Geology Along the Martha Layne Collins Bluegrass Parkway

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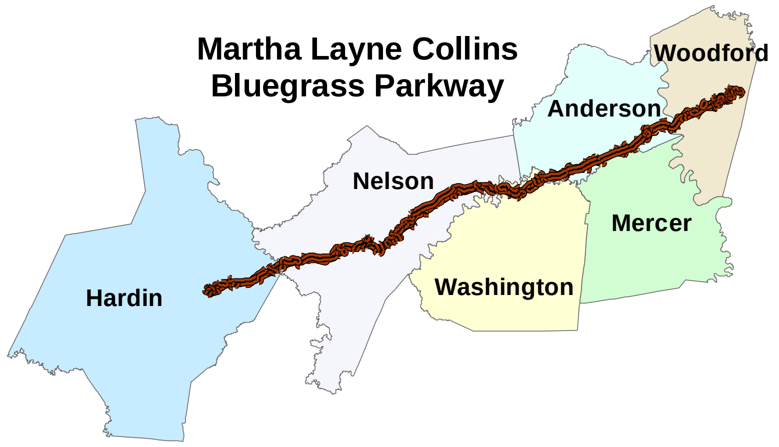
The oldest rocks exposed at the surface in Kentucky, the 450-million-year-old Camp Nelson Limestone formed in the Ordovician Period, can be seen at the Kentucky River Palisades.



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Kentucky Geological Survey

SPECIAL PUBLICATION 11
Series XII, 2011

Terrain Along the Bluegrass Parkway

While travelling the Bluegrass Parkway, you will see a variety of terrain. Where natural landforms (lay of the land) differ significantly from one area to another, this generally indicates that each landform is underlain by a different type of rock. These different areas are known as physiographic regions. The major physiographic regions crossed by the Bluegrass Parkway are the Pennyroyal, Muldraugh's Hill, Knobs, Outer Bluegrass, Bluegrass Hills, and Inner Bluegrass. Figure 1 shows all physiographic regions in Kentucky, as well as the location of the Bluegrass Parkway.

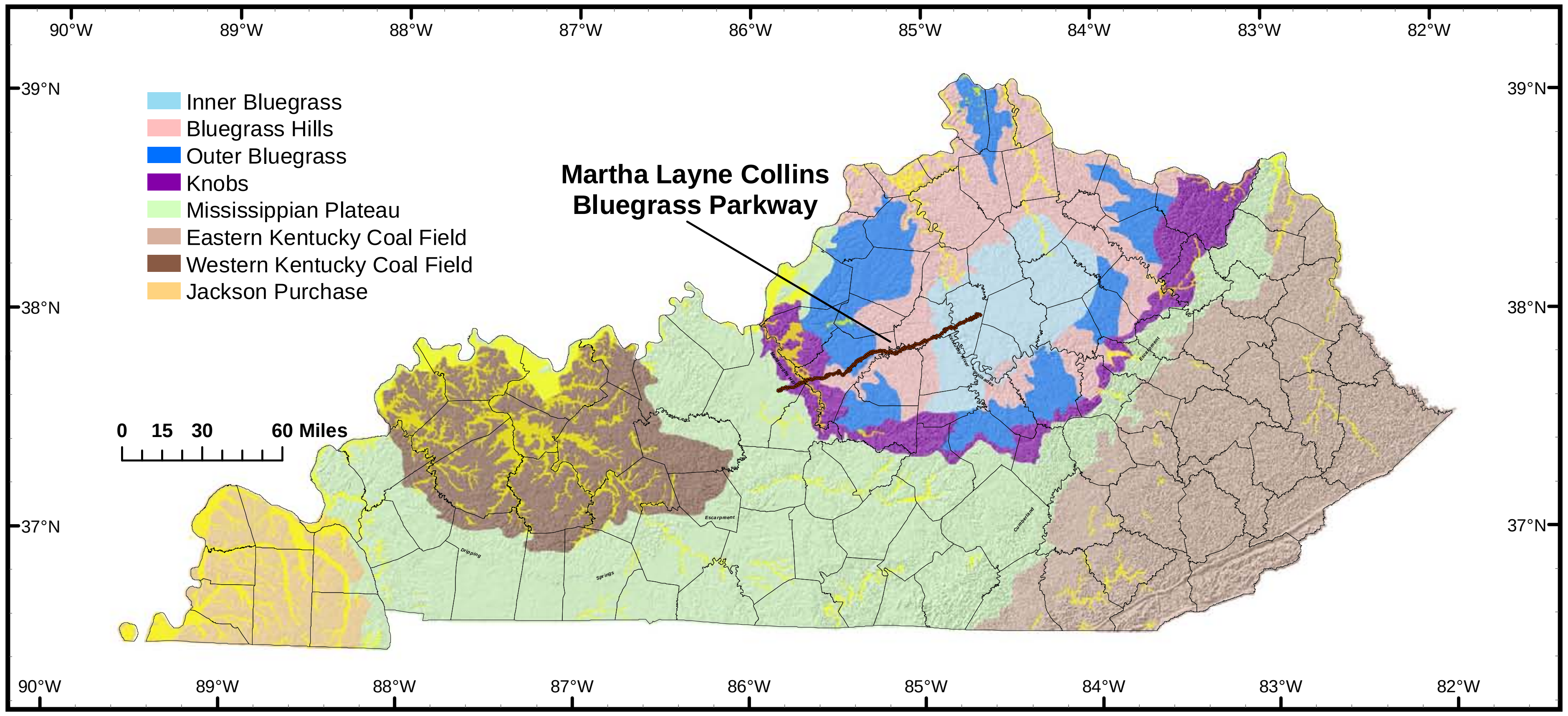


Figure 1. Physiographic regions in Kentucky and location of the Bluegrass Parkway.

As you drive east along the parkway to mile 3.5, you are in the Pennyroyal Region. The Pennyroyal is an upland underlain by limestone and characterized by complex underground drainage systems marked by sinkholes and caves; the limestone weathers to form thick, reddish residual soils. Most of the limestones in this area were deposited in an ancient sea that was similar to Florida Bay.

The Knobs are from mile 3.5 to 13.0. The area is a narrow belt of ridges and conical hills, many of which are capped by resistant siltstone and limestone. These hills are generally separated by broad, shale-floored valleys that are underlain by siltstone and silty shale.

The Outer Bluegrass is from mile 13.0 to 42.0, and is characterized by rolling uplands underlain by interbedded limestone, shaly limestone, and shale.

The Bluegrass Hills, underlain by impervious and easily eroded shales, is defined by steep-sided hills and narrow valleys that extend from mile 42.0 to 54.0.

The rich soils and gently rolling terrain of the Inner Bluegrass are underlain by interbedded limestone, dolomite, and shale stretching from mile 54.0 to the end of the parkway. All the rocks underlying the parkway formed while Kentucky was beneath ancient shallow seas near the equator.

Roadlog and Strip Maps

Geologic units are shown approximately 0.5 mile on either side of the highway. Figure 2 shows the symbols used on all the strip maps. The construction of these continuous strip maps was facilitated by the availability of detailed 1:24,000-scale (1 inch on the map equals 24,000 inches or 2,000 feet on the ground) geologic data in digital form for the entire state; the digital data were converted from geologic quadrangle maps published by the U.S. Geological Survey in a joint project with the Kentucky Geological Survey from 1960 to 1978. The parkway's area is covered by 14 of these maps. Figure 3 shows the 7.5-minute quadrangles the parkway passes through.

The roadlog covers the entire extent of the Bluegrass Parkway. All descriptions of rock strata and geologic features are referenced to the highway mile markers that are located at 1-mile intervals along the shoulder of the highway. Mile-marker numbers are the same on both sides of the highway. Some of the roadcuts identified during a survey in the 1990's, particularly into shale, may now be revegetated. The descriptions are nonetheless retained in order to identify what now lies beneath the overgrowth.

