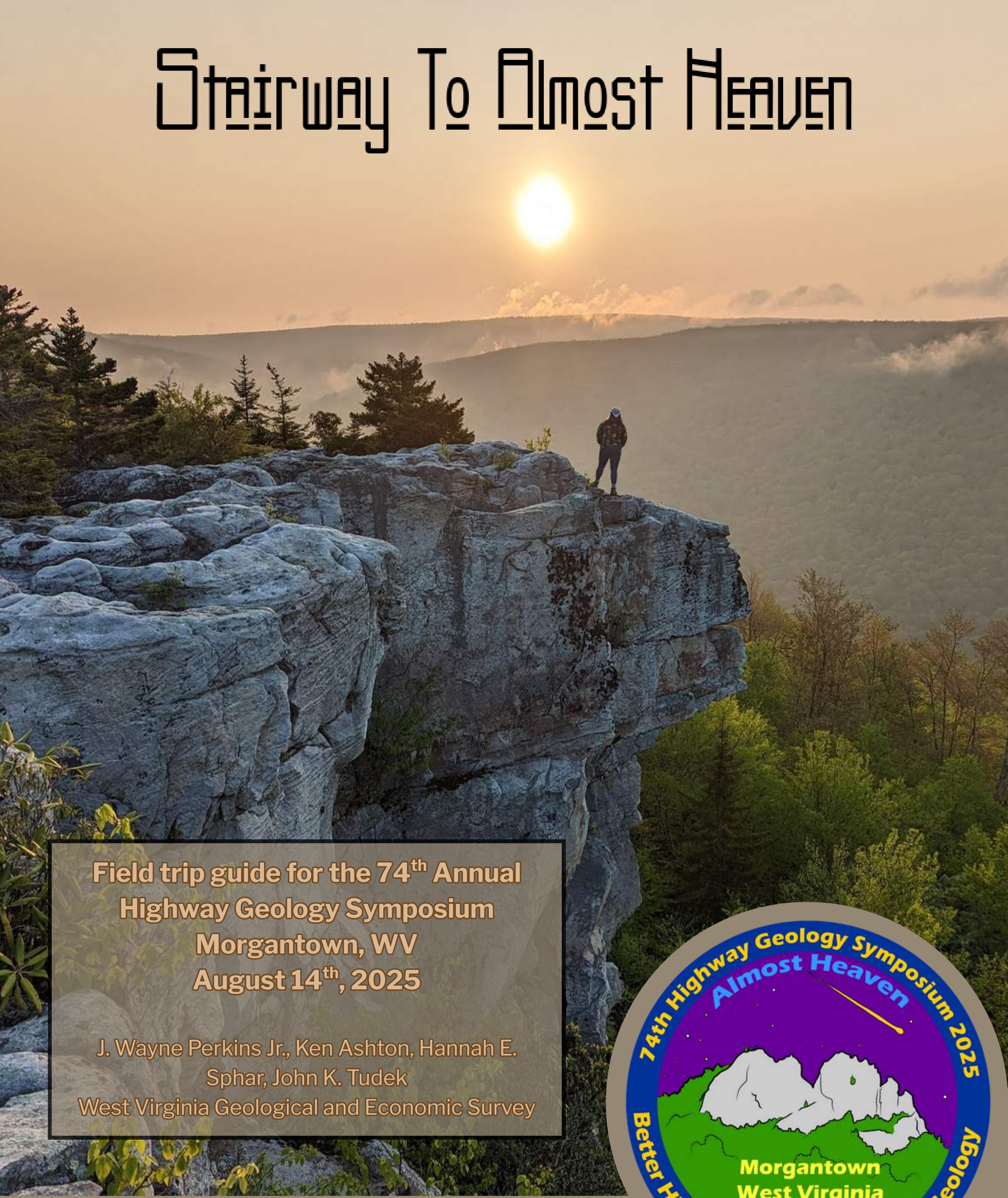
Stairway To Almost Heaven



Field trip guide for the 74th Annual Highway Geology Symposium
Morgantown, WV
August 14th, 2025

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West Virginia Geological and Economic Survey

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Front Cover: The Lions Head Overlook in the Dolly Sods Wilderness, Monongahela National Forest. This overlook is composed of coarse-grained, occasionally conglomeritic, quartz arenites of the Lower Pennsylvanian Pottsville Group. Rear Cover: Elakala Falls in Blackwater Falls State Park, also flowing over sandstones of the Pottsville Group. Both photos by Wayne Perkins.

Contents

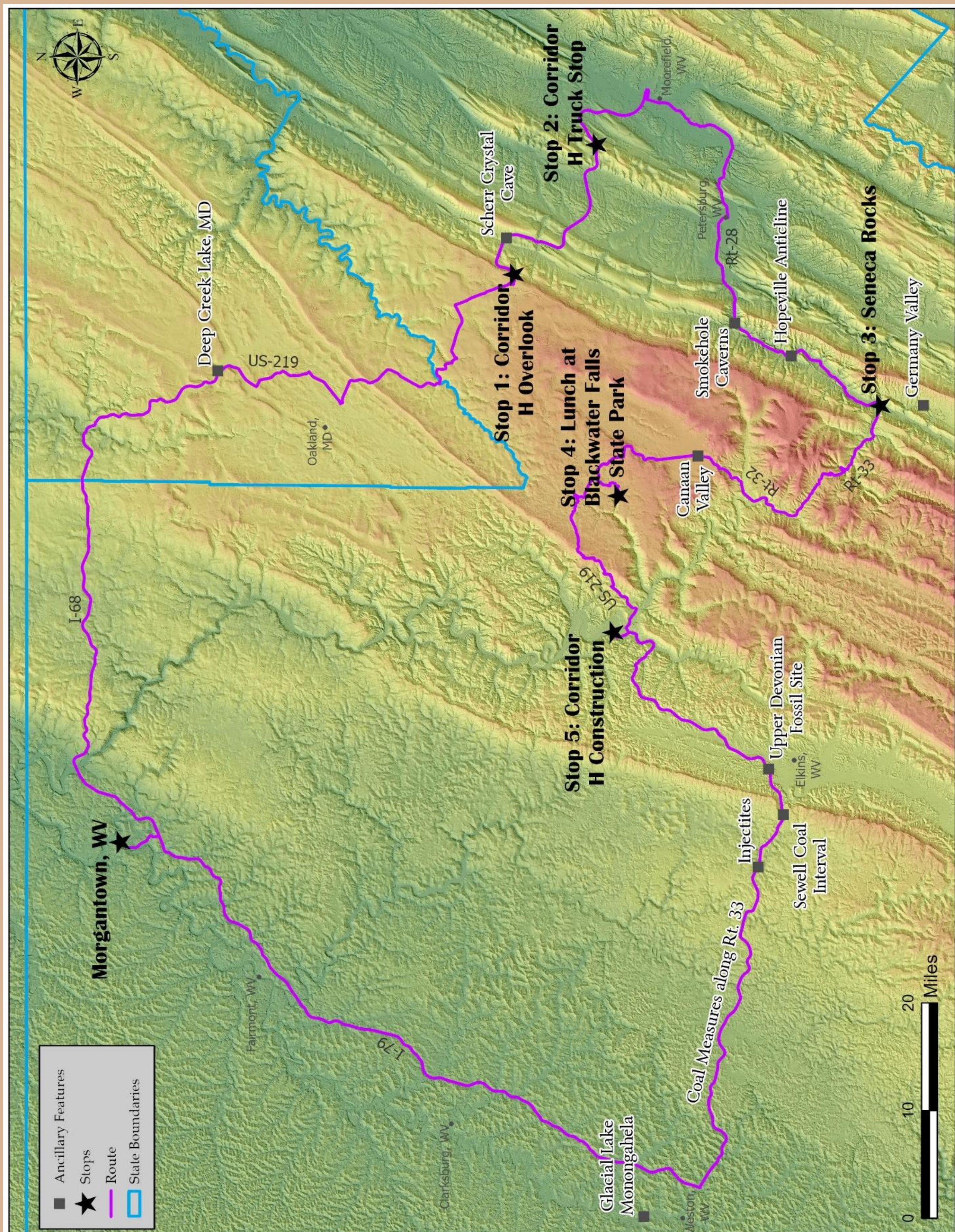
Bold text in the Table of Contents above indicates stops that will be made on this field trip. Non-bold text indicates ancillary information, interesting features between stops, or nearby attractions/features.

Itinerary

Time	Information
6:30 a.m.	Grab n' Go Breakfast
7:00 a.m.	Depart from Hotel
8:30 a.m.	Stop 1: Corridor H Overlook
9:00 a.m.	Depart from Stop 1
9:30 a. m.	Stop 2: Corridor H Truck Stop
10:00 a.m.	Depart from Stop 2
11:00 a.m.	Stop 3: Seneca Rocks
11:30 a.m.	Depart Stop 3
12:30 p.m.	Stop 4: Lunch at Blackwater Falls
1:30 p.m.	Depart Stop 4
2:15 p.m.	Stop 5: Corridor H Construction
4:30 p.m.	Depart Stop 5
6:00 p.m.	Arrive back at Hotel

Triangle Rock in the western limb of the Hopeville Anticline, *see page 23 for more information.*

Route Map


N
E
S
W
Stop 1: Corridor H Overlook
Stop 2: Corridor H Truck Stop
Stop 3: Seneca Rocks
Stop 4: Lunch at Blackwater Falls State Park
Stop 5: Corridor H Construction
Morgantown, WV
Deep Creek Lake, MD
US-219
Oakland, MD
Scherr Crystal Cave
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Ancillary Features
Stops
Route
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0
10
20
Miles

Introduction

Welcome to the 2025 Highway Geology Symposium in "Almost Heaven®," West Virginia, which is the only state in the United States entirely contained within the Appalachian Mountains of the eastern U.S. This field trip will concentrate on the geology of the north-central portions of the state within the Appalachian Plateau and Valley and Ridge Physiographic Provinces (Figure 1). Contained within this guidebook is information detailing five separate locations, as well as information about the sites and features that will be seen along/near the roughly 300-mile route.

Physiographic Provinces

West Virginia is divided into three distinct physiographic provinces (Appalachian Plateau, Valley and Ridge, and the Blue Ridge) with two sub-provinces (The Allegheny Mountain Section of the Appalachian Plateau and the Great Valley sub-province of the Valley and Ridge) (Figures1, 2 and 3). Morgantown, WV is nestled within the Appalachian Plateau province, and this field trip will visit the Appalachian Plateau (including the Allegheny Mountain Section) and the Valley and Ridge.

The Appalachian Plateau is characterized by the gently folded sedimentary strata of Pennsylvanian and Mississippian age that outcrops at the surface across much of the state. The Allegheny Mountain Section of the Appalachian Plateau fits within this definition but also includes some Upper Devonian units that are exposed due to the high relief of this area. This high relief is a result of the highest elevations of the state, with numerous mountaintops over 4,000 feet (1,220 meters) above sea level.

The Allegheny Front is the structural divide between the gently folded Appalachian Plateau and the heavily folded and faulted Valley and Ridge.

The Valley and Ridge Physiographic Province is characterized by tightly and sharply folded and faulted sedimentary rocks of Devonian through Middle-Ordovician age. Unlike the Appalachian Plateau described above (where fold wavelength is typically measured in miles), the Valley and Ridge folding can span from micro- (inches to a few feet) to mega-scale (a few to thousands of feet), creating structures of intense complexity.

The Great Valley Physiographic sub-province, in WV, is characterized as heavily folded and faulted strata of Ordovician and Cambrian age; nearly all of which are limestones and dolostones. The Blue Ridge Physiographic Province is characterized as metamorphic rocks of Cambrian and Precambrian age. Aside from the igneous intrusions of Eocene and Jurassic ages, these are the only crystalline rocks in the state. This Province occupies a small area in the far-eastern portion of the panhandle around Harper's Ferry. The Great Valley Physiographic sub-province and Blue Ridge Physiographic Province will **NOT** be seen on this field trip.

Stratigraphy

Below is a complete list of all the stratigraphy present in the Appalachian Plateau, and Valley and Ridge (excluding the Great Valley sub-province) physiographic provinces (generalized stratigraphic column can be viewed in Figure 9 at the end of this section). Units shown in **bold** are those that will be observed on this field trip, and the rest are listed only for reference.

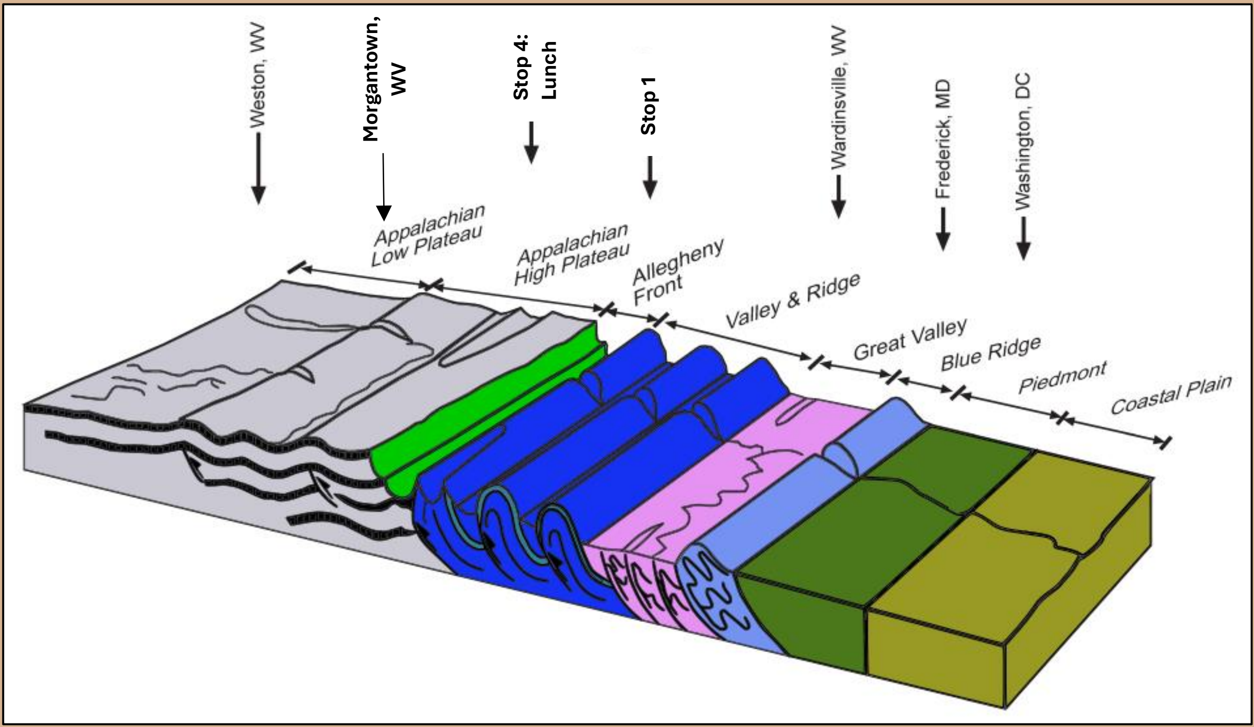

Figure 1. Generalized block diagram showing differences in geologic deformation in the physiographic provinces. The Piedmont and Coastal Plain are not present in West Virginia.

