9-19-2015

Field Trip #1 – "Stratigraphy and Sedimentology of the Upper Ordovician in Southeastern Indiana"

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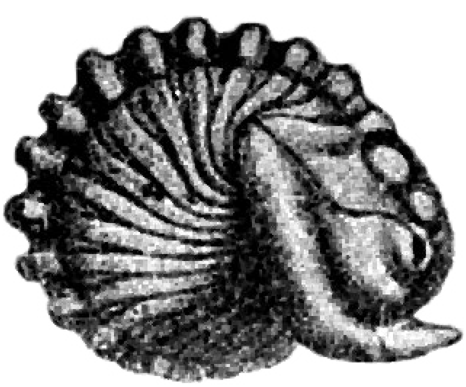
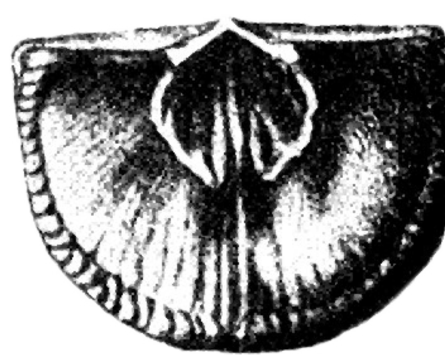
2015 ESAAPG Meeting Field Trip #1e Guidebook

Stratigraphy and Sedimentology of the Upper Ordovician Southeastern Indiana

Field Trip Leader: **Ben Dattilo**, Indiana University Purdue University Fort Wayne

Contributing Authors
Christopher Aucoin, **Carlton Brett**, University of Cincinnati, **Thomas J. Schramm**, Louisiana State University





Guidebook
2015 ESAAPG Meeting Field Trip #1

Stratigraphy and Sedimentology of the Upper Ordovician in Southeastern Indiana

Saturday, September 19, 2015 8:00 AM to 6:30 PM

Field Trip Leader: Benjamin F. Dattilo

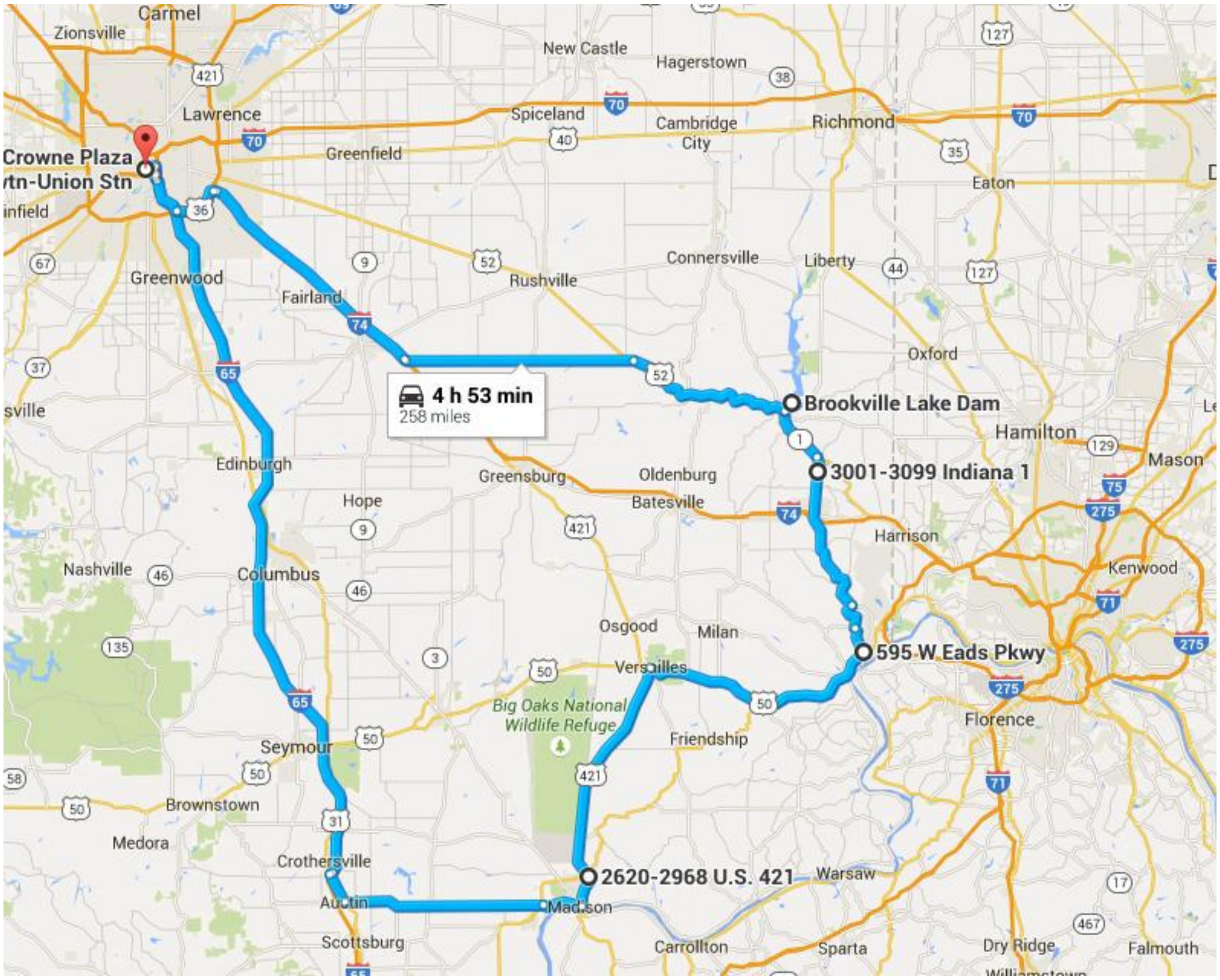
Contributing Authors: Christopher Aucoin, Carlton Brett, Thomas Schramm

This trip will cover the high-resolution sequence stratigraphy, depositional environment, process sedimentology, and paleontology of four spectacularly fossil-rich exposures of the Cincinnati Upper Ordovician (internationally the Katian Stage; in North America the Cincinnatian Series) in southeastern Indiana. Stops include Madison (Richmondian through Silurian), Lawrenceburg (Edenian and Maysvillian), Southgate Hill (Deeper water Richmondian), and Brookville Dam (Maysvillian) . The Cincinnatian is characterized by alternating beds of shell-rich limestones (shell beds) and fossil poor, mudstones. Limestone-rich and mud-rich intervals define meter scale and 10-meter-scale cycles.

The sedimentological processes that generated these beds and cycles are the subject of recent research. We will discuss the role of high energy events and fluctuating sediment supply in generating these strata, and discuss the possibility of correlating meter-scale cycles across facies transitions over tens of kilometers of distance using physical, paleontological, and geochemical techniques. We will also discuss how sedimentological processes lead to the destruction of organic matter in a succession of obviously fossil-rich strata. There will be ample opportunity to collect a spectacularly fossil-rich slab, and perhaps even a perfect trilobite! The trip will depart from the Crowne Plaza Indianapolis at 8:00 AM and return at 6:30 PM. Antendees are urged to be flexible in scheduling Saturday evening activities.

Contents

Road Log



Map showing the route of the field trip

Start: Crowne Plaza Indianapolis 123 West Louisiana Street, Indianapolis

Leave 8:00

1. Head north on S Illinois St toward W Louisiana St (0.2 miles)
2. Turn right onto W Maryland St (0.4 miles)
3. Slight right onto E Maryland St (0.1 miles)
4. Slight right onto E Washington St (0.3 miles)
5. Turn right onto the Interstate 65 S/Interstate 70 W ramp to Louisville/St. Louis (0.4 miles)
6. Merge onto I-65 S/I-70 W (0.4 miles)
7. Keep left at the fork to continue on I-65 S, follow signs for Louisville (73.6 miles)

8. Take exit 36 for US-31 toward Austin/Crothersville (0.4 miles)

9. Turn left onto US-31 S (3.0 miles)

10. Turn left onto IN-256 E/E Main St Continue to follow IN-256 E (19.5 miles)

11. Turn left onto IN-56 E/Ohio River Scenic Byway (3.9 miles)

12. Turn left onto US-421 N/Jefferson St. Follow US 421 north to large roadcut (3.2 miles)

Total Leg: 106 mi / 1 h 50 min

Arrive 10:00

Stop 1: Madison, Indiana US 421 near Indiana 62 (38.778182, -85.365295)

Leave 11:30

13. Head northwest on US-421 N toward IN-62 E (22.4 miles)

14. Turn right onto US-50 E/Indiana's Historic Pathways - North Spur (24.1 miles)

15. Turn left onto Bielby Rd (354 feet)

Total Leg: 46.6 mi / 53 min

Arrive 12:23 (Lunch)

Stop 2: Lawrenceburg, Beilby Road (Indiana 48) and US 50 (39.092605, -84.872221)

Leave 13:15

16. Head northwest on IN-48 W/Bielby Rd toward Tower Rd (2.6 miles)

17. Turn right onto Pribble Rd (3.0 miles)

18. Turn left onto IN-1 N, drive north to the large road cut (15 miles)

Total Leg: 20.7 mi / 28 min

Arrive 13:45

Stop 3: St Leon/Southgate Hill, 3001-3099 Indiana 1, West Harrison, Indiana (39.343371, -84.954095)

Leave 15:00

19. Head north on IN-1 N toward Old Indiana 1 (1.6 miles)

20. Turn left onto US-52 W (5.9 miles)

21. Continue straight onto State Rte 101 N/Main St, Continue on Rte 101 N (1.3 miles)

22. Turn left (0.2 miles)

23. Slight left (0.2 miles)

Total Leg (9.2 mi / 16 min)

Arrive 15:20

Stop 4: Brookville Dam Spillway (39.439262, -84.999815)

Leave 17:00

28. Slight left onto IN-244 W (21.8 miles)

29. Turn right onto the I-74 W/US-421 N ramp to Indianapolis (0.2 miles)

30. Merge onto I-74/US-421 N (24.4 miles)

31. Take the Interstate 465 N exit toward Shadeland Ave. (0.2 miles)

32. Keep left at the fork, follow signs for Interstate 465 S/Interstate 74 W and merge onto I-465 S (4.6 miles)

33. Take the exit onto I-65 N (3.9 Miles)

34. Take exit 110A for Morris St toward Prospect St (0.3 miles)

35. Slight right toward Leonard St (371 feet)

36. Continue onto Leonard St (0.2 miles)

37. Turn left onto Virginia Ave (0.6 miles)

38. Turn left onto E South St (0.6 miles)

39. Turn right onto S Illinois St (371 feet)

Total Leg: 76.1 mi / 1 h 26 min

Arrive 18:30

End: Crowne Plaza Indianapolis 123 West Louisiana Street, Indianapolis

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

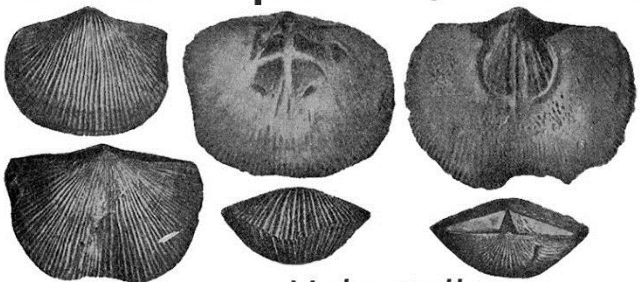
In this guidebook you will see hints of a complex history of stratigraphic nomenclature. Early stratigraphic work by Cummings (1907) in Indiana and others in the immediate area of Cincinnati (summarized by Caster et al., 1955) relied heavily on fossil content to correlate relatively thin units over large 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.

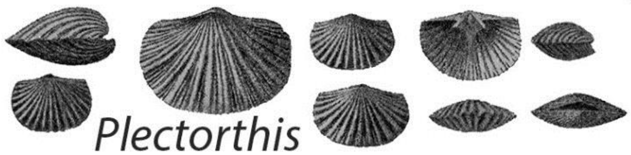
Fossil Identification Charts

Brachiopods (assorted)



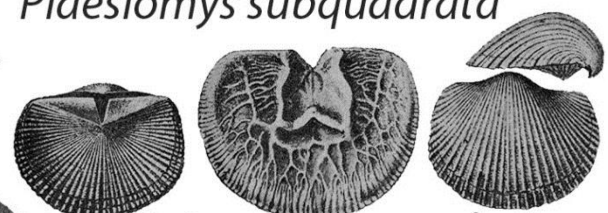
Hebertella

Glyptorthis insculpta



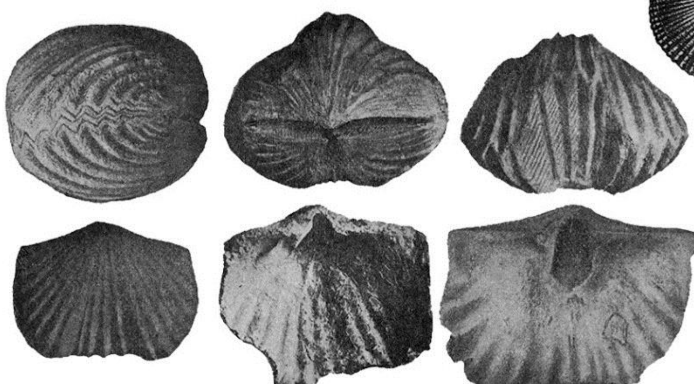
Plectorthis

Plaesiomys subquadrata



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

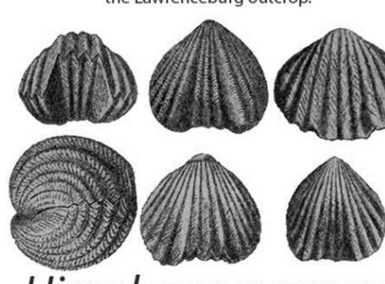
P. ponderosa is the most recognizable of the various named species. It has recently been reassigned to the genus *Vinlandostrophia* by someone from Northern Europe (of course). There is some grumbling about this by North American Paleontologists. Look for it at the top of the Lawrenceburg outcrop.