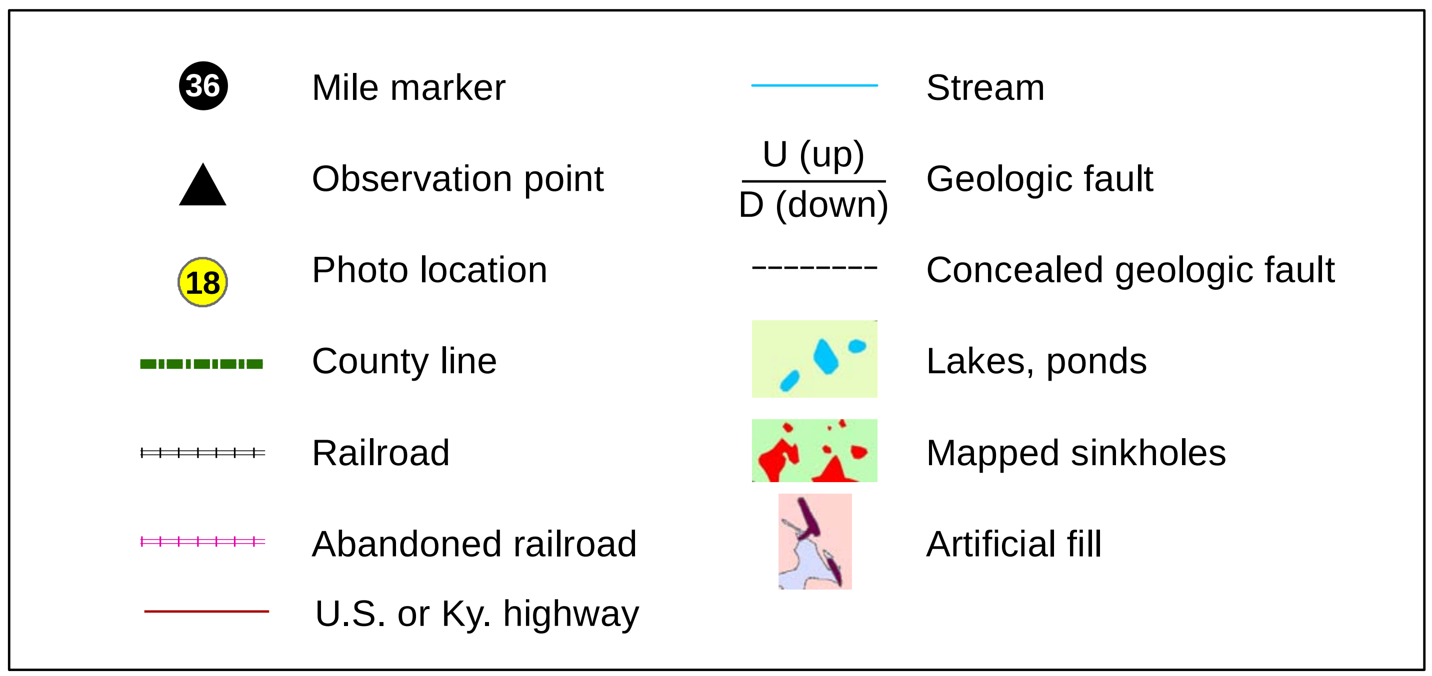


Figure 2. Symbols used on the strip maps.

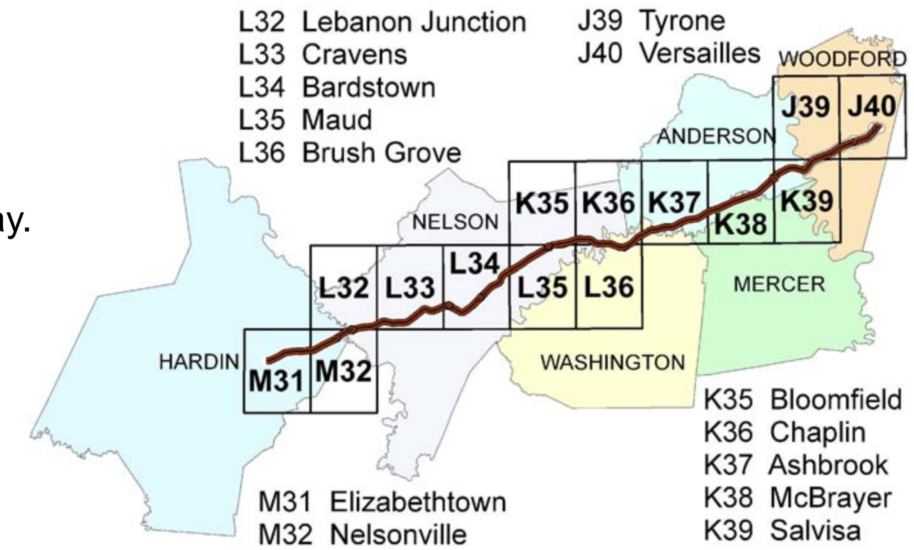


Figure 3. Index of 7.5-minute geologic quadrangles maps covering the Bluegrass Parkway.

Stratigraphy

A stratigraphic column (Fig. 4) is a generalized graphic representation of the rock layers present at the earth's surface. Figure 4 shows the rock units exposed along the Bluegrass Parkway, and indicates the units' geologic ages. To make it easier to study and describe these stratigraphic units, geologists have subdivided them into groups, formations, members, and beds. A group is a major stratigraphic unit containing two or more formations. A formation is a unit of rock that has characteristic and distinctive rock types and layering that are mappable. A member is a subdivision of a formation that is distinguishable from adjacent parts of the formation. A bed is a rock unit lower in rank than a member, which has a distinctive lithology (for example, a coal bed). The abbreviations used on geologic maps to designate specific rock units are indicated in parentheses after the unit name in Figure 4.

Geologic Time Scale		Unit	Description
Present		Alluvium (Qal)	silt, clay, sand, and gravel
2 million years ago		Terrace deposits (Qtf)	sand
		Nearly 300 million years of the geologic record are absent in Kentucky, either from nondeposition or erosion, including the Jurassic, Triassic, Permian, and part of the Pennsylvanian Periods	
325 million years ago	Mississippian	St. Louis Limestone (Msl)	cherty limestone
	Mississippian	Salem Limestone (Ms)	shaly limestone
	Mississippian	Harrodsburg Limestone (Mhb)	crossbedded limestone
	Mississippian	Borden Formation (Mb)	shale and siltstone
	Mississippian	Muldraugh Member (Mbm), Borden Formation	dolomitic siltstone dolomitic limestone
	Mississippian	Nancy Member (Mbn), Borden Formation	greenish-gray shale
	Mississippian	New Providence Member (Mbnp), Borden Formation	greenish-gray shale
		New Albany Shale (Dna)	carbonaceous shale
355 million years ago	Devonian	Sellersburg Limestone (Dsb)	limestone
	Devonian	New Albany Shale and Beechwood Limestone (Dnsb)	carbonaceous shale limestone
415 million years ago		Louisville Limestone (Slv)	dolomitic limestone
	Silurian	Louisville Limestone, Waldron Shale, and Laurel Dolomite (Slwl)	limestone, shale, dolomite
	Silurian	Waldron Shale (Sw)	clay shale
	Silurian	Laurel Dolomite (Sl)	dolomite
440 million years ago		Osgood Formation (So)	interbedded shale and dolomite
		Brassfield Dolomite (Sb)	dolomite

