GEOLOGY OF THE PIEDMONT LOLANDS

York and Lancaster Counties

Hosted by Jeri L. Jones
With Contributions from Dr. Charles Scharnberger, Millersville University, Randy Newcomer, Rohrer's Quarry, and David Hopkins, Baker Refractories

YORK COUNTY PARKS GEOLOGIC GUIDE #8
APRIL 28, 2001

INTRODUCTION

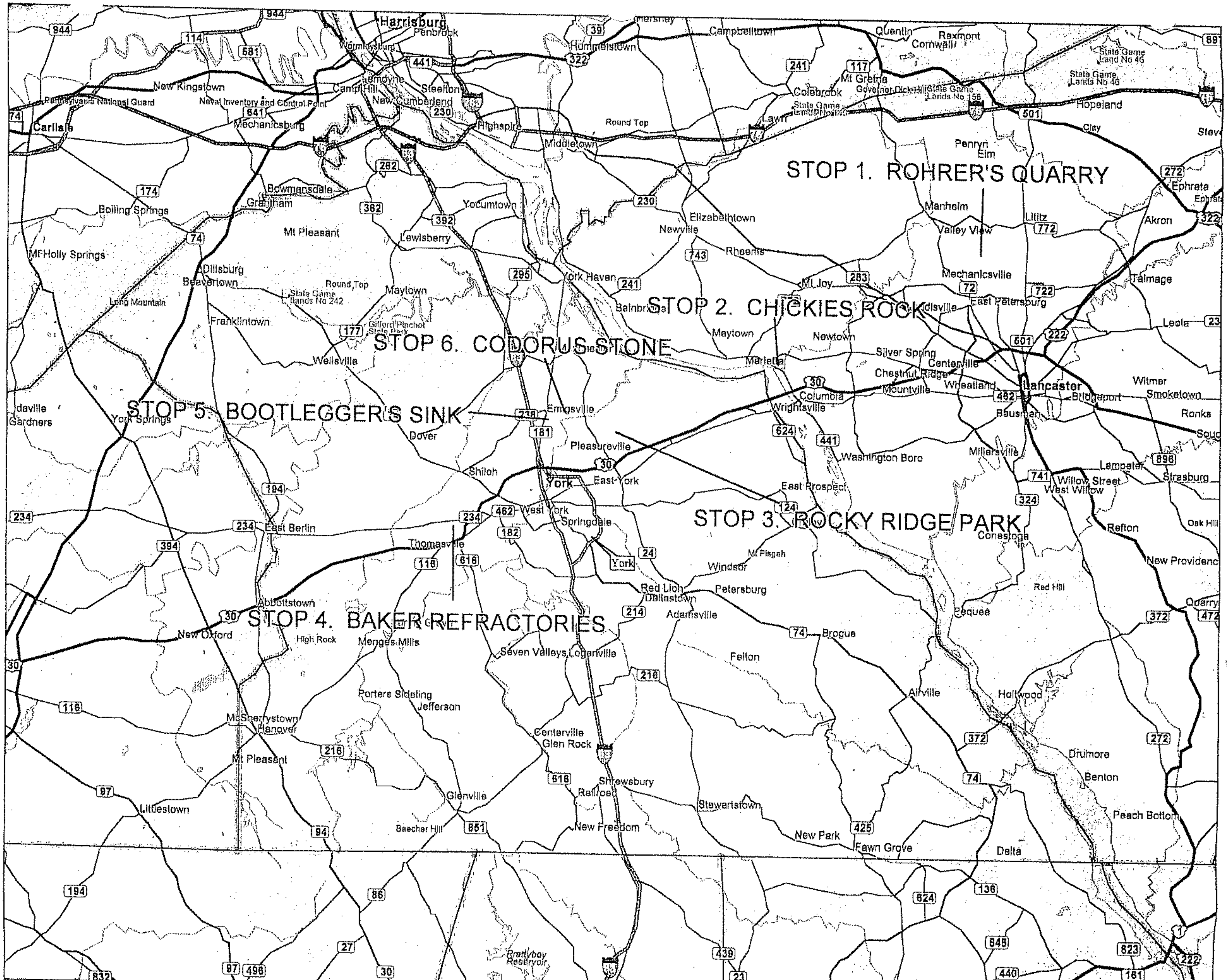
On behalf of the York County Parks, welcome to the Spring edition of the "Traveling Geology Workshop." Traditional, these trips stay within York County, but today to show you a wider variety of features, we also include Lancaster County. The theme, Piedmont Lowlands Section, is an important area to us, as some of the finest limestone and dolomite resources are mined from this area. Also, you will examine one of the best examples of an anticline on the East Coast and learn how a geologist interprets the information. If you like fossils, we will also examine a world-renown "Ice Age" site where these remains tell us what York County was like some 10,000-12,000 years ago. At the end of the day, it is hoped that you have a better understanding of how local mineral resources are mined and their uses, the complexity of the geology and just how important several geologic sites are.

ACKNOWLEDGEMENTS

These trips cannot be made possible with out the cooperation of others. This particular trip will visit the most quarries ever on one of these excursions, so the owners have to be thanked. Randy Newcomer at Rohrer's Quarry and David Hopkins at Baker Refractories not only are hosts to their operation, but also gathered information which is included in the guidebook. Dr. Charles Scharnberger, Professor of Geology at Millersville University, wrote about the geology of Rohrer's Quarry. Unfortunately, due to other commitments, it is unable to join us today. Thanks also to the York County Firemen Training Center who is allowing us to inspect the Bootlegger's Sink. Finally, thank to all of the participants who make the trip possible.

ITINERARY

9:00 AM	Depart Rudy Park
9:40-10:40 AM	**Stop #1** – Rohrer's Quarry
11:05-11:35 AM	**Stop #2** – Chickies Rock
11:55 AM – 12:55 PM	**Stop #3** – Rocky Ridge Park North Overlook *(lunchtime)*
1:25-2:30 PM	**Stop #4** – Baker's Quarry
2:55-3:20 PM	**Stop #5** – Bootlegger's Sink
3:25-3:55 PM	**Stop #6** – Codorus Stone
4:00 PM	Arrival back to Rudy Park



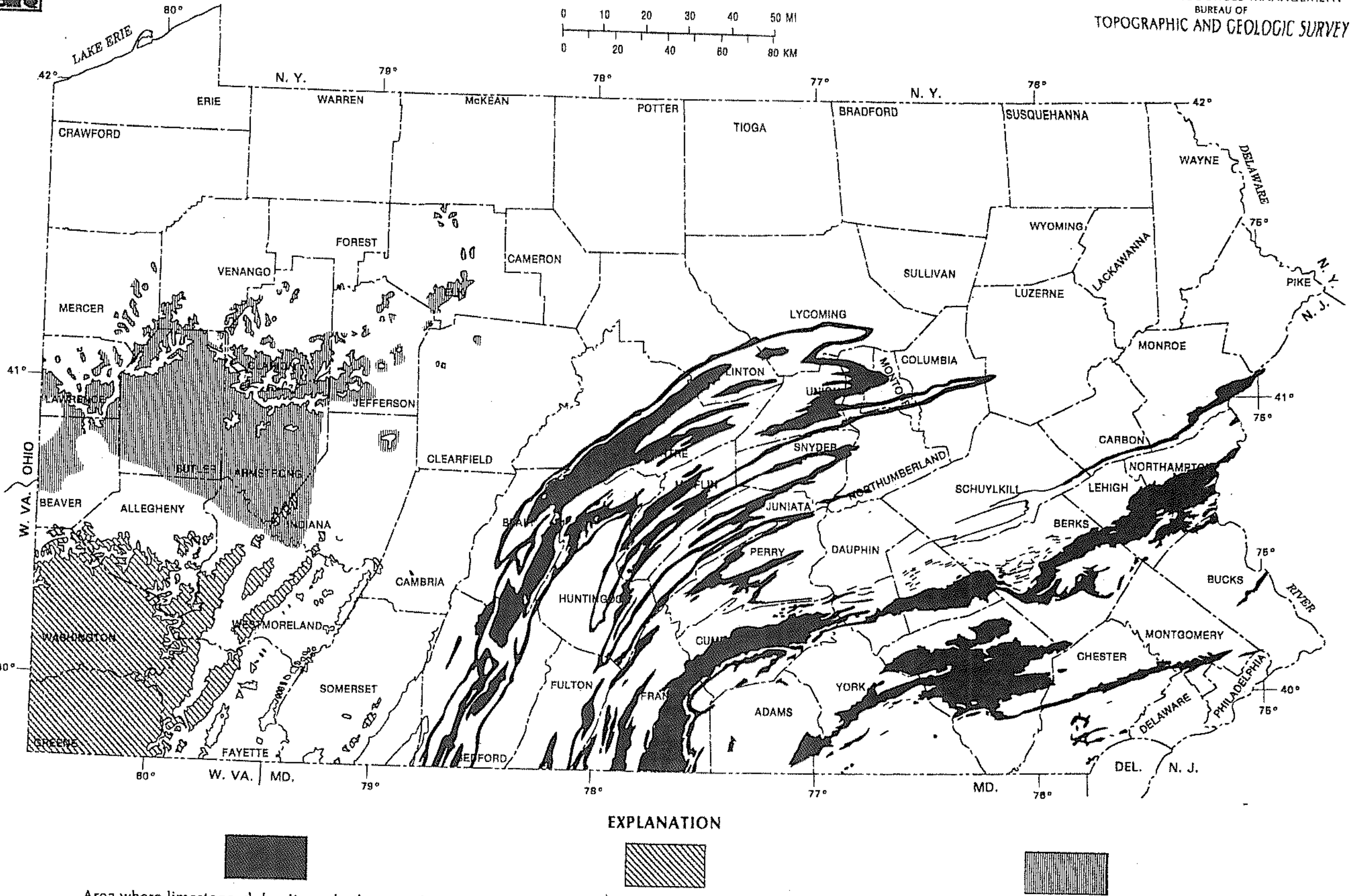
 2 mi Scale: 1 : 375,000 Detail: 9-1 Datum: WGS84