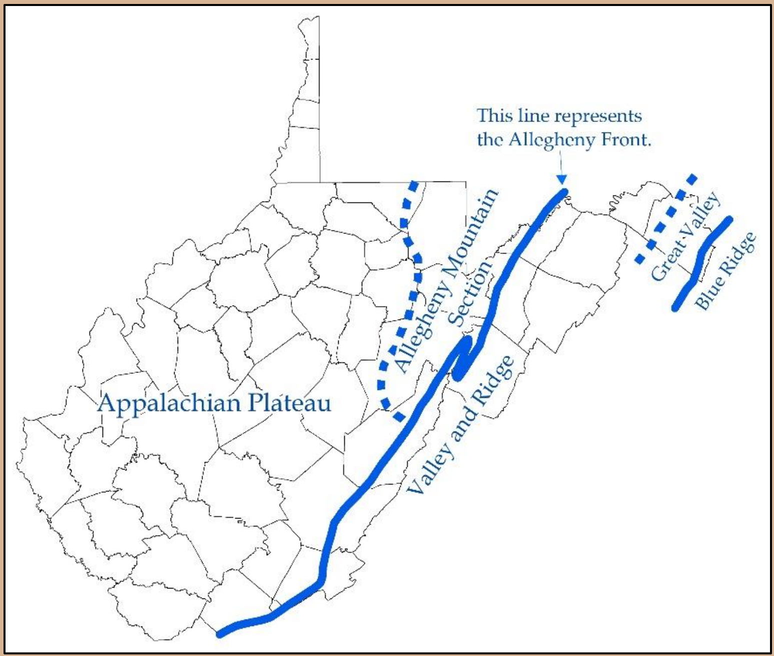

Figure 2. Simplified view of the physiographic provinces in West Virginia.

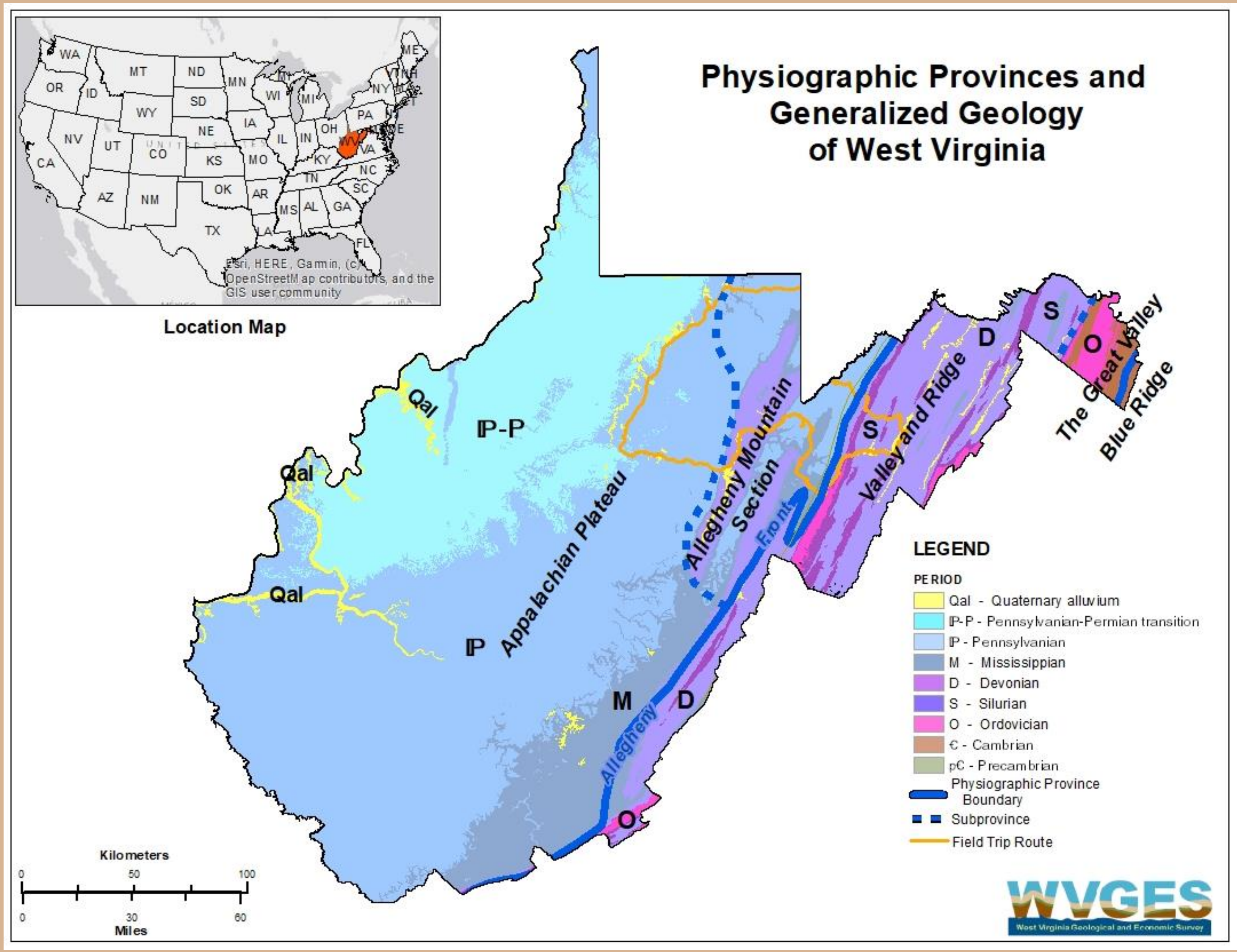

Figure 3. Physiographic Provinces of West Virginia, with generalized, statewide geology.

Eocene/Jurassic (56 to 33.9 mya/201 to 143 mya)

Igneous intrusions of Jurassic and Eocene age are present in southeastern Pendleton County (Figure 4). The Jurassic-aged intrusions are related to the breakup of Pangea, while the source of the Eocene deposits are still under debate. Both sets of intrusives are largely basaltic though localized rhyolitic zones have been identified. See the section titled "The Sugar Grove Igneous Complex" on page 29 for more information.

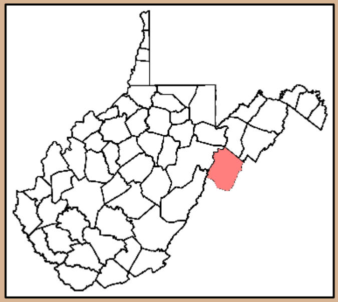

Figure 4. Pendleton County, shown in red.

Pennsylvanian-Permian (299 to 252 mya)

Dunkard Group – (Figure 5) consists of interbedded black, grey, green, and red claystone and mudstones, grey and green siltstone, grey and green lithic, medium- to coarse-grained micaceous sandstone, nonmarine limestone, and generally thin coals (White, 1891, Fedorko and Viktoras, 2013, and Rhenberg et al., 2024). The Dunkard Group can be broken into the Washington Formation, and the overlying Green Formation and are separated by the discontinuous Jollytown Coal (Rhenberg et al., 2024). This unit spans the Pennsylvanian-Permian boundary but the exact interval is unknown – this boundary is typically defined by marine biostratigraphy, however, no marine strata is present in this unit (Rhenberg et al., 2024).

Pennsylvanian (323 to 299 mya)

Monongahela Formation – (Figure 5) consists of largely terrestrial, interbedded sequences of sandstones, siltstones, red and grey shales, limestones, and coals. This unit is defined by the Waynesburg Coal at the top through the Pittsburgh Coal at the base. Also contained within this formation are the economically viable Sewickley and Redstone coal seams. Plant fossils are abundant throughout (Hennen and Reger, 1913, Hennen and Reger, 1914, and McColloch and McColloch, 2011).

Conemaugh Group – (Figure 5) consists of the largely terrestrial Glenshaw and Casselman Formations, which are separated when the Ames Marine Zone is present to differentiate them (typically only in northern West Virginia). This unit is defined by the Connellsville Sandstone at the top and by the top of the Upper Freeport at the base. The Conemaugh Group is made up of bluish grey to grey to brown, cross bedded, and sometimes lenticular, lithic arenite sandstones,

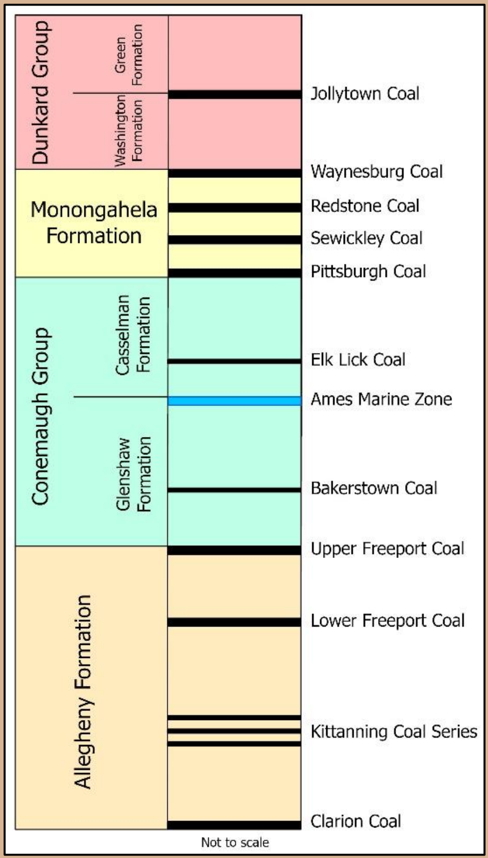

Figure 5. Generalized stratigraphic column showing the middle and upper Pennsylvanian and Permian with select coals represented. In total, these groups and formations would contain 27 distinct coals.

interbedded with light to dark grey to black, occasionally calcareous, sometimes carbonaceous, fissile to platy shales, and coal seams. Thin marine and nonmarine limestones are present, and plant fossils are abundant throughout (White, 1903, White, 1908, Hennen and Reger, 1914, Repine et al., 1993, Rice et al., 1994, and McColloch et al., 2016).

Allegheny Formation – (Figure 5) consists of largely terrestrial, fine- to coarse-grained, thin bedded to massive, tan to grey sandstones (which are notorious acid producers near the top of the formation) interbedded with thin intervals of grey to black shales and thin, lenticular limestone zones. The Upper Freeport coal seam is at the top of this unit, and the base is defined by the Clarion Coal. Numerous other coal seams exist within the Allegheny Formation including the Lower Freeport and the Kittanning series of coals. Plant fossils are abundant throughout (Hennen and Reger, 1914, Fonner et al., 1981, and Tudek et al., 2024).

***Pottsville Group* – in southern WV, the Pottsville Group is comprised of the Kanawha Formation, the New River Formation, and the Pocahontas Formation (youngest to oldest), however, in northern WV (the area of this field trip) these units are too thin to be definable, so the Group is treated as a Formation. This unit is dominated by largely terrestrial, thick, fluvial, coarse-grained, conglomeritic, quartz arenite sandstones, interbedded with some dark shales and coal zones. The top of this unit is defined by the Homewood Sandstone and the base by the Connoquenessing Sandstone. Plant fossils are abundant throughout (Hennen and Reger, 1914, and Tudek et al., 2024). This unit will be viewed at Stop 4 and can be seen in the images on the front and rear covers.**

Mississippian (359 to 323 mya)

***Mauch Chunk Group* – In southeast West Virginia, the Mauch Chunk Group consists of, the Bluestone Formation, the Princeton Sandstone, the Hinton Formation, and the Bluefield Formation (youngest to oldest) (Reger et al., 1926). However, the unit thins considerably to the north and in the area of the field trip, these units are too thin to be definable; hence it is treated as a Formation. The Mauch Chunk is dominated by terrestrial red shales and mudstones, some mottled green, interbedded with reddish to brown, fluvial, crossbedded, lithic sandstones and marine zones possible near the base (Reger and Price, 1923, Reger, 1931, and Perkins et al., 2018). This unit will be observed at Stop 1.**

Greenbrier Group – In southeastern West Virginia, the Greenbrier Group is over 1,200 feet thick (Reger, 1926) and, in descending order, consists of the Alderson Limestone, Greenville Shale, Union Limestone, Pickaway Limestone, Taggard Shale, Patton Limestone, Sinks Grove Limestone (the Patton and Sinks Grove can also be grouped into the Denmar Formation), and the Hillsdale Limestone. Much like the Mauch Chunk, the Greenbrier thins considerably to the north and these formations are undefinable; hence it is also treated as a Formation. The Greenbrier is composed of light to dark grey limestones ranging from (marine) mudstones to wackestone/packstones, often oolitic, typically fossiliferous (brachiopods, crinoids, bryozoans, and others), with interbedded, terrestrial, red mudstones in the upper half of its thickness (Reger and Price, 1923, Reger, 1931, and Perkins et al., 2018).

Price Formation – dominated by a massive, quartz pebble conglomerate zone that contains flattened and elongate pebbles up to 3 inches (7.6 cm) on the long axis, overlying a fossil lag deposit containing brachiopods, bivalves, and crinoid columnals. Sandstones tend to be light to dark grey, grey-green, greenish-brown, and typically argillaceous. Common shales and siltstones are greenish-grey, grey, and greenish-brown, with occasional carbonaceous material (Reger, 1931, and Perkins et al., 2018). This unit is largely terrestrial, with some marine zones present. The base of the Price Formation is Devonian-aged, and it correlates with the Rockwell and Purslane Formations to the north.

Devonian (419 to 359 mya)

Hampshire Group – consists of terrestrial, interbedded mudstones, shales, siltstones, and micaceous sandstones. Sandstones are fine- to medium-grained, red, reddish-brown, green, greenish-brown, and brown in color, occasionally bioturbated, thin- to medium-bedded, and often cross bedded. Shales are typically fissile, red, green, or red with mottled green (Reger, 1931, and Perkins et al., 2018). While this unit is considered a group, it is rarely split into its members (the Cannon Hill and Rowlesburg Formations).

***Greenland Gap Group* – consists of the Foreknobs and Scherr Formations (Dennison, 1970), however publications are currently being prepared to eliminate the Scherr Formation and the Greenland Gap Group, leaving only the Foreknobs Formation at this stratigraphic interval (Pitts and Doctor, *in press*). This unit is composed of interbedded, fine-grained, tan to olive-green to grey sandstone, siltstone, mudstone, and shales. This near-shore marine unit contains abundant marine fossils (including brachiopods, crinoids, and others), trace fossils, tool marks, and interference ripples (Reger, 1931, Matchen et al., 2008, and Chapman et al., 2017). This unit will be viewed at Stop 5.**

Brallier Formation – comprised of marine, tan to olive-green shales, weathering to brown or tan, and varying from fissile to platy, often bioturbated. Sparse, thin- to medium-bedded, fine-grained sandstones are interbedded, often with the same colors as the shales noted above. The index trace fossil *Pteridichnites biseriatus* (Figure 6) is found in the Brallier Formation (McDowell et al., 2007), and this unit is devoid of marine body fossils (Reger, 1931, and Perkins et al., 2024).

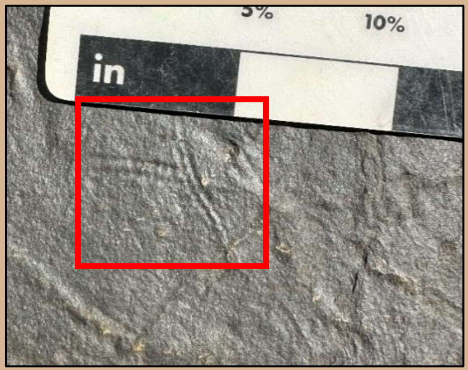

Figure 6. Pteridichnites biseriatus from the Brallier Formation.

This section is a bit confusing as it can vary from the northern end of the trip to the southern (Figure 7). In the north the following exists:

Harrell Formation – comprised of marine, medium to dark grey shales, sometimes dark grey to black, ranging from fissile to platy (Dennison, 1963). Ostracod zones are also locally present (Reger and Tucker, 1924, Dennison, 1963, and Perkins et al., 2024).

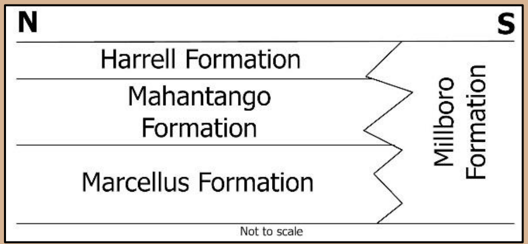

Figure 7. Relationship between the northern Middle Devonian shales, and the southern Millboro Formation.

Mahantango Formation – comprised of marine, medium to dark grey, sometimes olive-green, shales, siltstones, or sandy shales, typically fossiliferous, with sparse, thin-bedded, medium to dark grey sandstones (Reger and Tucker, 1924, Dennison, 1963, and Perkins et al., 2024).

Marcellus Formation – comprised of marine, black, fissile shale, with some iron staining and thin carbonate units possible near the center of its thickness (Reger and Tucker, 1924, Dennison, 1963, and Perkins et al., 2024). This unit is heavily developed for natural gas to the west.