Geologic Time Scale		Unit	Description
440 million years ago	Ordovician	Drakes Formation (Od)	limestone, dolomite, and shale
	Ordovician	Saluda Dolomite (Ods)	shaly dolomite
	Ordovician	Bardstown Member (Odb), Drakes Formation	nodular-bedded limestone and shale
	Ordovician	Rowland Member (Odr), Drakes Formation	greenish-gray, dolomitic limestone and shale
	Ordovician	Ashlock Formation (Oa)	limestone and shale
	Ordovician	Grant Lake Limestone (Ogl)	nodular-bedded limestone and shale
	Ordovician	Gilbert Member (Oag), Ashlock Formation	micrograined limestone
	Ordovician	Calloway Creek Limestone (Occ)	interbedded limestone and shale, limestone dominant
	Ordovician	Clays Ferry Formation (Ocf)	interbedded limestone and shale
	Ordovician	Upper part of the Lexington Limestone (Olu)	crossbedded limestone nodular-bedded limestone
	Ordovician	Millersburg Member (Olm) , Lexington Limestone	nodular-bedded lime-stone and shale
	Ordovician	Tanglewood Member No. 3 (Olt3), Lexington Limestone	clastic limestone cross-bedded limestone
	Ordovician	Sulphur Well Member (Ols), Lexington Limestone	nodular-bedded limestone
	Ordovician	Tanglewood Member No. 2 (Olt2), Lexington Limestone	nodular-bedded lime-stone and shale
	Ordovician	Brannon Member (Olb), Lexington Limestone	interbedded limestone and shale
	Ordovician	Tanglewood Member No. 1 (Olt1), Lexington Limestone	crossbedded limestone
	Ordovician	Grier Limestone Member (Olg), Lexington Limestone	nodular-bedded limestone
	Ordovician	Lower part of the Lexington Limestone (Ollr)	crossbedded limestone nodular-bedded limestone
480 million years ago	Ordovician	Tyrone Limestone and Oregon Formation (Oto)	limestone, limestone and shale, cherty shale dolomite

Figure 4. Generalized stratigraphic column.

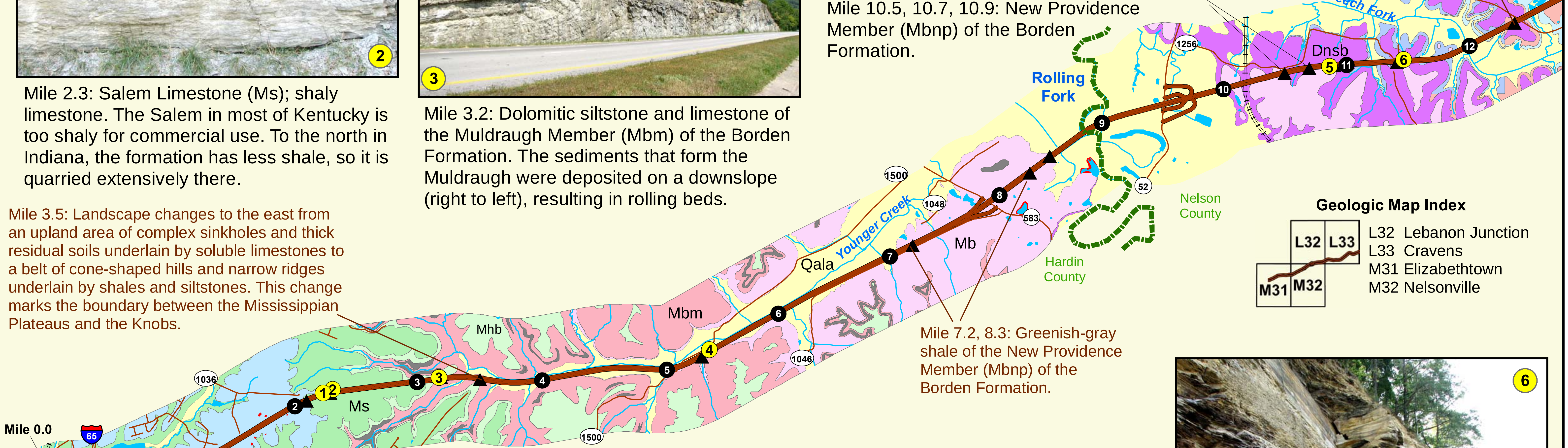
Geology Along the Martha Layne Collins Bluegrass Parkway: Miles 0.0–12.9

Mile 2.3: Salem Limestone (Ms); shaly limestone. The Salem in most of Kentucky is too shaly for commercial use. To the north in Indiana, the formation has less shale, so it is quarried extensively there.

Mile 3.2: Dolomitic siltstone and limestone of the Muldraugh Member (Mbm) of the Borden Formation. The sediments that form the Muldraugh were deposited on a downslope (right to left), resulting in rolling beds.

Mile 10.5, 10.7, 10.9: Thin, laminar layers of greenish-gray New Providence shale.

Mile 10.5, 10.7, 10.9: New Providence Member (Mbnp) of the Borden Formation.



Mile 12.4: Louisville Limestone (Slv), Waldron Shale (Sw), Laurel Dolomite (Sl)

Mile 3.5: Landscape changes to the east from an upland area of complex sinkholes and thick residual soils underlain by soluble limestones to a belt of cone-shaped hills and narrow ridges underlain by shales and siltstones. This change marks the boundary between the Mississippian Plateaus and the Knobs.

Mile 7.2, 8.3: Greenish-gray shale of the New Providence Member (Mbnp) of the Borden Formation.

Mile 11.4: The New Albany Shale (Dna) was formed in low-oxygen (anaerobic) seas that preserved the organic matter in the sediments. In some areas, the black shales contain enough organic matter to burn, and are a potential source of oil. The shale provides rolling land for agriculture, but is unstable on slopes and requires drainage management.

Mile 11.4: Closeup of the New Albany Shale (Dna) reveals the fissile (almost paper-thin layers) weathering and pyrite (yellow) formation. Photo by Brandon Nuttall, Kentucky Geological Survey.

Mile 5.3: Silty shale containing glauconite (greenish iron silicate crystals) of the Nancy Member (Mbn) of the Borden Formation. The shale breaks down quickly when exposed to air and water, and is unstable on slopes. In this case, stone barricades are used to provide support.

Mile 2.1: St. Louis Limestone (Msl); cherty limestone.

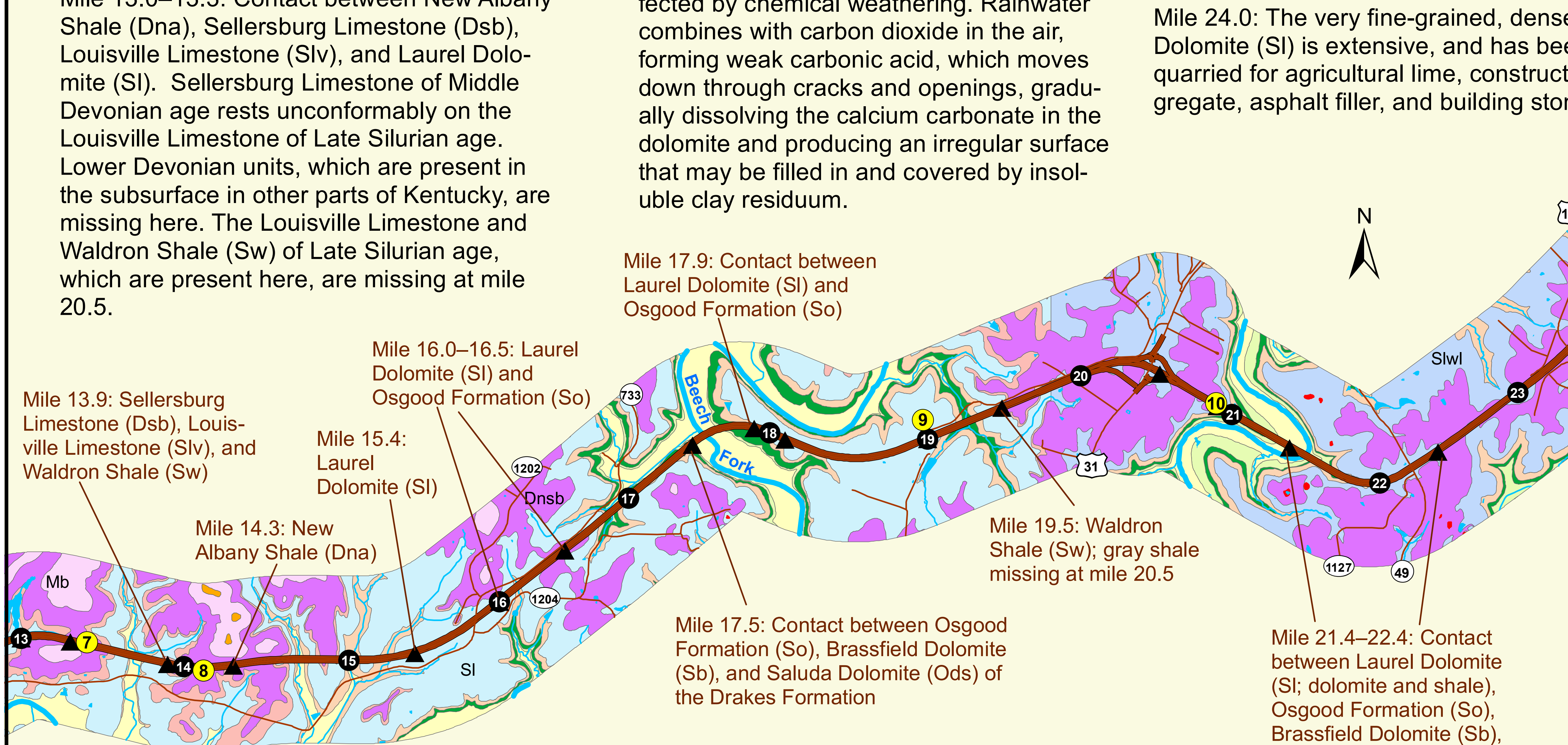
Mile 2.1: Closeup of chert nodules in the St. Louis Limestone.