MAP 15

LIMESTONE AND DOLOMITE D RIBUTION IN PENNSYLVANIA

COMMONWEALTH C NNSYLVANIA
DEPARTMENT OF ENVIRO. NTAL RESOURCES
OFFICE OF RESOURCES MANAGEMENT
BUREAU OF
TOPOGRAPHIC AND GEOLOGIC SURVEY

SCALE 1:2,000,000



EXPLANATION

Area where limestone, dolomite, or both are at the surface. Layers are usually strongly folded and steeply dipping. Includes the economically important high-calcium limestones of the Kinzers, Annville, Benner, and Keyser Formations and the Cockeysville Marble, as well as the high-magnesian dolomites of the Ledger Formation and the Cockeysville Marble.

Area underlain by flat-lying, generally thin, but locally thick, limestone beds which may be discontinuous; frequently interbedded with shale.

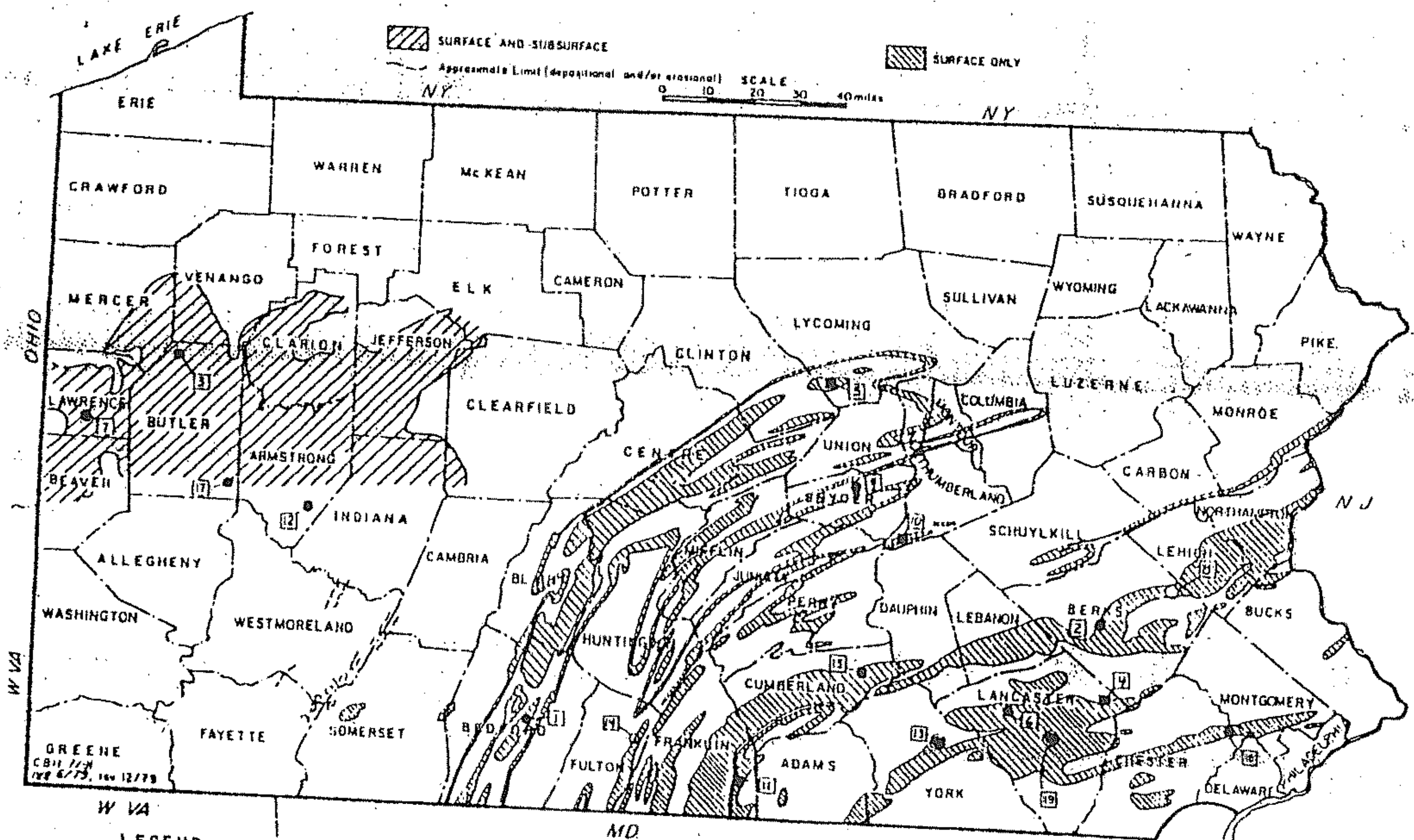
Area underlain by the generally flat lying Vanport Limestone, a high-calcium limestone. Generally overlain by *less than 100 feet of sedimentary rocks*, except in the southern part of the area.

DER #497-2/90

DUNN CORPORATION

LIMESTONE & DOLOMITE DISTRIBUTION in PENNSYLVANIA

AFTER BUREAU OF TOPOGRAPHIC AND GEOLOGIC SURVEY



LEGEND

- ● TYPE HC, High Calcium (CaO minimum 45%)
- ○ TYPE HM, High Magnesium (MgO minimum 12%)
- ◎ TYPE HC and HM
- ■ OTHER AG-LIME SOURCE

(INDEX OF PLOTTED LOCATIONS ON REVERSE SIDE)

LOCATION OF NATURAL AG-LIME SOURCES

Pennsylvania Aggregates and Concrete Association

Ag Lime Standing Committee
3509 North Front Street
Harrisburg, PA 17110 (717) 234-