In the south, the above correlate to the following:

Millboro Formation – comprised of marine, black, fissile to platy shale interbedded with dark, brownish-grey, silty shale. Calcareous zones and concretions up to 1.6 feet (0.5 m) are common. Sparsely fossiliferous with articulate brachiopods and some unidentified arthropod fragments (Dennison et al., 1996, McDowell et al., 2014, and Soeder et al., 2014). This single unit correlates with the Harrell, Mahantango, and Marcellus described above.

Needmore Formation – comprised of marine, medium to dark grey, fissile shales (weathering light) with thin or lenticular carbonate zones (Soeder et al., 2014, Hunt et al., 2017, and Perkins et al., 2024).

Oriskany Sandstone – comprised of medium- to thick-bedded, medium- to coarse-grained marine sandstones often cemented with calcite or silica, very fossiliferous (primarily with brachiopods), and locally crossbedded. Gradational contact with the underlying Helderberg Group can create difficulties in differentiation (Dean et al., 2011). This unit is highly dynamic and can, at some locales, be mistaken for a limestone if caution is not exercised (Reger and Tucker, 1924, Dennison, 1963, and Perkins et al., 2024). This resistant unit often forms the small ridges found in the Valley and Ridge Physiographic Province.

***Helderberg Group* – comprised of the Shriver Chert, the Licking Creek Formation, the Mandata Shale, the Corriganville Formation, the New Creek Formation, and the Keyser Formation (youngest to oldest). The base of this unit is Silurian in age and composed of massive bedded, fossiliferous, marine limestones (grainstones and packstones) with abundant algal mounds and stromatoporoids. The upper units tend to be medium to thick bedded and can contain significant chert (Reger and Tucker, 1924, and Hunt et al., 2017). This unit will be viewed at Stop 2.**

Silurian (443 to 419 mya)

Tonoloway Formation – comprised of finely-bedded to laminated, light to dark grey, marine limestones and limey-shales grouped in shallowing-upwards sequences capped with tan limestone or dolostone. Desiccation features are common in the form of mud cracks, and halite and gypsum casts (Maryland Geologic Survey, 1923, Reger and Tucker, 1924, Brezinski and Conkwright, 2013, and Perkins et al., 2024).

Wills Creek Formation – consisting of marine, thin-bedded, grey to tan, micritic limestones, as well as thick, grey to tan fossiliferous limestones, interbedded with calcareous shales ranging from tan to brown. Desiccation features are abundant in the form of mud cracks, and halite and gypsum casts (Maryland Geologic Survey, 1923, Reger and Tucker, 1924, Brezinski and Conkwright, 2013, and Perkins et al., 2024).

Bloomsburg/Williamsport – this stratigraphic interval is occupied by either the Bloomsburg Formation (terrestrial, in the north) or the Williamsport Sandstone (marine, in the south). The Bloomsburg is comprised of non-calcareous, red mudstones and sandstones (Brezinski and Conkwright, 2013, and Perkins et al., 2024). The Williamsport Sandstone is comprised of thin bedded, tan to white, non-calcareous sandstones. Trace fossils are often found on the underside of beds (Maryland Geologic Survey, 1923, Reger and Tucker, 1924, McDowell et al., 2007, and Perkins et al., 2024).

McKenzie Formation – made up of marine, calcareous shales, ranging in color from tan, to brown, to grey, and interbedded with thin-bedded, micritic limestones, some of which can be fossiliferous (Maryland Geologic Survey, 1923, Reger and Tucker, 1924, Brezinski and Conkwright, 2013, and Perkins et al., 2024).

Keefer Sandstone – comprised of marine, thin- to medium-bedded, fine- to medium-grained sandstones, ranging in color from light grey to red, often fossiliferous, bioturbated and limonitic; can also be calcareous or dolomitic (Maryland Geologic Survey, 1923, Reger and Tucker, 1924, Brezinski and Conkwright, 2013, and Perkins et al., 2024).

Rose Hill Formation – comprised of marine, fissile shales, ranging in color from reddish-brown, to tan, to dark grey. At or near the base of the unit are distinctive ironstones that are composed of fine-grained, hematitic, sometimes oolitic, sands. The basal sands can vary based on geographic location; however, they always have a notable iron content and range from rust colored to red to pink (Maryland Geologic Survey, 1923, Reger and Tucker, 1924, Brezinski and Conkwright, 2013, and Perkins et al., 2024).

***Tuscarora Sandstone* – composed of marine, thin- to medium-bedded, fine- to medium-grained, light-grey to white, bioturbated, quartz arenites. The Tuscarora is resistant to weathering, often forming impressive cliffs (Maryland Geologic Survey, 1923, Reger and Tucker, 1924, Tilton et al., 1927, and McDowell et al., 2014). This unit will be viewed at Stop 3.**

Ordovician (487 to 443 mya)

Juniata – comprised of marine, pink to dark maroon, fine- to very fine-grained quartz sandstone, interbedded with maroon mudstones and occasional pale green mudstones. Localized zones of bioturbation possible (Tilton et al., 1927, Diecchio, 1985, and McDowell et al., 2014).

Oswego Formation – consisting of marine, grey-green, thin-bedded, fine-grained sandstone (Diecchio, 1985, and McDowell et al., 2015).

Reedsville/Martinsburg Formation – composed of light tan shale, interbedded with thin, sometimes lenticular, dark grey fossiliferous, marine limestones, and tan, fossiliferous, marine siltstones. An index zone of *Orthorhyncula (brachiopod)* fossils (Figure 8) (Diecchio, 1980, 1985) is an effective marker bed (Tilton et al., 1927, Ryder, 1992, and McDowell et al., 2015). The name for this stratigraphic zone is currently under debate, hence both possible names are included here.

Figure 8. Orthorhyncula fossils, scale is in millimeters.

Trenton Group

Dolly Ridge Formation – comprised of dark grey to black, nodular-bedded, micritic, fossiliferous, marine limestones, weathers to white, interbedded with black shale (Tilton et al., 1927, Perry, 1972, and McDowell et al., 2015).

Nealmont Limestone – comprised of thin- to medium-bedded, light- to medium-grey, marine limestones, fossiliferous (in some cases, almost a coquina) and bioturbated. K bentonite beds are also present (Tilton et al., 1927, Kay, 1956, Perry, 1972, and Haynes et al., 2015).

Black River Group

McGraw Limestone – composed of dark grey to black, micritic, marine limestones with sparse fossils and burrow moldic porosity (Tilton et al., 1927, Kay, 1956, Perry, 1972, and Haynes et al., 2015).

McGlone Limestone – comprised of marine, light grey fenestral mudstones, dark grey grainstones and packstones, and laminated mudstones. Local bioturbation, and possible desiccation cracks have been noted (Tilton et al., 1927, Kay, 1956, Perry, 1972, and Haynes et al., 2015).

Big Valley Limestone – includes the Benbolt Limestone, the Peery Limestone and the Ward Cove Limestone (youngest to oldest). This unit is made up of marine, light to dark grey, interbedded argillaceous, nodular bedded mudstones (weathering to a shale), some sparsely to moderately fossiliferous zones, with sparse lenses and nodules of black chert. Red argillaceous zones common near the top (Tilton et al., 1927, Kay, 1956, Perry, 1972, and Haynes et al., 2015).

St. Paul Group

Lincolnshire Formation – consisting of dark grey, fossiliferous (brachiopods, bryozoans, echinoderms, trilobites, corals, sponges, cephalopods, pelecypods, and stromatolites), marine limestones with common to abundant lenses, nodules, and discontinuous beds of black chert (Tilton et al., 1927, Kay, 1956, Perry, 1972, and Haynes et al., 2015). Pyrite is also sometimes found in this interval.

New Market Limestone – composed of light to medium (dove) grey, weathering to white, fenestral, marine micrite that often fractures conchoidally. Fossils tend to be sparse (Tilton et al., 1927, Kay, 1956, Perry, 1972, and Haynes et al., 2015).

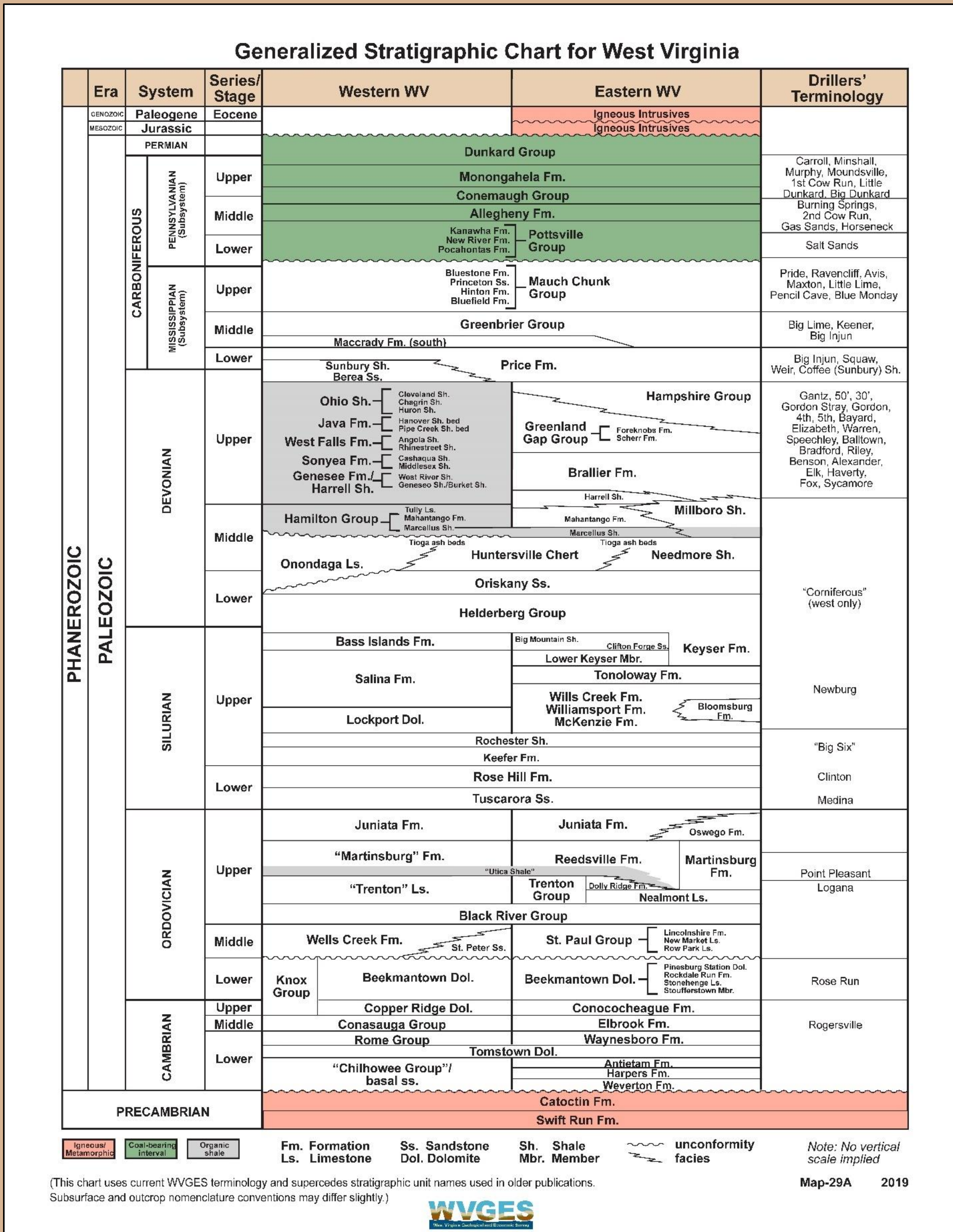

Figure 9. Generalized stratigraphic column for West Virginia.

Deep Creek Lake, Maryland

Deep Creek Lake is a manmade lake in Garrett County, Maryland (Figure 10) that was originally impounded as a means of generating hydropower in 1925 (Maryland Department of the Environment, 2025). However, this area has since evolved into the premier tourist destination of Western Maryland. Aside from the expected boating, fishing, and swimming, this area also supports skiing (Figure 11), fine dining, and hiking. There are no natural lakes in this region due to the continental glaciation only extending as far south as central Pennsylvania during the glacial maximums of the Pleistocene. The lake is formed by impounding a small tributary of the Youghiogheny River that created a lake of roughly 3,900 acres and covers stratigraphy ranging from the Lower Pennsylvanian Pottsville Group through the Upper Devonian Foreknobs Formation.

Figure 10. Deep Creek Lake in February.

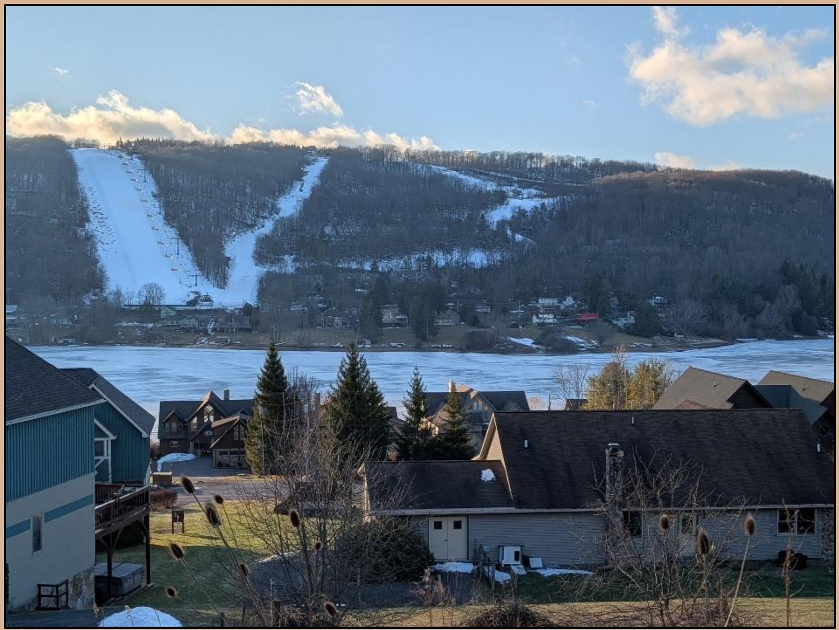

Figure 11. The Wisp Ski Resort at Deep Creek Lake.

Previous Corridor H Geology Guides

The section of Corridor H between Mount Storm and Baker, WV has only been open to the public for a little over a decade and therefore has some of the most pristine road cuts through the Valley and Ridge stratigraphy in the region. Due to the pristine nature of these recent cuts, this corridor has undergone extensive study by local geologists. A multitude of educational material has been generated concerning the Corridor; much of it freely available to the public. Rather than reinvent the wheel, two separate field trip guides to this section of road can be accessed via the QR Codes below. The two stops that will be made in this section will be detailed in this guide; however, the field trip guides below contain even more detailed discussions for many of the road cuts observed along this trip.

What the H? Field guide for the Eastern Section of AAPG, 2017

Eustasy from the Blue Ridge to the Allegheny Front, Field guide for GSA 2015

In addition to the previous field guides, researchers have also developed digital models and high-resolution images for many of the roadcuts which can be viewed via the QR Codes below.

3D photogrammetric models of features along Corridor H by Ryan Shackleton

Collection of Gigapixel resolution images (various authors) from along Corridor H

Stop 1: Corridor H Overlook

Figure 12. Views of the Valley and Ridge Physiographic Province from Stop 1.

The first stop of the field trip is located on the Allegheny Front with sprawling views of Valley and Ridge Physiographic Province to the east (Figure 12). Opposite the viewshed (on the other side of the road) is an exposure of red shales from the Upper Mississippian Mauch Chunk Group (Figure 13). The Mauch Chunk is a largely terrestrial deposit comprised primarily of paleosols and fluvial sandstones. Near the base of this unit are a series of marine zones, however, these zones are considerably thicker in the southeastern portion of West Virginia. Further downhill from this stop is a roughly 20-foot-thick limestone that represents the only marine zone in this area.

