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Fossils and Stratigraphy of the Upper Ordovician Standard in South Eastern Indiana

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2013 Joint PGI all Universities Roaming Field Trip

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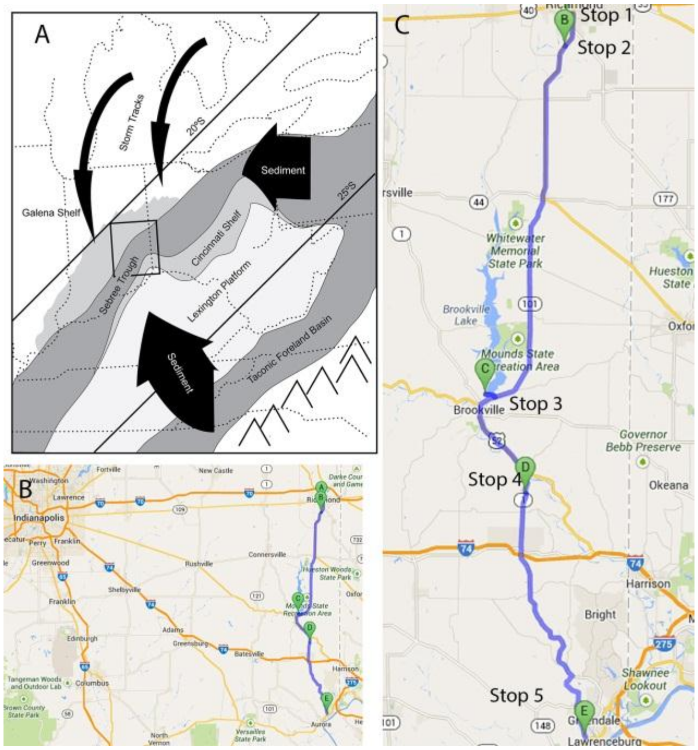
Field Trip Location and Itinerary



Maps showing the field trip route. A. Index map showing the Ordovician paleogeography of the region including reconstructed storm tracks and possible routes for sediment transport from the Taconic Orogen. B. Route map. C. Detailed route map.

Stop 1 (Start) Whitewater Gorge at Richmond High School (39.820943,-84.899555).
1. Head south on Hub Etchinson Pkwy toward SW G St 223 ft
2. Take the 1st left onto SW G St 0.4 mi
3. Turn right onto US-27 S/S 8th St Continue to follow US-27 S 2.4 mi

2.9 mi – about 5 mins

Stop 2 Richmond 27: Roadcut on US 27 3.0 miles south of US 40 in Richmond (39.787537, -84.901698)
4. Head southwest on US-27 S toward Liberty Ave 11.1 mi
5. Continue onto IN-101 S/State Rte 101 S/S Main St Continue to follow IN-101 S/State Rte 101 S 15.2 mi
6. Turn right 0.2 mi

26.4 mi – about 31 mins

Stop 3 Brookville Dam Spillway: Indiana 101 just north of Brookville (Lunch-- 39.439756, -85.005441)
7. Head south toward IN-101 N/State Rte 101 N 0.2 mi
8. Turn right onto IN-101 S/State Rte 101 S 1.3 mi
9. Continue onto IN-1 S/US-52 E/Main St Continue to follow IN-1 S/US-52 E 5.9 mi
10. Turn right onto IN-1 S 1.8 mi

9.1 mi – about 14 mins

Stop 4 South Gate Hill: Roadcut on Indiana 1, 4.4 miles north of I-74 (39.341100, -84.953195)
11. Head south on IN-1 S 14.7 mi
12. Turn right onto Pella Crossing 0.4 mi
13. Continue onto Pribble Rd 2.6 mi
14. Turn left onto IN-48 E/Bielby Rd 2.1 mi

19.9 mi – about 31 mins

Stop 5 Lawrenceburg: Roadcut on Indiana 48 at US 50 near Lawrenceburg (39.096214, -84.875969)

Fossils and Strata of the Cincinnatian

Cincinnati Fossils

Given the lack of economic deposits, the Upper Ordovician rocks in and around the Cincinnati region, including southeastern Indiana, have received remarkably consistent attention from geologists since the mid to late 1800s. This is, largely, because they are among the most richly fossiliferous deposits in the world. Fossils are intrinsically interesting if for nothing more than their beauty. The following plates include some of the most common fossils and some of the most sought-after fossils that might be encountered on the fieldtrip. With the exception of two photos, the fossil figures were taken from Cummings (1907). The abundance of fossils makes the deposits a convenient natural laboratory, and recent studies include the ecological dynamics of species migration (the Richmondian invasion; e.g. Stigall, 2010), the exploration of continent-scale evolutionary relationships (e.g. Jin 2001; 2012), and the day-to-day interactions of extinct forms (Dattilo et al. 2010; Freeman et al. 2013).

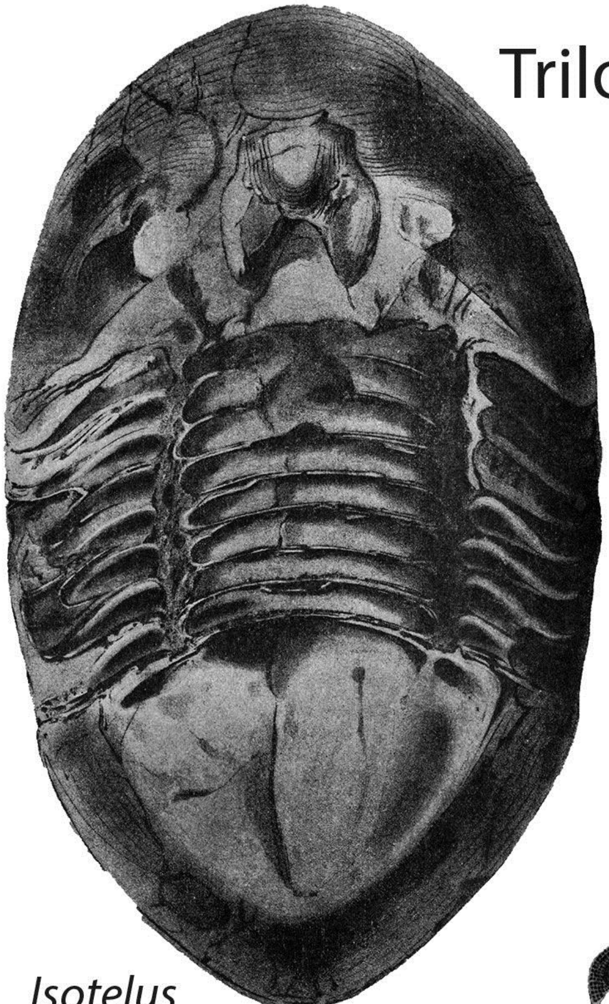
Stratigraphy

In this guidebook you will see hints of a complex history of stratigraphic nomenclature. Early stratigraphic work by Cummings (1907) in Indiana and others in the immediate area of Cincinnati (summarized by Caster et al., 1955) relied heavily on fossil content to correlate relatively thin units over large areas. In the 1960s (e.g. Peck, 1966; Brown & Lineback, 1966), an emphasis on the facies concept and the strict separation of lithostratigraphy and biostratigraphy inspired a proliferation of new named units that tend to follow political boundaries like state lines. The resulting correlation chart (Cuffey, 1998: copied herein) is a bit confusing, in part because it reflects the concept that lithologic units are facies mosaics and that tracing thin units for long distances is impossible. With the advent of event stratigraphy and sequence stratigraphy, the concept of “stratigraphic surfaces” was added to the geologist’s lexicon. Older stratigraphic approaches were revived and revised in a new sequence stratigraphic system (e.g. Holland and Patzkowski, 1996). Ongoing work is sequence stratigraphic in basis and has resulted in the extension and refinement of the earlier stratigraphic system, as well as the elimination of “state line stratigraphy” (e.g. Brett & Algeo. 2001).

Sedimentology—The origin of shell beds

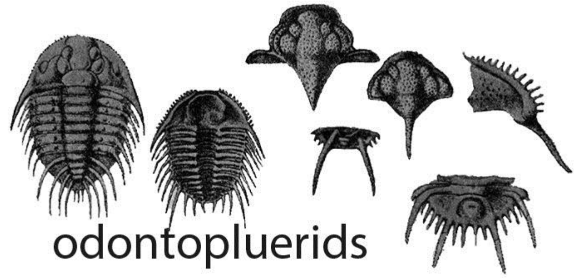
Underlying stratigraphy is sedimentology, and the key sedimentological question in the Cincinnatian is the origin of shelly limestone beds intercalated with mudstone beds, as well as small scale cycles that consist of alternating limestone and mudstone rich phases. If these meter-scale cycles are so extensive that they can be traced individually across the Ohio, Kentucky and Indiana outcrop area, how are they generated and how is it that they don’t disappear into a mosaic of facies. Since most shell beds contain abundant evidence of reworking, and since the area was in the tropical storm belt during the Ordovician, these beds and cycles have long been interpreted as storm beds or “tempestites” that formed from storm winnowing (Kreisa, 1981). More recently arguments have been made in support of basin-scale fluctuations in the supply of mud from the Taconian Orogen (Brett et al., 2008; Dattilo et al., 2008, 2012) as the principle cause of bedding, with ubiquitous storm (or tsunami?) reworking playing only a minor role.

Trilobites (& ostracods)



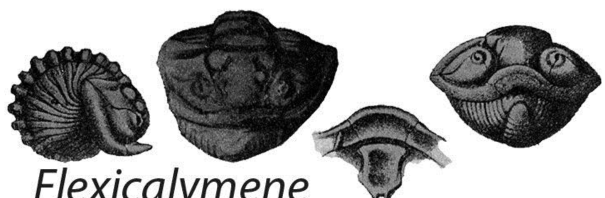
Isotelus

Isotelus is the largest trilobite, anywhere, any time. Finding one whole usually requires digging. They are very common as fragments. Recent work with the forked mouthpart, the hypostome (look between the eyes on this "transparent" reconstruction) suggests that it was used like the claws in a hammer to pry worms out of their burrows.



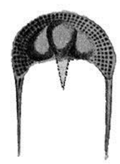
odontopluerids

Whole odontopleurids are very rare, but their parts are actually common in certain beds. These pictures illustrate the different types of "trilo**bits**" that you might find while looking for "trilo**bites**".



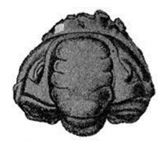
Flexicalymene

The classic Cincinnati trilobite. Most of the small fragments you find will belong to this trilobite. For a chance at collecting one, try the thick shaly inerval at near the base of Southgate Hill. Very tiny specimens can be found in the thinner shaly interval higher up in the same outcrop.



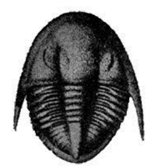
Cryptolithus

The "lace collar trilobite" is common in certain parts of the Kope Formation at the base of the Lawrenceburg cut.