Rohrer's Quarry

Geologic Setting

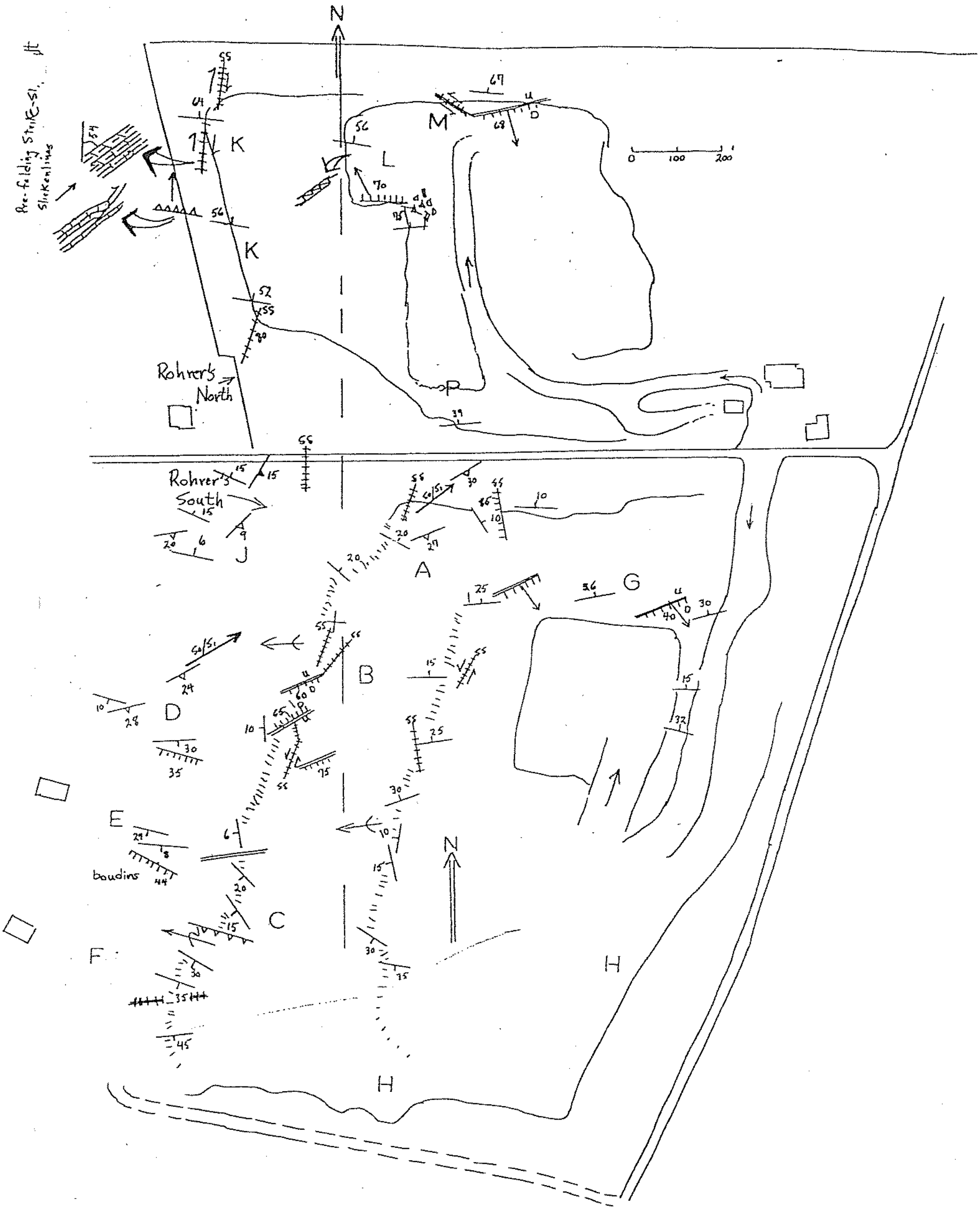
Rohrer's Quarry is located in Lancaster County, Pennsylvania, in the southwestern portion of the Lititz 7.5-minute quadrangle, on the boundary between Penn Township to the west and Warwick Township to the east. The north pit of the quarry, on the north side of Lititz Road, exposes rock of the Epler Formation, of early to middle Ordovician age. This makes the rock roughly 460 to 500 million years old.

The Epler Formation consists of interbedded limestone (calcite rock) and dolostone (dolomite rock.) Calcite is calcium carbonate, while dolomite is calcium-magnesium carbonate. As a general rule, in the Epler Formation the limestone beds are dark gray, whereas the dolostone beds are a lighter shade of gray. You can test this for yourself by putting a drop of dilute hydrochloric aced on the rock. If it fizzes vigorously, the rock is limestone. Dolostone does not fizz, or fizzes only weakly, but can be made to fizz more vigorously by first powdering the rock by scratching it with a geologic pick (or other hard object) and then applying the acid.

The Epler Formation, like all sedimentary formations, consists of beds that were originally horizontal when they were formed. The beds exposed in the north pit of Rohrer's Quarry dip to the north at an angle approximately 50° below horizontal. This dip angle is the result of deformation of the beds at some time after they were originally deposited. The structure of the beds appears rather simple in this exposure, but geologic investigations on a regional scale have revealed a much more complex picture. Rohrer's Quarry is located within one of a series of large thrust sheets, or "nappes," that have been mapped by geologists in this part of Pennsylvania.

To understand the concept of a nappe, picture a number of playing cards lying side by side on a table. Now imagine that the cards are pushed together, so that each card rides up and partially over the card next to it. We end up with a stack of overlapping cards that cover a much shorter amount of space on the table top than the cards did when they were lying side by side. Now think of each card as being somewhat thicker than a normal playing card and consisting of a series of thin layers representing an original succession of sedimentary rock formations in a region. In the original arrangement, the oldest layers are on the bottom of the cards and youngest are at the top. After the cards have been shuffled together, this original succession of layers is disturbed, and the oldest layer of one card will now be found overlying the youngest layer of the originally adjacent card. Finally, let's add one more element to this "thought experiment." Imagine that the cards are made of something like wax so that the layers within each card become contorted or "folded" as the cards move. This causes the layers to deviate from their original horizontal orientations, and even to fold back on themselves so that, in places, layers are completely inverted. We now have a fairly complete picture of a nappe. (The term "nappe" is derived from the French word for "cover.")

The limestone formation that lies directly underneath the Epler Formation is known as the Stonehenge Formation. Regional mapping has shown that another limestone formation, the Ontelaunee Formation, usually lies directly above the Epler Formation. These three formations


N
Pre-folding strike-slip slickenlines
K
K
L
M
0 100 200
Rohrer's North
Rohrer's South
J
A
B
C
D
E
F
G
H
H
H
boudins

form Earth's continents and ocean basins as we know them today. As the Atlantic Ocean began to open, the rocks of the Piedmont Province were stretched. Stretching of the crust is accommodated by the development of normal faults along which blocks of crust slip down on steeply dipping surfaces as the crust is extended in a horizontal sense. This type of tectonic activity in the Piedmont region during late Triassic and early Jurassic time, about 200 million years ago, produced a large down-dropped basin, or "graben," which then, over time, filled up with clastic sediments (gravel, sand and mud). The stretching also opened cracks through which basaltic magma could rise from Earth's mantle to intrude the crust and, perhaps, flow out on the surface. Any volcanoes or lava flows, however, have long since been eroded away, so that today we can observe only intrusive structures known as dikes and sills. Although formed in a basin, the Triassic and Jurassic rocks today form a belt of hills, known locally as the Furnace Hills, because they are more resistant to erosion than are the adjacent carbonate rocks.

Since Jurassic time, the Piedmont region has been undergoing erosion. Erosion has been accompanied by slow uplift of the crust, a process that geologists call epeirogeny. Ideally, if erosion and epeirogeny proceed at the same rate, a large volume of rock can be removed by erosion, while the region maintains a constant elevation above sea level. In any case, it is important to realize that the rock we observe today in quarries or natural exposures was once buried hundreds or thousands of feet beneath Earth' surface.

Specific Features Observable in the North Pit

Accompanying this discussion is a simple geologic map of Rohrer's Quarry that was made a few years ago by Donald U. Wise, a research associate at Franklin and Marshall College. The map depicts both the north and south pits, but the discussion here will focus only on the north pit.

Area K (see map): This area is on the upper bench level, along the western high wall of the quarry. Most obvious here is the bedding, dipping rather uniformly to the north, but steepening a bit from about 52° at the south end of the exposure to about 64° at the north end. At some places on exposed bedding planes, one can find striations, called "slickenlines," running down the beds parallel to the dip. Unfortunately, the best example of these is now covered over by material that has been dumped from the top of the wall. These bedding-plane slickenlines result from one bed moving past an adjacent bed as the beds fold. Think of what happens when you bend a phone book. In order to accommodate the folding, each page of the book must slip a little bit over the next page.

On the high wall itself, other slickenlines can be observed that plunge at about the same angle as the beds dip. These lines are not on the bedding planes, but rather on a surface that is oriented approximately perpendicular to bedding. This is a fault surface, and the slickenlines show us the direction of relative movement of the rock on either side of the fault. (The rock originally on "our side" of the fault has been removed by the quarrying operation, of course.) *Question*: Did the movement on this fault occur before or after the beds were tilted to their present attitude? If before, then the slickenlines were horizontal originally, and were rotated along with the beds during folding. That makes this a strike-slip fault, i.e., one on which the movement of the rocks was horizontal, parallel to the strike of the fault. If the movement occurred after the folding, then the slip was oblique, at an angle about 50° below horizontal. In that case, the fact that the plunge to the age of the fault, and what is the age of the shallowly pitching slickenlines relative to the calcite vein?

The two sets of slickenlines indicate two distinctly different episodes of movement on this fault, but two interpretations are possible. One is that the fault formed more recently than the folding. In that case the first movement on the fault was in a "normal" sense; that is, the hanging wall on the north moved down the fault relative to the footwall on the south. Then later, after the calcite vein had been emplaced, movement resumed, but this time with a significant component of strike slip, so that the movement was oblique, as shown by the younger set of slickenlines.