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.

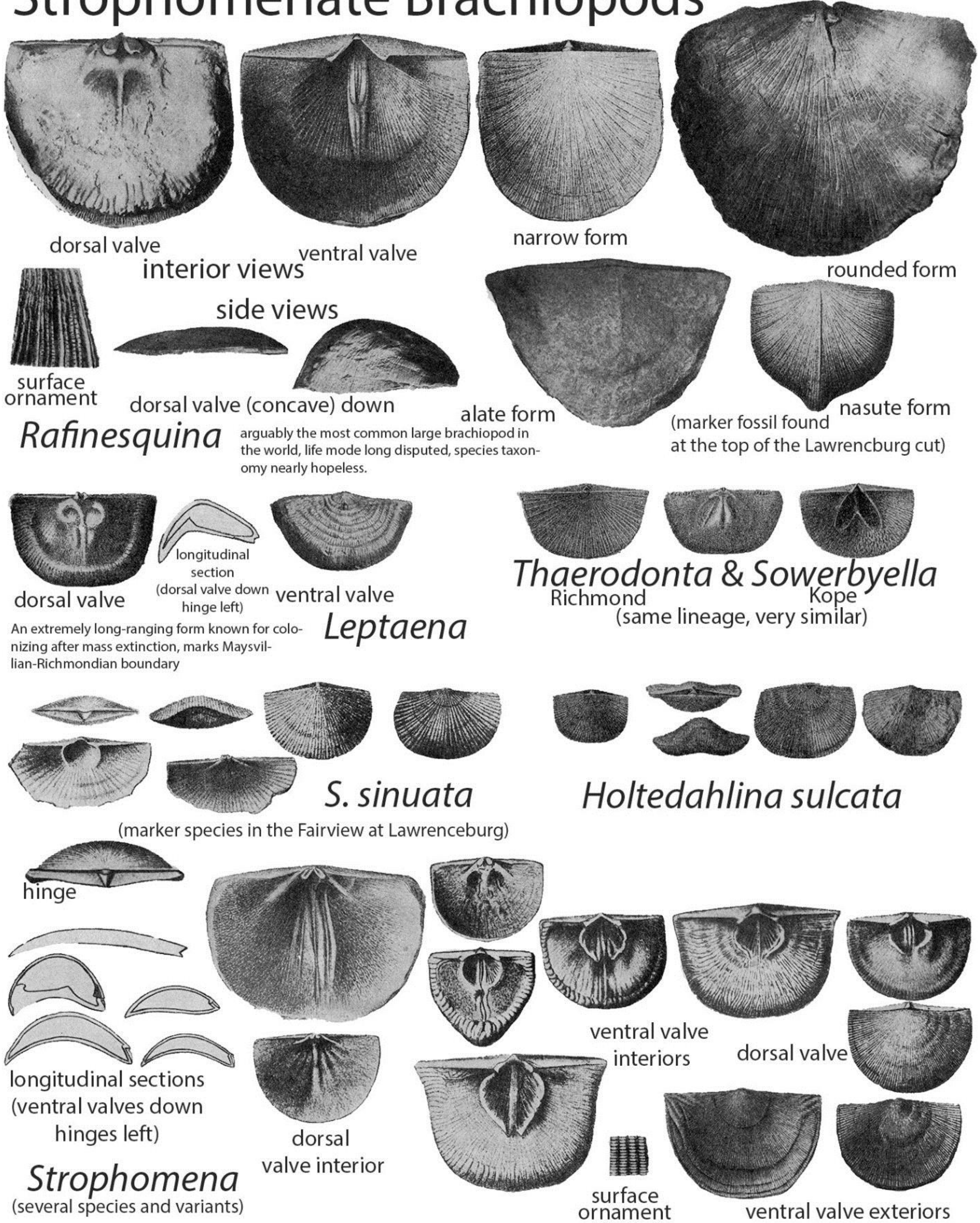
Zygospira

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 very abundant.

Rhynchotrema dentatum

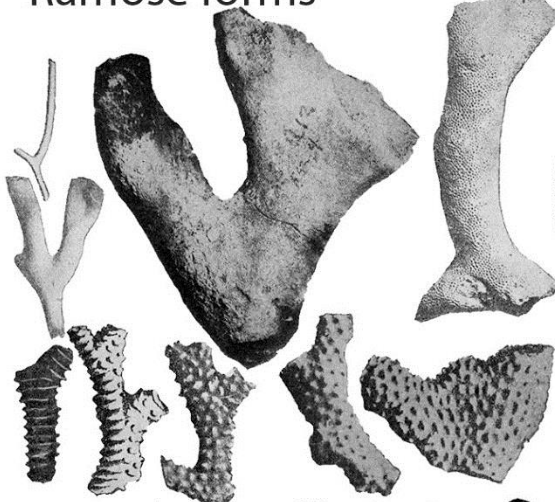
Resemble *Zygospira*, but more triangular. Look for them at the U.S. 27 cut near Richmond.

Strophomenate Brachiopods



Trepostome Bryozoans

Ramose forms

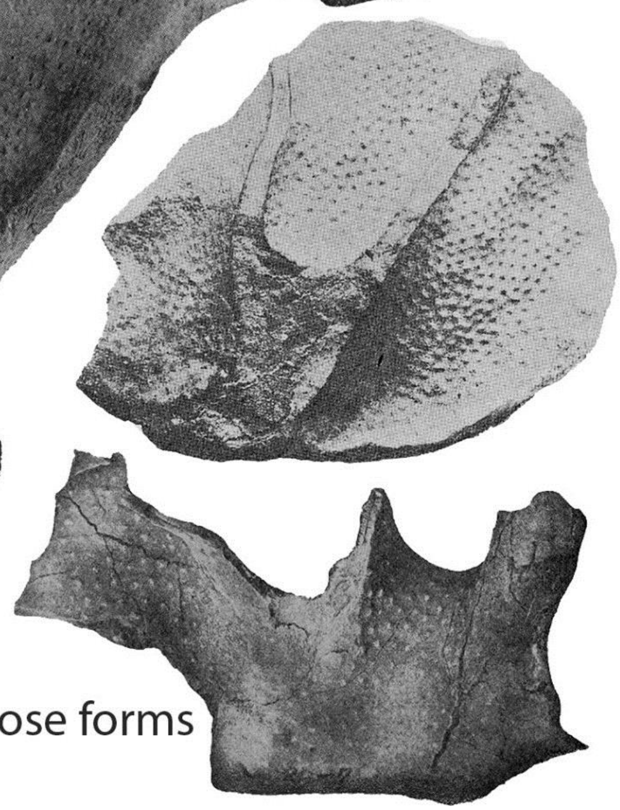


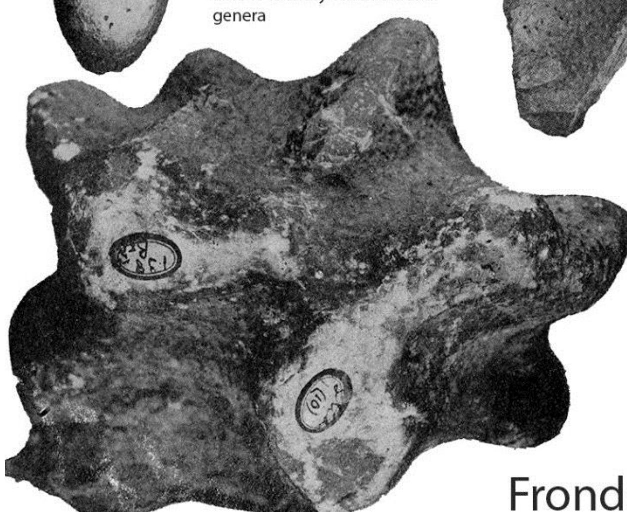
same species different species

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

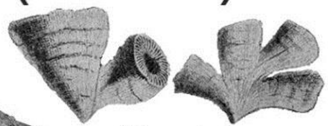




Frondose forms

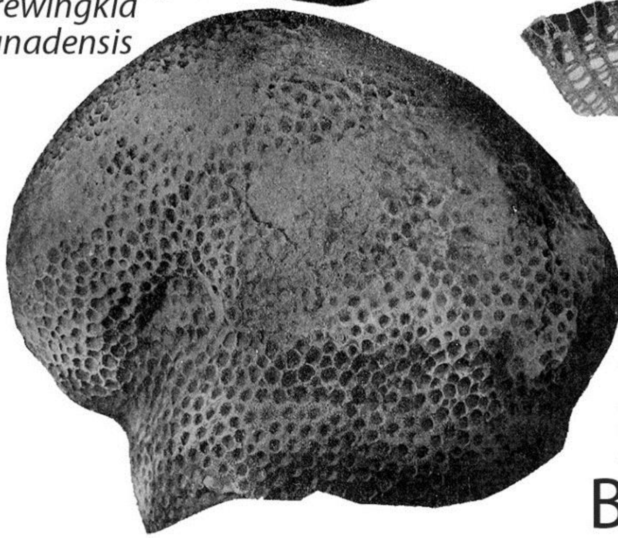
Massive colony

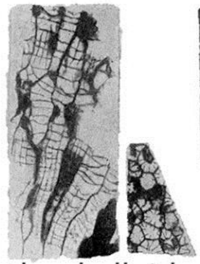
Corals (&stuff)



Streptalasma

Grewingkia canadensis

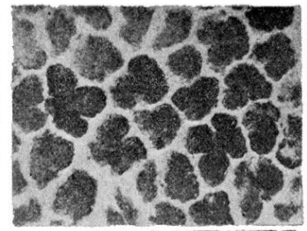




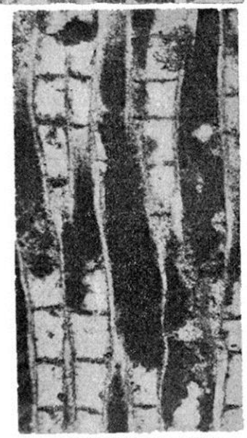
Cyathophylloides

Septae are well developed

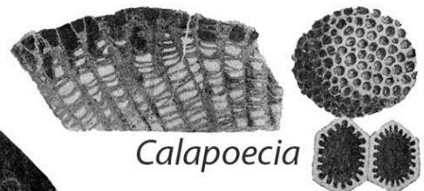
Tetradium



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



longitudinal section through *Tetradium*



Calapoecia

Protarea

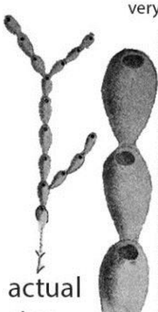
often found encrusting shells.

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

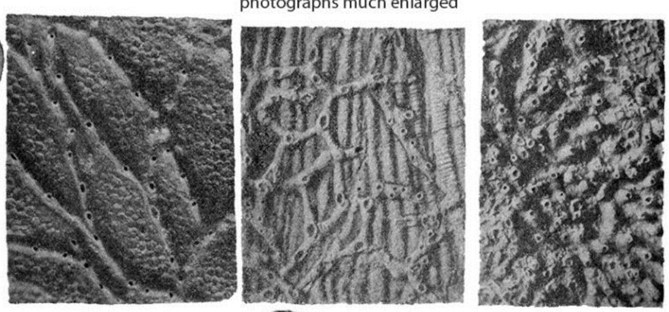
Bryozoans

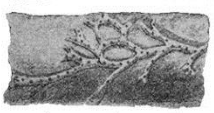
cyclostomes

very tiny lace like encrusters on shells and other bryozoans
photographs much enlarged

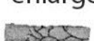


actual size



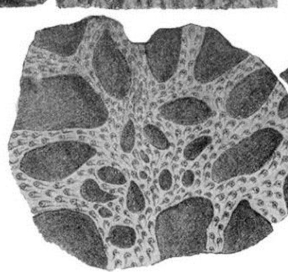


enlarged

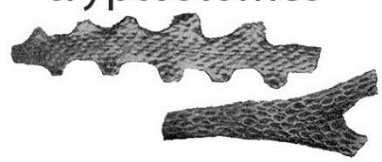


actual size

details

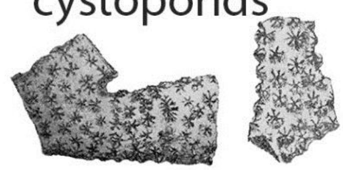


cryptostomes



(enlarged) Cryptostomes are common and commonly overlooked

cystoporids

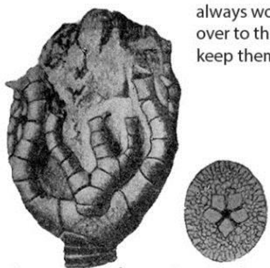


Constellaria

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.