Triarthrus

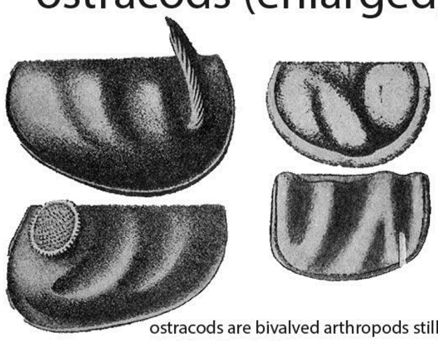
This trilobite is characteristic of deeper water environments than typically found in the Cincinnatian, but might be found in the middle part of the Kope Formation, near the base of the Lawrenceburg cut



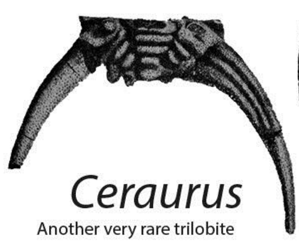
Proetus

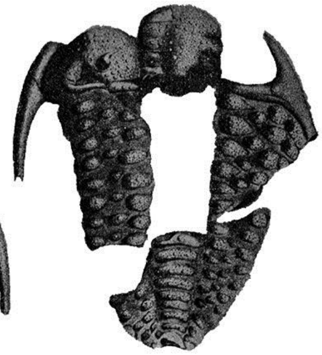
If you find this one, best not to tell the field trip leader. It is rather rare.

ostracods (enlarged)



ostracods are bivalved arthropods still common today. As Ordovician fossils, they are common and generally less than 1 mm across, so they are usually overlooked

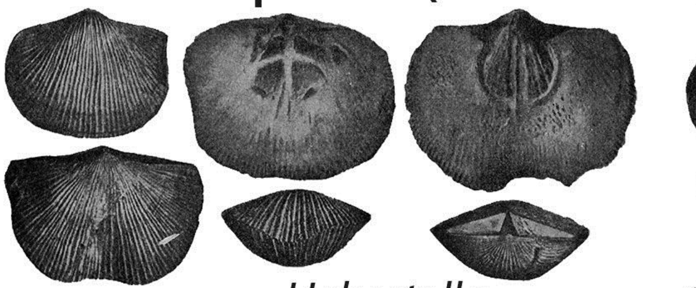




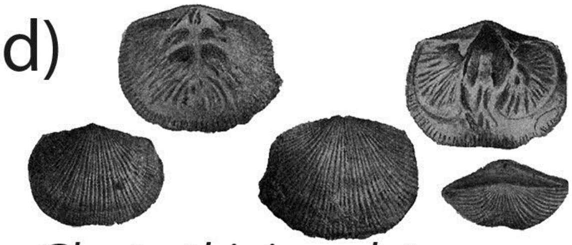
Ceraurus

Another very rare trilobite

Brachiopods (assorted)

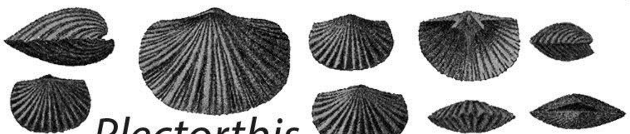


Hebertella

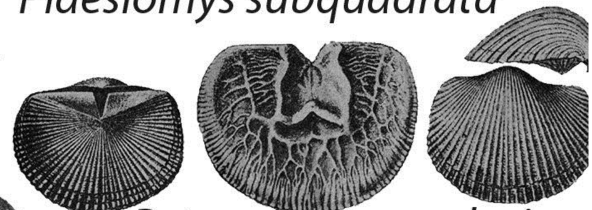


Glyptorthis insculpta

Plaesiomys subquadrata

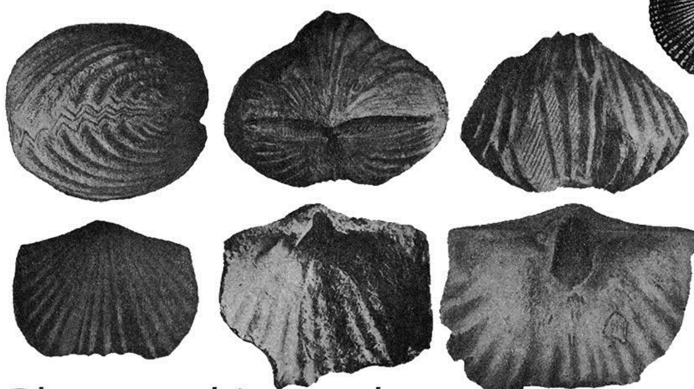


Plectorthis



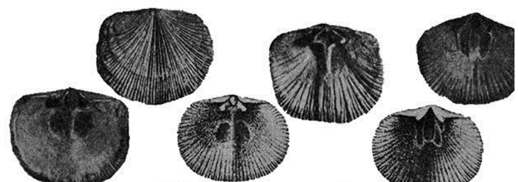
Retrorsirostra carleyi

This distinctive species is restricted to a narrow zone near the base of the Richmondian. One of the Richmondian invaders that failed to thrive. Look for it above the first bench at Southgate Hill.



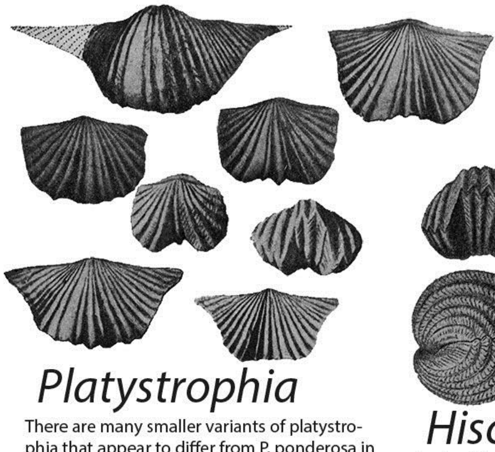
Platystrophia ponderosa

P. ponderosa is the most recognizable of the various named species. It has recently been reassigned to the genus *Vinlandostrophia* by someone from Northern Europe (of course). There is some grumbling about this by North American Paleontologists. Look for it at the top of the Lawrenceburg outcrop.



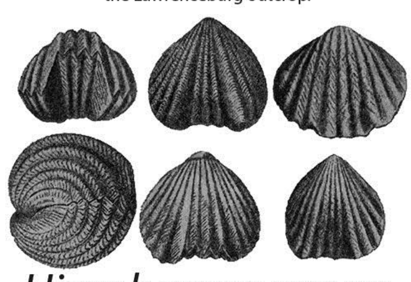
Cincinnetina

The Brachiopod f.k.a. *Onniella*, *Dalmanella*, or *Resserella*, Several species, each of which can be found in some abundance at one stratigraphic level, have recently been reassigned to *Cincinnetina*. North Americans like this new name.



Platystrophia

There are many smaller variants of platystrophia that appear to differ from P. ponderosa in being attached throughout life. There are a few different named species, but taxonomy is almost as bad as for *Rafinesquina*.

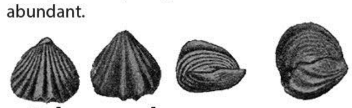


Hiscobeccus capax

a.k.a. *Lepidocyclus*. Similar to *Platystrophia* in appearance, but entirely different ancestry. Descended from earlier forms of *Rhynchotrema*. This is a Richmondian species.

Zygospira

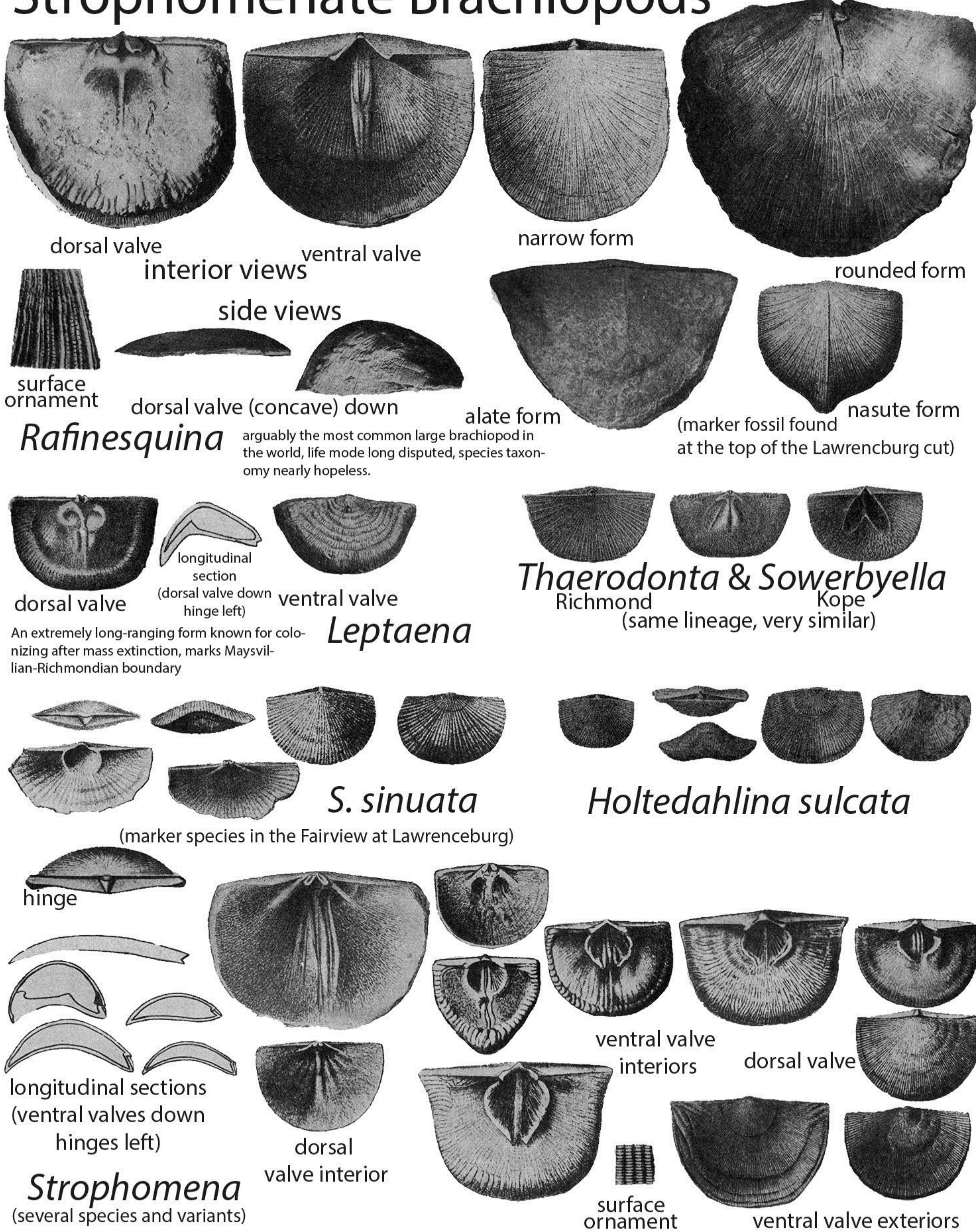
Look like little bitty baby *Platystrophia* but are not even close--examine particularly the classic "lamp shell" pedicle opening in the dorsal valve. Can be ver abundant.



Rhynchotrema dentatum

Resemble *Zygospira*, but more triangular. Look for them at the U.S. 27 cut near Richmond.

Strophomenate Brachiopods



Trepostome Bryozoans

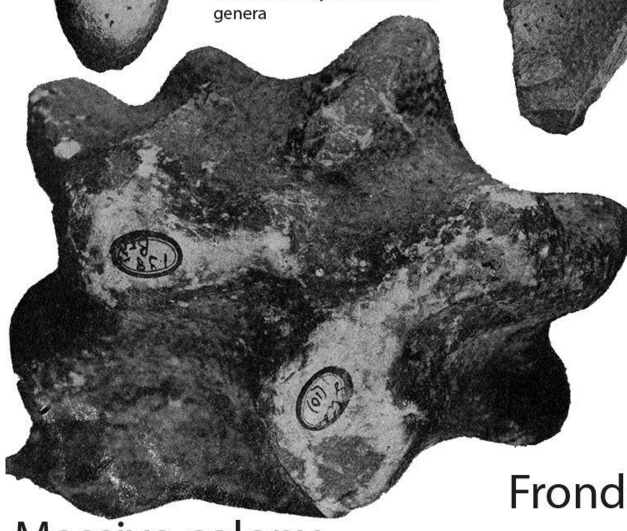
Ramose forms

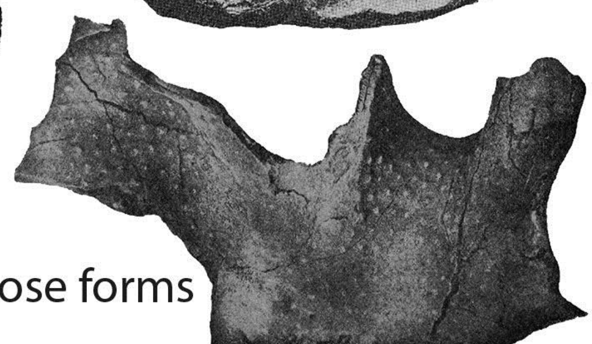
same species different species

Gross surface characteristics are unreliable. The three specimens on the left are the same species (middle specimen shows two patterns), while the three on the right are different species, but show the same pattern (yes, I included the one in the middle twice-intentionally).

