Geology of the Wellsburg, West Virginia Area and the Brilliant Outcrop

Wellsburg 17th Street Park
April 24, 2022, 1:00 to 2:30 PM
Fred Zelt, Ph.D.
Earth Science Excursions, LLC

Geology of the Wellsburg area and Brilliant outcrop

Come learn about the geology of our area, including the rock layers in the excellent outcrop across the river! Retired geologist Fred Zelt will speak with the public in Wellsburg's 17th Street Park at 1:00 to 2:30 PM on Sunday, April 24. Fred will speak about the regional geologic setting of the upper Ohio Valley, and will bring samples of local rocks and fossils. Do you have a rock or fossil you would like a geologist to identify? Fred will be available to speak with you and answer questions.

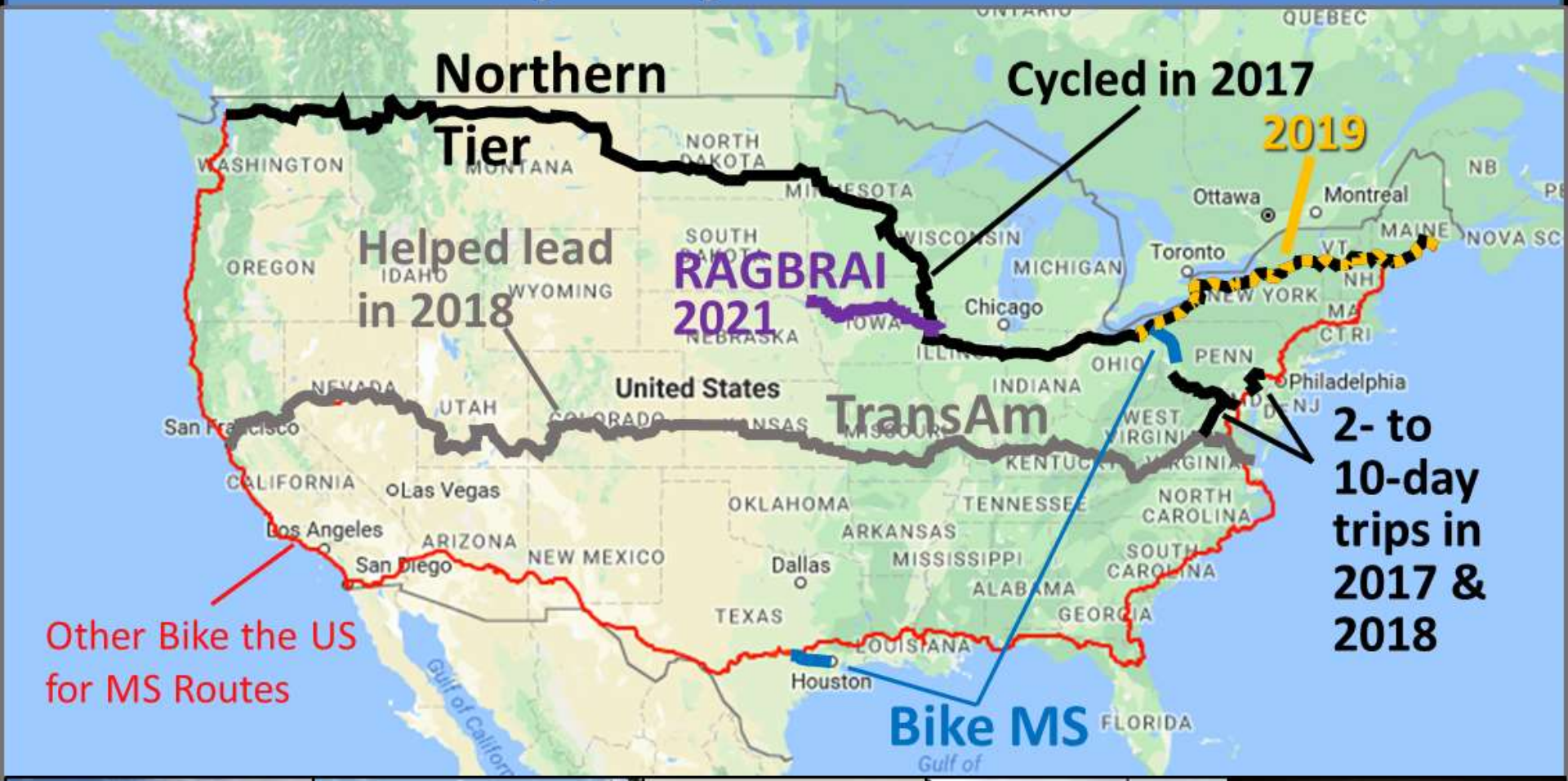
We will meet in 17th Street Park in the grassy area near the river, between baseball fields and past the end of 18th Street. Please dress for the weather and bring a folding chair. To help us observe and interpret the outcrop from a distance please bring binoculars, paper or a notebook, and a pencil. We will each have the opportunity to make a sketch of the rock layers in the outcrop.

Background about Fred Zelt

- Grew up in Bethel Park, PA
- Geologist, MIT and Princeton (Ph.D.)
- ExxonMobil 1985-2015
- Married since 1982 to a Bethel Park native, four kids and four grandkids
- Have lived in Boston, New Jersey, Maryland, Denver, Houston, Norway, England and New Orleans
- More than 2 years of geology field work

- Returned to Pittsburgh in 2015, live on Mt. Washington
- Certified League Cycling Instructor; ride & volunteer with charity bicycle rides including from Maine to Seattle; speak about energy, climate and PA geology
- Founded Earth Science Excursions, LLC with cycling & hiking geology excursions for adults; STEM and Cycling for grades 3-12

Fred's 2+ Day Bicycle Rides 2013-2021



Dr. Zelt's graduate school geology field area, southern Utah

Geology Event Objectives

1. Stay safe
2. Participants can identify the most common rocks in Brooke County, WV: Sandstone, siltstone, shale, limestone and coal
3. Participants understand and can explain the geologic origin of Upper Ohio Valley area landforms
4. View and discuss the outstanding outcrop across the Ohio River from Wellsburg

Presentation Outline

- Geology 101: Intro to Rock Types
- Intro to Paleoclimate
- Upper Ohio Valley Geology and Landscapes
- Shaping the Upper Ohio Valley: Rivers and Glaciations
- Introduction to Excursion

Intro to Rock Types

- Sedimentary
- Metamorphic
- Igneous

Natural Sedimentary Rocks

Sandstone

Limestone

Manmade Materials

Slag

Siltstone

Coal

Concrete

Mudstone or Shale

Ironstone

Brick

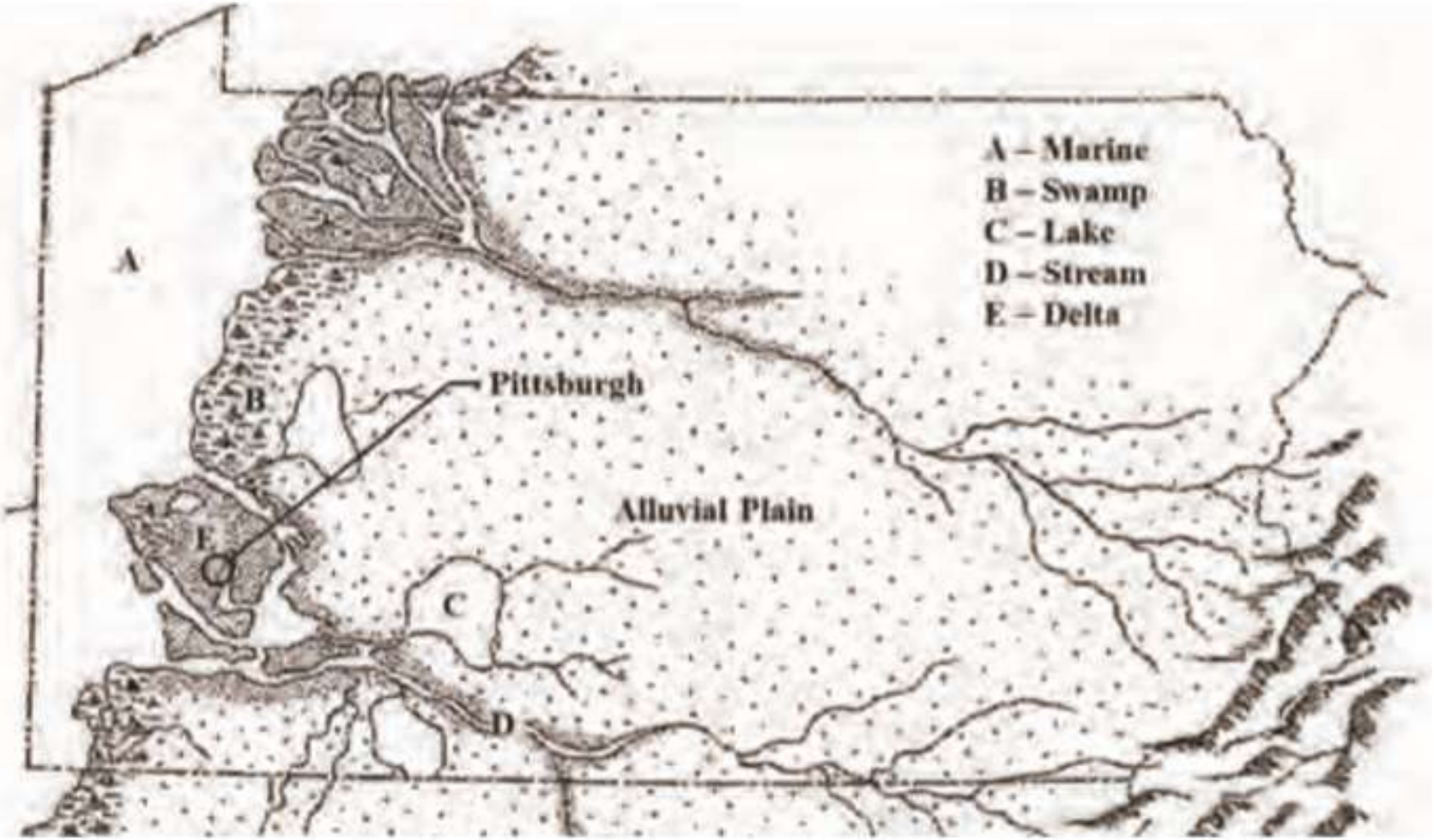


Figure 7. *Inferred Paleogeography of Pennsylvania during the Late Pennsylvanian when the rocks of Pittsburgh were being deposited* (Wagner et. al., 1970).

Gray et al, 2015

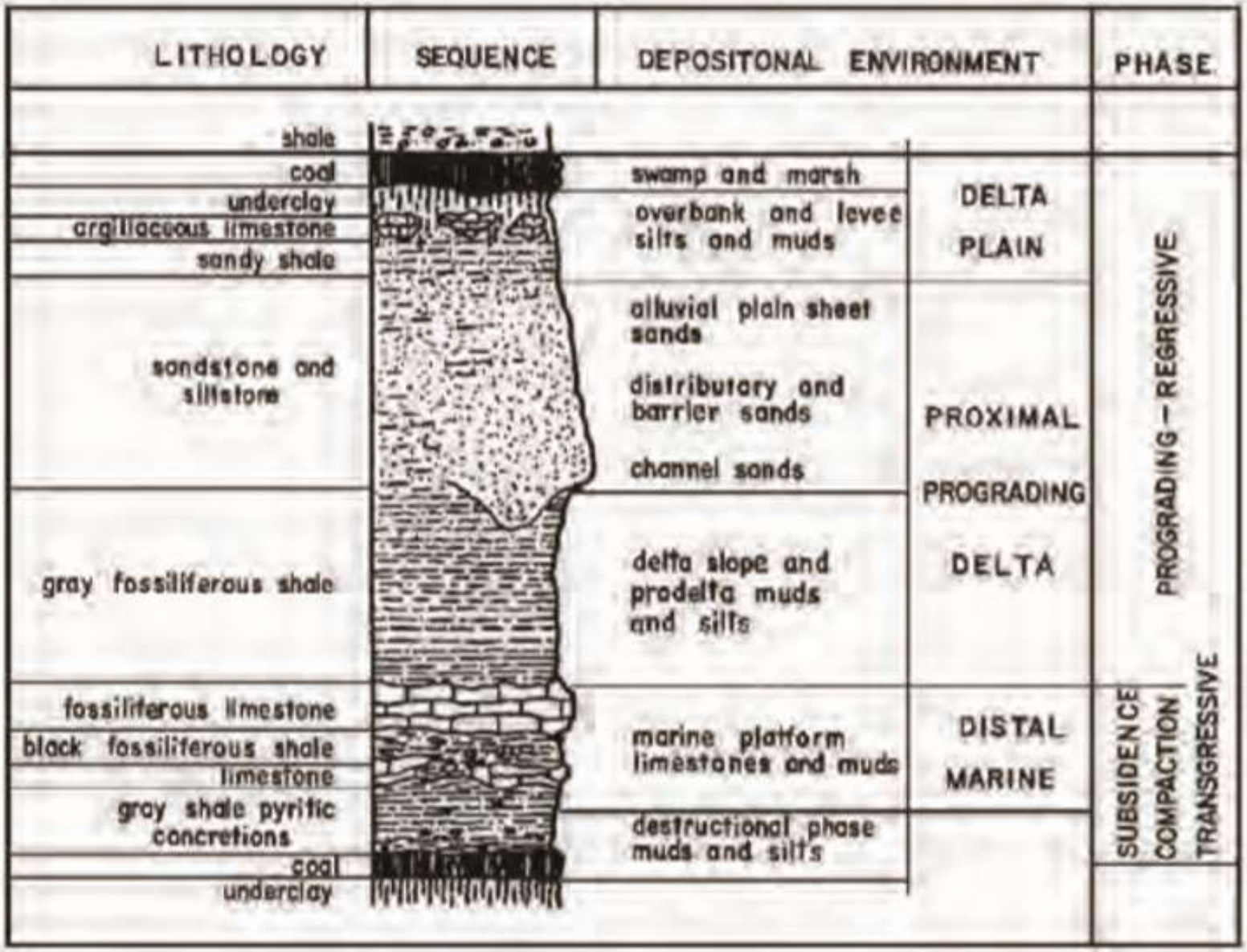
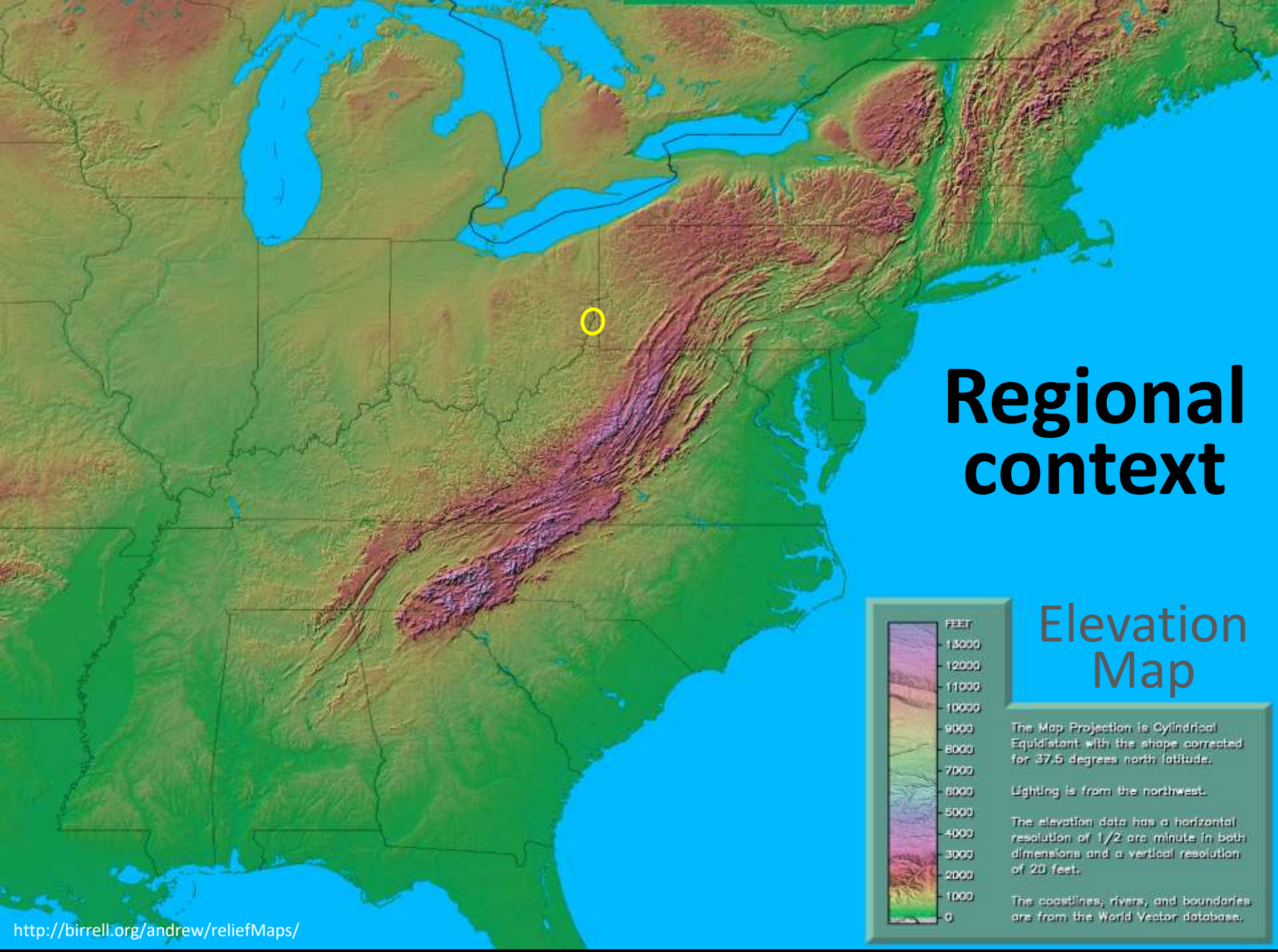
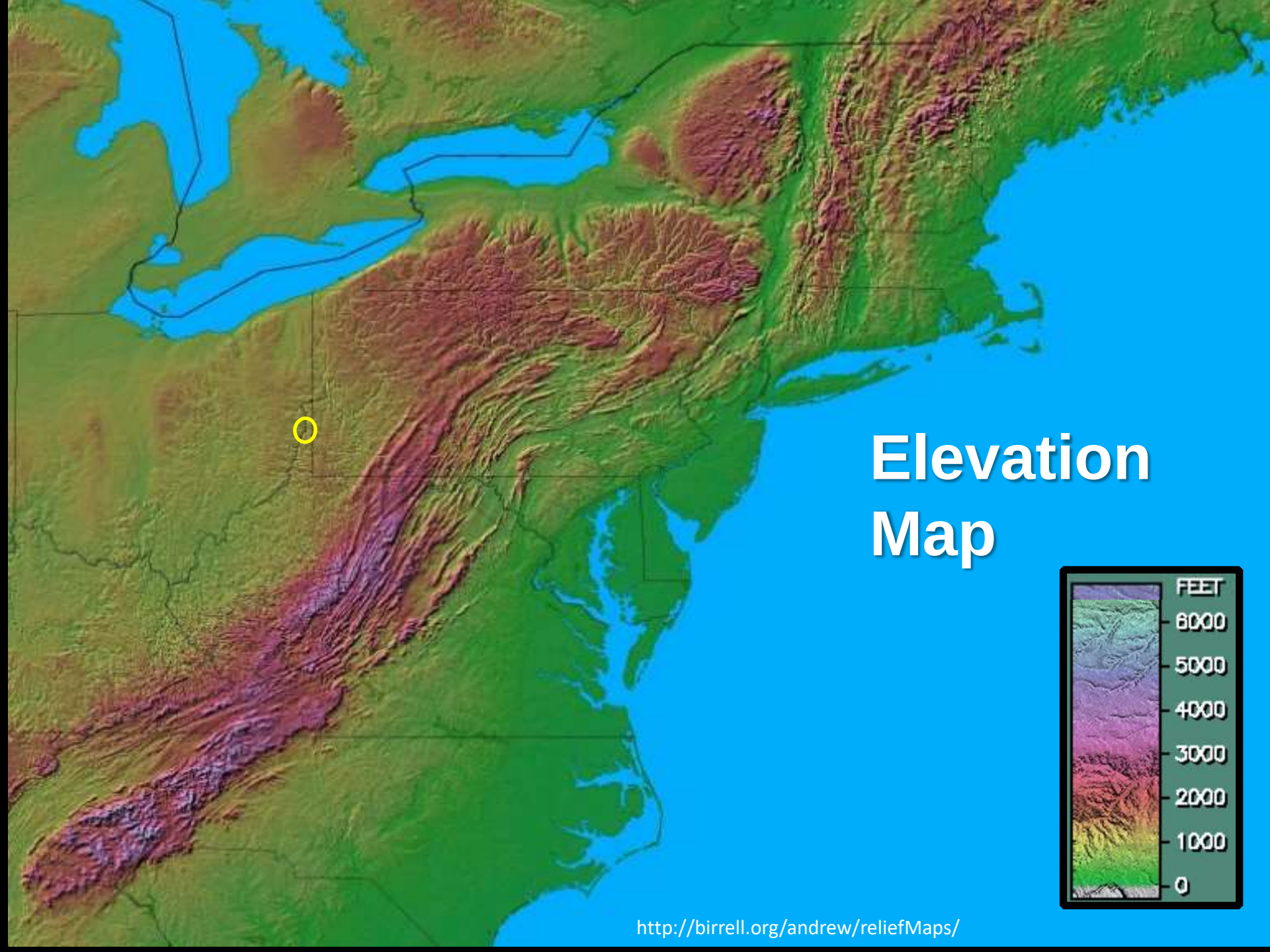


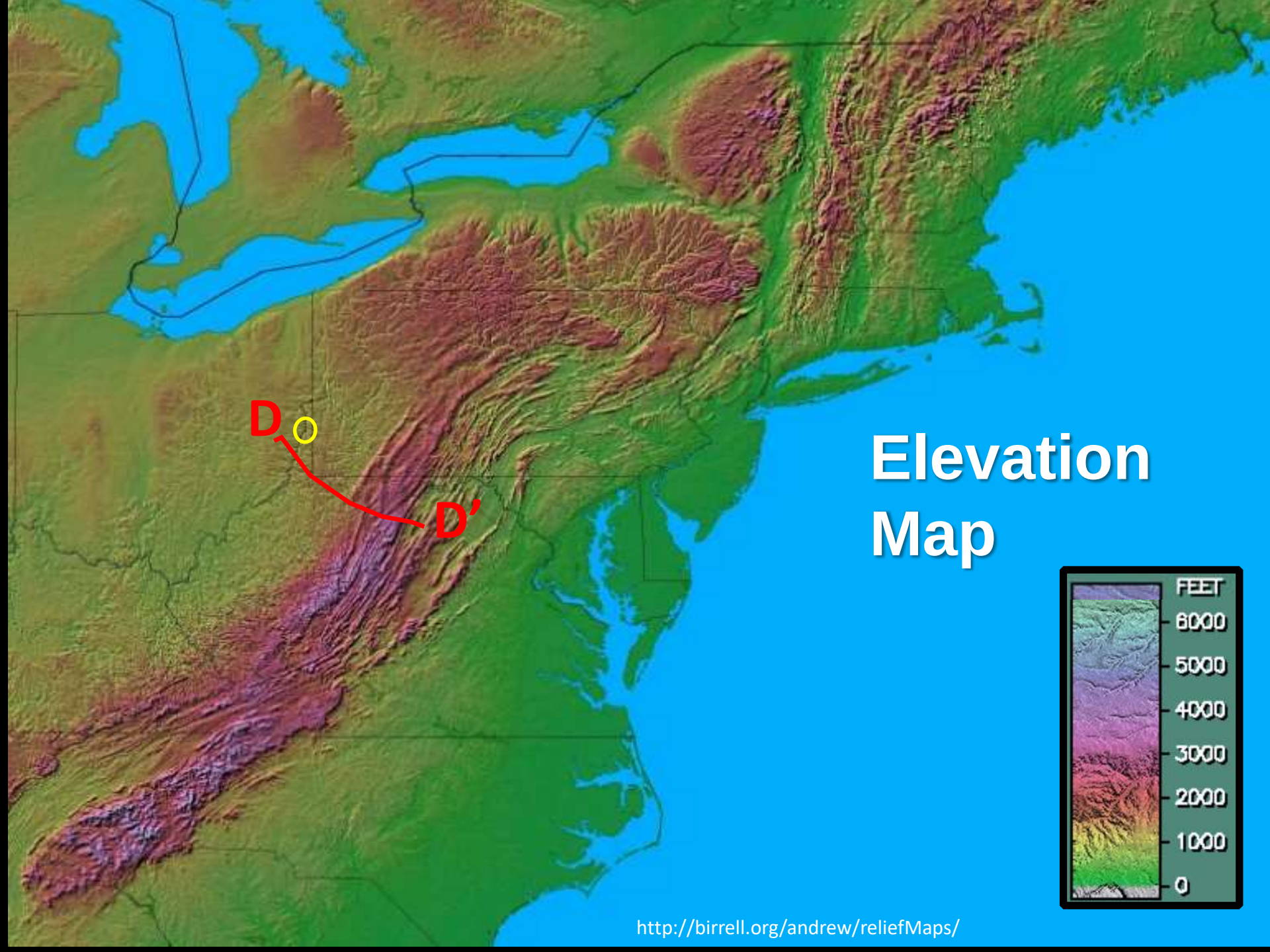
Figure 8. *Generalized Lithology Column of Southwestern Pennsylvania* (Pryor and Sable, 1974).

Gray et al, 2015

Upper Ohio Valley Geology and Landscapes

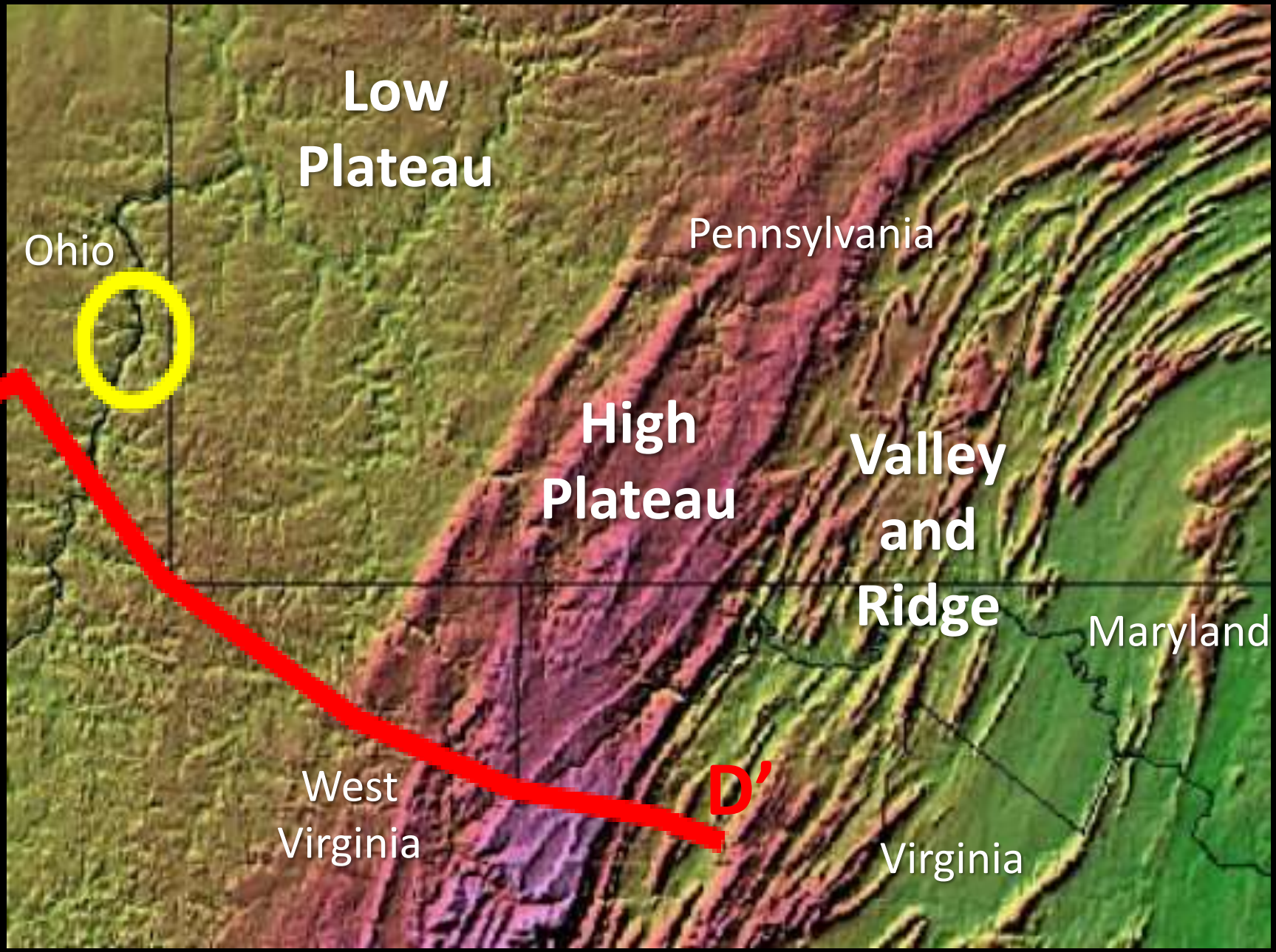

Regional context
Elevation Map
FEET
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
The Map Projection is Cylindrical Equidistant with the shape corrected for 37.5 degrees north latitude.
Lighting is from the northwest.
The elevation data has a horizontal resolution of 1/2 arc minute in both dimensions and a vertical resolution of 20 feet.
The coastlines, rivers, and boundaries are from the World Vector database.
http://birrell.org/andrew/reliefMaps/

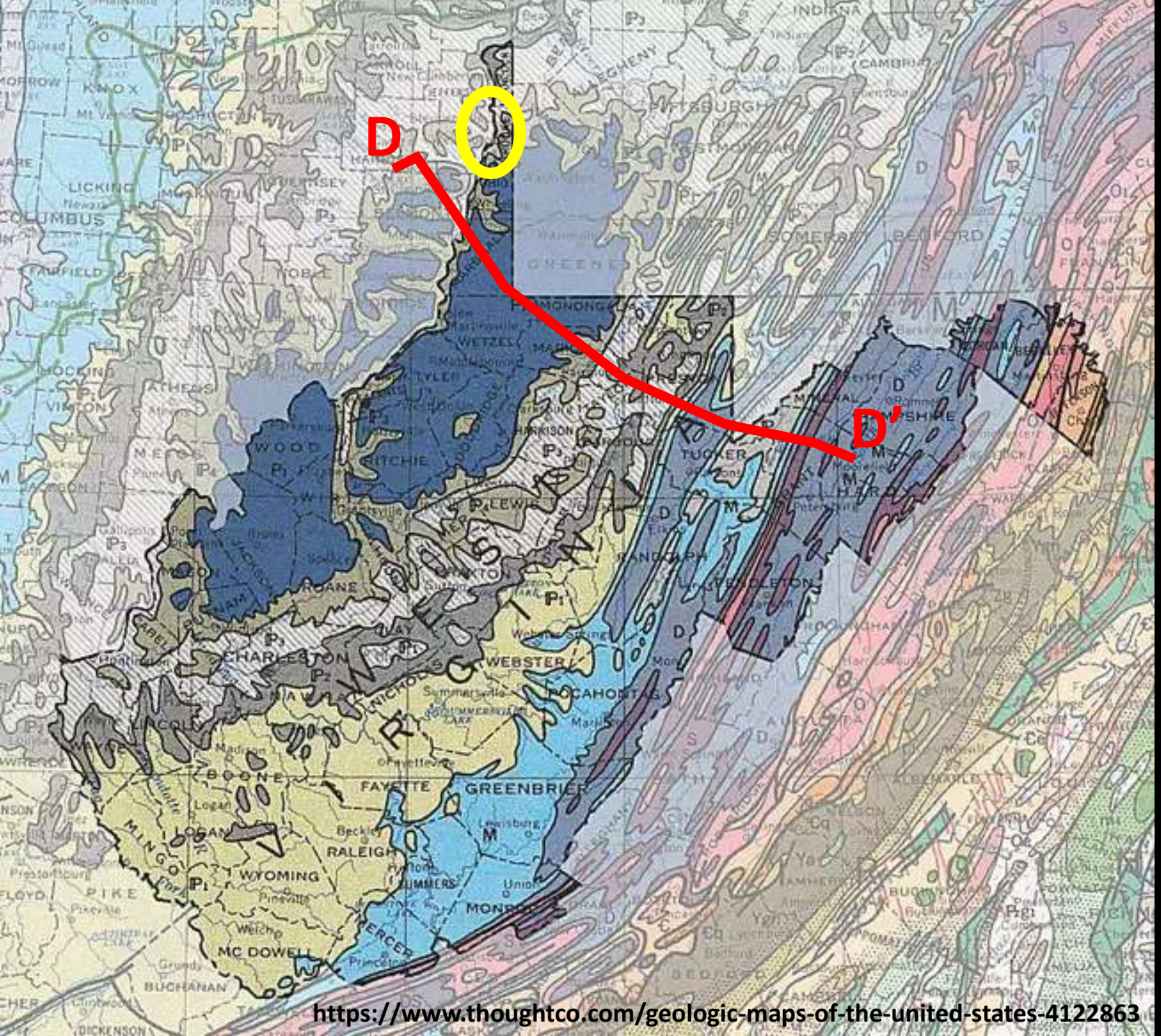

Elevation Map
FEET
6000
5000
4000
3000
2000
1000
0
http://birrell.org/andrew/reliefMaps/


