Geological Survey in this area – also see Meyer and Davis, 2009, p.p. 44-64; Cuffey, 1998, p.p. 2-9; and Davis, 1998, p.p. 13-14). The lower three formations (Kope, Fairview, and Grant Lake) are separately and excellently exposed along Kentucky 3071 and Kentucky 11. Each of these outcrop areas expose about 75 meters (250 feet) of these three formations.

SERIES	AGE	FORMATION
		Drakes Fm.
CINCINNATIAN	RICHMONDIAN	Bull Fork Fm.
	MAYSVILLIAN	Grant Lake Limestone
		Fairview Fm.
	EDENIAN	Kope Fm.

Figure 2. Upper Ordovician stratigraphic relationships and terminology used in this paper.

METHODS, LOGISTICS, AND OUTCROP STOPS

Maysville, Kentucky is about a 3.5 hour drive from the Marietta-Parkersburg area. Typically students and professors will meet at about 7:00 a.m. to begin the drive to Maysville. A stop may be made for a quick coffee and/or breakfast. By about 10:30 or 11:00 a.m. we arrive at the first outcrop location, across from the relatively new suspension bridge across the Ohio River (Figures 3 and 4) on Kentucky Route 3071.



Figure 3. Photo of the relatively new suspension bridge spanning the Ohio River between Aberdeen, Ohio and Maysville, Kentucky. This photo is looking to the southeast across U. S. Route 52. The hills across the river are in Kentucky and Kentucky Route 3071 is across the bridge (to the right in the photo).



Figure 4. Just across the suspension bridge looking south along Kentucky Route 3071 at a large outcropping of the upper portion of the Kope Formation and much of the Fairview Formation.

Upon arriving at the first stop, the field trip leader(s) gives a brief lecture on the general geologic setting of the Upper Ordovician strata in the Maysville area, including regional tectonics, regional paleogeography, formations that will be studied and sampled for rocks and fossils, and the paleoenvironments represented by the rocks. This first locality is referred to as **Stop 1**. Collections from the Kope Fm., Fairview Fm., and the lower portion of the Grants Lake Limestone will

be made at Stop 1. Stop 1 represents a vertical stratigraphic section of about 75 meters (250 feet), from the middle to upper portion of the Kope Fm. to the lower portion of the Grant Lake Limestone. During the remainder of the trip two more major stops will be made (but we may pull over briefly at other locations also) (see Figure 5 for stop locations).