There are more bryozoans and more different kinds of bryozoans than there are of any other Cincinnatian fossil. Unfortunately they are rather difficult to identify. This page shows you a range of external shapes that you might encounter. Sometimes these shapes help identify genus, more often they are a result of environment. Generally bryozoans look like corals with much smaller openings.

The gumdrop shape is usually the same genus, *Prasopora*. With a few months work, you might be able to identify ten additional genera

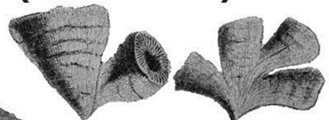




Frondose forms

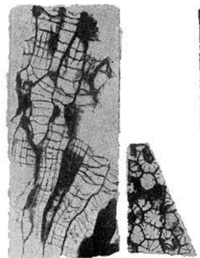
Massive colony

Corals (&stuff)



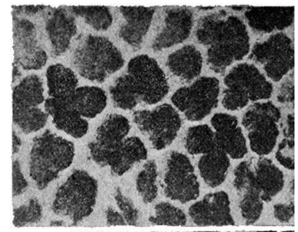
Streptalasma

Grewingkia canadensis



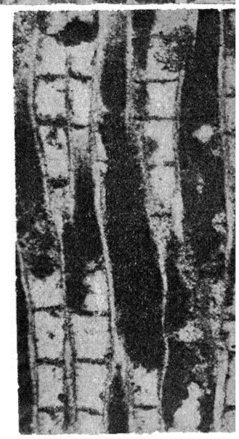
Cyathophylloides

Septae are well developed

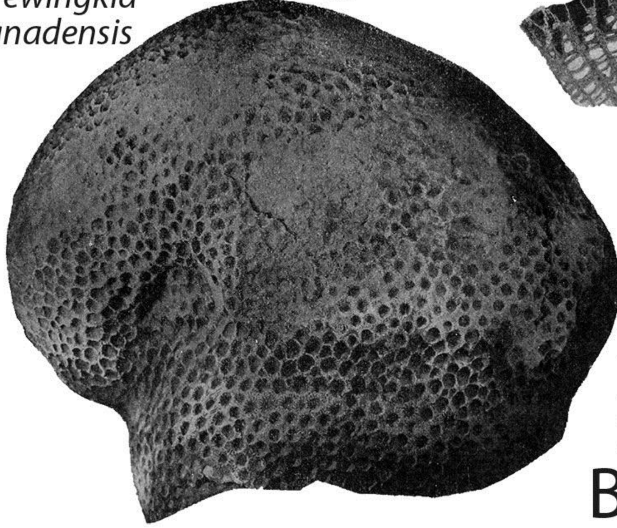


Tetradium

Is it a coral? sponge? algae? everyone has an answer, nobody knows. However, it forms large heads that look



longitudinal section through *Tetradium*



Calapoecia

to identify a coral head you need to look at the corallites and see if there are any septae.

Protarea

often found encrusting shells.

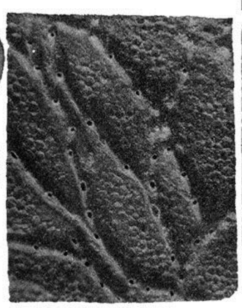
Bryozoans

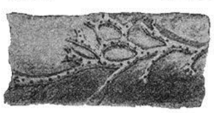
cyclostomes

very tiny lace like encrusters on shells and other bryozoans

photographs much enlarged

actual size

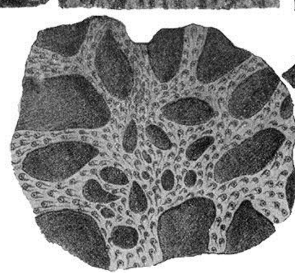




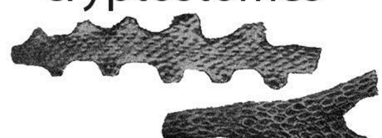
enlarged

actual size

details



cryptostomes



(enlarged) Cryptostomes are common and commonly overlooked

cystoporids

Constellaria

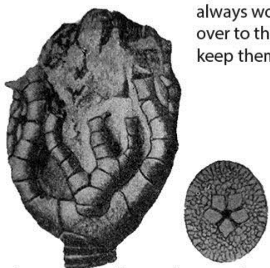
This is one of the most easily identified bryozoans characterized by its flower or star-like surface pattern. These can be found below the uppermost bench of the Lawrenceburg cut, where they are a marker for the Fairview Formation.

Echinoderms

Articulated echionoderms are always worth keeping, or turning over to the Field Trip Leader. He can keep them.

Crinoids (sea lillies)

crionids are consist of an attachment base, a column (stem) a cup and arms (together making the "head". They look a bit like flowers.



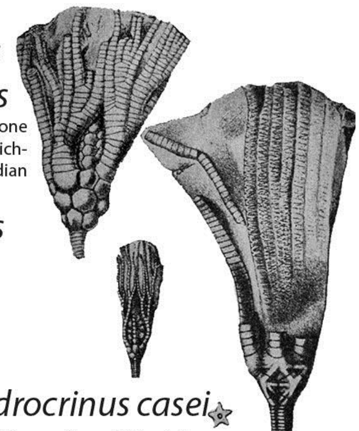
Anomalocrinus incurvus

Look for this in the Lawrenceburg cut, Bellevue Member, at the top of the exposure. It is by far the largest Cincinnatian crinoid.

it is very easy overlook whole specimens, because the cup is as small as the stem.

Cincinnaticrinus pentagonus

C. varibrachialus

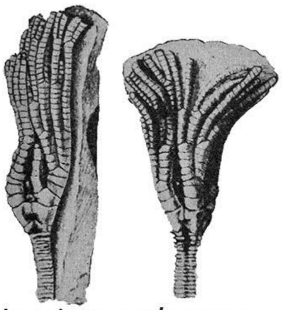


Cupulocrinus polydactylus

you might find this one anywhere in the Richmondian

Plicodendrocrinus casei

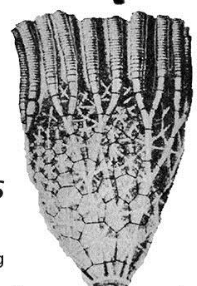
Mostly in the Waynesville and Liberty Formations



Iocrinus subcrassus

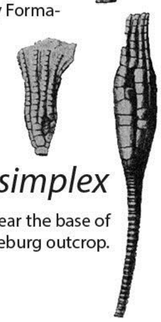
Glyptocrinus decadactylus

this form is restricted to the fairmount, near the top of the Lawrenceburg cut.



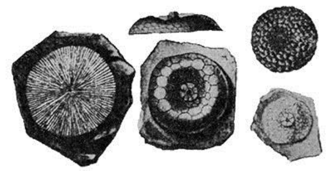
Pychnocrinus dyeri

Maysvillian and lower Richmondian



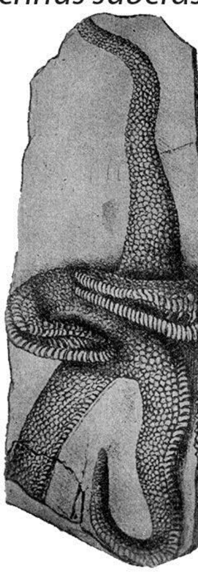
Ectenocrinus simplex

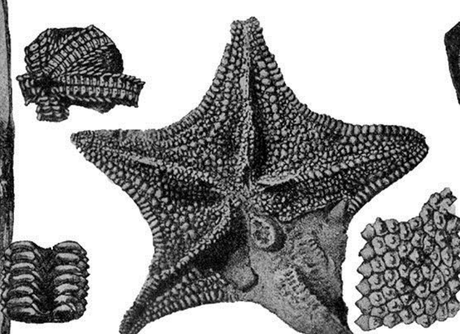
Common in the Kope, near the base of the Lawrenceburg outcrop.



Crinoid holdfasts

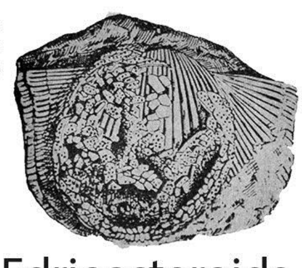
hodfasts are attachment bases for the crinoid. They are often preserved without the rest of the animal.

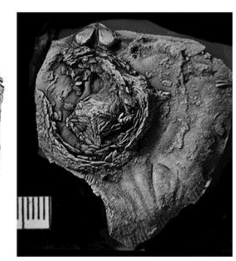




Sea stars

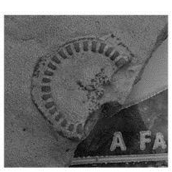
very very very rare. It is best not to let anyone know that you found one until months later. Could lead to violence.





Edrioasteroids

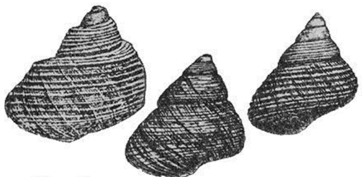
Edrioasteroids look like sea stars on a coin. They are usually attached to the brachiopod *Rafinesquina*. They are rare, but not extremely rare. I found thisone at the top of the Lawrenceburg cut. Complete specimens (not pictured) are spectacular.



Cyclocystoids

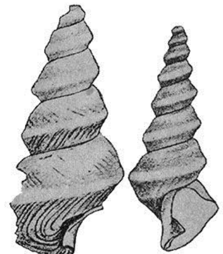
Cyclocystoids are very rare, but there is a chance of finding one near the base of the Southgate Hill cut. I found this one in Kentucky. They consiste of a ring of large ossicles surrounding a thin disk of small ossicles. Very strange.

Snails



Cyclonema

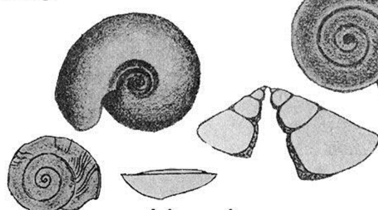
Cyclonema is the only genus of gastropod with an originially calcitic shell, so its shell is preserved more readily than the shells of other snails. It is often found attached to the anal opening of crinoids, and may have been capable of boring.