D
D'
Elevation Map
FEET
6000
5000
4000
3000
2000
1000
0
http://birrell.org/andrew/reliefMaps/

Elevation map, SW PA

http://www.jamestown-ri.info/appalachian_chain.jpg

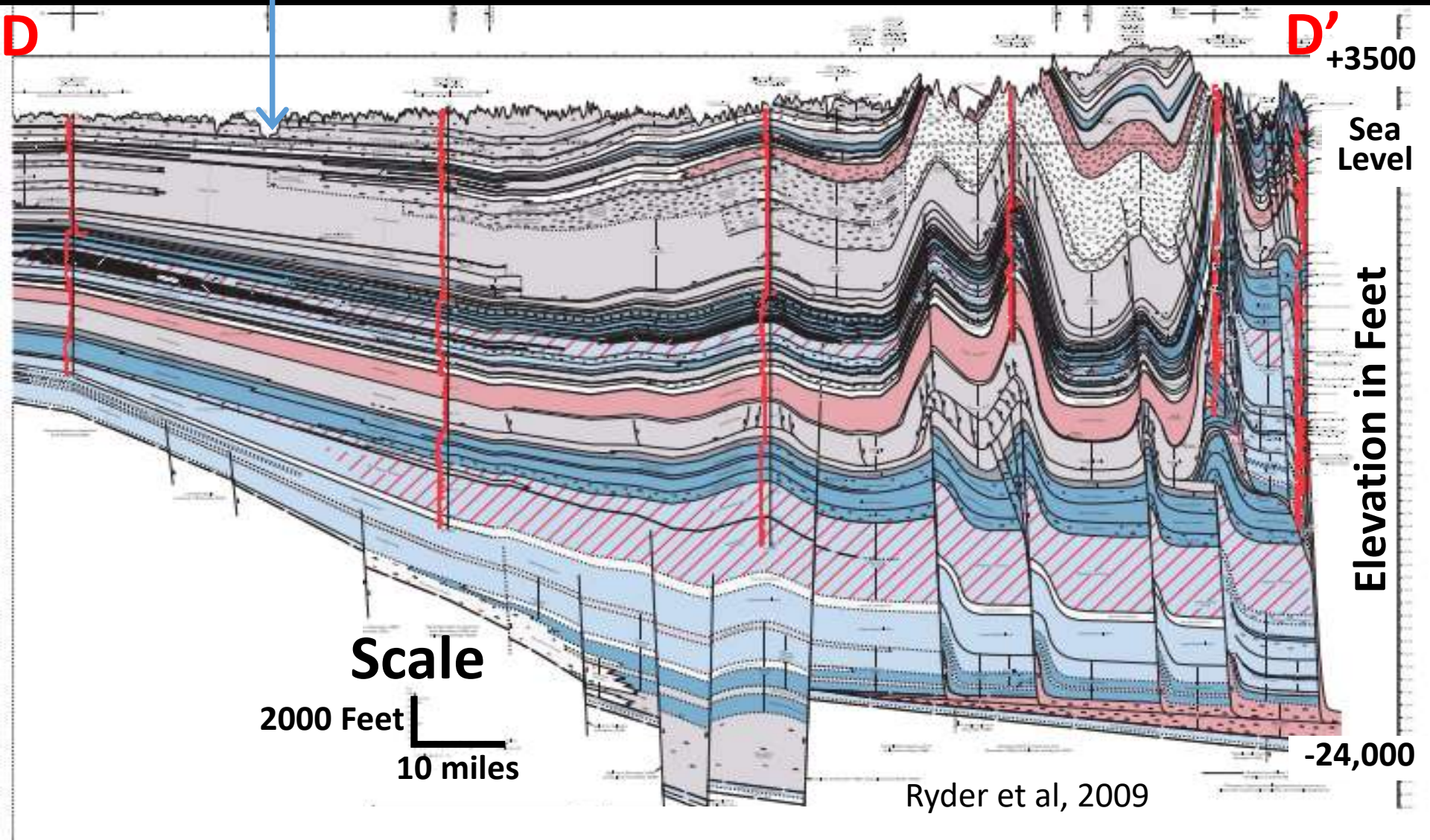


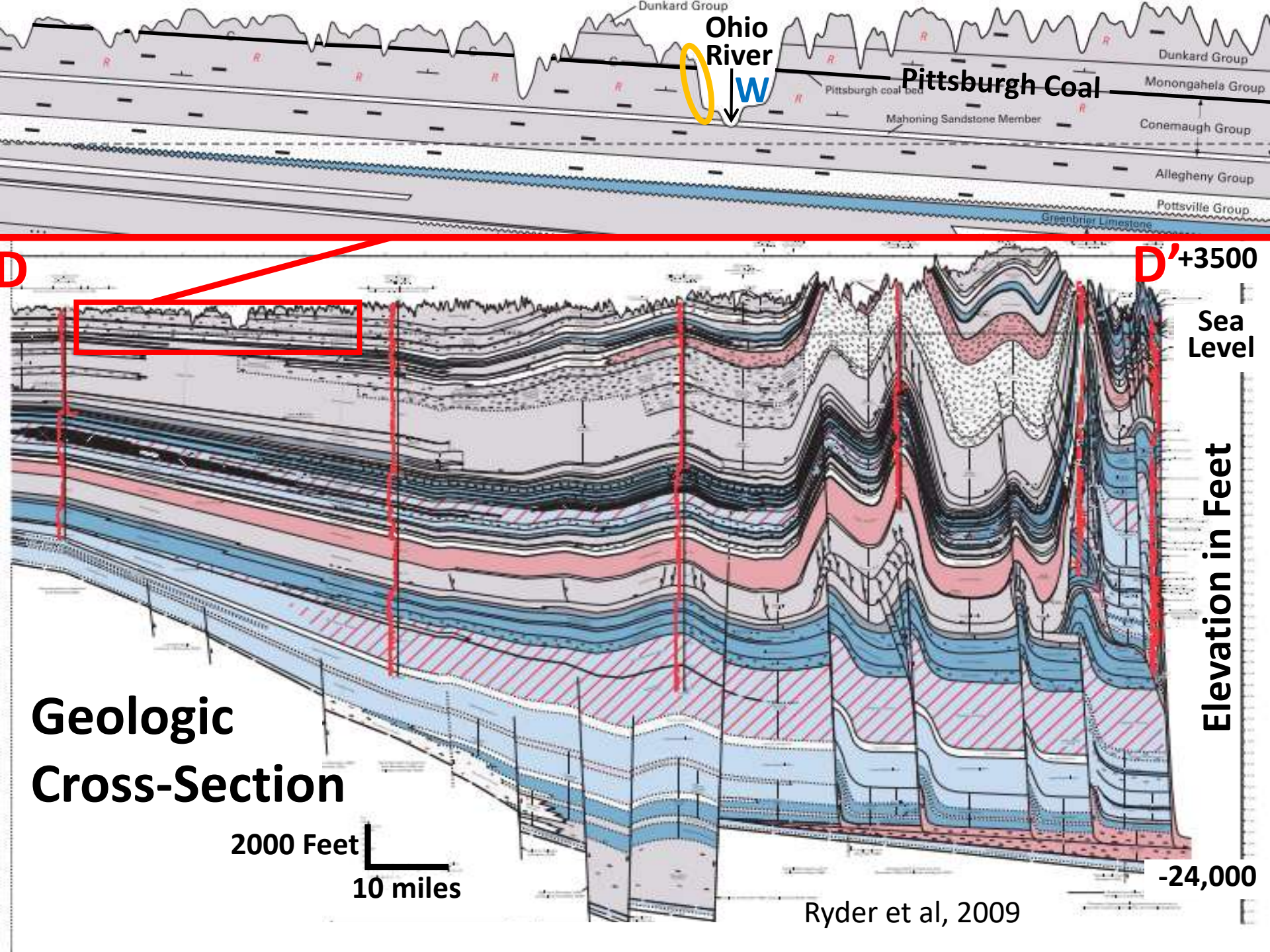

D
O
D'
https://www.thoughtco.com/geologic-maps-of-the-united-states-4122863

Northwest

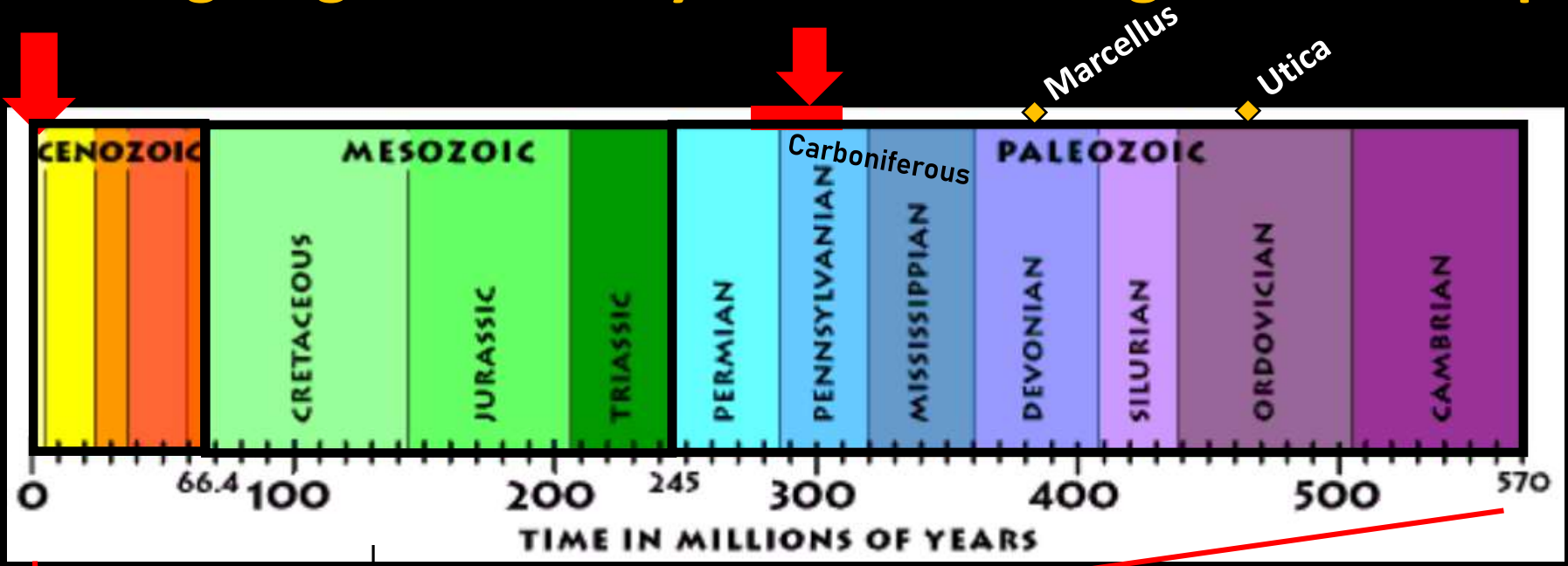
Geologic Cross-Section

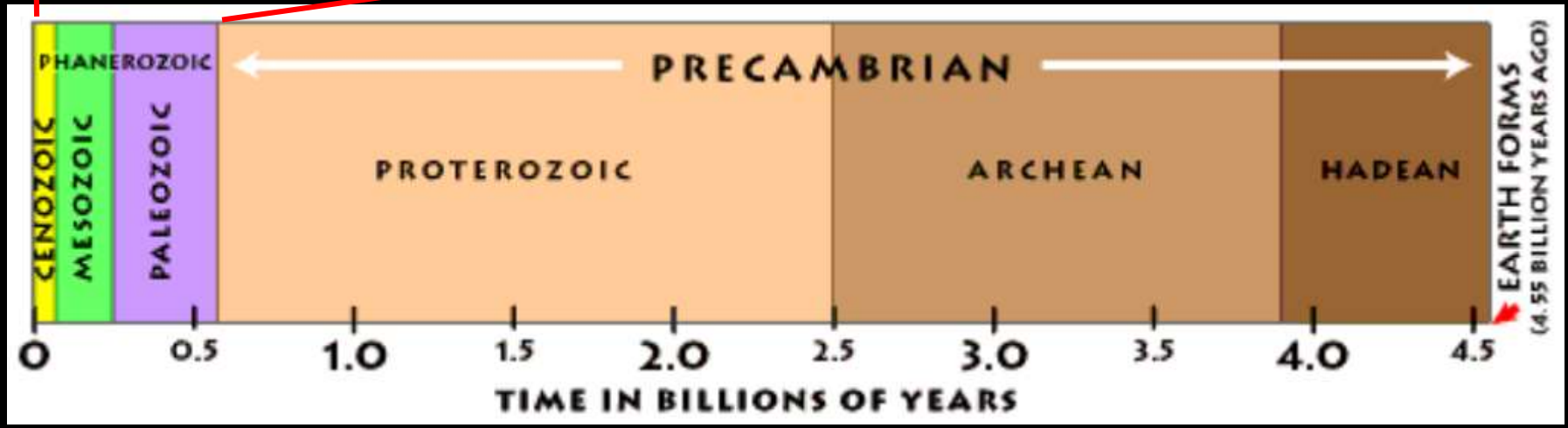
Southeast



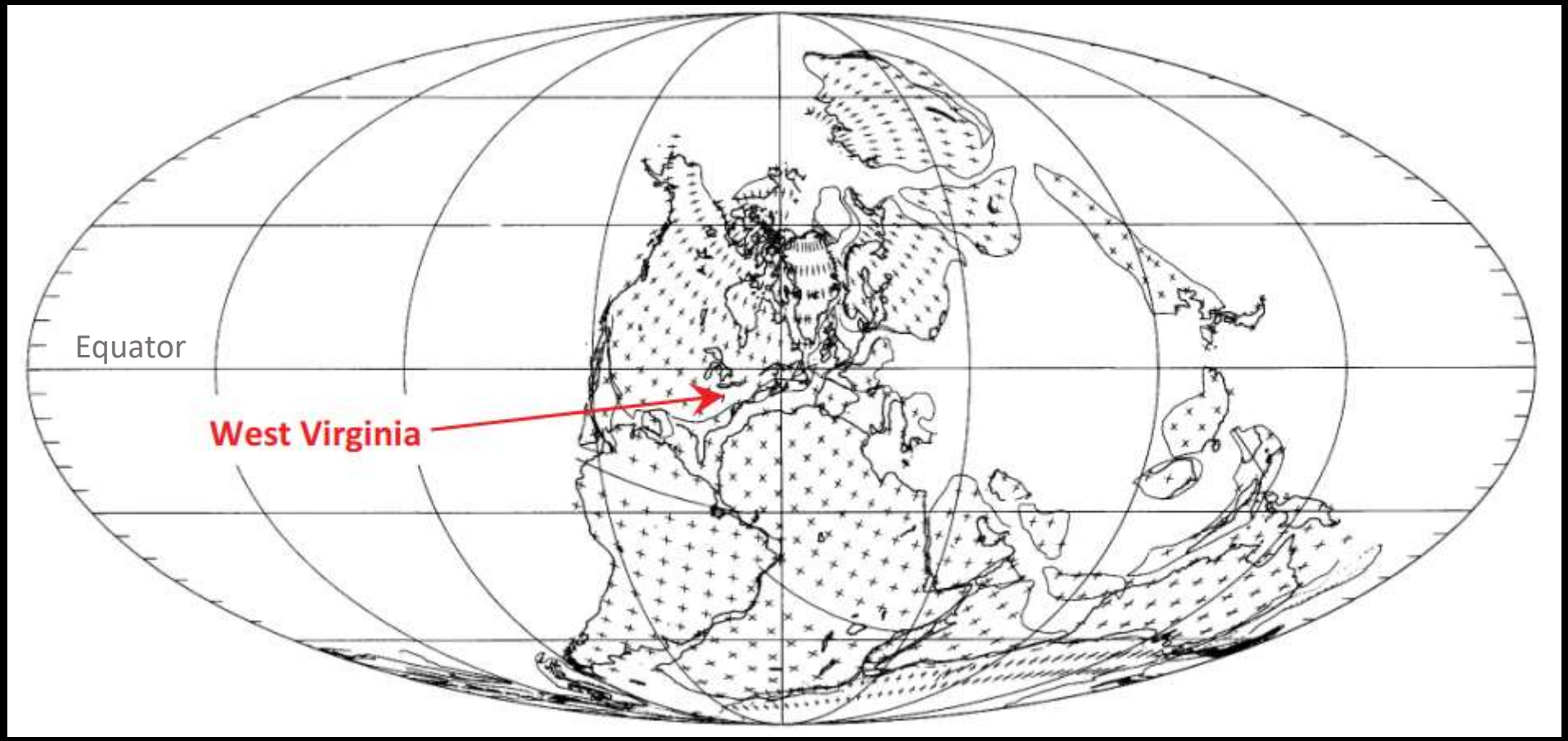

Dunkard Group
Ohio River
W
Pittsburgh Coal
Pittsburgh coal bed
Mahoning Sandstone Member
Dunkard Group
Monongahela Group
Conemaugh Group
Allegheny Group
Pottsville Group
Greenbrier Limestone
D
D'
+3500
Sea Level
Elevation in Feet
-24,000
Geologic Cross-Section
2000 Feet
10 miles
Ryder et al, 2009

Geologic age of rock layers in Wellsburg-area outcrops





Late Carboniferous (Pennsylvanian) world



- Collision and mountain belt between North American, African and South American plates, flanked by sedimentary basins near the Equator
- Continents near South Pole provided opportunity for thick glaciers to develop

From Scotese and McKerrow, 1990 in Hunt et al, 2017
http://downloads.wvgs.wvnet.edu/pubcat/docs/FTG-9_WVGES-ESAAPG17_FieldTrip_US48-CorridorH.pdf

Subsurface Rock Correlation Diagram Oil and Gas Producing Regions of Pennsylvania

Permian

Pennsylvanian

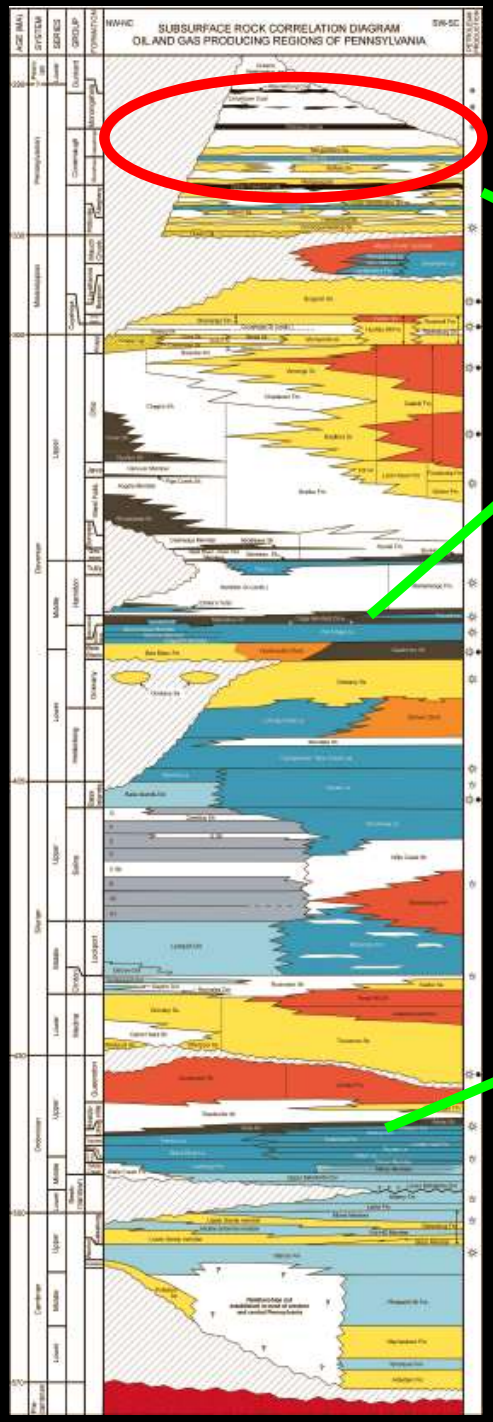
Mississippian

Devonian

Silurian

Ordovician

Cambrian



Pennsylvanian Rock Layers with Coals

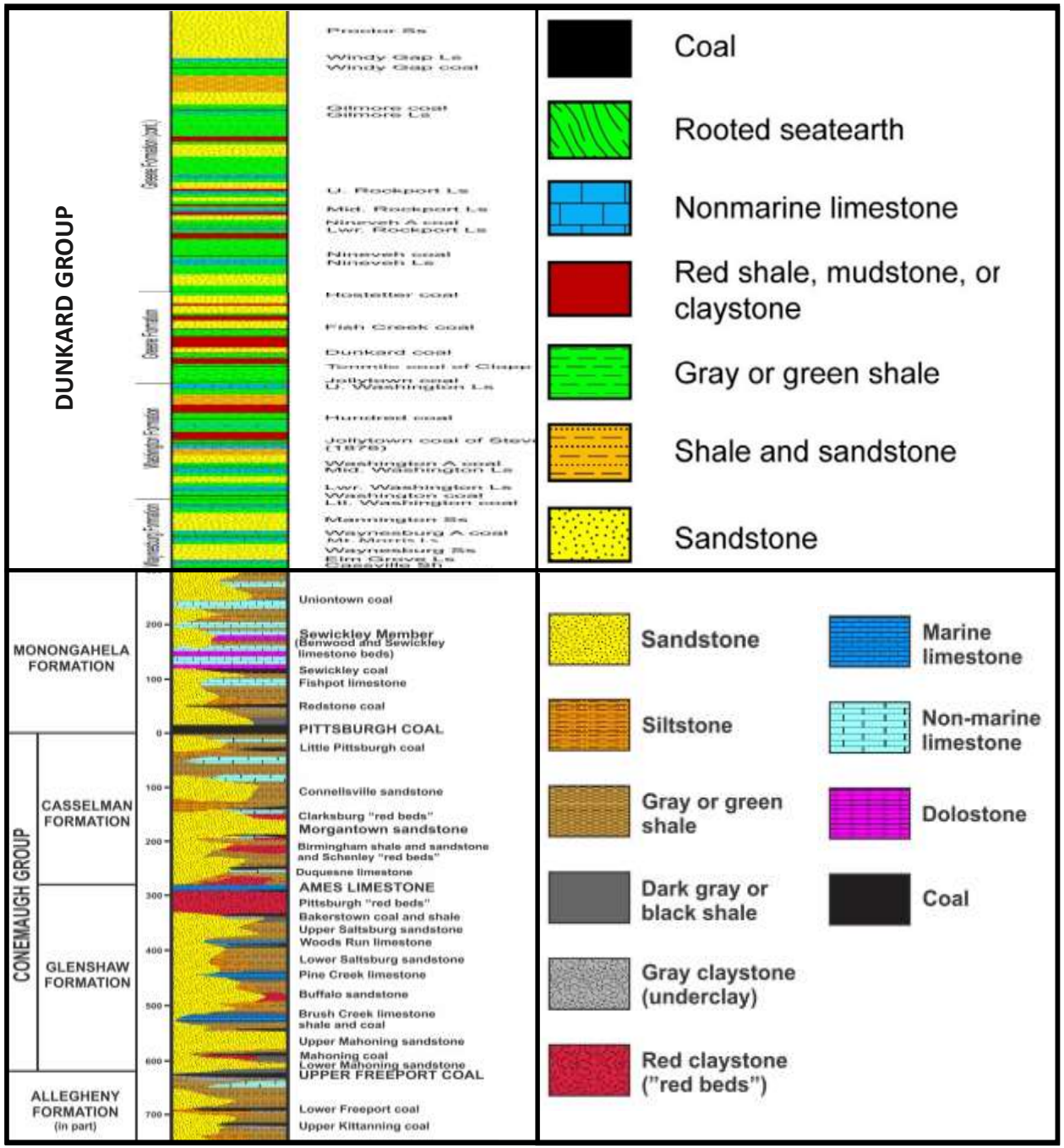
Marcellus Shale (Middle Devonian)

Utica Shale (Ordovician)

http://www.dcnr.state.pa.us/topogeo/drc/drcdiagram.aspx

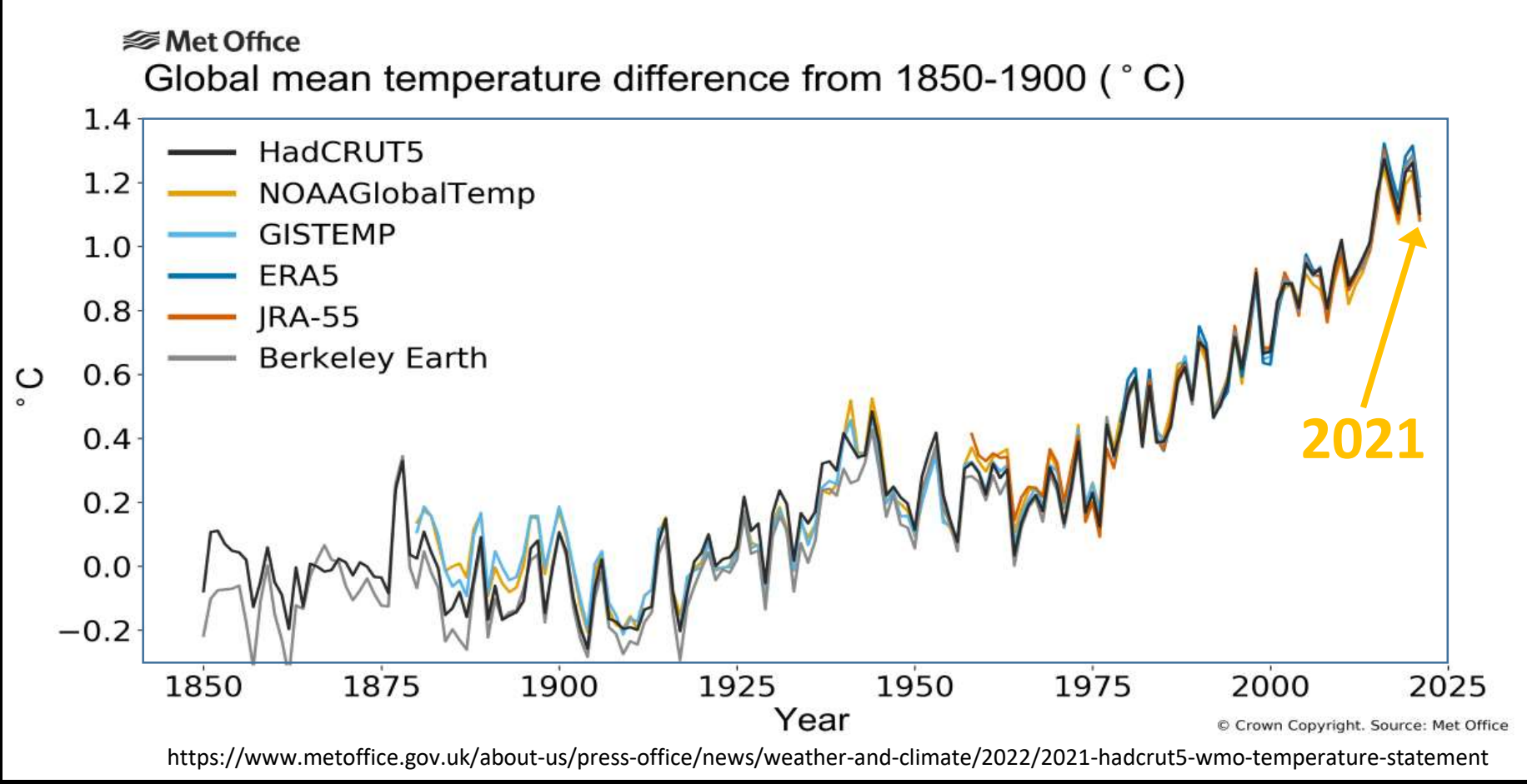
Bedrock at surface in West Virginia Panhandle area

From Harper, 2013



Paleoclimate

Recent Global Warming

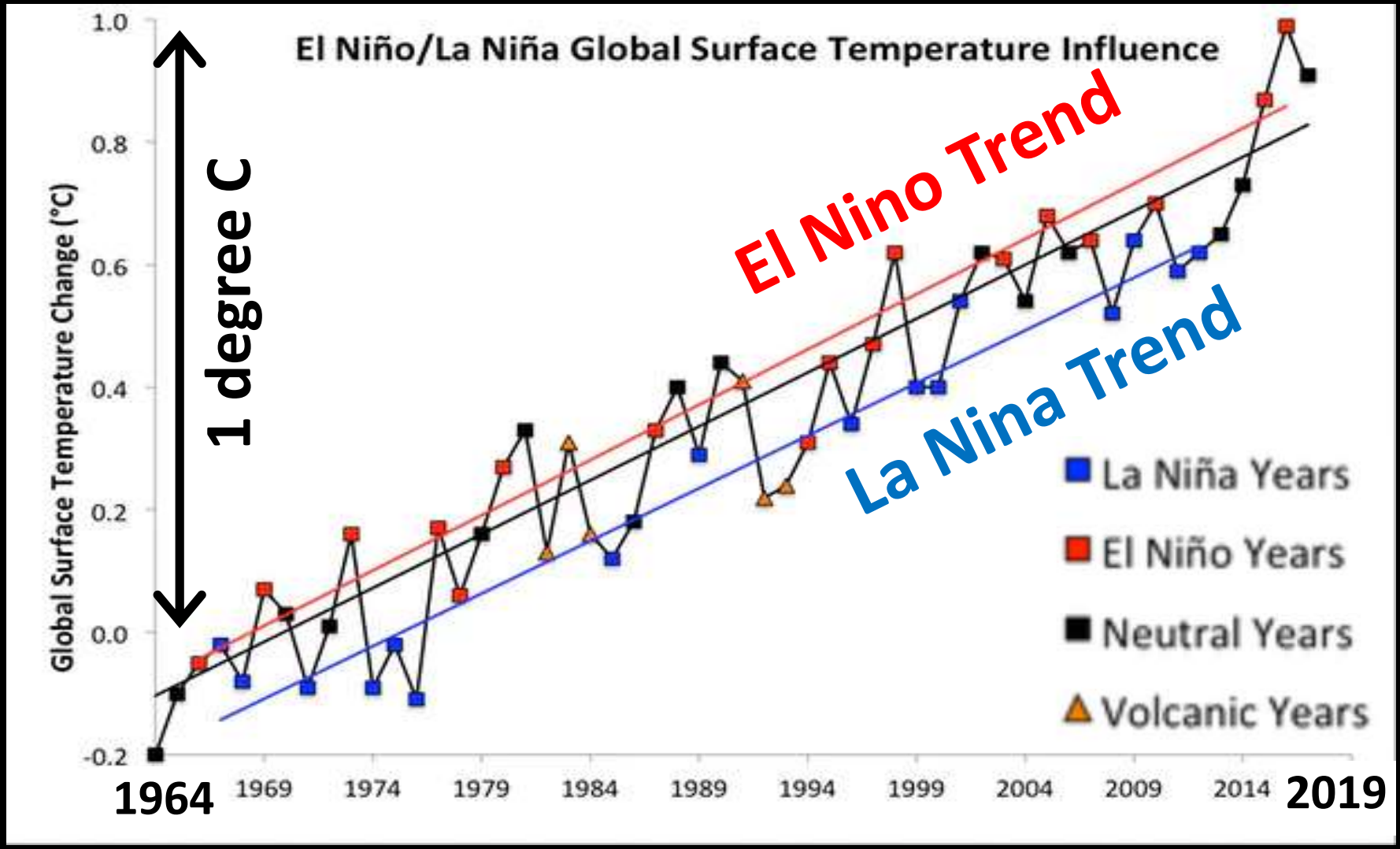


https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2022/2021-hadcrut5-wmo-temperature-statement