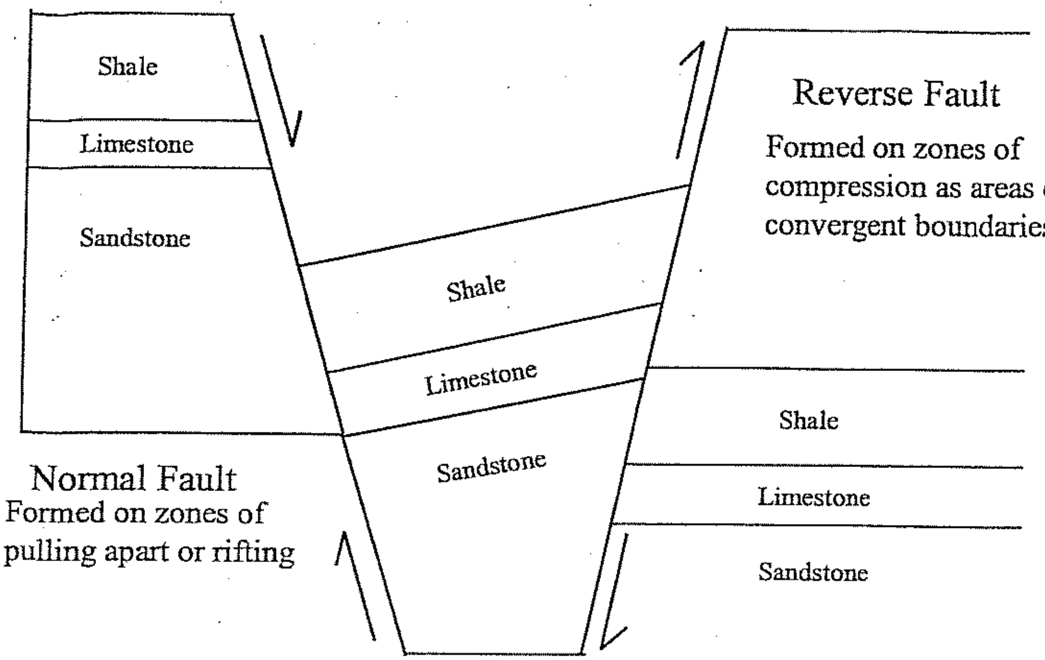
The other interpretation is that the first movement occurred before the folding. If you mentally rotate the beds back to their original horizontal attitude, you will see that the fault would dipabout 20° to the north. Such a shallow dip angle suggests a thrust (reverse) fault, rather than a normal fault. On a thrust fault, the hanging wall moves up relative to the footwall, so the sense of thrusting would have been north to south. This is opposite the general direction of thrusting associated with the major nappes, so it would be an example of "antithetic" faulting. This would not at all be unusual, however. (Note: the fault observed on the upper bench level, at location K, would also be an antithetic fault, assuming it is a thrust.) Sometimes it is possible to find small step-like features on fault surfaces that suggest the sense of relative movement. The usual interpretation is that the rock that is now gone because of erosion or quarrying moved "down the steps" on the preserved surface. *Question*: Can you find any step-like features on this fault surface? If so, what sense of movement do they suggest? Does this help answer the question as to whether this is a post-folding normal fault or a pre-folding thrust fault?

The second set of slickenlines almost certainly represents renewed movement on this fault, at some time after the bedding was rotated to its present attitude. Again, it is reasonable to hypothesize that this movement occurred during late Triassic or early Jurassic time.

On the west high wall, just north of the fault, several zones of "marble" can be observed. Unlike the rest of the rock in the quarry, this rock appears to have been sheared and recrystallized. Close examination reveals that the thin dark layers are complexly folded on a very small scale. The asymmetry of these folds, which look a bit like the letter "S," indicates that the sense of shearing was "top up." That is, the north side of the marble zone, which is above the zone in its present orientation, moved up relative to the south side, which is below the marble zone This sense of movement is the same as what we would expect during folding as one bed slips relative to the next bed, as was described earlier in the discussion for location K. Here, however, the folding seems to have been accommodated by ductile shearing, rather than by discrete slip. The reason for this ductile behavior, seen only at this one location, is not understood at the present time.

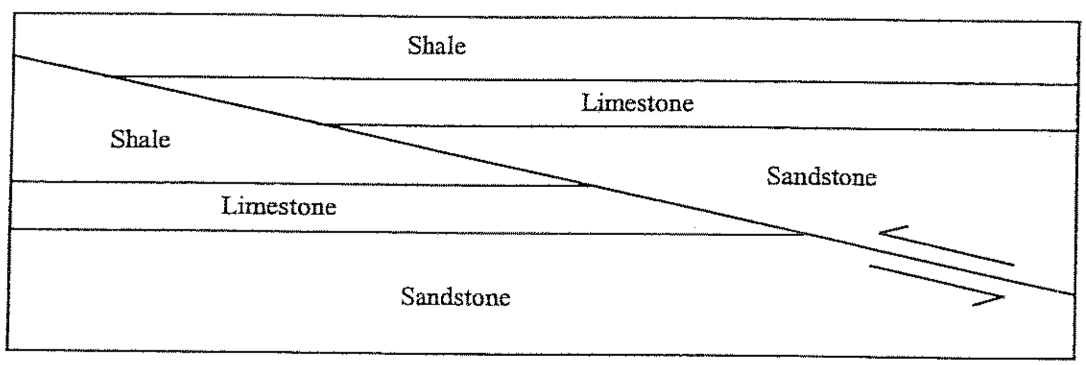
Finally, if you walk to the lip of this bench level, beyond the east end of the fault exposure, you will find pieces of rock that can be described as breccia (pronounced "brechia."). In a breccia, angular pieces of rock are cemented together, in this case by calcite. Note that many of the highly angular pieces "float" in the calcite cement, not touching any of the other pieces. This may be a fault breccia, formed when calcite crystallized around pieces of rock that had been broken up within the fault zone as a consequence of fault movement. The fact that the angular

Types of Faulting



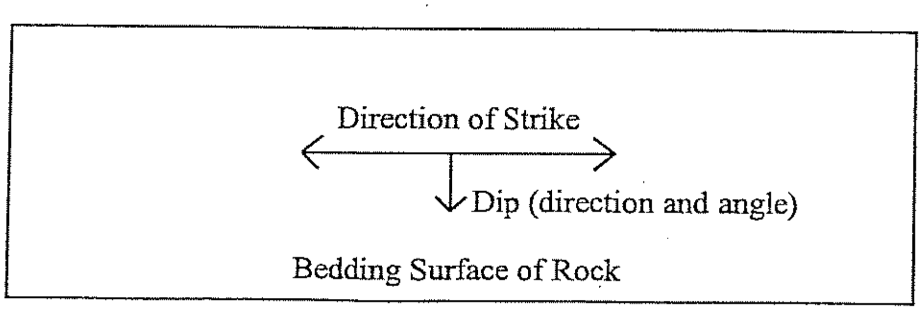
Reverse Fault
Formed on zones of compression as areas of convergent boundaries

Normal Fault
Formed on zones of pulling apart or rifting

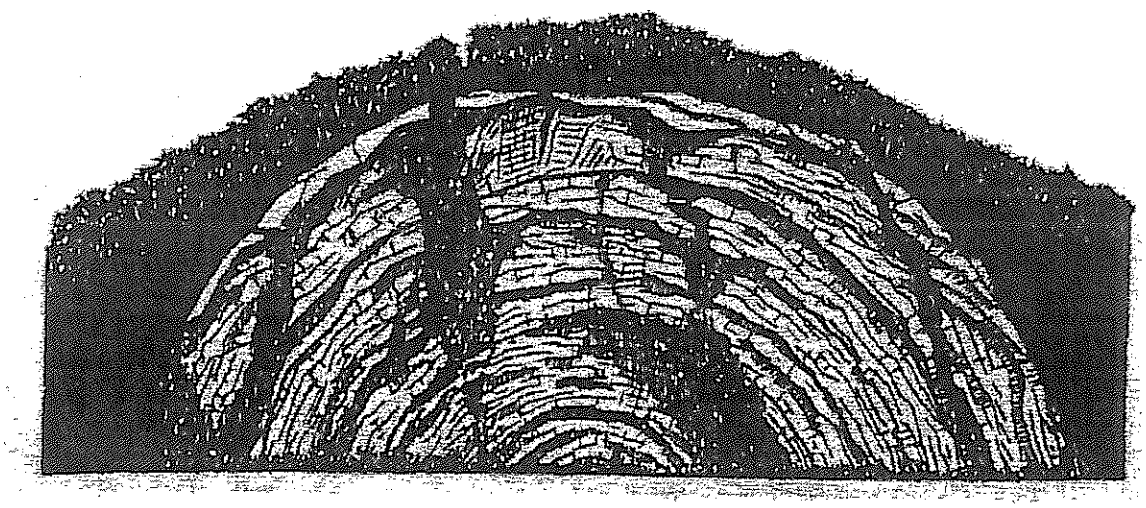


Thrust Fault
A low-angle reverse fault where one body of rock is thrown up and over another body of rock. Common along convergent plate boundaries