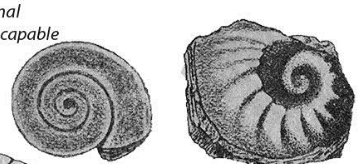
Loxoplocus bowdeni

Hormotoma

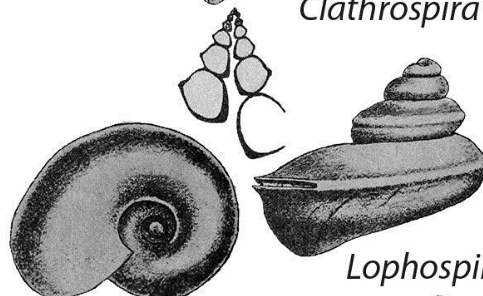
Clathrospira



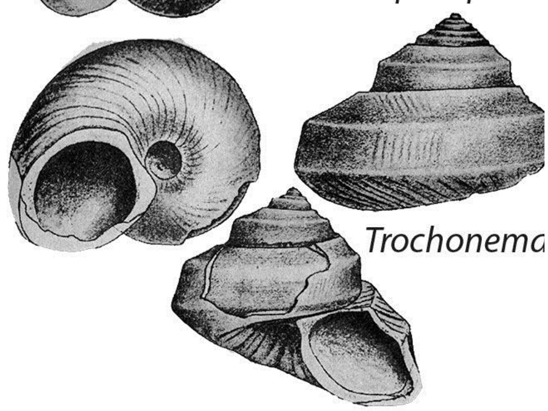
Liospira



Cyrtolites

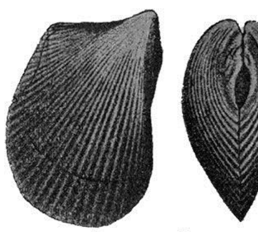


Lophospira



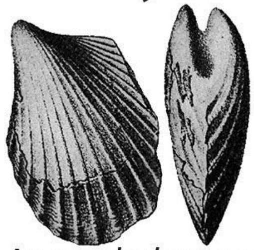
Trochonema

clams

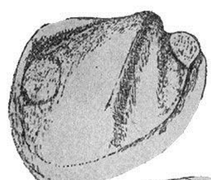


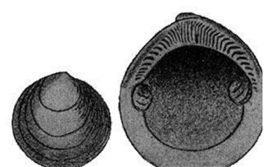
Ambonychia

Anomalodonta gigantea

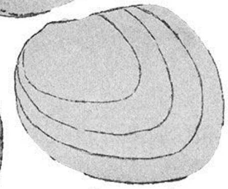


Anomalodonta costata

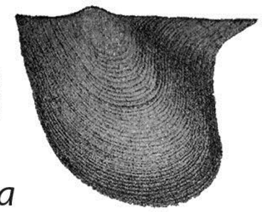




Ctenodonta

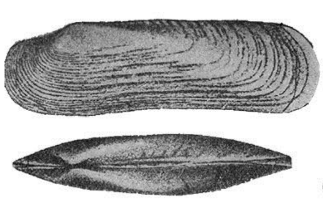


Ischyrodonta ovalis

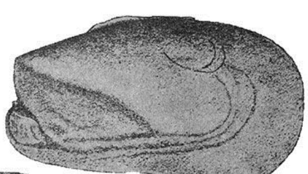


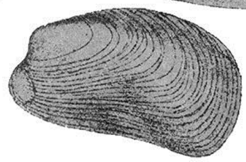
Caritodens

Like both the scallops and the oysters that decended from it, this bivalve had an outer calcite shell and an inner aragonite shell. It is the only one whose shell is regularly preserved.



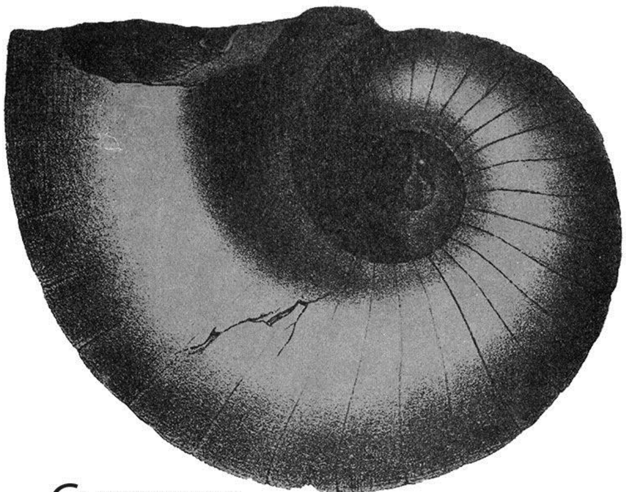
Cymatonota





Ischyrodonta elongata

Cephalopods



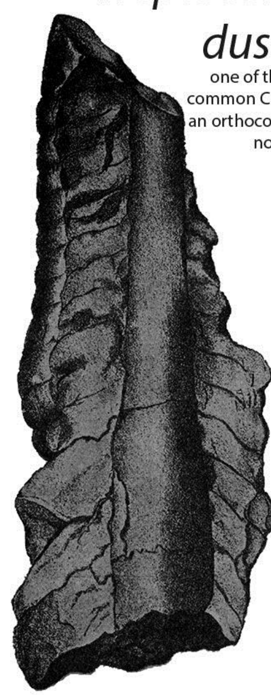
Gyroceras

Actinoceroids

Generally straight shells with these "beaded" looking siphuncles

Treptoceras duseri

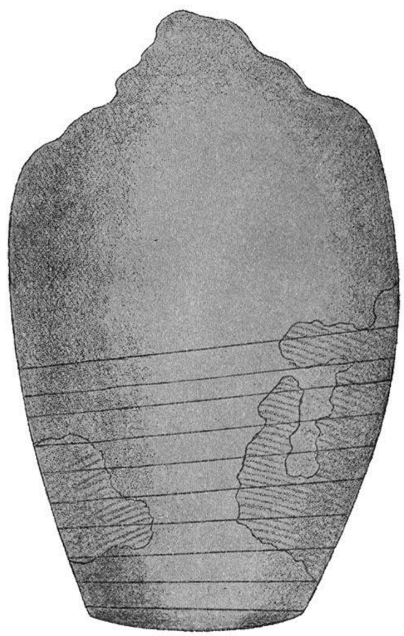
one of the more common Cincinatian orthoconic actinoceroids.



Endoceroids

Endoceroids are characterized by straight shells with fat cone-shaped siphuncles.

"Cyrtoceras"

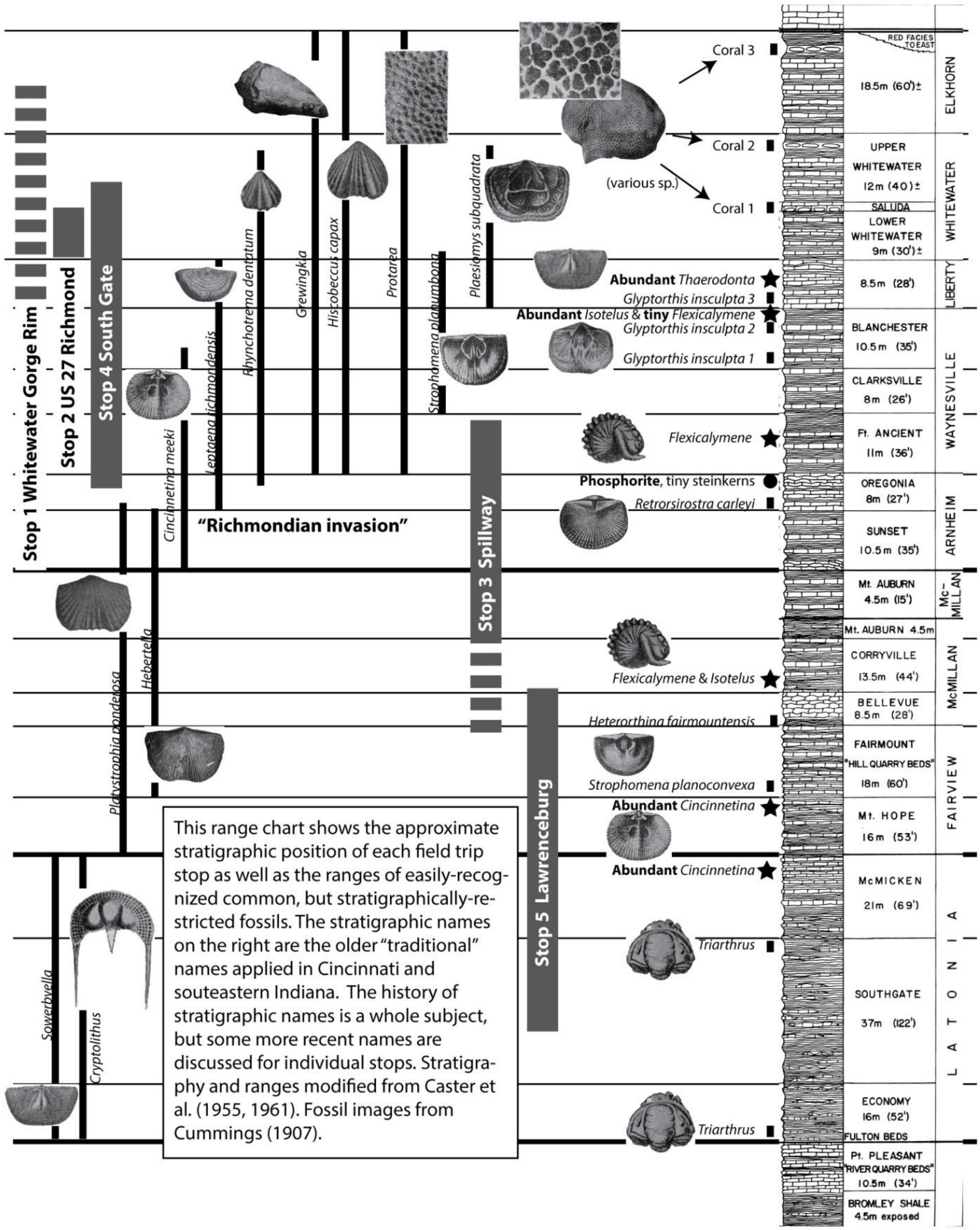


Gomphoceras

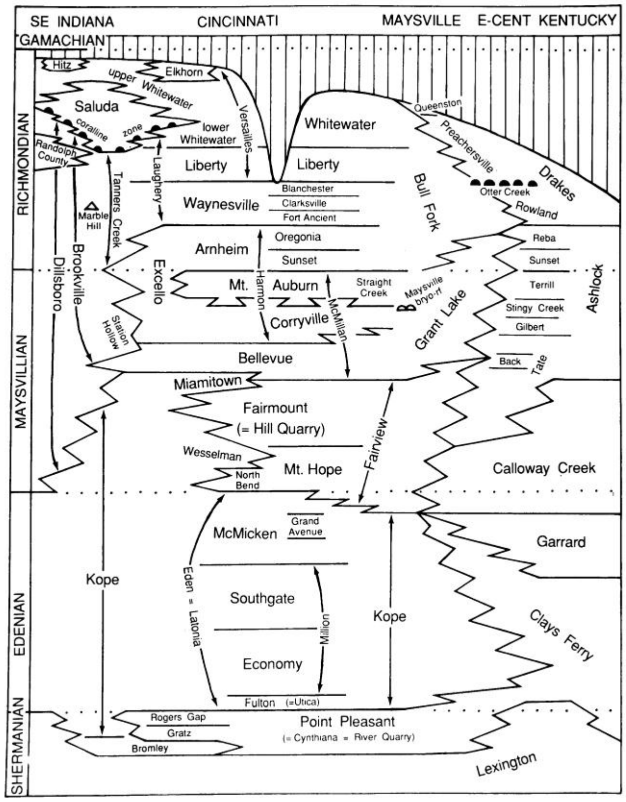
These are rather rare.

Tentaculites

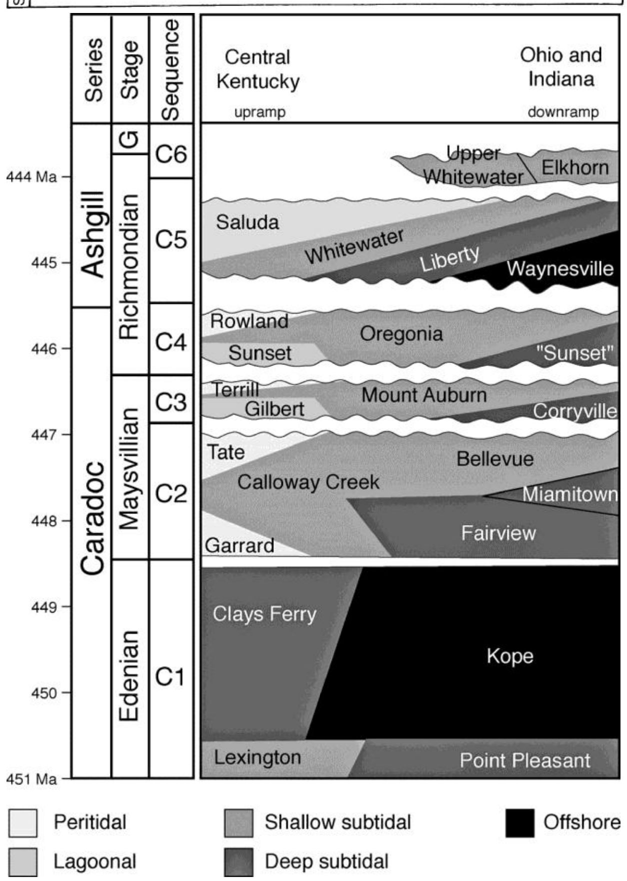
Not a cephalopod! Tentaculites is . . .something else. Look for them, rather small things, on the first shaly bench at Southgate Hill exposure.