- New annual average global temperatures are compared with thermometer-based global temperature records since 1850
- About 1 deg C warming has been observed since the 1970's

Recent Global Warming

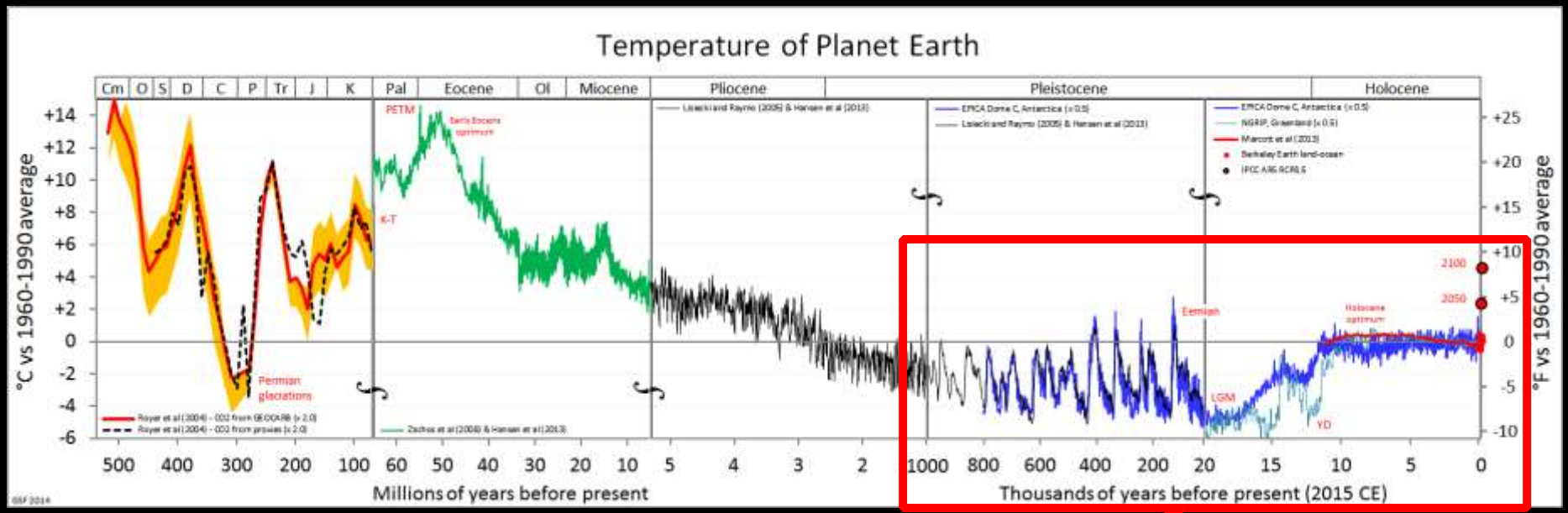
Data from NASA



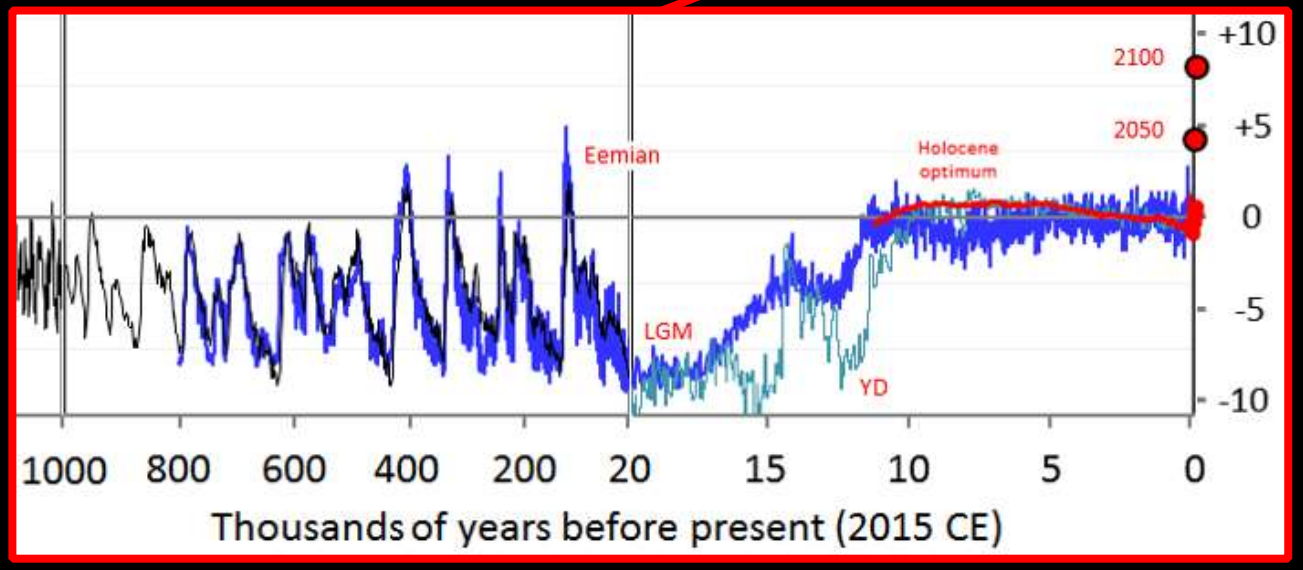
Global temperature during El Nino versus La Nina years

https://www.theguardian.com/environment/climate-consensus-97-per-cent/2018/jan/02/2017-was-the-hottest-year-on-record-without-an-el-nino-thanks-to-global-warming

Deep time context of global temperature



- Global temperatures similar to today have occurred during other interglacial periods
- Hotter periods were common in distant past



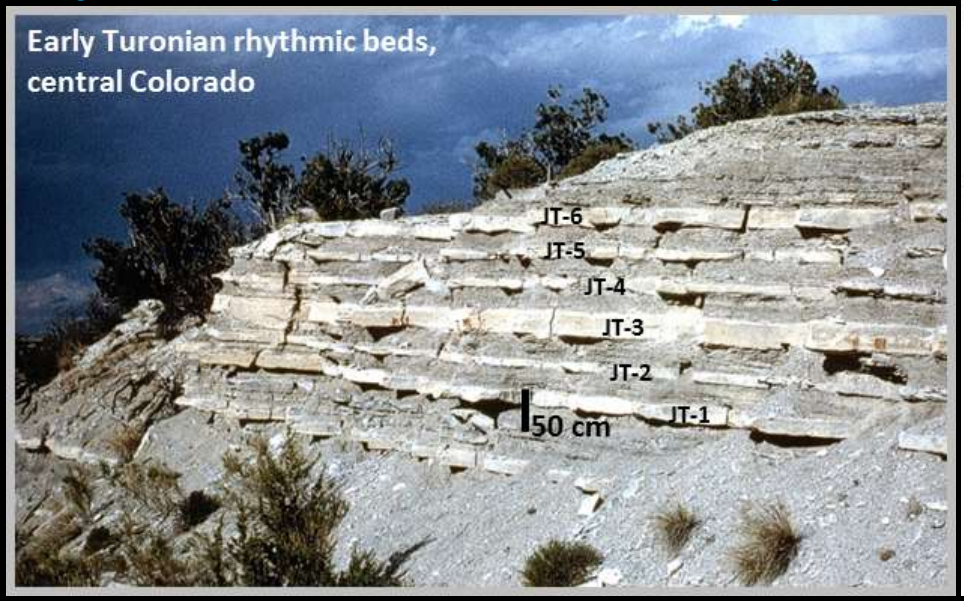
https://upload.wikimedia.org/wikipedia/commons/f/f5/All_palaeotemps.png

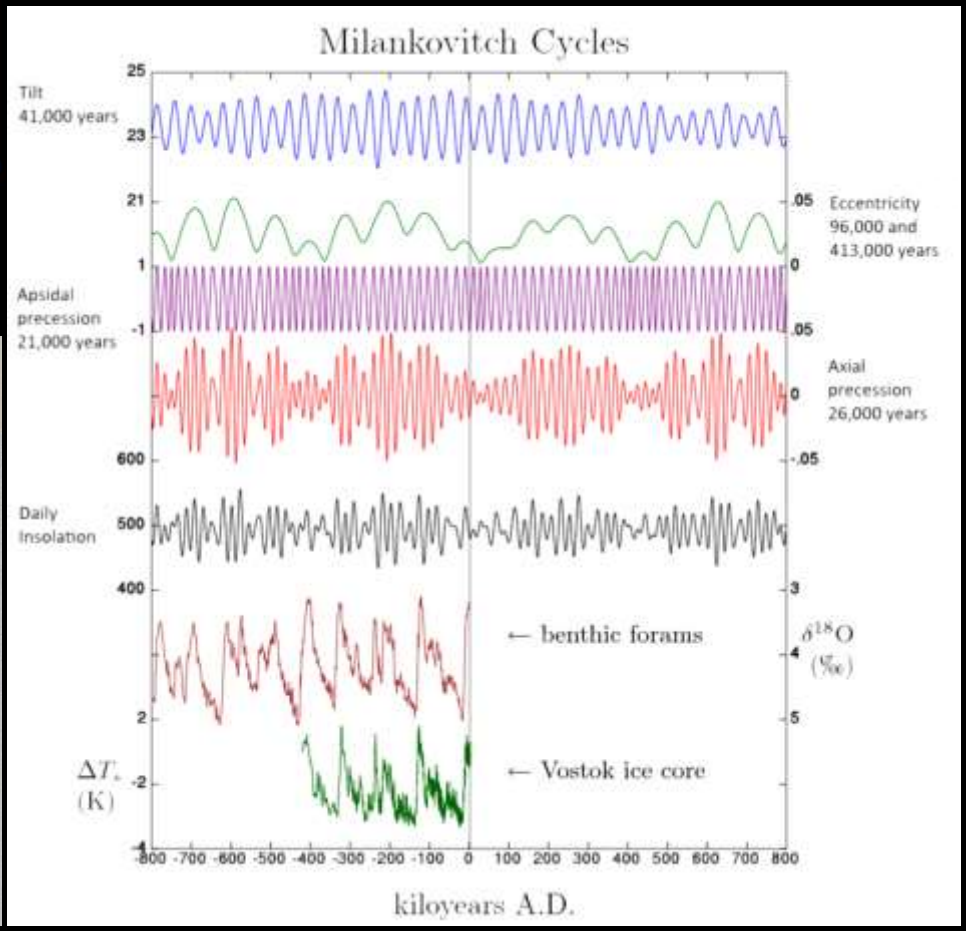
Milankovich Cycles

Three main cycles in Earth's orbit around the Sun are thought to have affected global climate throughout geologic history

- Precession: 21,000 years
- Obliquity (Tilt): 41,000 years
- Eccentricity: 100,000 years

Interpreted Evidence of 40,000-100,000 Climate Cycles in Cretaceous Marine Sedimentary Rocks

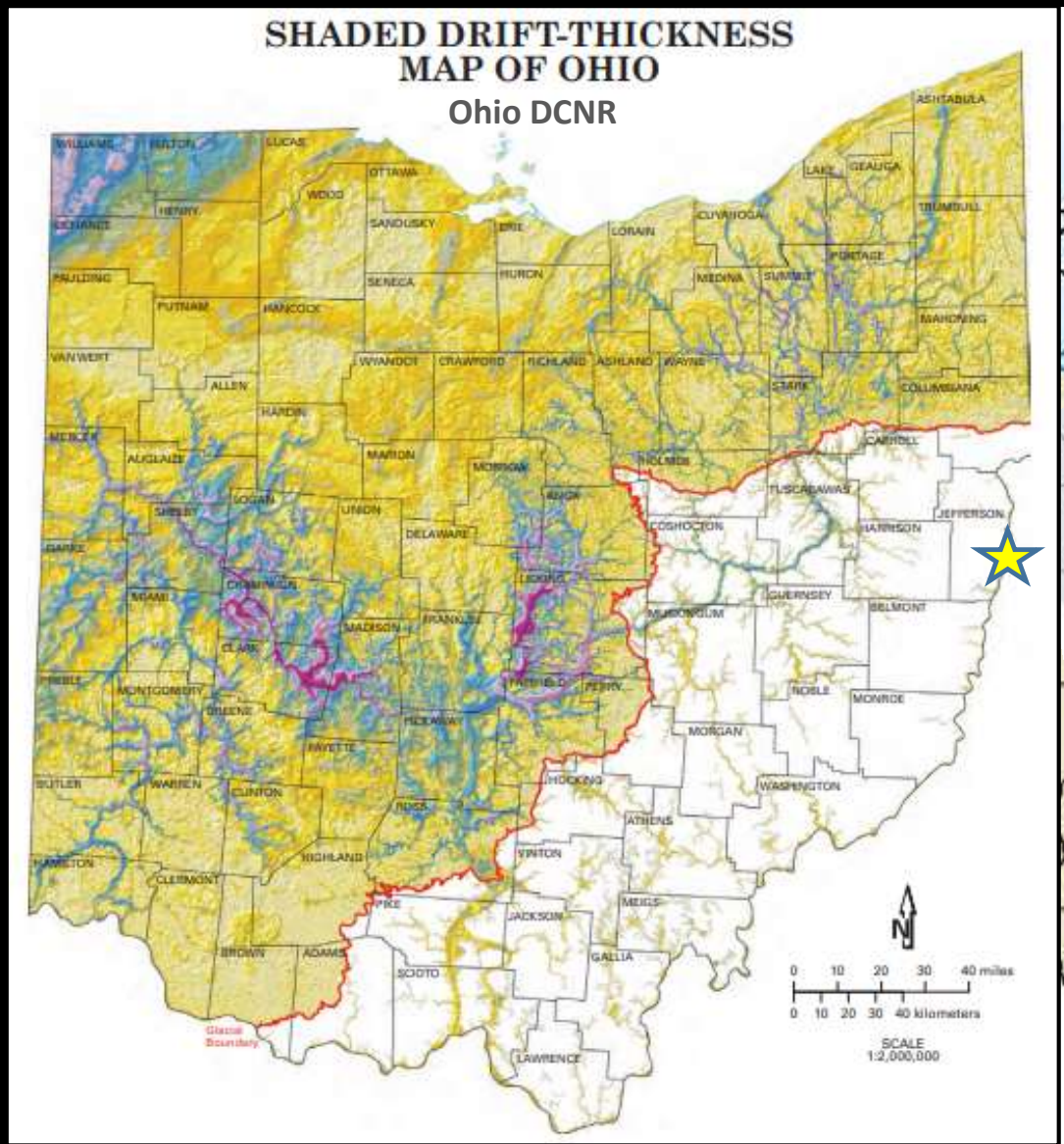


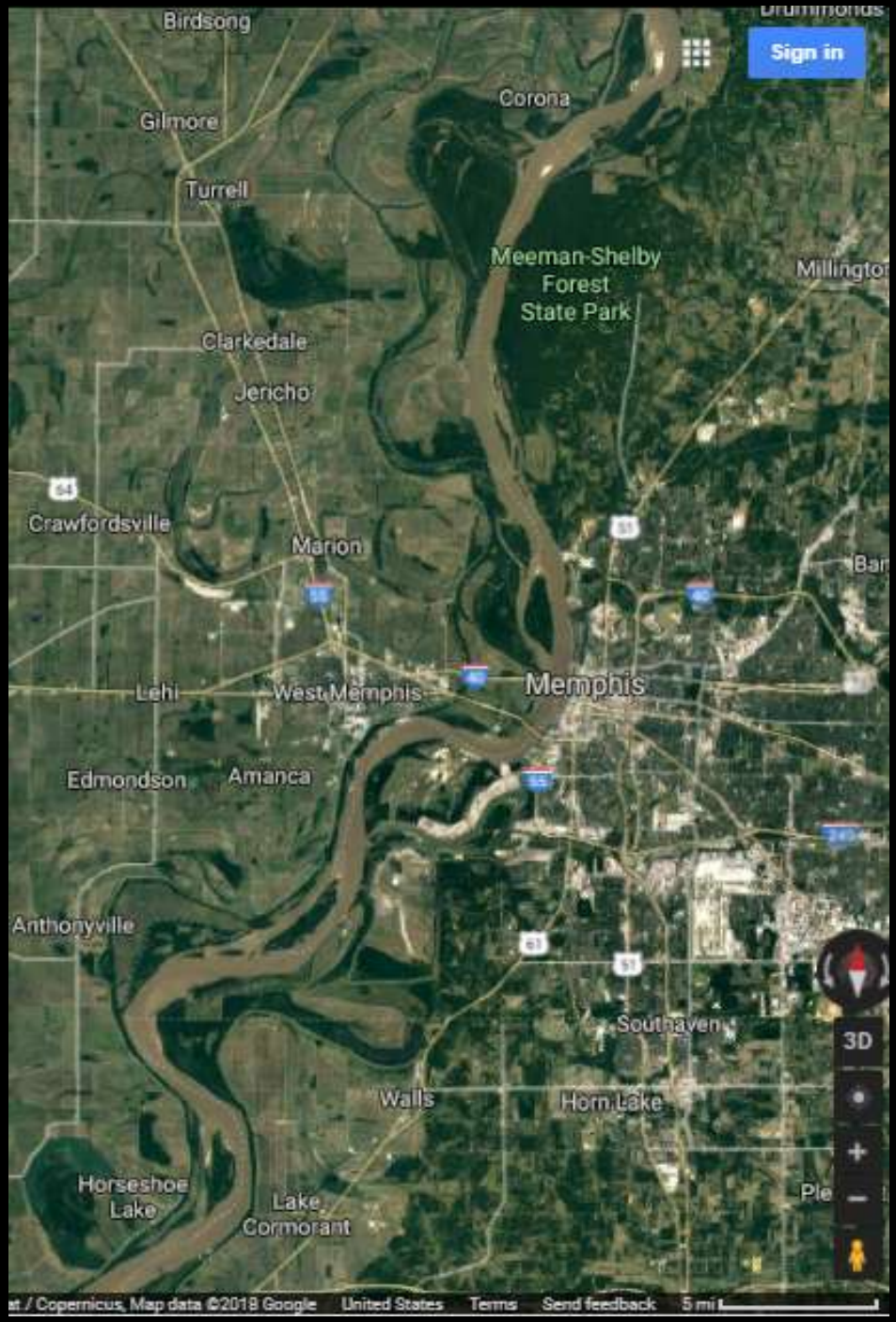


Shaping the Upper Ohio Valley: Rivers and Glaciations

Extent of glaciers in the last 2.6 million years

Pre-glacial Teays River





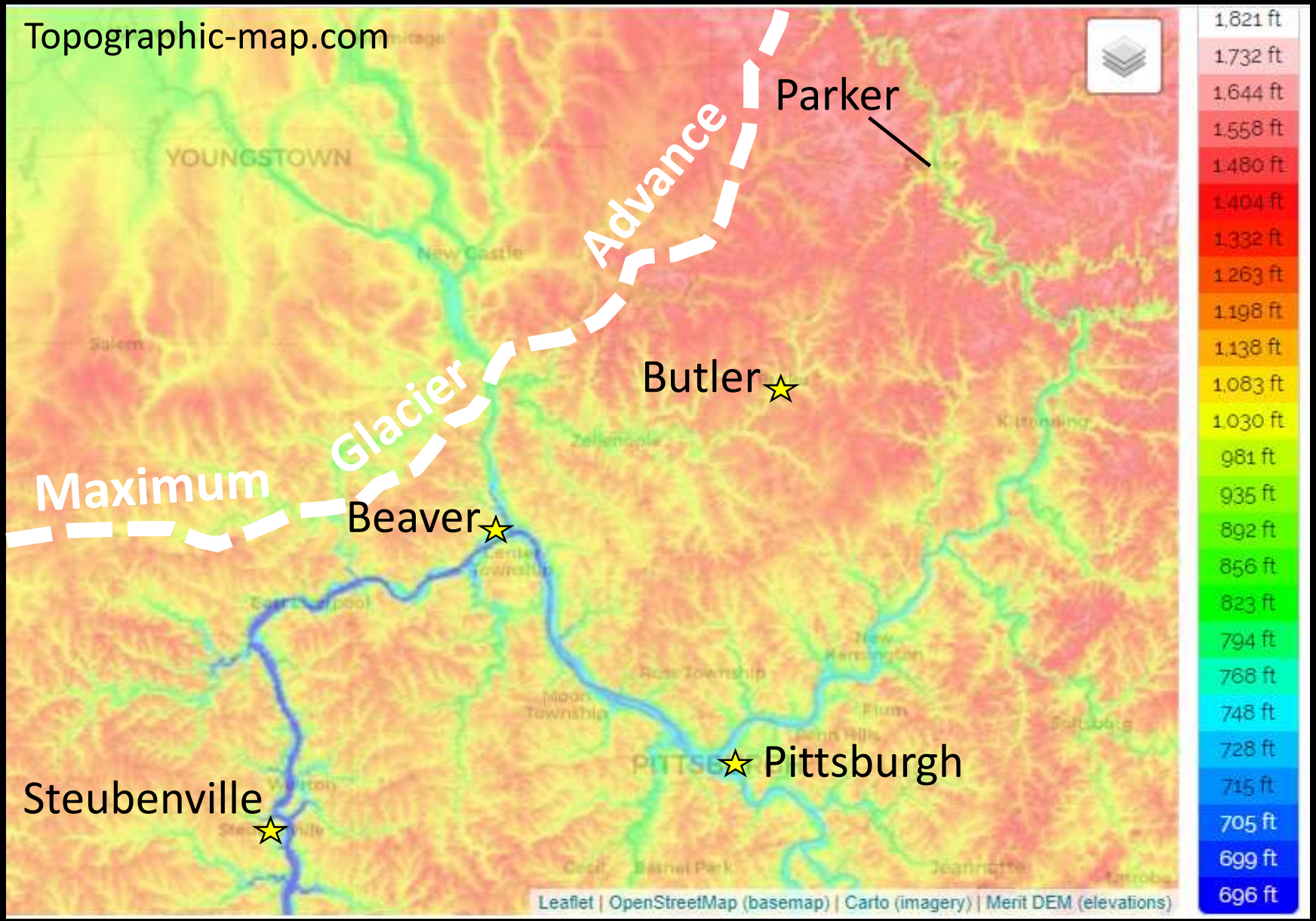
Example of an analog: Mississippi River meanders

Example of a physical model: Stream table

Emriver Em4 run, June 20, 2011.

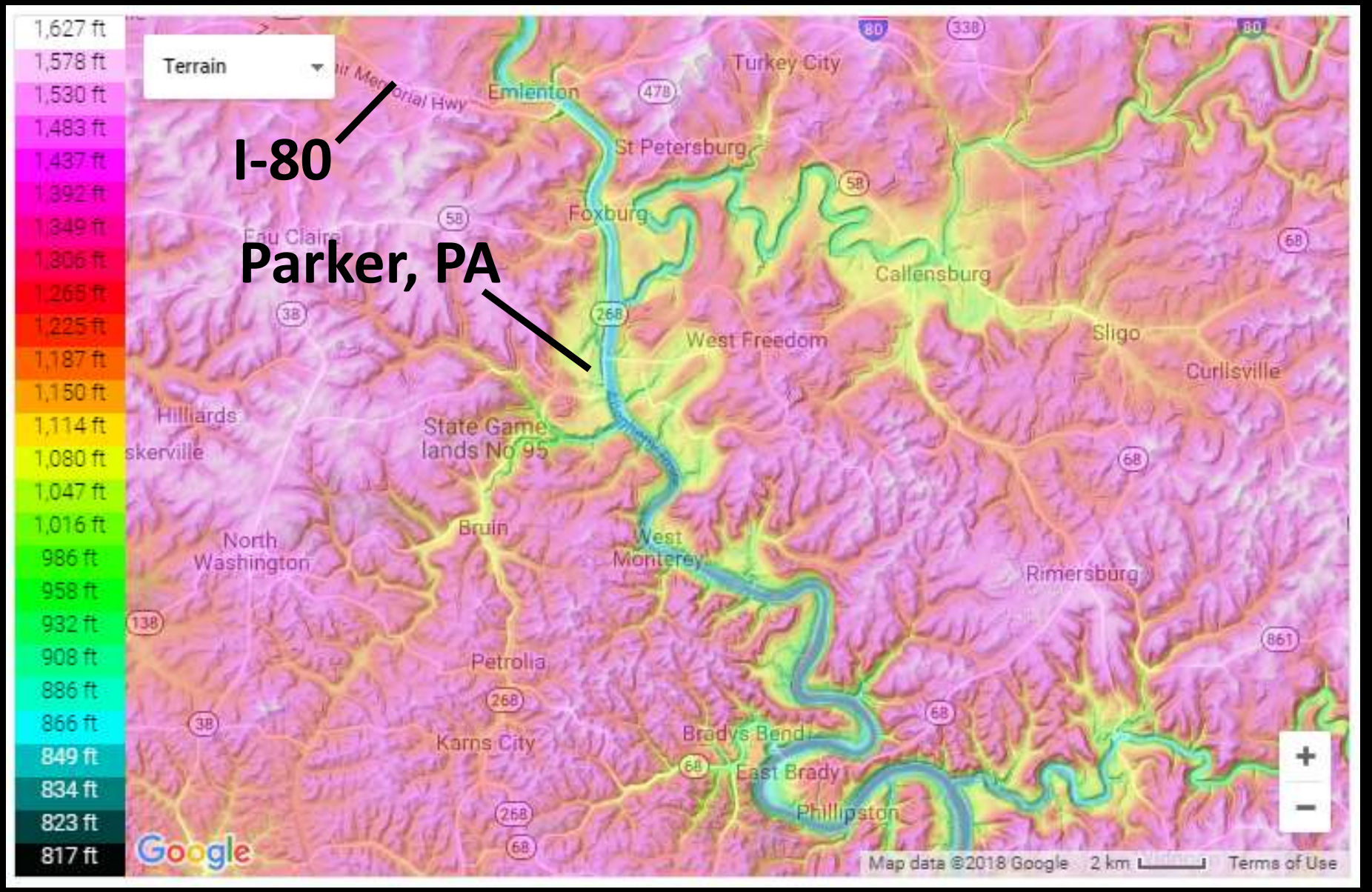
https://www.youtube.com/watch?v=5kdwaFsCtPs

Regional river and stream valleys



Glacier Limit from Glacial Map of Ohio (ODGS, 2005) and Geologic Map of Pennsylvania (Berg et al, 1990)