Geology Along the Martha Layne Collins Bluegrass Parkway: 12.9–27.0

Mile 13.0–13.3: Contact between New Albany Shale (Dna), Sellersburg Limestone (Dsb), Louisville Limestone (Slv), and Laurel Dolomite (Sl). Sellersburg Limestone of Middle Devonian age rests unconformably on the Louisville Limestone of Late Silurian age. Lower Devonian units, which are present in the subsurface in other parts of Kentucky, are missing here. The Louisville Limestone and Waldron Shale (Sw) of Late Silurian age, which are present here, are missing at mile 20.5.

Mile 18.1–19.0: Laurel Dolomite (Sl) affected by chemical weathering. Rainwater combines with carbon dioxide in the air, forming weak carbonic acid, which moves down through cracks and openings, gradually dissolving the calcium carbonate in the dolomite and producing an irregular surface that may be filled in and covered by insoluble clay residuum.

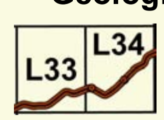
Mile 24.0: The very fine-grained, dense Laurel Dolomite (Sl) is extensive, and has been widely quarried for agricultural lime, construction aggregate, asphalt filler, and building stone.



Mile 20.5–20.9: Middle Devonian Sellersburg Limestone (Dsb) rests unconformably on Middle Silurian Laurel Dolomite (Sl). The missing Lower Devonian units, present in the subsurface in other parts of Kentucky, and Upper Silurian units, exposed at mile 12.4, 13.0, and 14.0, represent an interval of 30 million years. The fine-grained dolomite is quarried for building stone. Other units are quarried for construction aggregate and agricultural lime.

Mile 13.0: Landscape changes to the east, marking the boundary of the Knobs and Outer Bluegrass Regions. The Knobs are hundreds of isolated, steep-sloping, often cone-shaped hills at the outer edge of the Bluegrass Region. The hills are monadnocks (erosional remnants) that were originally part of the Mississippian Plateaus (Pennyroyal Region), but were separated from the plateau by stream erosion. Many of the knobs are still capped by erosion-resistant limestones or sandstones. The sloping sides are mostly shales of the 350-million-year-old Mississippian Borden Formation (Mb), which are more easily eroded than the overlying limestones and sandstones. The Knobs are associated with the outcrop belt of Silurian and Devonian black and clay shales. Streams such as the Rolling Fork River carve wide valleys with fertile alluvium.

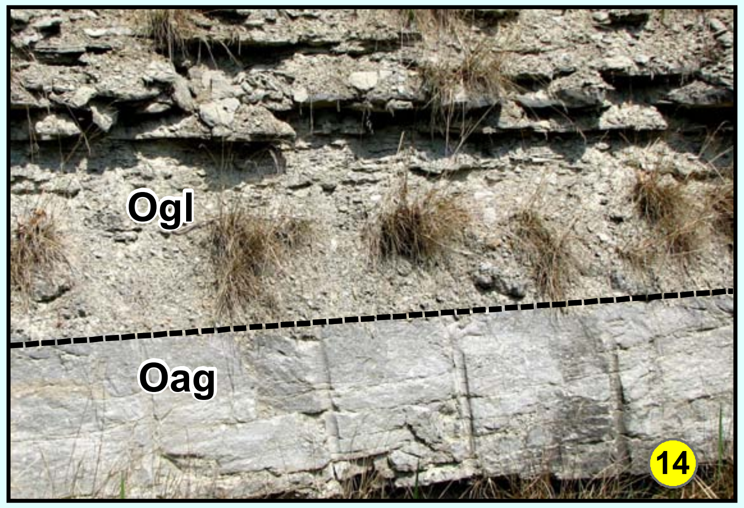
Geologic Map Index



L33 Cravens
L34 Bardstown

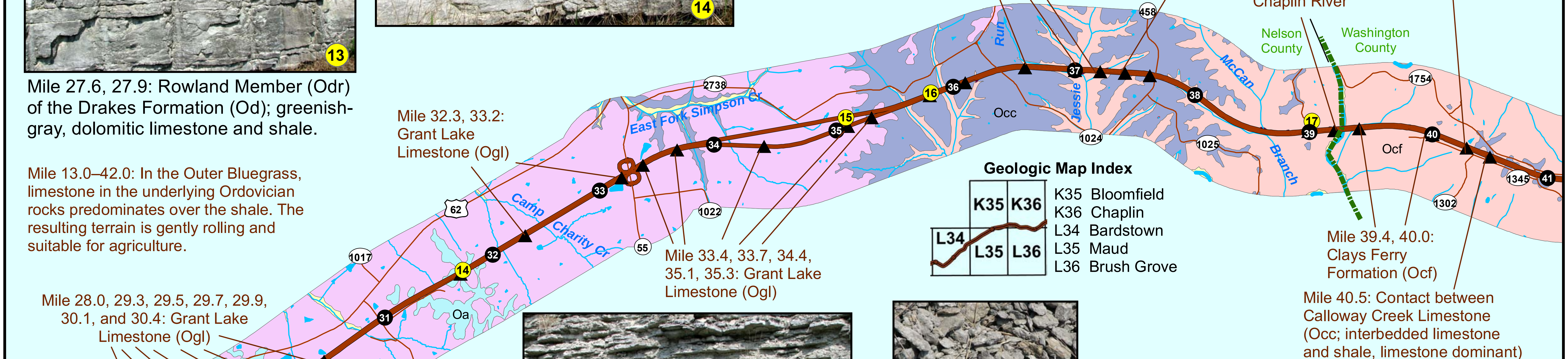
Geology Along the Martha Layne Collins Bluegrass Parkway: Mile 27.0–41.2

Mile 27.6, 27.9: Rowland Member (Odr) of the Drakes Formation (Od); greenish-gray, dolomitic limestone and shale.



Mile 31.7: Contact between Grant Lake Limestone (Ogl; nodular-bedded limestone and shale, limestone dominant) and Gilbert Member (Oag; micro-grained limestone) of the Ashlock Formation (Oa).

Mile 13.0–42.0: In the Outer Bluegrass, limestone in the underlying Ordovician rocks predominates over the shale. The resulting terrain is gently rolling and suitable for agriculture.