Strike and Dip of a Rock

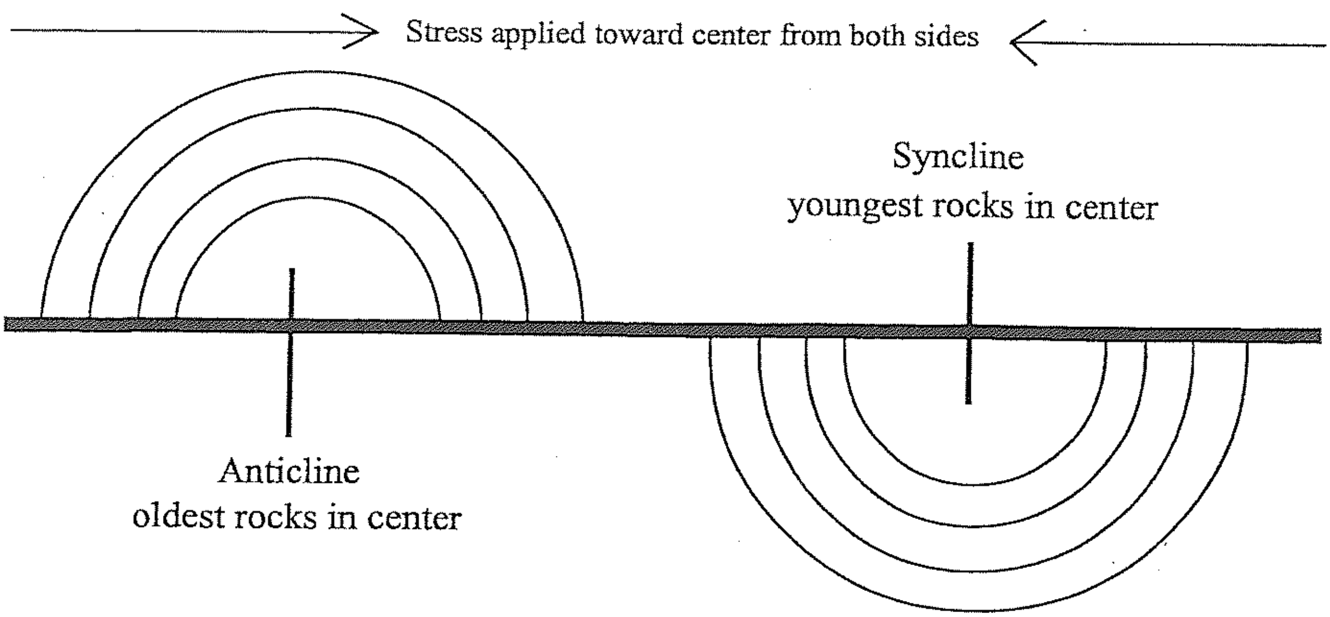


-The **Chickies Furnace No. 1** was built in 1845 and was run by the Haldemans.
-The **Henry Clay Furnace** was built in 1845. It was the first of the anthracite furnaces built in the area. There is evidence that the tavern house located beside the furnace used to lodge the furnace manager.
-The **Chickies Silica Sales Company Stone Crusher** was built at the beginning of the 20th century and primarily crushed limestone used in the construction of railroads. It was later converted to a crush quartzite that was mined from Chickies Rock. The quartzite was used to make refractory linings for furnaces.
-The **St. Charles Furnace** was built in 1854. The remains of the stack can be seen in the winter from the eastbound lane of Rt. 30.



From Chrastina and Jones (1989)

Types of Folding



the Hellam Hills). Evidence of these fragments tells a geologist that weathering and erosion were taking place on the surface, washing those particular rock fragments in the body of water.

Looking at the exposure as a whole, bedding (or sometimes referred to as layering) can be seen in the rock. Some layers contain no pebbles, while other layers contain many pebbles. The layers, when deposited, were laid close to the horizontal, but today are tilted. This is due to the various mountain-building events that have affected our Earth in the last 500 million years and recent weathering and erosion processes.

How Non-Foliated Rocks are Formed

Sedimentary Stage	Metamophic Rock	Mineral Composition and Texture
Sandstone	Quartzite	Quartz with minor amount of mica Coarse-grained texture
Limestone	Marble	Calcite with minor amount of mica Coarse-grained texture

Mining operations in the northwest corner of the quarry have recently exposed the unconformable contact with the overlying Triassic age rocks. These Triassic sedimentary rocks mark the southern edge of the Newark-Gettysburg basin, a remnant of the splitting apart of the supercontinent, Pangaea. Several paleokarst (Triassic age caves) features are also exposed in the west face of the quarry.

The high purity and oolitic nature of the Lower Dolomite Member suggest a carbonate platform and/or platform margin environment. The evidence, along with additional information from the underlying and overlying formations in the Piedmont Lowlands Section, suggest that this was the eastern edge of an ancient "North American" continent known as Laurentia during the Cambrian and Early Ordovician time (Ganis and Hopkins, 1990).

A second pit was opened in 1990 on the east side of Baker Road, and south of East Berlin Road. This pit has produced approximately 400,000 tons of clay, primarily for landfill applications. This area will also eventually be quarried. Several interesting geologic features have been exposed in this pit. This pit contains an algal reef complex that has generated much academic interest. This pit has also generated the first fossils ever found in the Ledger Dolomite formation. Another interesting feature found here are the large pinnacles weathered in the limestone and dolomite.

The Baker Refractories Company goes to great lengths to be a good neighbor in the community. Extensive use of berming and tree plantings is utilized to help reduce the visual impact of the operation. Blasting operations at the quarry are always monitored with a seismograph.

Difference between Limestone and Dolomite

Rock	Major Mineral	Color	Chemical Test
Limestone	Calcite	White to Gray	Will react with hydrochloric acid
Dolomite	Dolomite	White to Gray	Will not react with hydrochloric acid

FAUNAL LIST RECOVERED AT BOOTLEGGER'S SINK
EXCLUDING MAMMALS
(adapted fromGuilday and others, 1966)

Diplopoda:

Millipede (2 species)

Gastropoda:

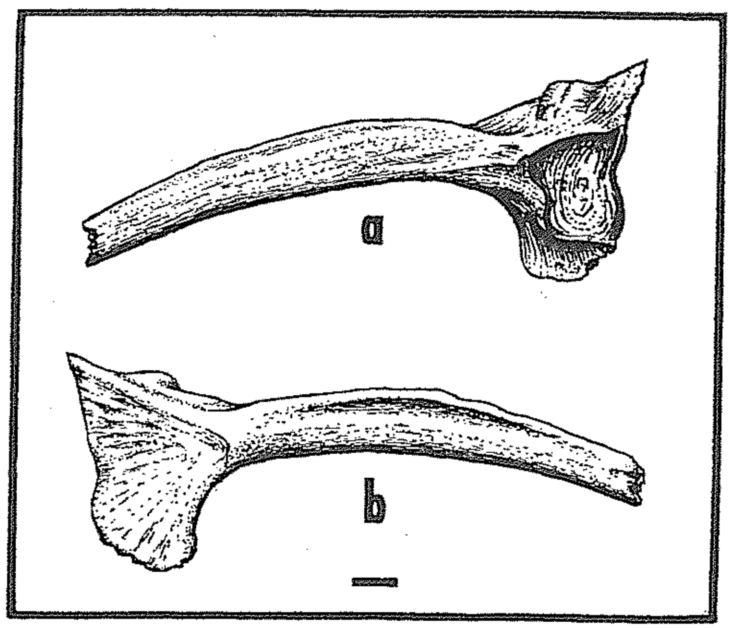
Snail

Amphibia:

Salamander
Spadefoot toad
American toad
Fowler's toad
Tree frog
Leopard frog

Reptilia:

Box turtle
Worm snake
Black racer
Mole snake
Garter snake
Rattlesnake
Copperhead



Drawing of Spadefoot toad vertebra. A. External view. B. Internal view. Bar = 2 mm.
(From Guilday and others, 1966)

Stop 6 – Codorus Stone Company Quarry

This particular stop brings us to a mineral resource that has made this section of the Piedmont famous – its limestone and dolomite. In York County, seven different quarries currently are active, removing limestone and dolomite for a wide variety of uses. These include construction materials, fertilizers, agricultural products, road aggregate, cement, refractories, and pet food. Here at Codorus, the stone is used entirely for road aggregate.

The quarry was incorporated by the Parthmer family of Mt. Wolf in 1954. Work progressed slowly until 1972, when the Susquehanna Quarries Company took over the quarrying operation. From 1984 to 1993, General Crushed Stone Company quarried the rock. Presently, Benchmark Company does the quarrying, while Codorus Stone Company is responsible for the sale of the stone. Today, five benches (or also known as levels or lifts), have been developed at a depth of approximately 160 feet. The quarry has been worked along the strike of the strata for a distance of over 2,000 feet with a width of about 500 feet. Excavations generally continue toward the east.

The rocks exposed in the quarry belong to the Vintage Formation, named from its great, continuous exposures in the railroad cuts near Vintage, Lancaster County. The Vintage formation is the oldest limestone/dolomite (here to referred to as carbonate) unit in the York Valley. Based on fossils, the formation is believed to be about 540 million years old. The contact between this formation and the older, underlying, Antietam Formation (sandstone and quartzite) is located about 300 feet north of the active quarry. Thickness of the formation could be as much as 1,000 feet, but probably is about 650 feet.