Anomalocrinus incurvus

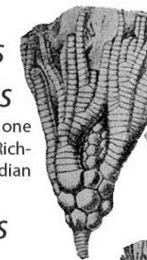
Look for this in the Lawrenceburg cut, Bellevue Member, at the top of the exposure. It is by far the largest Cincinnatian crinoid.

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

Cincinnaticrinus pentagonus

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.



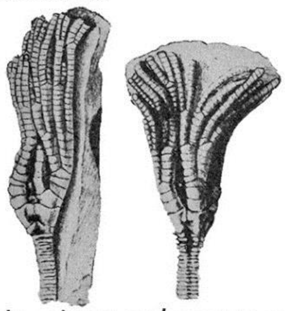
Cupulocrinus polydactylus

you might find this one anywhere in the Richmondian

C. varibrachialus

Plicodendrocrinus casei

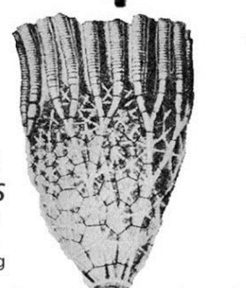
Mostly in the Waynesville and Liberty Formations



Iocrinus subcrassus

Glyptocrinus decadactylus

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

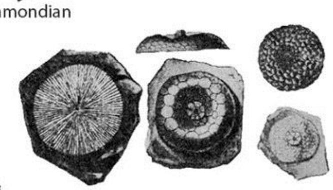


Pychnocrinus dyeri

Maysvillian and lower Richmondian

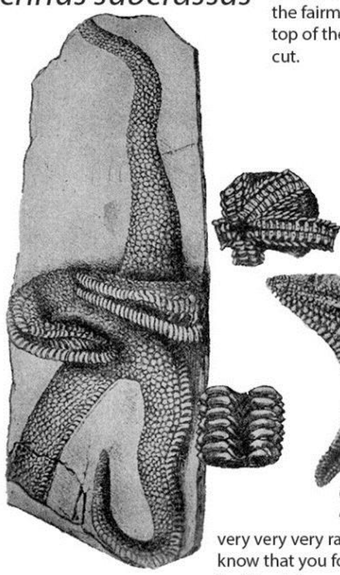
Ectenocrinus simplex

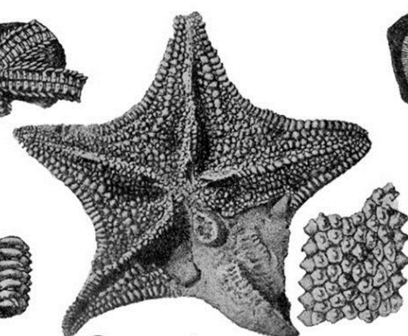
Common in the Kope, near the base of the Lawrenceburg outcrop.



Crinoid holdfasts

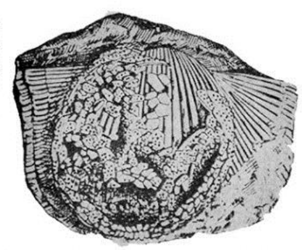
hodfasts are attachment bases for the crinoid. They are often preserved without the rest of the animal.

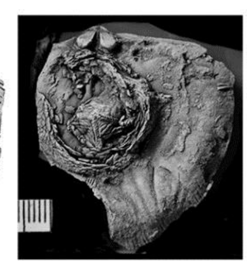




Sea stars

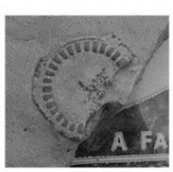
very very very rare. It is best not to let anyone know that you found one until months later. Could lead to violence.





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

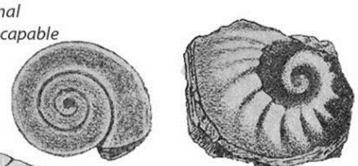
Cyclonema

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.

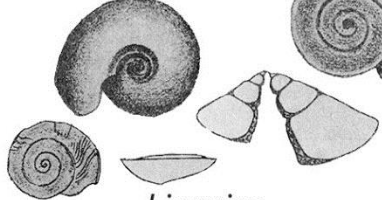
Loxoplocus bowdeni

Hormotoma

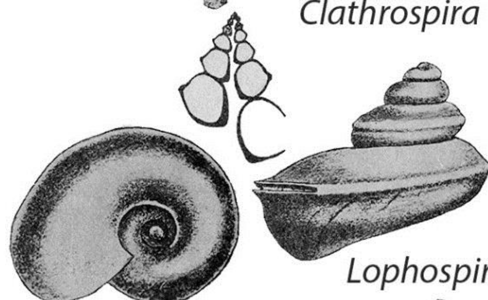
Clathrospira



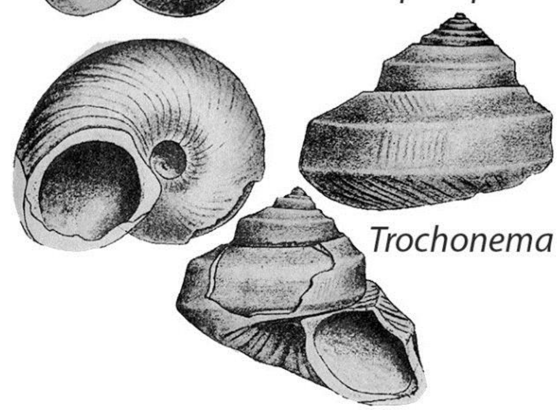
Cyrtolites



Liospira

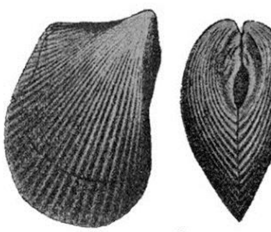


Lophospira

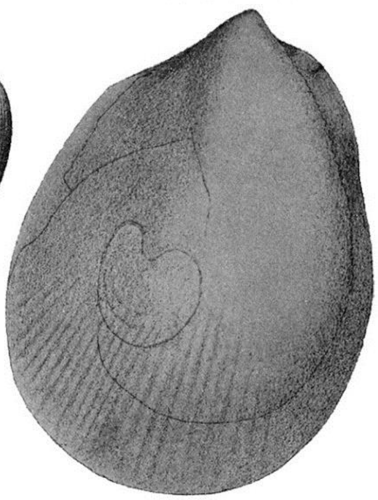


Trochonema

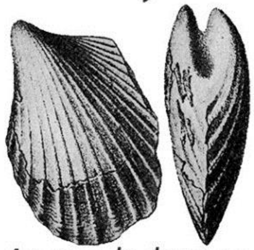
clams



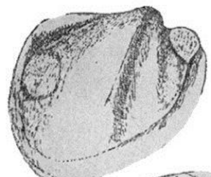
Ambonychia

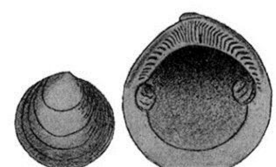


Anomalodonta gigantea

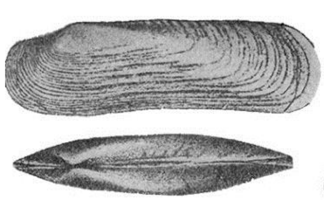


Anomalodonta costata

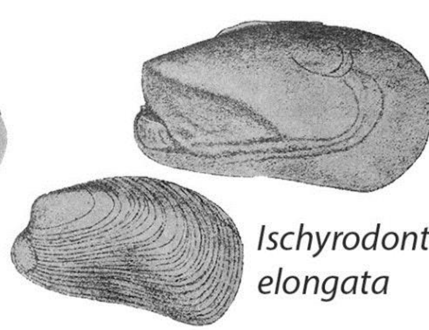




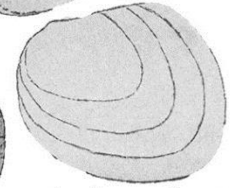
Ctenodonta



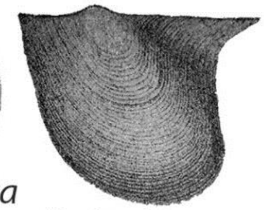
Cymatonota



Ischyrodonta elongata



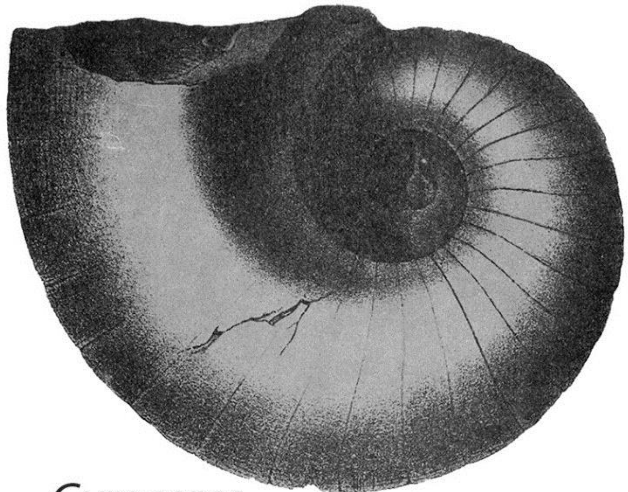
Ischyrodonta ovalis



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.

Cephalopods



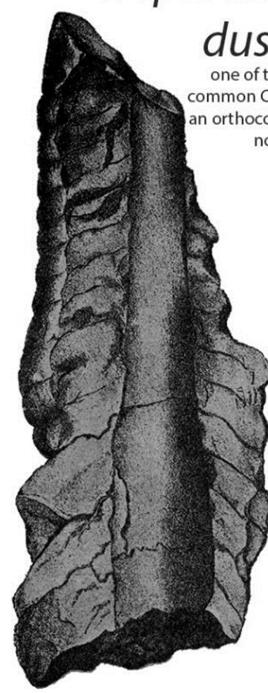
Gyroceras

Actinoceroids

Generally straight shells with these "beaded" looking siphuncles

Treptoceras duseri

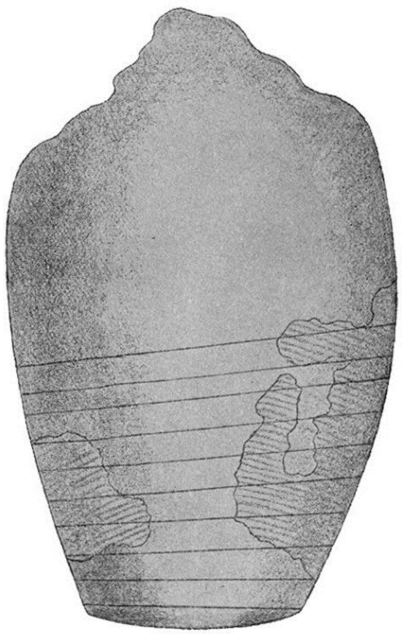
one of the more common Cincinatian orthoconic actinoceroids.