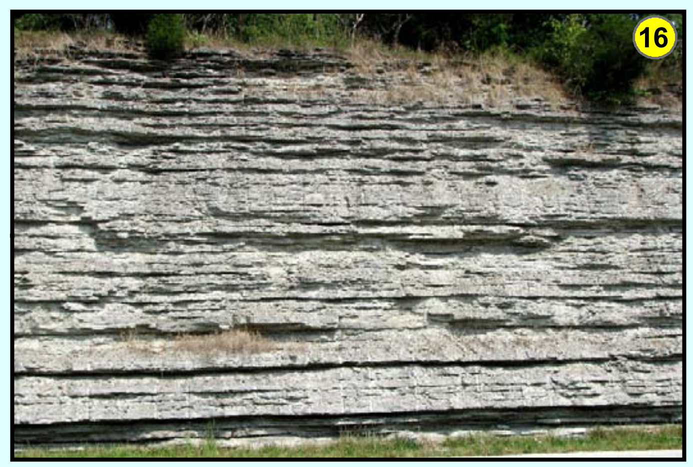


Geologic Map Index

K35 Bloomfield
K36 Chaplin
L34 Bardstown
L35 Maud
L36 Brush Grove

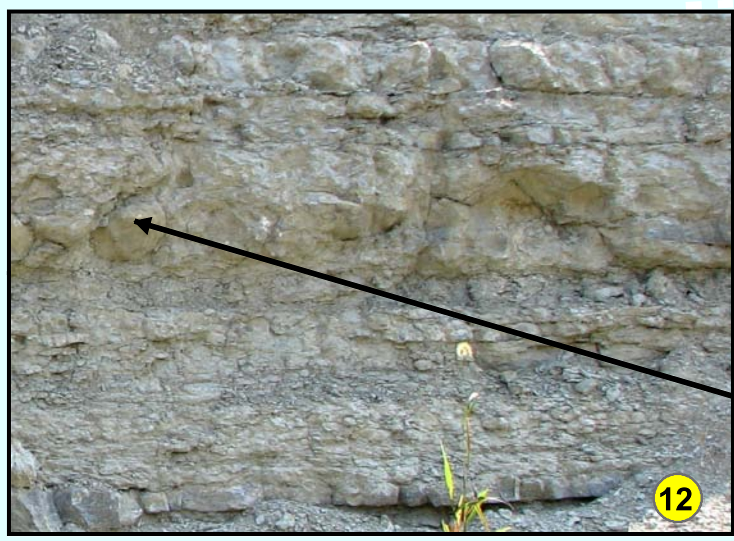
Mile 35.1: Grant Lake Limestone (Ogl; nodular-bedded limestone and shale). The Grant Lake provides rolling terrain and fertile soils for the Outer Bluegrass.

Mile 35.1: Rubble at the base of the Grant Lake clearly shows the nodularity of the limestone.



Mile 35.8, 36.1, 37.6: Calloway Creek Limestone (Occ), interbedded limestone and shale, limestone dominant. Contrasted with the rubbly appearance of the Grant Lake Limestone (Ogl), the evenly bedded Calloway Creek appears neat and orderly.

Mile 39.0: Clays Ferry Formation (Ocf); interbedded limestone and shale. Shale beds between the limestone are thicker in the Clays Ferry. When exposed to air and water, the shale breaks down quickly, which leaves overlying limestone layers with no support, and they collapse. This process creates a more rugged terrain, and the rolling Outer Bluegrass is transformed into the Bluegrass Hills (Eden Shale Belt).



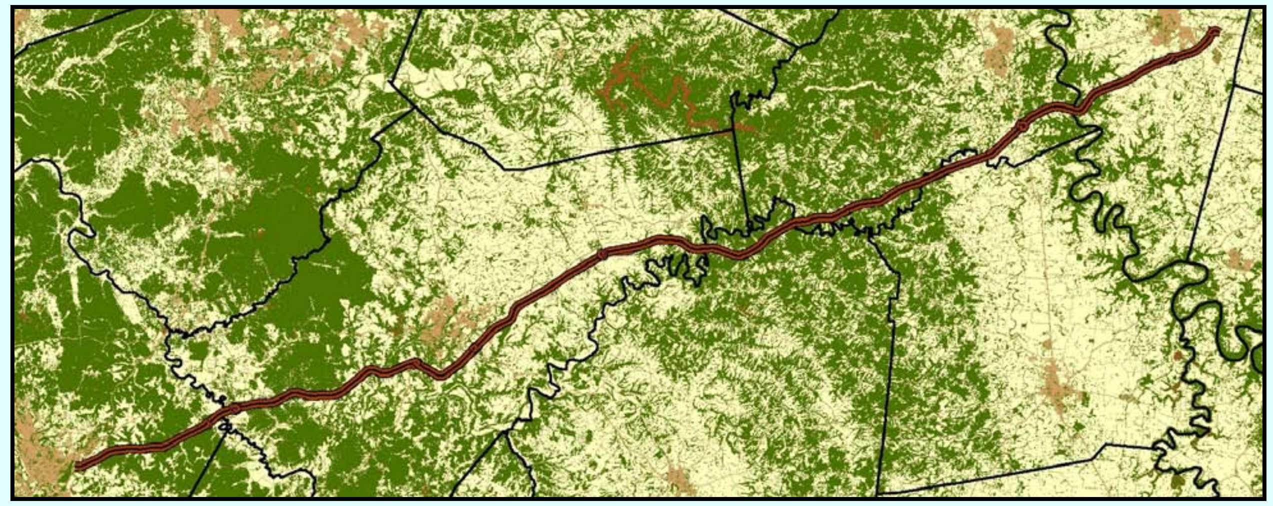
Mile 27.5: Bardstown Member (Odb) of the Drakes Formation (Od); nodular-bedded limestone and shale.

Mile 27.5: Coral that grew on the seabed that was Kentucky over 425 million years ago is preserved in the rock along the parkway.

Geology Along the Martha Layne Collins Bluegrass Parkway: Miles 41.2–57.0

Mile 44.6: The Clays Ferry Formation (Ocf); weathered interbedded limestone and shale. The Clays Ferry bedrock creates the rugged topography of the Bluegrass Hills along the parkway between the Chaplin River and the Salt River.

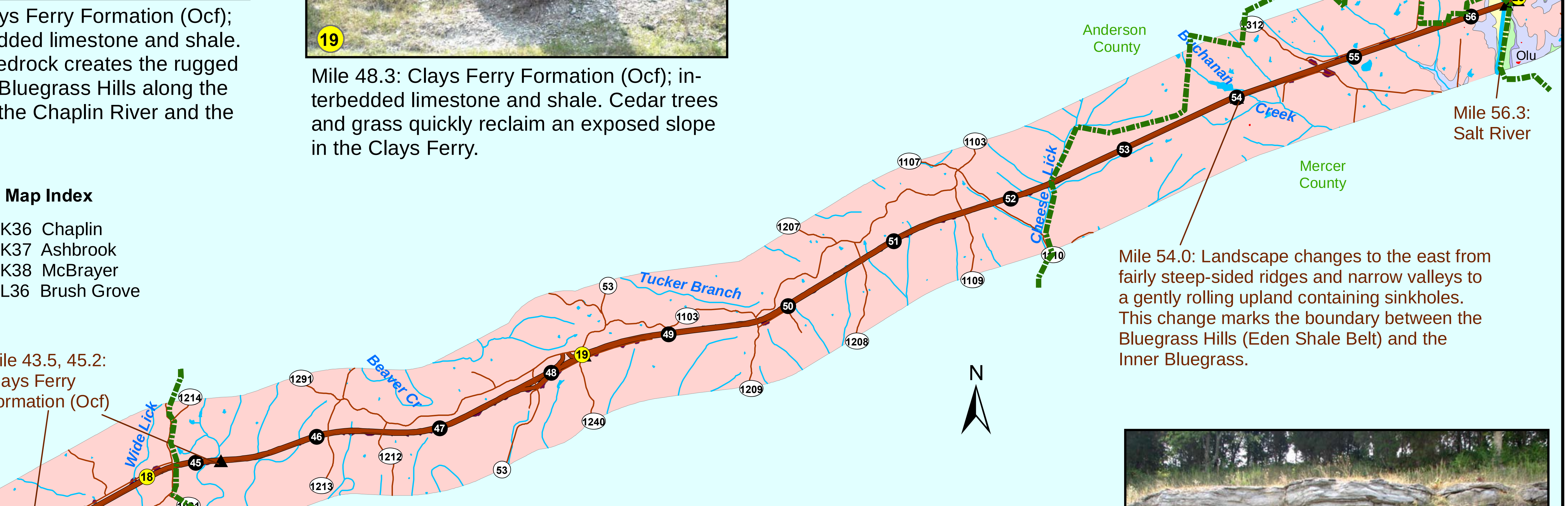
Mile 48.3: Clays Ferry Formation (Ocf); interbedded limestone and shale. Cedar trees and grass quickly reclaim an exposed slope in the Clays Ferry.



