INTRODUCTION

Welcome to the 2023 edition of the annual Institute's geology trip. Today, we are traveling to York County to take a glimpse of its geology, which I find fascinating, so I should, it is my home county. Actually, other unique in some ways with its geology, there are similarities with Adams and Franklin counties which you will discover.

Because of time restraints we are not able to explore every corner of York County, but when this day is complete, you will have a good understanding of the "lay of the land." Our day will start with rocks that were formed on an early continental shelf off of an ancient continent that we know as Laurentia. Laurentia was just a piece of the world's land crust that was part of a supercontinent about 1 billion years ago known as Rodina. This supercontinent was located in the area of the South Pole and starting about 900 million years ago (mya), Rodina began to rift apart and Laurentia was born.

Because of our route, we cannot do this stops in a sequence from oldest to youngest in age. For example our second stop at Codorus State Park will jump ahead into the geologic record and talk about a major collision between Africa and Laurentia. As the day progresses, we will add in a bit of history as in iron making at Codorus Furnace. After that point the remainder part of the day will be spent living in the Mesozoic Era with the dinosaurs and show you what occurred around here during the time. Our last stop will focus on the topic of geologic hazards as we discuss the Dillsburg Earthquake Swarm.

At the end of the day if you care to, a small collection of rocks and minerals will be able to be gathered by you to take home. All three rock classes, igneous, sedimentary and metamorphic, and calcite, azurite, malachite and maybe serpentine will be yours for sovereigns. Please take pictures and ask questions either on or off the bus.

I would like to thank Patrick McGrath, Superintendent of the Vulcan Materials Hanover Plant for agreeing to take us on a "drive-through tour of the facility. It is a rare opportunity for a group to get such a tour within an active quarry. Also, Hope Grace Church are allowing us to utilize their parking lot to talk about the Dillsburg Earthquake Swarm.

Jeri Jones

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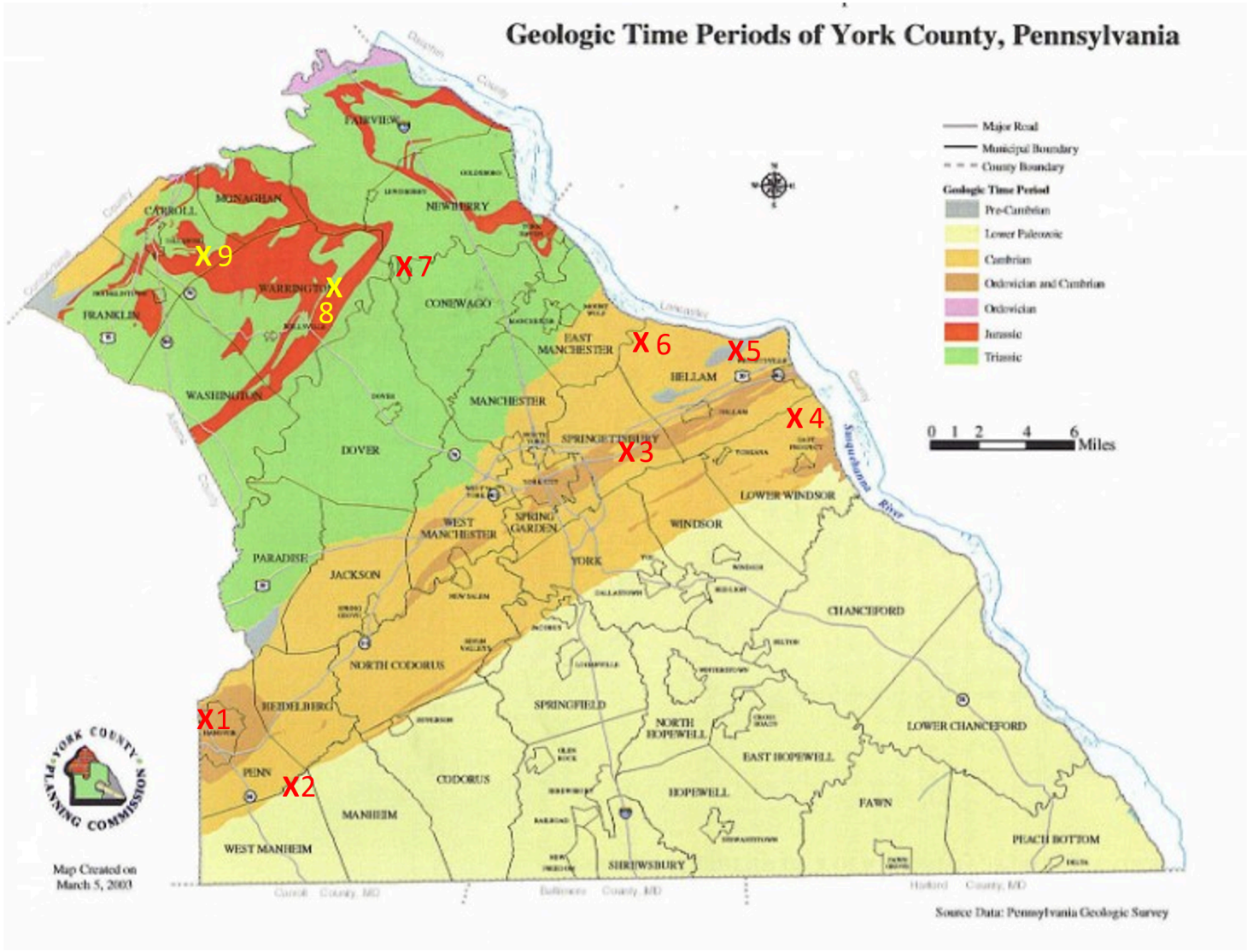

Geologic Time Periods of York County, Pennsylvania
Major Road
Municipal Boundary
County Boundary
Geologic Time Period
Pre-Cambrian
Lower Paleozoic
Cambrian
Ordovician and Cambrian
Ordovician
Jurassic
Triassic
0 1 2 4 6 Miles
X1
X2
X3
X4
X5
X6
X7
X8
X9
FAIRVIEW
NEWBERRY
MONAGHAN
CARROLL
WARRINGTON
FRANKLIN
CONEWAGO
EAST MANCHESTER
HELLAM
WASHINGTON
MANCHESTER
DOVER
SPRINGETTSBURY
LOWER WINDSOR
WEST MANCHESTER
SPRING GARDEN
WINDSOR
YORK
PARADISE
JACKSON
CHANCEFORD
NORTH CODORUS
HEIDELBERG
SPRINGFIELD
NORTH HOPEWELL
LOWER CHANCEFORD
EAST HOPEWELL
PENN
CODORUS
HOPEWELL
FAWN
MANHEIM
PEACH BOTTOM
WEST MANHEIM
SHREWSBURY
YORK COUNTY PLANNING COMMISSION
Map Created on March 5, 2003
Source Data: Pennsylvania Geologic Survey

STOP 1. Vulcan Materials Company Hanover Quarry

Calcite Specimen from Vulcan Quarry. Don Hubbell Collection.

Mammoth low maniple from Vulcan Quarry.

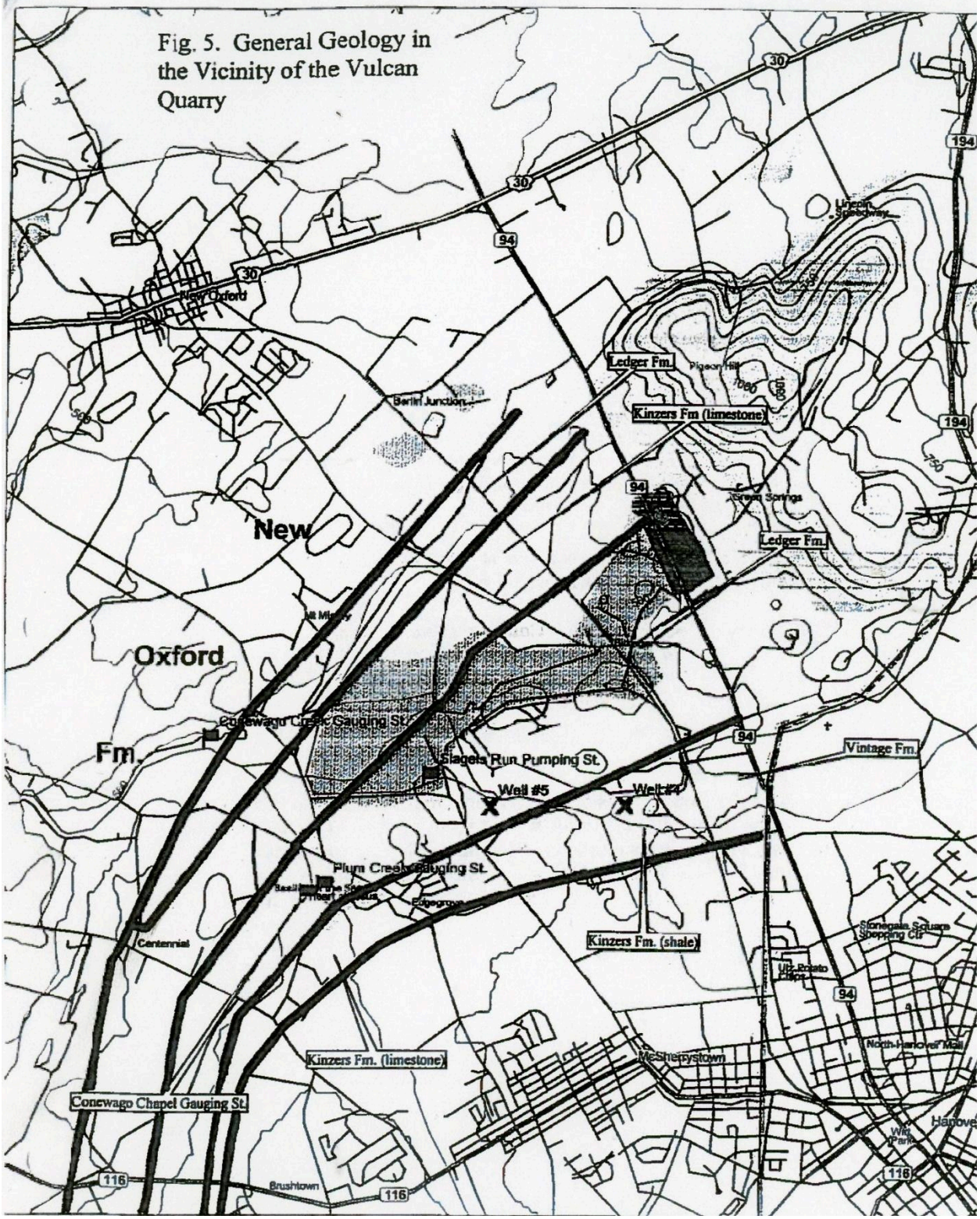


Fig. 5. General Geology in the Vicinity of the Vulcan Quarry

Vulcan
Materials Company

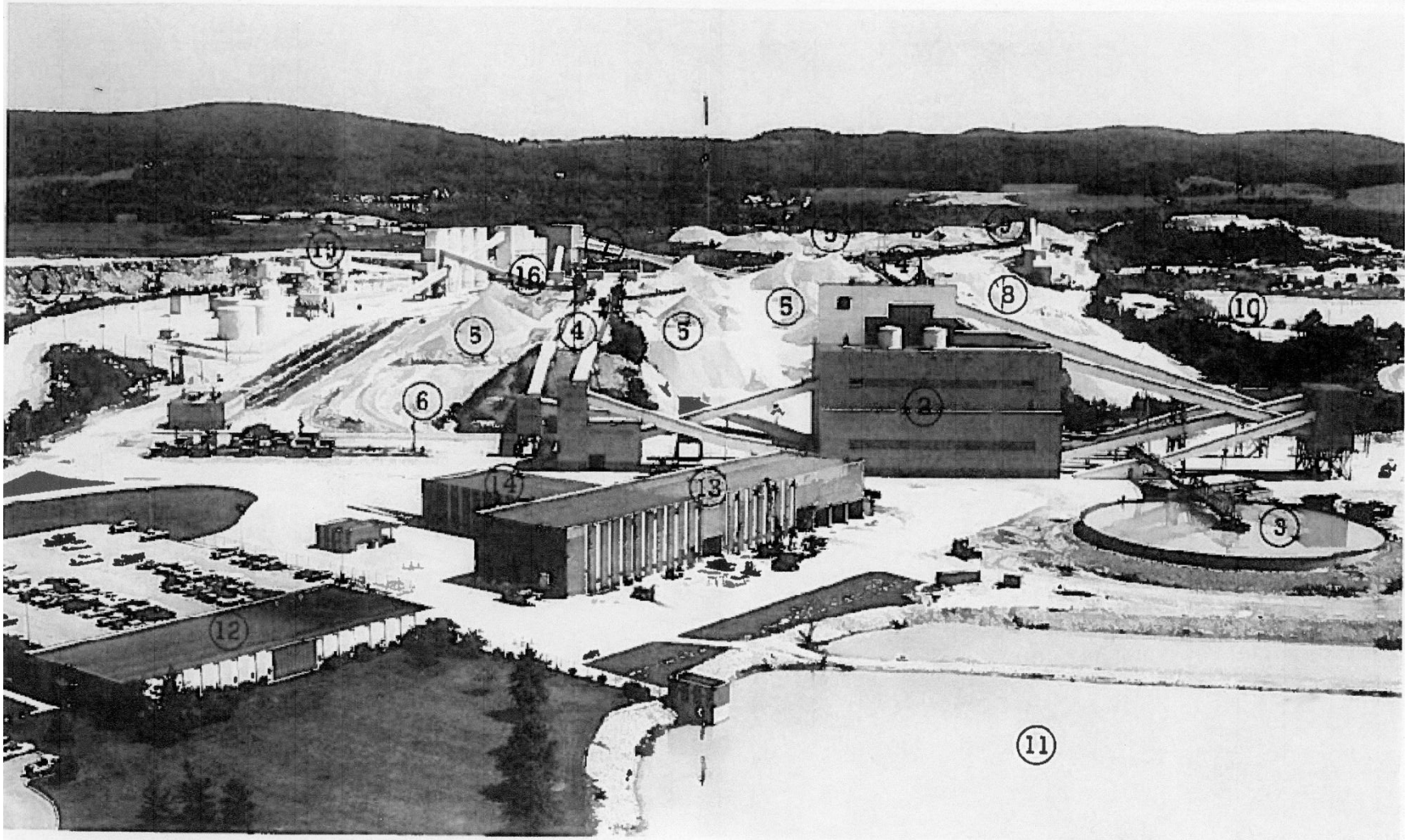
HANOVER QUARRY GEOLOGY

Hanover quarry is located in eastern Adams County about 3 miles northeast of the borough of Hanover and 12 miles east of Gettysburg. This is an active mine currently operated by Vulcan Materials Company. The quarry was originally started by R. J. Bittinger in the early 1900's. The Bittinger Quarry was purchased by Bethlehem Steel Corporation in 1918 and the name was changed to Hanover Quarry. The original pit is now the abandoned number 1 pit west of and adjacent to route 94. The active pit was started about 50 years ago for chemical grade limestone and dolostone. During the 50 years of operation this pit has grown in size to about 300 acres with a depth exceeding 250'.