Endoceroids

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

"Cyrtoceras"

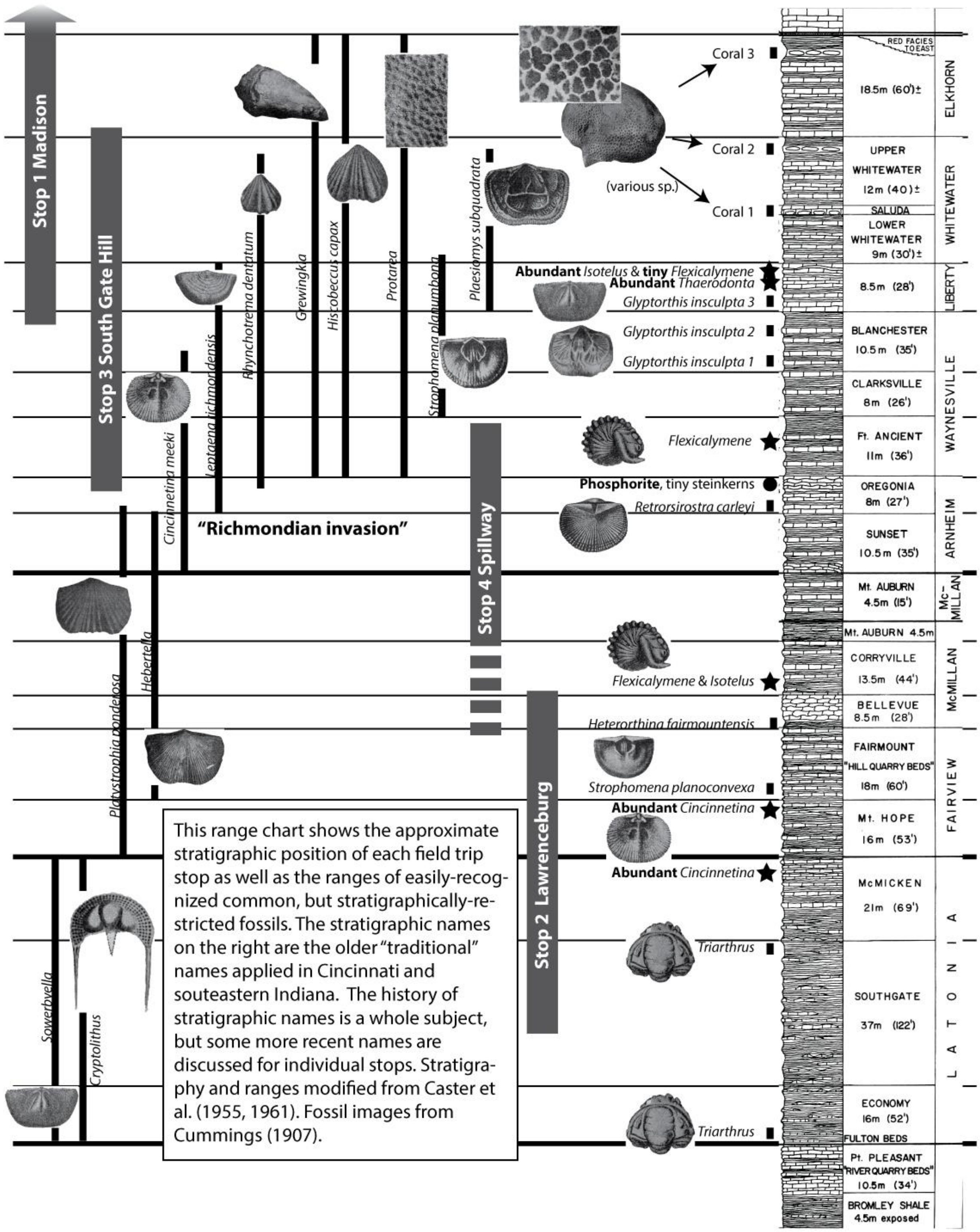


Gomphoceras

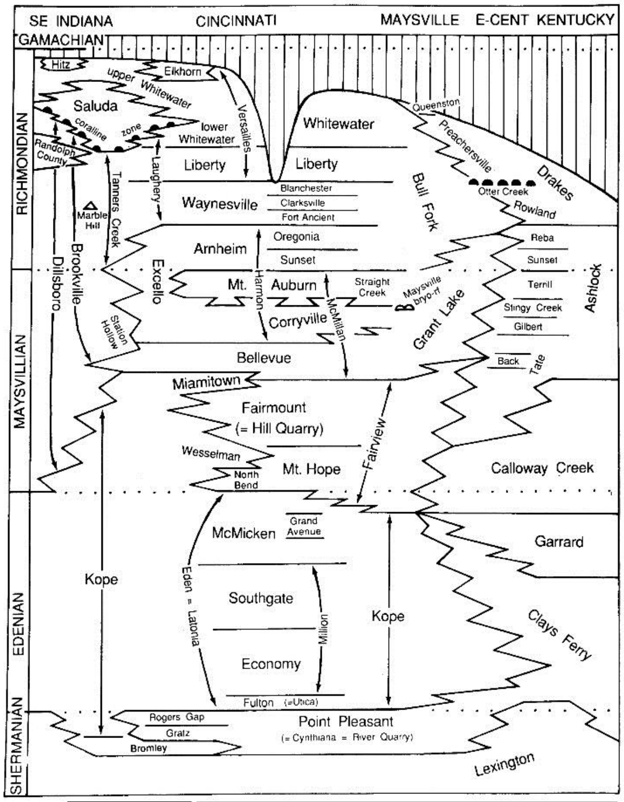
These are rather rare.

Tentaculites

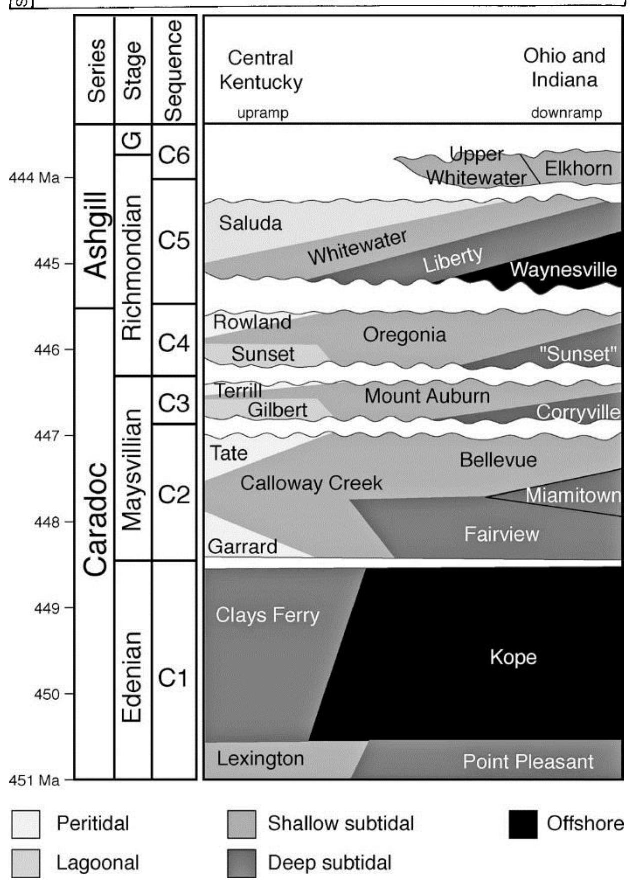
Not a cephalopod! Tentaculites is . . .something else. Look for them, rather small things, on the first shaly bench at Southgate Hill exposure.



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).

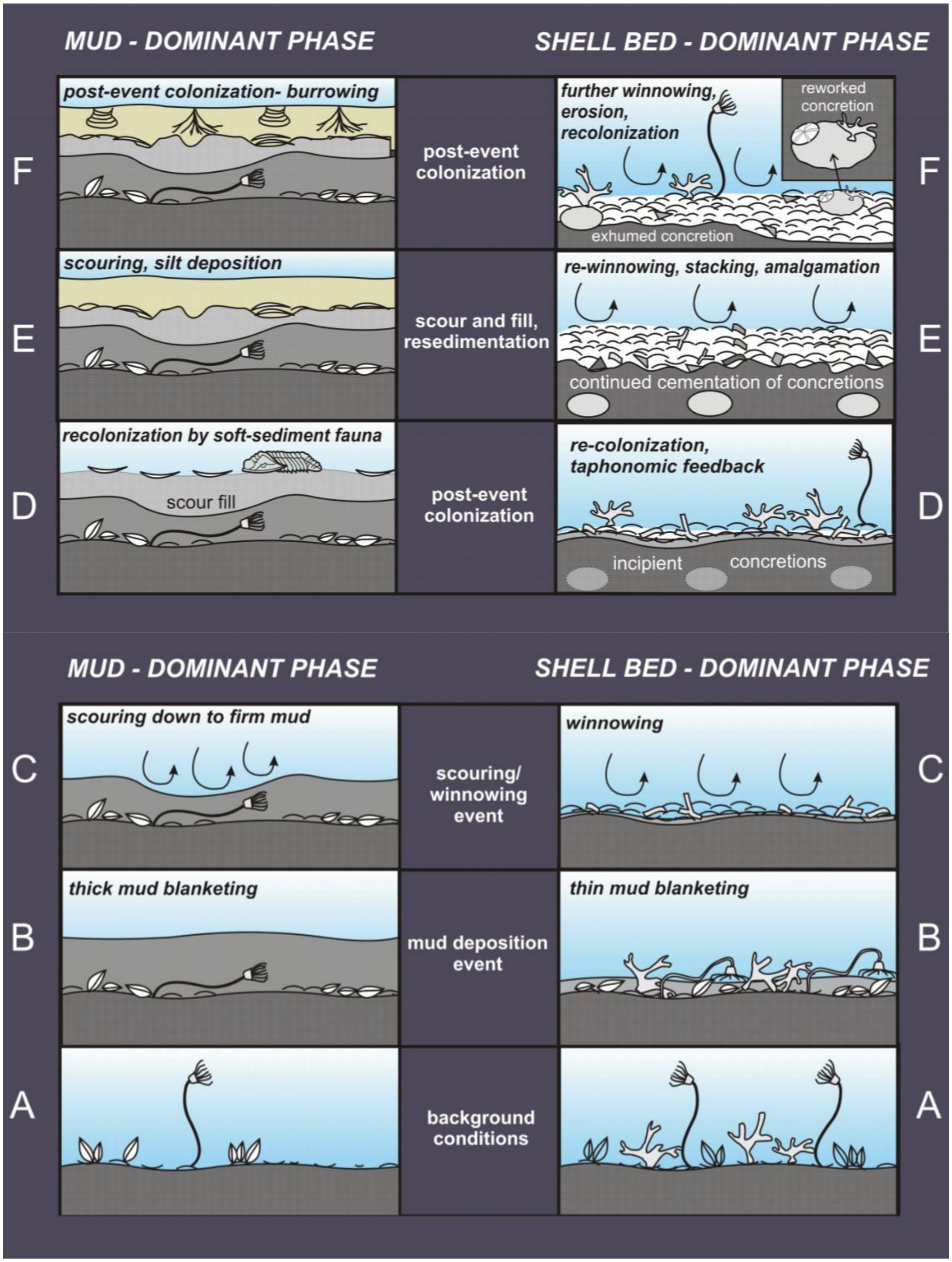


Diagram showing the development of muddy and shelly horizons in the Cincinnatian. Shell beds develop during periods of low siliciclastic sediment supply. Mud beds develop during times of high sediment supply. Storms (or other high energy events like tsunami) affect both types of beds, and do not constitute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