The landscape of the Bluegrass Parkway is revealed in satellite imagery. The dark green areas are the Knobs, Bluegrass Hills, and Kentucky River Palisades. The light yellow areas are the Outer and Inner Bluegrass. Tan areas are urban. Source: Kentucky 2001 Anderson Level III Land Cover, Kentucky Division of Geographic Information.

Geologic Map Index

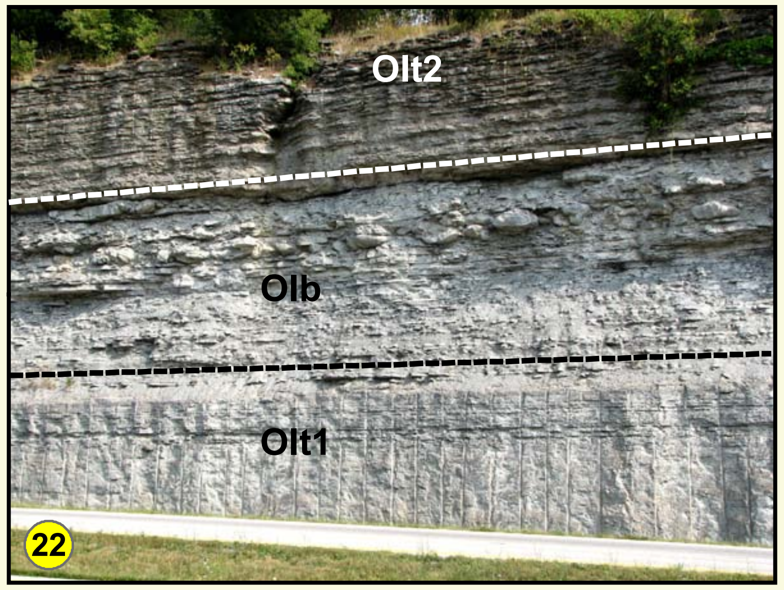
K36 Chaplin
K37 Ashbrook
K38 McBrayer
L36 Brush Grove



The Clays Ferry Formation (Ocf) underlying the Bluegrass Hills has a higher shale content than the limestones of the Inner and Outer Bluegrass. The resulting terrain is more rugged. It can serve as pasture land, but has limited row crop potential. Small ponds on the impermeable shale are common.

Mile 56.4: Sulphur Well Member (Ols) of the Lexington Limestone; nodular-bedded, fossil-rich (bryozoan) limestone.

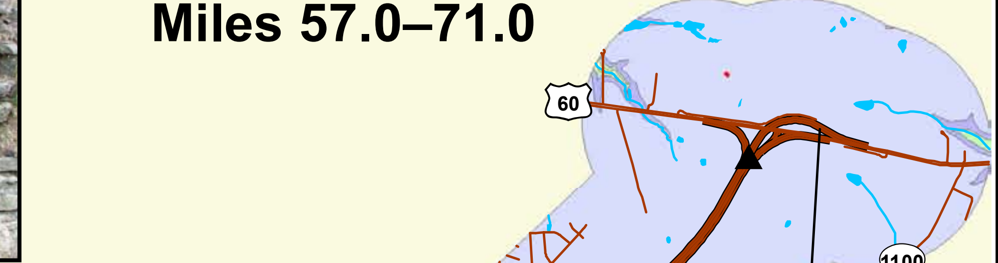
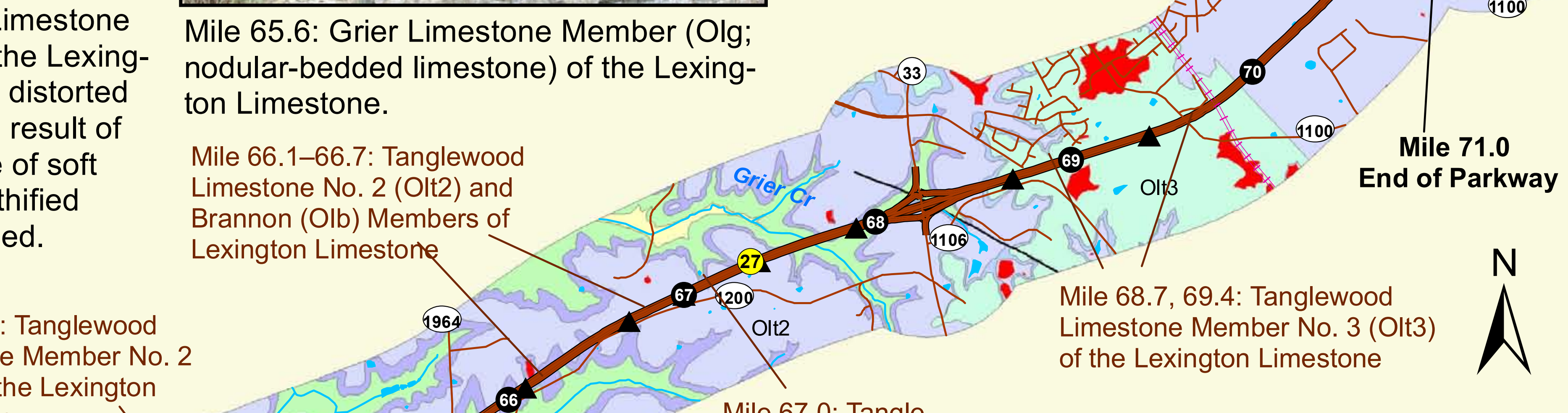
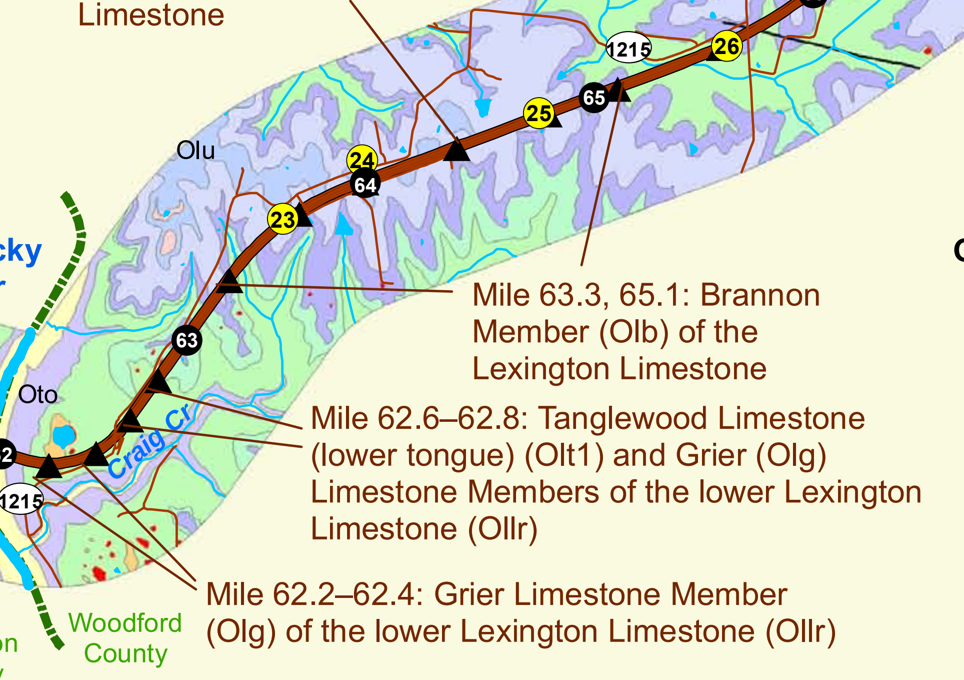
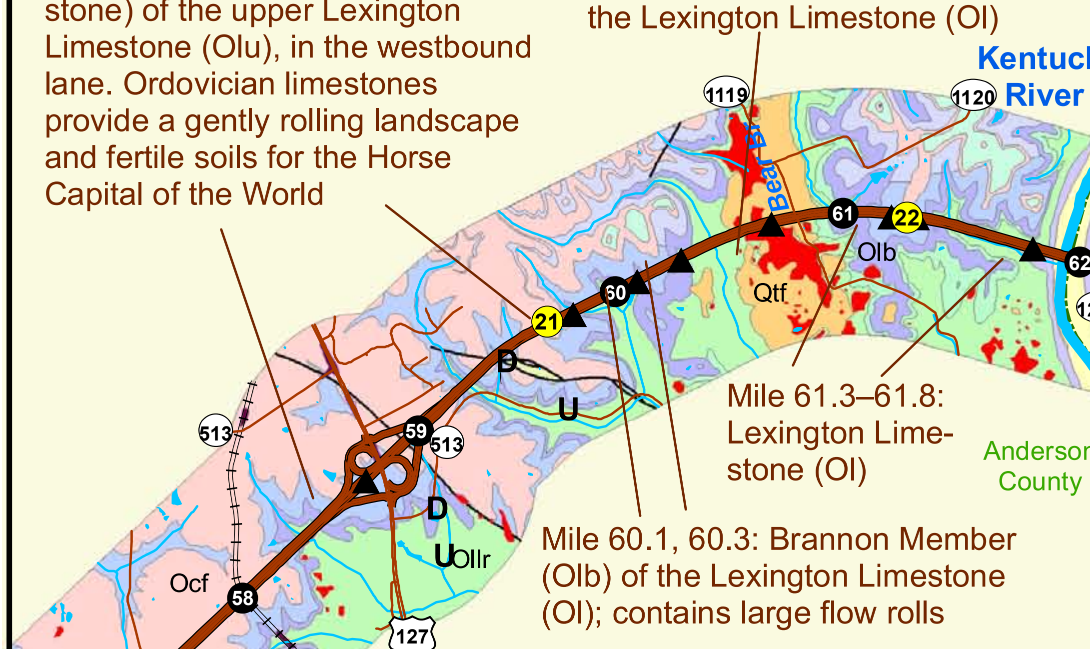
Geology Along the Martha Layne Collins Bluegrass Parkway: Miles 57.0–71.0