Note the relatively flat orientation of these beds and all of those encountered between here and the bottom of the hill, then compare that to the other units we see between Stops 1 and 2. From the bottom of the hill and on, you will note that the orientation will vary dramatically (dip specifically, the strike will remain largely static) from flat, to vertical, and everything in-between. This is one of the defining differences between the Appalachian Plateau and the Valley and Ridge Physiographic Provinces.

Figure 13. Red shales of the Mauch Chunk Group at Stop 1.

Scherr Crystal Cave

While blasting through the Tonoloway Formation, construction workers accidentally broke into a previously unknown, small cave (Figure 14). Though the landowner asked the Department of Highways to fill the cave back in, a small crew of local cavers were able to survey and document this peculiar void, and the unexpected beauty contained therein, before it was permanently sealed back off. Measuring at only 408 feet long, and 49 feet deep, this cave has no natural opening to the surface, hematite and fluorite deposits, an abundance of gypsum crystals and bushes (Figure 15), strange colored precipitates (no thorough geologic study was performed), as well as the standard stalagmites and stalactites (Dasher, 2010). The lack of an entrance, coupled with the strange mineralogy could indicate that this cave formed via dissolution by rising water (hypogenic speleogenesis) as opposed to the much more common, and better understood, dissolution by water percolating down from the surface (epigenic speleogenesis). Unfortunately, with the entrance now buried under riprap, the geologic mysteries of this cave will likely never be answered.

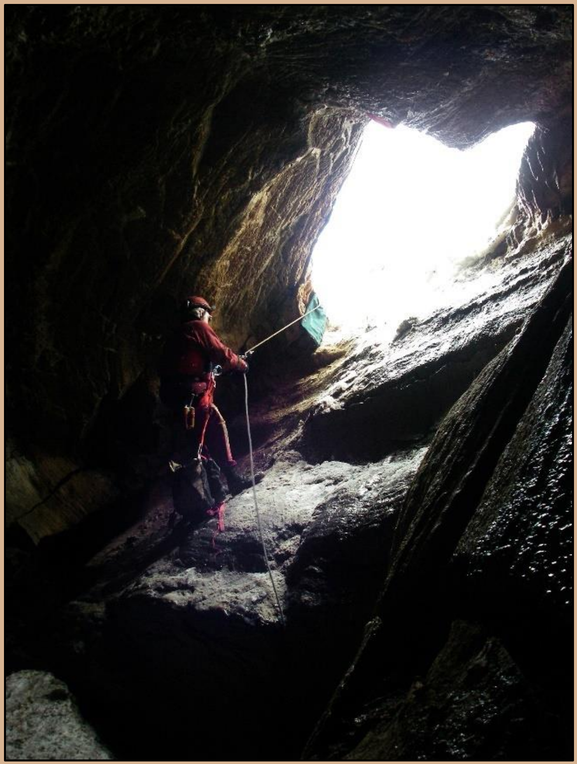

Figure 14. Rappelling the 30-foot entrance to Scherr Crystal Cave. Photo by Nikki Fox.

Figure 15. Gypsum formations in Scherr Crystal Cave. Photo by Nikki Fox.

Stop 2: Corridor H Truck Stop

Figure 16. Carbonates of the Helderberg Group at Stop 2.

Stop 2 is one of the more dramatic road cuts along the Corridor H route (Figure 16), exposing almost the entirety of the Helderberg Group (see the generalized stratigraphic description above, or refer to the detailed descriptions in the linked field guides). Figure 17 shows some of the fossils present near the base of this stop. Compared to Stop 1 along the Allegheny Front, first note that these beds are not flat lying. Upon entering the Valley and Ridge Province all the bedding has undergone various degrees of deformation, as characteristic of this Province, including the dramatic box folding of the Tonoloway Formation only ½ mile west of this stop (Figure 18).

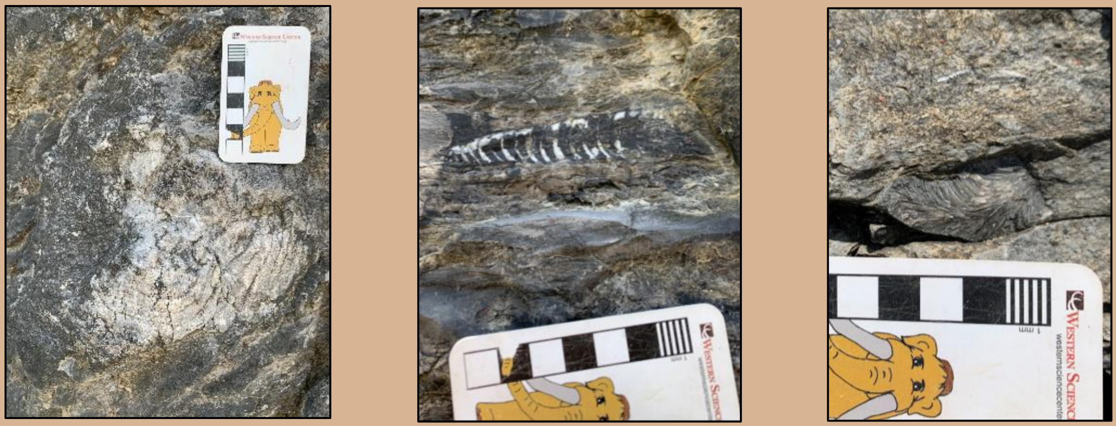

Figure 17. Left: Favosites, a tabulate coral, center: a nautiloid, right: another Favosites.

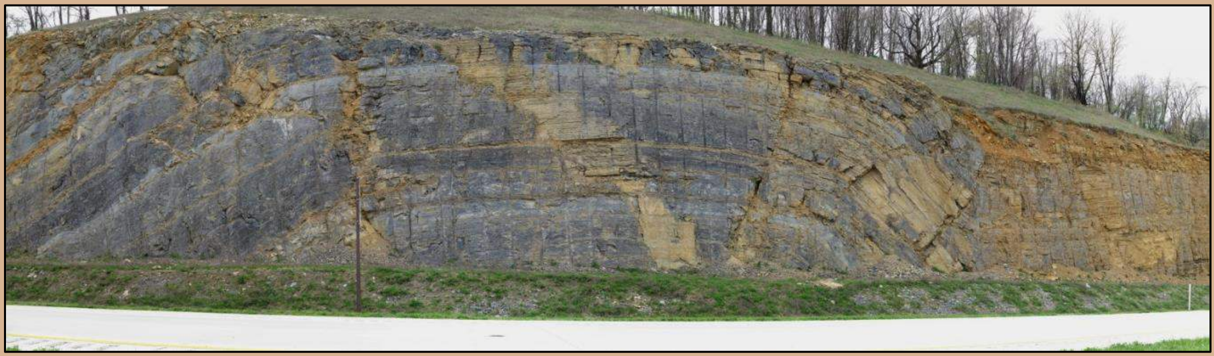

Figure 18. Box folds in the Tonoloway Formation 1/2 mile west of Stop 2. Gigapan by Alan Pitts.

South Branch Valley: 1985 Flood

On Monday November 4th, 1985, the remnants of Hurricane Juan joined with a stalled stormfront over West Virginia creating the perfect conditions for the worst state-wide flood in West Virginia's history. Nearly every river in the state jumped its banks and, in the hours and days that followed, 38 people were killed, 2,587 people were left homeless, 9,984 homes were damaged, destroyed, or condemned, and approximately $500 million in total damages were accrued across the state (Teets and Young, 1985).

Following Stop 2, the field trip exits the Corridor H portion at Moorfield, WV and follows the South Branch of the Potomac River upstream to Petersburg, WV. The nearest historic stream gauge statistics for this stretch are from 44.6 river miles downstream in Paw Paw, WV, which is about 6.5 river miles downstream of where the South Branch of the Potomac and the North Branch of the Potomac merge into the Potomac River proper (yes, it's a mouthful). Here, the stream crested late on Tuesday November 5th with a maximum stage height of 54 feet; the flood stage at this gauge was 25 feet (Teets and Young, 1985).

This section of valley was among some of the hardest hit areas in the state, as are depicted in the imagery that follows (Figures 19 through 22).

Figure 19. Flood debris outside of a school in Moorefield, WV. Photo from Teets and Young, 1985, originally published by the Moorefield Examiner.

Figure 20. A car washed into a market in Petersburg, WV. Photo from Teets and Young, 1985, originally published in the News Tribune.

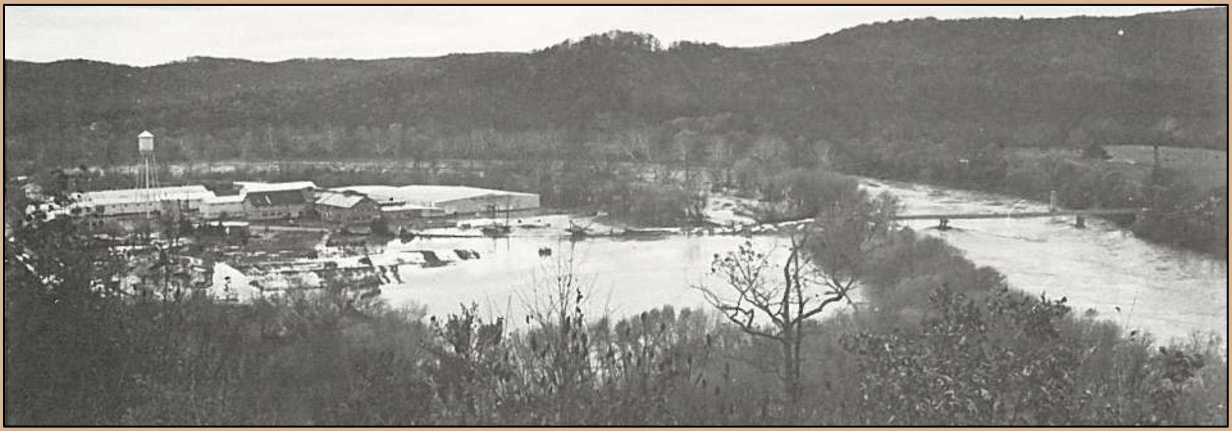

Figure 21. Paw Paw, WV on November 6th, still flooded after the peak of the flood pulse had passed. Photo from Teets and Young, 1985, originally published in The Morgan Messenger.

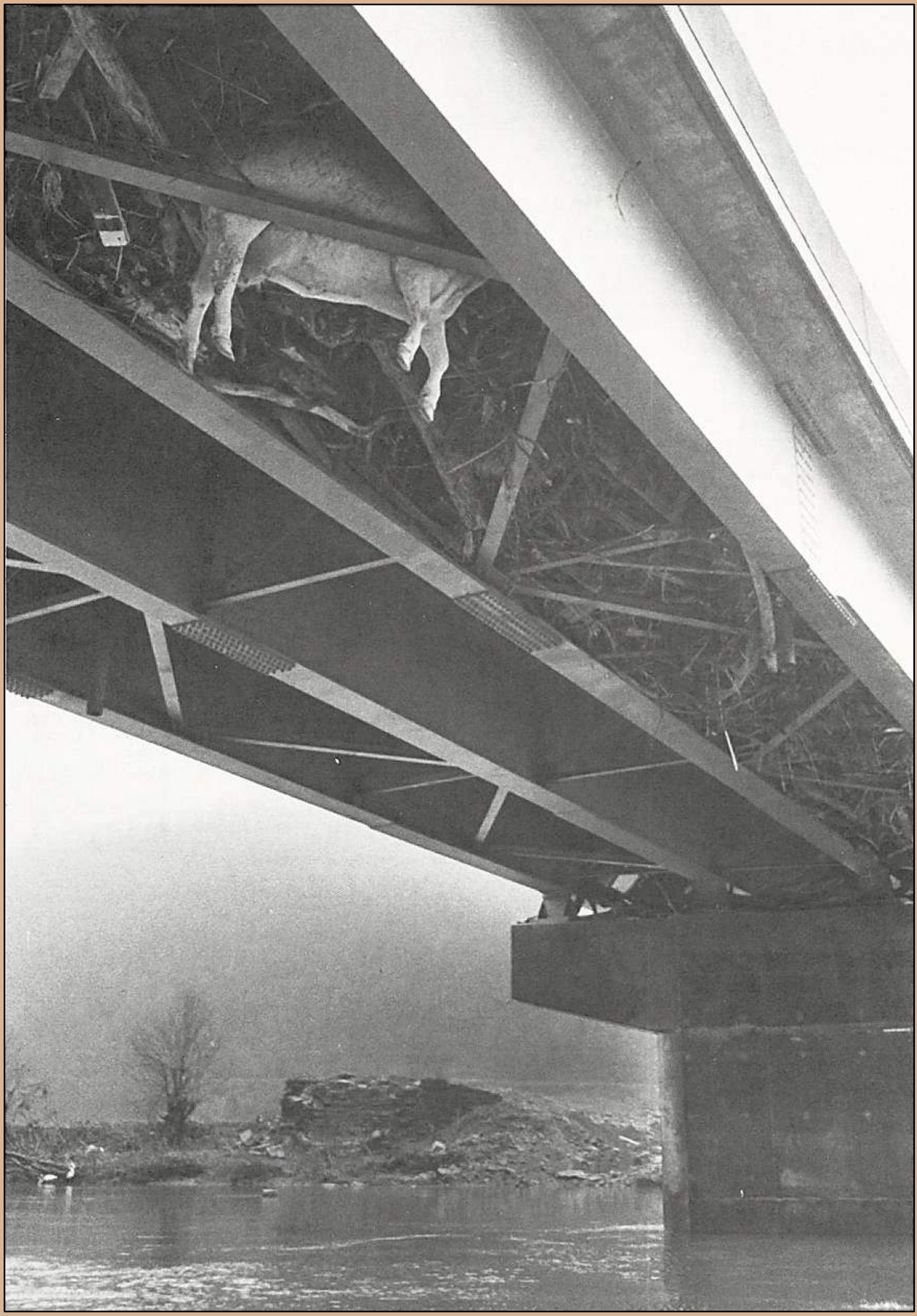

Figure 22. This scene is not from the South Branch Valley but from St. George, WV, along the Cheat River and just a few miles away from Stop 5 of this trip. Photo from Teets and Young, 1985, originally taken by John Warner.

Smoke Hole Caverns

Figure 23. Smoke Hole Caverns Visitor Center and Gift Shop. The entrance to the cave is at the far-right side of the picture. Photo from Google Maps Streetview.

Link to the Smoke Hole Caverns website.

Smoke Hole Caverns (Figure 23) is a small (1,750 feet long and 70 feet deep [Dasher, 2010]) commercial cave developed in the Tonoloway Formation along a small thrust fault visible at the entrance. Due to the thin-bedded nature of the Tonoloway, it is typically a less competent unit causing it to deform more drastically than some of the other units around it (especially above). The commercial tour runs for less than an hour and this structural complexity is easily seen along the route which also passes through numerous galleries of stalagmites, stalactites, and calcite encrusted walls (Figure 24).

Figure 24. Flowstone in Smoke Hole Caverns. Photo from the Smoke Hole Caverns website.

In operation since the 1940's, Smoke Hole Caverns has operated more or less continuously throughout that time. About 15 years ago, the Visitor Center and Gift Shop suffered a complete loss due to a fire and the future of the operation was, for months, in question. The newly rebuilt facility utilizes the natural cave stream that flows out of the cave for geothermal heating/cooling. In the years since reopening, the business has expanded to serve nearly every need of tourists to the area including cave tours, lodging, guided fishing trips, and even motorcycle tours. For more information on any of the above, see the QR Code for the website.

Hopeville Anticline

Figure 25. The western limb of the Hopeville Anticline along the North Fork of the South Branch of the Potomac River. Note the axis of the fold at the top of the ridge.

The Hopeville Anticline (Figure 25 and the image on page 1) is a small structure, relative to the larger Wills Mountain Anticline immediately to the east (more information on this structure in the next section) and is well defined by the resistant Oriskany Sandstone. The LiDAR imagery in Figure 26 shows that the entire structure is contained within the Oriskany, which defines the shape of the entire ridge. Where the western limb is cut by the river (and in the images referenced above), is a scenic spot known as Triangle Rock, where the river has carved out a small "cave." While the Oriskany is known for having calcite cement, this "cave" is an erosional feature, not a karst feature. This small fold is quite illustrative of the structures present in the Valley and Ridge Physiographic Province.