This range chart shows the approximate stratigraphic position of each field trip stop as well as the ranges of easily-recognized common, but stratigraphically-restricted fossils. The stratigraphic names on the right are the older "traditional" names applied in Cincinnati and souteastern Indiana. The history of stratigraphic names is a whole subject, but some more recent names are discussed for individual stops. Stratigraphy and ranges modified from Caster et al. (1955, 1961). Fossil images from Cummings (1907).



Lithostratigraphic Cross Section of the Cincinnati Region from central Kentucky to southeastern Indiana. While this might represent the reality of a facies mosaic, there is also evidence of arbitrary differences in scale and state line limits on jurisdictions, where prominent "shazam lines" are placed. From Cuffey (1998).



Sequence Stratigraphic Interpretation of Cincinnatian lithostratigraphic units. Here lithostratigraphic units are interpreted as facies within a sequence stratigraphic framework. From Holland & Patzkowski (1996).

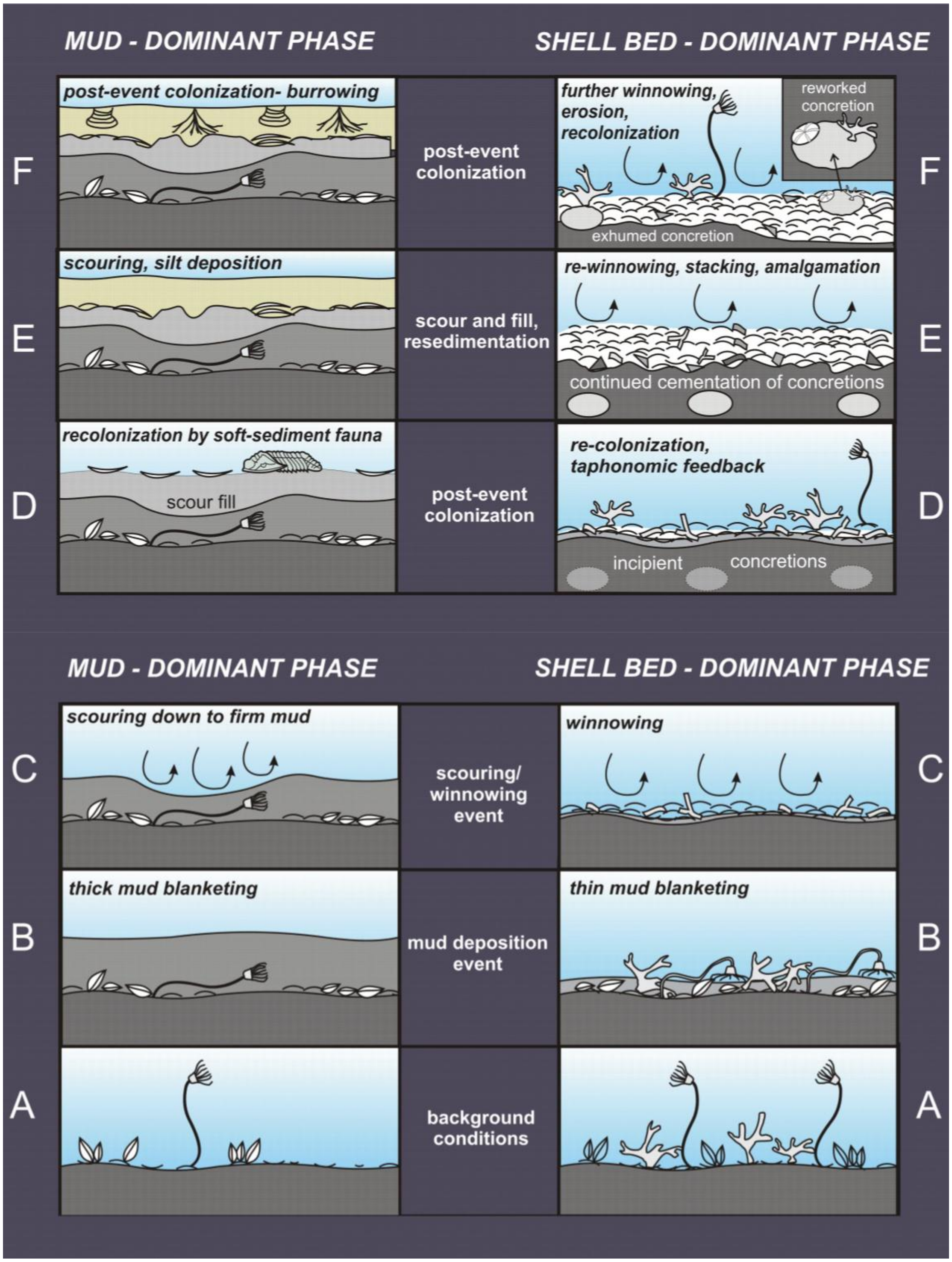
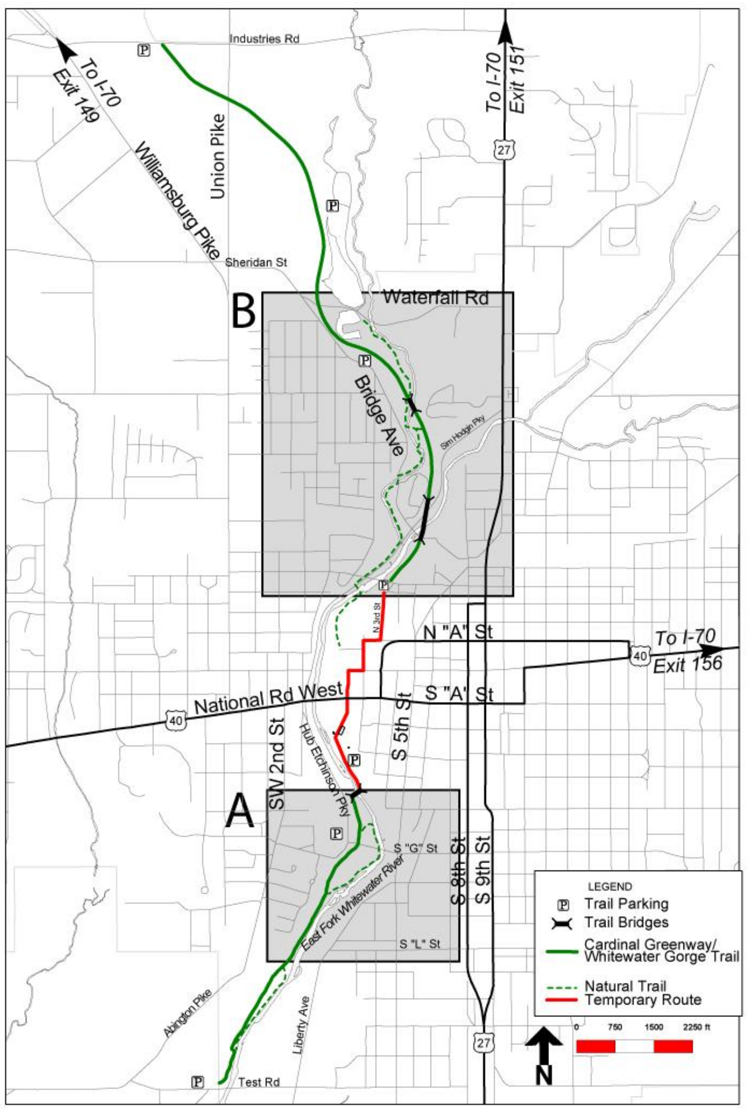


Diagram showing the development of muddy and shelly horizons in the Cincinnatian. Shell beds develop during periods of low siliciclastic sediment supply. Mud beds develop during times of high sediment supply. Storms (or other high energy events like tsunami) affect both types of beds, and do not constitute the critical difference between them: all are tempestites (Modified from Brett et al., 2008)

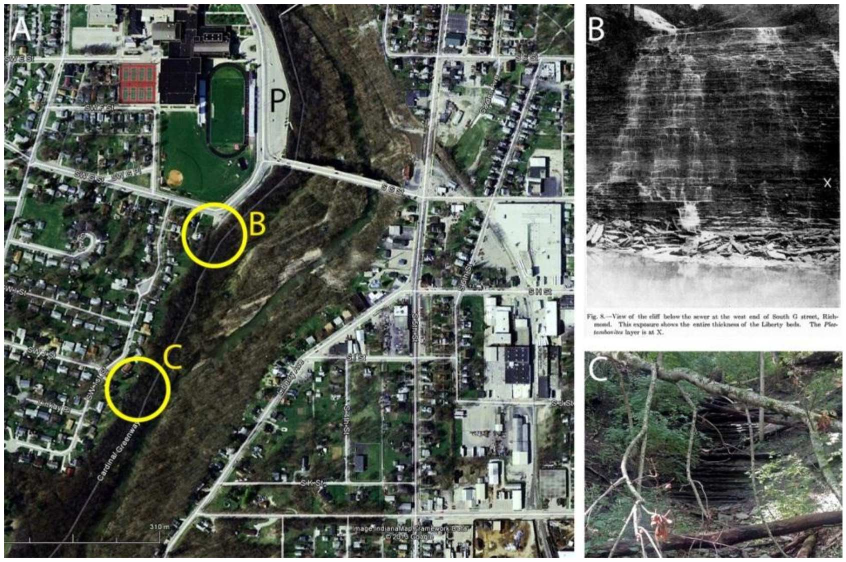
Stop 1. Whitewater Gorge.

Meet at Richmond Highschool Parking Lot
39.820943,-84.899555
Location and directions:
(Parking on East side of road, NOT handicapped accessible - Stairs lead to trail)
West:Take Exit 149A. Follow Williamsburg Pike as it turns into NW 5th Street. Go East on U.S. 40. At first light turn south onto Hub Etchison Parkway. Park on east side of road across from high school.
East:Take Exit 156A. Follow U.S. 40 West through town. After crossing the U.S. 40 bridge turn south onto Hub Etchison Parkway. Park on East side of road across from High School.
North/South:Go West on U.S. 40. Follow instructions for east.

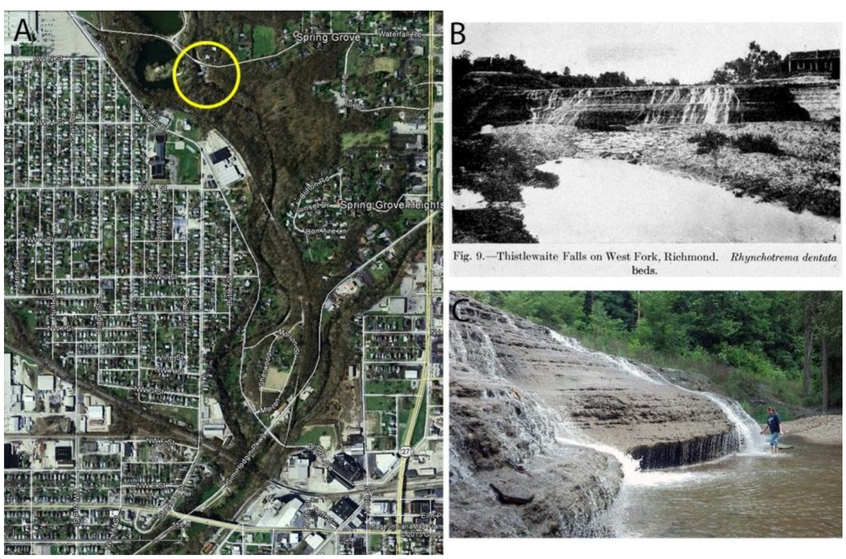
We will meet at 8:30 at the Richmond High School parking lot along the Whitewater Gorge.