Products presently quarried include high purity dolomite, high calcium limestone, and commercial stone. Ag lime and white limestone for ornamental stone and fine grind whitening applications are also sold. All of the above are produced from Cambrian age Kinsers and Ledger Formations. The Kinsers Formation is characterized by white to dark gray limestone while the Ledger is a white to light gray to light yellowish brown dolomite. In the northern portions of the pit thin argillaceous layers occur within the limestone section otherwise the limestone is relatively low in silica. Minor amounts of limestone occur in the dolomite section and localized dolomite replacement has occurred in the Kinsers Formation limestone. Dark gray shale is exposed in the eastern portions of the pit and can be seen in quarry faces along the main entrance ramp. All lithologies strike northeast-southwest.

Hanover Quarry is noted for calcite crystals that range in habit from dogtooth spar to rounded twinned crystals. Color ranges from milky to golden to clear. Calcite crystals commonly coat open spaces in numerous calcite filled faults. Spectacular specimens have also been found in fault breccias where calcite occurs as cement that binds the breccia fragments, as coatings on the surface of the fragments, and as individual crystals attached to the sides of vugs. Multiple depositional events have been noted as in the case of specimens of dogtooth spar that are covered with rounded colorless crystals. Other minerals identified include milky dolomite aggregates that line 0.1" to 0.5" long vugs in dolomite. Specular hematite and pyrite are found predominately in argillaceous limestone.

No fossils have been found. Recrystalization has occurred to some extent in all rock types and as a result most primary textures have been destroyed. The most recognizable primary texture identified to date is a relict oolitic texture characterized by rounded 0.1" dark gray spheres in a light gray groundmass. This texture has been observed in massive to thinly banded dolomite near the center of the pit.



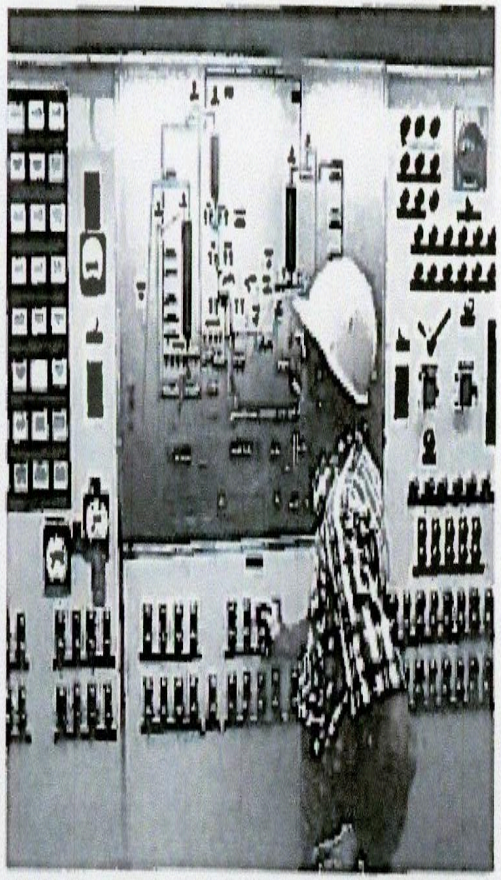
A stone quarry is a large operation

1. Quarry
2. Main Processing Plant
3. Thickener tank
4. Stacking conveyors
5. Stockpile area
6. Reclaiming tunnel
7. Railroad loading bins
8. Sinter Flux Sand Plant
9. Commercial Stone Processing Plant
10. Tailings area
11. Impounding basin
13. Repair shop
14. Warehouse
15. Lime Plant
16. Lime loading

(top left) Shovels scoop up 10-cubic-yard bites of stone and load them into 65-ton heavy duty trucks for hauling

(top right) This Primary Crusher — the largest ever made — descends 80 feet below the quarry floor. The crusher reduces rough stone to 8-inch top size, then feeds it to an underground conveyor that carries the stone through a tunnel to the Main Processing Plant.

(bottom) The 10-story Main Processing Plant has the capacity to handle almost 2,000 tons of stone per hour



(top) The entire operation at the Main Processing Plant is controlled by just one person

(bottom) Inside the Main Processing Plant, a maze of feeders, crushers, screens, and scrubbers produce finished crushed stone products ranging from 4-inch stone down to 100-mesh fines

STOP 2.
Codorus State Park, Smith Station Road Sailboat Launch Area
The Martic Line

Codorus State Park, located about three miles south of Hanover, occupies 3,500 acres, 1,275 of that is Lake Marburg. The Park is situated within Heidelberg, Manheim and West townships. During the summer all types of boats can be seen on the lake, the campground is buzzing with family activity and bird watchers are scouting the shorelines throughout the year.

I doubt that many people look at the park as I do. What types of rocks are beneath the parklands? I became familiar with the geology of the park in 2006 when I teamed up with the United States Geological Survey in conducting a groundwater survey for West Manheim Township.

Although you can't physically see it, there is a major fault line passing straight down across Lake Marburg. First, realize that the West Branch of the Codorus Creek was dammed up on the northern side of the park to create Lake Marburg. Even before the lake was created the West Branch of the Codorus Creek flowed rather straight from Black Rock Road in a northeastward direction. Why? Because it was flowing in the Martic Overthrust. Today, if you stand at the boat launch on Black Rock Road, you can see the whole way to the dam, a distance of over 3.5 miles. Along this fault as you face northeast, crust on your right has been pushed up and over the land to your left. Several of the wells developed by the State Parks near the Martic Overthrust have water yields of 1,000 gls. per minutes.

Underlying the lake is a limestone rock unit known as the Conestoga Formation. This rock, although not seen in the park, formed on a continental shelf approximately 500 million years ago. As you traverse the lake in a boat from Black Rock Road to Pa. Route 216, the land on the left is composed of a sedimentary rock known as sandstone and a metamorphic rock known as phyllite respectively belonging to the Antietam and Harpers formations of Lower Cambrian age. On the south side of the lake the greenish Marburg Formation schists are found.

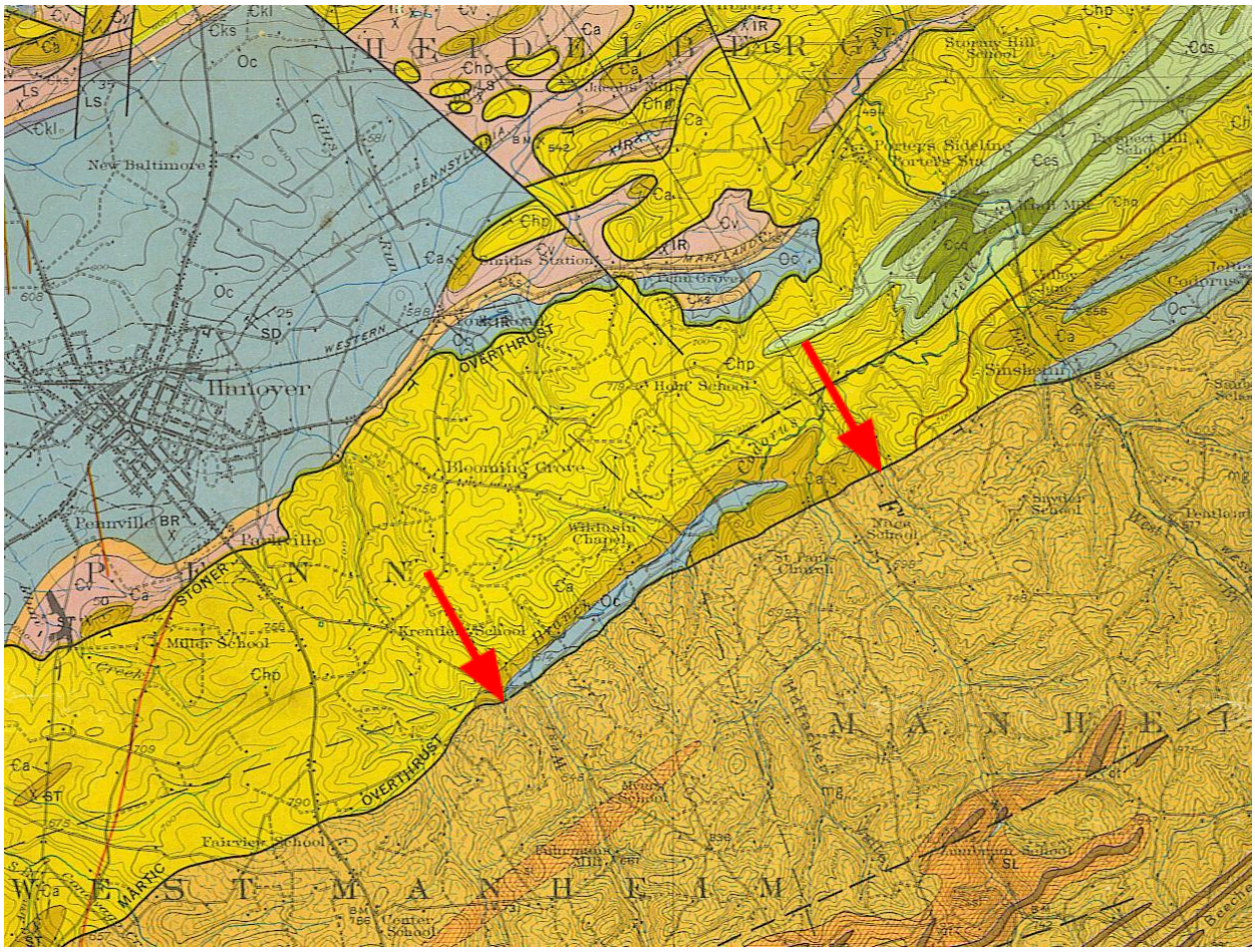
Once you go under the Pa. Route 216 bridge heading toward the dam, things change due to another fault that runs in a northwestern direction. On the north side of the lake you will find quartzite and slate belonging to the Chickies Formation, sand and mud found on a beach some 540 million years ago. On the south side of the lake including the bedrocks islands Long Island and Round Island are Antietam and Harpers formations rocks.

Approaching the dam, nice exposures of the most durable Chickies Formation quartzite are exposed along the shoreline on your left. Pull the boat closer and you will see some evidence of the layering within the original sand before the rock was changed by heat and pressures during a continental collision in our area some 320 million years ago. On closer examination of the quartzite you may spot small sand-filled tubes running perpendicular to the

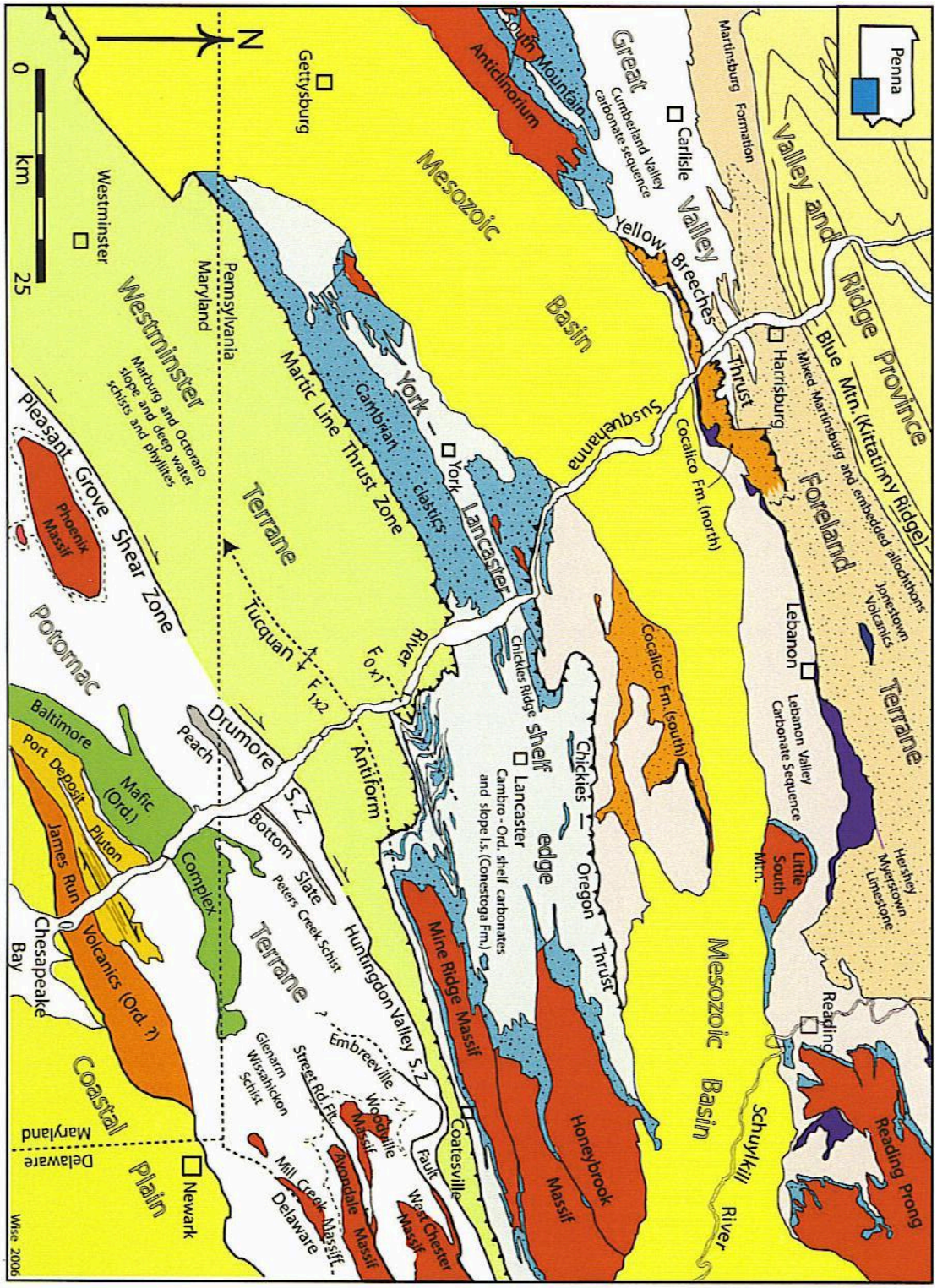
layering. These are known as Skolithos linerais believed to be the borrow of an extinct marine worm.