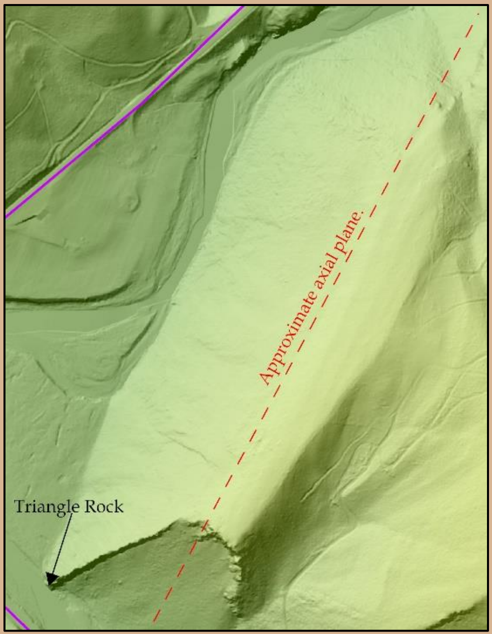

Figure 26. LiDAR imagery showing the Hopeville Anticline.

Stop 3: Seneca Rocks

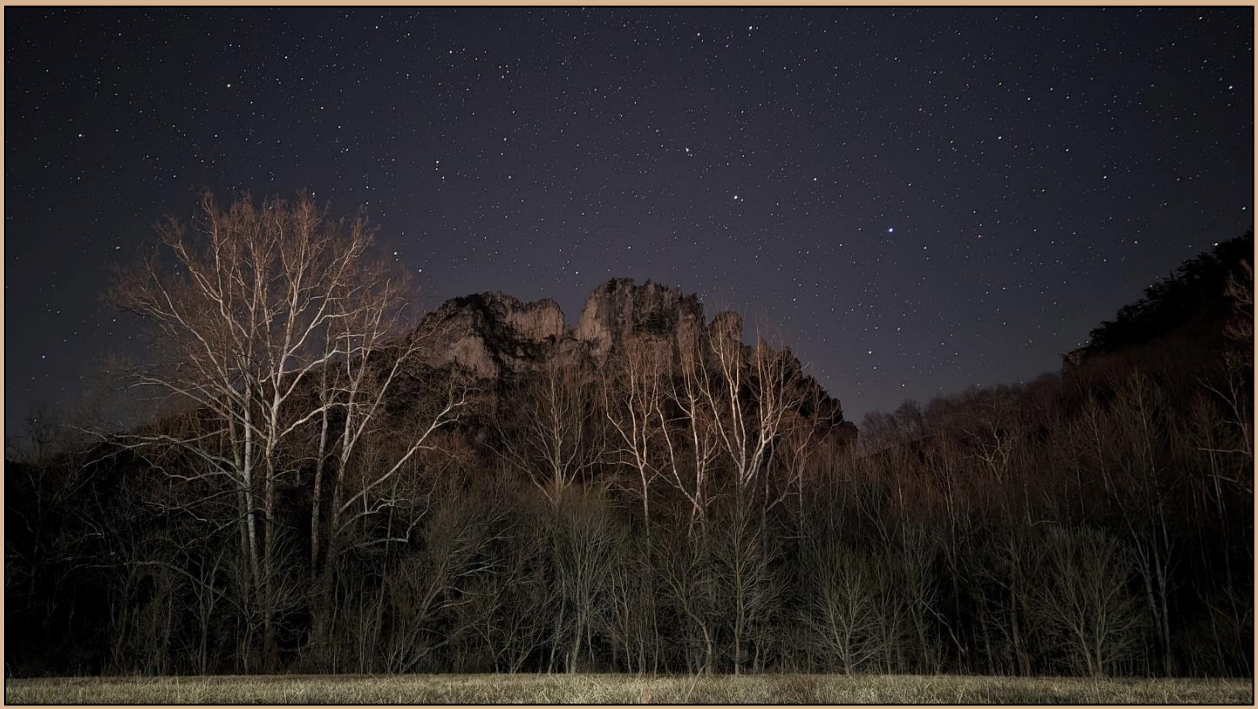

Figure 27. Seneca Rocks, formed in the Tuscarora Sandstone in the western limb of the Wills Mountain Anticline.

Seneca Rocks (Figure 27), located in the Monongahela National Forest, is one of the most famous natural viewscapes in the state of West Virginia and attracts tourists from all over the region for a multitude of outdoor recreational activities. Seneca Rocks is formed in the Tuscarora Sandstone; a very resistant, fine- to medium-grained, quartz arenite of early Silurian age. This outcropping is in the vertically oriented, western limb of the Wills Mountain Anticline, which is a doubly-plunging, asymmetric structure. In this area, the western limb of the Wills Mountain Anticline is sub-vertical to vertical, typically between 85° and 90° dip, creating the scenic outcropping enjoyed by both tourists and rock climbers alike. The eastern limb is more gently inclined, typically between 40° and 60°, and forms the cap on North Fork Mountain to the east of Seneca Rocks (Figure 28). The relationship between the two limbs of the Wills Mountain Anticline is well displayed in a block diagram shown in Figure 29.

Seneca Rocks has a long history as a climbing attraction with the earliest known ascent in 1908. This is evidenced by the inscription "D.(B.) Sept. 16, 1908" on the south summit, however, no one is certain of D.(B.)'s identity. The first recorded ascent took place over two days in 1939 (O'Brien and Weinman, 2021) and climbing the rocks of the North Fork Valley really took off in the 1940's. From 1943-44, both Seneca Rocks, Champe Rocks (another impressive vertical face 5 miles to the north), and Nelson Rocks (11 miles south) were heavily used by the 10th Mountain Division of the U.S. Army to train soldiers for WWII combat in the Apennines of Italy. The remains of the 75,000 pitons used in these trainings are still an abundant sight to this day. Since the 1960's, more difficult routes were established in sync with the free climbing revolution of the 1970's and beyond (O'Brien and Weinman, 2021).

Figure 28. View from Chimney Rock of the Tuscarora Sandstone, in the eastern limb of the Wills Mountain Anticline, at the ridge of North Fork Mountain. Photo by Wayne Perkins.

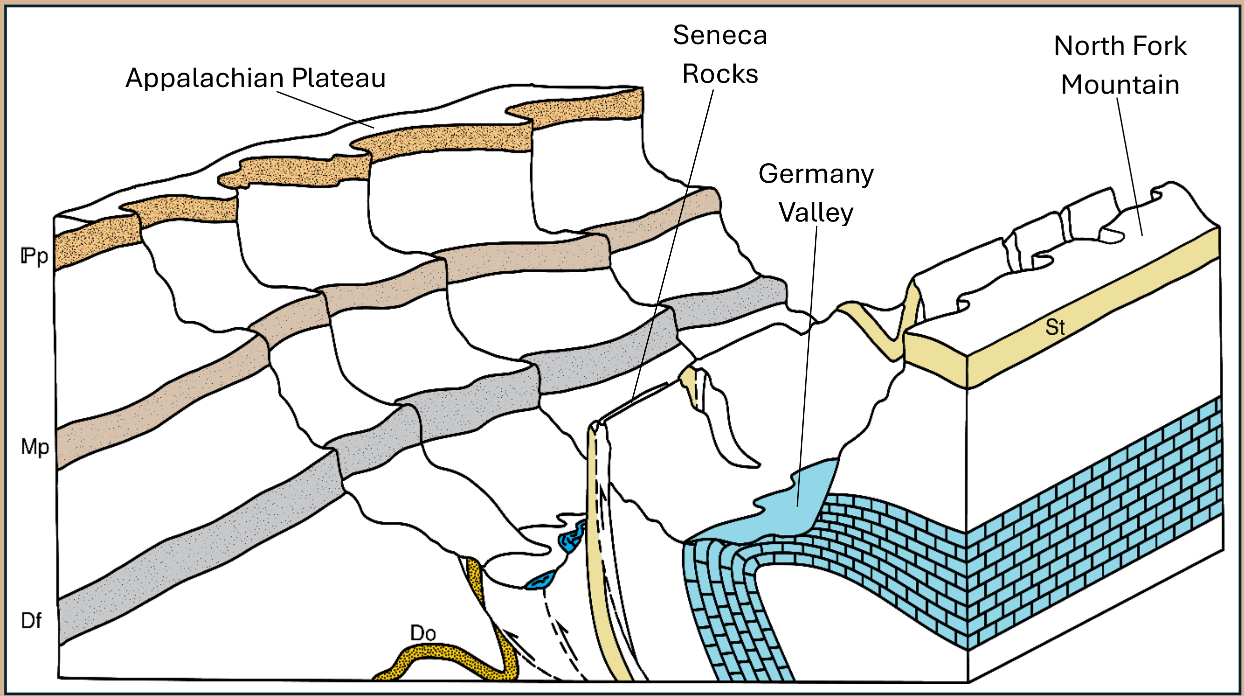

Figure 29. Generalized block diagram of the Seneca Rocks/Germany Valley area. Marker beds are Pp – Pennsylvanian Pottsville Formation. Mp – Mississippian Price Formation. Df – Devonian Foreknobs Formation. Do – Devonian Oriskany Sandstone. St – Silurian Tuscarora Formation. Adapted from Dasher and Sites, 2000.

Germany Valley

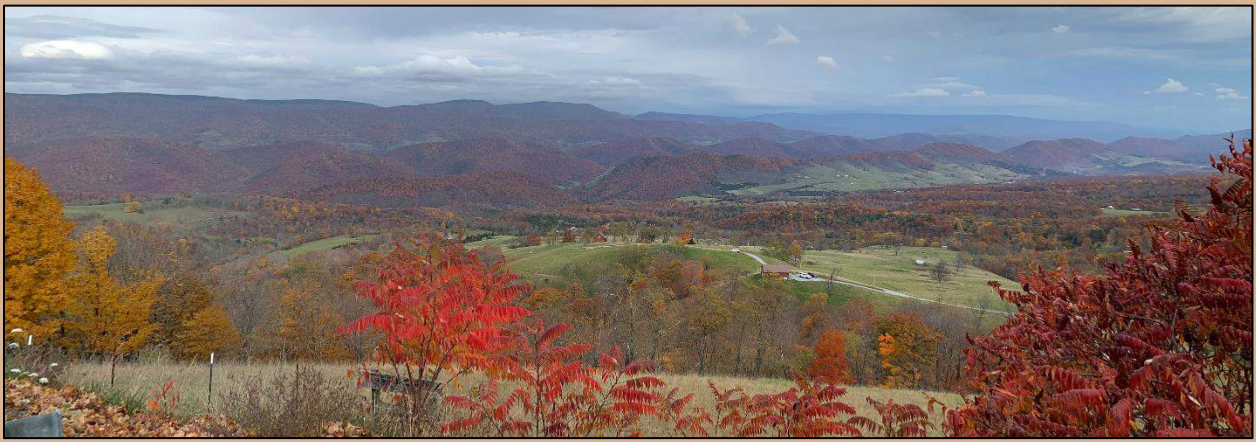

Figure 30. Germany Valley Overlook along Route 33 on the flank of North Fork Mountain.

Seneca Caverns website.

Designated as a National Natural Landmark by the U.S. National Park Service in 1973 (NPS, 2022), Germany Valley (Figure 30) serves as an intersection between the realms of structural, economic, and karst geology. Arguably one of the most structurally complex regions in the state, Germany Valley is wholly formed within the Wills Mountain Anticline (Figure 29) and is dominated by sharp folding and meso-scale faulting. This doubly plunging fold brings Middle Ordovician-age limestones to the surface (the only place in the region these rocks can be seen) where they have been extensively developed for use as aggregate and, in terms of the New Market Limestone, as medical-grade filler. This 545-feet-thick (Haynes et al., 2015) carbonate package is also home to an incredibly dense network of caves.

Figure 31. A cluster of hibernating Virginia Big Ear Bats in Hellhole Cave. Photo by Gabby Zawacki.

These caves form a 3D maze network of over 90 miles of passage including the 3rd longest cave in the state, Hellhole, at 43+ miles and still going (WVASS, 2025). Ongoing exploration in the valley has uncovered deep pits, 500+ foot domes, strange mineral formations, and a deep network of subterranean streams. It is impossible to predict what future discoveries will be made, and how those discoveries will further shape our understanding of this structurally complex valley, but the importance of these caves is not limited to geologic understanding. Several of these caves have proven important for local biota. For example, Hellhole Cave has been utilized by roughly 45% of the known population (Thompson and Arling, 2009) of federally listed, endangered Virginia Big Eared Bats (*Corynorhinus townsendii virginianus*) for winter hibernation (Figure 31). Due to the vertical nature of these caves (Figure 32), they are not for amateur explorers. There is, however, one commercial cave in the valley, Seneca Caverns, that leads tours into a small corner of this complicated karst system.

Figure 32. 154-foot, vertical entrance to Hellhole Cave. Photo by Brian Masney.

By this point in the trip, it is likely apparent that caves and karst features are prevalent in West Virginia. As evidenced by the following statistics and graphs, West Virginia is one of the most karst-rich states in the nation with over 5,100 cave and karst features consisting of 3,652 known caves, 378 karst springs, and untold acreages of sinkhole-laden karst plains (D.R. Riggs, *personal communication*, 2025). Figures 33 and 34 below were created utilizing data from the World Long Cave List (Burger, 2025).

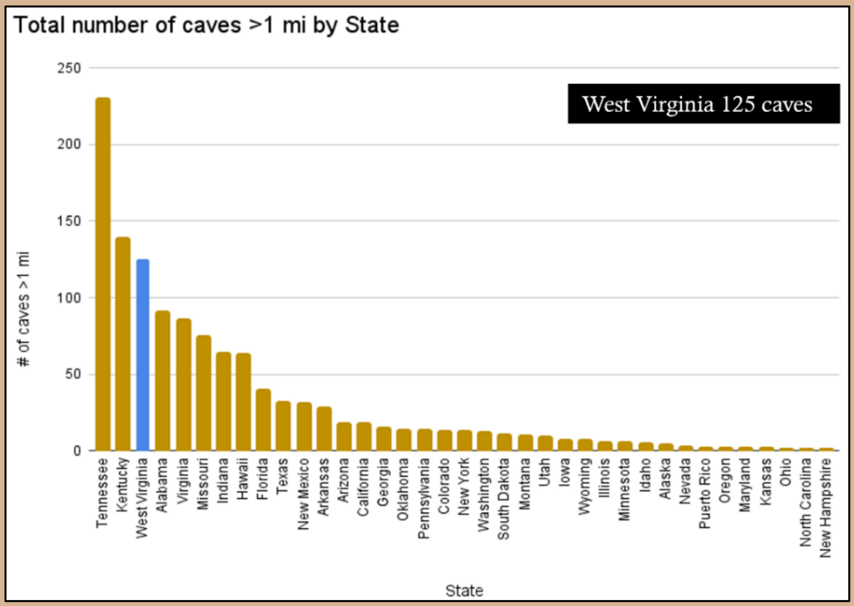

Figure 33. Total number of caves per state greater than 1 mile in length.