Parker Strath, Allegheny River Valley

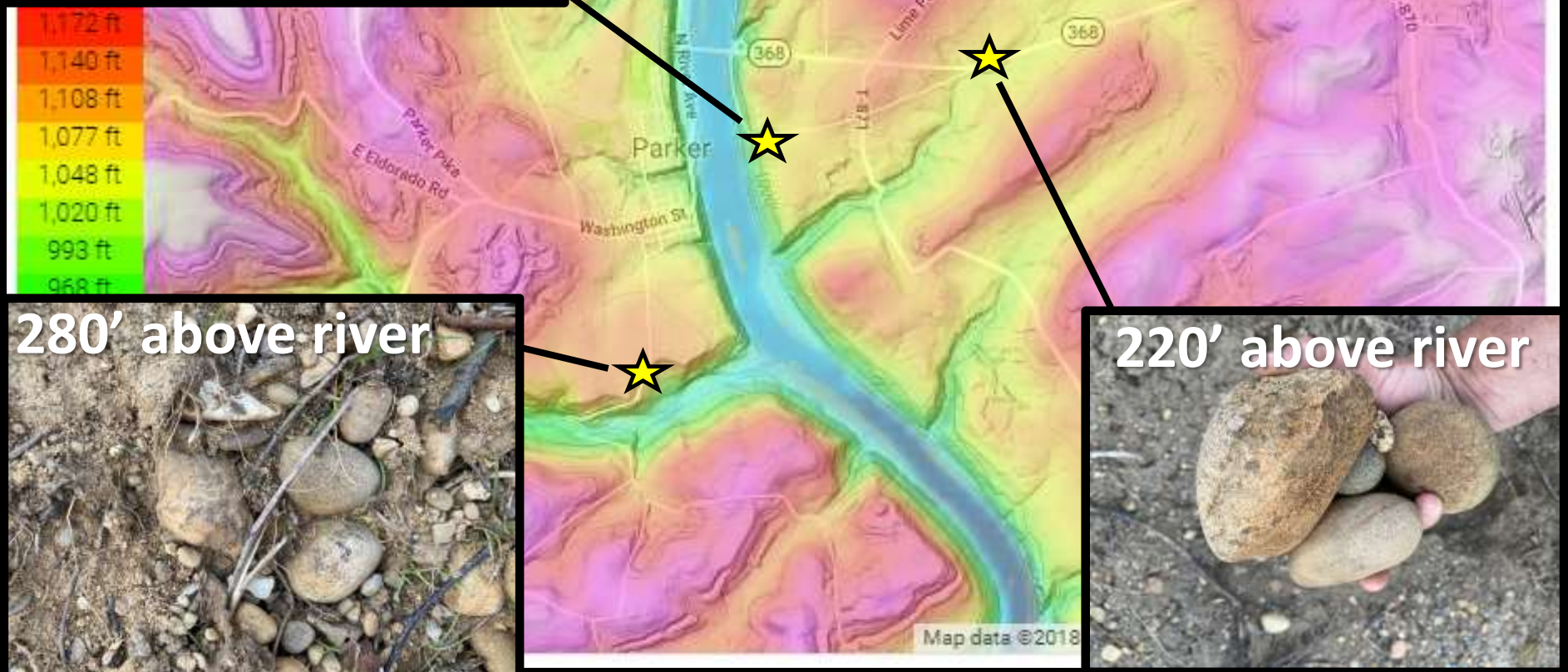


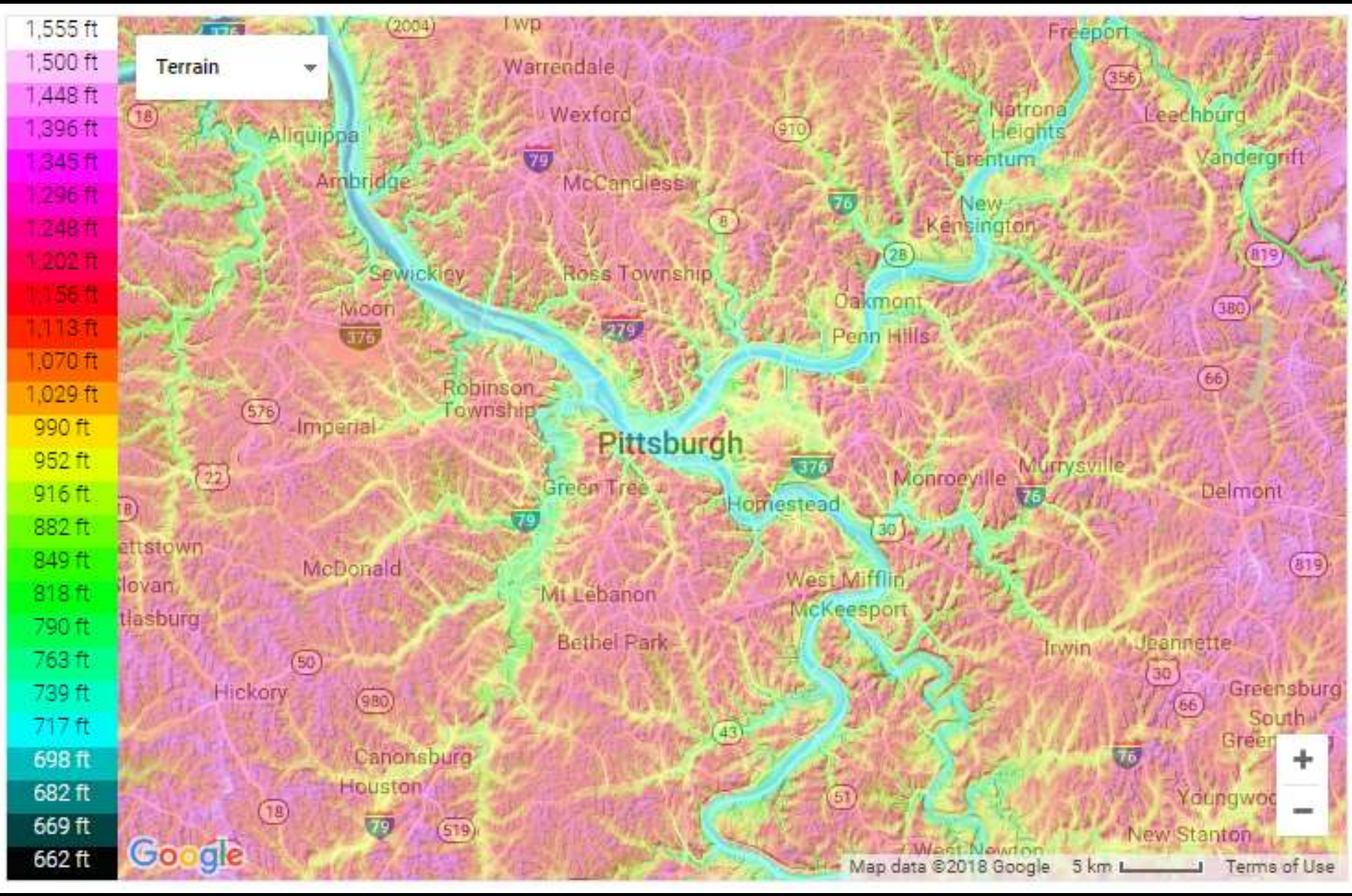
https://en-us.topographic-map.com/maps

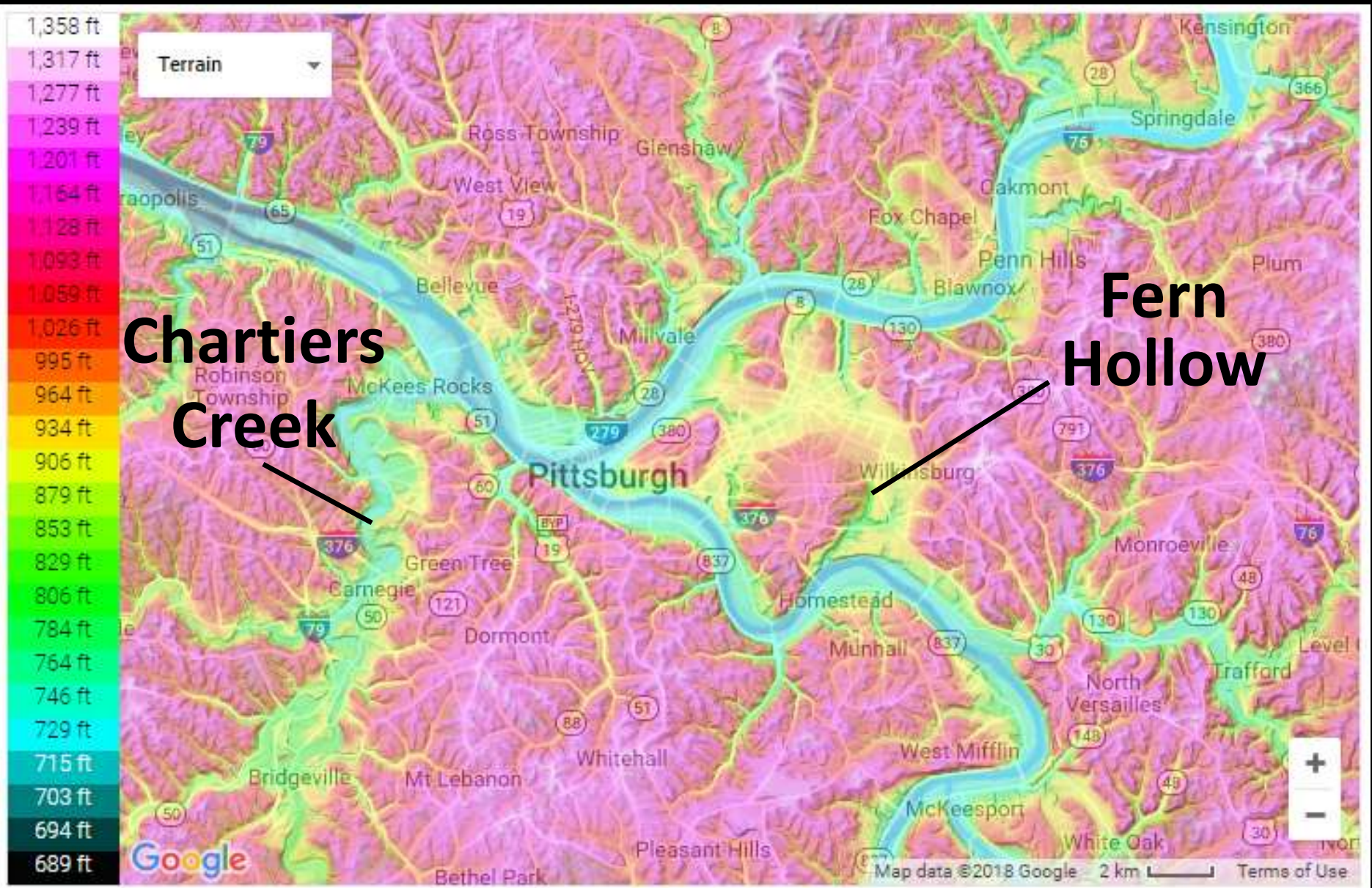
Parker Strath, Allegheny River Valley

https://en-us.topographic-map.com/maps

Cobbles in Parker Strath



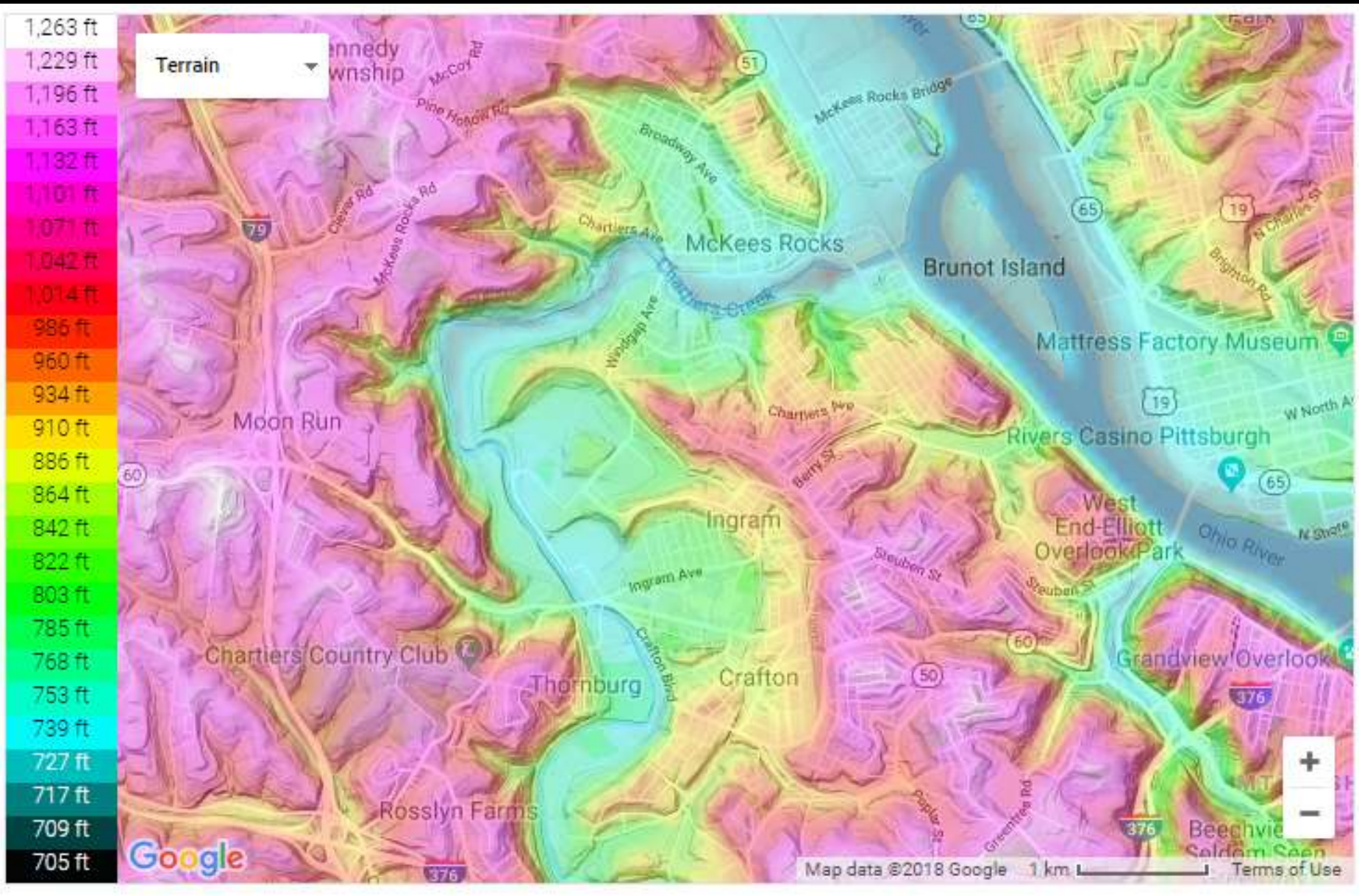

1,555 ft
1,500 ft
1,448 ft
1,396 ft
1,345 ft
1,296 ft
1,248 ft
1,202 ft
1,156 ft
1,113 ft
1,070 ft
1,029 ft
990 ft
952 ft
916 ft
882 ft
849 ft
818 ft
790 ft
763 ft
739 ft
717 ft
698 ft
682 ft
669 ft
662 ft
Terrain
Pittsburgh
Warrendale
Wexford
Aliquippa
Ambridge
McCandless
Freeport
Natrona Heights
Leechburg
Tarentum
Vandergrift
New Kensington
Sewickley
Ross Township
Moon
Oakmont
Penn Hills
Robinson Township
Imperial
Green Tree
Homestead
Monroeville
Murrysville
Delmont
McDonald
Mt Lebanon
West Mifflin
McKeesport
Bethel Park
Irwin
Jeannette
Greensburg
Hickory
Canonsburg
Houston
New Stanton
Google
Map data ©2018 Google
5 km
Terms of Use


1,358 ft
1,317 ft
1,277 ft
1,239 ft
1,201 ft
1,164 ft
1,128 ft
1,093 ft
1,059 ft
1,026 ft
995 ft
964 ft
934 ft
906 ft
879 ft
853 ft
829 ft
806 ft
784 ft
764 ft
746 ft
729 ft
715 ft
703 ft
694 ft
689 ft
Terrain
Chartiers Creek
Fern Hollow
Pittsburgh
Ross Township
Glenshaw
West View
Bellevue
Millvale
McKees Rocks
Robinson Township
Green Tree
Carnegie
Dormont
Mt Lebanon
Bridgeville
Whitehall
Pleasant Hills
Bethel Park
Homestead
Munhall
Monroeville
Springdale
Kensington
Oakmont
Fox Chapel
Penn Hills
Plum
Blawnox
Trafford
North Versailles
West Mifflin
McKeesport
White Oak
Google
Map data ©2018 Google
2 km
Terms of Use

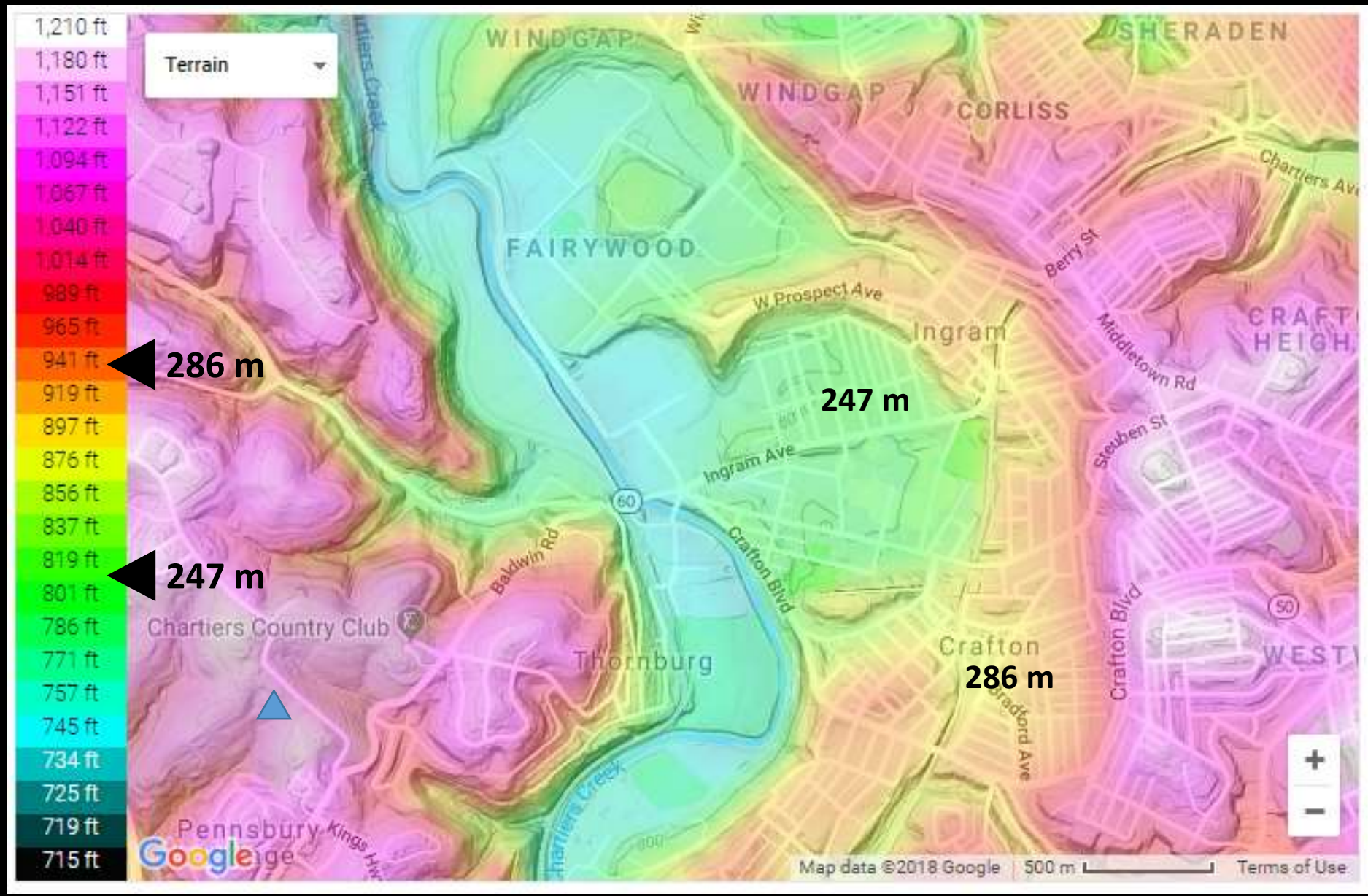
River terrace deposits along Fern Hollow

River rock on terrace 170 feet above Monongahela River, in place under 200+ year old trees

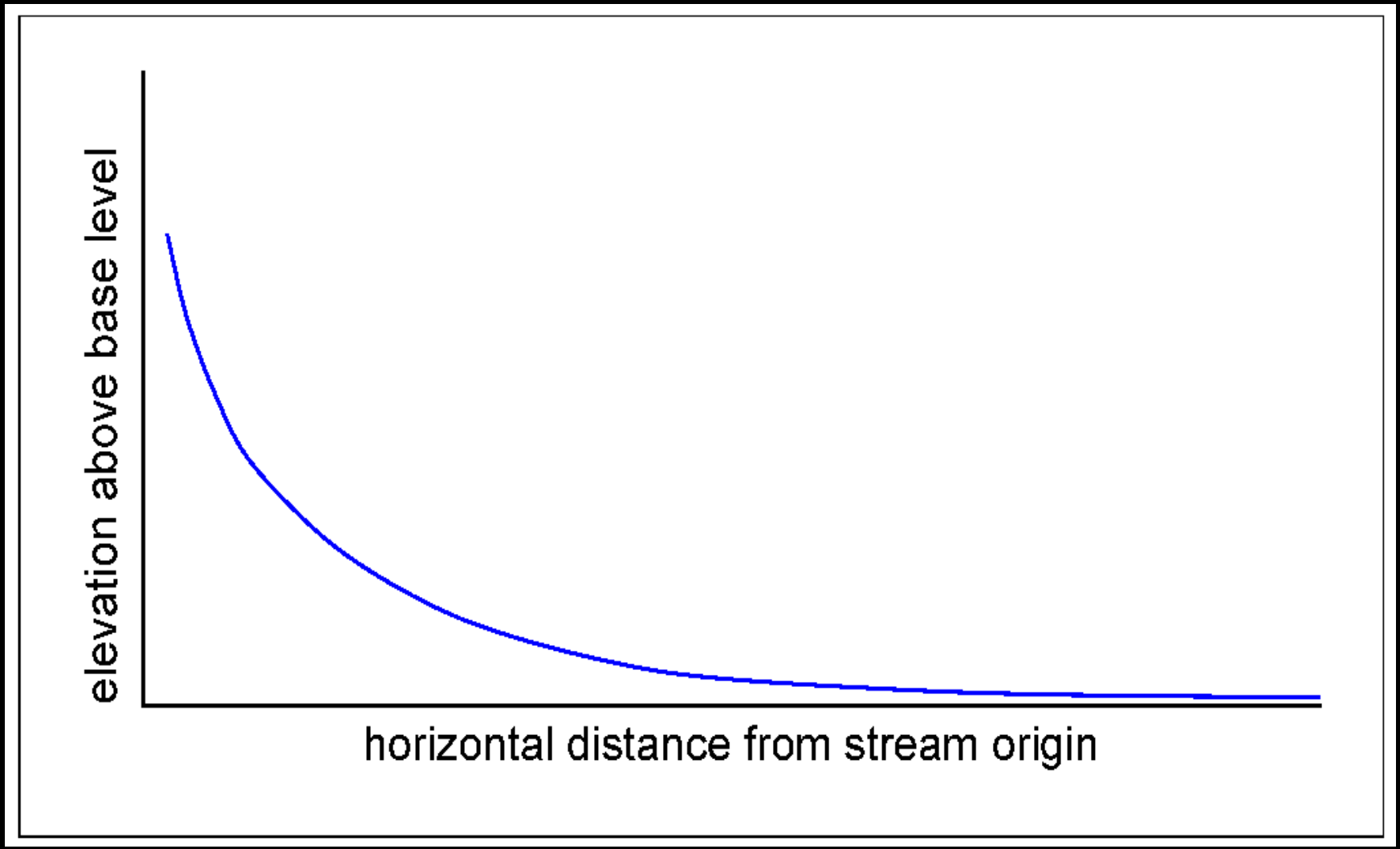
Lower Chartiers Creek Valley



Lower Chartiers Creek Valley, Crafton-Ingram

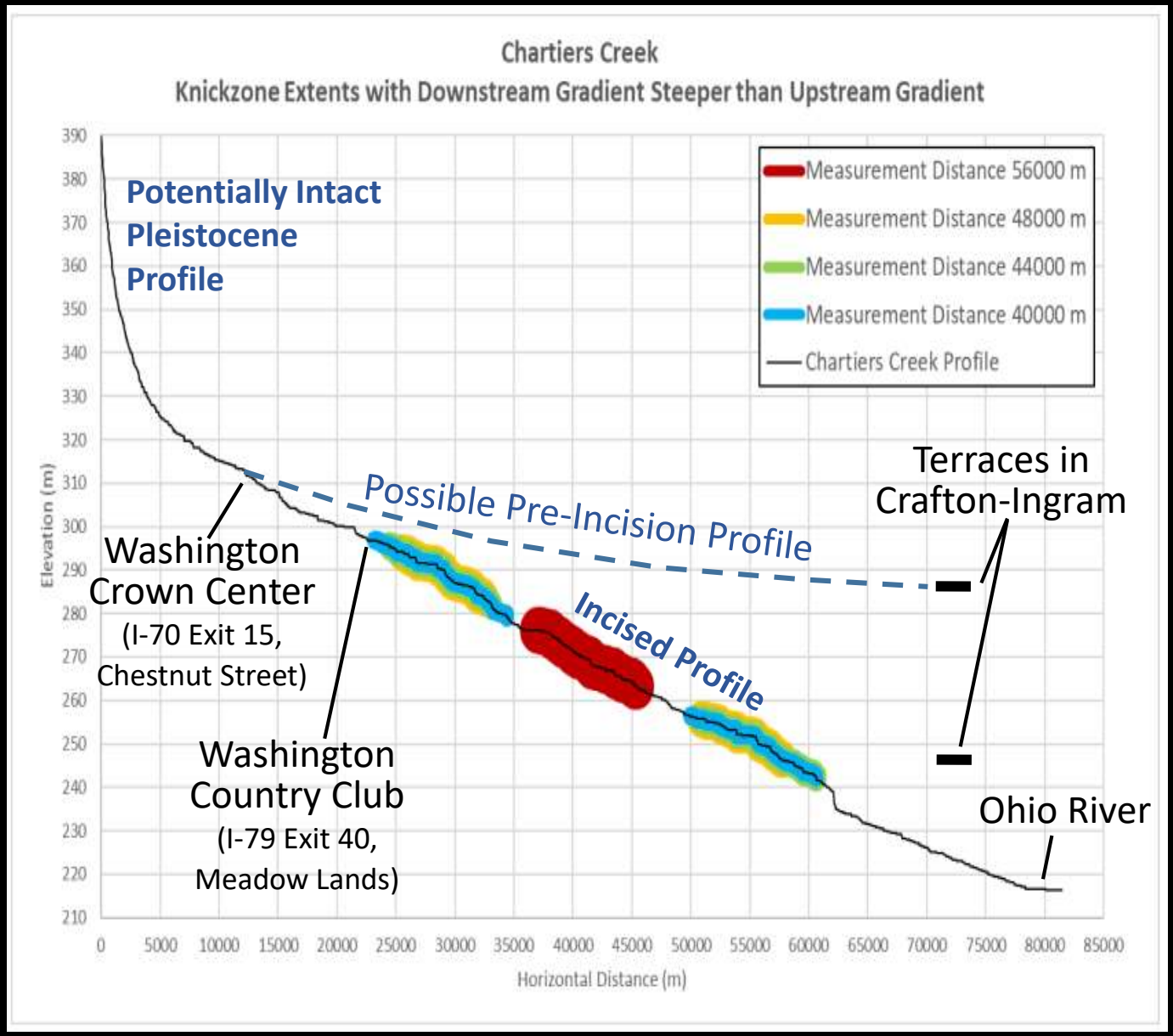


Ideal stream elevation profile



https://courses.lumenlearning.com/wmopen-geology/chapter/outcome-rivers-and-streams/

Elevation profile of Chartiers Creek



Profile from Swift, 2020; interpretation consistent with Kite & Swift, 2019

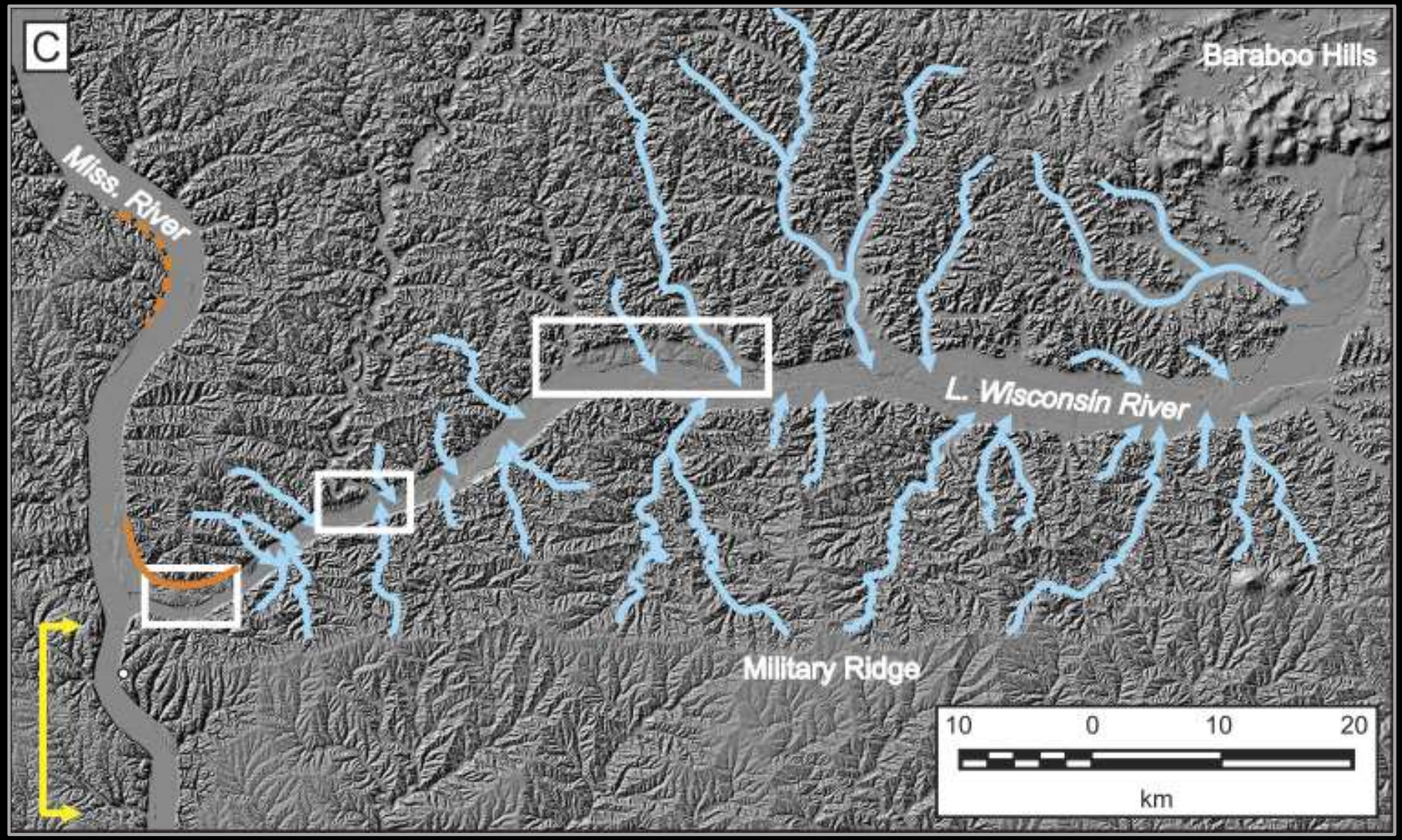
Allegheny River terraces

Table 2. Terraces of the Allegheny River and tributaries

Terraces	Ft (m)Above River Level	Ft (m) Above Sea Level
First *(modern floodplain)*	Variable	Variable
Second	200-210 (61-64)	900-920 (274-280)
Third	250-270 (76-82)	960-980 (293-299)
Fourth	290-310 (88-95)	1000-1020 (305-311)
Fifth	330-350 (101-107)	1040-1060 (317-323)

Marine and Donahue, 2000

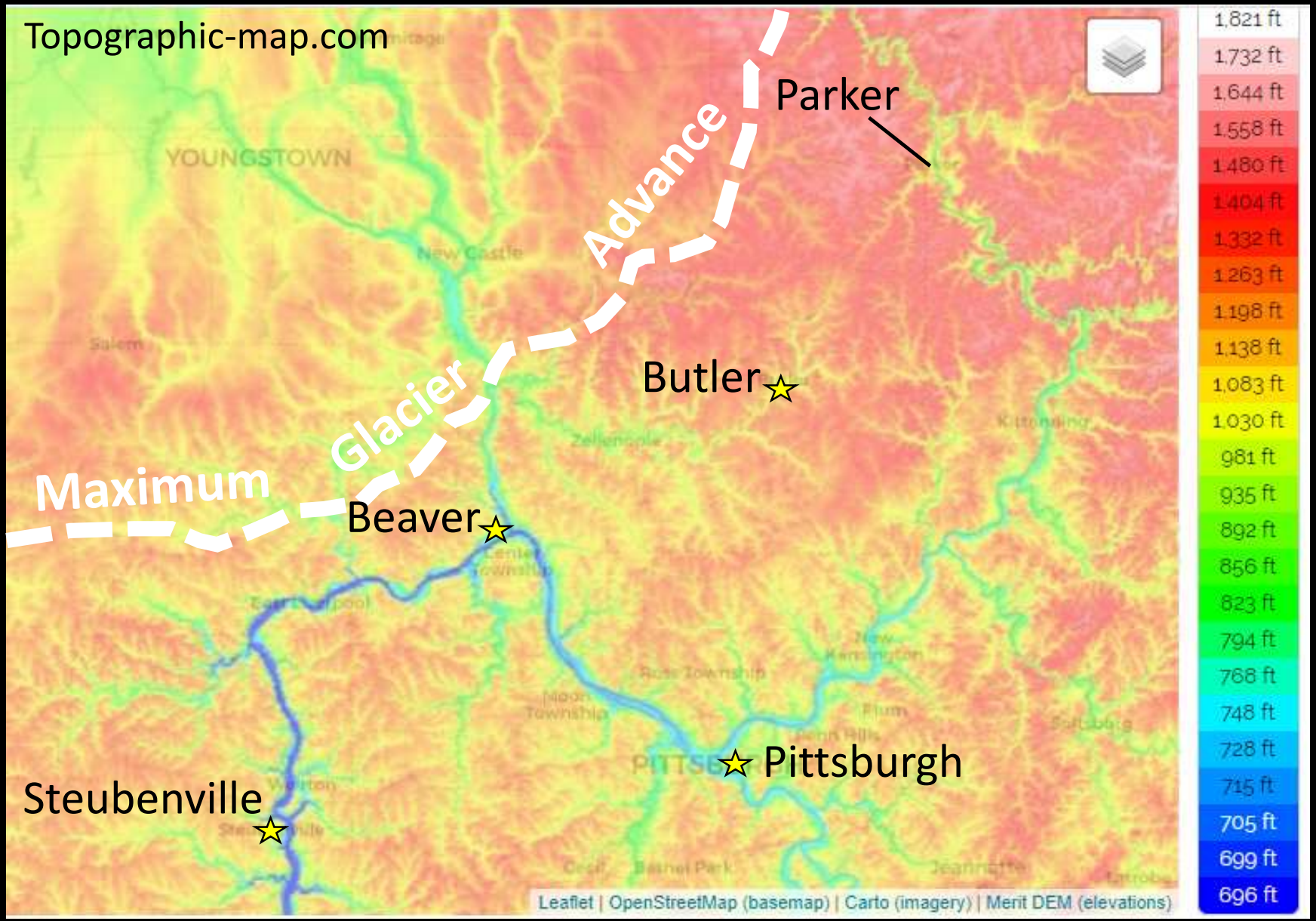
Example of drainage direction reversal: Wisconsin River



- Perched terraces are lower to east
- Entries of tributaries suggest flow to east
- Narrow Mississippi Valley south of confluence (former drainage divide)

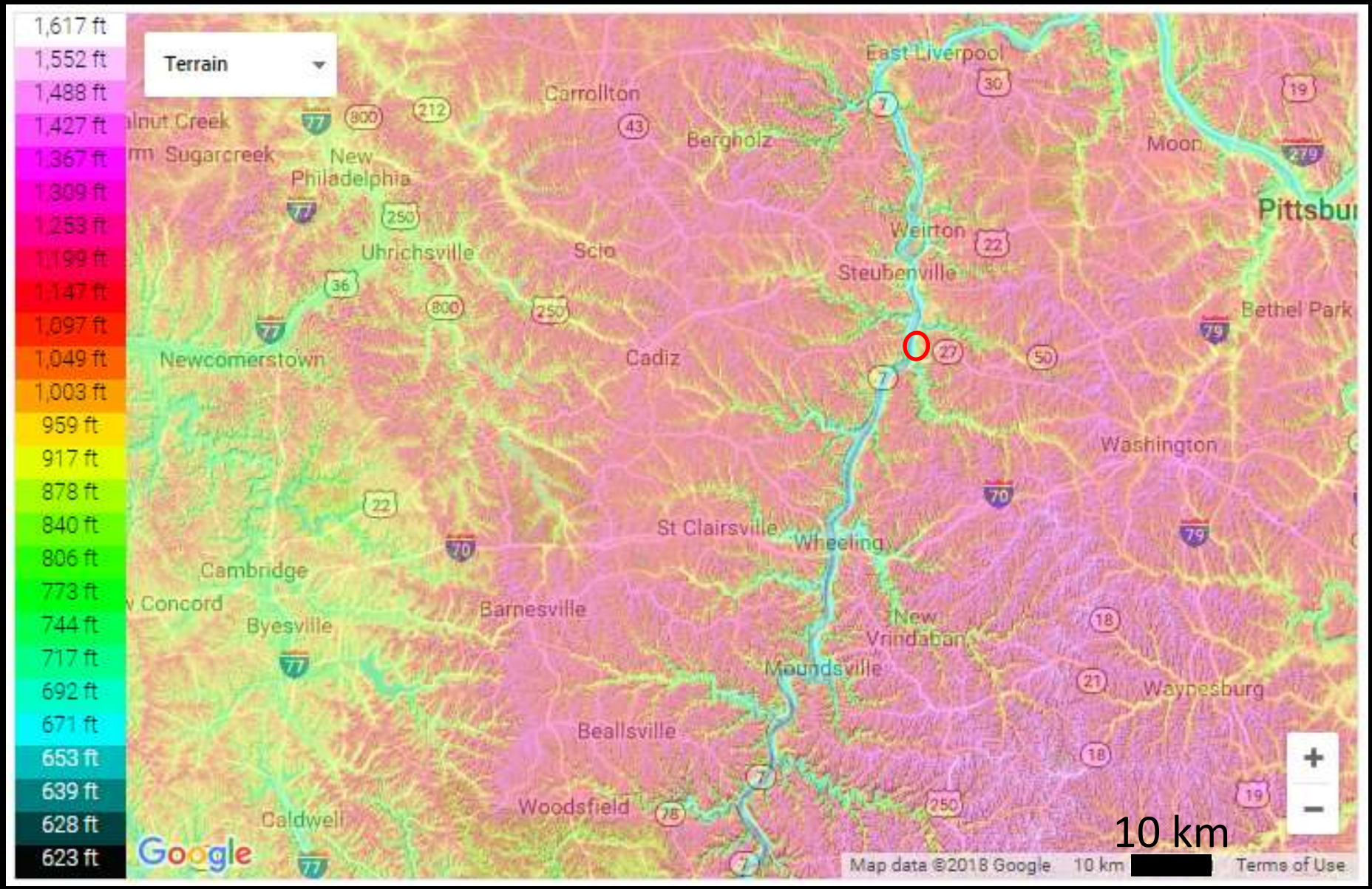
(Carson et al, 2018)