Not to be outdone, the Antietam and Harpers Formation rocks contain their own treasure. Look for squarish and cubic brown crystals either within the rock or laying loose along the shorelines. These are called limonite pseudomorphs and were once pyrite crystals that have weathered (or actually rusted). They come in different sizes and sometimes you find two crystals that are grown together known as twinning. However, remember collecting of natural items at Codorus State Park is not permitted, so take pictures only to document your visit.

Finally, a piece of 19th century history should be included here. In the southwestern corner of Codorus State Park is the Mary Ann Furnace Parking Area located near the green metal maintenance building along Black Rock Road. It was here that the oldest iron furnace west of the Susquehanna River was started in 1762, making stove plate, cannons, ammunition and other iron implements until 1803. Stop in at the Park office/Nature Center off of Smith Station Road to view some artifacts made from the furnace.



From Stose and Jonas, 1939



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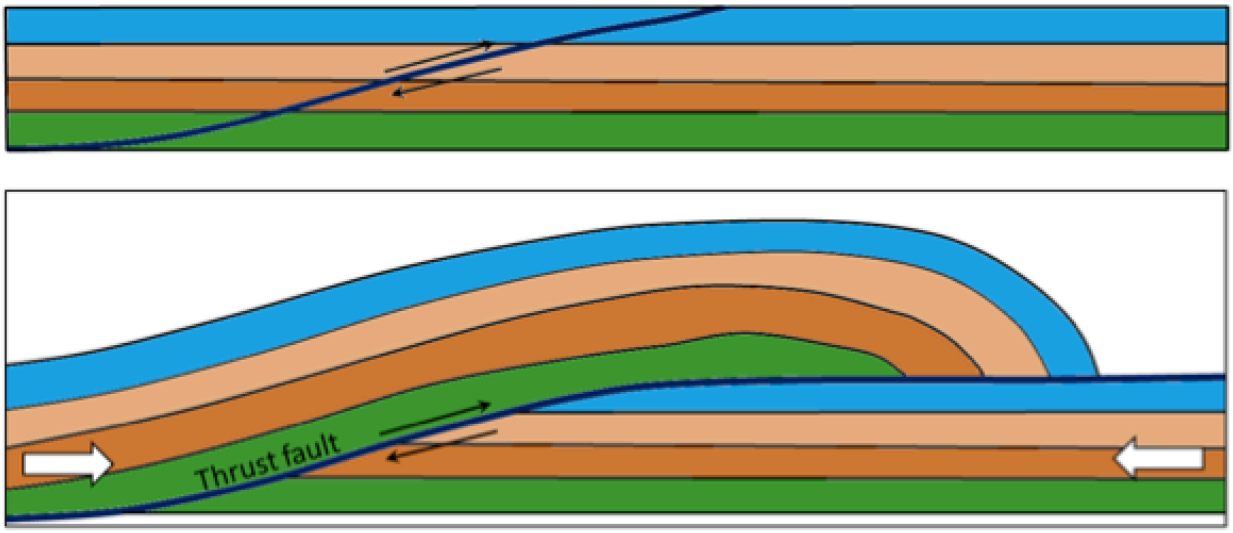


Example of a thrust fault

STOP 3. Stony Brook Dike
Springettsbury Township
Keywords: Dike, Diabase, Intrusion, Hornfels

Location: Along the railroad, about 100 feet west of Pleasant Acres Road and 0.13 miles north of Pa. Rte. 462 (West Market Street). The dike is observed on the north side of the railroad , while a good exposure of the limestone is located on the south side of the railroad just west of Pleasant Acres Road.

Coordinates: 39° 59' 10.50"
-76° 38' 54.82"

Province: Piedmont
Section: Lowlands
Elevation: 437 feet

Features: A classic example of a diabase dike intruding limestone that shows the affects of thermal metamorphism
Formations: Diabase and Conestoga Formation
Age: Jurassic/Cambro-Ordovician

What To See Here? This is one of the classic sites remaining in southeastern Pennsylvania to see a diabase dike. The dike itself is about 20 feet wide and is easily detected. Try breaking a piece of diabase laying on the ground. You will easily discover why this rock is known as "iron stone." Because diabase is very resistant to weathering, the diabase sticks out toward the railroad tracks the furthest. Following the exposure to the east, the rock here is known as a hornfels – in this case the rock was a limestone which became heated by the magma in the dike and changed into a new distinct rock type. Notice the layering in the rock has been destroyed with the change. Continuing on the south side of the railroad tracks further east is an exposure of the limestone, appearing unchanged. Layering is very noticeable here with a dip to the southeast. Along the bottom of this section of outcrop, notice a thicker-layered rock. This is a sandstone layer within the Conestoga formation. Also look for mud cracks in the limestone which indicate a piece of the rocks history.

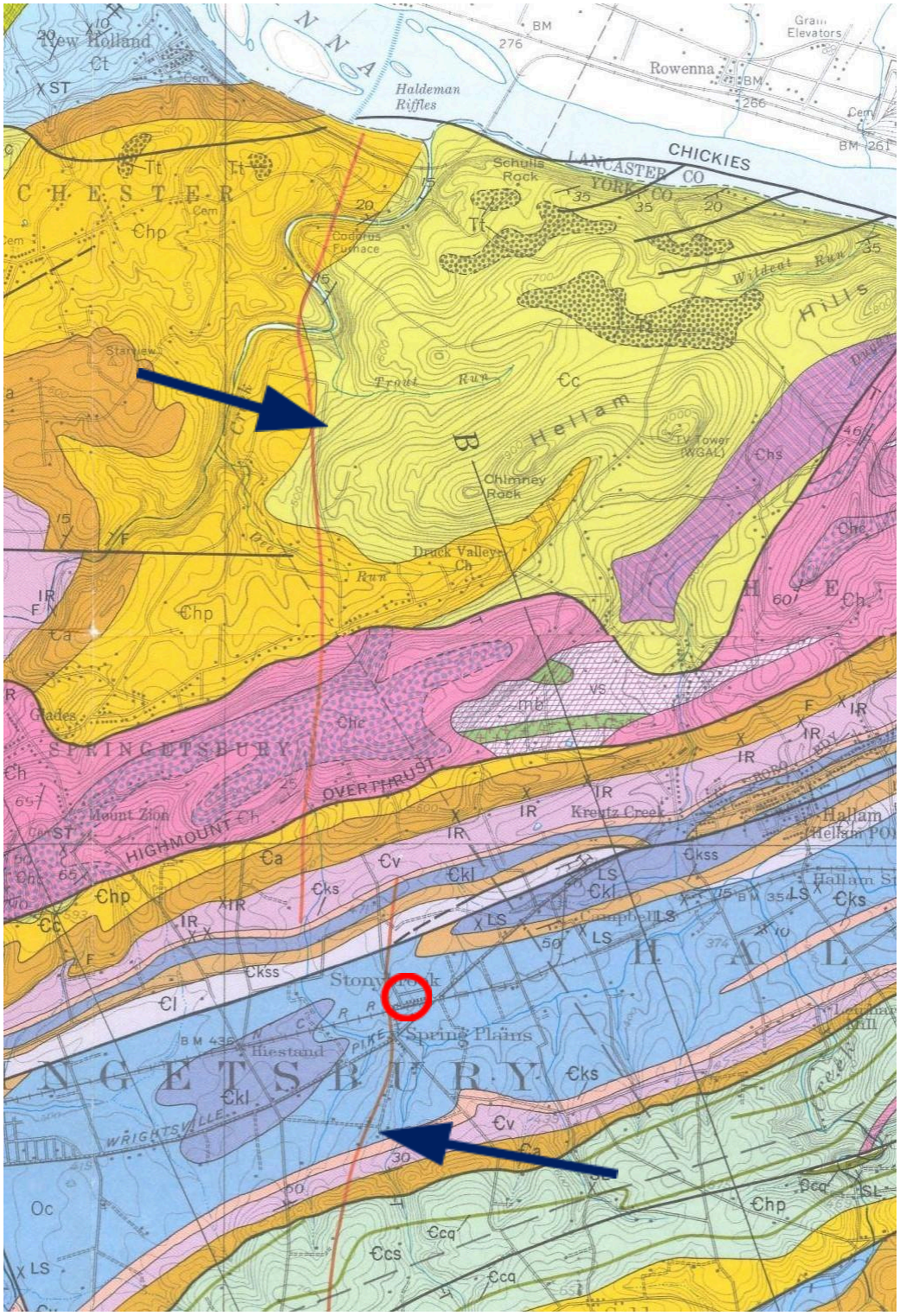
Geologic History: Standing in this railroad cut, you are witnessing geologic history spanning over 300 million years. The limestone was deposited as part of a continental shelf during the Early Paleozoic. Notice how thinly-bedded the rock is would represent short periods of periodic sedimentation. The presence of ripple marks within the limestone indicates that the limey sediment was exposed at times to the air. The sandstone layer would indicate a period when sand was deposited, probably during a time of heavier erosion of Laurentia.

The diabase dike formed in association with the rifting apart of Pangaea during the Mesozoic Era. Although diabase is usually associated with the Gettysburg-Newark Section of the Piedmont, diabase dikes extending out into the surrounding older rocks are numerous. In this case, the Stony Brook dike can be traced from Harford County, Maryland, northward through York County, terminating near Elizabethtown, Lancaster County. North of here, this dike passes through Rocky Ridge County Park. Where the dike crosses the Susquehanna River, Haldeman's Riffles south of Saginaw represents the dike.

Reference: Jones 1981; Stose and Stose, 1944; Stose and Jonas, 1939; Ehrenfeld, 1889

Stony Brook Diabase Dike

Conestoga Limestone (not layering)



Stoney Brook Dike (Stose and Jonas, 1939)

STOP 4.

Sam Lewis State Park
Windsor Township

Location: South of Mt. Pisgah Road, 0.51 miles southwest of Cool Creek Road.

Coordinates: 39.996281°
-76.547936°

Province: Piedmont
Section: Uplands
Elevation: 861

Features: Overlook featuring the Piedmont and exposures of the conglomerate and black shale
Formations: Chickies Formation
Age: Early Cambrian

What To See Here: A spectacular view of the Piedmont region in York, Lancaster and Dauphin counties. Also outcrops of a sedimentary rock containing rounded quartz pebbles known as a conglomerate and black shale.

Sam S. Lewis State Park has been a favorite destination for several generations of area residents. I remember going there for my church summer picnics as a teenager and playing softball on the baseball diamond and racing an adult by foot along the park roads. O yes, how could you not forget about climbing on the rocks, more about that alittle later.

First, let travel to the pavilion on top of the hill at what is called the overlook. Undoubtedly, one of the best overlooks in York and Lancaster counites. Over 200 square miles of landscape can be observed from here. Afterall, the overlook is 865 feet above sea level and at least 500 feet higher than the surrounding landscape. You have good views virtually in every direction. Every bit of this landscape belongs to the Piedmont physiographic province. There is a display plaque at the pavilion identifying the various outstanding peaks and valleys as seen from here. The most distant feature is Governor Dick Hill Hill located near Mt. Greta, Lebanon County. This 1,150 foot hill is composed of Jurassic-aged diabase and is 18 miles in distant. If you can see this hill on a clear day, you will see the landscape belonging to Gettysburg-Newark Section of the Piedmont. The Susquehanna River is easy to find as it comes into view to the north at Hellam Point and Chickies Rock and can be followed south to Safe Harbor Dam, a distant to 13 miles and falling only 14 feet in elevation due to the formation of Lake Clarke with Safe Harbor Dam. The towns of Wrightsville and Columbia and the buildings along U.S. Route 30 at Centerville, Lancaster County are marking the Lowlands Section of the Piedmont. This valley is composed of mostly of shale. Sam Lewis Park and the remaining landscape is located with the Uplands Section of the Piedmont and is composed of sedimentary and metamorphic rocks. Looking across the river, you should be able to locate the wind turbines at Turkey Hill near the river and the large water tank in Millersville to the left and more distant of the wind turbines.