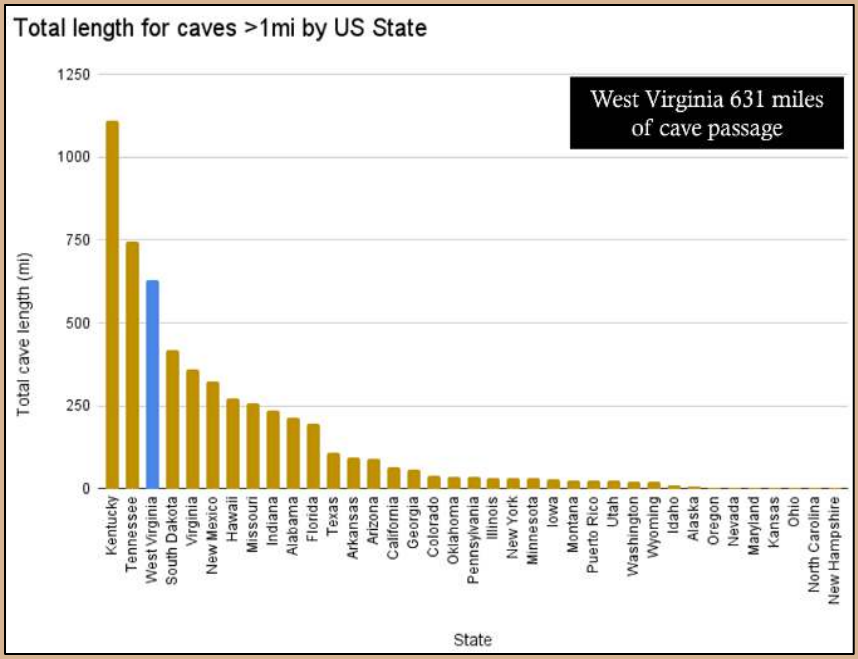

Figure 34. Total mileage of mapped cave passages per state (only considering caves longer than 1 mile in length).

Sugar Grove Igneous Complex

Figure 35. Sugar Grove Igneous Complex. Left: an Eocene-age basalt dike-sill intruding the Millboro Formation. Right: a Jurassic-age gabbro dike.

The Sugar Grove Igneous Complex is located just outside the southern extent of the Route Map, and, rather than a point, is a region of (mostly) mafic dikes (Figure 35), sills, plugs and diatremes that extend from Pendleton and Pocahontas Counties, WV to the southeast into Highlands and Augusta Counties, VA (Figure 36). The Jurassic-age intrusives range in age from 143.8±1.8 to 157±8 million years, while the Eocene-age intrusives range from 48.4±1.3 to 35.0±0.5 million years old; with most ages clustered around 47 million years (Southworth et al., 1993). Contact metamorphism is prevalent, but to varying degrees.

The Late Jurassic igneous suite is associated with the tensional regimes introduced by the rifting of Pangaea while the root cause for the Eocene intrusives is not understood. Both seem to have originated from deep-seated, upper mantle derived magma but it is unclear what reinitiated the Eocene conduits along the same passive margin that still exists today.

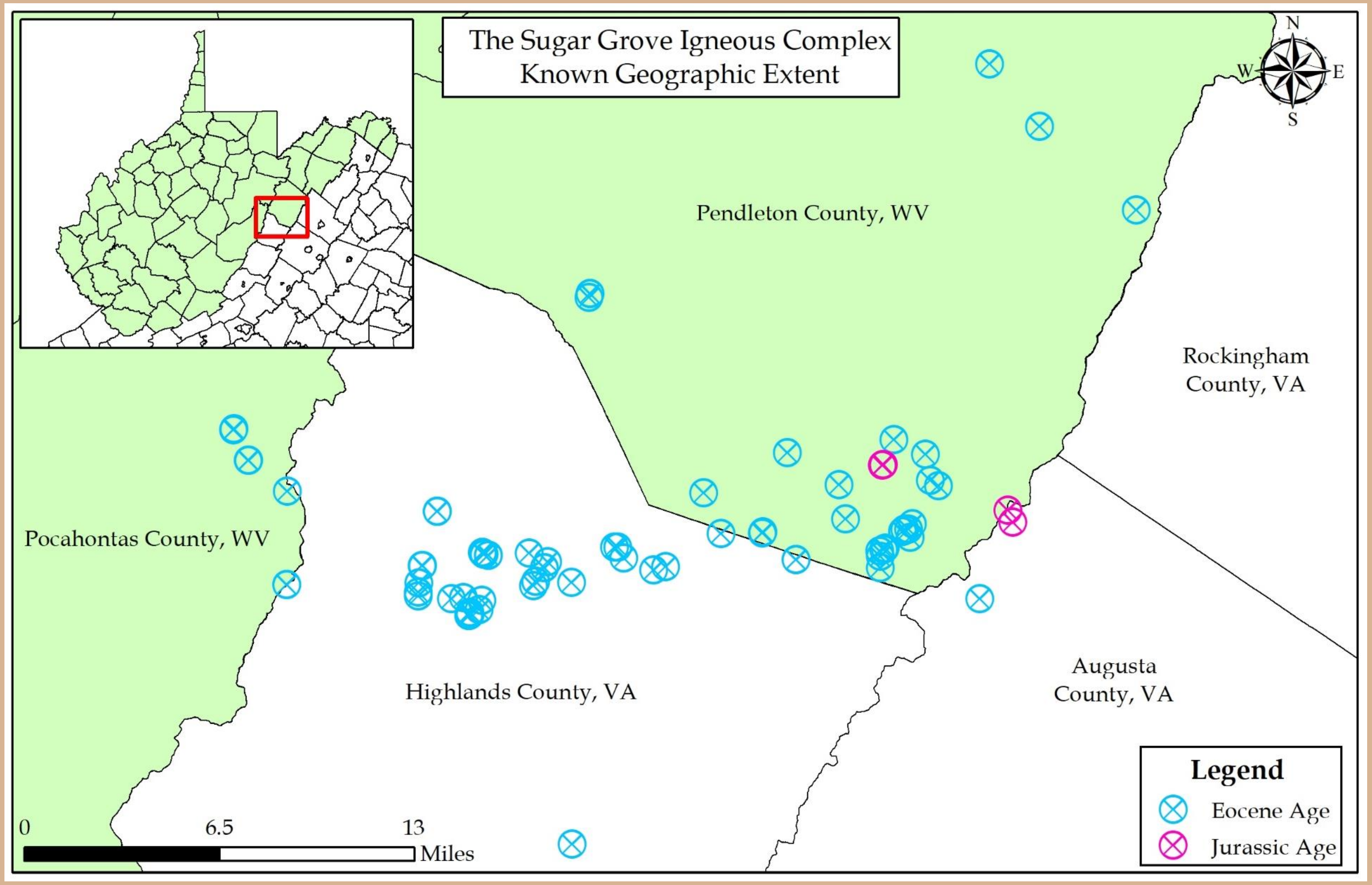

Figure 36. Geographic distribution of known igneous intrusions of the Sugar Grove Igneous Complex.

Physiographic Transition

As the trip leaves Seneca Rocks, following Route 33 east, the Allegheny Front (the boundary between the Appalachian Plateau and Valley and Ridge Physiographic Provinces) is immediately entered. Within this narrow zone, the vertically bedded (in some cases slightly overturned) strata of the Silurian and lower Devonian transition back to the low-angle, long-wavelength folds of the Appalachian Plateau (Figure 37). In the course of about 2 miles, roughly 7,500 feet of strata is traversed. The remainder of this trip will be in the Allegheny Plateau Province.

Most of the trip between Seneca Rocks and Canaan Valley will be in the late Devonian Hampshire Formation (Figure 38) and ample exposures of the red shales, mudstones, and paleosols, interbedded with fluvial, lithic sandstones, of this terrestrial unit will be on display. The thin Price Formation and basal limestones of the Greenbrier Group can also be seen along the top of the Eastern Continental Divide on Cheat Mountain; as well as around Harman, WV and on the ascent up to Canaan Valley.

Figure 37. Transition zone from vertical bedding occurs at roughly the location of the geologist pictured. Beds to their right are notably sub-vertical, while the left is vertical or perhaps slightly overturned. These sandstones are part of the Foreknobs Formation

Figure 38. Gently dipping beds of the Upper Devonian Hampshire Formation. Note the interbedded, red mudstones and fluvial sandstones, indicating the terrestrial nature of this unit.

Canaan Valley

Figure 39. Canaan Valley, view from the Lower Pennsylvanian Pottsville Formation on the eastern edge of the valley.

Canaan Valley (Figure 39) is a high elevation (lowest elevation of around 3,300 feet [1,005 meters] above sea level), breached anticlinal valley (Figure 40, next page) exposing strata from the Lower Mississippian through the Pennsylvanian (Matchen et al., 2008). The walls of the valley are composed of resistant, Pennsylvanian sandstones (Figures 41 and 42), while the valley floor is composed of the soluble Mississippian Greenbrier Group limestones (Figure 43). Outcrops are difficult to find in the Valley, with most areas covered by wetlands. Canaan Valley has turned into an important tourist destination in northern West Virginia with ample hiking areas, a flourishing mountain biking reputation, three different skiing areas, and is home to Canaan Valley State Park.

Figure 41. Iron concretions in the Pottsville sandstones.

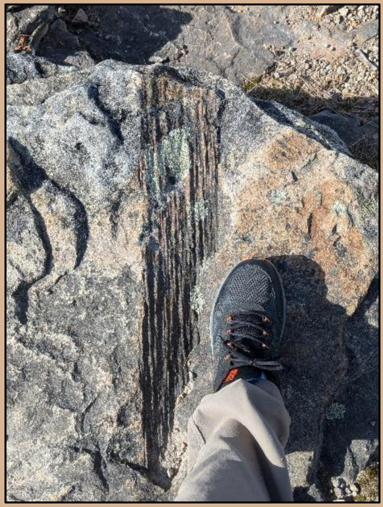

Figure 42. Plant fossil in the Pottsville sandstones.

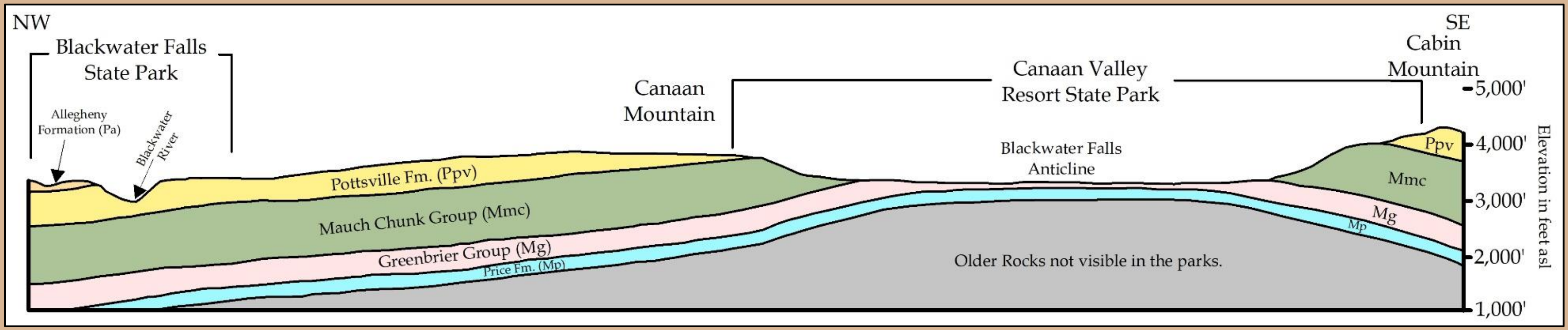

Figure 40. Cross section through the Canaan Valley breached anticline, and Blackwater Falls (next stop). Adapted from Ashton and Stocks, 2008.

Canaan Valley Resort State Park website.

Blackwater Falls State Park website.

Figure 43. Greenbrier Group limestone along the headwaters of the Blackwater River. Note the solutional enhancement along fracture zones and joints.

Stop 4: Lunch at Blackwater Falls State Park

Figure 44. Blackwater Falls in high flow.

Blackwater Falls State Park is named for and has been developed around its namesake waterfall (Figure 44). Here the South Fork of the Blackwater River, which originates in Canaan Valley, falls over the resistant Connoquenessing Sandstone of the Pennsylvanian Pottsville Group (Figure 45) for a distance of 57 feet (the tallest in the state – above ground) before joining with the North Fork downstream and continuing a steep descent in the Blackwater Canyon en route to the Cheat River and, eventually, the Mississippi. The Blackwater River received its name from the high concentration of organic acids produced by the slow decomposition of spruce and hemlock needles that give the water the yellow, to brown, to black color, depending on depth, sediment load, and channel properties.

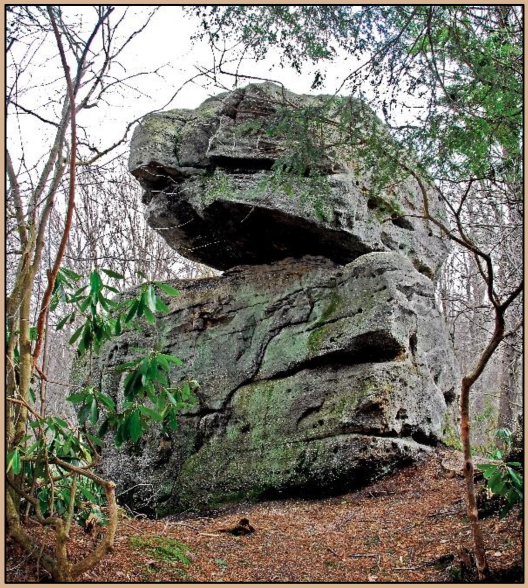

Figure 45. Balanced Rock in Blackwater Falls State Park, made up of Pottsville sandstones.

Lunch will be catered in the Blackwater Falls State Park Lodge which sits a short distance downstream of the falls and atop the plateau created by the resistant Connoquenessing. At the western edge of the clearing for the lodge is the Elakala Trail which offers more views of the Pottsville sandstones at Elakala Falls (rear cover) after only 200 to 300 feet of walking.

Stop 5: Corridor H Construction

Figure 46. Corridor H bridge Construction over the Cheat River, taken in November of 2024.

The portion of Corridor H (Figures 46 & 48) between Kerens and Parsons, WV is entirely concentrated within the Late Devonian Foreknobs Formation, which, in this area, is much more structurally complex than most of the surrounding stratigraphy. The Foreknobs are primarily composed of thin-bedded, fine-grained, lithic sandstones, interbedded with shales and siltstones, thus making it much less competent than the units above it. While all these stratigraphic units follow the typical Allegheny Plateau structural regime of long-wavelength folds, the Foreknobs tend to also contain smaller-scale, parasitic folding superimposed on the overarching structures. These parasitic folds (Figure 47), which can occur at any scale, make predicting the strike and dip effectively impossible over even small distances. This structural unpredictability can have a profound influence on road design and planning, and often leads to unforeseen issues, and engineering headaches.

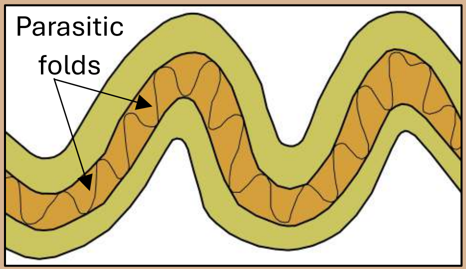

Figure 47. Left: small parasitic syncline in the Foreknobs Formation in an old roadcut only a few hundred feet from the current construction zone for Corridor H. Note the camouflaged geologist near the axis for scale (red arrow). Right: a schematic showing parasitic folding superimposed on a larger fold. The yellow beds are more competent that the orange bed sandwiched in the middle, hence the orange bed is more heavily deformed. Adapted from Park, 1997.