The rock exposed in the quarry is a generally thick bedded, well stratified dolomite. Because the layers are dipping southeast, the younger dolomites are found in the southeast corner, while the oldest rocks are found on the north wall. The presence of layering is quite obviously as you look on the east wall. Upon closer inspection, one can spot a difference between the beds – layers magnesium rich are darker in color than those layers that are calcium rich, which are lighter. Also, some of the dolomite contain sub-angular rock fragments, making this rock a limestone conglomerate. Some of the fragments are up to 0.75 inches across. It is believed that this conglomerate may represent an underwater "landslide" in an ocean from which these sediments eventually formed these carbonate rocks.

Within the quarry and so much typical of the York Valley, many faults disturb the strata. Several faults are evident on the south, north, and east wall and are often times marked with calcite veins. One particular fault zone located at the top two levels of the quarry near the northeastern corner is well marked by numerous calcite veins, tightly folded carbonate rock and occasional slickenlines (striations produced as two masses slide past each other). Other than the faults and consistent dipping of the strata toward the southeast, the rock is uniform throughout the operation.

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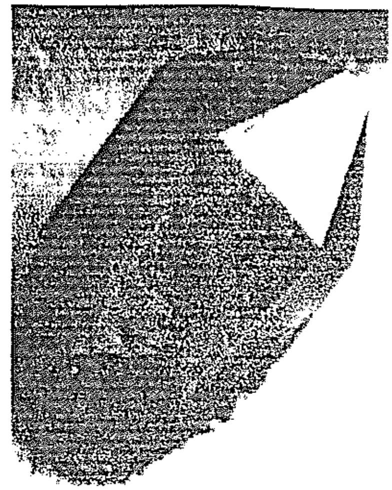
ZION'S VIEW LOCALITY

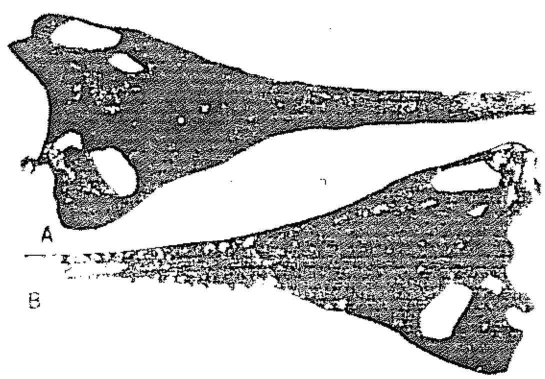


QUARTZ CRYSTAL

GEOLOGICAL HIGHLIGHTS

OF

YORK COUNTY



RUTIODON SKULL, LITTLE CONEWAGO CREEK

JERI L. JONES, 1998
PROGRAM FACILITATOR
YORK COUNTY DEPARTMENT OF PARKS AND RECREATION

INTRODUCTION

Believe it or not, everyone of us is exposed to the science of geology, or better known as the earth sciences. We live on this planet known as the Earth, which is of course, a member of the solar system. With our technology of today, we are now able to send un-manned missions to the planets, and through these efforts thus far, we have gained much knowledge about the planets Venus, Mars, Jupiter and our Moon. Our Earth is very special to us and is provides a perfect home for us.

The question here, though, is how much have you played attention to the landscape, valuable mineral resources, the type of rocks we walk on every day and the effects that geologic hazards may have on our terrain. York County is full of beautiful landscapes, from the rolling hills in the southern section, to the linear valley in the Wrightsville-York-Hanover area to the mountainous appearance of the extreme northern part, geology plays a major role in the development of our landscape and culture. Past and present, York County has played host to a number of mineral resources. Iron, copper, clay, limestone, dolomite, and sand and sandstone have all been removed to benefit us. Geologic hazards such as sinkholes, ground water contamination and landslides and earthquakes have affected our residents.

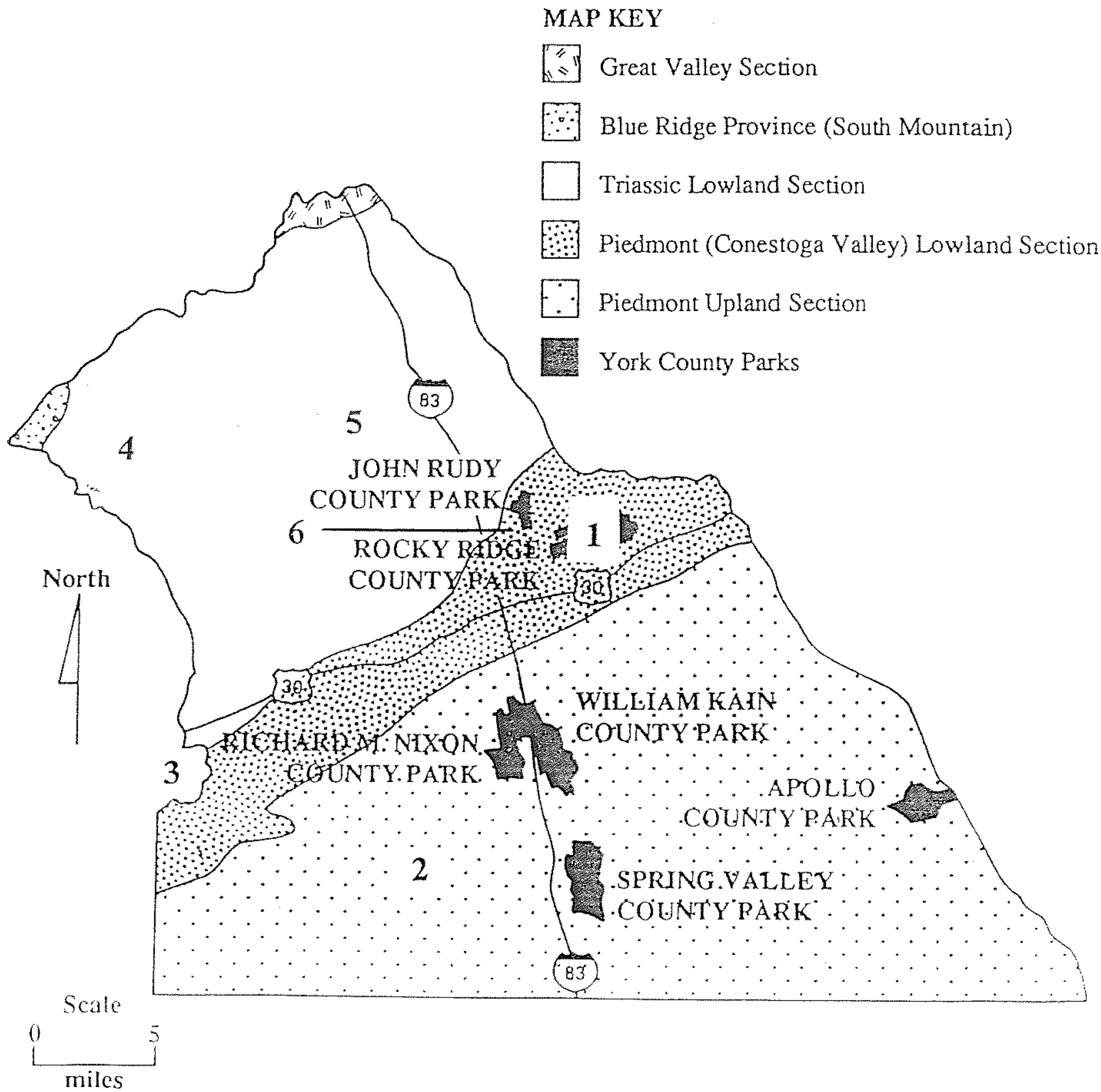
With York County containing all three rock classes (igneous, sedimentary and metamorphic) with ages ranging from 820 million years to 170 million years, our Earth's crust in the area shows a geologist what this area has been through in some 650 million years of the Earth's 4.6 billion year history. From this field trip, you will learn that several different episodes of continental collisions and "splitting apart" have left a scar in our bedrock.

The field trip to designed to show you some of the "key" geologic locations in York County. It is not the intention of this guide to provide all of the information about the region, but to give you a general understanding of the surroundings. A number of geologic aspects will be examined, from rock types, mineral resources, geologic history and geologic hazards. You will see how a geologist views the landscape as they drive down a road, looking at roadcuts and natural exposures.

It is hoped that you find this guide useful in learning more about our section of the Earth. If you view the Earth's geology as a jigsaw puzzle, York County is only a very small piece of the entire puzzle. As we learn more about our piece of the puzzle, this information will assist in putting several more pieces of the puzzle together. But, don't think a geologist has all of the answers about what this area was like, say 500 million years ago. Like any other scientist, a geologist often works on theories or developed ideas, and like a detective, the geologist looks for any clues to help in "firming up" their theory. As technology continues to advance, better methods of investigation will be developed to improve this process.