Turning toward the west, you can continue the Lowlands Section Valley toward York and identify the Hellam Hills to the north of the valley. Follow the Hellam Hills to the river and continue the ridge to the east. Chickies Rock stands out with its 100-foot high rock cliff along the river and then continues with Chickies Ridge and Chestnut Hill continuing to the Rohrerstown exit of U.S. Route 30 in Lancaster County. Think about the amount of history that could be discussed from here dating back to prehistoric times up through the mid 20th century. I just wonder how many residents migrated to this overlook during the burning of the bridge over the river during the Civil War?

Ok, let's turn our attention to the rocks seen t Same Lewis State Park. There are some boulders located in the woods east of the overlook, but the larger outcrops are found south of the lower parking lot near the ball diamond. The rock is known as a conglomerate since it contains large rounded quartz pebbles. Known as the Hellam Conglomerate, the rock is a member of the Chickies Formation dating back to the earliest days of Cambrian times, about 540-530 million years ago. Rock outcropping along Mt. Pisgah Road near the park main entrance is a black slate. Some of the slate contains pyrite crystals now rusted to limonite psuedomorphs. Pyrite contains iron and Sulphur but during weathering, the sulphur leaches out and is replaced by oxygen, forming limonite. Since the crystals shape remained that of pyrite (cubes) we call them pseudomorphs. The conglomerate is found elsewhere through the park. Notice some of the quartz pebbles have been flattened and elongated by the deformation. Cutting across the conglomerate are many white, glassy quartz veins 1 to 4 inches wide. Because these veins are more resistant to weathering, these veins project above the conglomerate. The projecting quartz pebbles and quartz veins is what have prevented many people from falling from these rocks as they played on them.

A Geologic View of the Susquehanna River

The mighty Susquehanna River, what a story it holds to tell as it weaves its path from Cooperstown, New York on the Main Branch, and from western Pennsylvania along the West Branch. Near Northumberland is where the two branches meet to continue its path southeastward, eventually draining into the Chesapeake Bay. The river drops 1,191 feet from its journey from Cooperstown, New York to the Chesapeake Bay. It has seen many changes in the landscape in which it flows through over the past 325 million years (mya). Today, the Susquehanna River is considered if not the oldest river in the United States, one of the oldest. The river flows over rocks that are younger than itself and that is unique.

Rewind the Earth's geologic video to at least 325 mya. To our south in the vicinity of Baltimore, Maryland and Wilmington, DE, there were the Taconic Mountains, formed from an island arc collision some 425 mya. The Appalachian Mountains were even thought of yet. An ocean occupied the area where the famous mountain range is located today. Although the

Taconic Mountains have eroded down some by 325 mya, the river was flowing in its opposite direction as today, creating its early channel.

Fast forward slightly to 300 mya and a huge collision between Africa and North America occurred to help in forming the supercontinent Pangaea. This collision is known to geologists as the Alleghanian Orogeny seriously deformed or crust into a series of folds and broken pieces of crust containing faults. The Appalachian Mountains were pushed up during this episode that lasted about 20 million years. Yes, it is true the Appalachian Mountains were as high as the present-day Rockies. During this mountain-building episode, the direction of the drainage reversed itself. Now with the Appalachian Mountains the high point, the Susquehanna River reversed its course and flowed in a southeastern direction.

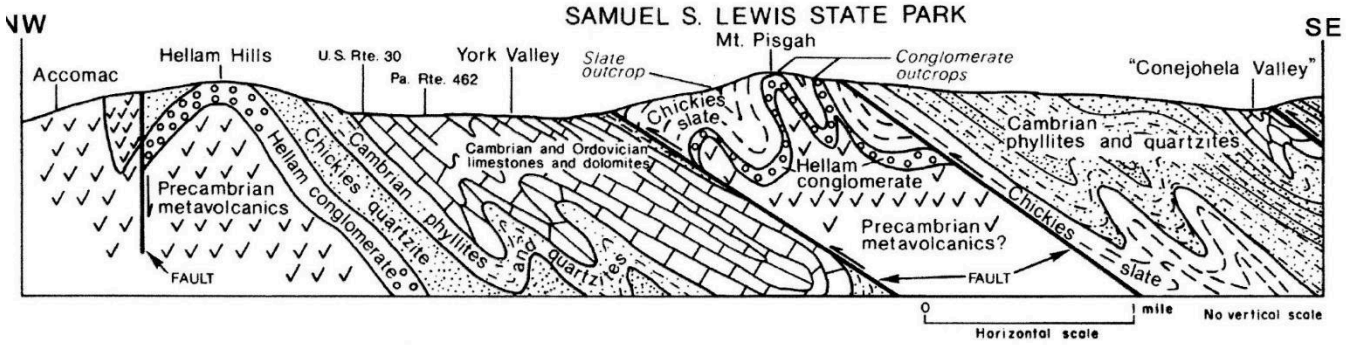
The question was, would the Susquehanna River continue its flow direction for a long time? Yes, it would and continues to flow in that direction, but the story is not complete yet. A long period of quietness occurred along the East Coast in geology terms with only weathering and erosion working on the landscape. The constant downward erosion of the river cut into the crust establishing its channel and claiming its real estate. About 200 mya, Pangaea was well underway to splitting apart into the world we know of today. This series of rifts did not play a big role in the life of the Susquehanna. The river was flowing through a relatively flat plain as the crust was deciding to either go with Africa or stay with North America.

Again, advancing the video ahead to post Pangaea, severe weathering and erosion worked on the landscape and the Susquehanna River carried much sediment downslope onto a continental shelf of the newly born North America. Some researchers suggest that some 4-5 miles of the crust were removed over our heads by these processes with assistance by the river.

About 35.5 mya, our area was greeted with an extraterrestrial visitor. An asteroid collided with Earth in what is today the southern portion of the Chesapeake Bay. Traveling at about 144,000 miles per hour, the bolide created a 25-mile wide crater and 0.5 miles deep. This event was the first step in creating the Chesapeake Bay. The Chesapeake Bay Impact is one of the world's best-preserved craters in the world, although today sediments have slumped into the large depression.

The final chapter of this story involves Pennsylvania's last geologic event known as the Ice Age. From at least 770,000 to 17,000 years ago, four ice advancements brought a one-mile-high wall of ice into northern and northwestern Pennsylvania. Meltwater from each advancement found its way down the Susquehanna River adding to the erosional rate. Particularly at the end of the Ice Age, the additional meltwater from the glaciers created severe downcutting of the Susquehanna River and forming large potholes in the bedrock. In some cases, we can show you where the river once flowed about 200 feet higher than its present-day elevation. Eventually, around 10,000-8,000 years ago, the Susquehanna River had formed a 400-foot deep canyon where it flowed into the Chesapeake Bay. Today, sedimentation has filled-in the canyon and helped create what we know of today as the Atlantic Coastal Plain.

The Hellam Conglomerate Member of the Chickies Formation.



Schematic Geologic Cross Section

From Inners, 1983

STOP 5. Accomac Metabasalts, Hellam Township

Location: Roadcut on the south side of Accomac Road, 0.05 miles southwest of the intersection

with River Road

Coordinates: 40.044817°
-76.563961°

Province: Piedmont
Section: Uplands
Elevation: 279 feet

Features: Exposure of the igneous rock known as a metabasalt
Formations: Formation
Age: Proterozoic

What To See Here: A long roadcut of a volcanic rock that makes up the oldest part of the Hellam Hills in York County. Look for circular quartz filled voids that were at one time gas bubbles. Besides quartz, you may see chlorite (dark green), epidote (grass green) and malachite (brighter green).

We have two types of volcanic rocks in York County. Research conducted by geologists have shown that these volcanic rocks were formed about 600-550 million years ago associated with the breakup of a supercontinent known as Rodinia. One of the volcanic rocks is known as rhyolite, a rock containing quartz and feldspar and is equivalent to granite. Rhyolite is formed as a lava while granite is formed by cooling magma deep underground. The second rock is basalt. Basalt, a rock formed from lava, is composed of dark minerals such as pyroxene and olivine with the absence of quartz. Because these two volcanic rocks went through some changes in later periods of collisions and rifting these rocks have the word "meta" in front of them, i.e. metarhyolite and metabasalt.

Ok, a field trip time to see these volcanic rocks. Our first stop is in the Hellam Hills in Hellam Township. The best exposure is found on the south side of Accomac Road just west of River Road near the Accomac Inn. This roadcut is composed of greenish metabasalt. In places you may see rounded quartz zones which also contain a grass-green mineral epidote and sometimes a lighter green copper mineral malachite. These circular inclusions were once cavities in the lava that later filled in with these minerals. Also, toward the western end of the roadcut, you may find a fibrous light green mineral chrysotile, a type of serpentine filling veins within the metabasalt. Walk across the road and check out the stream and its ravine. Large blocks of metabasalt have been brought down by the stream, especially about one year ago when this area went through severe flooding.

Our next area is in the western end of York County within the Pigeon Hills. Actually located within Berwick County, Adams County, this small roadcut containing metabasalt is found on the

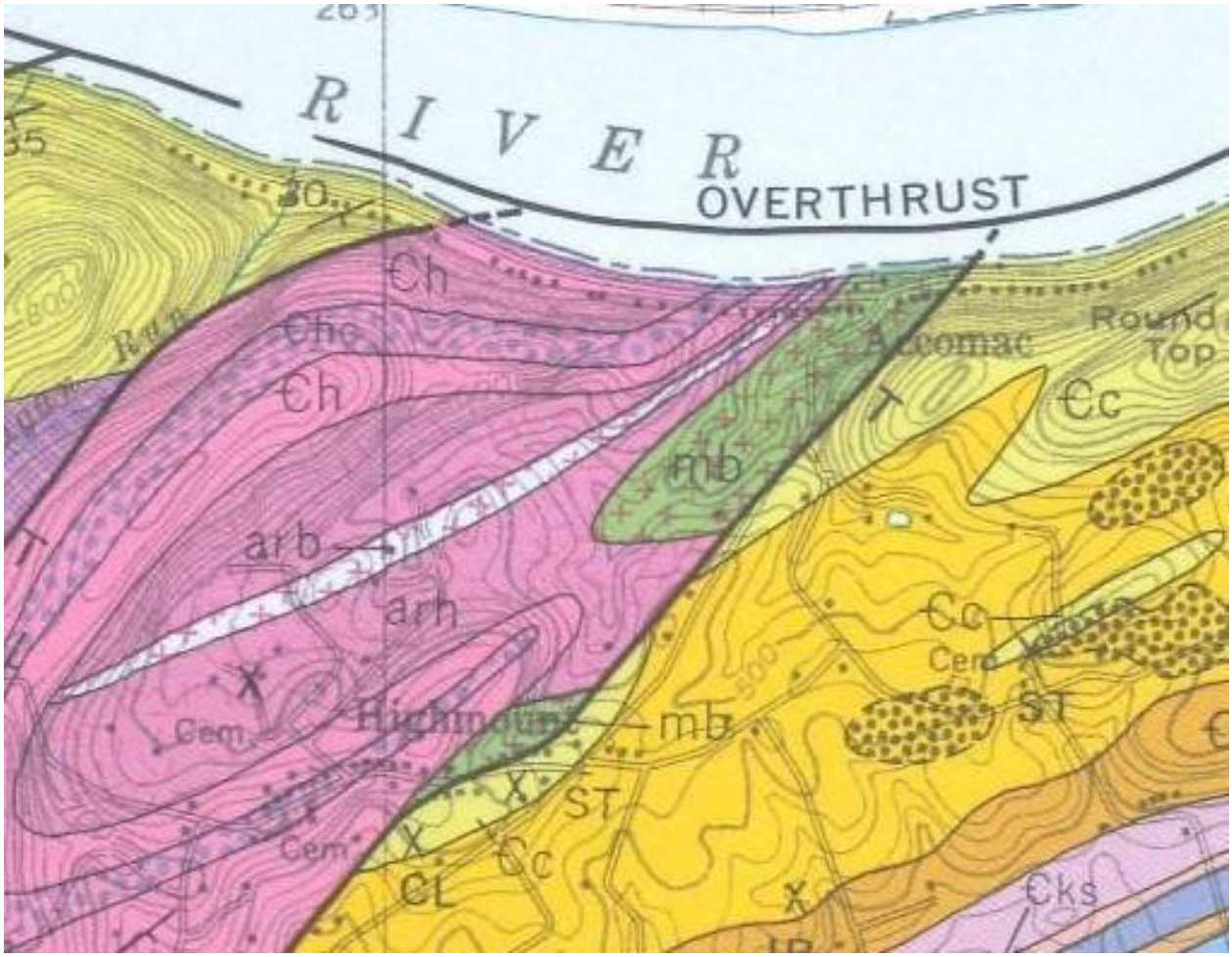
east side of Beaver Creek Road about 0.24 miles south of the intersection with Maple Grove Road. Bedrock is hard to find here, but pieces of the volcanic rock is laying on the hillside next to the road. The rock is dark-green and may show a slight luster on its surface due to the addition of mica. This metabasalt has been metamorphosed more than that found in the Hellam Hills.

Our next stop is in southeastern York County at Holtwood Dam along the Susquehanna River. This was an interesting find to geologists as many scientists that visited the site mapped all of the rocks as a metamorphic rock known as a mica schist formed on the bottom of an ancient ocean. It wasn't until the early 1990's that geologists recognized that among the schists were metabasalts. Some of these volcanic rocks contain pillow structures suggesting that the lava was subaqueous in origin. The best exposure is on the York County side of the dam within the recently renovated bank just below the dam.

Another metabasalt location is along the York County Heritage Rail Trail south of Glen Rock. The trail passes through numerous lenses of metabasalt between Glen Rock and New Freedom. The best exposure is found about a quarter mile north of Taylor Hill Road, Shrewsbury Township. Look for a greenish rock that contains cavities. These cavities were gas bubbles within the lava that never were filled in with minerals. An observant person will also be able to tell that the metabasalt is more resistant to erosion than the surrounding mica schists. The volcanic rocks stick out of the hillside further than the schists.