Regional river and stream valleys

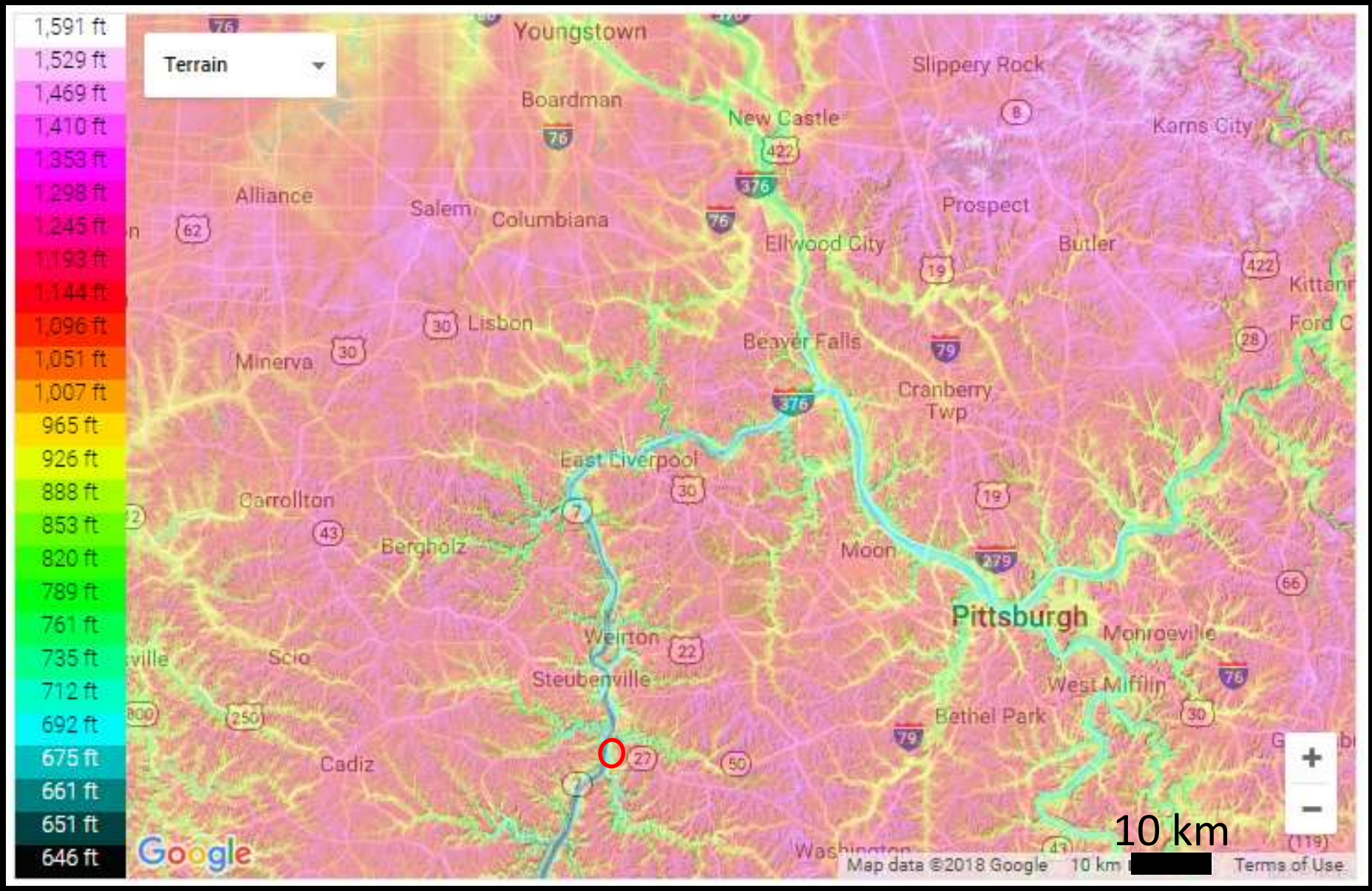


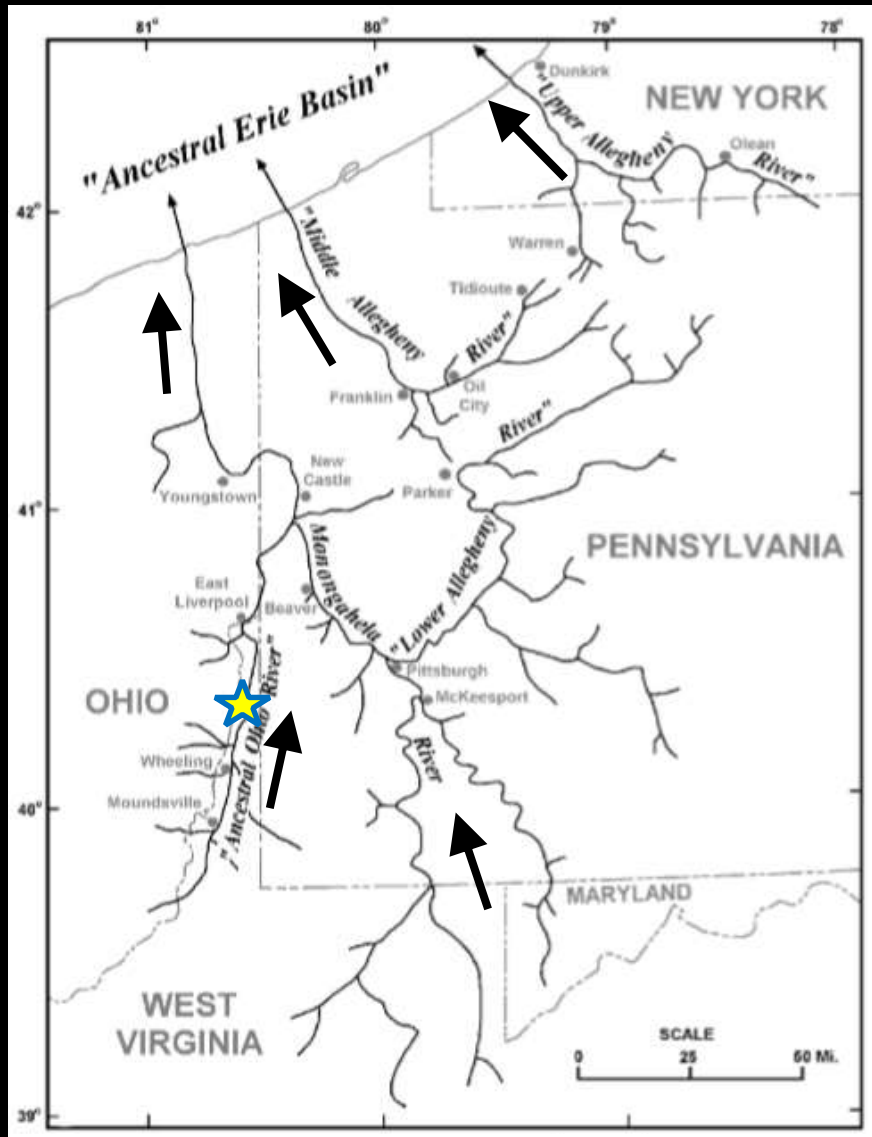
Glacier Limit from Glacial Map of Ohio (ODGS, 2005) and Geologic Map of Pennsylvania (Berg et al, 1990)

Upper Ohio River Valley

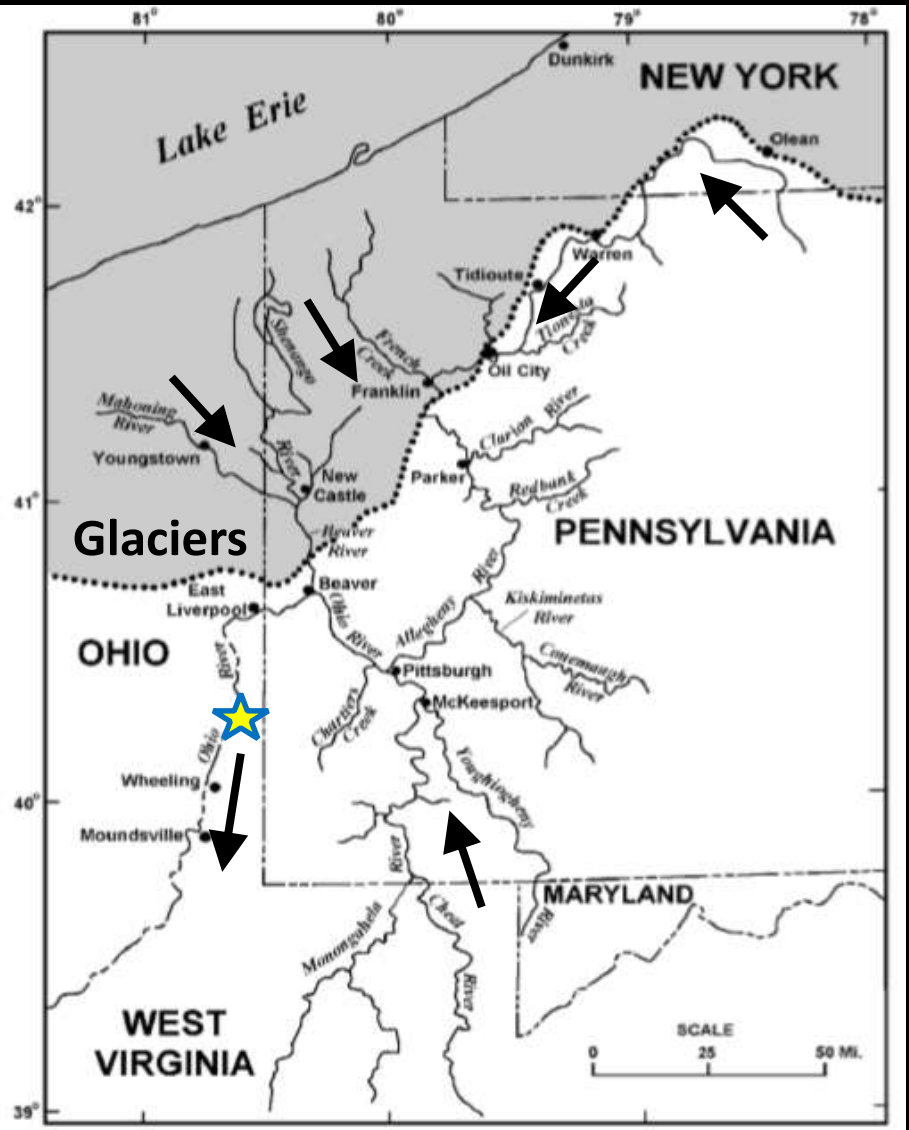


River valleys in Pittsburgh-Steubenville area



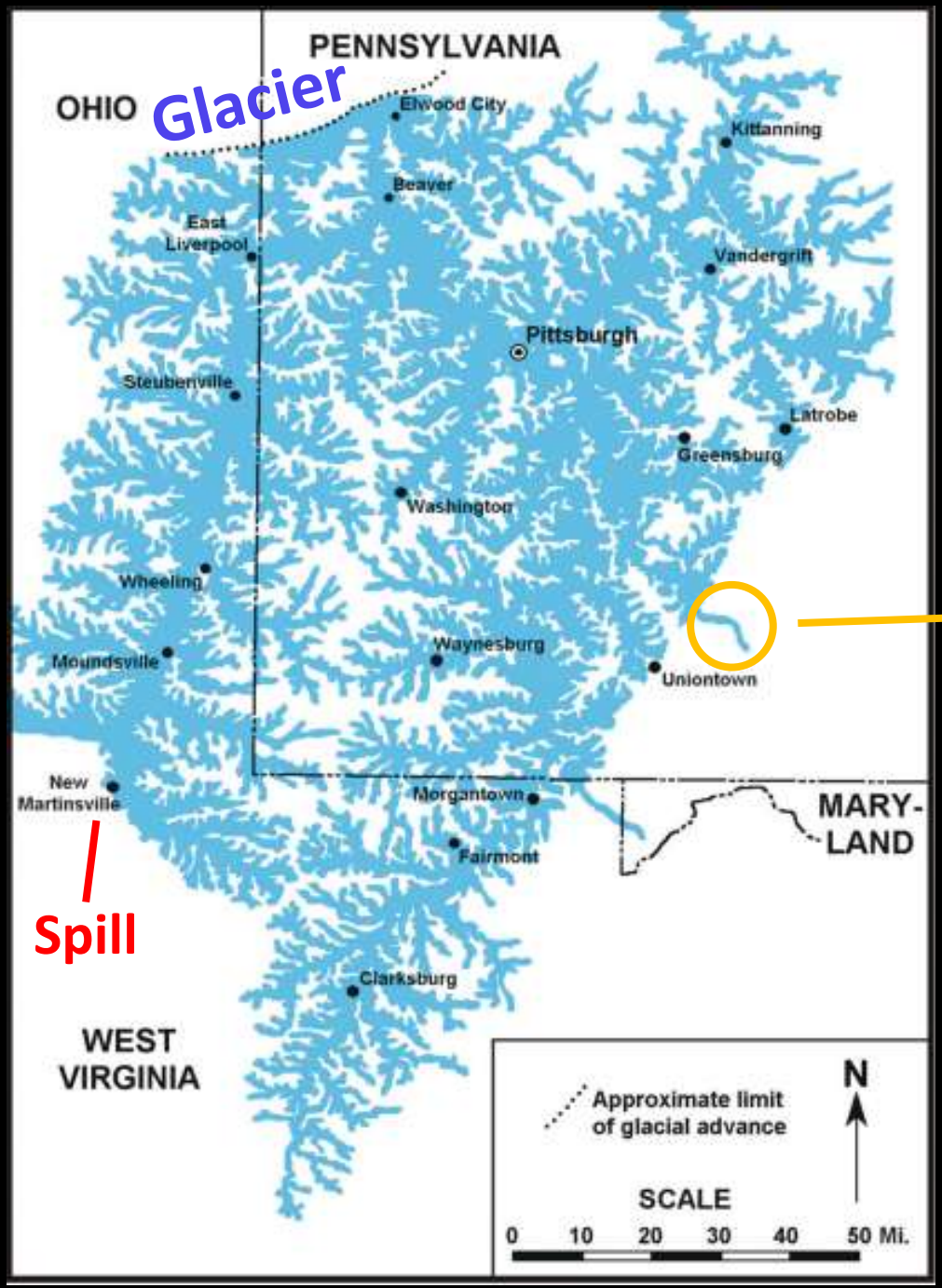


Interpreted preglacial drainage pattern



Current drainage with extent of glaciation shaded

Marine and Donahue, 2000



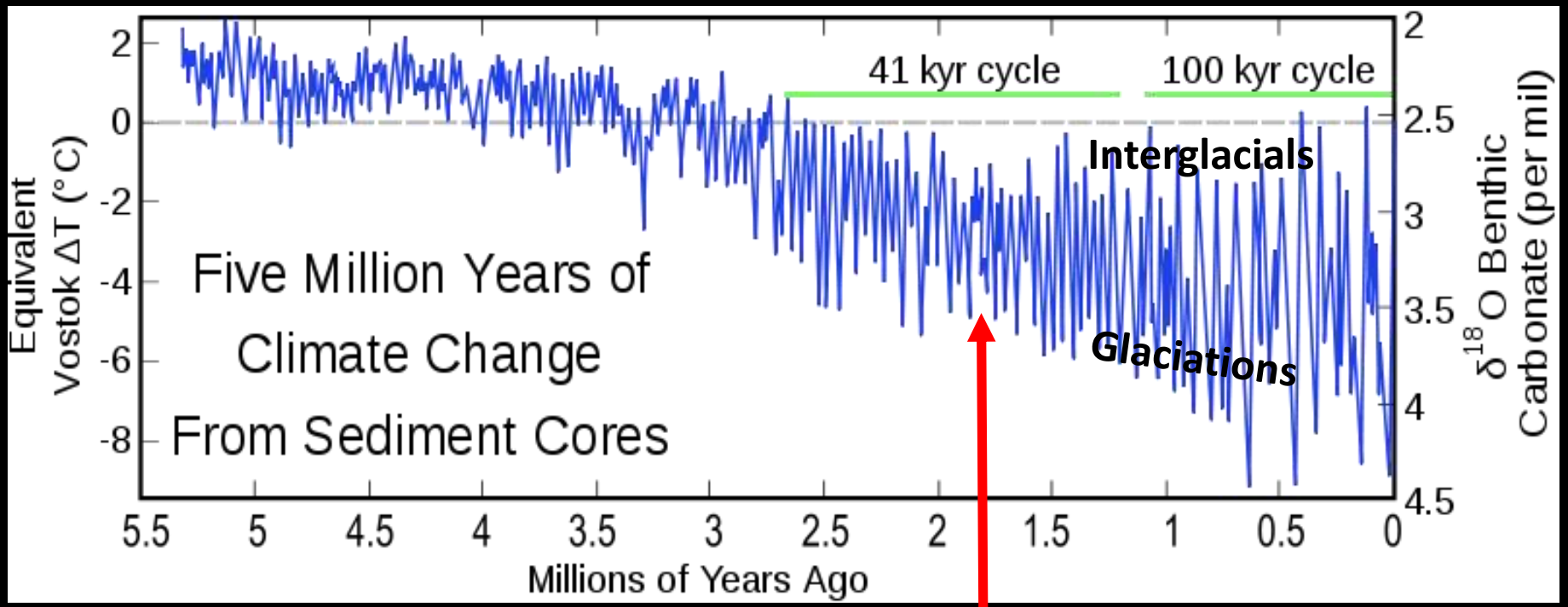
Pleistocene Lake Monongahela

Possible maximum elevation 1,100 ft (335 m)

Interpreted lake sediment in Youghiogheny River Valley was deposited 1.8 million years ago (Kurak et al, 2021)

Modified from Marine, 1997 by Harper, 2011 and 2013

Global climate in last 5 million years

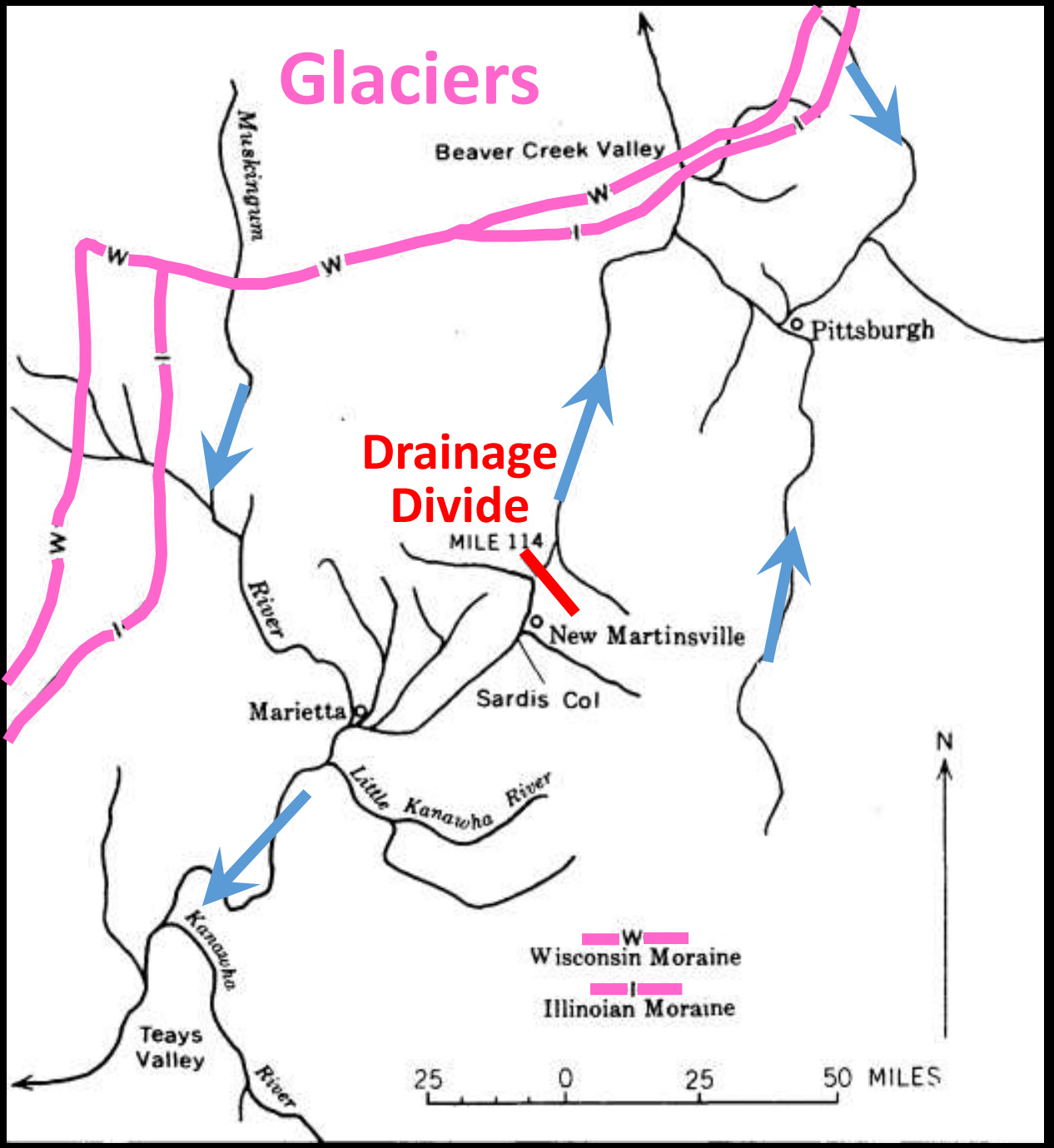


Approximate age of Lake Monongahela: 1.8 million years (Kurak et al 2021)

At least 30 glacial advances since the formation of glacial Lake Monongahela!

https://commons.wikimedia.org/wiki/File:Five_Myr_Climate_Change.svg

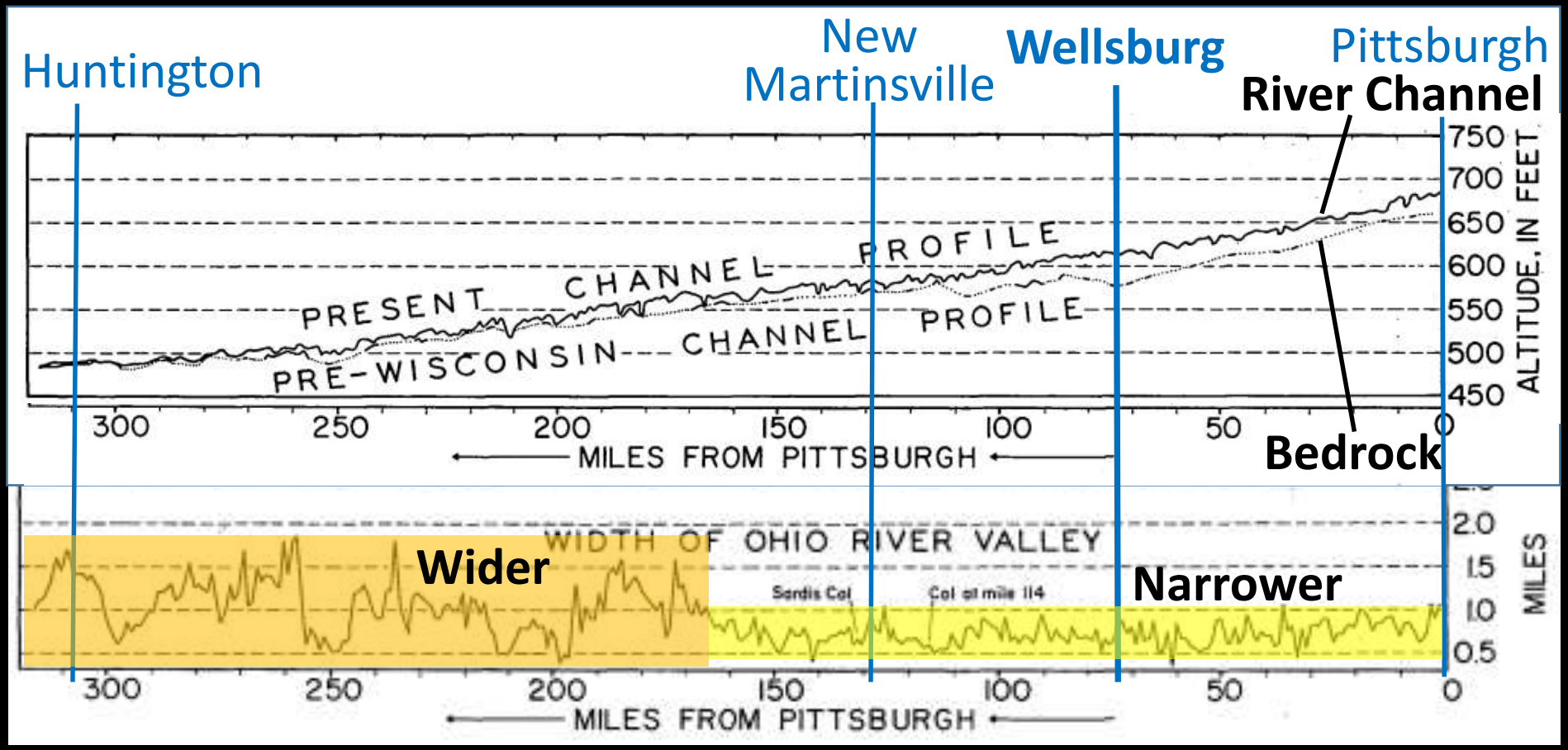
Upper Ohio River before glaciation



Carlston, 1962

https://pubs.usgs.gov/bul/1141i/report.pdf

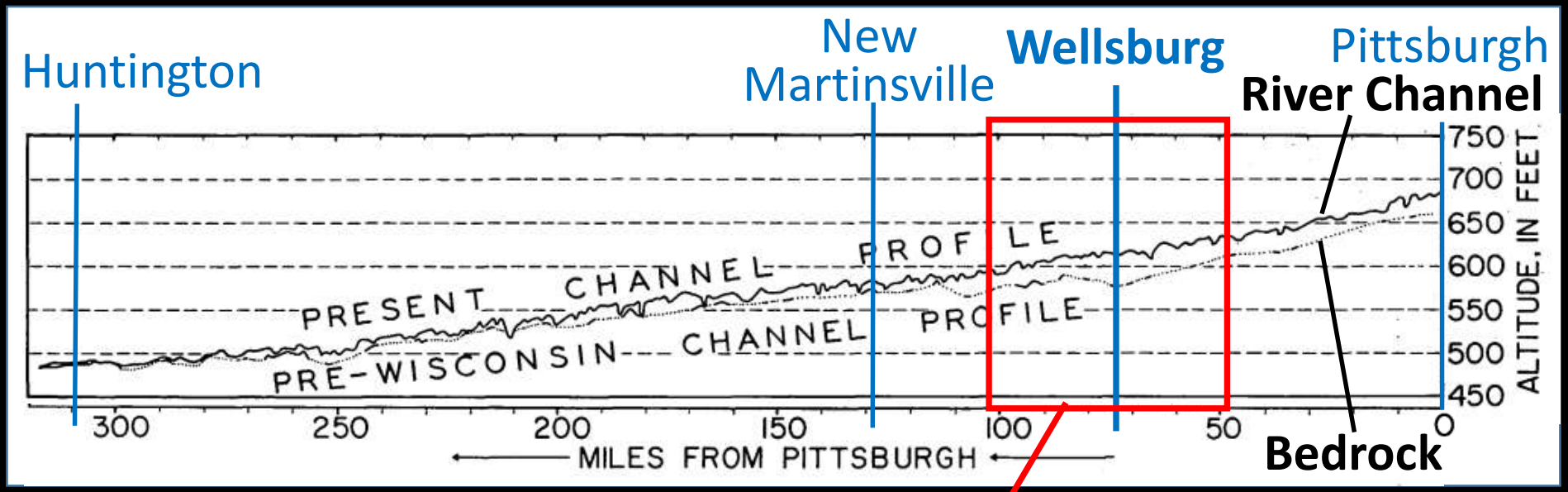
Profile of Upper Ohio River Valley

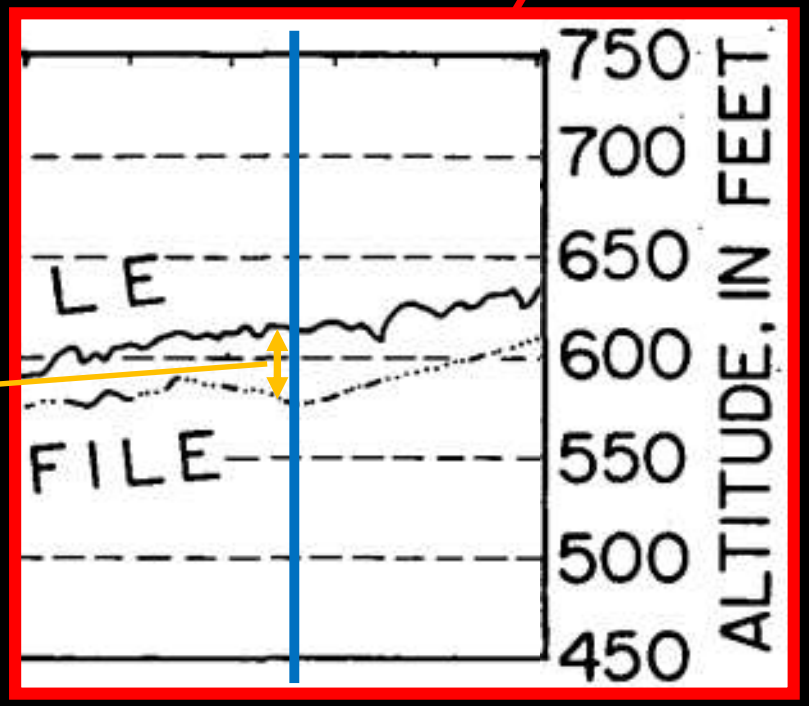


Carlston, 1962

https://pubs.usgs.gov/bul/1141i/report.pdf

Profile of sediment under Ohio River Channel

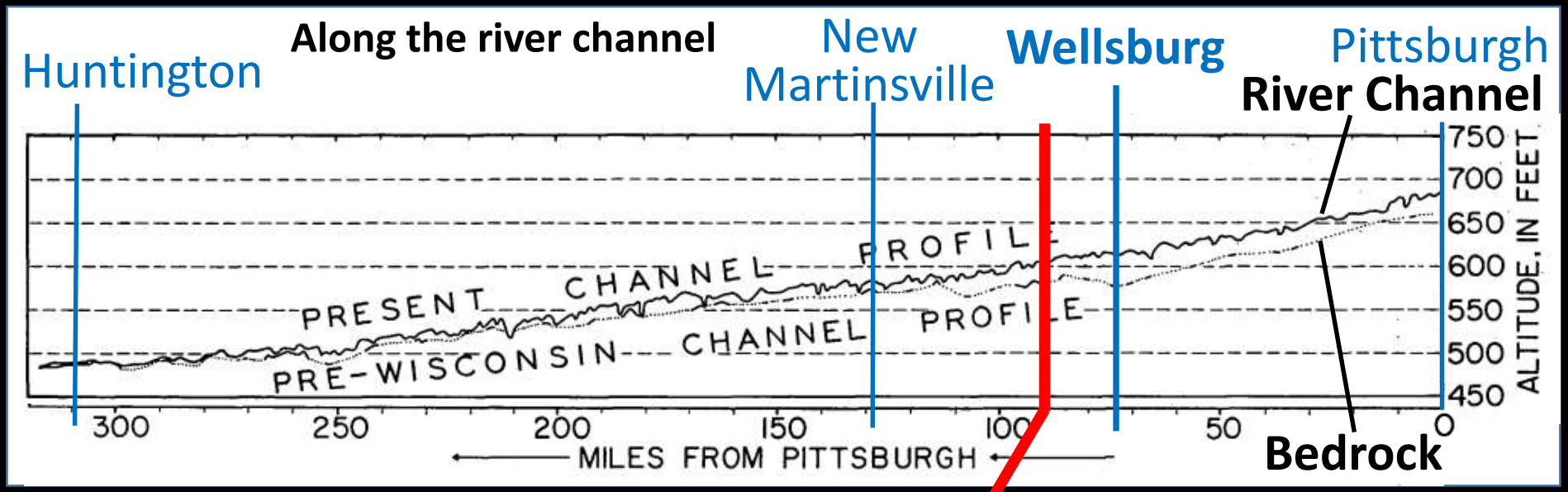


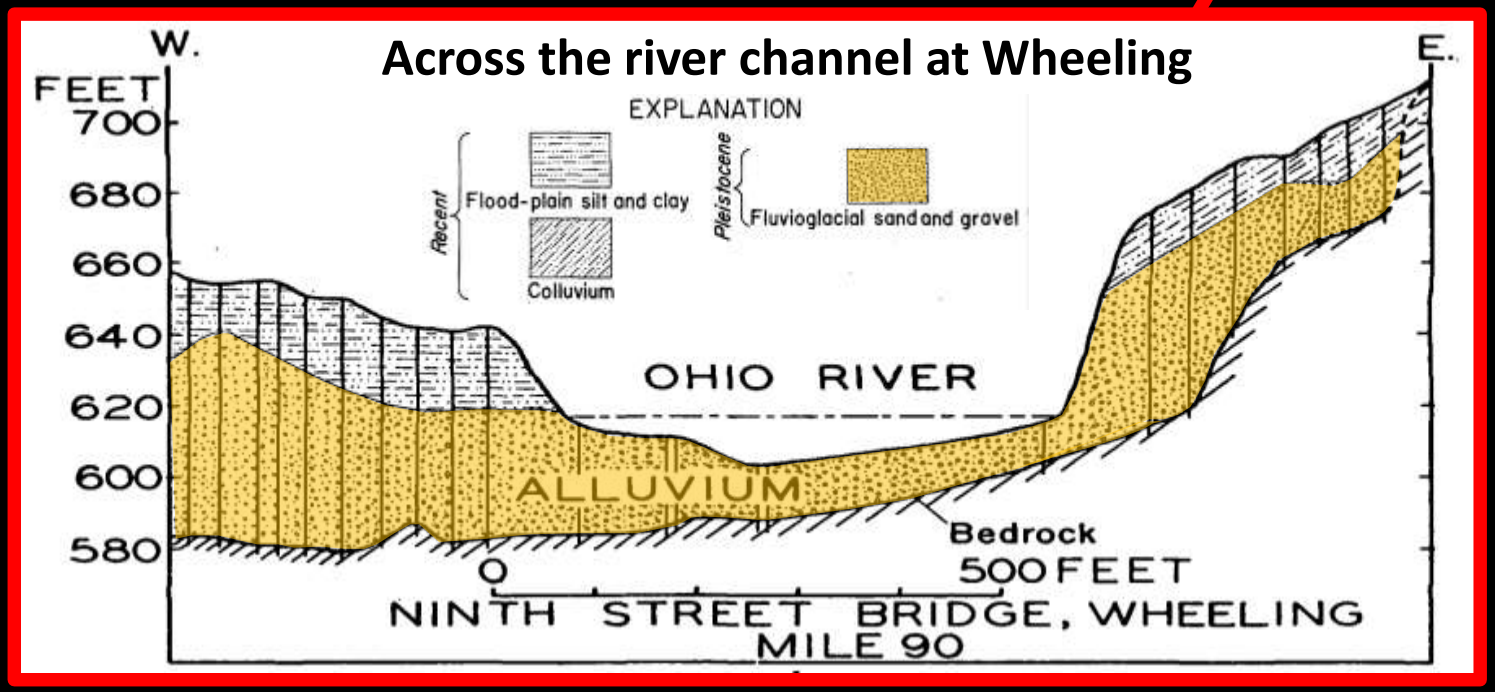


40 feet of sediment between the bottom of the Ohio River channel and bedrock at Wellsburg