Mile 61.2: Tanglewood Limestone No. 2 (Olt2; nodular-bedded limestone and shale), Brannon (Olb; thin-bedded limestone and shale), and Tanglewood Limestone No. 1 (lower tongue) (Olt1; crossbedded limestone) Members of the Lexington Limestone, in the westbound lane.

Mile 63.7: Tanglewood Limestone Member No. 2 (Olt2) of the Lexington Limestone. A unique distorted bedding that may be the result of dewatering and collapse of soft sediments before they lithified (turned to rock) is exposed.

Mile 65.6: Grier Limestone Member (Olg; nodular-bedded limestone) of the Lexington Limestone.


Mile 66.1–66.7: Tanglewood Limestone No. 2 (Olt2) and Brannon (Olb) Members of Lexington Limestone

Mile 68.7, 69.4: Tanglewood Limestone Member No. 3 (Olt3) of the Lexington Limestone

Mile 64.4: Tanglewood Limestone Member No. 2 (Olt2) of the Lexington Limestone

Mile 67.0: Tanglewood Limestone Member No. 2 (Olt2) of the Lexington Limestone

Mile 60.7: High-level grass-covered sand deposits (Qtf) of the ancient Kentucky River, which was part of the preglacial Teays River system, overlie the Grier Limestone Member (Olg) of the Lexington Limestone (Ol)

Mile 58.7, 59.8: Contact between Clays Ferry Formation (Ocf; interbedded limestone and shale) and Sulphur Well Member (Ols; nodular-bedded, bryozoan-rich limestone) of the upper Lexington Limestone (Olu), in the westbound lane. Ordovician limestones provide a gently rolling landscape and fertile soils for the Horse Capital of the World

Mile 63.3, 65.1: Brannon Member (Olb) of the Lexington Limestone

Mile 62.6–62.8: Tanglewood Limestone (lower tongue) (Olt1) and Grier (Olg) Limestone Members of the lower Lexington Limestone (Ollr)

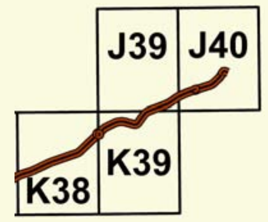
Mile 61.3–61.8: Lexington Limestone (Ol)

Mile 62.2–62.4: Grier Limestone Member (Olg) of the lower Lexington Limestone (Ollr)

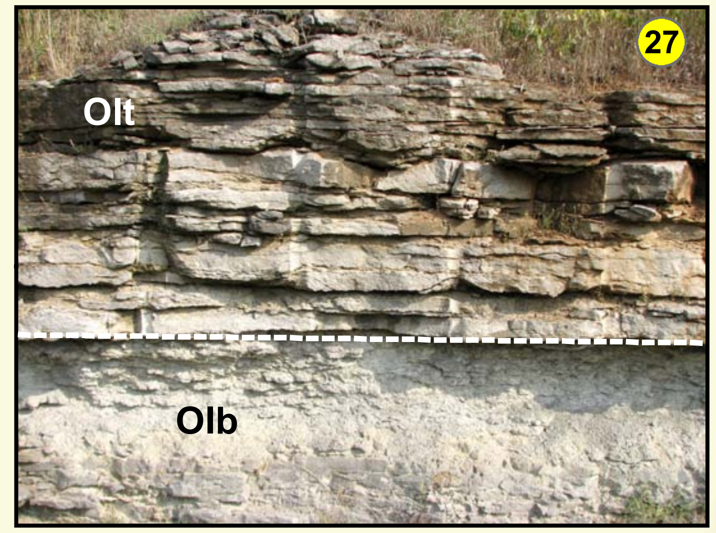
Mile 60.1, 60.3: Brannon Member (Olb) of the Lexington Limestone (Ol); contains large flow rolls

Mile 57.2: Contact between Clays Ferry Formation (Ocf) and the upper Lexington Limestone (Olu)

Geologic Map Index

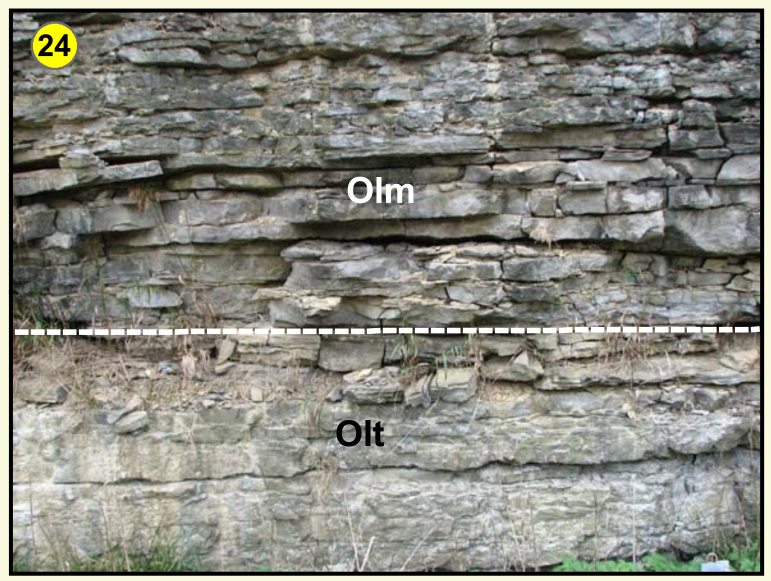


J39 Tyrone
J40 Versailles
K38 McBrayer
K39 Salvisa



Mile 67.4, 67.9: Tanglewood Limestone No. 2 (Olt2; clastic limestone) and Brannon (Olb; interbedded thin limestone and shale) Members of the Lexington Limestone (Ol).