The final stop is literally at the northwestern corner of York County where Cumberland County and Adams Count merge. Exposures of metarhyolite are rare in this area. The best location to collect a sample is on the south side of County Line Road some 0.17 mile west of the intersection of Town Hill Road. County Line Road is the dividing line between York and Adams counties and so technically the exposure is in Adams County. Pieces of light gray metarhyolite can be seen laying on the hillside. When hammered, the rock emits a metallic ring.

On the north side of the road is a waterfall cutting into the metabasalt. Notice different stages of pothole formation and how the water is cutting into the bedrock. Major flooding occurred here in 2018 destroying Accomac Road and several structures downstream. The roadway was only repaired in 2021.



Mb – metabasalt; arh – metarhyolite; arb – metarhyolitic breccia

From Stose and Jonas, 1939

STOP 6. Codorus Furnace, Hellam Township

Location: On the south side of Codorus Furnace Road, 0.04 mile west of the Codorus Creek bridge.

Coordinates: 40.051947°
-76.655323°

Province: Piedmont
Section: Uplands
Elevation: 266

Features: Restored 18th century iron furnace
Formations: Chickies Formation quartzite
Age: Early Cambrian

What To See Here: The York Conservation Society has restored this important iron furnace that once was the highest productive furnaces in York County. The structure on top of the furnace is unique where the heat produced by the furnace was recycled through a series of pipes back into the internal workings. The York County Conservation Society has recently been awarded a total of $200,000 to repair and restore the top of the furnace. Also, the Lancaster Conservancy has recently purchased the iron master's house up the road a short distance.

Tucked into the deeply entrenched landscape formed by the Codorus Creek in Hellam Township is one of the oldest remnants of once a flourishing industry. The Codorus Furnace is one of five iron furnaces in York County. Much has been written about the history of this furnace which can be found on the Internet.

For this column we will be taking a closer look on how a furnace during this era was operated and the amount of teamwork it took to make the operation successful. This is the best time of year to visit this furnace due to the absence of leaves and groundcover. When you pull into the small parking lot along Codorus Furnace Road at the south side of the Codorus Creek, the actual furnace portion of the stack which measures 30 feet square at the base and is 12 feet in height can be seen. In the front is where a door was opened to allow the liquid iron to run out in a trough into sand molds to make pig iron for various sized cannonballs and cooking vessels. As you look at the furnace from the front, a bellows was inserted to provide air to the furnace to heat its contents. To the right of the bellows was a rotating axle known as a cam that was turned by the use of a water-powered wheel to power the bellows. The race carrying water into the wheel from the Codorus Creek is located near the parking lot paralleling the road.

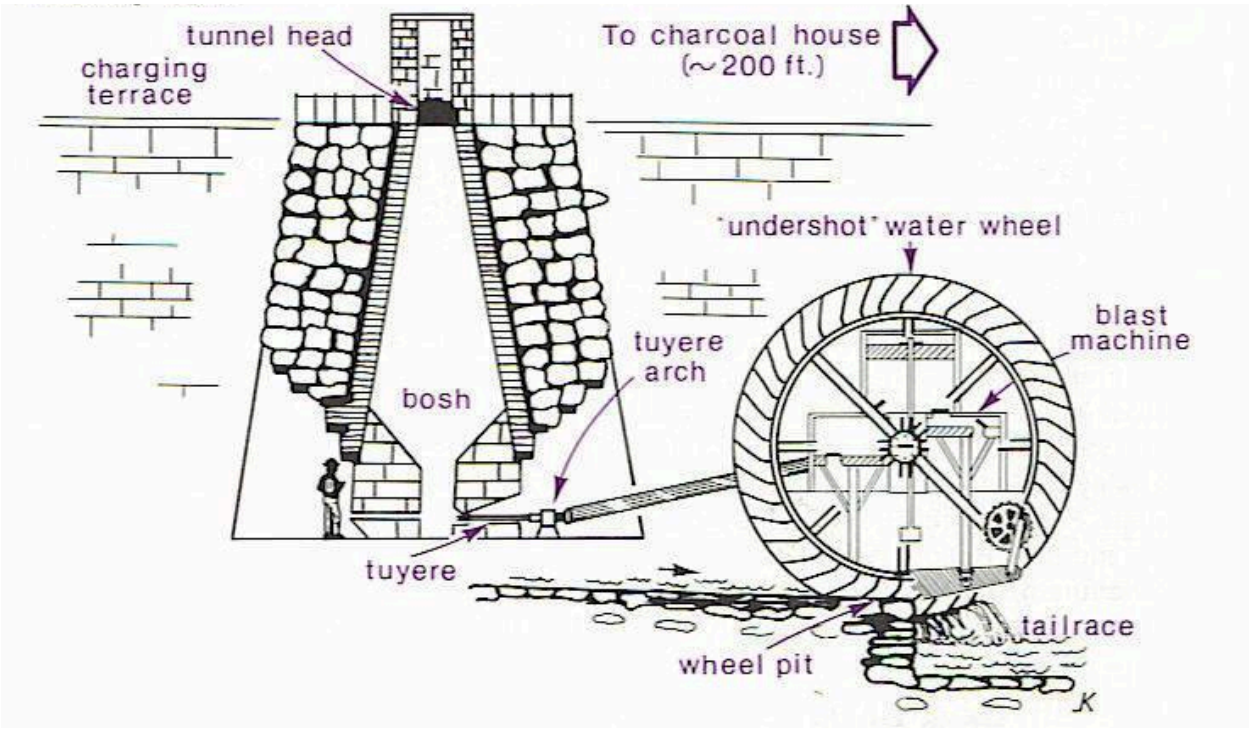
Now follow a gentle-sloped trail up the hill from the parking lot that will bring you to the back of the furnace. Be careful and do not climb on the structure. Notice the rocks that have been carefully placed to build the stack. Whitish quartzite, brown sandstone and a dark rock known as diabase were used in the stack construction. These are all local rocks. Notice the iron bands going around the furnace stack. These were used to hold the stack together as it aged and may or may not have been used in the original operation.

So why is the furnace (or any furnace you may see) built into a hillside? It is because the materials used in the furnace were loaded from the top. Over your head as you stand behind the furnace was the bridge where workers carried baskets of charcoal, iron ore and limestone to load in the furnace. An iron furnace used these three ingredients; charcoal, iron ore and limestone which were loaded in layers with the charcoal on the bottom. The charcoal was burned hotter with the bellows, the iron ore was melted at a high temperature to a liquid which flowed down to the base and where the limestone was used as a flux which removed impurities from the iron. The waste material floated to the top of the stack and was known as slag. The slag was skimmed off the top and hauled away onto dump piles. Much of the topography around the furnace are formed by slag. If you could dig into the hillside you would find slag in all sizes.

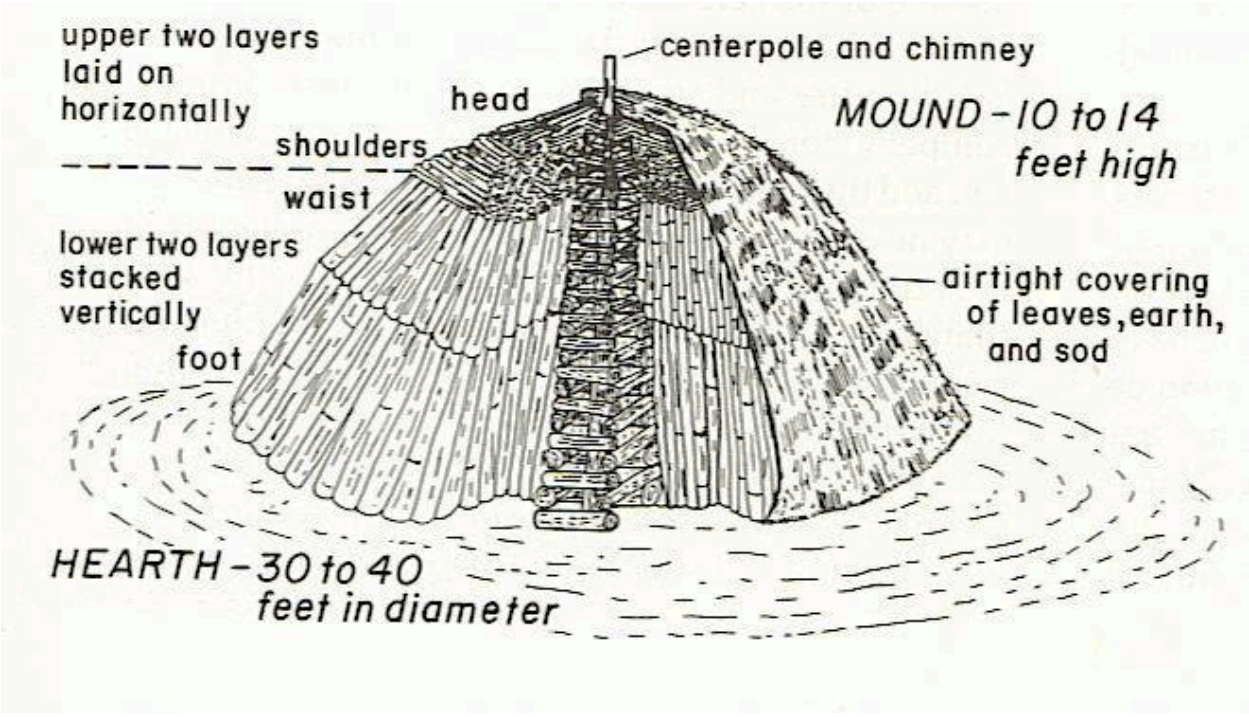
Continue walking the trail uphill and you will come to a flat area. Notice the quartzite rock walls bordering the plateau. This is the outline of a storage barn where fresh materials were stored until they were used in the furnace.

If you would take a short walk up Codorus Furnace Road you will spot several buildings associated with the furnace. Near the sharp turn in the road on the left side is the ironmasters house, still lived in today. If you look to the right toward the Codorus Creek, there are remnants of rock walls that once was the final on-site operation, a flint mill. Here, pure quartz was brought here from the Hellam Hills and manufactured into flints. The quartz was used to make fire starters and rifle firing.

Travel around the sharp corner of the road and notice the notice barn on the left. This structure was here during many of the years of operation of the furnace. Just past the barn is a meadow with some immature trees. On this site during the furnace days was a schoolhouse. Workers' houses, probably built of wood, surrounded the school on both sides of the road.



Example of a charcoal furnace



The making of charcoal for the iron furnace
STOP 7.
Gettysburg Formation Sandstone/Shale, Newberry Township

Location: On the north side of Sheep Bridge Road, 0.05 mile north of the Conewago Creek bridge.

Coordinates: 40.110924°
-76.798395°

Province: Piedmont
Section: Gettysburg-Newark Lowlands Section
Elevation: 334

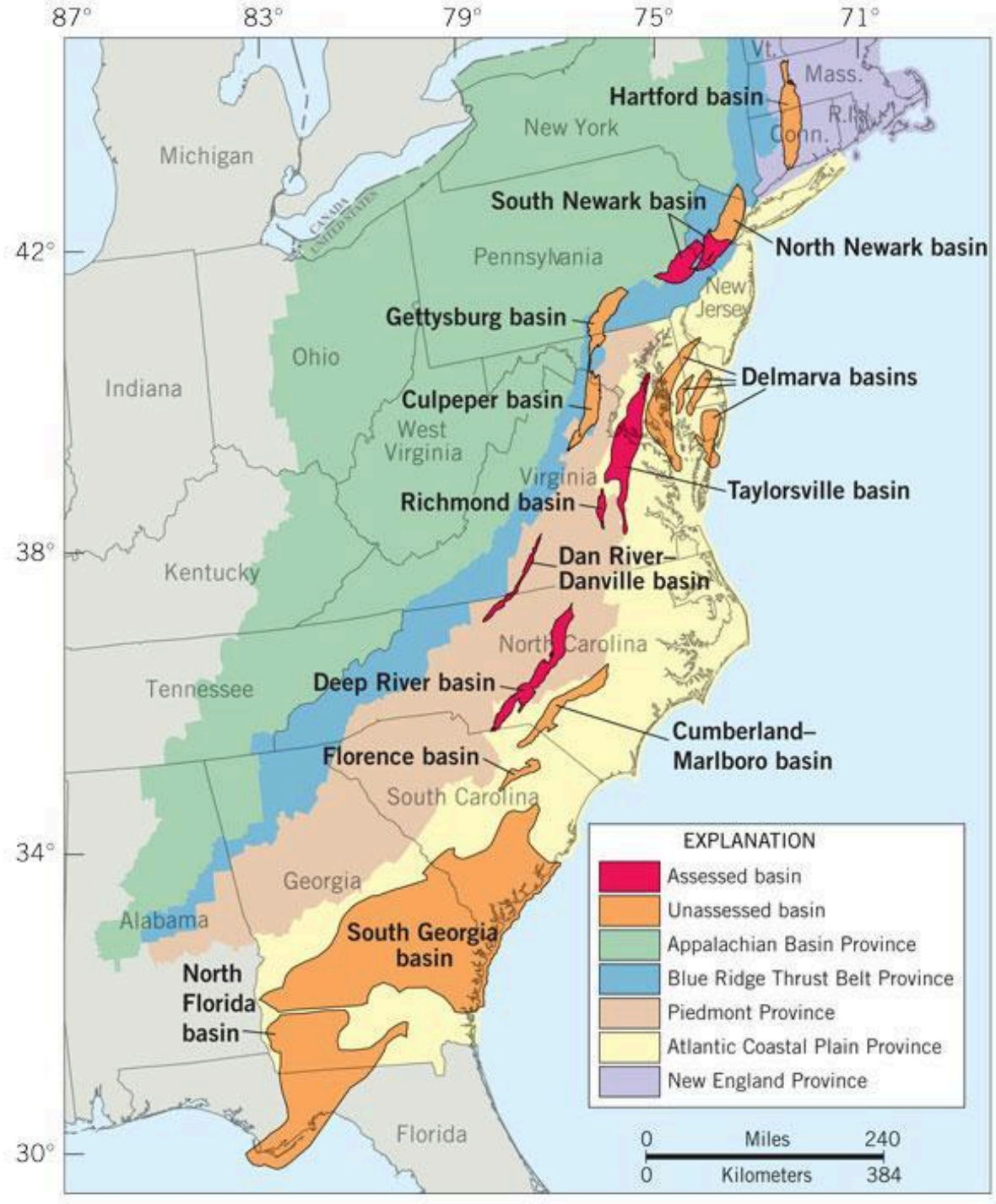
Features: Well exposed sandstone and shale
Formations: Gettysburg
Age: Triassic

What To See Here: This sedimentary rock exposure has not been modified by any tectonic events, laying just how it was deposited during the "Age of the Dinosaurs." Notice the layers. Which direction are the layers tilting into the Earth? Can you tell which of the two rock types is more durable to weathering? And finally, what color is the rock? Where is the oldest layer?