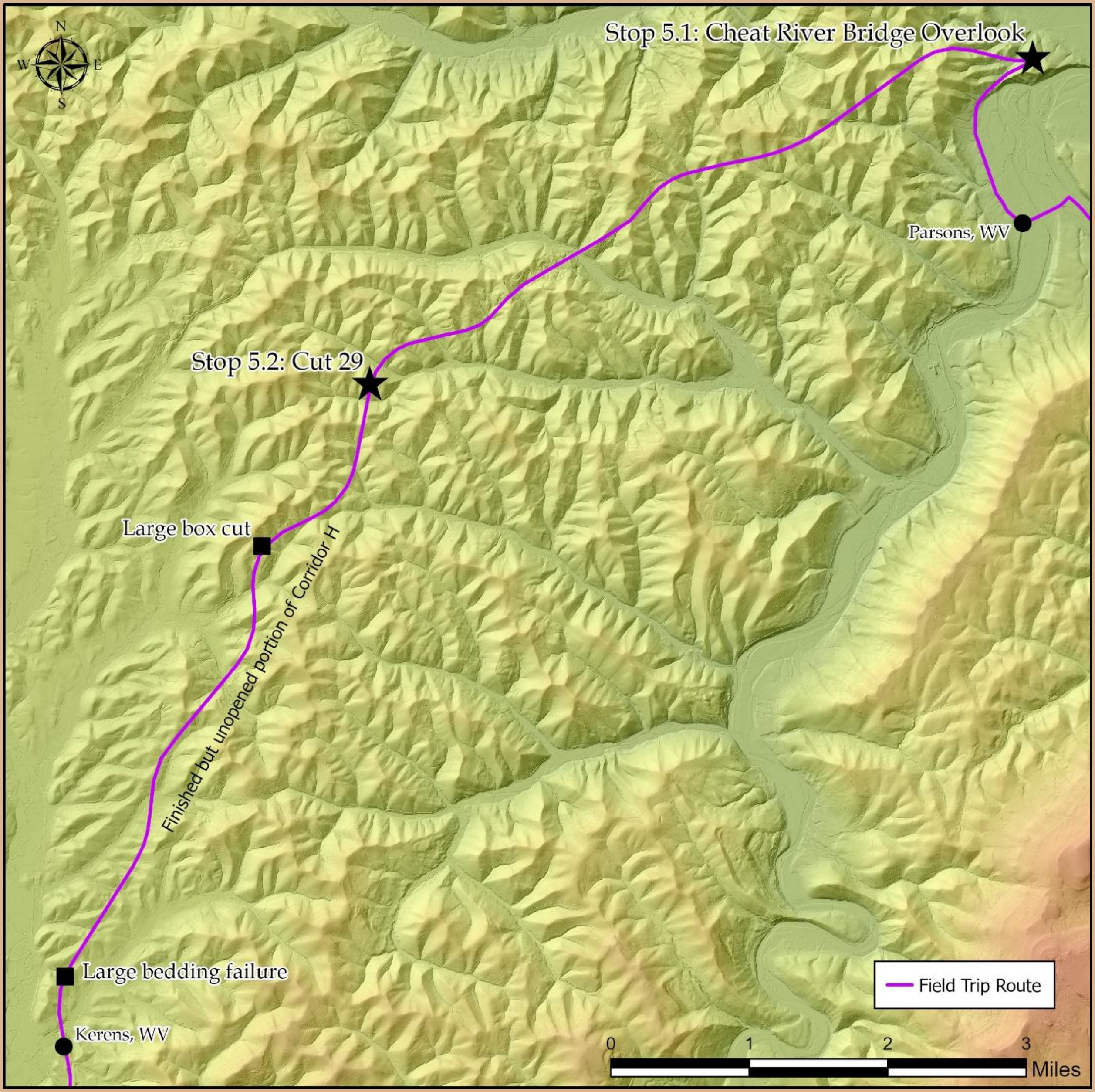

Figure 48. Detail map of Corridor H between the Cheat River and Kerens, WV.

In addition to the structural complexity, some unpublished investigations have revealed that this area, and strata (including the overlying Hampshire Formation), is prone to large-scale landslides and slumping. These large slump blocks are likely related to gravitational settling along the flanks of anticlines, and may be defined by small, unidentified transform faults running perpendicular to the fold structures, all of which originate from the Alleghenian Orogeny (B.M. Blake, *personal communication*, 2025). These structures have only been recently identified as high-resolution LiDAR imagery (Figure 49) has become widely available within the state.

Stop 5.1: Cheat River Bridge Overlook

This stop offers a great view of the Cheat River Bridge (Figures 46 and 50) from Abutment 1 (on the western edge), as designated by the construction design plans, which spans the 6,000+ foot wide valley including the Cheat River on the far eastern side. When completed, this bridge will contain nine spans, one of which will be the longest span of a steel plate girder bridge in the United States at 620 feet, and tower 190 to 210 feet over the river below. Abundant paleo-river terraces can be identified in this area (Reger and Price, 1923, and Lasko, John *personal communication*, 2025), and along the many tributaries of the Cheat River; no radiometric dating of these deposits is known. It is theorized that the present location of the Cheat River (along the eastern edge of the valley) is due to a large,

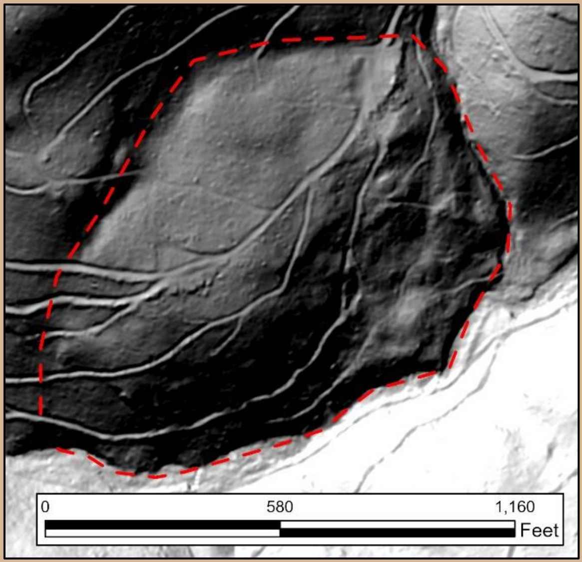

Figure 49. LiDAR imagery of a large slump block (outlined in red) in the Hampshire Formation roughly 3.5 miles away from the construction zone.

Figure 50. View of the bridge construction from Stop 5.1 in March of 2025.

ancient, landslide that likely involved the area of this stop (Lasko, John, *personal communication* 2025).

Stop 5.2: Cut 29

Figure 51. Steeply dipping strata (to the southeast) at Cut 29 with the finished roadway in the background.

Cut 29, also designated from the construction design plans, required the removal of relatively little material but revealed unforeseen geotechnical hazards; some of which still require stringent monitoring. This stop is a highly effective example of the intersection of the local issues in the Foreknobs described above. At this site, the Foreknobs exhibits parasitic folding, with the strata dipping to the southeast (Figure 51) towards the roadway. Bedding plane failure at this site has led to the reactivation of large slump blocks moving along dip almost immediately after the toe of the slope had been cut (Figures 52-55).

Figure 52. Cracks forming at the top of the large slump blocks (indicated by red arrows) during the early construction phase of Cut 29. Photo provided by John Lasko.

Figure 53. An aerial view of the slump blocks partway through the construction process at Cut 29. Photo provided by John Lasko.

Figure 54. A worker walks through one of the cracks between a slump block and bedrock at Cut 29. Photo provided by John Lasko.

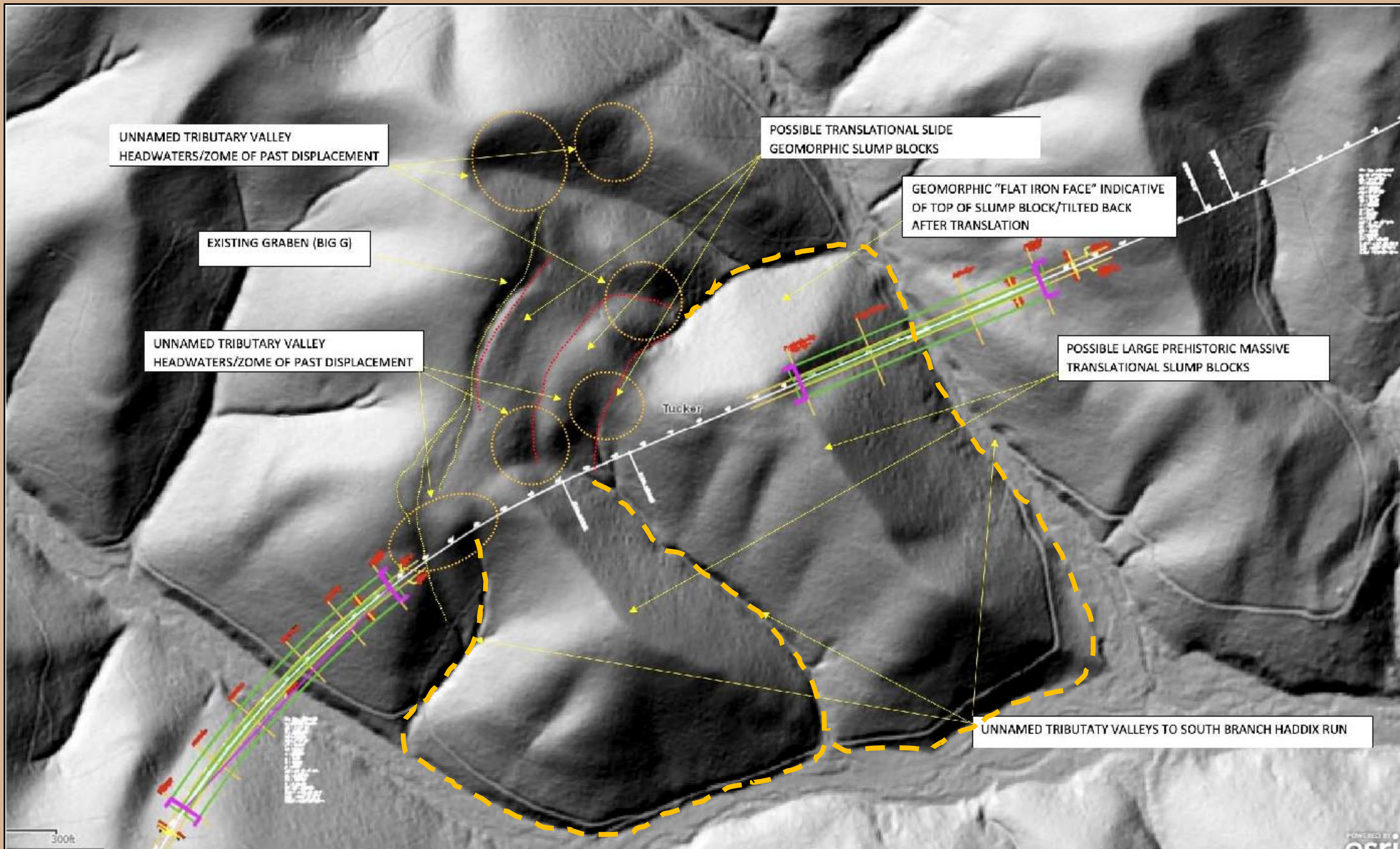

Figure 55. Pre-construction LiDAR image showing planned highway route as well as previously unidentified slope failures and basic hydrography. Large, previously active slump block lobes are outlined in orange dashes. Note the red, arcuate, dashed lines (near the center) indicating previous movement at this site that was not identified until the toe of the slope was cut, and movement was reactivated. Image adapted to illustrate the slump block lobes from one provided by John Lasko with WVDOH approval.

Following the initial slumping after construction began, further investigations revealed a large, previously existing slump structure immediately uphill of the affected area (Figures 55-57) and likely due to the large slump block lobes outlined in orange in Figure 55. While the age of the slumping is unknown, the large graben-like feature found ("Big G") contains mature trees (Figure 57) which suggest decades at a minimum. It's important to note that, while the "Big G" helped with understanding the geotechnical challenges of this site, it has not moved because of the construction of this highway, nor does it appear to be moving at this time.

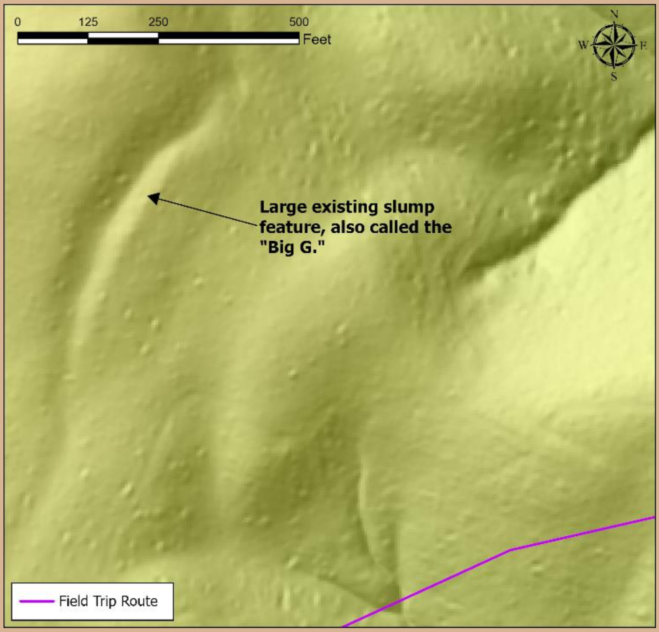

Figure 56. Detailed pre-construction LiDAR imagery showing the "Big G" graben.

Figure 57. A view inside the "Big G". Note the mature trees and graben walls (denoted by red arrows).

Following identification of the issue, it was decided to remove roughly 1.1 million cubic yards of material that constituted the top of the original slide to eliminate any additional downward pressure on the old slump blocks; this removal created the new topography present around the road today. In the time since the original slumping, the block has still been actively moving downhill. As of

Figure 58. View of the latest cracks at Cut 29 looking downhill from the "Big G."

Figure 59. View of the slump block zone in Cut 29 from across the road. The current cracks and the "Big G" are shown with red arrows.

March 2025, the pace of the movement has slowed from feet per day to now just four inches per year. This continued movement has generated new cracks along the hillside which can be seen during this stop (Figures 58 and 59).

Large Box Cut

The large box cut (Figure 60) along this section of Corridor H exposes some 300 feet of strata contained within the Foreknobs Formation. This section is very effective at showing the interbedded sandstones and shales of this formation and will aid stratigraphers in better understanding Devonian strata in this area.

Figure 60. View of the large box cut.

Large Bedding Failure

Approximately 500 feet before the bridge at Kerens, a large bedding zone failure (Figure 61) is visible on the north side of the road. Unlike the slump at Cut 29, this failure does not seem to be associated with any deep-seated slumps and only collapsed along the bedding plane exposed at the road grade. As a result, a significant amount of material (100 vertical feet and approximately 590,000 cubic yards [Lasko, personal communication]) had to be removed before this section could be considered complete.

Figure 61. A view of a large bedding failure near the end of the unopened section of Corridor H.

Upper Devonian Fossil Site

Figure 62. Devonian Foreknobs roadcut along Route 33.

Another exposure of the Upper Devonian Foreknobs Formation along Route 33, outside of Elkins, WV (Figure 62), is one of the best Foreknobs exposures in the region, complete with symmetrical ripple marks and marine fossil-filled (Figure 63), thin-bedded, fine-grained sandstones. The Foreknobs Formation was deposited under shallow water conditions, with the wave action well represented by the preserved ripple marks and the dense fossil hashes of primarily brachiopods and crinoid stems. Other marine fauna can be found here, such as fish bones and an abundance of trace fossils.

Figure 63. Fossils from the Foreknobs Formation at Stop 6.

Top Left: Mediospirifer genus brachiopod fossils.

Top Right: Widbornella genus brachiopod fossil fragment.

Left: Unidentified crinoid stem fragment.

Sewell Coal Interval Along Route 33

Figure 64. The Sewell Coal horizon along Route 33. The white bar is approximately 10 feet long.

This site is near the base of the lower Pennsylvanian Pottsville Formation. Palynological results from the extraction of ancient spores from this coal seam (Figure 64) determined that this is the northern extent of the Sewell Coal Seam (B.M. Blake Jr, *personal communication*, 2023) that was mined extensively around what is now the New River Gorge National Park (approximately 2 hours to the south). The Sewell Seam was also known as one of the "Smokeless" seams (NPS, 2009) due to its high quality which meant that it burned very cleanly. This played a large role in World War 1 when the American Navy, burning "Smokeless" coal, was able to spot German war boats over the horizon due to their smoke plumes from burning dirtier coal. The shales around the coal at this site contain abundant plant fossils (Figure 65) but they are very fragile and likely will not travel well.

Figure 65. Lycopod tree fossils from the Sewell Interval.

Left: Sigillaria bark impression.

Above: Lepidodendron bark impression.

Injectites Along Route 33

Figure 66. Lower Allegheny Formation injectite outcrop.