Carlston, 1962
https://pubs.usgs.gov/bul/1141i/report.pdf

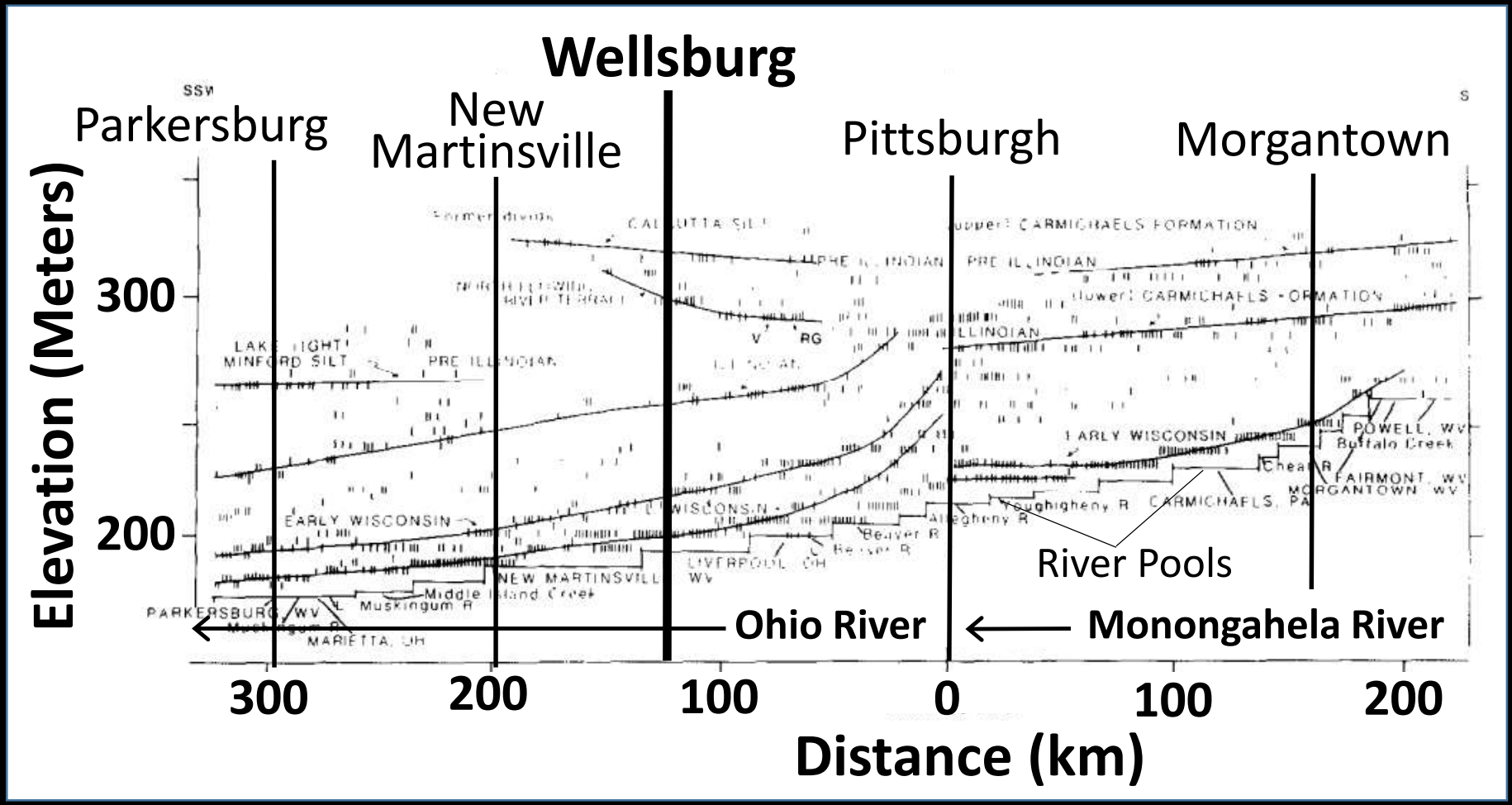
Profiles of sediment Ohio River Channel





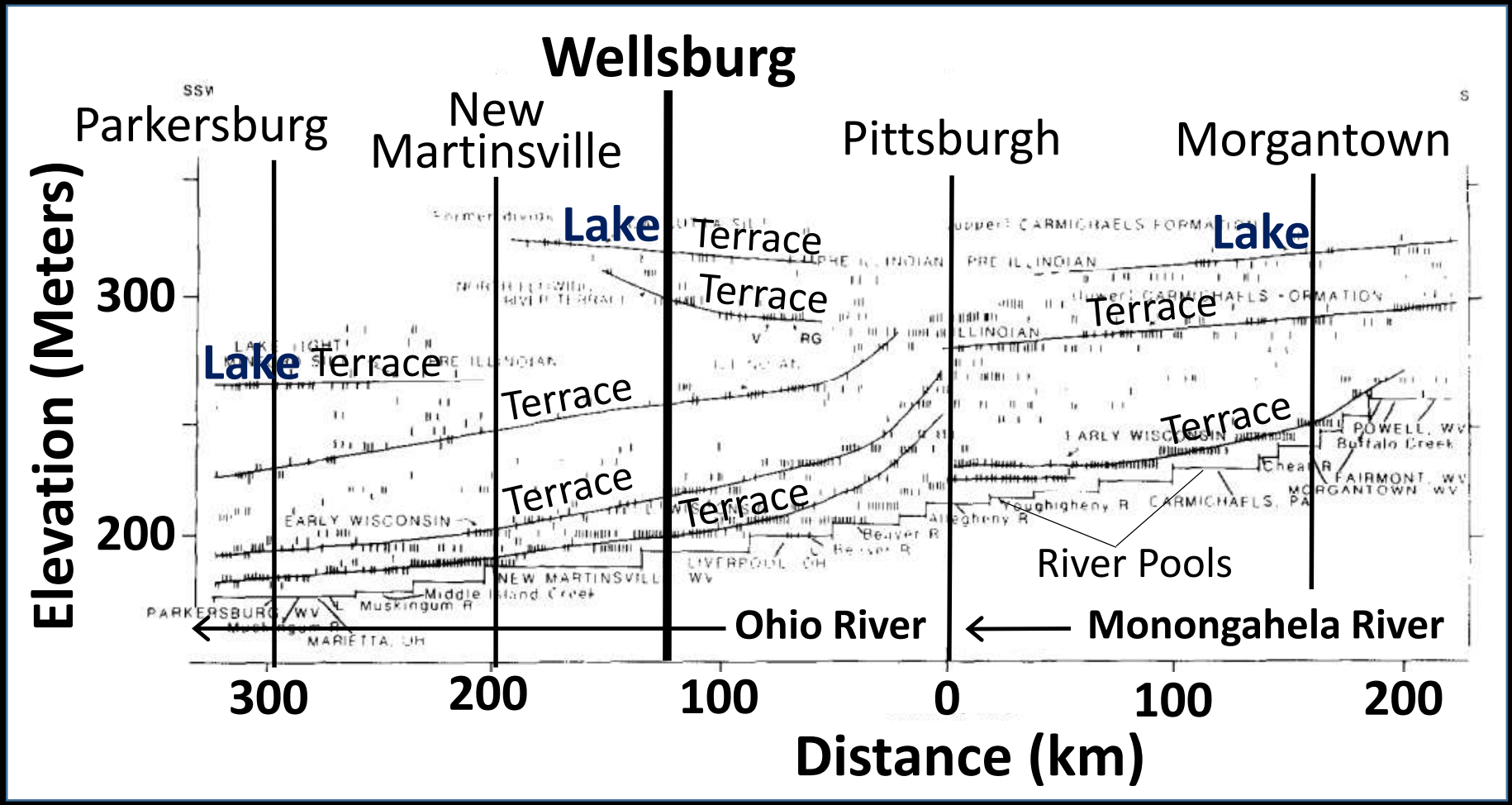
Carlston, 1962
https://pubs.usgs.gov/bul/1141i/report.pdf

River terraces along the upper Ohio and Monongahela river valleys



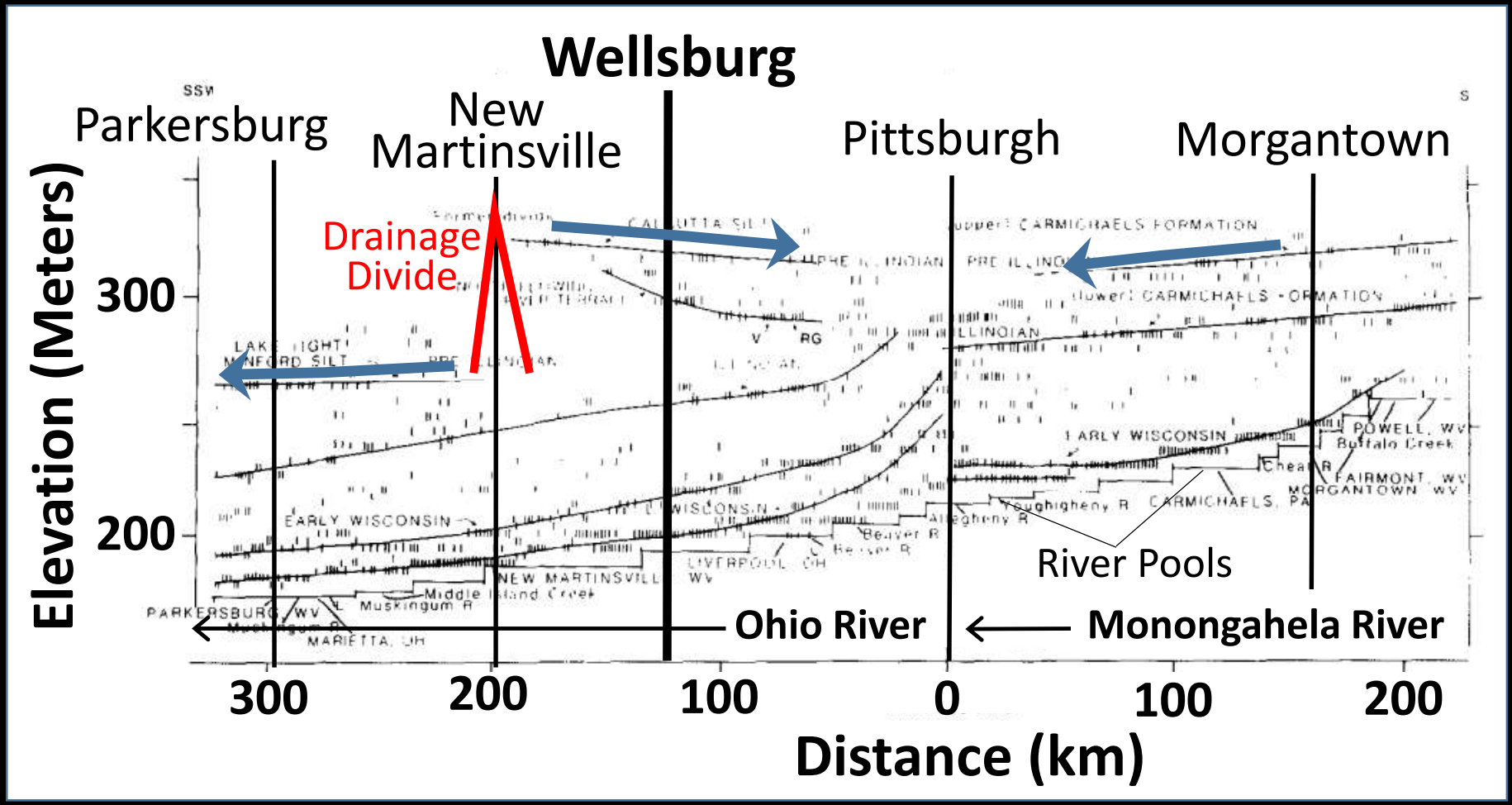
Jacobson et al, 1988

River terraces and lake deposits along the upper Ohio and Monongahela river valleys