Mile 59.7: Clays Ferry Formation (Ocf); interbedded limestone and shale.



Mile 64.0: Millersburg (Olm; nodular-bedded limestone and shale) and Tanglewood Limestone No. 3 (Olt3; granular limestone) Members of the Lexington Limestone (Ol).

Mile 64.8: Tanglewood Limestone Member No. 2 (Olt2) of the Lexington Limestone contains phosphate, which has been mined on a small scale nearby.

References

Carey, D.I., 2007, Generalized geologic map for land-use planning, Washington County, Kentucky: Kentucky Geological Survey, ser. 12, Map and Chart 158, scale 1:48,000.

Carey, D.I., 2011, Kentucky Landscapes Through Geologic Time: Kentucky Geological Survey, ser. 12, Map and Chart 200, 1sheet.

Carey, D.I., and Eclov, P., 2007, Generalized geologic map for land-use planning, Mercer County, Kentucky: Kentucky Geological Survey, ser. 12, Map and Chart 135, scale 1:48,000.

Carey, D.I., and Hounshell, T.D., 2008, Kentucky terrain: Kentucky Geological Survey, ser. 12, Map and Chart 187, scale 1:750,000.

Carey, D.I., Hounshell, T.D., and Kiefer, J.D., 2008, Geologic hazards in Kentucky: Kentucky Geological Survey, ser. 12, Map and Chart 185, scale 1:750,000.

Carey, D.I., and Noger, M.C., 2004, Generalized geologic map for land-use planning, Anderson County, Kentucky: Kentucky Geological Survey, ser. 12, Map and Chart 74, scale 1:48,000.

Carey, D. I., Noger, M.C., Haney, D.C., and Dever, G.R., Jr., 2011, Geology Along Interstate 64: Winchester to Ashland: Kentucky Geological Survey, ser. 12, Special Publication 12, 13 p.

Carey, D. I., Noger, M.C., Haney, D.C., and Greb, S.F., 2012, Geology Along the Wendell H. Ford Western Kentucky Parkway: Kentucky Geological Survey, ser. 12, Special Publication 13, 16 p.

Carey, D.I., Noger, M.C., and Howell, P., 2003, Generalized geologic map for land-use planning, Woodford County, Kentucky: Kentucky Geological Survey, ser. 12, Map and Chart 49, scale 1:48,000.

Ciszak, E.A., 2000, Spatial database of the McBrayer quadrangle, Anderson and Mercer Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1079. Adapted from Cressman, E.R., 1973, Geologic map of the McBrayer quadrangle, Anderson and Mercer Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1079, scale 1:24,000.

Crawford, M.M., 2001, Spatial database of the Elizabethtown quadrangle, Hardin and Larue Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-559. Adapted from Kepferle, R.C., 1966, Geologic map of the Elizabethtown quadrangle, Hardin and Larue Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-559, scale 1:24,000.

Crawford, M.M., 2003, Spatial database of the Brush Grove quadrangle, Nelson and Washington Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1076. Adapted from Peterson, W.L., 1973, Geologic map of the Brush Grove quadrangle, Nelson and Washington Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1076, scale 1:24,000.

Greb, S.F., Davidson, B., and Carey, D.I., 2005, Generalized geologic map for land-use planning, Nelson County, Kentucky: Kentucky Geological Survey, ser. 12, Map and Chart 97, scale 1:63,360.

Johnson, T.L., 2002, Spatial database of the Nelsonville quadrangle, central Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-564. Adapted from Peterson, W.L., 1966, Geologic map of the Nelsonville quadrangle, central Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-564, scale 1:24,000.

McDowell, R.C., 1983, Stratigraphy of the Silurian outcrop belt on the east side of the Cincinnati Arch in Kentucky, with revisions in the nomenclature: U.S. Geological Survey Professional Paper 1151-F, 27 p.

McGrain, P., 1983, The geologic story of Kentucky: Kentucky Geological Survey, ser. 11, Special Publication 8, 21 p.

Nelson, H.L., Jr., 2000, Spatial database of the Salvisa quadrangle, central Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-760. Adapted from Cressman, E.R., 1968, Geologic map of the Salvisa quadrangle, central Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-760, scale 1:24,000.

Nelson, H.L., Jr., 2001a, Spatial database of the Cravens quadrangle, Bullitt and Nelson Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-737. Adapted from Peterson, W.L., 1968, Geologic map of the Cravens quadrangle, Bullitt and Nelson Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-737, scale 1:24,000.

Nelson, H.L., Jr., 2001b, Spatial database of the Lebanon Junction quadrangle, central Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-603. Adapted from Peterson, W.L., 1967, Geologic map of the Lebanon Junction quadrangle, central Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-603, scale 1:24,000.

Nelson, H.L., Jr., 2001c, Spatial database of the Tyrone quadrangle, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-303. Adapted from Cressman, E.R., 1964, Geology of the Tyrone quadrangle, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-303, scale 1:24,000.

Nelson, H.L., Jr., 2001d, Spatial database of the Versailles quadrangle, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-325. Adapted from Black, D.F.B., 1964, Geologic map of the Versailles quadrangle, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-325, scale 1:24,000.

Nelson, H.L., Jr., 2002, Spatial database of the Bardstown quadrangle, Nelson County, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-825. Adapted from Peterson, W.L., 1969, Geologic map of the Bardstown quadrangle, Nelson County, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-825, scale 1:24,000.

Nelson, H.L., Jr., 2003a, Spatial database of the Maud quadrangle, Nelson and Washington Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1043. Adapted from Peterson, W.L., 1972, Geologic map of the Maud quadrangle, Nelson and Washington Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1043, scale 1:24,000.

Noger, M.C., and Kepferle, R.C., 1985, Stratigraphy along and adjacent to the Bluegrass Parkway (guidebook and roadlog for Geological Society of Kentucky 1985 field conference): Kentucky Geological Survey, ser. 11, 24 p.

Peterson, W.L., 1981, Lithostratigraphy of the Silurian rock on the west side of the Cincinnati Arch: U.S. Geologica Survey Professional Paper 1151-C, 29 p.

Sable, E.G., and Dever, G.R., Jr., 1990, Mississippian rocks in Kentucky: U.S. Geological Survey Professional Paper 1503, 125 p.

Stickney, J.F., Carey, D.I., and Davidson, B., 2004, Generalized geologic map for land-use planning, Hardin County, Kentucky: Kentucky Geological Survey, ser. 12, Map and Chart 82, scale 1:63,360.

Zhang, Q., 2002a, Spatial database of the Bloomfield quadrangle, Nelson and Spencer Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1101. Adapted from Peterson, W.L., 1973, Geologic map of the Bloomfield quadrangle, Nelson and Spencer Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1101, scale 1:24,000.

Zhang, Q., 2002b, Spatial database of the Chaplin quadrangle, central Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1279. Adapted from Peterson, W.L., 1975, Geologic map of the Chaplin quadrangle, central Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1279, scale 1:24,000.

Zhang, Q., 2004, Spatial database of the Ashbrook quadrangle, central Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1289. Adapted from Peterson, W.L., 1976, Geologic map of the Ashbrook quadrangle, central Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1289, scale 1:24,000.