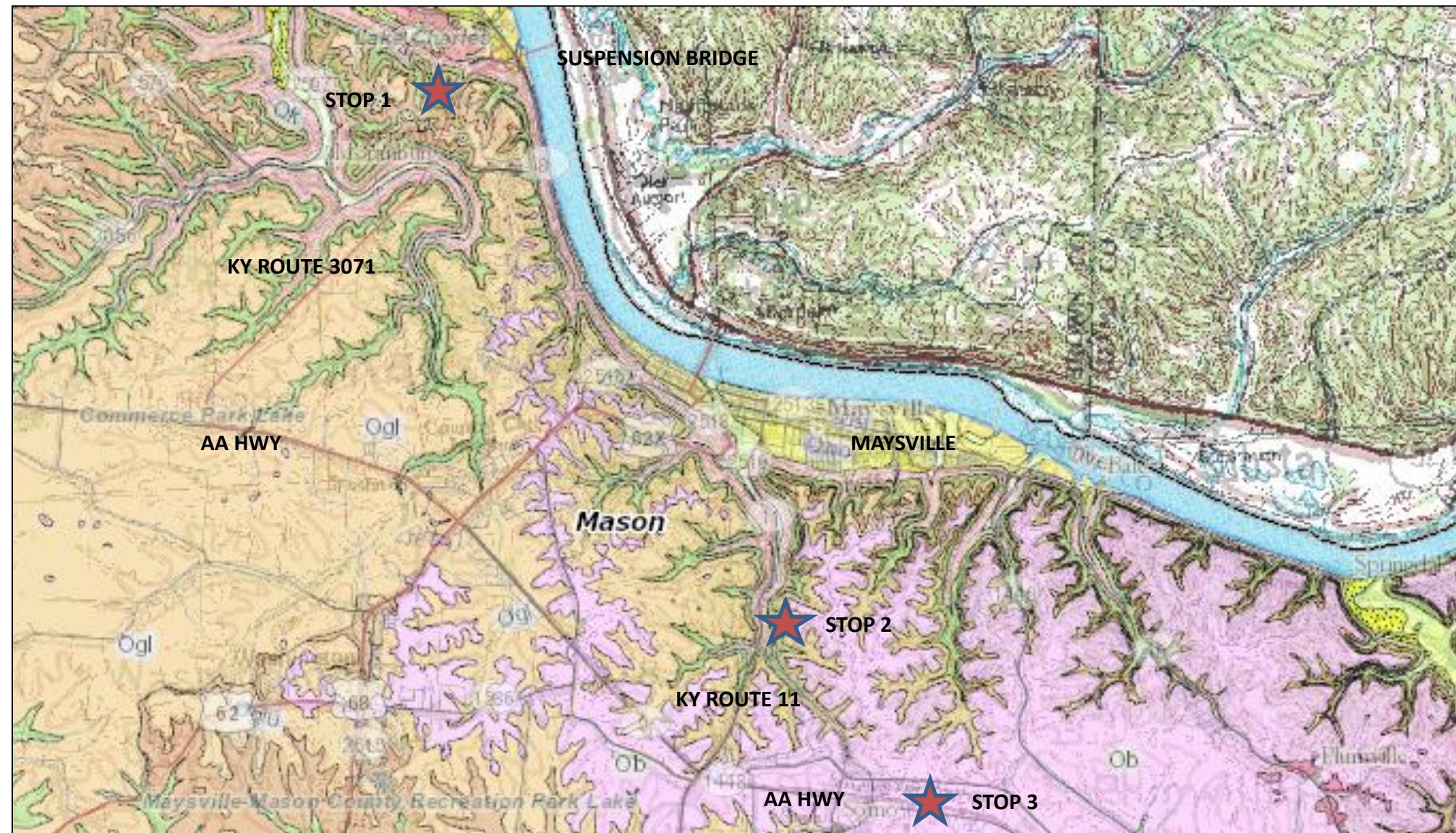


Figure 5. Location map superimposed onto the geologic map of the Maysville area (geologic map modified from Online Geologic Maps, Kentucky Geological Survey, at <http://kgs.uky.edu/kgsmap/kgsgeoserver/viewer.asp#>, accessed October 15, 2012).

The students and instructor(s) collect at stop 1 until about 1:30 p.m., before loading up and traveling to Stop 2 along Kentucky Route 11. On the way to Stop 2, a stop is made along the AA Highway (Kentucky Route 9) at a fast food facility for a quick lunch. The group then proceeds east on the AA Highway a short distance to Kentucky Route 11, where we take a left and proceed north. The Upper Ordovician rocks along this approximately 2 mile stretch of Kentucky Route 11 are excellent outcrop exposures of about 75 m (250 feet) of limestone and shale ranging from within the upper portion of the Grant Lake Limestone down to the upper portion of the Kope Formation (as we travel north on Highway 11) (Potter, et al, 1991).

The vans are stopped within a few hundred meters of the intersection to start observing and collecting fossils from the upper portion of the Grant Lake Limestone. The Grant Lake Limestone here contains large *Platystrophia ponderosa* shells with infillings (geopetals) (also see Potter et al, 1991). The approximately 30 meters (100 feet) of Grant Lake Limestone at **Stop 2** consists of about 75% medium gray, wavy to lenticular bedded fossiliferous grainstones and about 25% very fossiliferous calcareous shale (Potter, et al, 1991) (Figure 6).



Figure 6. Photo of Grant Lake Limestone showing the wavy to lenticular bedding.