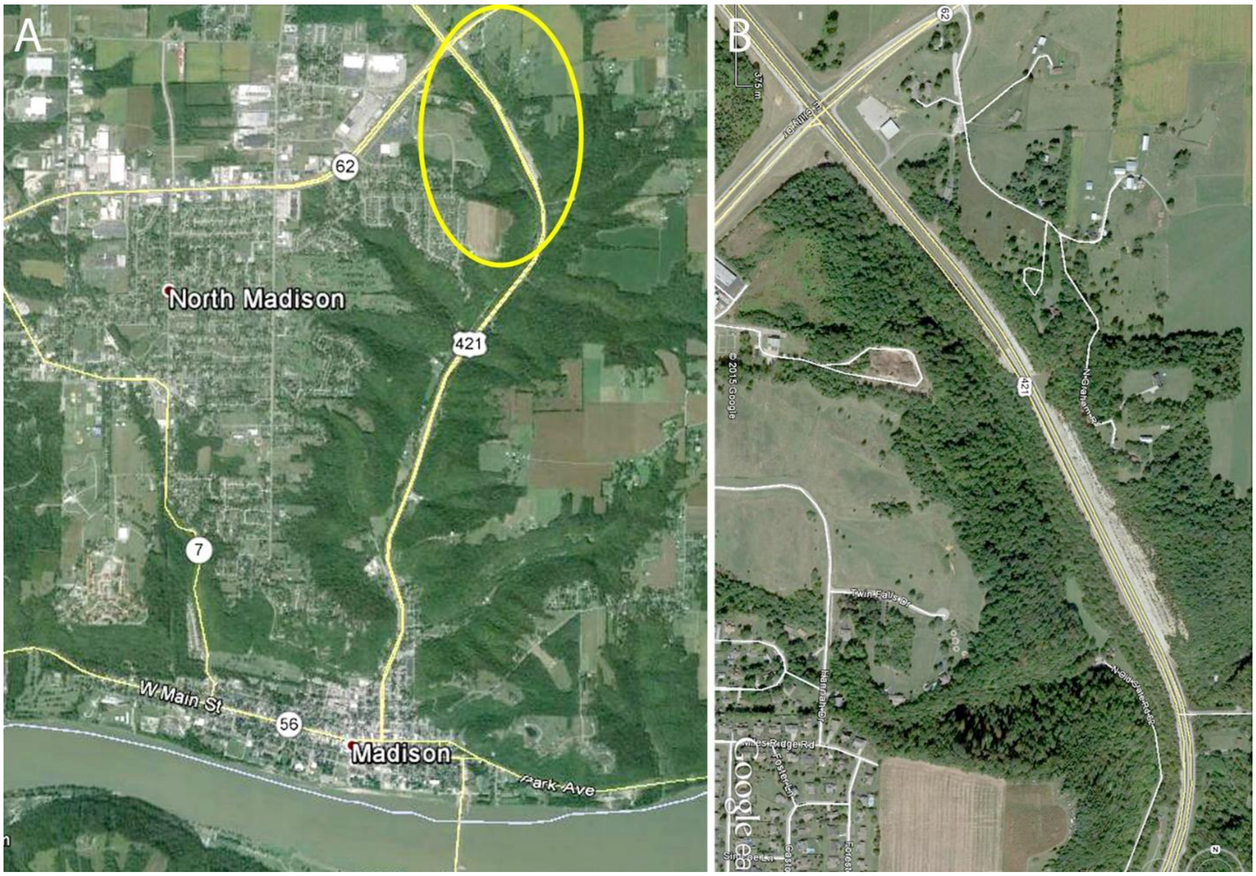
Stop Descriptions

Stop 1: Madison

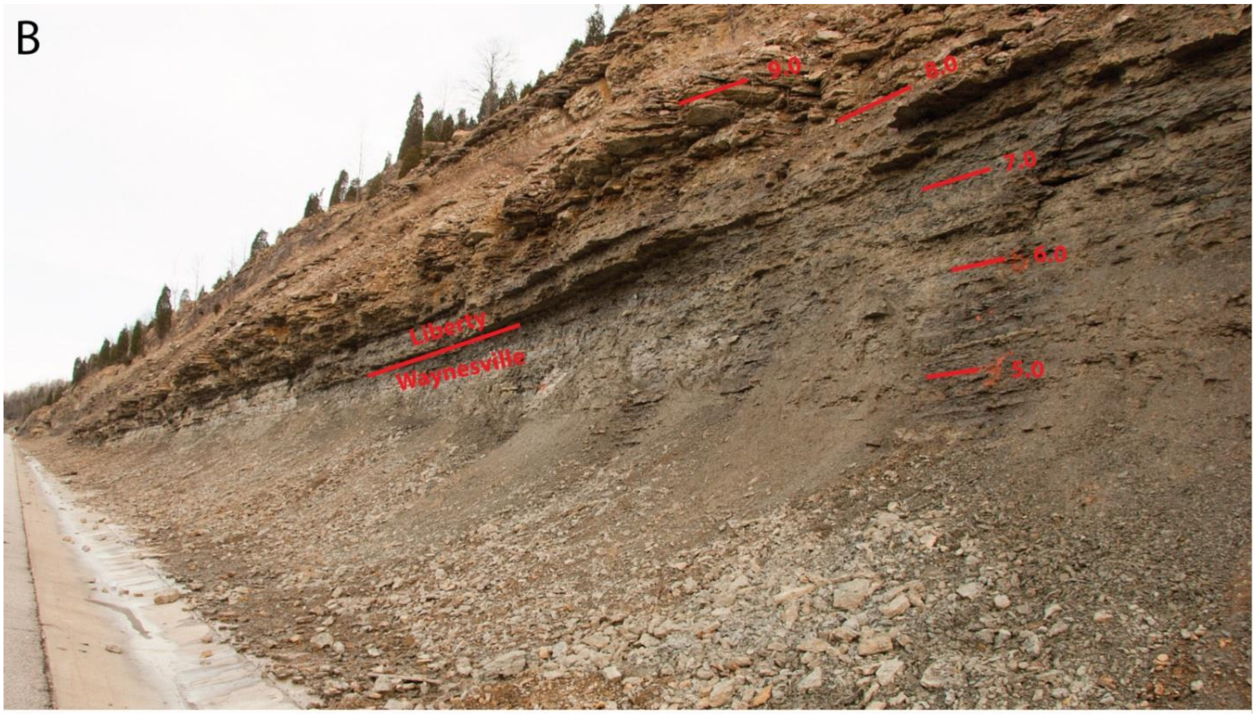
Ben Dattilo, Carl Brett, Christoper Aucoin

38.778182, -85.365295

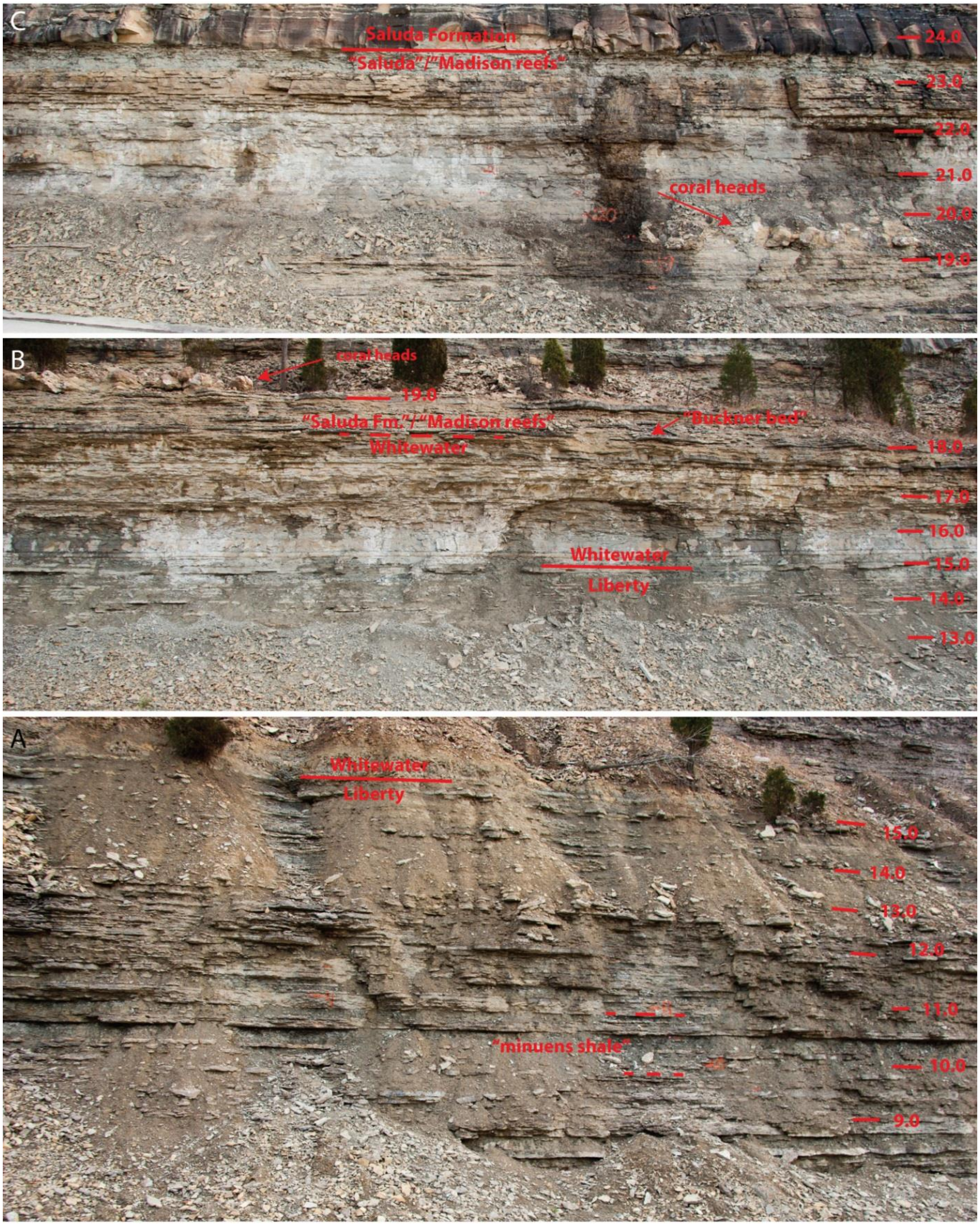
Road cut on US 421 near Indiana 62, Madison, Indiana



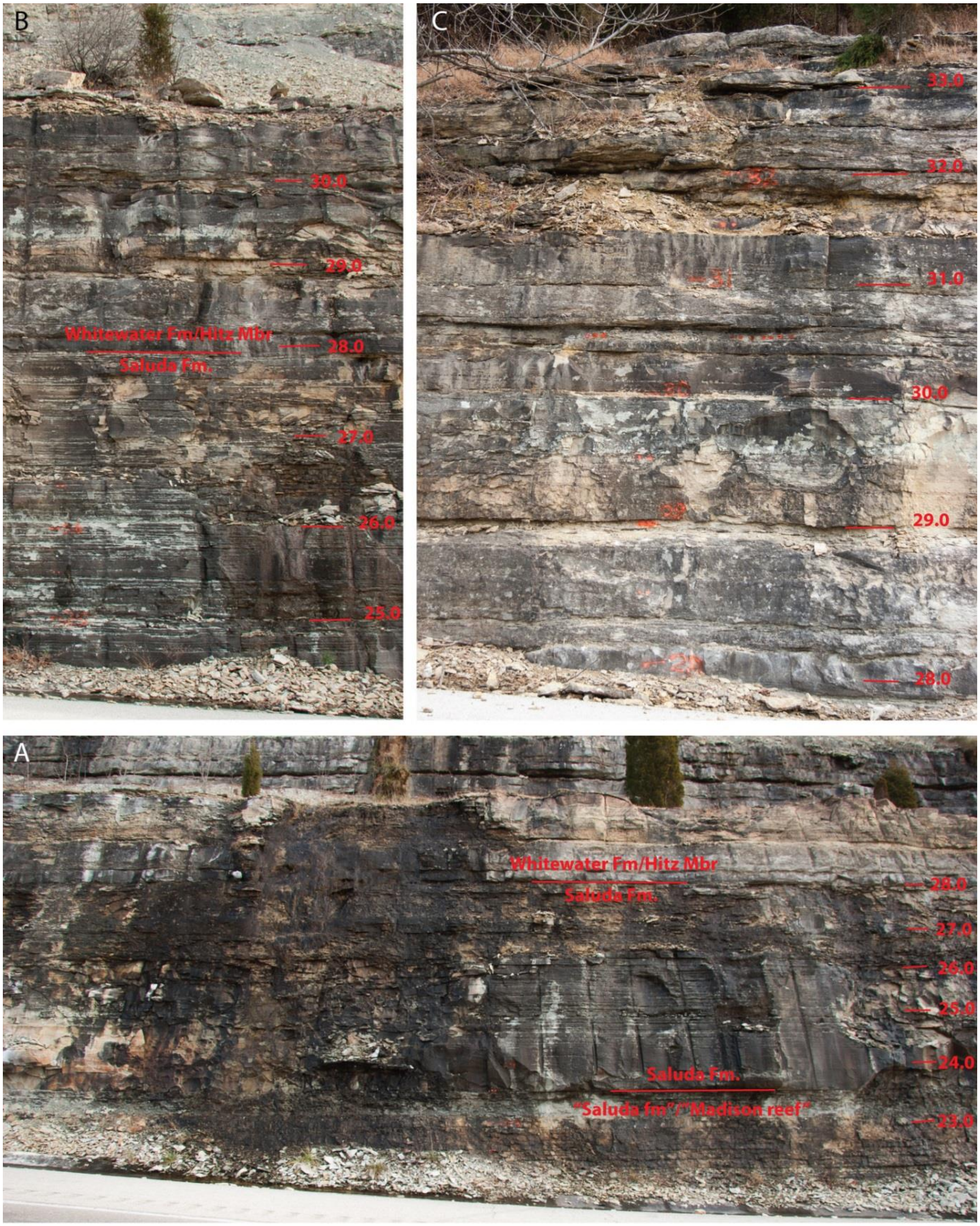
Satellite images of the Madison outcrop. A. Contextual view showing relationship to Madison and North Madison. B. Closeup view of this long outcrop.



Outcrop photos showing the interval 0.0 through 9.0 meters, Waynesville and Liberty Formations.