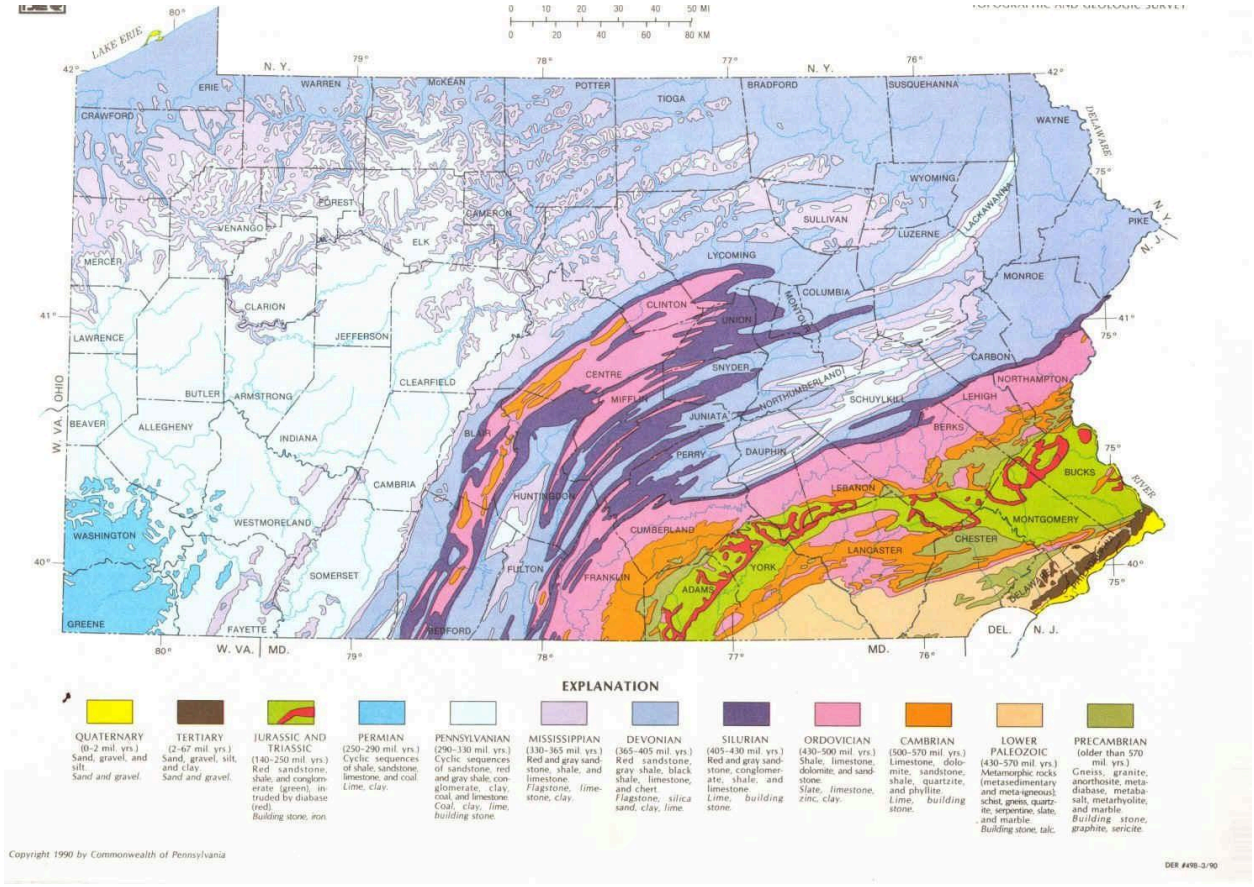
So now it is time to switch gears and go into a new chapter of our trip and it's geologic history. We are now moving up into a new section of the Piedmont that contains the youngest rocks in York County and southeastern Pennsylvania. Let's move up into the Mesozoic Era, specifically the Triassic and Jurassic periods, the time of the dinosaurs.

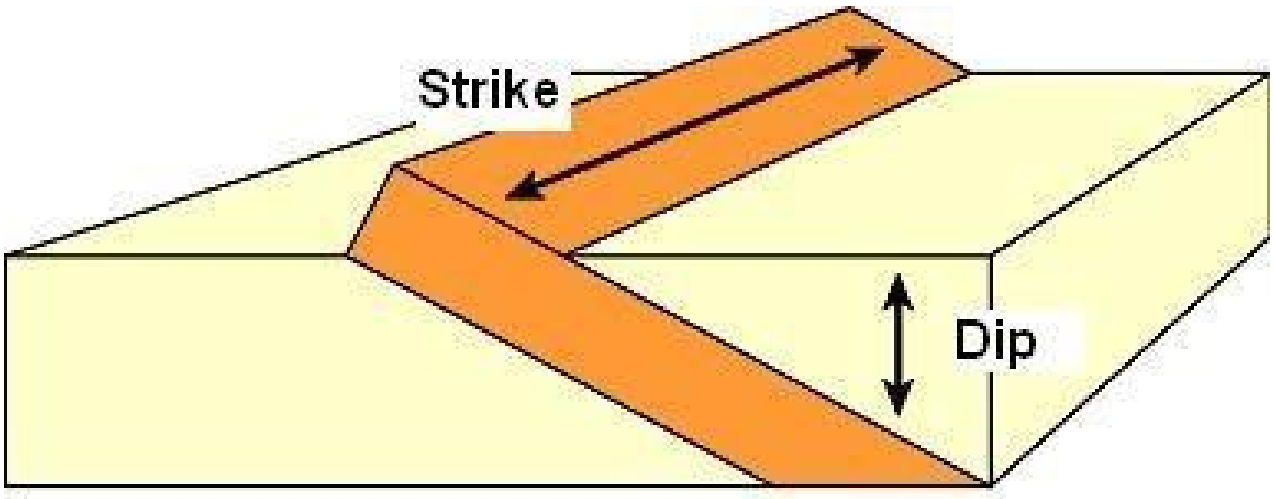
Have you ever thought about the beginning of the Era of the Dinosaurs during the Triassic Period? Approximately 200 million years during the Late Triassic times, we were located at the same latitude as Miami, Florida. The supercontinent Pangaea was breaking apart into the continents that we know of today. Several rift valleys, similar to today's Red Sea area, was pulling apart North America and Africa. This rift valley which we are now standing in had steep sides with a flat valley. There were meandering streams, oxbow lakes and isolated ponds dotting the landscape. Several species of dinosaurs, reptiles and amphibians lived in the water or were often found "hanging out" on the shores. Abundant vegetation with plants and trees. The weather was tropical with abundant vegetation with meandering streams, oxbow lakes and swamps. Today, the Triassic rocks in southeastern Pennsylvania consist of mostly reddish-brown sandstone, shale and conglomerate with a small amount of limestone. Our historic brownstone buildings were constructed of these rocks. Our Triassic area is only a small extent of what are called the Mesozoic rift basins along the East Coast. These discontinuous basins extend from Massachusetts southward into Alabama. At the end of the rifting, some 24,000 feet of clay, sand and cobbles accumulated in this rift valley which have become the New Oxford and Gettysburg formations in southeastern Pennsylvania.

US EAST COAST MESOZOIC BASINS



Source: US Geological Survey


LAKE ERIE
N. Y.
ERIE
WARREN
McKEAN
POTTER
TIOGA
BRADFORD
SUSQUEHANNA
WAYNE
CRAWFORD
FOREST
VENANGO
CAMERON
ELK
SULLIVAN
WYOMING
LUZERNE
LACKAWANNA
PIKE
MERCER
LYCOMING
COLUMBIA
MONROE
CLARION
CLINTON
UNION
MONTOUR
LAWRENCE
JEFFERSON
CARBON
CENTRE
SNYDER
NORTHUMBERLAND
NORTHAMPTON
CLEARFIELD
MIFFLIN
SCHUYLKILL
LEHIGH
BUTLER
ARMSTRONG
JUNIATA
BERKS
OHIO
W. VA.
BEAVER
ALLEGHENY
INDIANA
BLAIR
PERRY
DAUPHIN
BUCKS
DELAWARE RIVER
CAMBRIA
LEBANON
HUNTINGDON
MONTGOMERY
WASHINGTON
WESTMORELAND
CUMBERLAND
CHESTER
LANCASTER
SOMERSET
FULTON
FRANKLIN
YORK
ADAMS
GREENE
FAYETTE
BEDFORD
DEL.
N. J.
W. VA.
MD.
MD.
EXPLANATION
QUATERNARY
(0–2 mil. yrs.)
Sand, gravel, and silt.
Sand and gravel.
TERTIARY
(2–67 mil. yrs.)
Sand, gravel, silt, and clay.
Sand and gravel.
JURASSIC AND TRIASSIC
(140–250 mil. yrs.)
Red sandstone, shale, and conglomerate (green), intruded by diabase (red).
Building stone, iron.
PERMIAN
(250–290 mil. yrs.)
Cyclic sequences of shale, sandstone, limestone, and coal.
Lime, clay.
PENNSYLVANIAN
(290–330 mil. yrs.)
Cyclic sequences of sandstone, red and gray shale, conglomerate, clay, coal, and limestone.
Coal, clay, lime, building stone.
MISSISSIPPIAN
(330–365 mil. yrs.)
Red and gray sandstone, shale, and limestone.
Flagstone, limestone, clay.
DEVONIAN
(365–405 mil. yrs.)
Red sandstone, gray shale, black shale, limestone, and chert.
Flagstone, silica sand, clay, lime.
SILURIAN
(405–430 mil. yrs.)
Red and gray sandstone, conglomerate, shale, and limestone.
Lime, building stone.
ORDOVICIAN
(430–500 mil. yrs.)
Shale, limestone, dolomite, and sandstone.
Slate, limestone, zinc, clay.
CAMBRIAN
(500–570 mil. yrs.)
Limestone, dolomite, sandstone, shale, quartzite, and phyllite.
Lime, building stone.
LOWER PALEOZOIC
(430–570 mil. yrs.)
Metamorphic rocks (metasedimentary and meta-igneous): schist, gneiss, quartzite, serpentine, slate, and marble.
Building stone, talc.
PRECAMBRIAN
(older than 570 mil. yrs.)
Gneiss, granite, anorthosite, metadiabase, metabasalt, metarhyolite, and marble.
Building stone, graphite, sericite.
Copyright 1990 by Commonwealth of Pennsylvania
DER #498-3/90


Strike
Dip

STOP 8.
Rossville Copper Hornfels, Warrington Township

Location: On the east side of Old York Road, 0.6 mile north of the traffic light in Rossville.

Coordinates: 40.071146°
-76.922793°

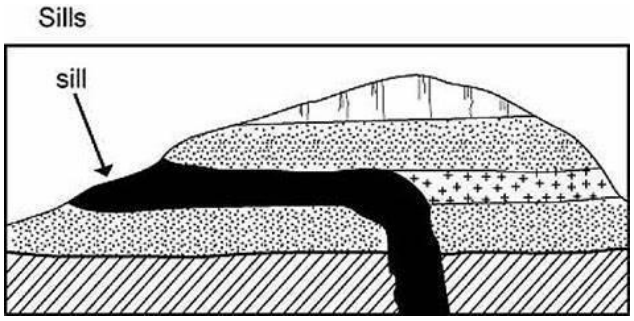
Province: Piedmont
Section: Gettysburg-Newark Lowlands Section
Elevation: 629 feet

Features: Well exposed hornfels
Formations: Gettysburg
Age: Triassic

What To See Here: See how thermal metamorphism affects rocks here. A hornfel is any rock changed by heat only and changed into a new distinct rock type (metamorphic). With this change at this locality, some copper was introduced during metamorphism creating small blebs of native copper in the hornfel. With weathering, the native copper has neutralized to adjust to the atmosphere now forming malachite (green) and azurite (blue).

Geologic History: A large diabase body is located just to the south of this stop including the village of Rossville. Unlike, Stop 3, the magma here formed a sill within the Gettysburg Formation. As the magma intruded through the sedimentary rocks of the Gettysburg formation, the sandstones and shales were heated. As a result of the chemical reaction between the rock and magma, a small amount of copper formed in the hornfel. As weathering of this rock occurred, the copper within the rock had to adapt to the atmospheric changes. As a result, malachite and azurite formed as secondary minerals on the exterior of the rock. If you would break the rock open, you would not find any green or blue coloration. The copper seam is very thin and not widespread. An attempt to trace the copper along the direction of dip or strike have not been successful. There are other minerals also found here formed as a result of the contact metamorphism including hyalite opal.

References: Jones, 2002c; Geyer and others, 1976; Smith, 1973.



What is a sill?

South Mountain

Hornfels

Diabase

Gettysburg ss/sh

Gettysburg ls

New Oxford rocks

STOP 9.
Dillsburg Earthquake Swarm, Carroll Township

Location: Parking Lot of Hope Grace Church on the south side of Old York Road, 0.15 mile east of the intersection with Ore Bank Road.