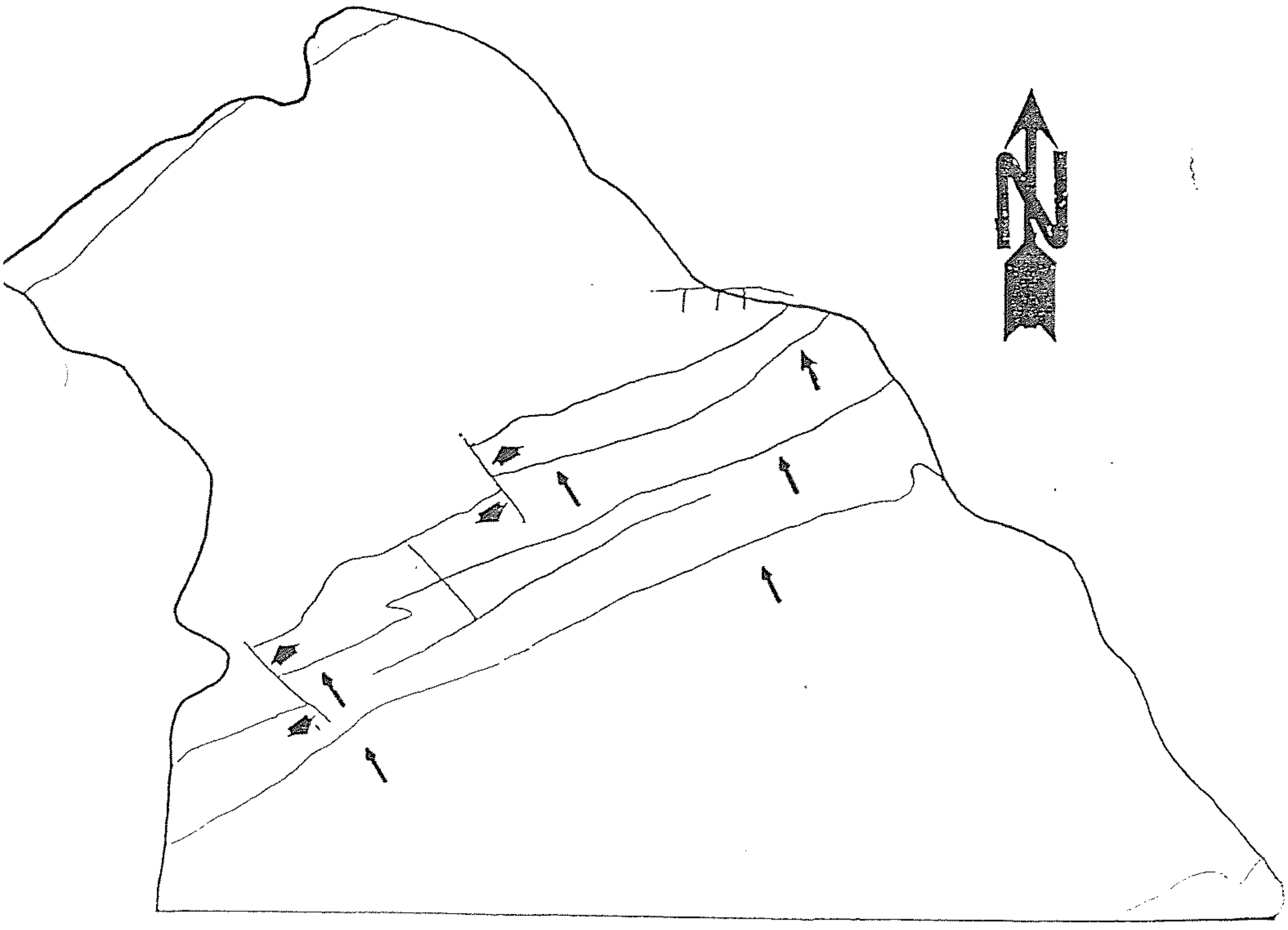
Enjoy our trip and please feel welcome to take home samples and knowledge

PHYSIOGRAPHIC PROVINCES OF YORK COUNTY



(MODIFIED FROM KREIGER AND JONES, 1992)

FAULTS OF YORK COUNTY



SOUTHWEST-NORTHEAST FAULTS WERE CAUSED BY THE AFRFICAN - NORTH AMERICAN COLLISION WHILE THE NORTHWEST-SOUTHEAST FAULTS WERE CREATED DURING THE BREAKUP OF PANGAEA.

ARROWS INDICATE DIRECTION OF RELATIVE MOVEMENT

GENERAL COMMENTS OF THE PHYSIOGRAPHY AND GEOLOGY

The topography of York County is greatly influenced by the underlying geology. As one would drive north to south on Interstate 83 or U.S. Route 74 or east to west on U.S. Route 30, a change in landscape is easily noticed. The topography in York County fall basically into two geologic regions: the Blue Ridge and Appalachian Piedmont provinces. Each province contains its own elevation above sea level, rock types, soil types, and in some cases, vegetation.

Locally the Blue Province, is known as South Mountain and is located in the northwestern corner of York County. The Blue Ridge continues southward into Tennessee, where the scenery along the Blue Ridge Parkway is breath taking in the "Smoky Mountains". The Blue Ridge terminates near White Rocks about two miles north of Dillsburg, marking the northern terminus of the Blue Ridge Mountains. Its elevation range from 600 feet o 1,400 feet above sea level. In fact, the highest point in York County, Stone Head, at the elevation of 1,380 feet above sea level, is located 3.5 miles southwest of Dillsburg. Rocks within the Blue Ridge represent igneous, sedimentary and metamorphic rocks ranging in age from 820 to 540 million years old, and have been strongly folded and faulted.

The remaining portion of York County belong to the Piedmont province, where again based on physical characteristics, the Piedmont can be divided into sections as follows:

TRIASSIC LOWLAND SECTION: Named from a geologic period 235 - 180 million years ago, this section occupies the northern third of the County. Route 74 crosses the section between Shiloh and Dillsburg or Interstate 83 from Emigsville and Reeser's Summit. The average elevation is 400 - 600 feet, however some peak like "Ski Roundtop", Blair Mountain and Neill's Hill rise above 1,200 feet above sea level. The rocks within this section have been nicknamed "brownstone" because of its characteristic color. The rocks are sedimentary in origin, and composed of sandstone, conglomerate shale, mudstone and minor amounts of limestone. Also the igneous rock, diabase (nicknamed by farmers as iron stone), occurs in the higher elevations due to its resistance to erosion and weathering. Because these rocks were deposited after the last major geologic event seen in York County, these rocks remained undeformed, and tilt into the Earth generally toward the northwest at a low angle. Few faults are known in the area, although the boundary between the Blue Ridge Province and the Triassic Lowland Section is marked by the "Border Fault", which has been an active earthquake feature in Berks County. Also, the first documented earthquake west of the Susquehanna River occurred within this section near Dillsburg in June, 1997.

CONESTOGA VALLEY SECTION - Also known locally as the York - Hanover Valley, this region is the heartland of York County. U.S. Route 30 is found in this region from Wrightsville westward through York to Thomasville. From here, Route 30 passes into the Triassic section, while Pa. Route 116 follows the valley to Hanover. General elevation in this section range from 250 - 550 feet above sea level. Rocks within the York Valley are mostly sedimentary, such as sandstone, limestone, dolomite, shale, and conglomerate. Two "highlands" found within this section are known as the Hellam Hills, located between Pleasureville and the Susquehanna River and the Pigeon Hills, located between Thomasville and Hanover. The eastern extension of the Hellam Hills in Lancaster County is known as Chickies Ridge and Chestnut Ridge, which contains one of the classic "arch-shaped" fold known as an anticline on the East Coast called Chickies Rock. Elevations here range from 350 feet to over 1,000 feet above sea level in the Hellam Hills and over 1,200 feet in the Pigeon Hills. Rocks within these highlands are mainly composed of the metamorphic rocks, quartzite and phyllite. The oldest rock in these two "highlands" are known as metabasalt and are believed to be about 820 million years old, meaning that, yes, the first recorded geologic event recorded within our rock was volcanic in origin. Faults are very numerous within this section, as both normal and reverse(thrust) faults are present. In York County and particularly in the Conestoga Valley Section, the north-south faults are normal faults while the northeast-southwest trending faults are thrust faults.

UPLANDS SECTION - This section occupies the southern third of York County. The area is characterized by northeast-southwest trending ridges and rounded hills separated by narrow valleys. Elevations range from 600 - 900 feet above sea level. The rolling effect is clearly seen along Interstate 83 from Leader Heights south to the Maryland line. Flat areas are a rarity with this "roller-coaster" topography. This entire section is composed of metamorphic rocks such as schists, marble, phylitte, metabasalt and slate. Most of these rocks have gone through at least two periods of intense heat and/or pressure created by continental collisions or rifting. Due to the multi-metamorphism of these rocks, their exact age has been debated by geologists for years, but are believed to be 450 - 375 million years old. Several reverse faults have been mapped within this section in York County. The most familiar and yet still debated structure is the "Martic Line", named from Marticville, Lancaster County. This structure is believed to be a fault, although the lack of good continuous exposures in York County and lack of evidence still allows geologists to debate its existence as a fault. The Martic Line has been associated with at least one earthquake in Lancaster County in 1984.