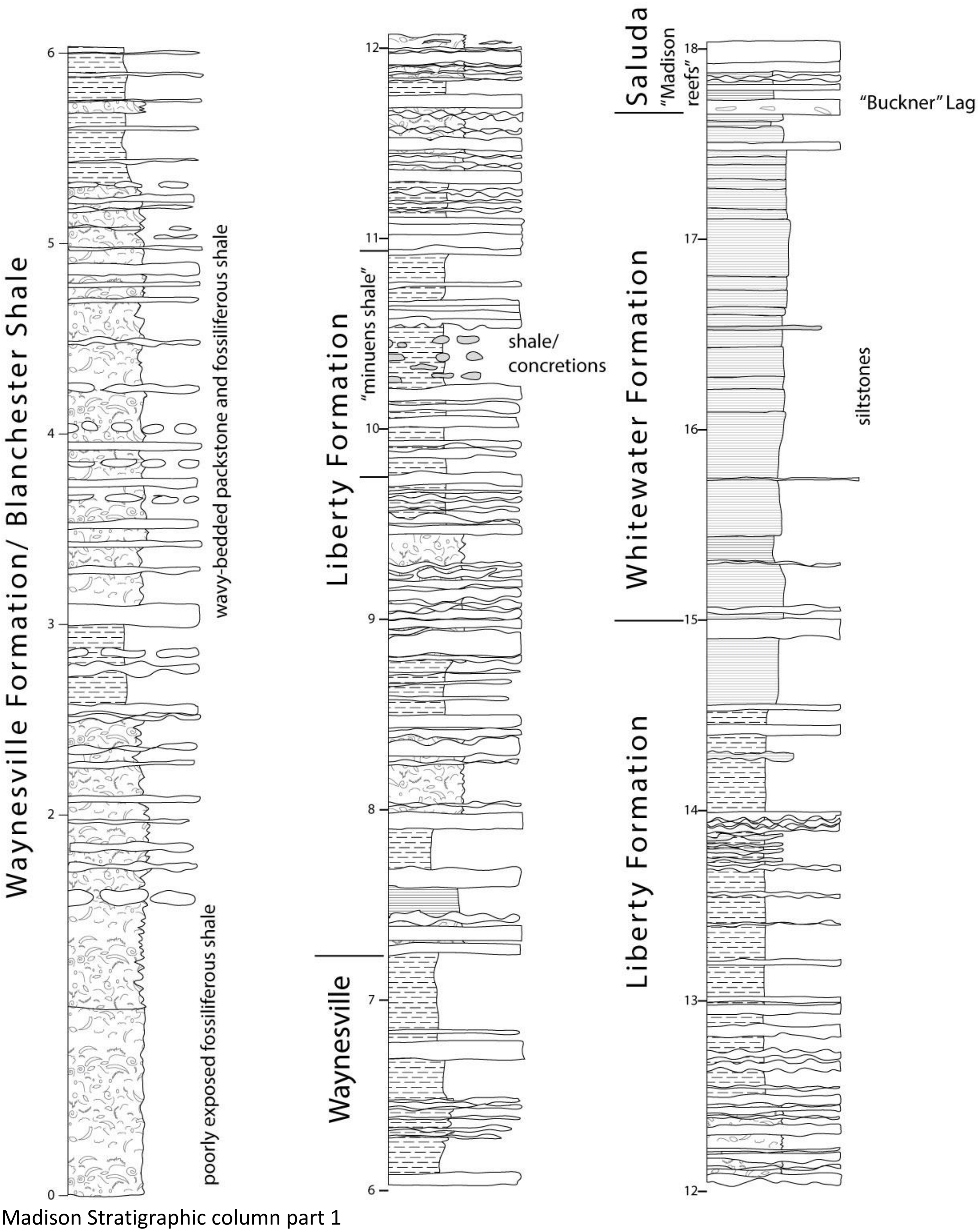


Outcrop photos showing intervals 9.0 m through 24.0 meters, Liberty, Whitewater, and Saluda formations.

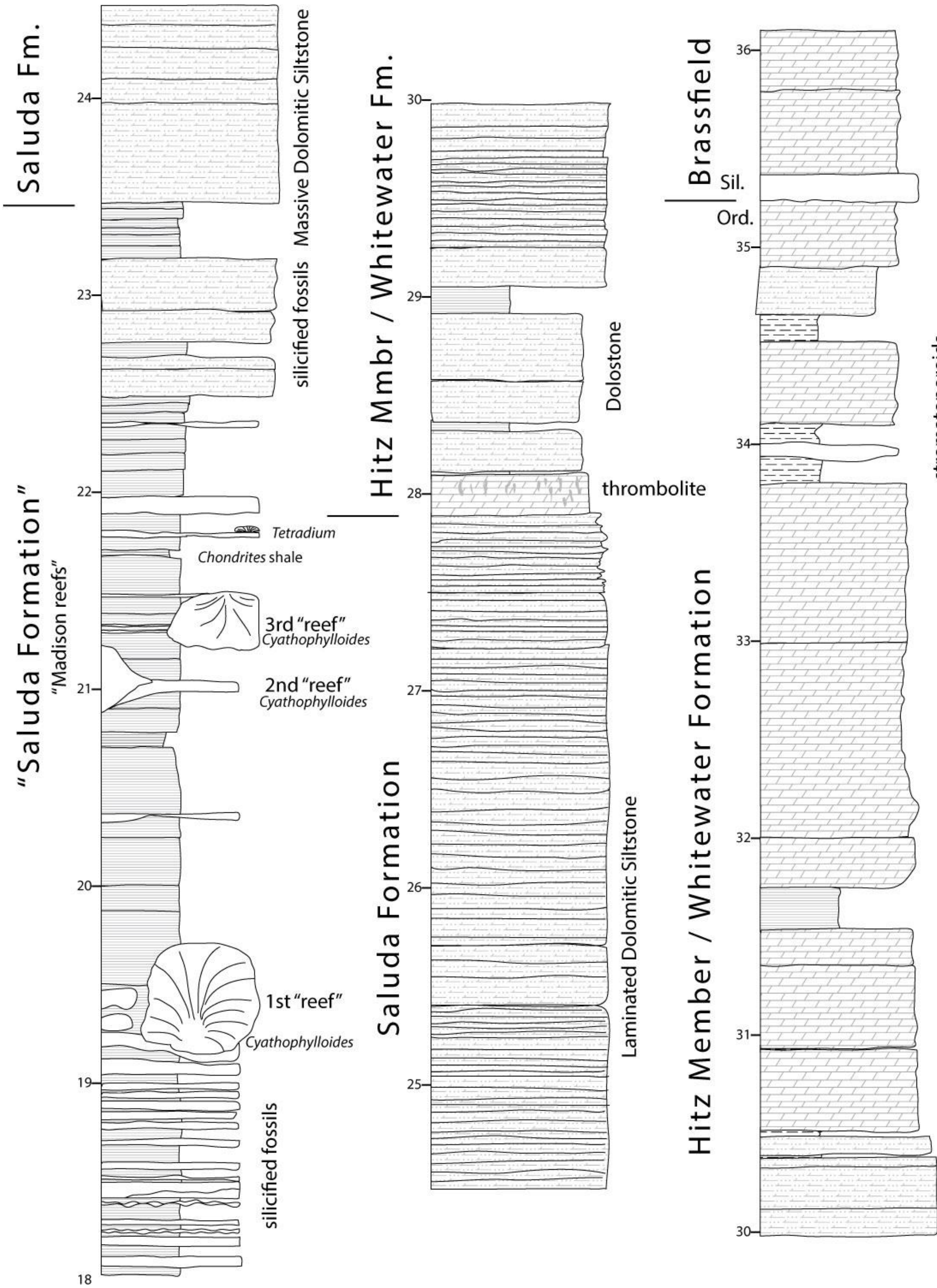


Outcrop photos showing interval 23.0 through 33.0 meters, “Madison reefs”, Saluda Formation, Whitewater Formation, Hitz Member.

Outcrop photographs of the upper part of the Madison outcrop showing the Ordovician-Silurian unconformity and the Silurian formation. Geologist, for scale, circled in upper photograph



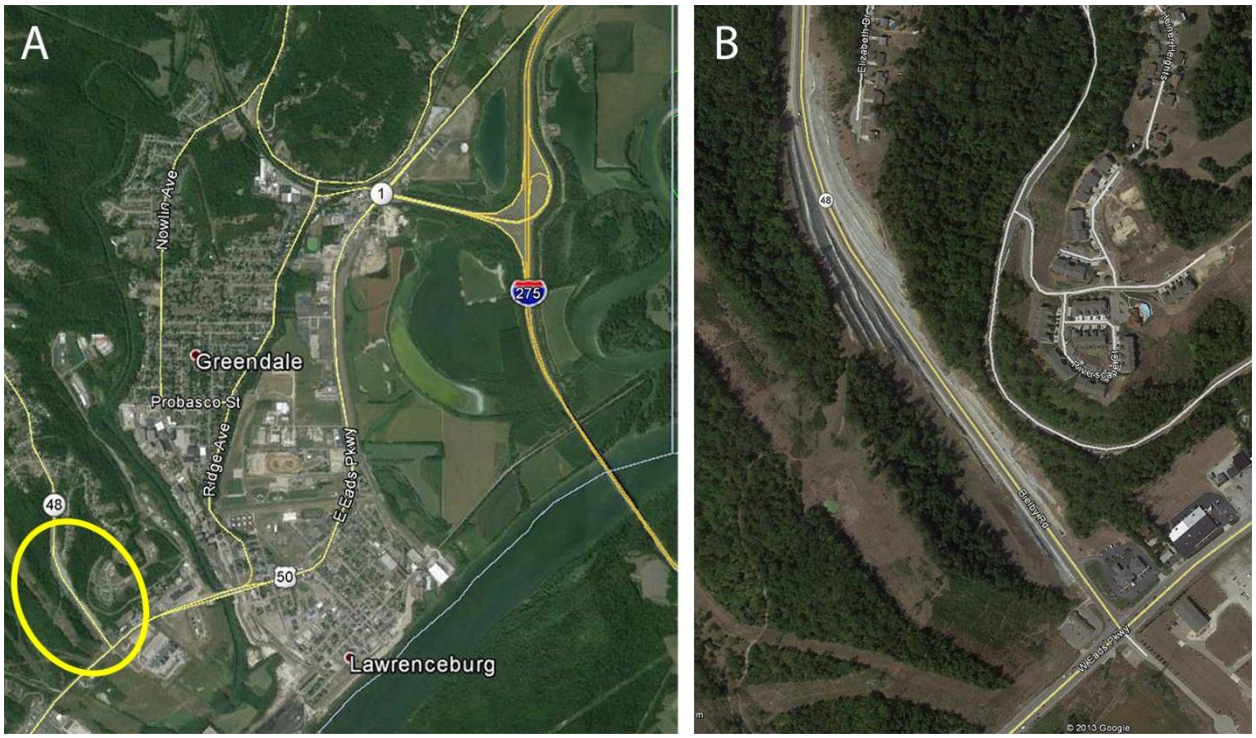
Madison Stratigraphic column part 1



Madison Stratigraphic column part 2

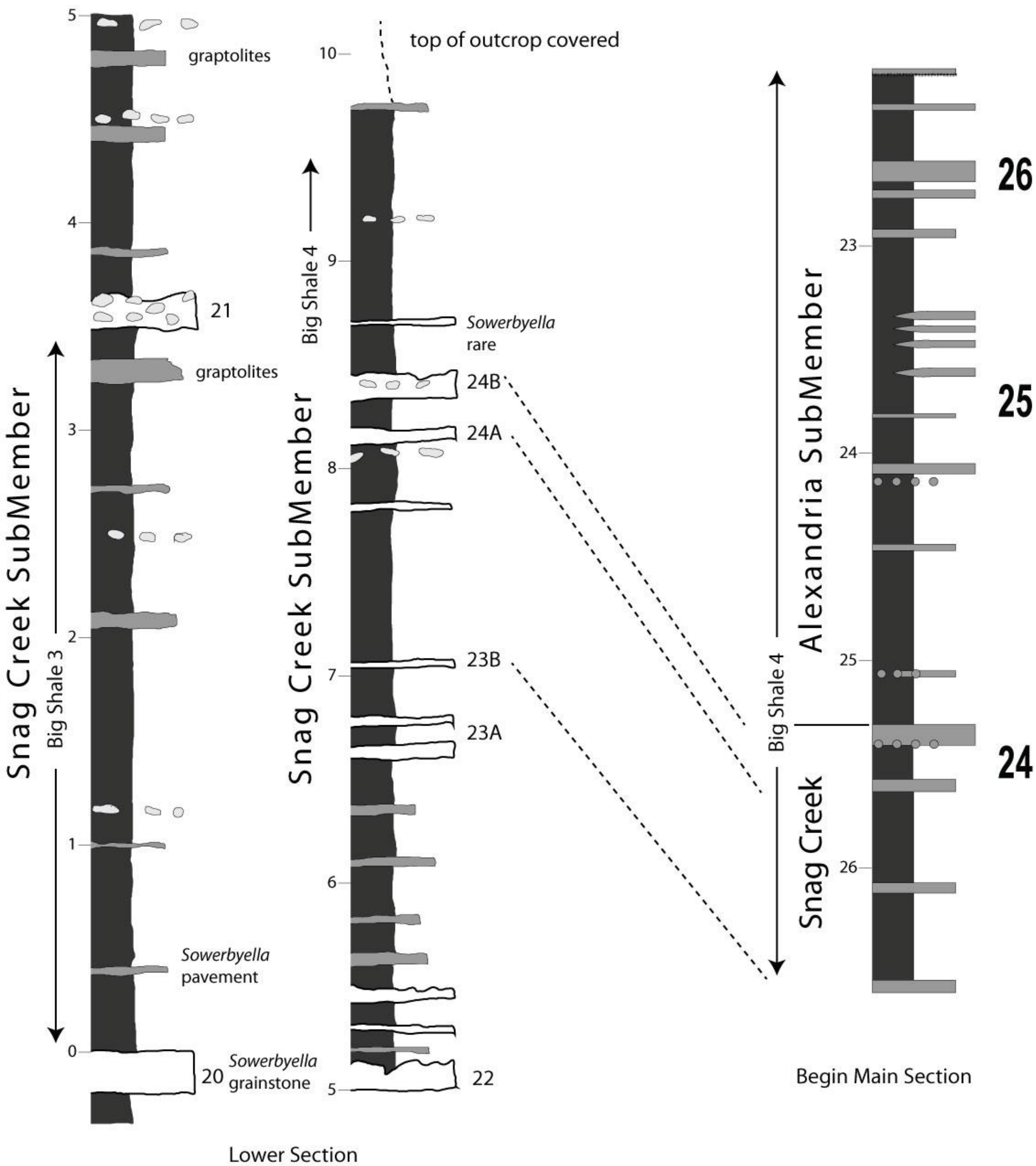
Stop 2. Lawrenceburg

Ben Dattilo, Tom Schramm, Carl Brett
39.096214, -84.875969
Roadcut on Indiana 48 at US 50 near Lawrenceburg, Indiana