Map of the Whitewater Gorge. Stop 1 is near two areas of interest. A. The area around the Richmond High School Parking lot where we will start the field trip. See Figure 1-2. B. The area around Thistlewaite Falls. See Figure 1-3. Figure based on trail map available at http://www.waynet.org/maps/parks-recreation/images/gorgetrail01-28-03.pdf



Satellite and outcrop images of Stop 1-1 The Whitewater Gorge in the Richmond High School Area. A. Google Earth Satellite View showing our parking area (P), and circled outcrops (B) and (C). B. The G-Street Sewer as photographed by Cummings (1908). The Brachiopod called *Plectambonites(X)* in this figure is currently known as *Thaerodonta*.. A sanitary sewer is still operational, but has been enclosed. The current outcrop is barely visible. C. Outcrop of same interval further downstream along the River Walk.



Satellite and outcrop images of Stop-1-2. (Auxilary stop) Thistlewaite Falls. A. Thistlewaite Falls is upstream from our first stop along a tributary of the Whitewater River. It can be most easily reached by turning west on Waterfall Road from US 27 in the North of Richmond. B. Cumming's (1907) picture of Thistlewaite Mill and Falls. C. Picture of the falls taken in the Summer of 2013 showing that the exposure remains in good condition. We will not visit This classic locality during the Field Trip because parking space can only accommodate a few vehicles.

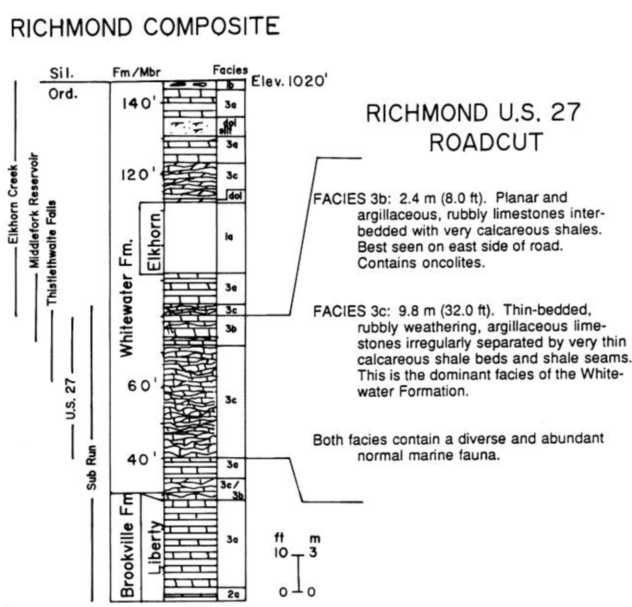
Stop 2. US-27 Road cut

39.787537, -84.901698

Roadcut on US 27 3.0 miles south of US 40 in Richmond

This roadcut duplicates some of the strata that were once well exposed in the Whitewater Gorge. Here you can collect a variety of different Richmondian fossils.

Satellite views of the Richmond/US 27 outcrop. A. contextual showing relationship to Richmond. B. Zoomed in.



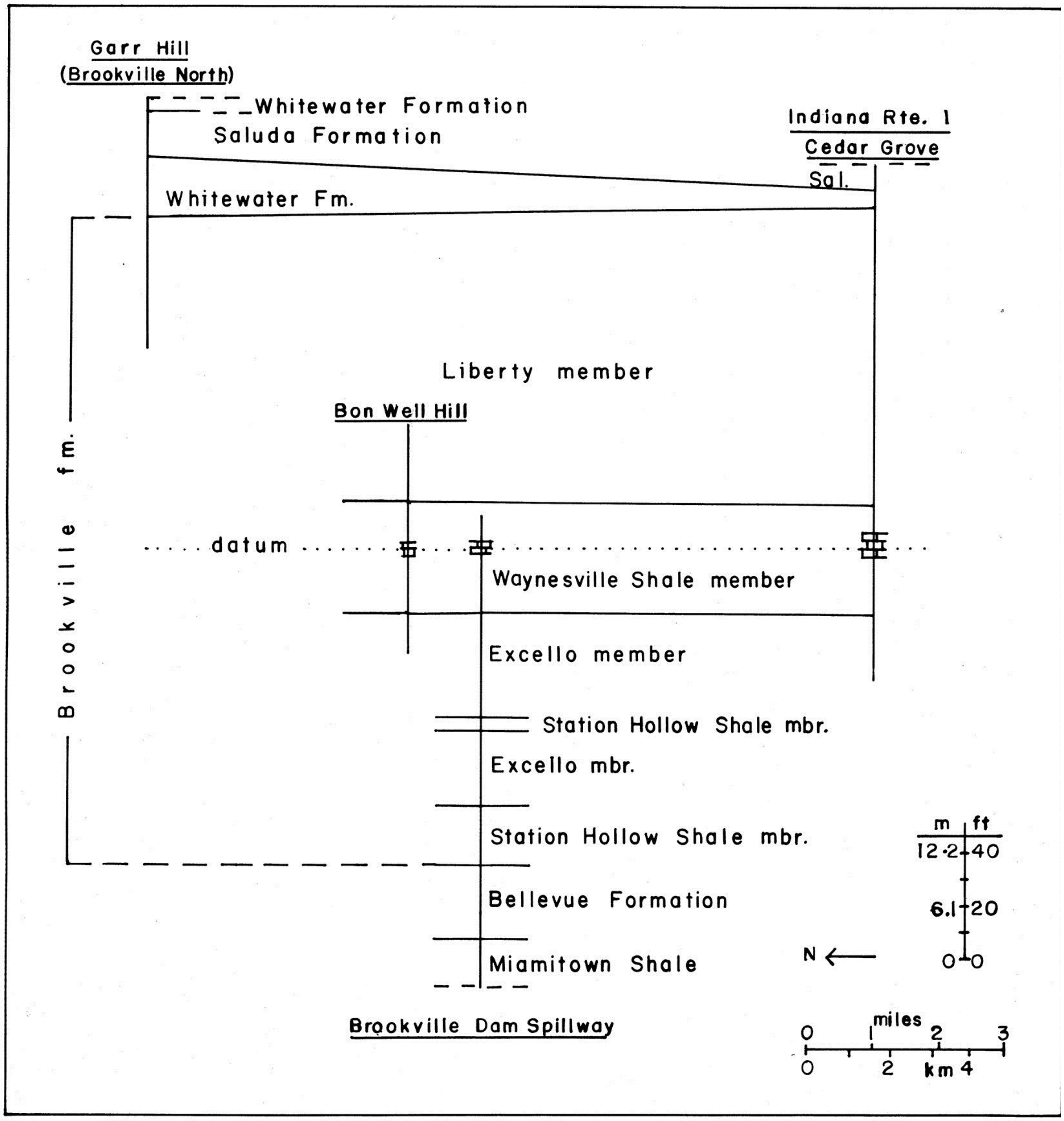
Composite stratigraphic column for the Richmond area (Hay & Cuffey, 1998b) showing Rock units exposed at various localities, including Thistlewaite Falls (see stop 1) and US 27. Note that the top of the US 27 outcrop is essentially equivalent to the strata exposed at Thistlewaite Falls, AND you are allowed to keep the fossils.

Stop 3. Brookville Dam Spillway

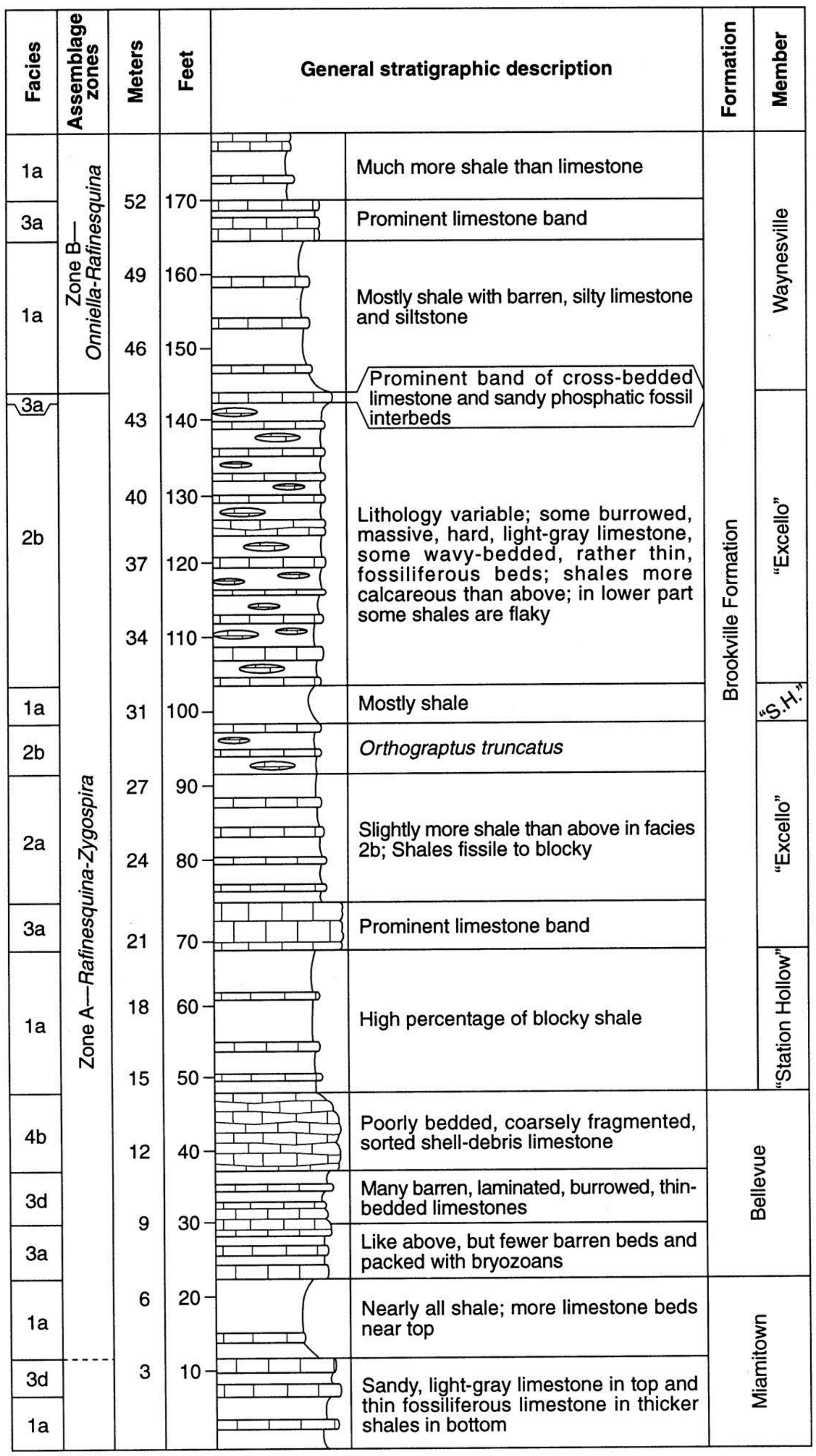
39.439756, -85.005441

Indiana 101 just north of Brookville

Satellite images of outcrops in the vicinity of Brookville Dam A. Overview of the Dam and spillway in relation to the town of Brookville. B. view of the spillway and Bon Well Hill outcrops. C. Closeup of the spillway. D. Closeup of Bon Well Hill.



Correlation of outcrops in the Brookville Reservoir area (Hay & Cuffey, 1998).