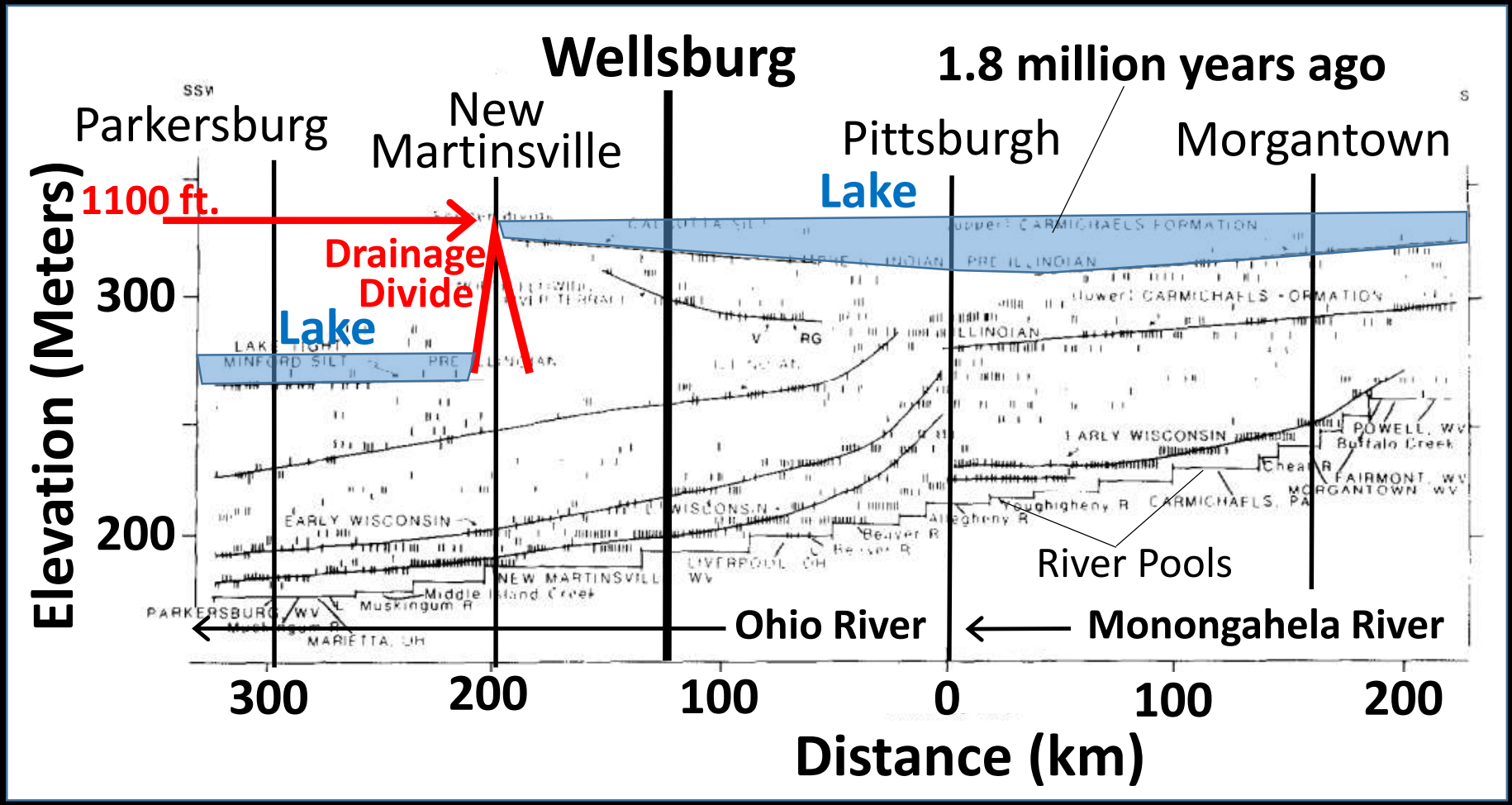
Jacobson et al, 1988

1. River drainage before glacial lakes



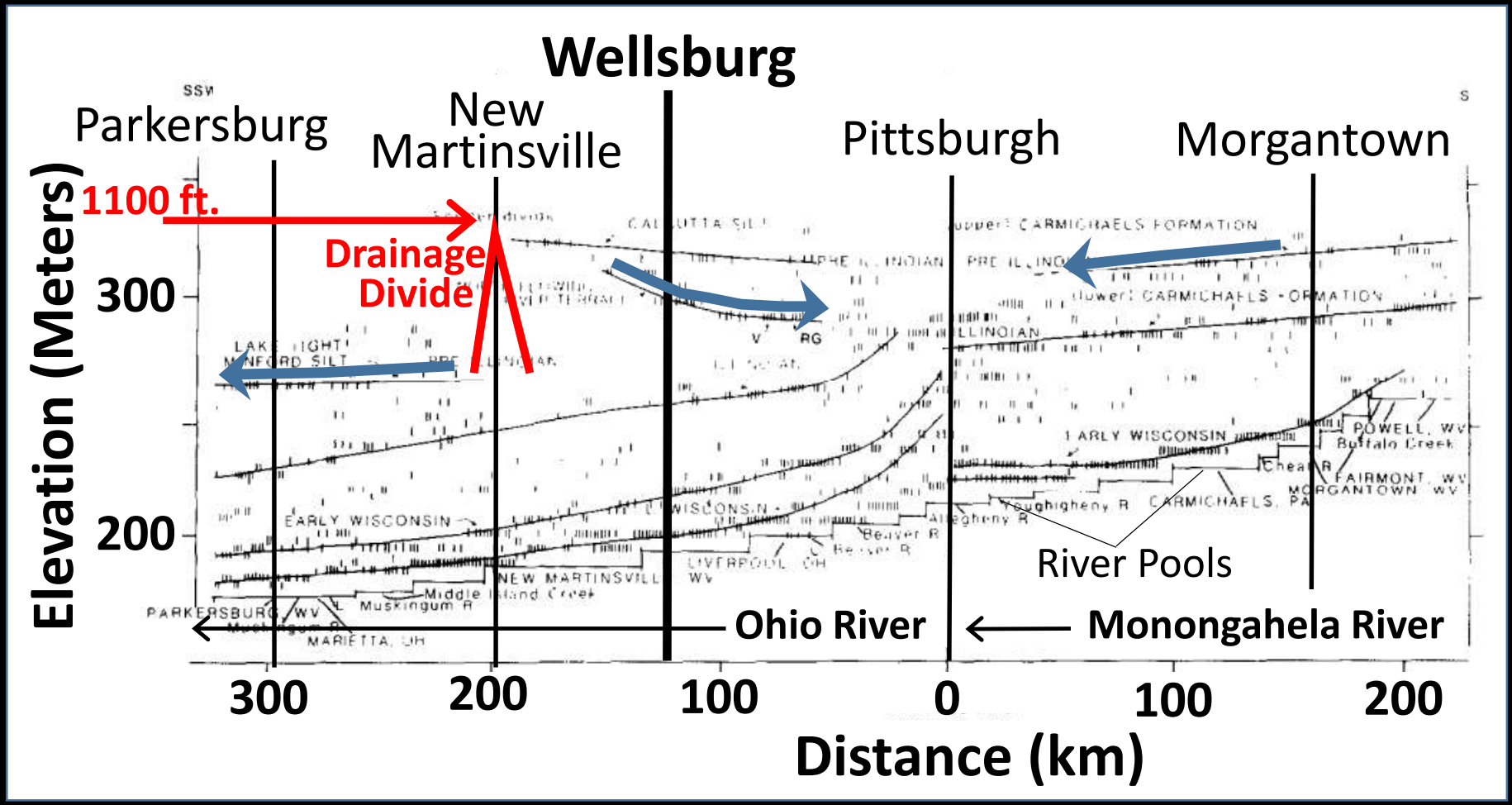
Jacobson et al, 1988

2. Lakes dammed by glaciers to north



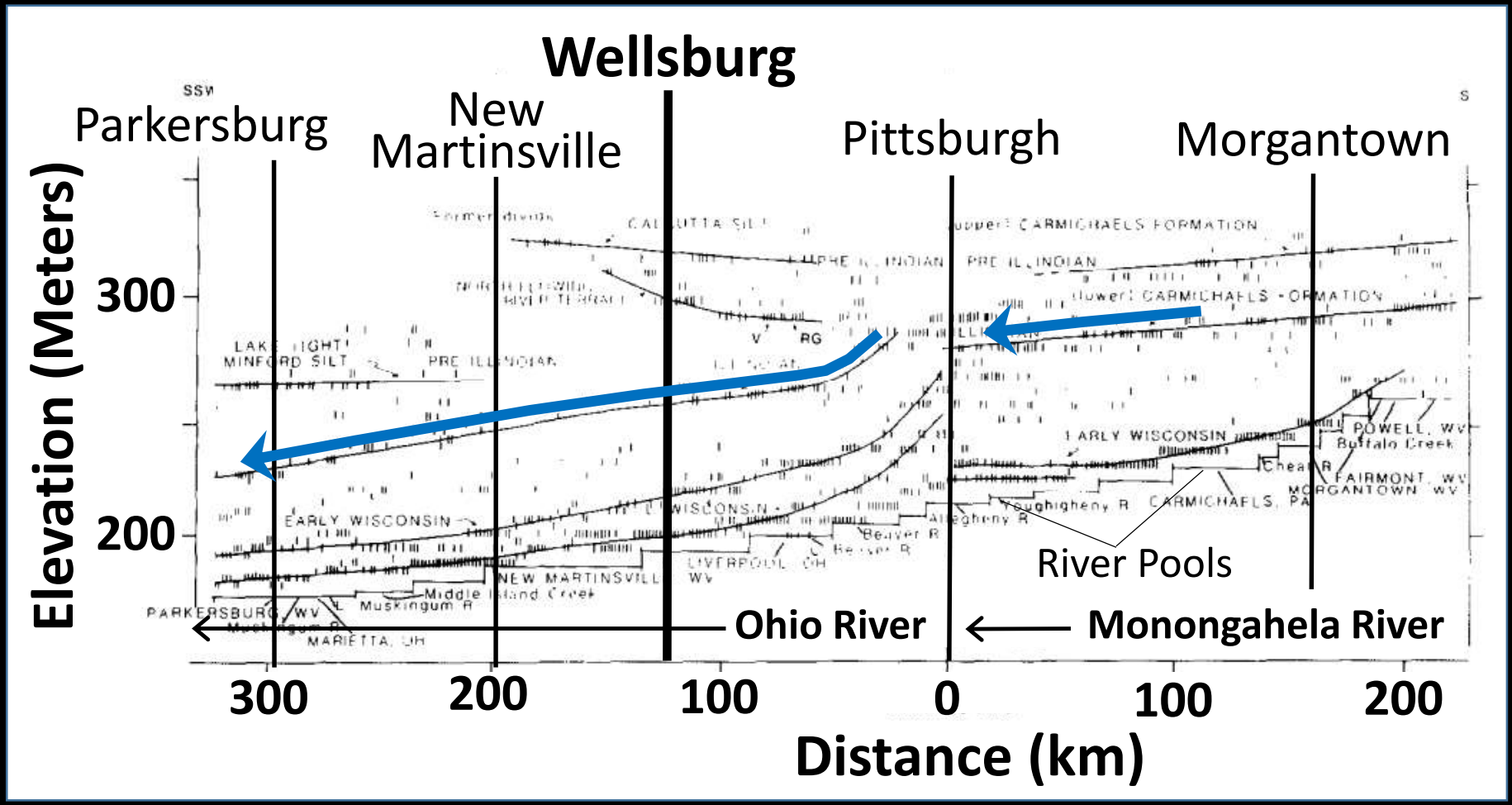
Jacobson et al, 1988

3. Upper Ohio continued flow to north



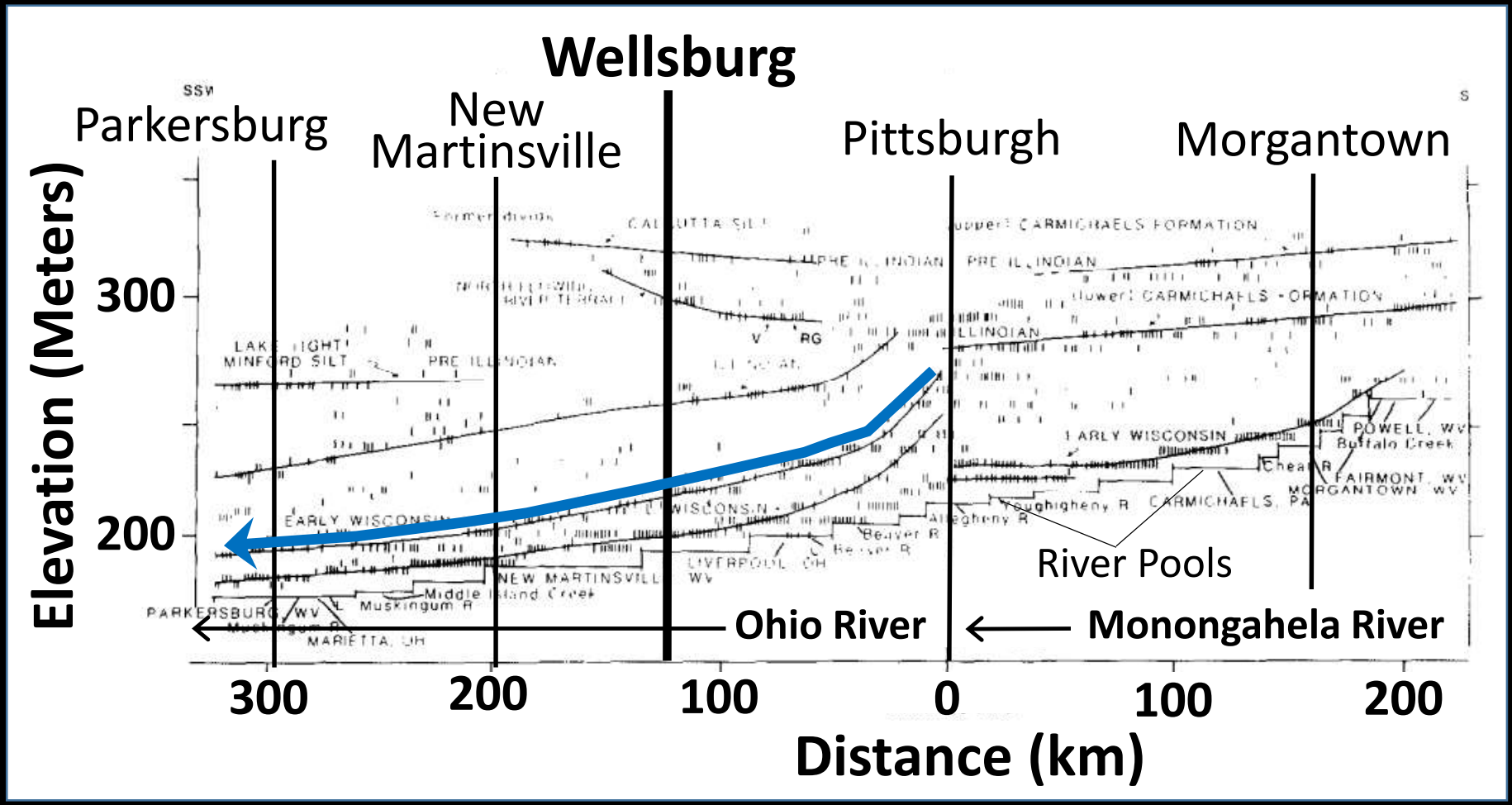
Jacobson et al, 1988

4. Reversal of flow in upper Ohio Valley



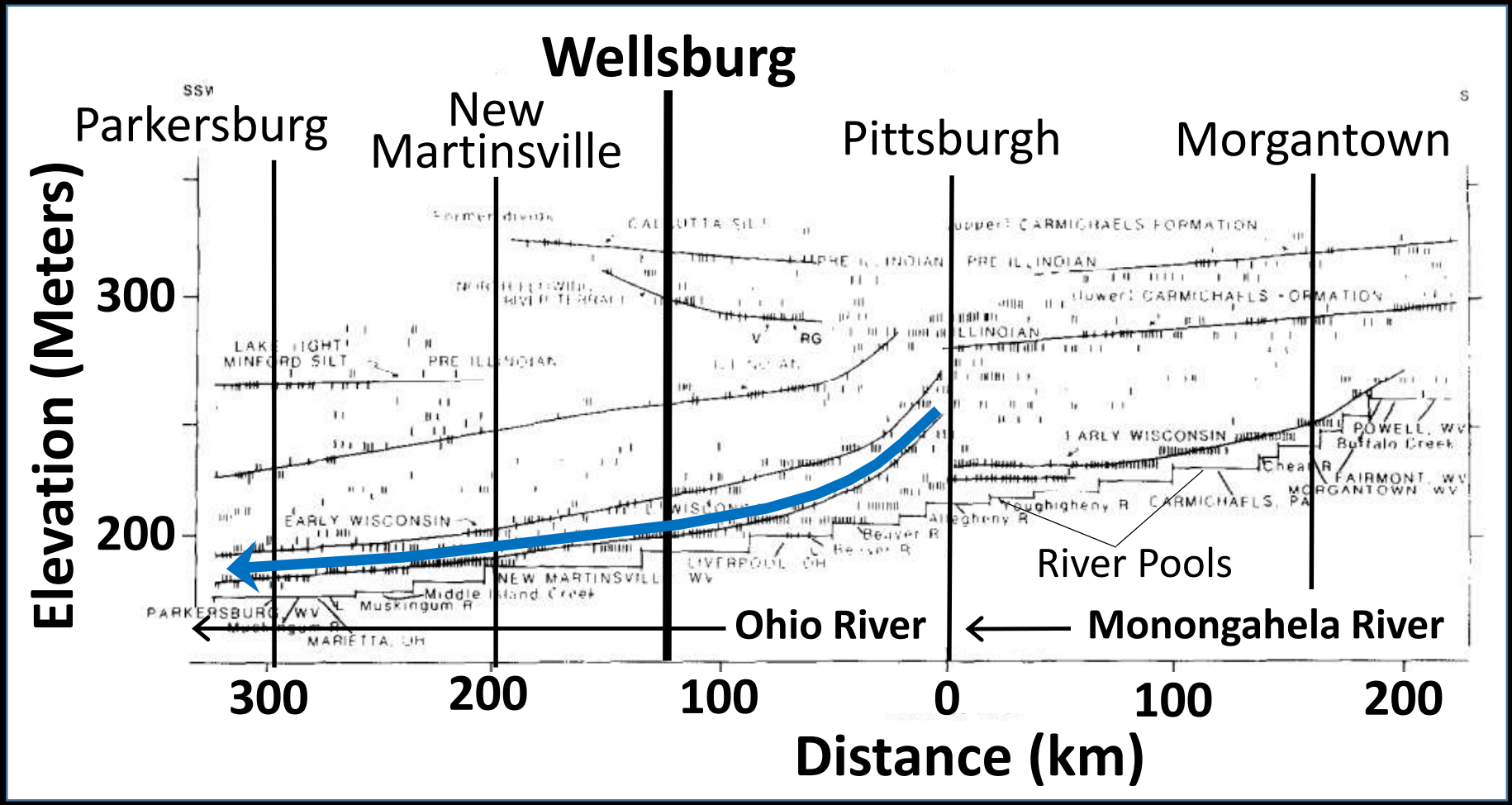
Jacobson et al, 1988

5. Downcutting of upper Ohio



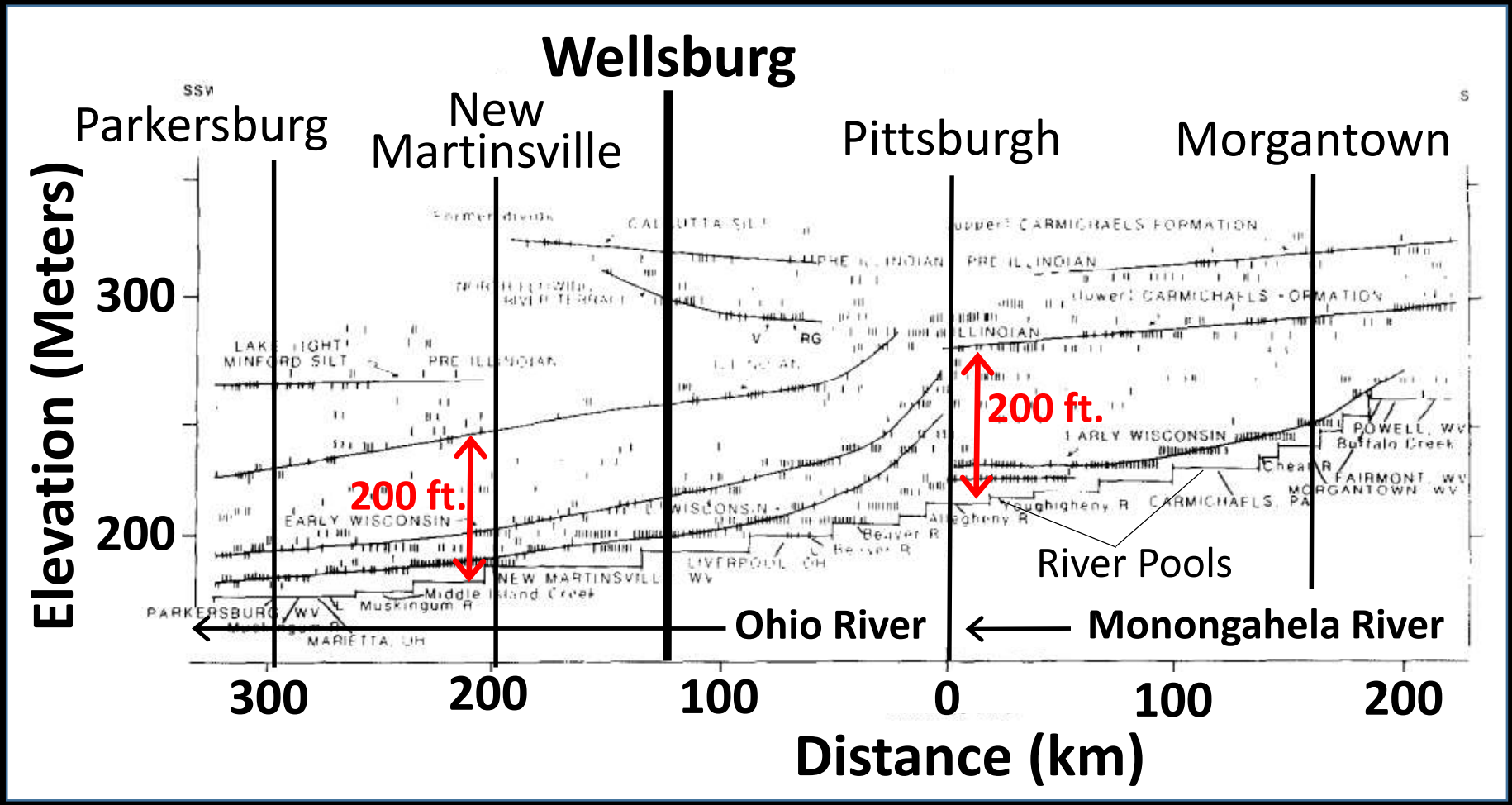
Jacobson et al, 1988

6. Continued downcutting of upper Ohio

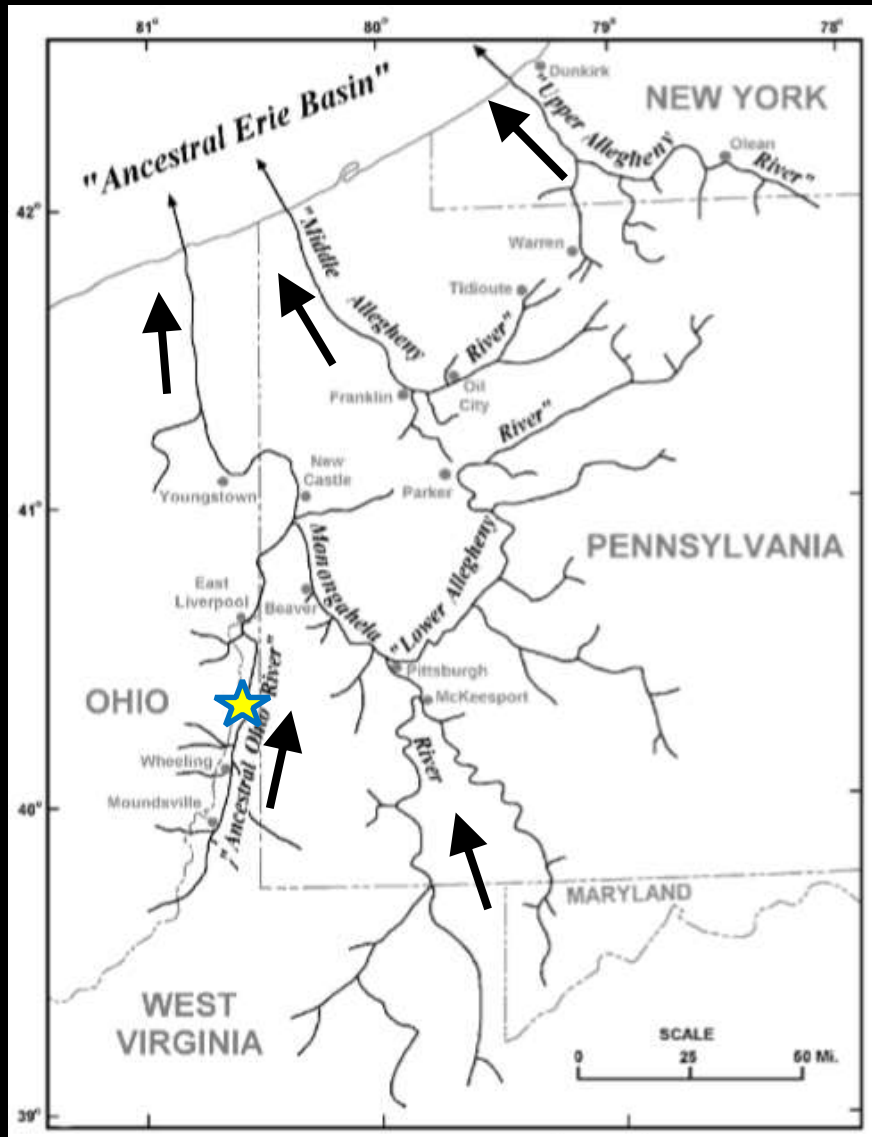


Jacobson et al, 1988

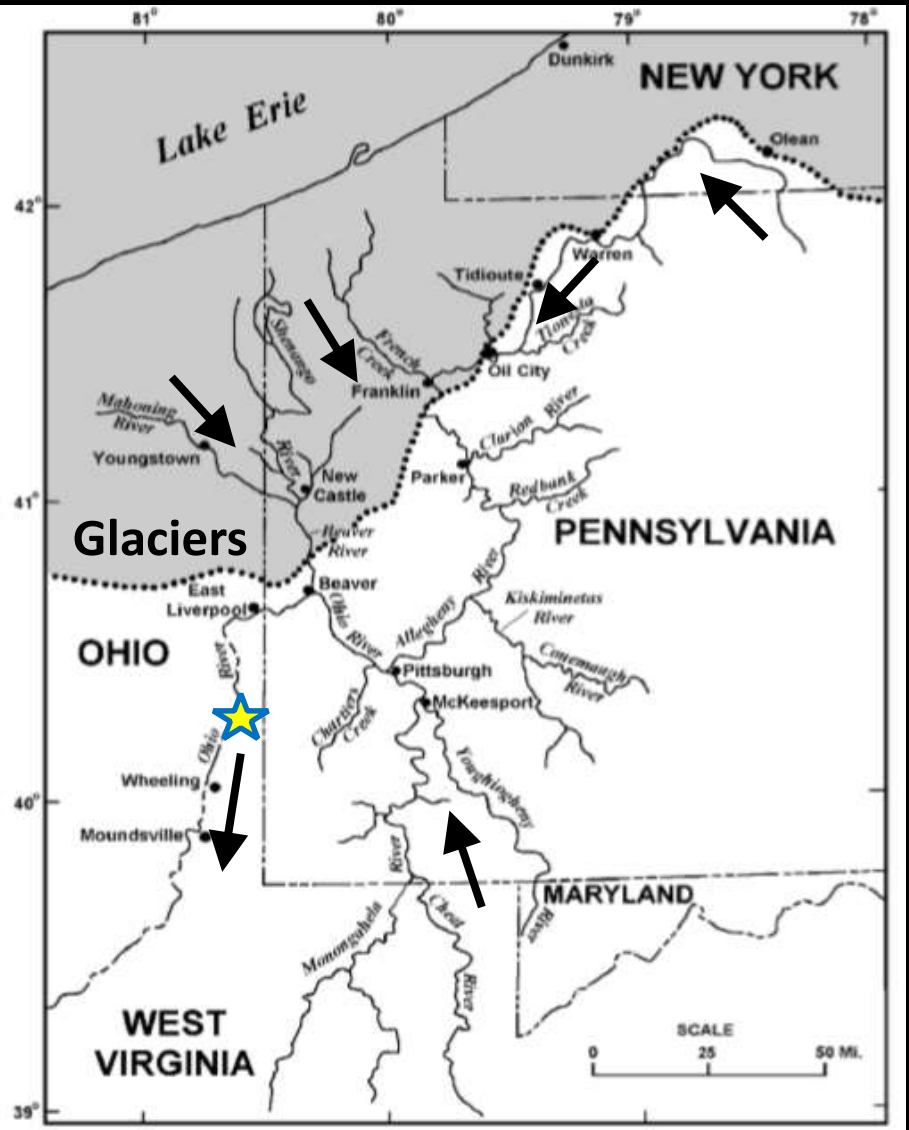
Ancient river terraces



Jacobson et al, 1988



Interpreted preglacial drainage pattern



Current drainage with extent of glaciation shaded

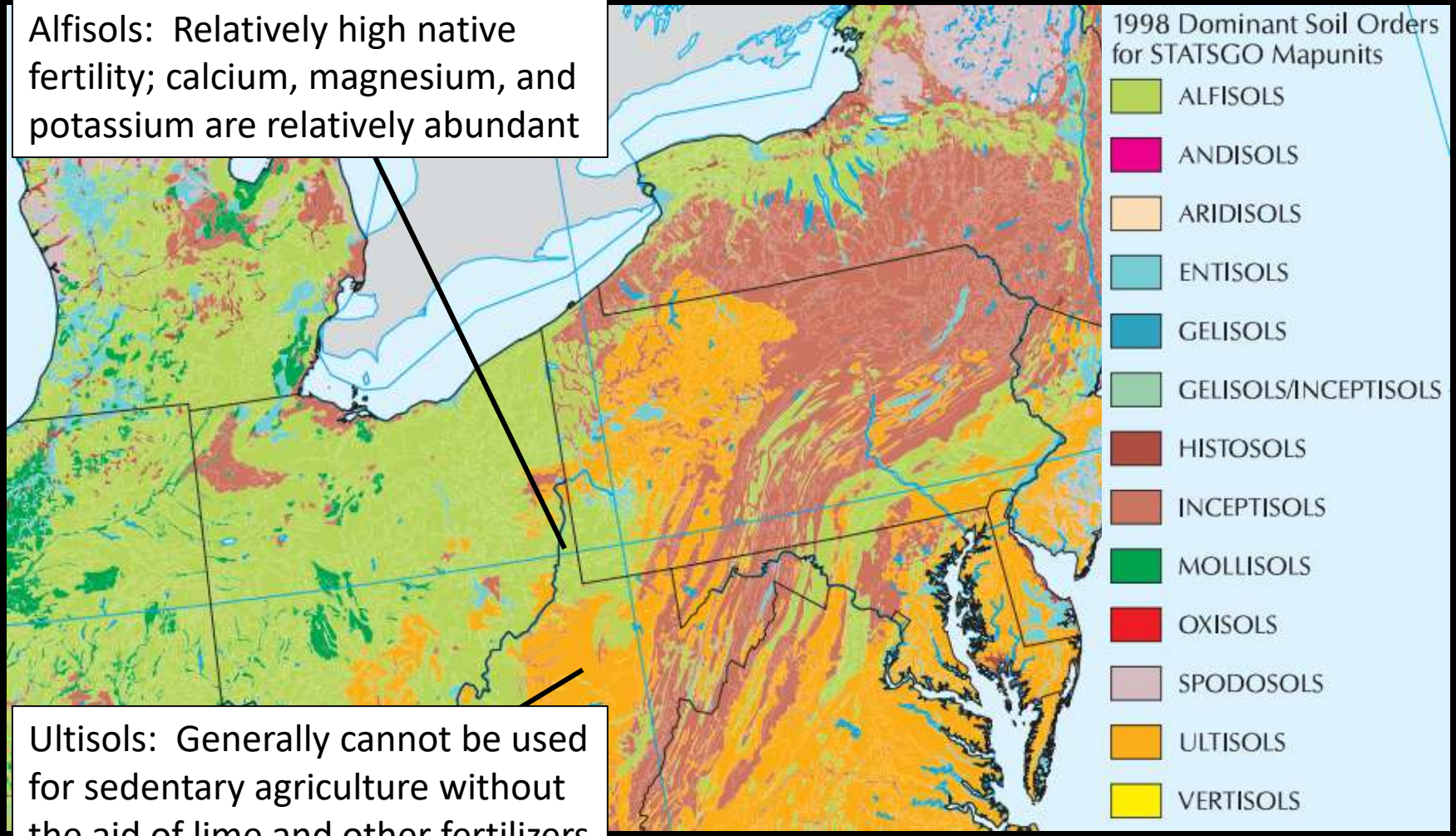
Marine and Donahue, 2000

Earth Resources

Water; soil; stone, gravel and clay; coal; oil and natural gas

Context of soil in Washington County

Alfisols: Relatively high native fertility; calcium, magnesium, and potassium are relatively abundant



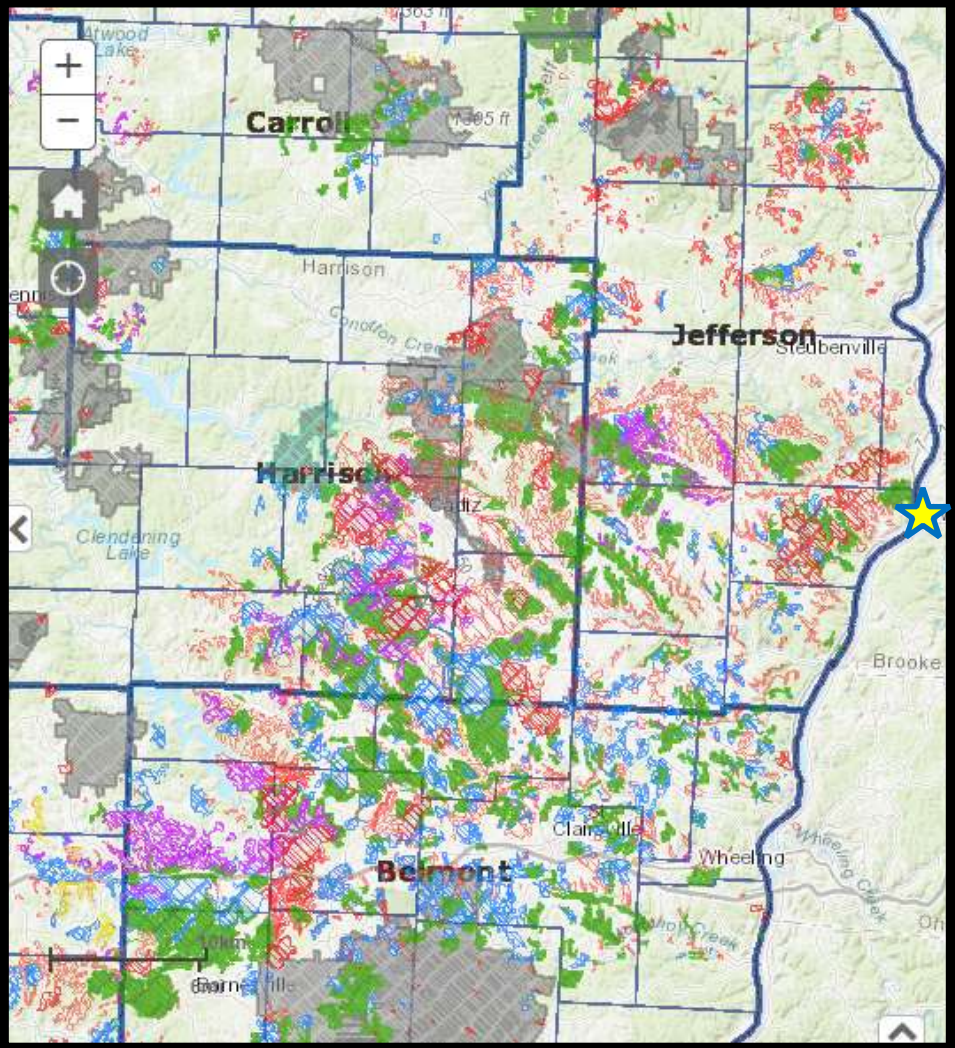
Ultisols: Generally cannot be used for sedentary agriculture without the aid of lime and other fertilizers

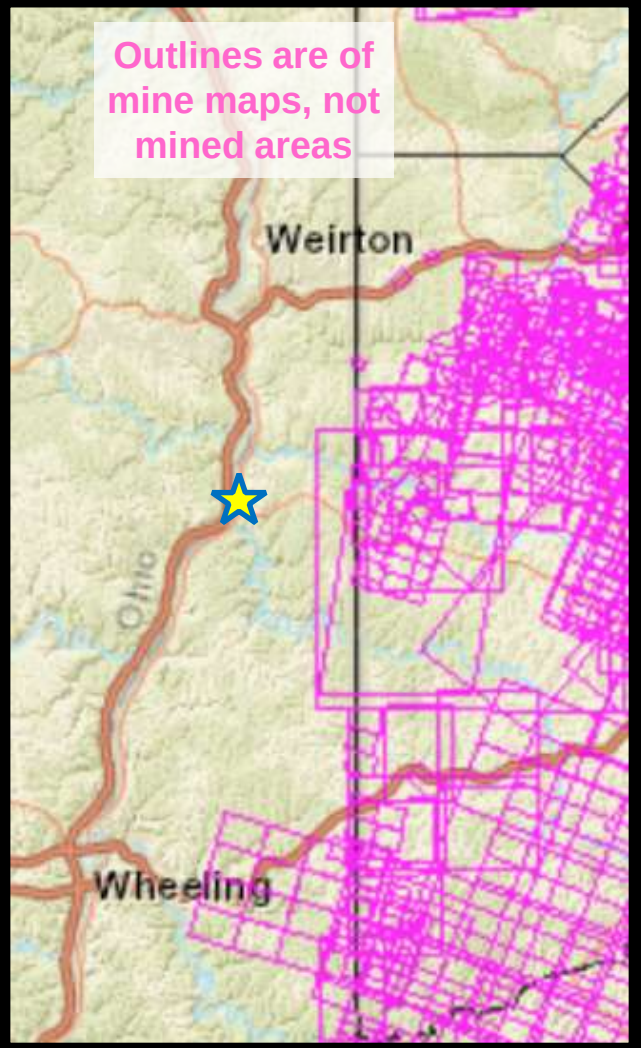
https://www.nrcs.usda.gov/Internet/FSE_MEDIA/stelprdb1237749.pdf

Soils information from Wikipedia

Maps of coal mines

Ohio | West Virginia | Pennsylvania





https://gis.ohiodnr.gov/MapViewer/?config=OhioMines

https://www.minemaps.psu.edu/

http://www.wvgs.wvnet.edu/GIS/CBMP/all_mining.html

Sources of Coal for Power Generation at Brilliant, Ohio

https://www.gem.wiki/Cardinal_Plant

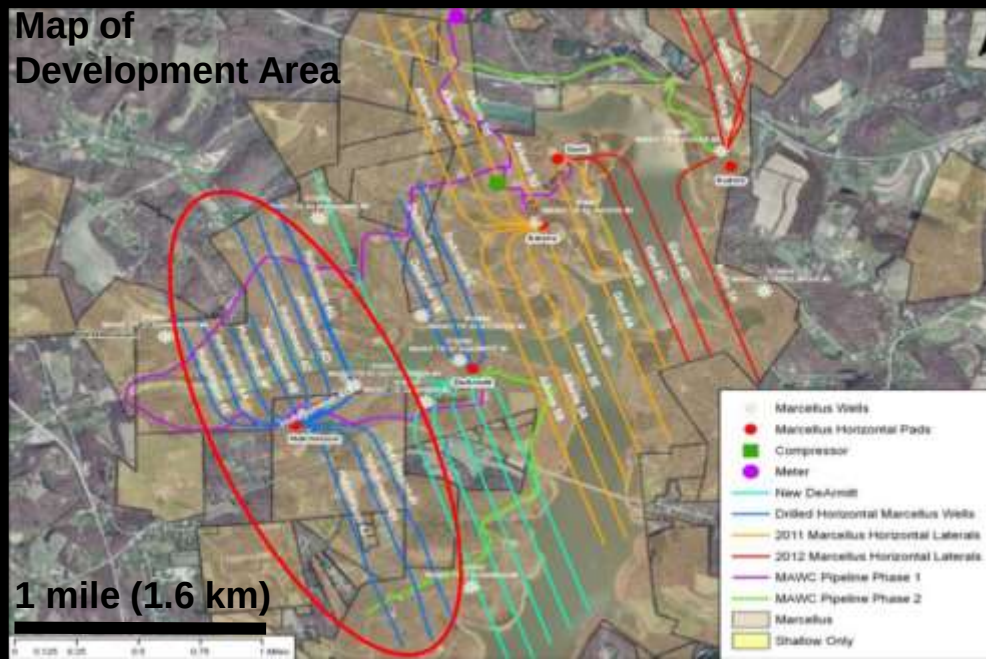
- **Owner**: Cardinal Operating Company
  - Unit 1: American Electric Power[1]
  - Units 2 and 3: Buckeye Power[1]
- **Parent Company**: American Electric Power , Buckeye Power
- **Plant Nameplate Capacity**: 1,880.4 MW (Megawatts)
- **Units and In-Service Dates**: Unit 1: 615.2 MW (1967), Unit 2: 615.2 MW (1967), Unit 3: 650.0 MW (1977)
- **Location**: 306 County Road 7 East, Brilliant, OH 43913
- **GPS Coordinates**: 40.251872, -80.648224
- **Technology:** Supercritical
- **Coal type:** Bituminous
- **Coal Consumption**:
- **Coal Source**: Hopedale Mine (Rhino Energy), Shoemaker Mine (Murray Energy), Cumberland Mine (Contura), Marshall County Mine (Murray Energy), Tunnel Ridge Mine (Alliance Coal), Vail Mine (Rosebud Mining), Century Mine (Murray Energy), Tusky Mine (Rosebud Mining)[2]
- **Number of Employees**: 300[1]
- **Unit Retirements**: Unit 1 is planned for retirement in 2030.[3]

- Hopedale Mine, underground, Harrison County OH, 0.286 million short tons in 2020
- Ohio County Mine, underground, Wheeling WV, 6.5 million short tons in 2020
- Cumberland Mine, underground, Waynesburg PA, 6.4 million short tons in 2018
- Marshall County Mine (formerly McElroy Mine), underground, Marshall WV, 11.4 million short tons in 2018
- Tunnel Ridge Mine, underground, Wheeling WV, 6.8 million short tons in 2018
- Century Mine, underground, Beallsville Monroe County OH, 7.1 million short tons
- Tusky Mine, underground, Tuscarawas County OH, 0.5 million short tons in 2007

Marcellus Shale Multi-well Pad Development, Western Pennsylvania

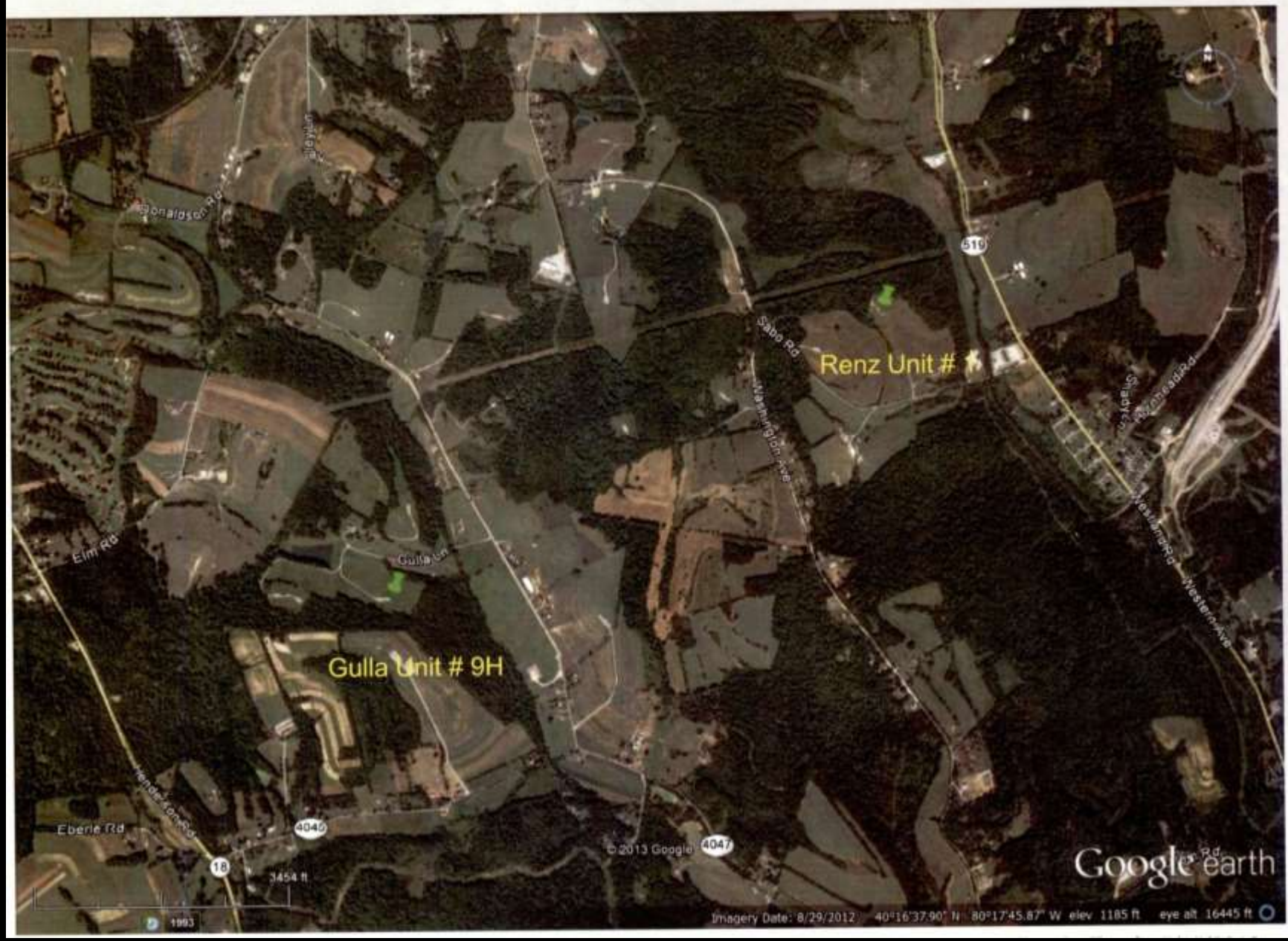
Consol Energy operation, 2011

Source: Consol Energy



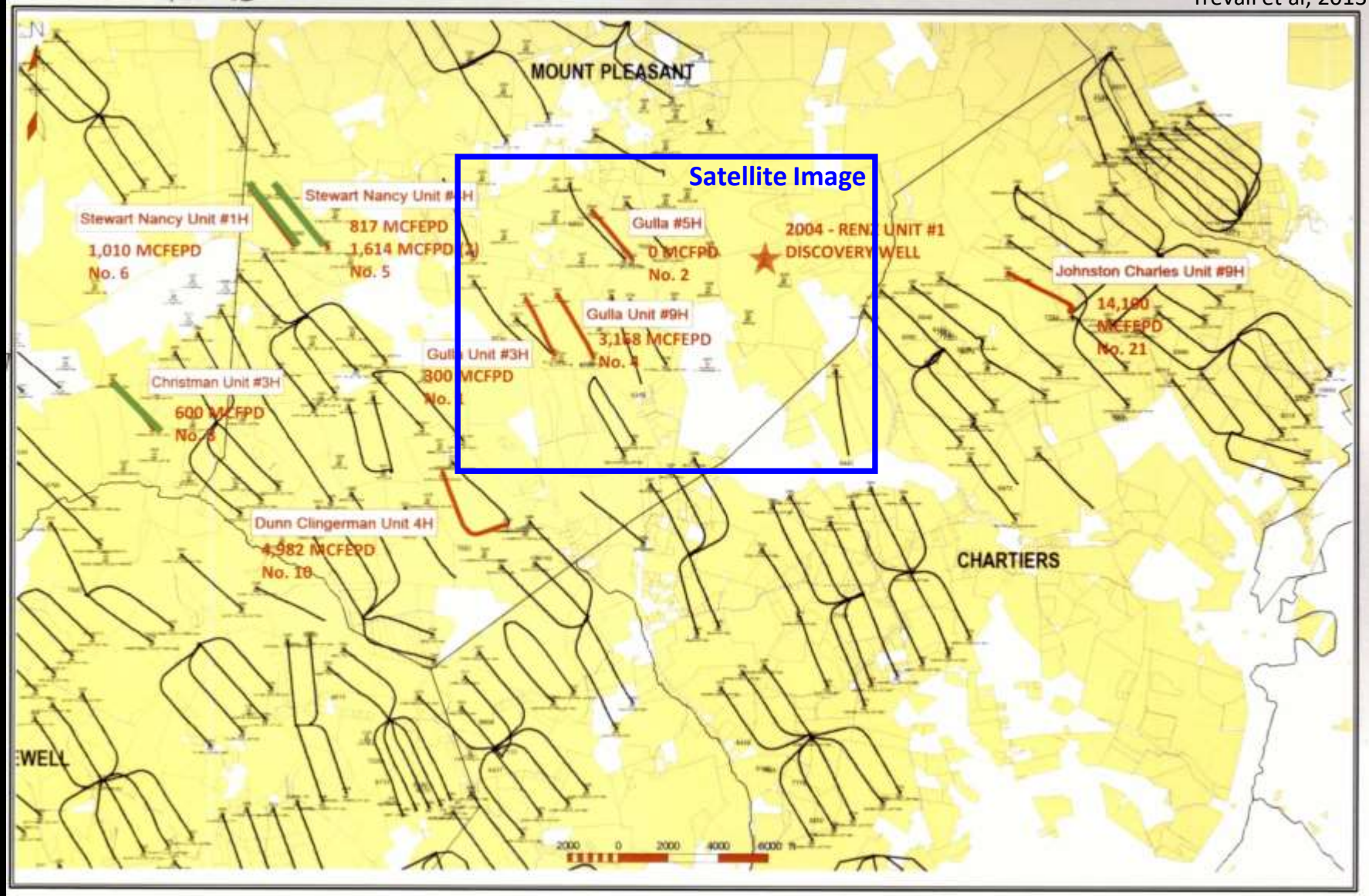
Location of Renz Unit # 1, vertical Marcellus Shale discovery well with respect to the Gulla Unit # 9H, the first successful horizontal well drilled in the play.