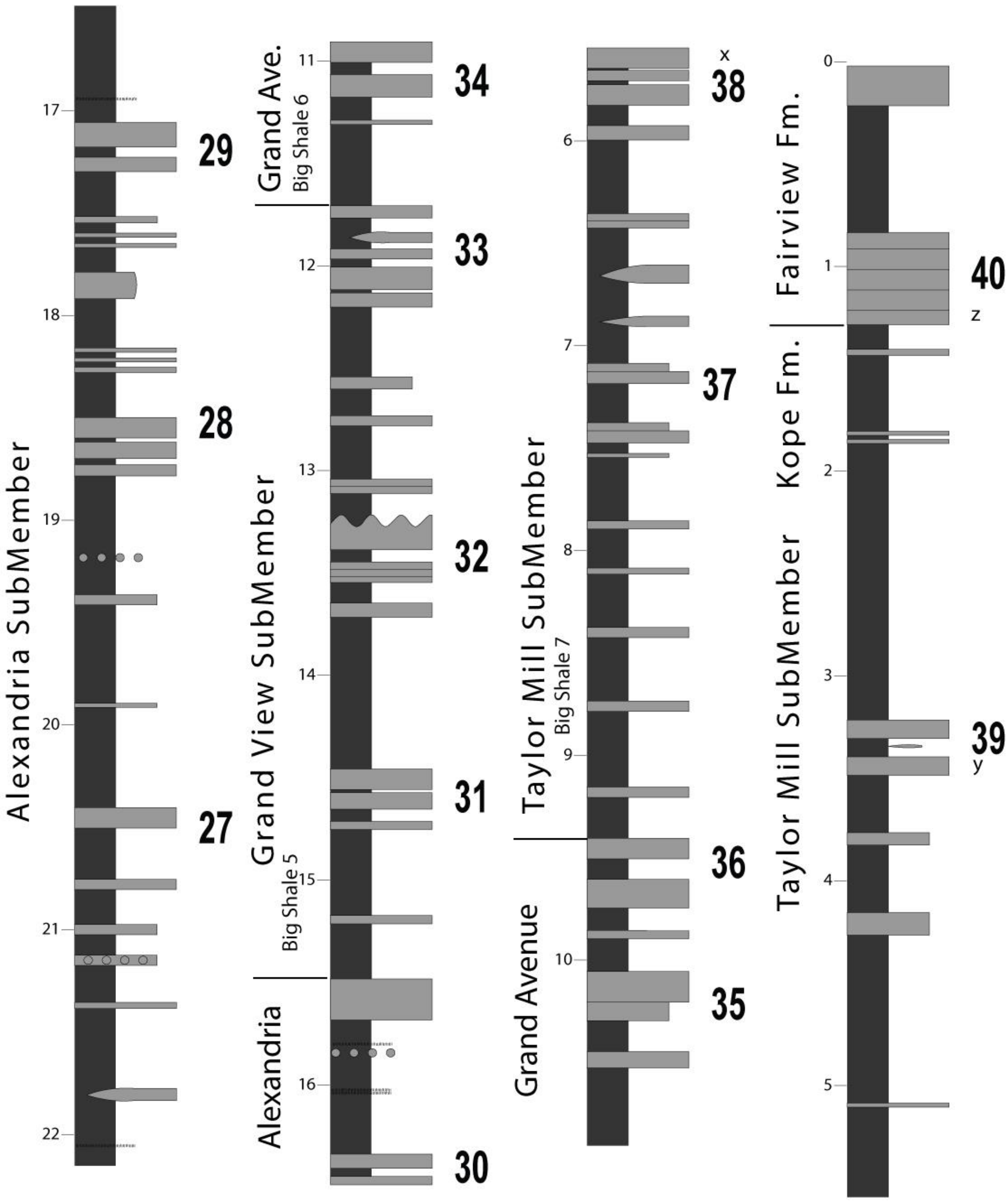


Satellite images of the Lawrenceburg outcrop. A. Contextual view showing relationship to Greendale and Lawrenceburg. B. Closeup view of this large outcrop.

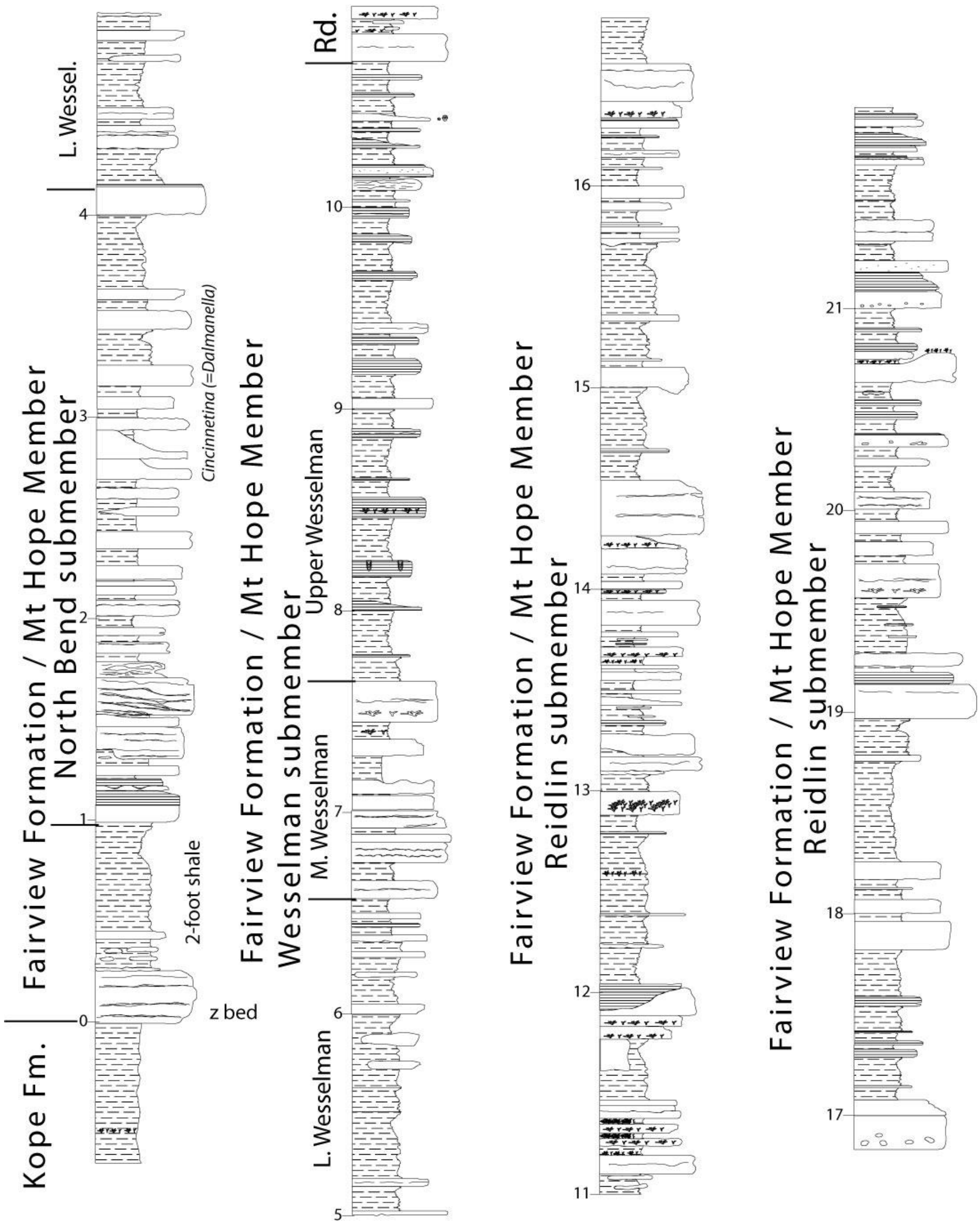
Outcrop photo of the Lawrenceburg cut showing nearly the entire succession from the Kope to the Bellevue.



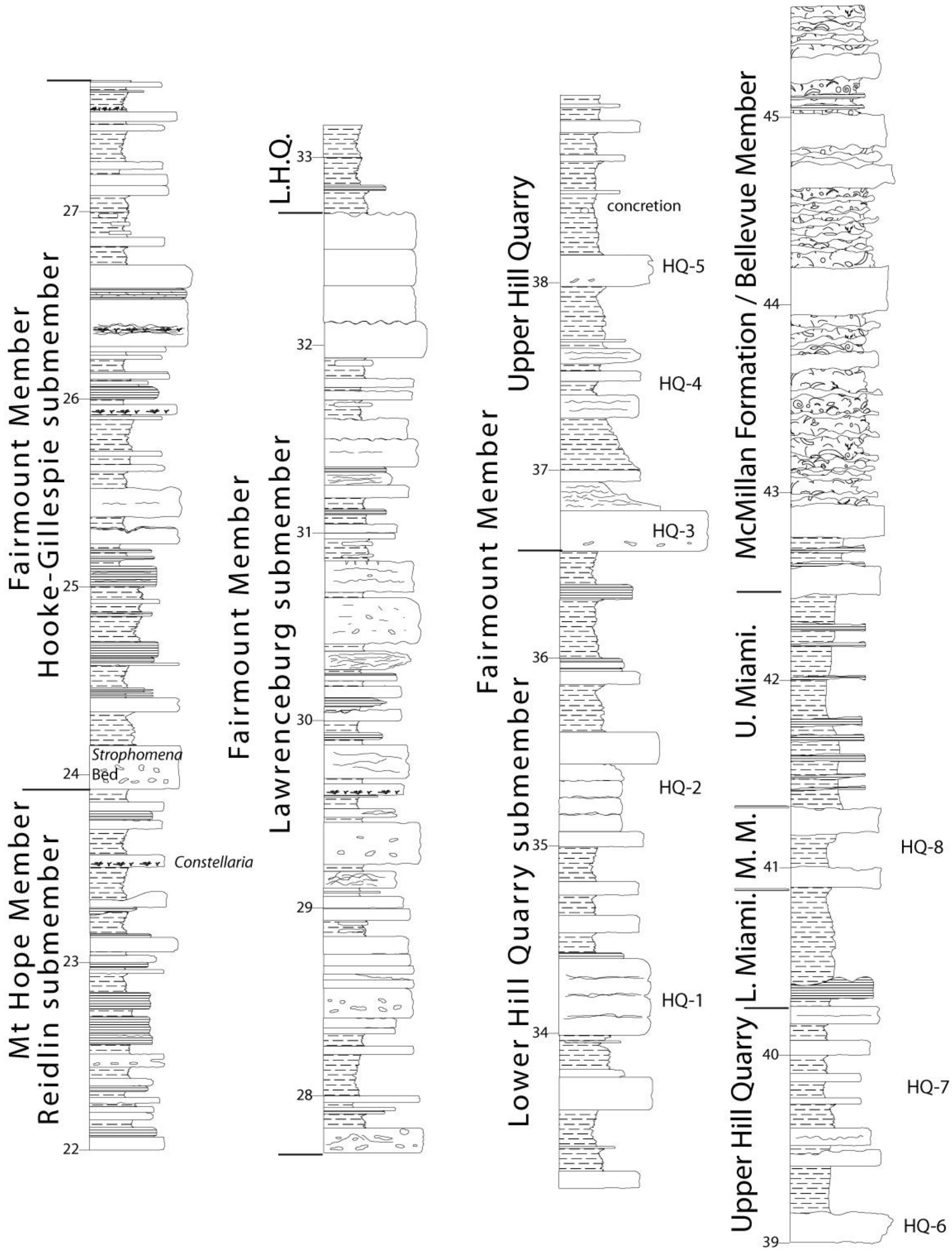
Lawrenceburg stratigraphic column part 1