Coordinates: 40.102981°
-77.015168°

Province: Piedmont
Section: Gettysburg-Newark Lowlands Section
Elevation: 689

Features: Proximity of the Dillsburg Earthquake Swarm epicenter
Formations: Gettysburg and Diabase
Age: Triassic/Jurassic

What To See Here: You are located very close to the epicenters of the Diullsburg Earthquake Swarm that occurred here from October, 2008 until April, 2010. Over 4,000 tremors occurred here, most of them creating "booms" and not much shaking. This was a great example of the community working with scientists as residents became reporters as they recorded events which were then added to our database. Because iron mining was a huge industry in this neighborhood, my first theory was centered on the collapse of mine shaft roofs creating the seismic event, but as additional tremors were recorded that theory was off of the table.

What do we know for sure?

1. About 4,000 tremors were reported to me or recorded on several seismic networks.
2. The tremors occurred about 0.75 mile deep, on or close to the boundary between diabase and Gettysburg Formation sedimentary/hornfels rocks.
3. No major structural damage occurred as the largest tremor was recorded at 2.4 on the Richter Scale.
4. Some residents were afraid of what was coming next.
5. I and several other geologists (including the State) had two community meetings to discuss the tremors and some preliminary findings.
6. A Columbia University seismic network and a privately-funded seismic network were used to record the tremors which located the eipcenters.
7. Diabase, being a dense rock, was fracturing causing the booms under some sort of pressure.

Why (Theories):

1. Groundwater Mining was taking place as houses in the developments were all about 11 years old. As residents withdrew water, weight was taken off of the crust, resulting in the crust "relaxing" with less weight.
2. With the area known to have been a rift valley during the Mesozoic Era, the crust is fractured. Perhaps pressure from our movement of the North American crust built up and reached a point of release.

Carroll Township and the Earthquake Swarm

Jeri L. Jones, Jones Geological Services
Dr. Charles K. Scharnberger, Professor Emeritus, Millersville University

The title sounds like a fairy tale and to some residents of Carroll Township, they wished it was. Beginning on Friday, October 3rd and still continuing at the writing of this articlein mid December, the area has been “rocked” or “boomed” by numerous tremors. Over 150 tremors have been felt or heard by area residents. Of the large number of tremors, 18 of these events were recorded by seismic stations at Millersville University, Franklin and Marshall College, Soldier’s Delight State Park, and several other seismograph stations in the region. Several dates on which recordable tremors were noted were Sunday, October 5th, Sunday; October 19th; Monday, October 20th; Thursday, October 23rd; Sunday, October 26th and Thursday, November 6th. The largest of these tremors had a magnitude of 2.1 on October 19th. The same day also included 11 other tremors recorded at the above stations.

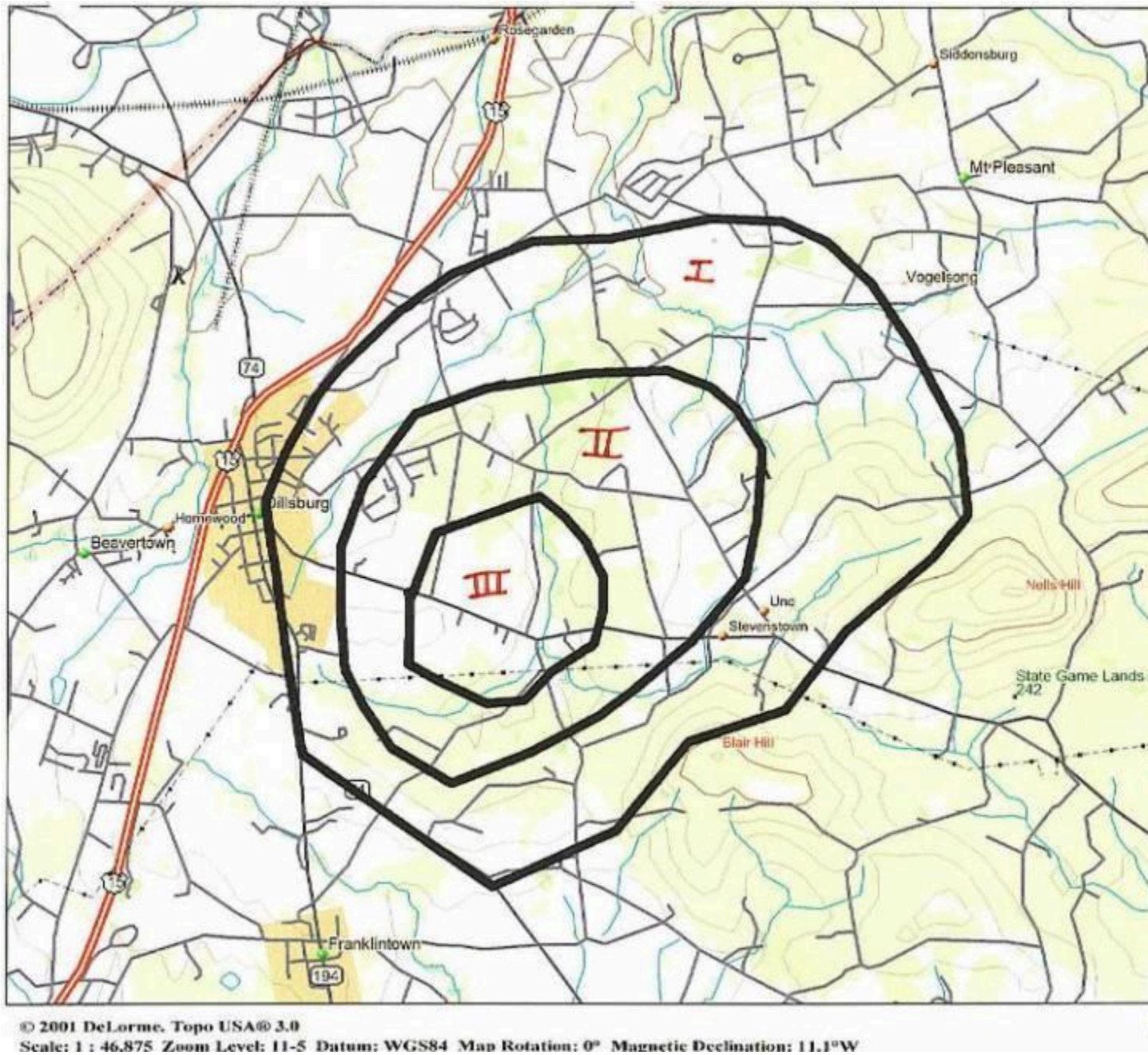
Much information from area residents was reported to these investigators. From the township website and television channel, personal and telephone interviews and constant record keeping of residents, we have been able to construct intensity maps for the October 5th and October 19th events as well as a listing of all of the tremors felt. The quadrant between Mandy Lane, Old York Road, Warrington Road and Stoney Run Road has the highest intensity for these tremors. Along with the booms and rumbles, during the 2.1 tremor of October 19th, items fell off of shelves, the feeling that the house floor rose up two feet and a old window pane cracking were among the responses from residents.

On Friday, October 24th, personnel from Lamont-Doherty Earth Observatory of Columbia University installed four portable seismographs in the Dillsburg area. These portable units will record all of the tremors, many of which are not strong enough to be recorded at the permanent stations. From data retrieved from these stations, the epicenters and depths of these tremors can be precisely located. This information is not expected back to us until late December.

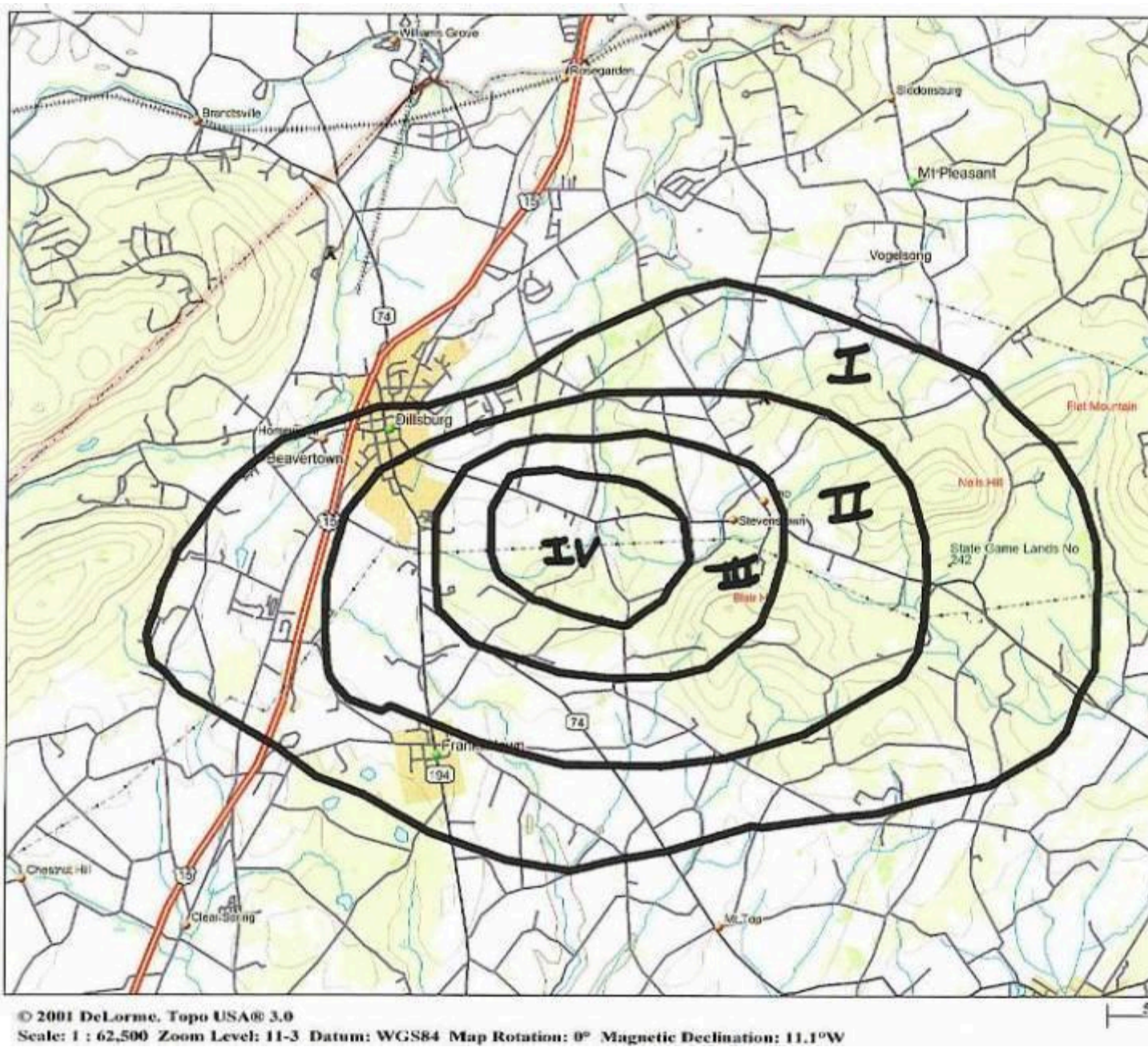
A community meeting was held on October 28th at the township building. During the meeting, the local geology was explained, history of earthquakes in the eastern United States and a lengthy question and answer period eased the minds of some of the area residents. Based on the history of earthquakes in the eastern section of the United States, there is a low probability that a severe earthquake will occur in the Dillsburg area.

What makes this swarm of shallow earthquakes interesting to investigate?
1). The number of tremors felt over the last ten weeks
2). The regular “boom” that accompanies many of these tremors
3). A sulfur smell associated with the larger tremors and sometimes within the groundwater

These issues are being investigated by us. We hope to schedule another informational meeting early in 2009 at a meeting place to be announced. There will be information also placed on the Carroll Township website and here at this website.

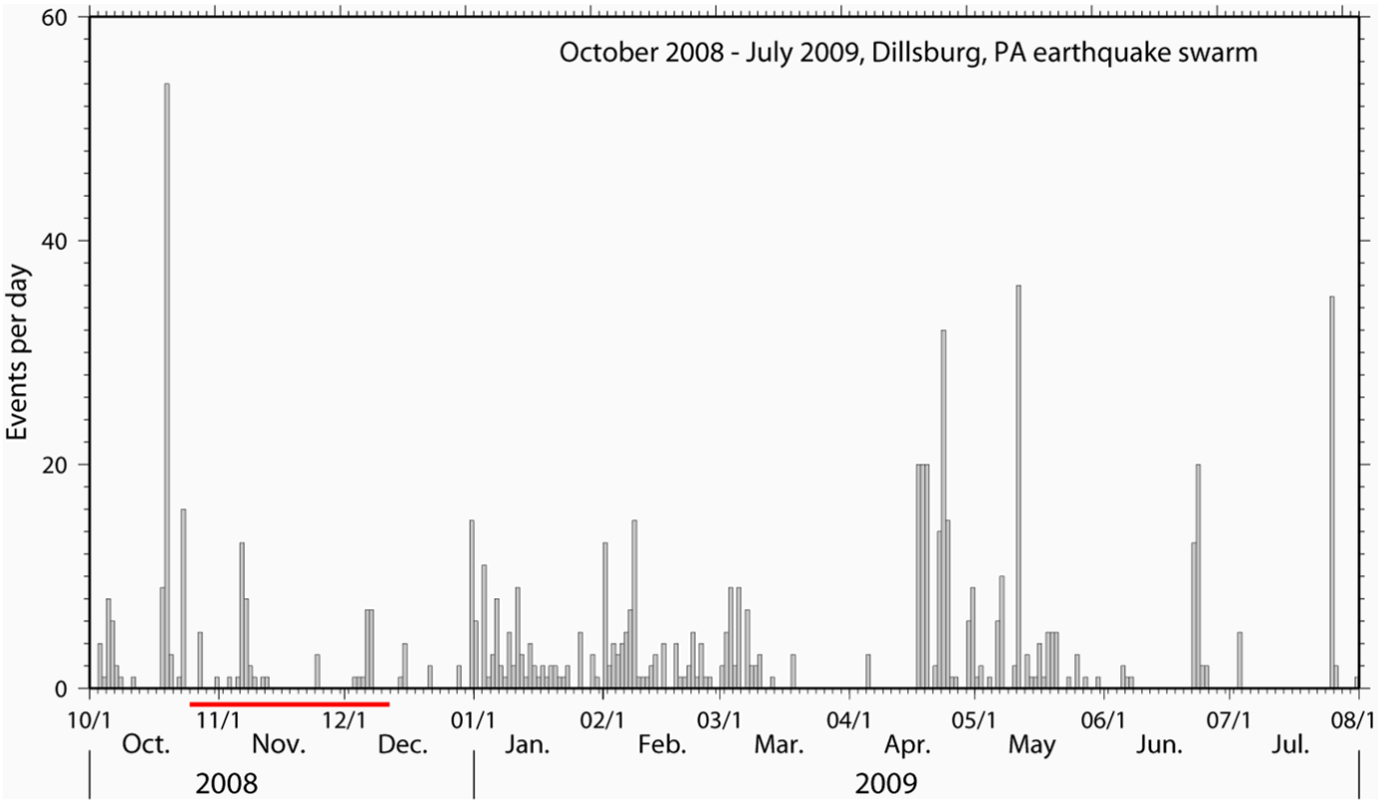


Intensity map of the October 5, 2008 2.0 earthquake. Zone III is the epicenter area