This site is likely the least understood of this guide and, unfortunately, is aging poorly. For this reason, if you take a closer look, please be gentle and don't disturb or destroy the features. The first thing to note is that this outcrop appears to contain a thin band of shale and coal sandwiched between two thicker sandstones (Figure 66). Upon closer inspection, vertical columns of sandstone that extend from the basal sandstone up into and through the coal and shale layers (Figures 67 and 68) can be observed. The current hypothesis for this outcrop is that the vertical sandstone columns are injectites. If this is correct, it would infer that pressure forcing down on the lower sandstone caused the vertical columns to push upward, somewhat similar to squeezing a tube of toothpaste. It is also possible that this pressure could have been induced by an ancient earthquake causing the sediments collected above the lower sand to settle and compact downward. It is important to note that whatever the source of the morphology of the deposits, it certainly happened before these sediments underwent lithification. If you look closely, you will see that while all of the surrounding rock is largely flat lying, the lower sandstone no longer shares that orientation (Figure 69). In it, the bedding seems to have been twisted, folded, churned, and, in the columns especially, lost due to the vertical movement.

Figure 67. Detail picture of a vertical sandstone column cutting through the shale and coal layers. The white bar is approximately 2 feet long.

Figure 68. Vertical sandstone columns cutting through the thin shale and coal units above the geologist's head.

Figure 69. Non-flat bedding in the lower sandstone when compared to upper sandstone.

Coal Measures Along Route 33

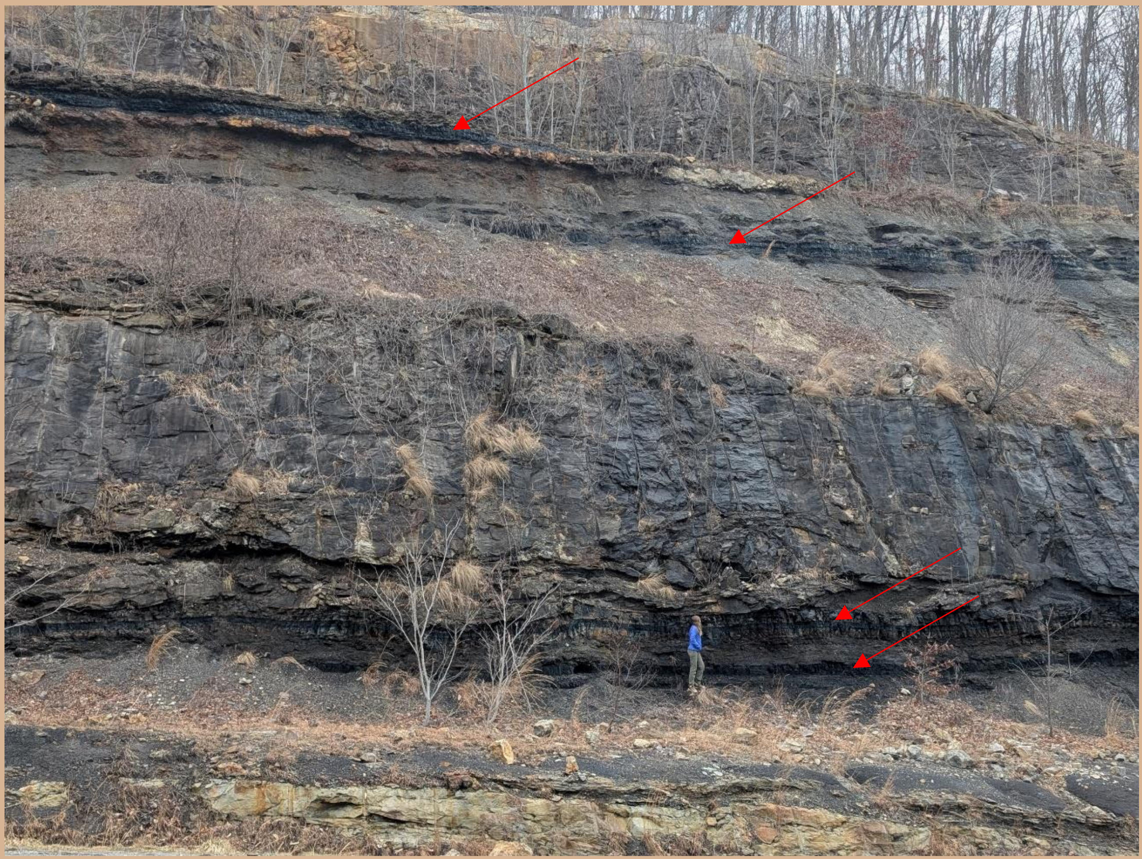

Figure 70. Small coal seams (red arrows) in the Kittanning Coals Interval of the Allegheny Formation.

The remainder of this trip along Route 33 will travel up-section through the Middle- and Upper-Pennsylvanian coal measures contained within the Allegheny Formation, the Conemaugh Group, and the Monongahela Formation (oldest to youngest).

Almost immediately following the injectite site, the trip will drive past the Kittanning Coal interval in the Allegheny Formation (Figure 70). This interval can contain up to three economically viable coal seams (the Upper, Middle, and Lower Kittanning seams) and while they are not thick enough to be considered mineable in this immediate area, they have been heavily mined in other parts of the state. This bituminous coal is mined for use as both steel-making (metallurgical) and power production fuel (thermal). Outcrops of the Allegheny Formation persist for roughly 10 miles west of the injectite site.

Following the advent of tanks during World War II, large earth moving machines became more commonplace which led to newer and more efficient means of mining coal. One of the earliest techniques used was strip mining. This process involved blasting and removing any overburden (dirt, rock, etc.) along the outcrop line of the coal and for a short distance into the hillside; typically, a few tens to a hundred feet. With the coal then exposed, the mining was as simple as scooping up the coal and following the outcrop line farther around the hillside. At the intersection of Route 33 and Interstate 79 you will find a relatively new road cut, however, it is still rather denuded (Figure

71). Along the top of the first bench of this cut is the Redstone Coal Seam (underlined in red), in this location it is quite thin and easy to miss, but it thickens (up to 5 feet) to the east and was heavily strip mined during the 1960's and 70's between the towns of Weston and Buckhannon. Figure 72 shows the area around the I-79 and Route 33 interchange (marked with a red star) and further east with the strip-mined areas highlighted in pink (CBMP, 2023). Many of these abandoned strip mines have been reclaimed into productive fields and forests but some remain as reminders of this area's industrial and natural resources history.

Figure 71. The Redstone Coal horizon along the road cut at the I-79 off-ramp. The white bar is approximately 10 feet long.

Figure 72. Area around the Rt 33 and I79 interchange showing strip mined areas of the Redstone Coal Seam.

Glacial Lake Monongahela

After exiting Route 33 onto Interstate 79 (I-79), which loosely parallels the path of the West Fork River, the trip enters the area of the Pleistocene-aged, Glacial Lake Monongahela. All the lowlands in the Monongahela River watershed were inundated by the lake waters covering a maximum area spanning northern West Virginia, southwestern Pennsylvania, and eastern Ohio (Figure 73, next page). The entirety of our trip back to Morgantown on I-79 would have afforded views of this massive lake (in some areas the road would have been inundated) during glacial maximums. Lake Monongahela formed due to glacially derived ice dams in the rivers downstream (to the north of modern Pittsburgh) and levels within the lake varied considerably as the glaciers expanded and contracted. When the glaciers contracted, the lake was likely little more than a river. When the glaciers reached their furthest southern extent, Lake Monongahela extended farther south than the modern town of Weston, WV (near this trips intersection with I-79); with a maximum depth of around 300 feet and a surface ponding elevation of around 1,100 feet above modern sea level (Blake, 2010). The earliest sediments deposited by Lake Monongahela are thought to be between 900,000 and 730,000 years old (Blake, 2010) and numerous lake deposits have been located and studied in the vicinity of Morgantown; some of which reach thicknesses of 90-100 feet (B.M. Blake, *personal communication*, 2023). These lake sediments have also proven to be a palaeobotanical treasure due to the exquisite preservation of flora (Figure 74), allowing scientists to study ecological evolution during periods of great climactic change (Blake, 2010).

Figure 74. Leaf fossils from sediments collected in Glacial Lake Monongahela.

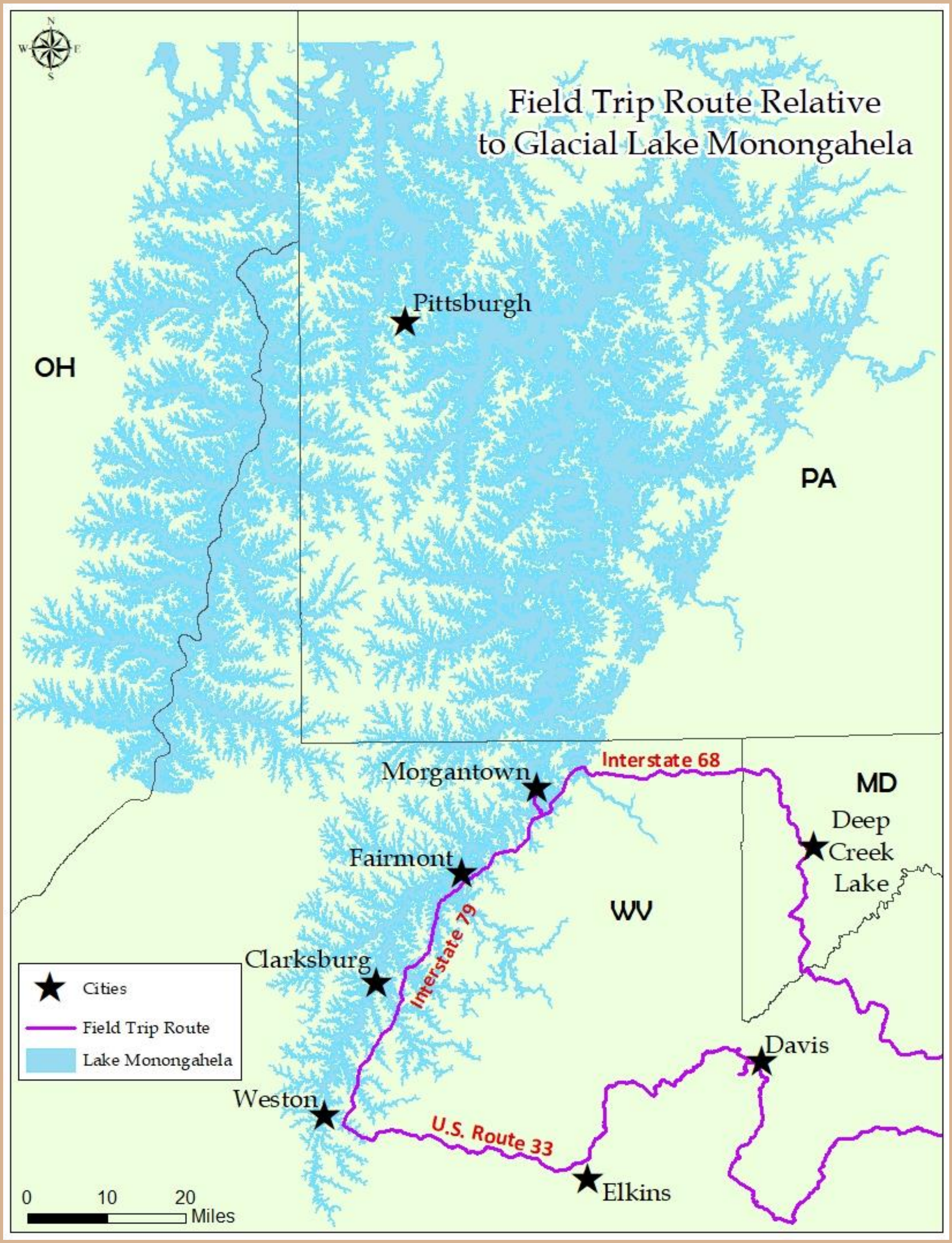

Figure 73. Projected extent of Glacial Lake Monongahela.

Detailed Route Information

Transcribed from Google Maps

Marriott Waterfront Hotel, Morgantown, WV to Stop 1 (Corridor H Overlook) 83.8 miles

- Right on Don Knotts Blvd/University Ave for 3.4 miles.
- Turn right onto I-68 east towards Cumberland, MD, follow for 34.3 miles.
- Take MD exit 4 onto MD-42 S/Friendsville Rd, follow for 7.5 miles.
- Merge onto US-219 S and follow for 7.9 miles.
- Left onto Sand Flat Rd, follow for 4.4 miles.
- Right onto MD-135 W, follow for 3.3 miles.
- Left onto Gorman Street, follow for 270 feet.
- Continue straight onto Paull St follow for 0.1 miles.
- Left onto E 3rd St, follow for 0.2 miles.
- Straight onto MD-560 S/Lothian St follow for 8.9 miles.
- Left onto US-50 E follow for 7.4 miles.
- Right onto WV-42 S, follow for 4.4 miles.
- Right onto WV-93 W, follow for 0.1 miles.
- Left onto Communications Dr, follow for 0.2 miles.
- Left onto US-48/Corridor H, follow for 1.3 miles.

Stop 1 (Corridor H Overlook) to Stop 2 (Corridor H Truck Stop) 16 miles

- Merge back onto US-48/Corridor H, follow for 16 miles.
    - Scherr Crystal Cave – 3 miles from Stop 1.

Stop 2 (Corridor H Truck Stop) to Stop 3 (Seneca Rocks) 44.9 miles

- Merge back onto US-48/Corridor H, follow for 8.3 miles.
- Take WV-55 W ramp to US-220 at the Moorefield exit.
- Turn left onto US-220 S, follow for 13.4 miles.
    - South Branch Valley: 1985 Flood occurred along this entire valley.
- Right onto N Main St, follow for 0.3 miles.
- Keep left to continue on WV-28 S/Keyser Ave, follow for 21.7 miles.
    - Smokehole Caverns – 8 miles from intersection.
    - Hopeville Anticline – 13 miles from intersection.

Stop 3 (Seneca Rocks) to Stop 4 (Lunch at Blackwater Falls) 34.3 miles

- Take US-33 W for 12.1 miles
    - Physiographic Transition – ½ mile from intersection.
- Slight right onto WV-32, follow for 19.3 miles.
    - Canaan Valley – 8 miles from intersection.
- Left onto Blackwater Falls Rd, follow for 1.2 miles.
- Left onto Blackwater Lodge Rd, follow for 1.6 mile.
- Blackwater Falls Lodge on the right.

Stop 4 (Lunch at Blackwater Falls) to Stop 5 (Corridor H Construction) 20.7 miles

- Left on Blackwater Lodge Rd, follow for 1.6 miles
- Right onto Blackwater Falls Rd, follow for 1.2 miles.
- Left onto WV-32 N, follow for 2.6 miles
- Left onto US-219 S for 13.7 miles.
- Right on US-72 for 1.6 miles (Cheat Bridge Construction overlook).

Stop 5 (Corridor H Construction) Stops, 16.4 miles

- Cheat Bridge Construction Overlook to Cut 29
    - Left on US-72 for 1.6 miles.
    - Straight at light onto US-219 for 4.5 miles.
    - Left onto construction access road for 1.5 miles
    - Continue on unopened Corridor H for 1.5 miles.
- Cut 29 to active Corridor H at Kerens, WV.
    - Continue on unopened Corridor H for 7.3 miles.

End of Stop 5 (Corridor H Construction at Kerens) to Marriott Waterfront Hotel, Morgantown, WV, 94.6 miles

- Continue straight onto US-250 N/US-33 W/US-48 W (Corridor H) 39.9 miles.
    - Upper Devonian Fossil Site – 7 miles from Kerens.
    - Sewell Coal Interval – 9 miles from Kerens.
    - Injectites – 13.5 miles from Kerens.
    - Coal Measures – 14 miles from Kerens.
- Merge onto I-79 N towards Clarksburg, follow for 49.5 miles.
    - Glacial Lake Monongahela occupied all of this segment
- Merge onto I-68 E, follow for 1.1 miles
- Take Exit 1 toward University Ave/Downtown
- Left onto US-119 N, follow for 3.4 miles.
- Marriott Waterfront Hotel on the left.

Total Mileage: 310.7 miles

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