Lawrenceburg stratigraphic column part 2



Lawrenceburg stratigraphic column part 3



Lawrenceburg stratigraphic column part 4

Stop 3. South Gate Hill

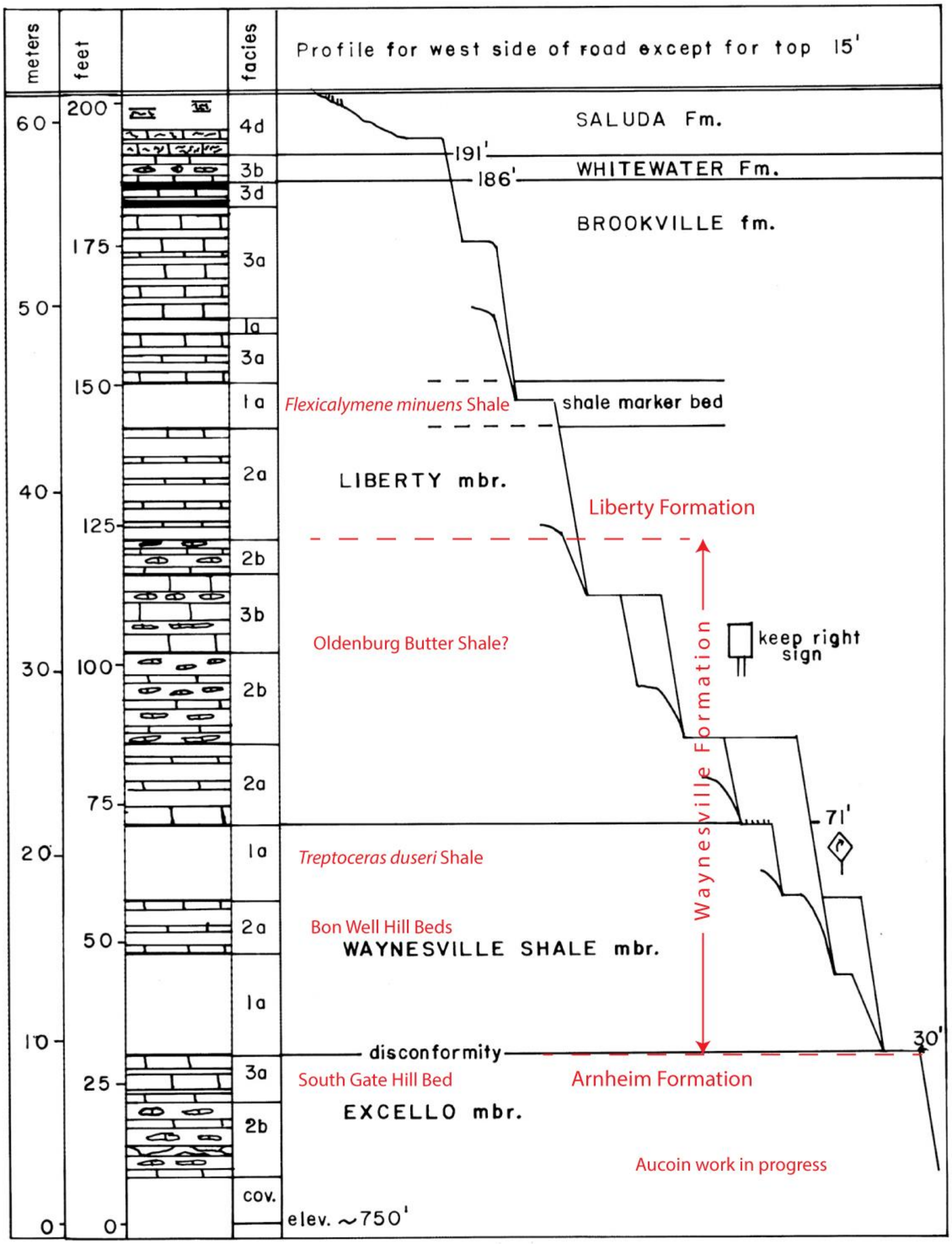
Christopher Aucoin, Ben Dattilo

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.

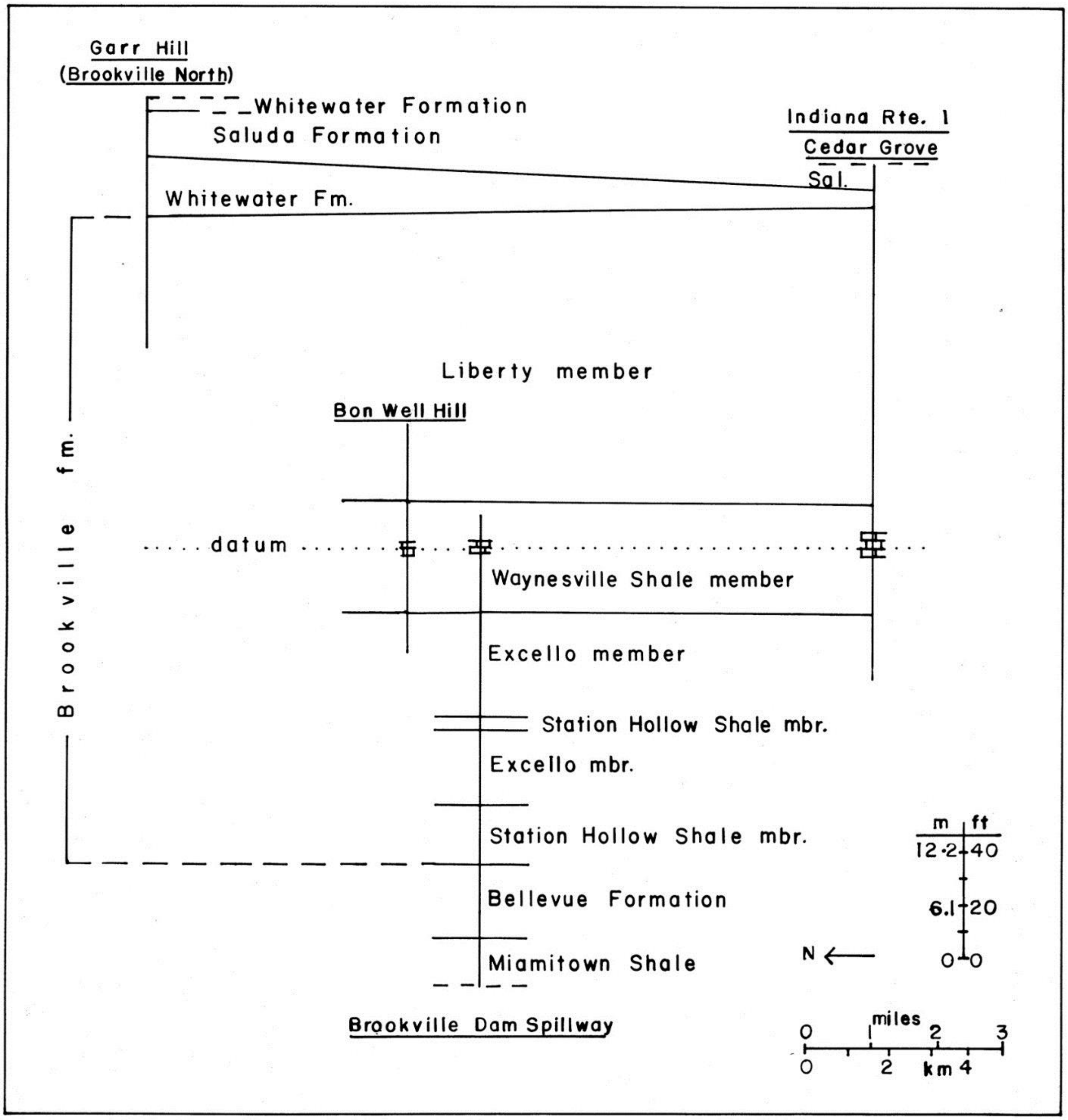


Stratigraphic Section of South Gate Hill (Hay et al., 1998). Note that terraces and road signs are included to help you find your way in the outcrop. Red annotations show stratigraphic units identified by Aucoin.

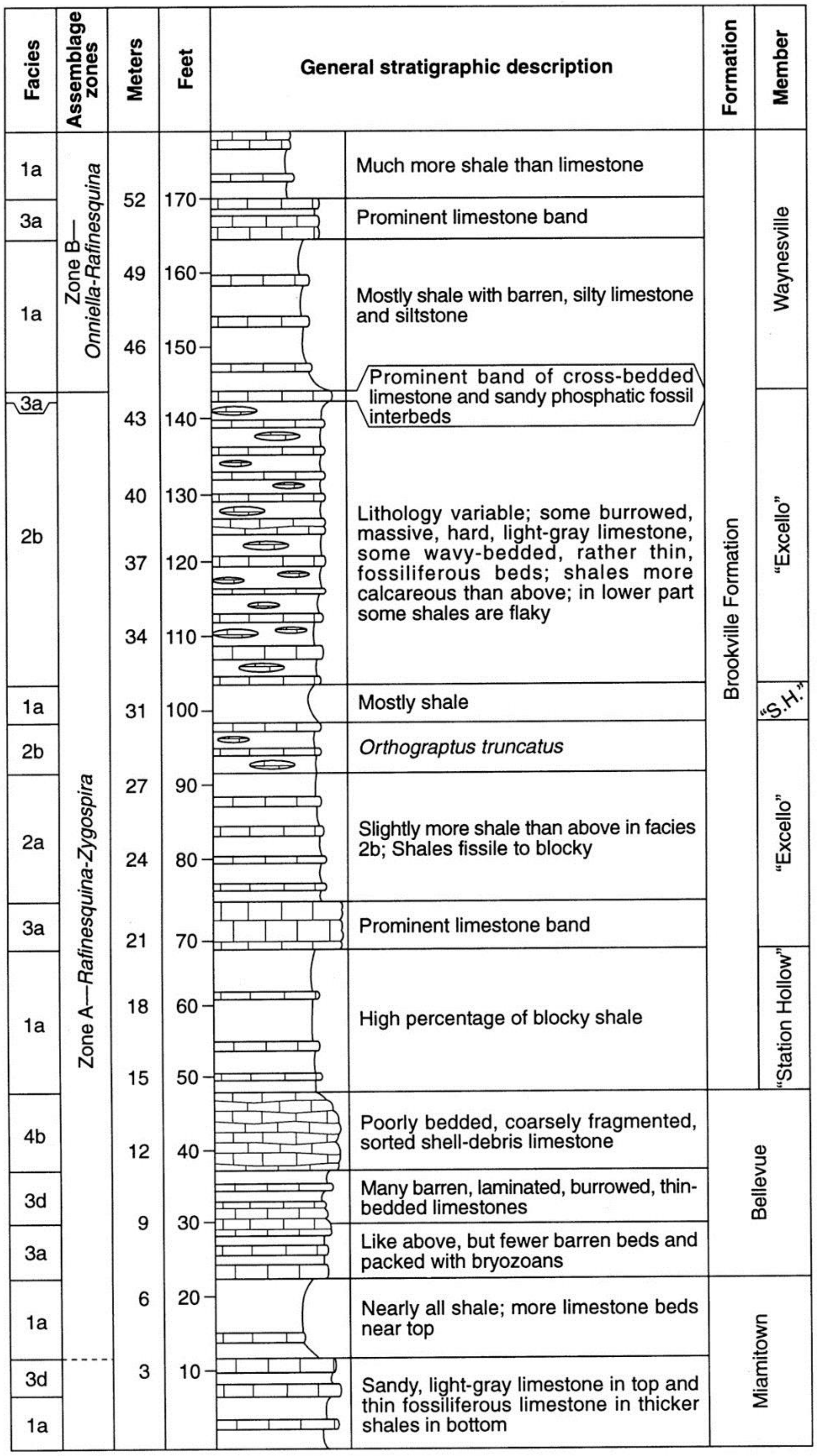
Stop 4. Brookville Dam Spillway

Ben Dattilo
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)

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Field Trips

All field trips will leave from the hotel lobby

Field Trip #1

Stratigraphy & Sedimentology of the Upper Ordovician in Southeastern Indiana

Saturday Sep 19, 2015, 8:00 am to 6:30 pm

Leader:
Dr Benjamin F. Dattilo
(Indiana University-Purdue University Ft Wayne)

This trip will cover the high-resolution sequence stratigraphy, depositional environment, process sedimentology, and paleontology of four spectacularly fossil-rich exposures of the Cincinnati Upper Ordovician (internationally the Katian Stage; in North America the Cincinnatian Series) in southeastern Indiana. Stops include Madison (Richmondian through Silurian), Lawrenceburg (Edenian and Maysvillian), Southgate Hill (Deeper water Richmondian), and Brookville Dam (Maysvillian). The Cincinnatian is characterized by alternating beds of shell-rich limestones (shell beds) and fossil poor mudstones. Limestone-rich and mud-rich intervals define meter scale and 10-meter-scale cycles.

The sedimentological processes that generated these beds and cycles are the subject of recent research. We will discuss the role of high energy events and fluctuating sediment supply in generating these strata, and discuss the possibility of correlating meter-scale cycles across facies transitions over tens of kilometers of distance using physical, paleontological, and geochemical techniques. We will also discuss how sedimentological processes lead to the destruction of organic matter in a succession of obviously fossil-rich strata. There will be ample opportunity to collect a spectacularly fossil-rich slab, and perhaps even a perfect trilobite!

Note: Attendees are urged to be flexible in scheduling Saturday evening activities. Rain or shine. Bring rain gear as appropriate.

Please see the following link for more information:

www.opus.ipfw.edu/geosci_facpubs/82