Trevail et al, 2013



Initial Discovery Well and Key Horizontal Tests to 2008

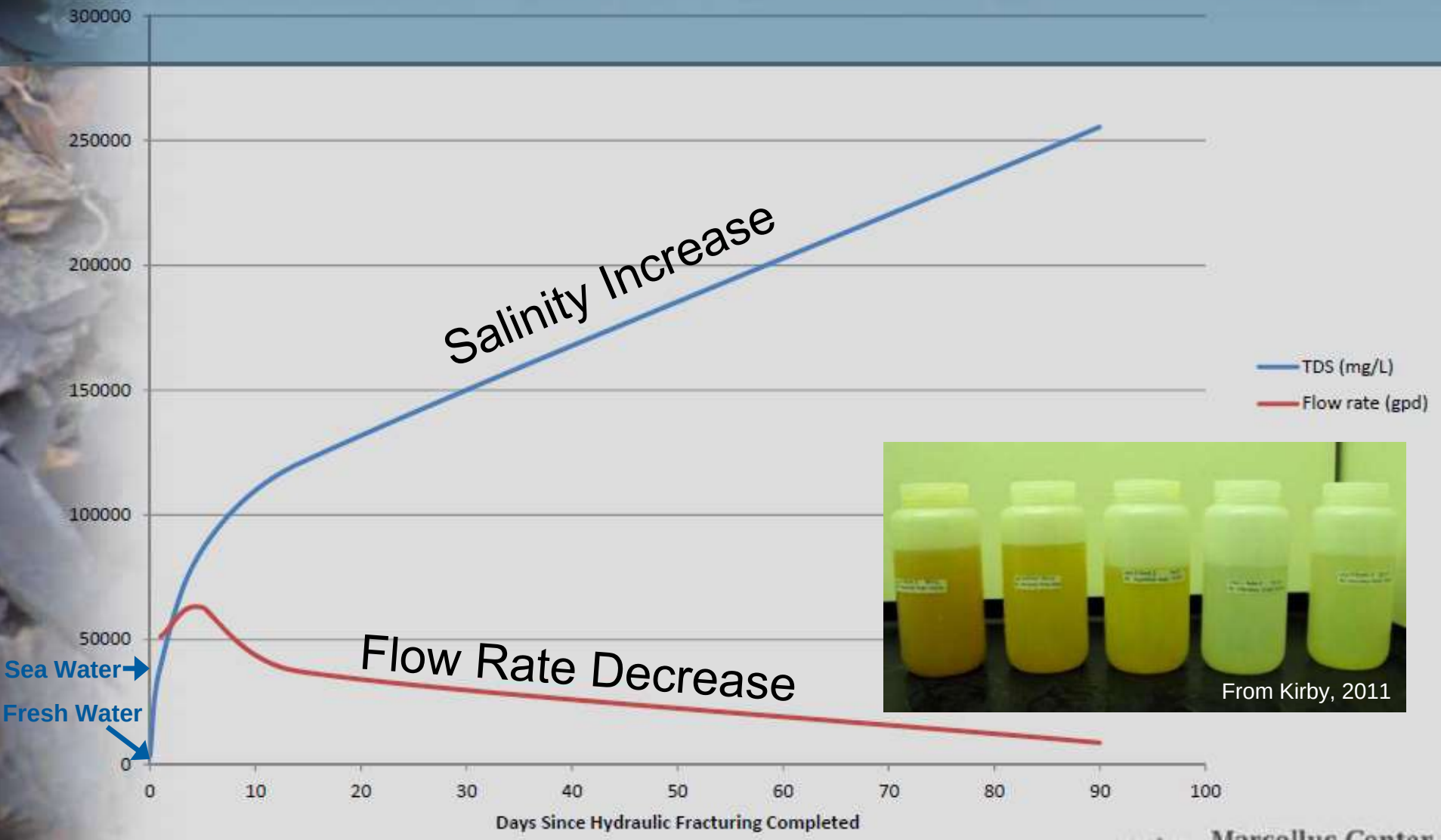
Trevail et al, 2013



First three lateral wells tested 0 MCFPD to 600 MCFPD. Fourth and afterwards tested 1,614 MCFEPD to 14,100 MCFEPD. What was the driver? All have similar azimuths and length. Initial laterals in liquids rich portion of play highlighted in green and were among the first laterals in the play. Numbers following flow rates are referenced on following cross-section.

Flowback Water Quality Trends

Average Flowback TDS Concentration and Discharge Rate vs. Time



From Kirby, 2011

PENNSTATE Marcellus Center for Outreach and Research

Outdoor Geology Event

Event Objectives and Activities, April 24, 2022

Meet at 1:00-2:30 PM in 17th Street Park, Wellsburg, WV.

Our main objective is to safely ensure that everyone can identify in hand sample and at a distance the types of rocks that are most common at the surface near Wellsburg

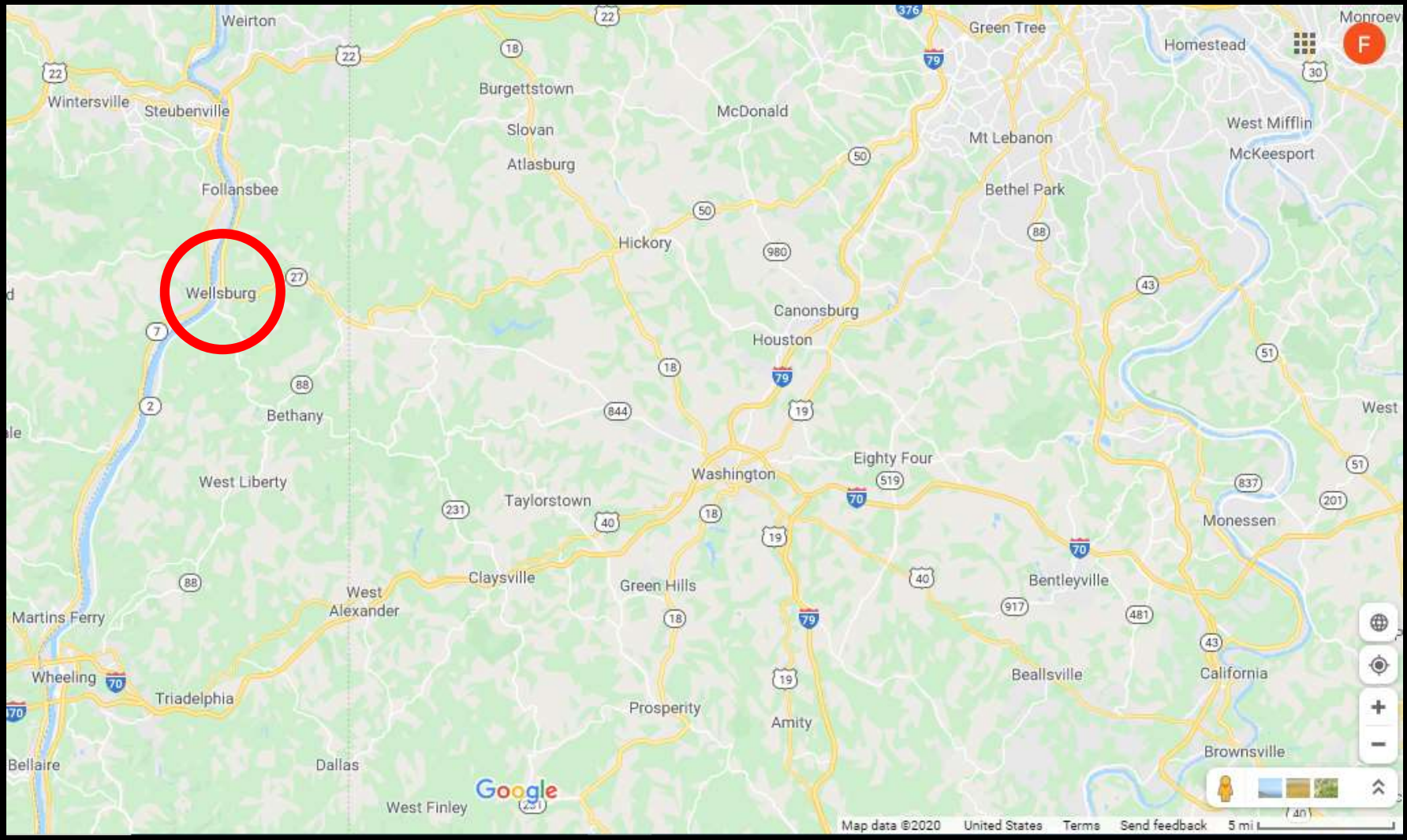
The secondary objective is to discuss the geology of the large outcrop across the river from Wellsburg

1. Start with an orientation, followed by a rock identification exercise using samples supplied by the discussion leader
2. Observe and sketch and discuss the large rock outcrop across the river

Materials

- **Recommended: Folding chair; Paper, pencil, eraser and clipboard** or another type of backing for drawing; **Face mask** or face covering, **Binoculars** or a spotting scope
- Helpful but Optional: Hand lens (10X) or magnifying glass
- Dilute acid will be available to assist with rock identification, if desired
- Optional opportunities: Bring rocks for Fred to identify and discuss with you

Geology Event Location: Wellsburg, WV



Will observe the Brilliant outcrop from across the Ohio River in 17th Street Park, Wellsburg, WV

Meeting Place

40.2809, -80.6134

General Information

- Meet at 1:00 in 17th Street Park, Wellsburg WV
- Will spend an hour sitting outdoors. A folding chair will help.
- Dress for comfort and weather: sunscreen, hat, insect repellent, and fluids may be helpful
- Port-a-potties may be available

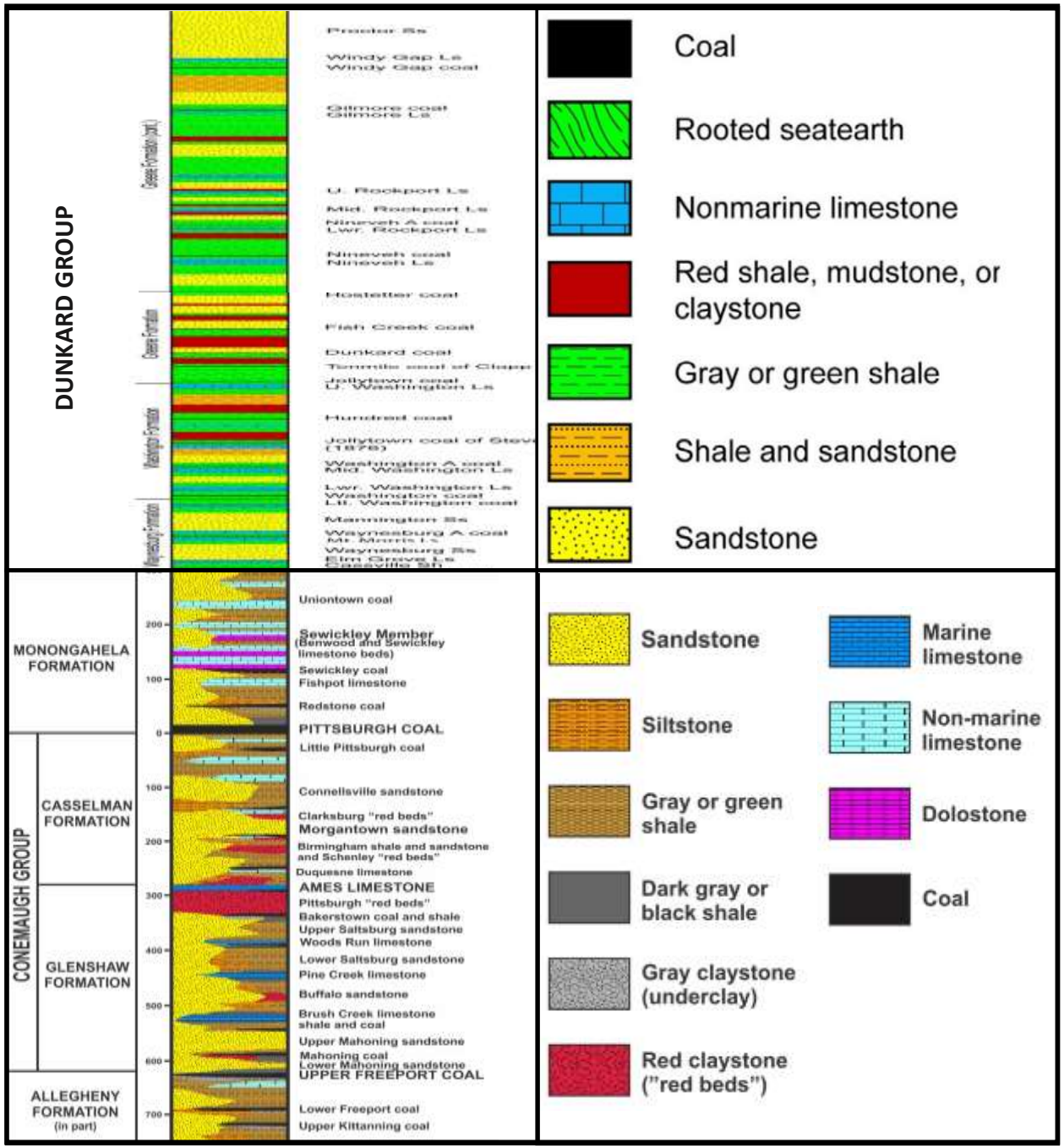
Parking and Access

There is access to the park from near the west end of 16th Street, with lots of street parking in the neighborhood and from Marianna Street south of 20th. The main entrance to the park is from 17th Street, which also has street parking nearby. Please park courteously and do not block a driveway. The park has baseball fields and the neighbors are used to people parking along the surrounding streets for a few hours. We will meet in the grassy area by the river, past the end of 18th Street (40.2809, -80.6134).


North
40.2809, -80.6134
Ohio River
17th Street Park
20th Street
Marianna Street
First Baptist Church of Wellsburg
18th Street
Wellsburg City Park
Route 2 (Commerce Street)
17th Street
17th Street Park
Main Street
Charles Street
16th Street
17th Street Park
Wellsburg, WV

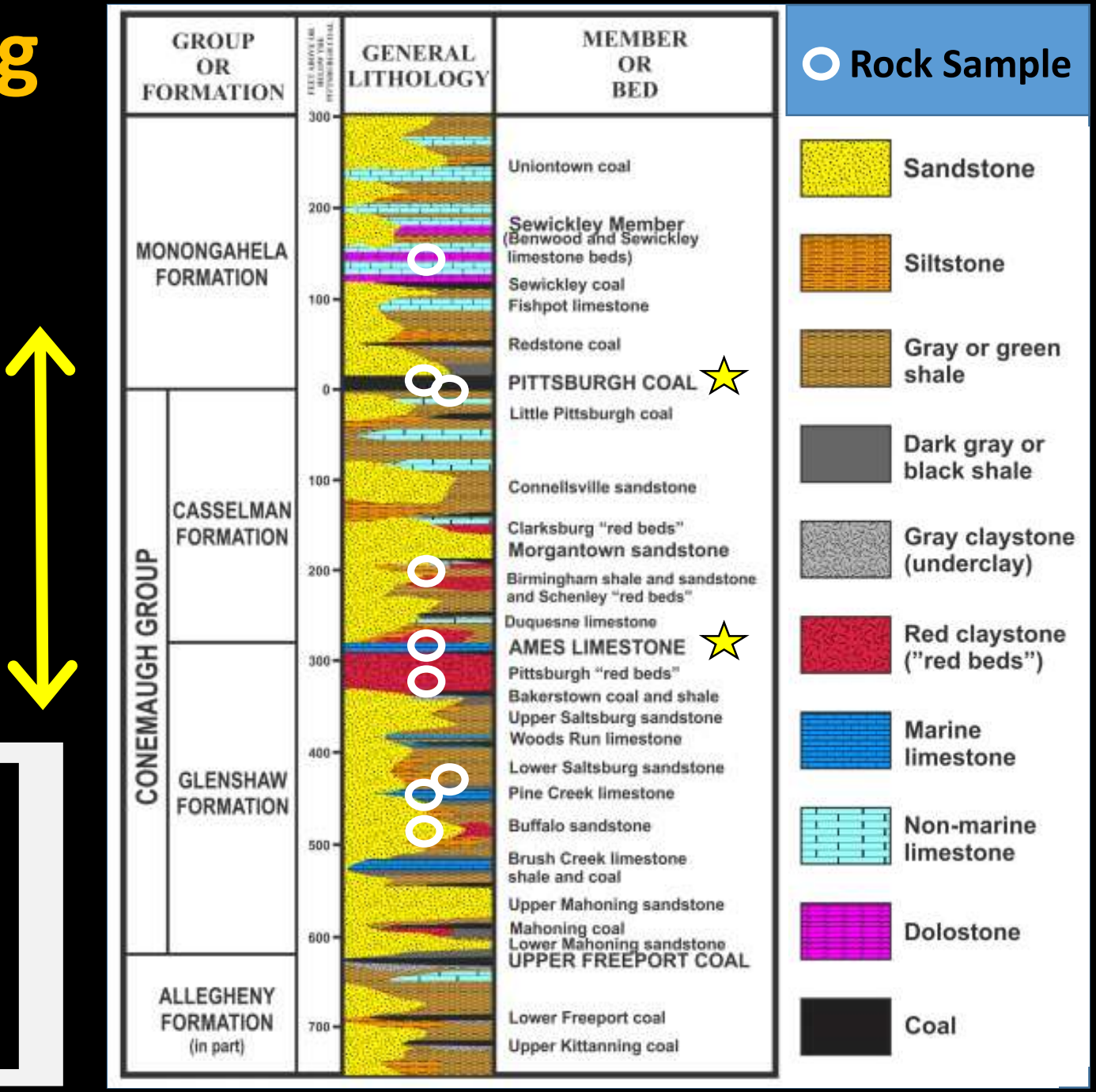
Bedrock at surface in West Virginia Panhandle area

From Harper, 2013



Wellsburg Geology Outing

Brilliant Outcrop

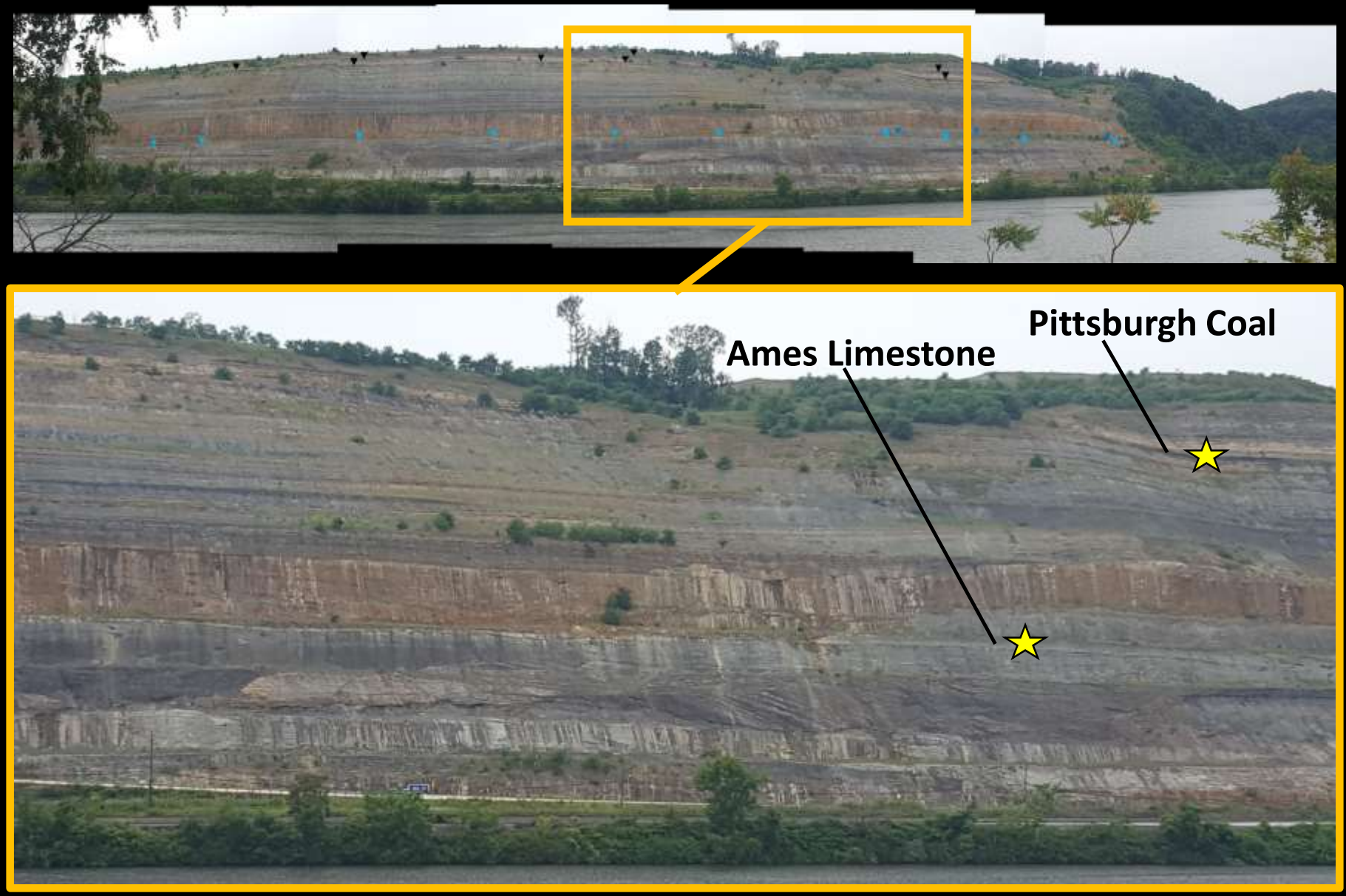


Scale

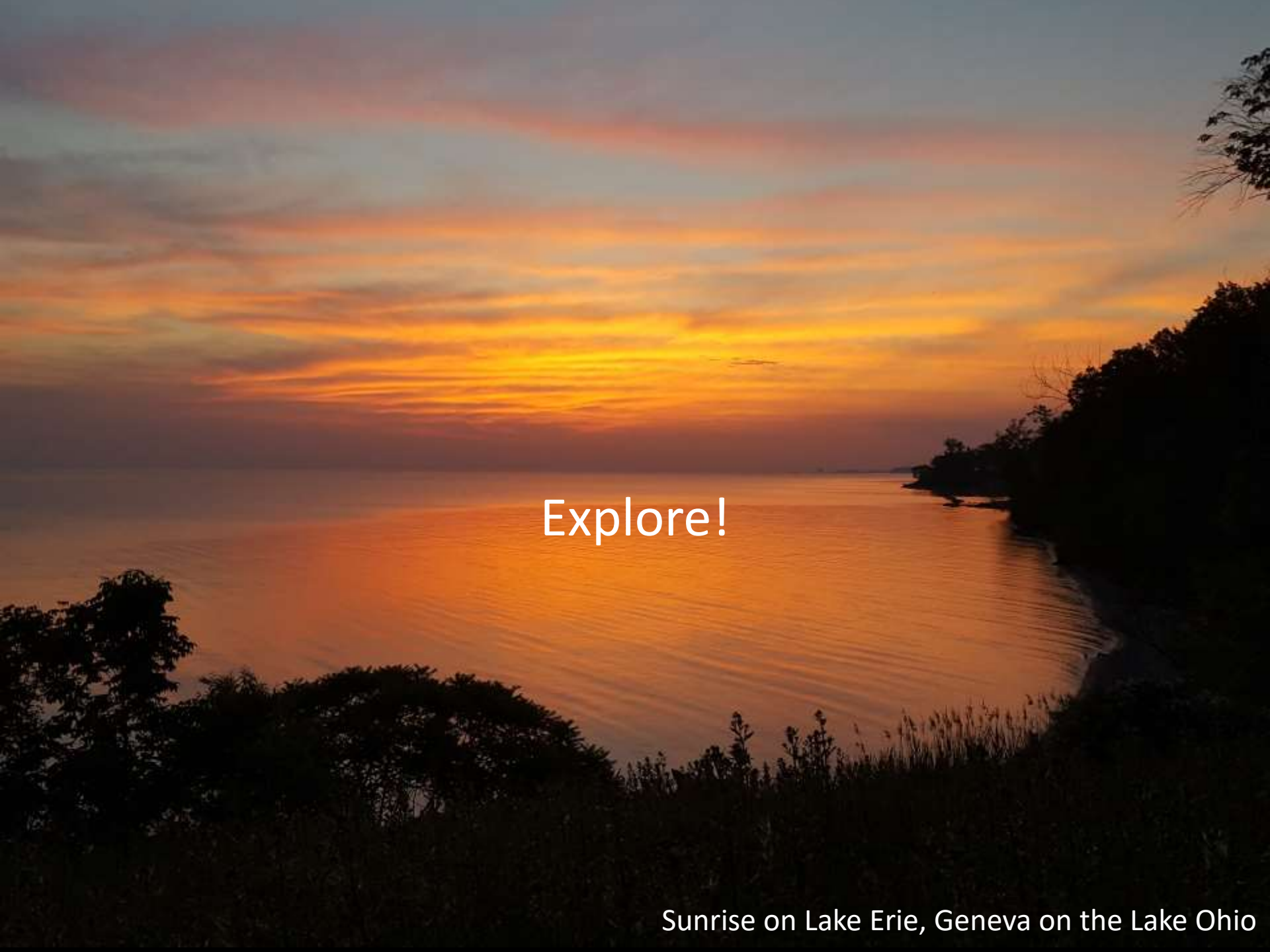
100 m. (328 ft.)

Section from Harper, 2013

Brilliant Outcrop

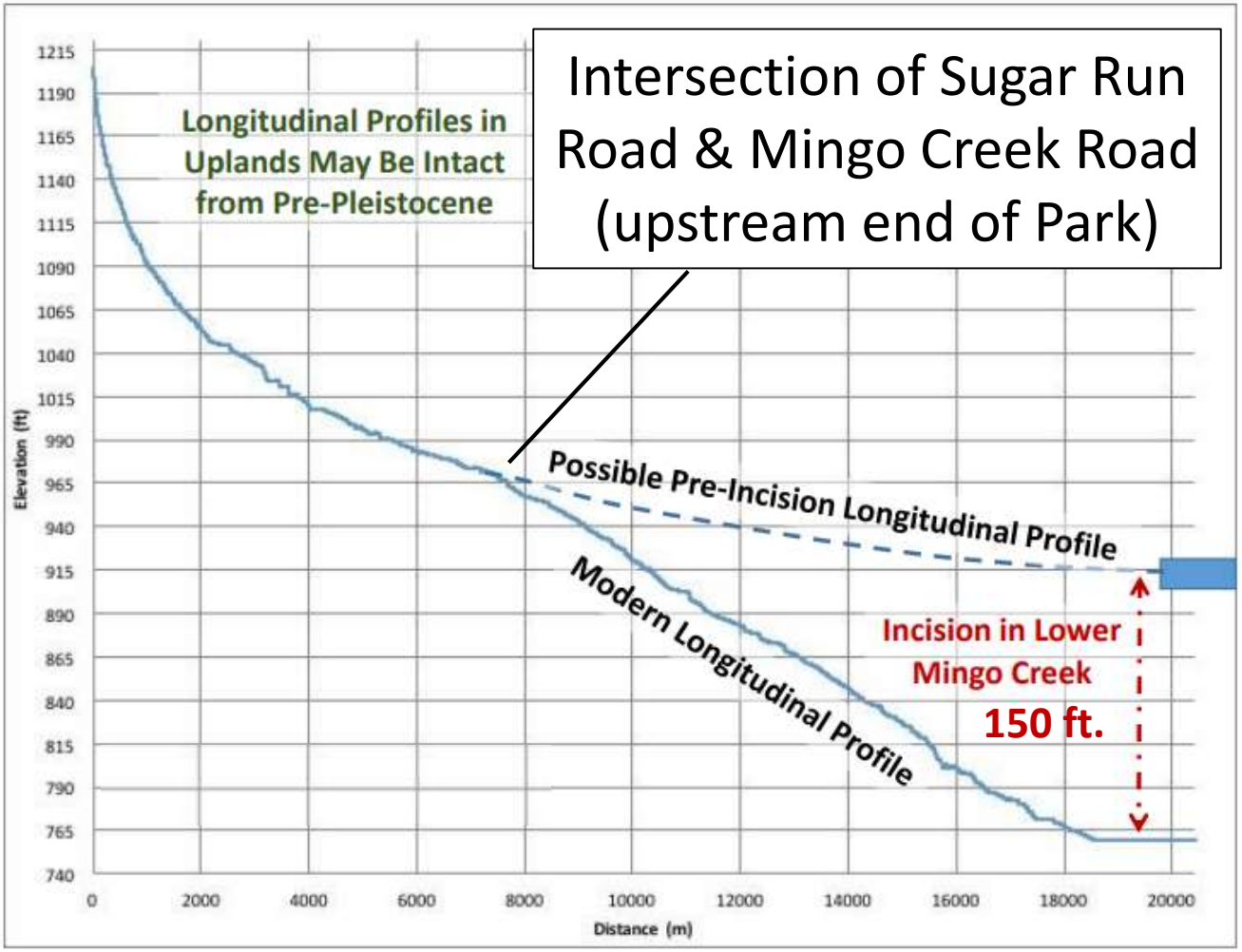


Marine Fossils in Ames Limestone



Sunrise on Lake Erie, Geneva on the Lake Ohio

Interpreted elevation profile of Mingo Creek



Effects of River Incision on Tributaries

Mark Swift,
WVU Geography
M.A. Research

Ancestral Monongahela River (Pittsburgh River) Terrace ~ 900 ft

Kite and Swift, 2019

Preglacial drainage map

From Jacobson, 1988 based on Leverette 1934 and Stout et al 1943