Proceeding down the grade of Kentucky Route 11 northward (we go down the section into older rocks because it is easier for the students and instructors to walk down rather than up the grade), the Grant Lake Limestone transitions into the Fairview Fm. over a few feet. According to Potter, et al, 1991 the boundary is placed about halfway in the zone of gradation. The Fairview Fm. is about 28 meters (93 feet) thick and consists of about 60 percent limestone and calcisiltite and about 40 percent shale (Potter, et al, 1991). The limestone and calcisiltites are medium gray planar to lenticular beds, with the limestones being packstones to grainstones (Potter, et al, 1991) and although not as fossiliferous as the Kope Fm. and Grant Lake Limestone, may be quite fossiliferous in places. Fairview Fm. limestones and calcisiltites contain abundant primary sedimentary structures including tool and sole marks, rip-up clasts, small scale cross-bedding, and ripple marks (Figure 7) (also see Potter, et al, 1991). Trace fossils are also abundant in the calcisiltites, including the dumb-bell shaped *Diplocraterion* and horizontal worm traces (Figure 8). Of particular interest at Stop 2 in the Fairview Fm. are three zones of ball and pillow structures and convolute bedding (Figures 9 and 10) (Potter, et al, 1991) representing soft sediment deformation that is interpreted by several authors to be seismites formed by regional earthquake activity during Fairview time (see discussions in Potter, et al, 1991 and Meyer and



Figure 7. Photo of blocks of calcisiltite containing wave-formed interference ripple marks from the Fairview Fm. at Stop 1. The larger block is about 1 meter in length.



Figure 8. Photo of horizontal worm traces on the surface of a Fairview Fm. calcisiltite at Stop 2..



Figure 9. Photo of the upper portion of the Fairview Fm. showing three zones of soft sediment deformation forming ball and pillow structures and convoluted bedding interpreted to represent three separate seismites that recorded three separate regional earthquake events during Late Ordovician time.



Figure 10. Close-up photo of the lower distorted zone. The large "ball" is about 1 meter across.

Davis, 2009).

Only the upper 15 meters (about 50 feet) or so of the Kope Formation is exposed at Stop 2. The Kope Formation is mostly shale, about 65%, interbedded with limestone and calcisiltite (Potter, et al, 1991) and represents the deepest water conditions of the four formations seen in the Maysville area. The limestone and calcisiltite beds (mostly packstones and grainstones) are mostly planar bedded and contain abundant fossils, whereas the shale beds are typically sparsely fossiliferous (Potter, et al, 1991). Primary sedimentary structures are fairly similar as in the Fairview Fm. The Kope Fm./Fairview Fm. contact is fairly sharp and is picked at the base of a 1 to 2 meter thick fairly continuous ledge-forming limestone with thin shale partings that forms the base of the Fairview Fm. (Figures 11 and 12).



Figure 11. Photo showing the contact between the Kope Fm. (below) and the Fairview Fm. (above) at Stop 2.



Figure 12. Photo showing the contact between the Kope Fm. (below) and the Fairview Fm. (above) at Stop 1.

After observing the outcrops and collecting fossils at Stop 2 for about 2 hours (to about 4:00 p.m.), the group moves on to **Stop 3**. The students and instructor(s) load back up in the vans and head south on Kentucky Route 11. At the intersection of Kentucky Route 11 and the AA Highway, a left turn is made to travel eastward on the AA Highway. The lower part of the Bull Fork Fm. outcrops on both sides of the road. The rocks of the lower half of the Bull Fork Fm. that outcrop for the next 3 miles or so are irregular wavy to nodular bedded limestones with thin interbedded shales and are highly fossiliferous with a diverse marine fauna of brachiopods, bryozoans, bivalves, gastropods, crinoids, rugose corals, and trilobites (Potter, et al, 1991). In fact, at about 2.5 miles from the intersection of Kentucky Route 11 and the AA Highway is an excellent stop for collecting Richmond stage fossils, including the large horn coral *Grewingkia*. This location is Stop 3. The students collect fossils at Stop 3 for about half an hour and it is getting to be time (4:30 to 5:00) for the long drive home

CONCLUSION

The Upper Ordovician rocks in the vicinity of Maysville, Kentucky (and generally in the vicinity of the Cincinnati area of northern Kentucky, southwestern Ohio, and southeastern Indiana) are an excellent field laboratory in which to present and demonstrate principles and concepts of historical geology. Students become excited and invigorated when exposed to the excellent rock outcrops in this area that are loaded with fossils.