Stratigraphic column of the Brookville Dam Spillway (Hay & Cuffey, 1998)

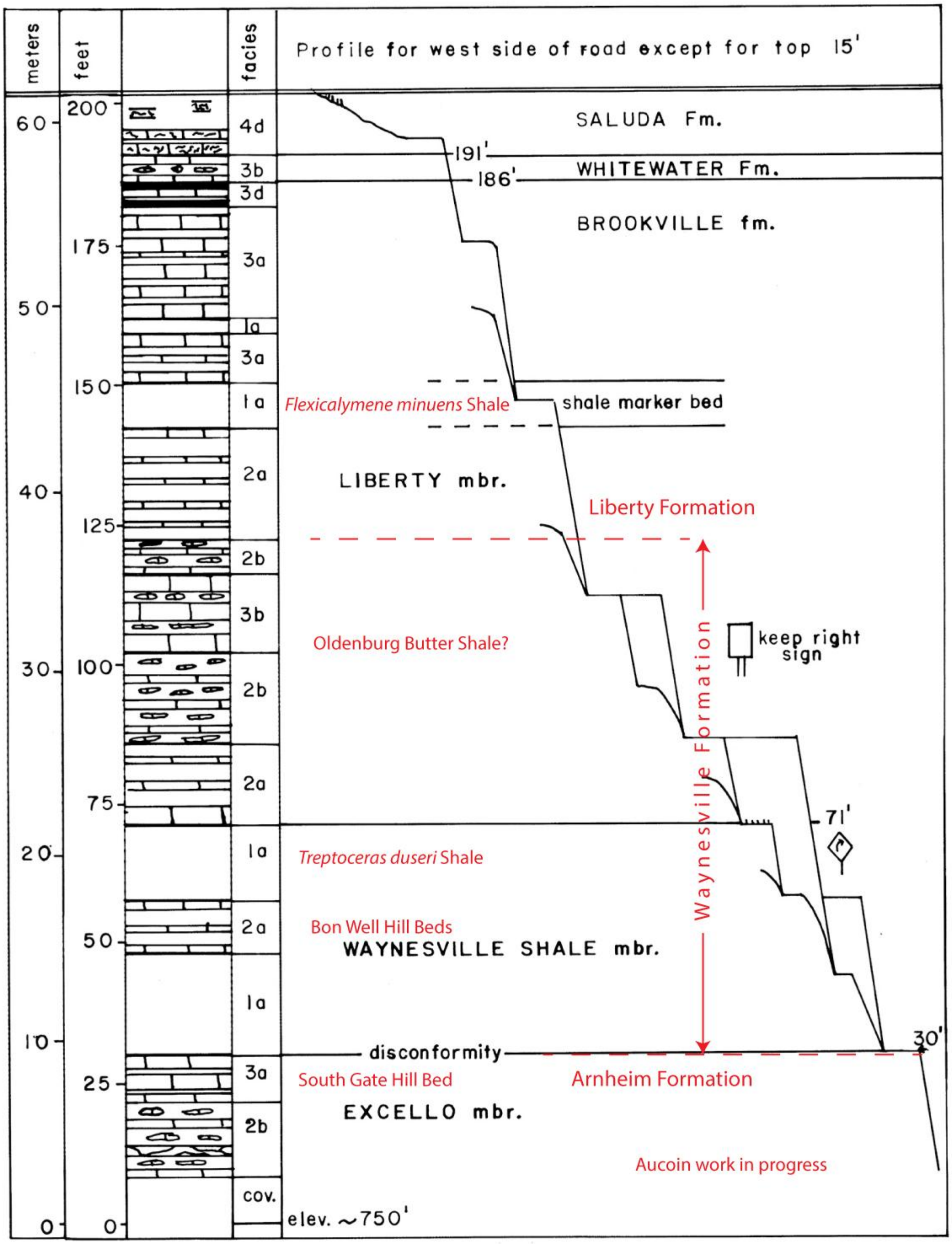
Stop 4. South Gate Hill

39.341100, -84.953195

Roadcut on Indiana 1, 4.4 miles north of I-74

Satellite view of the Southgate Hill outcrop. A. contextual view showing Cedar Grove to the north. B. Close up view of the extensive South Gate Hill outcrop.

Outcrop Photo showing the top of the Arnheim and the Waynesville members. Marks show Aucoin unit identifications, work in progress.

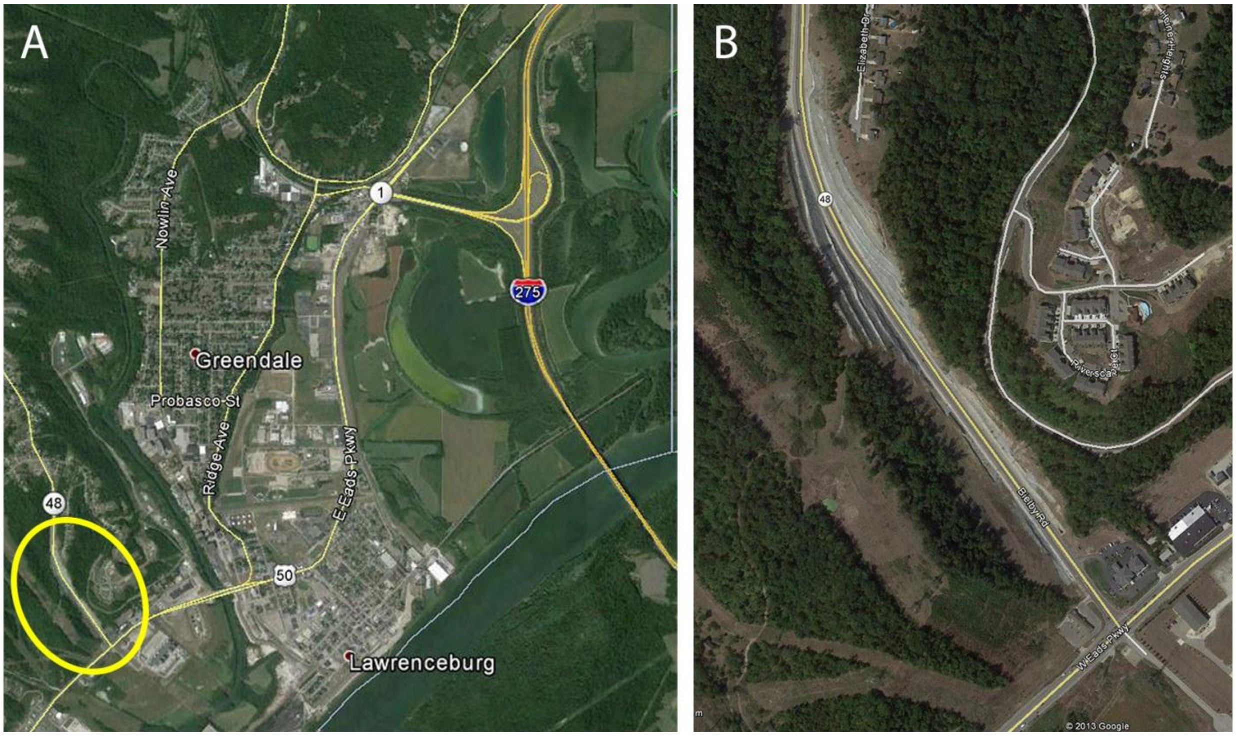


Stratigraphic Section of South Gate Hill (Hay et al., 1998). Note that terraces and road signs are included to help you find your way in the outcrop. Red annotations show stratigraphic units identified by Aucoin.

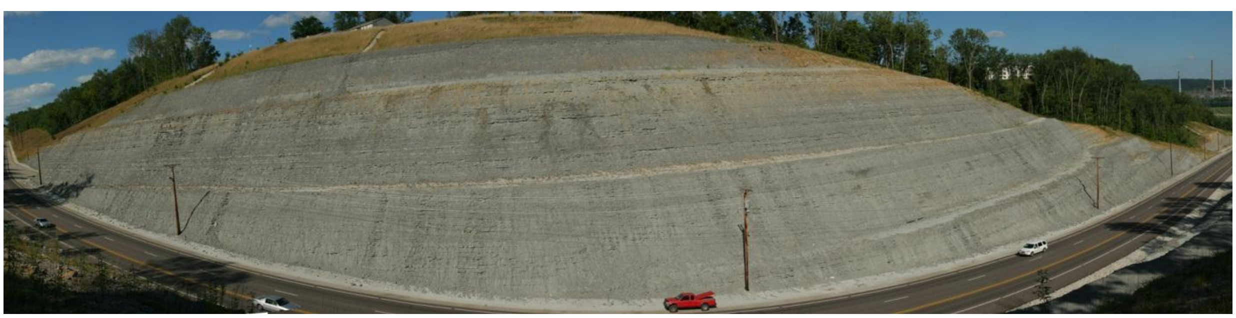
Stop 5. Lawrenceburg

39.096214, -84.875969

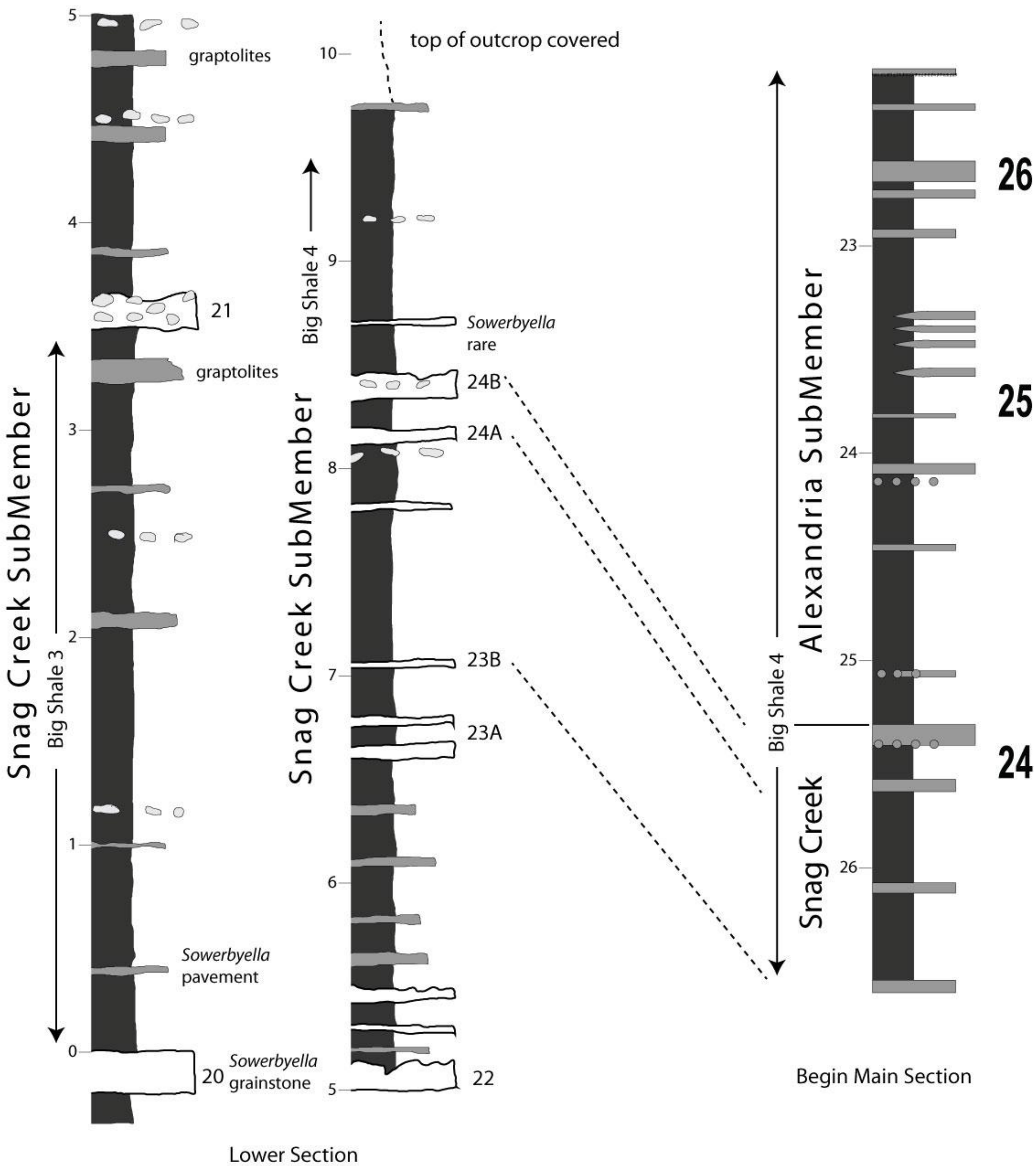
Roadcut on Indiana 48 at US 50 near Lawrenceburg, Indiana