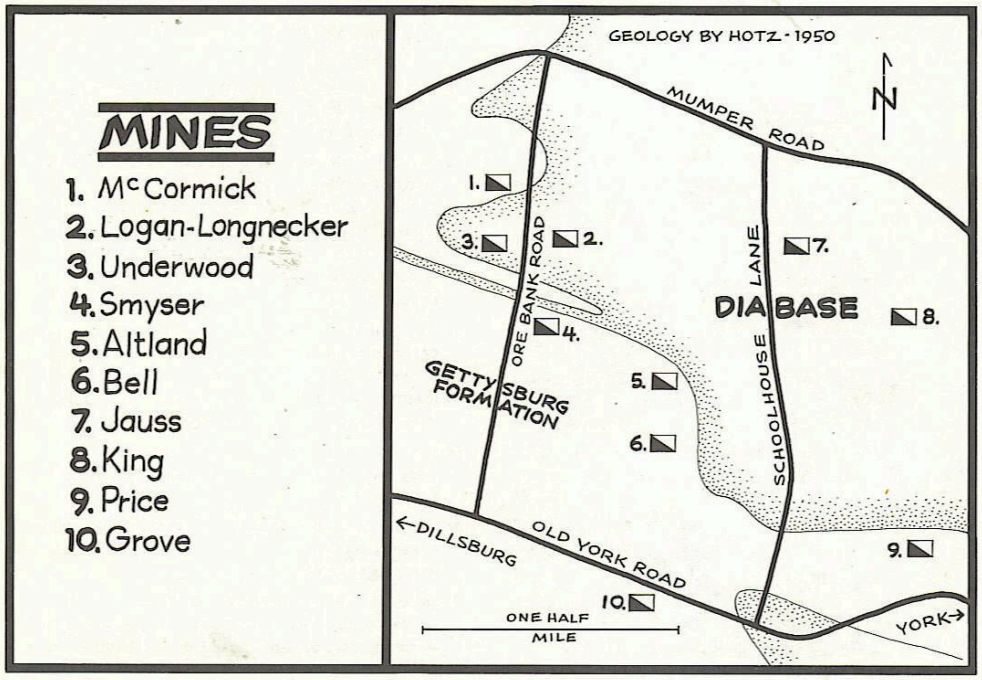


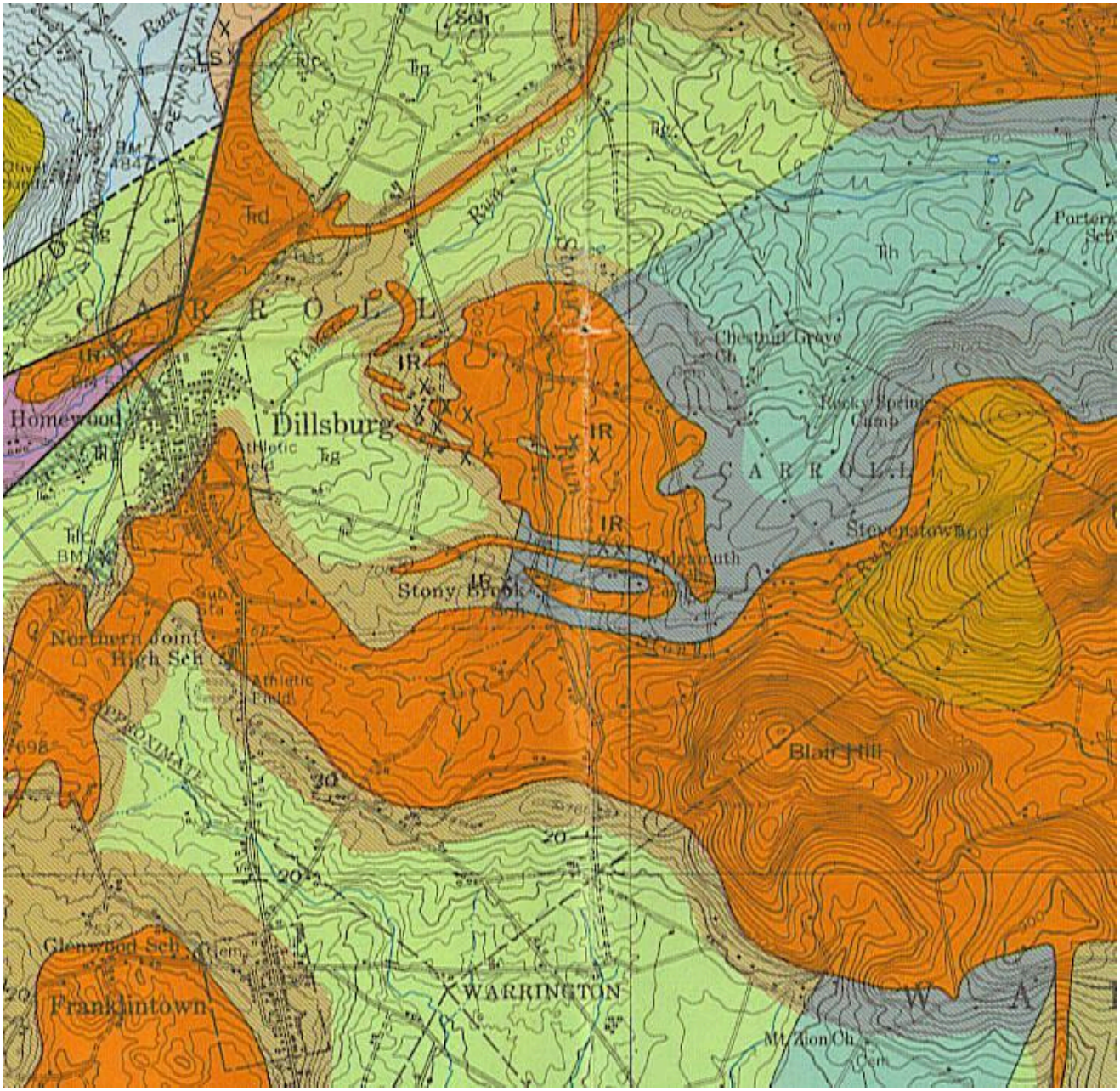
Intensity map of the October 19, 2008 2.1 earthquake - Zone IV in in the epicenter area and was a more widely felt event than the October 5th tremor

Measurable Earthquakes from the Lamott-Doherty Cooperative Seismographic Network from the Dillsburg Pennsylvania area


October 2008 - July 2009, Dillsburg, PA earthquake swarm
Events per day
60
40
20
0
10/1
11/1
12/1
01/1
02/1
03/1
04/1
05/1
06/1
07/1
08/1
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
2008
2009

Location of the principal mines in the Dillsburg Magnetite District.





Stose and Jonas, 1939

Date	Local Time	Magnitude
October 5, 2008	6:36	2.0
October 19, 2008	4:21	1.9
October 19, 2008	4:22	2.1
October 19, 2008	4:26	1.2
October 19, 2008	4:58	1.8
October 19, 2008	5:06	1.0
October 19, 2008	5:08	0.8
October 19, 2008	5:08	1.0
October 19, 2008	5:17	1.7
October 19, 2008	5:45	1.5
October 19, 2008	5:49	1.5
October 19, 2008	5:50	1.6
October 20, 2008	10:16	1.5
October 20, 2008	20:08	1.2
October 20, 2008	20:14	1.1
October 23, 2008	11:55	1.2
November 6, 2008	23:07	1.4
December 31, 2008	00:34	2.1

Date	Local Time	Magnitude

April 22, 2009	9:21	1.1
April 23, 2009	6:26	2.4
April 24, 2009	1:36	2.9
April 30, 2009	18:36	2.0
May 11, 2009	1:18	1.3
May 11, 2009	1:34	1.2
October 25, 2009	7:16	2.6
October 25, 2009	7:18	1.8
October 25, 2009	7:21	2.8
June 3, 2010 **	8:25	2.9

A detailed reported is published at https://maps.dcnr.pa.gov/publications/Default.aspx?id=637.

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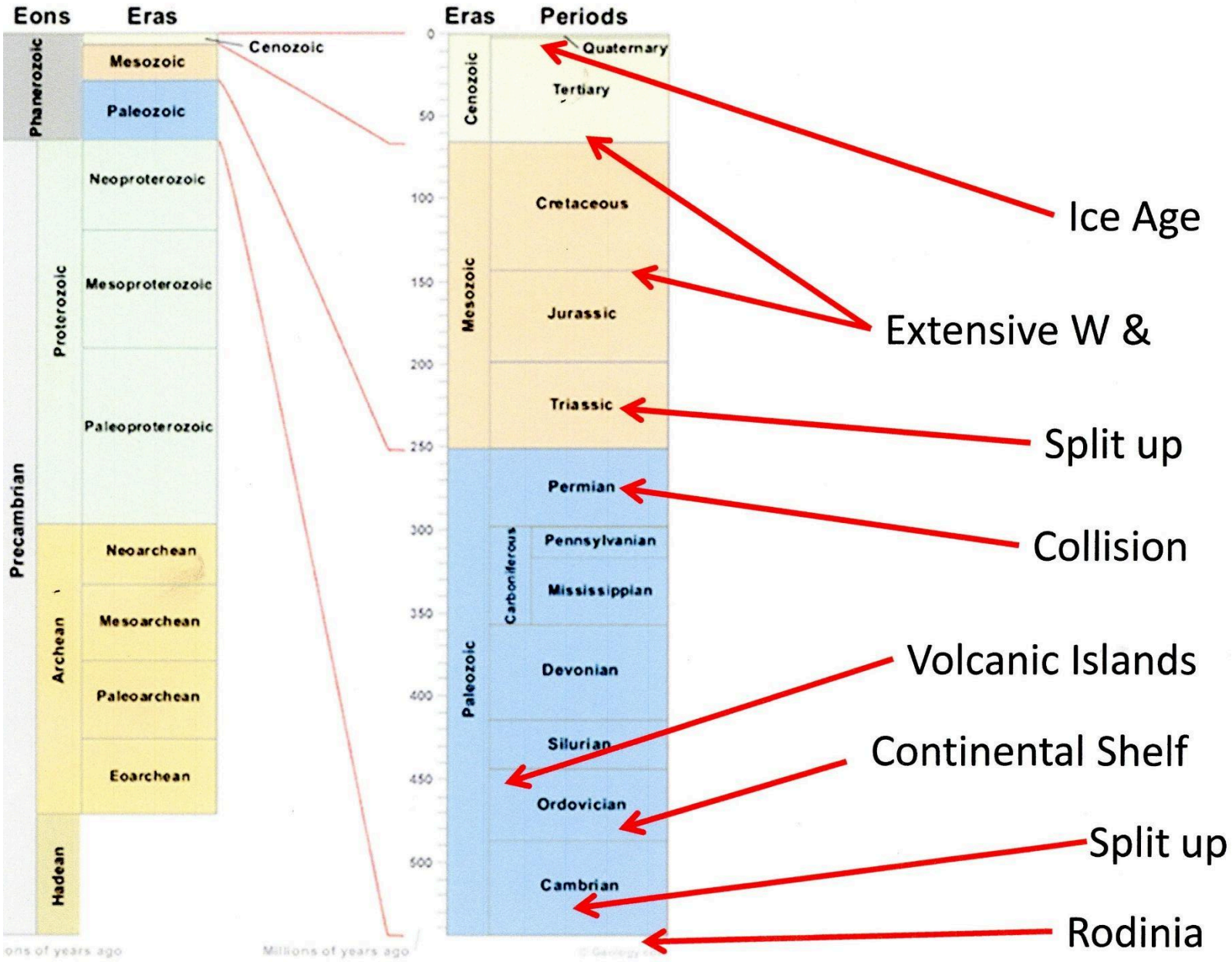
Eons
Eras
Phanerozoic
Mesozoic
Paleozoic
Cenozoic
Precambrian
Proterozoic
Neoproterozoic
Mesoproterozoic
Paleoproterozoic
Archean
Neoarchean
Mesoarchean
Paleoarchean
Eoarchean
Hadean
Millions of years ago
Eras
Periods
Cenozoic
Quaternary
Tertiary
Mesozoic
Cretaceous
Jurassic
Triassic
Paleozoic
Permian
Carboniferous
Pennsylvanian
Mississippian
Devonian
Silurian
Ordovician
Cambrian
0
50
100
150
200
250
300
350
400
450
500
Ice Age
Extensive W &
Split up
Collision
Volcanic Islands
Continental Shelf
Split up
Rodinia