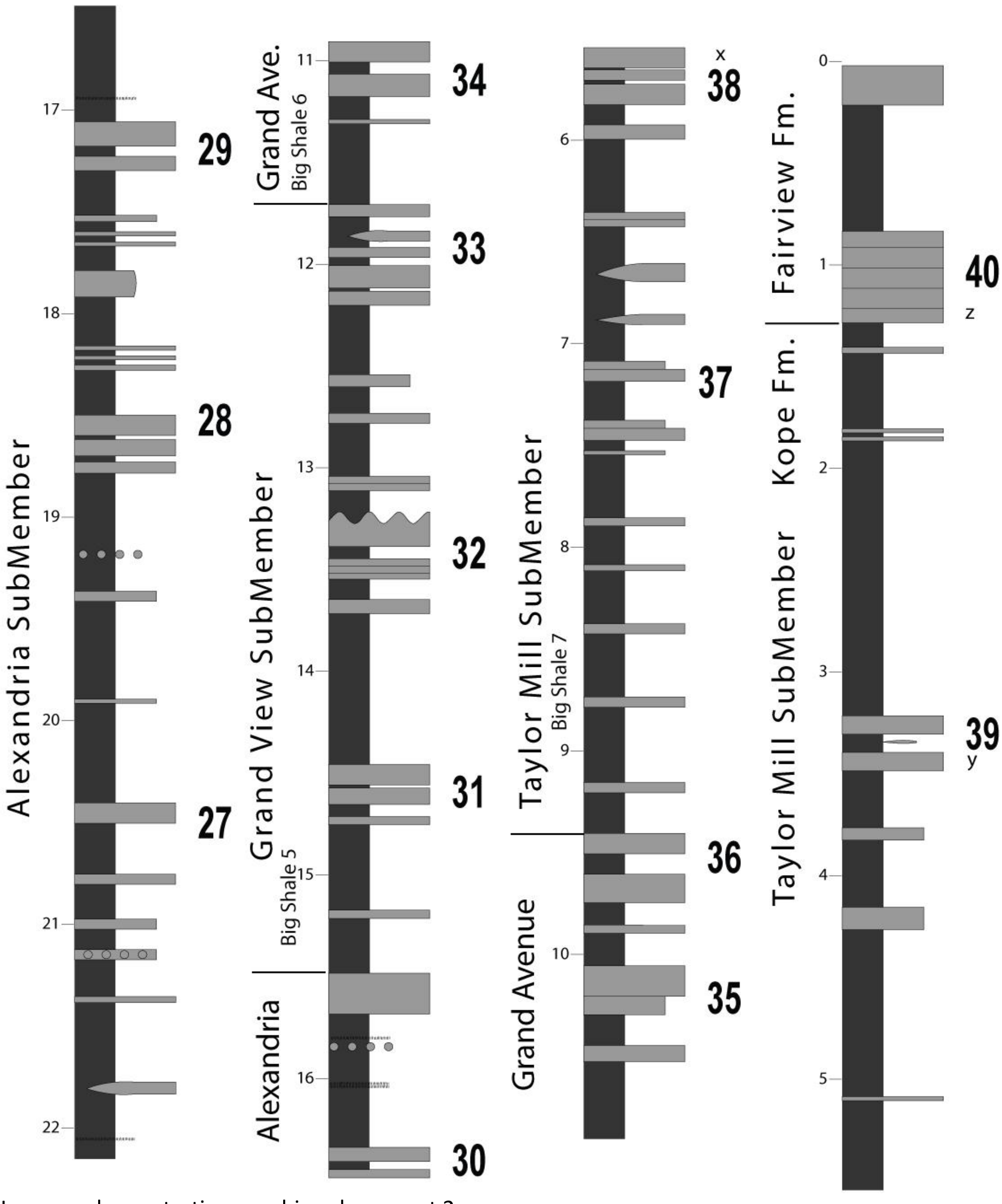
Satellite images of the Lawrenceburg outcrop. A. Contextual view showing relationship to Greendale and Lawrenceburg. B. Closeup view of this large outcrop.



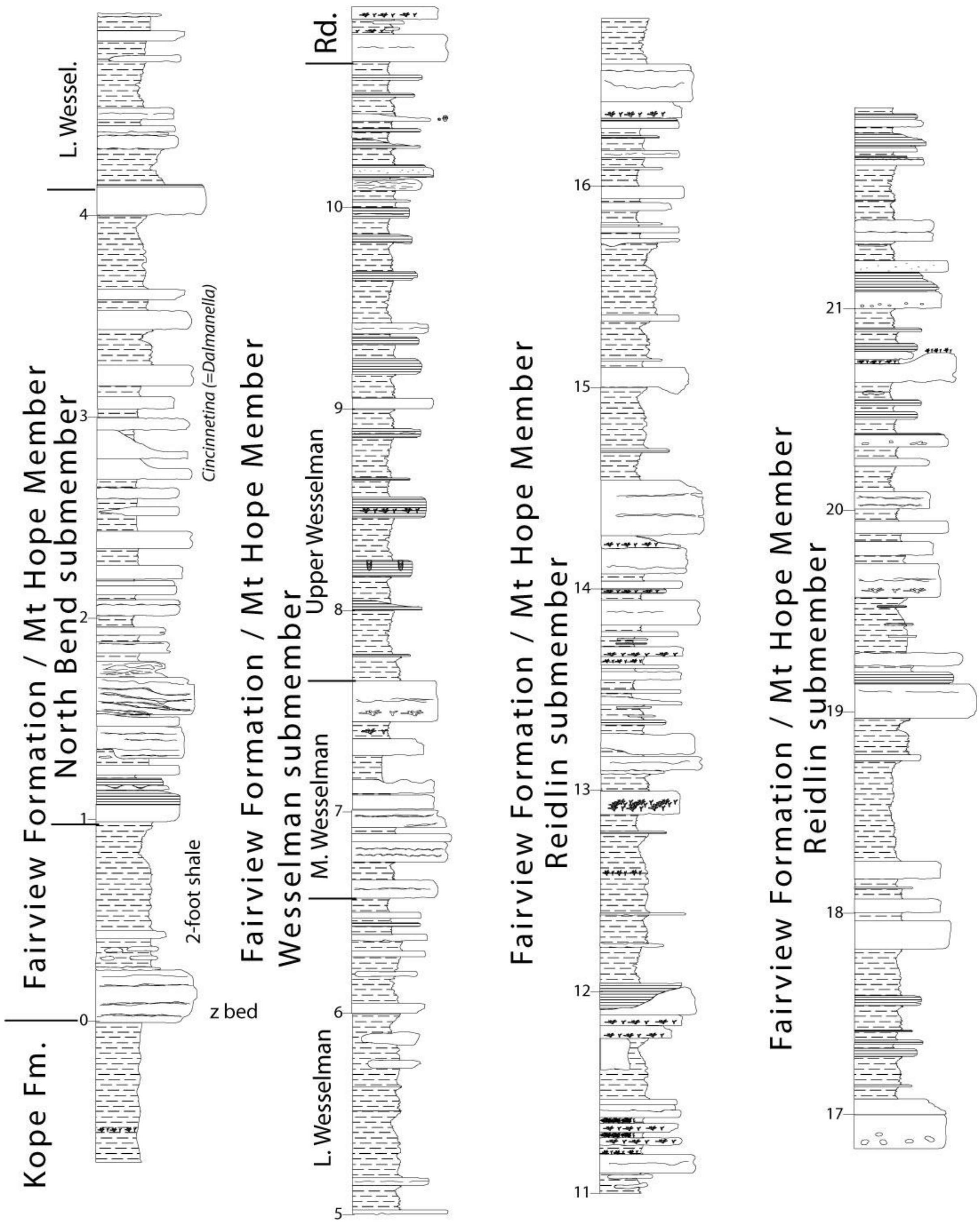
Outcrop photo of the Lawrenceburg cut showing nearly the entire succession from the Kope to the Bellevue.



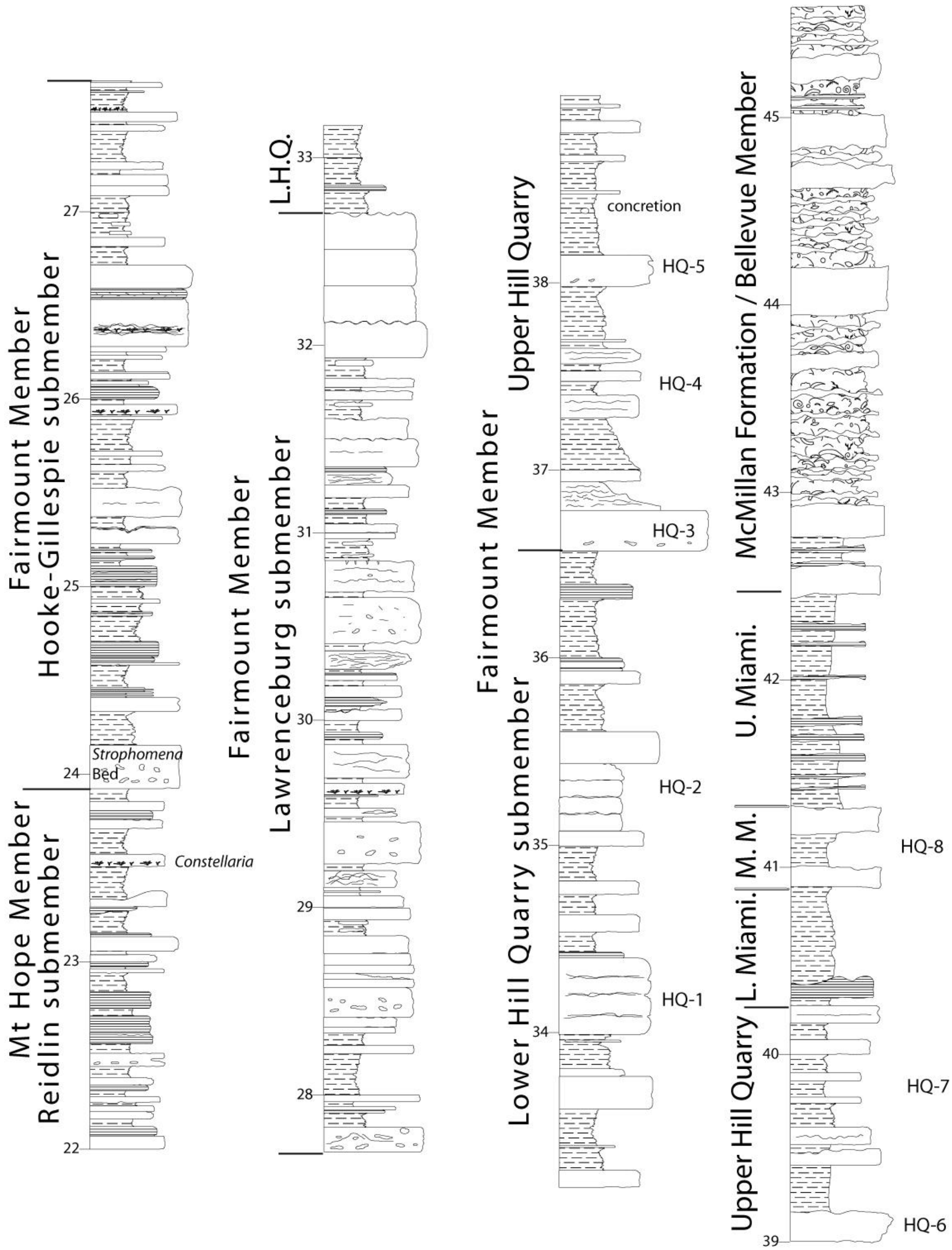
Lawrenceburg stratigragraphic column part 1



Lawrenceburg stratigragraphic column part 2



Lawrenceburg stratigragraphic column part 3



Lawrenceburg stratigragraphic column part 4

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