Because of our climate and variety of rock types, continuous rock exposures similar to the western states do not occur. Without these continuous exposures, some guess work by the geologist has to be done to complete a geological map of an area Often times, structural features like faults will not be seen. One example of this seems to have occurred associated with the June, 1997 earthquake south of Dillsburg Through fieldwork following the seismic event. a possible unknown fault has been proposed and is currently being researched further attempting to prove its existence.

Some of the best rock exposures in York County occur along the major transportation routes such as roads and railroads. Also, the existence of a quarry or a stream often opens up new views of the Earth's crust that aids in the placing the correct pieces of the puzzle together.

STOP 1 - ROCKY RIDGE COUNTY PARK NORTH OVERLOOK

HIGHLIGHTS HERE - (1) scenic overlook to the north and east and (2) exposure of the Hellam Conglomerate.

One of the best views of northern York County and points north and east is found here. With the more resistant conglomerate underlying the Hellam Hills at this point and the less resistant, softer rocks making up the valleys, this scenic overlook provides us a lovely setting. As you look north from this point, the cooling towers of Three Mile Island are evident. In front of the cooling towers, you will see the smoke stack of Pennsylvania Power and Light Company's Brunner's Island, located near York Haven. Located just the left of these facilities, you can pick out one of the water gaps located near Goldsboro. These water gaps have made the Susquehanna River nationally famous, as it has cut through massive rock strata within the Appalachian Mountains and the Piedmont Province. If you look to the northwest, the furtherest, highest peak is Ski Roundtop, a popular ski resort. As you continue to turn toward the east from Three Mile Island, a small ridge with three "peaks" just to the right of the nuclear power plant is found just north of Middletown. Further east and when the Sun is at the appropriate angle, you may see a tall antennae, which is the radio tower located at the junction of Pa. Route 741 and Pa. Route 283 at Elizabethown. Slightly to the left of this tower, you may be able to pick out a large "mansion-like" brown building. This is the Masonic Home just south of Elizabethtown. Closer to us in front of the Masonic Home, the white smoke stack is that of the Lancaster County Solid Waste Authority Incinerator near Bainbridge. Finally, facing slightly south of east and looking at the nearby peaks of the Hellam Hills, the tall tower is that of WGAL TV's transmitter. Just to the right of the tower, you will notice a tower that resembles "a golf ball sitting on a tee". This is the WGAL Dropper Radar unit.

One may ask, exactly how far can you see from this point? Well, on a clear day, the high range seen in the distance is known as Blue Mountain, the first ridge of the famous Appalachian Mountains (also known as the Valley and Ridge Province), north of Harrisburg. If you follow this ridge to the east where it almost disappears, you will see a "gap" in the ridge. This is where Pa. Route 61 travels north through the ridge heading toward Pottsville, located about 3 miles north of Hamburg, Berks County. This is a distance of 52 miles as a crow flies from here.

Druck Valley Road runs parallel to the Hellam Hills to the north The trailer park visible on the north side of the road is Brookside Trailer Park. A line of houses running left to right on ridge above the trailer park marks the location of Codorus Furance Road east of Mt. Wolf. In front of these houses, you may be able to pick out a meandering wooded line which marks where the Codorus Creek flows from North Sherman Street Extended to the Susquehanna River.

The rock exposes here at Rocky Ridge County Park is known as the Hellam Conglomerate. As mentioned above, we are situated on top of the Hellam Hills, that runs from Pleasureville to our west to the Susquehanna River to the east. This conglomerate is the oldest sedimentary rock found within this area. The Hellam Conglomerate is a member of a larger rock unit known as the Chickies Formation, named after Chickies Rock along the Susquehanna River, the eastern extension of the Hellam Hills. The Hellam Conglomerate is somewhat localized though, as it only extends from Mt. Zion Road east to the river and is not found in Lancaster County.

Not only is the conglomerate the oldest sedimentary rocks in the Hellam Hills, but is also regarded as one of the oldest sedimentary rocks in Pennsylvania. It has been dated at 620 million years old. One theory on its origin suggests that this may have represented a delta environment, where a body of water is flowing into a larger body of water. Similar modern day examples would be where the Codorus Creek flows into the Susquehanna River or where the Susquehanna River flows into the Chesapeake Bay. The velocity of the water had to be strong to be able to carry these large rock fragments making up the conglomerate, but as it intersected the large body of water, it's velocity dropped, not able to carry the fragments and dropping the well-rounded rock pebbles to the stream bed. The higher the velocity of the water, the larger a pebble it can carry.

The majority of the pebbles are composed of quartz, one of the most durable minerals. Because of their resistance, one will notice that the pebbles actually "stick up" higher out of the rock. The groundmass of the rock is composed of small crystals of quartz, mica, and chlorite. With a closer inspection of the rock, a few of the pebbles are made up of the oldest rock in the Hellam Hills, metabasalt, which has been dated at 820 million years old. This shows that sometime after the volcanic rock was formed, erosion and weathering was taking place with small pieces of rock being carried into a body of water.

Also, looking at the rock exposure here as a whole, evidence for bedding (or sometimes referred to as stratification), can be seen. This is present in all sedimentary rocks, since these rocks have been formed in a water environment. Each layer would represent a short geologic period where deposition took place. Since the Hellam Hills have been affected by weathering and erosion for literally millions of years (the last major geologic episode to occur in this area occurred some 175 million years ago), these big boulders of conglomerate are slowly creeping down the hill due to gravity. Although, it appears that the layers are tilting (or dipping) into the Earth at a high angle, a geologist has to remember that this would not represent a true angle reading. If you would walk the trails here at the park, you would notice thousands of the well-rounded pebbles laying lose on the ground as they have weathered out of the rock as the Hellam Hills slowly erodes down.

Within the Chickies Formation, ***Scolithus*** tubes have been found in the quartzites (metamorphosed sandstone). These tubes are believed to represent a borrow made by a worm that resided in a very shallow marine water. As the waves disturbed the bottom, the ***Scolithus*** fed on small organism. Because worms are soft-bodied animals, their remains do not fossilize, only leaving their borrows present for geologists to ponder over.

STOP 2 - GLEN ROCK RAILROAD CUT
YORK COUNTY HERITAGE RAIL/TRAIL COUNTY PARK

HIGHLIGHTS HERE - Metamorphic rocks - Wissahickon Schist and metabasalt

This exposure is located along the York County Heritage Rail/Trail County Park on the northeast side of the South Branch of the Codorus Creek, about 1600 feet southwest of the Glen Rock Borough square. This stop contains two exposures totaling more than 1650 feet.

This location contains a good exposure illustrating the contact of the Wissahickon formation with metabasalt. The Wissahickon Formation was named by F. Bascom from the exposures along Wissahickon Creek, in Philadelphia. This formation occupies the southeastern section of the county. The predominate rocks are composed of schists that vary in color within a matter of several feet due to variation in composition but are basically closely folded, coarse-grained, sparkling, and grayish-blue in color. All weather to a dark reddish-brown color. What appears to be layering or stratification, like seen in sedimentary rocks, is actually known as schistosity,, a feature characteristic only to metamorphic rocks. Under a microscope, the schist is composed of albite, chlorite, muscovite, and quartz. Accessory minerals also seen here include epidote, garnet, ilmenite, apatite, titanite, and iron oxide. Selenite, the fibrous variety of gypsum is often seen on weathered surfaces of both the schists and metabasalts.

The metabasalt occurs as narrow lenses infolded with the Wissahickon rocks and can be differentiated from the schists in outcrop by its lack of cleavage, and a more dense sound when struck with a hammer. A fresh surface of the metabasalt is distinctly dark green in color and is fine grained than the schists. Albite, hornblende, epidote, and chlorite are the main components and give the rock its green color.

Quartz veins and pods commonly are infolded with the metamorphic rocks. Occasional mica fragments and iron oxides are present in the quartz. It is also believed that the native gold is found in quartz veins and pods. Because the gold is so small, the mineral has never been found "in situ" in any of the rocks. In the case of Spring Valley County Park where the East Branch of the Codorus Creek contains placer gold, located about 7 miles east of here, the mineral is originating from the quartz veins within the metabasalt, since gold commonly forms around volcanic regions. Al in all, about 15% of the streams in York County contain gold, mostly associated with igneous rocks.

As one starts at the northern end of this stop and proceeds southward, the Wissahickon schists are exposed. Note the close folding, well developed cleavage and schistosity, grain size and color variation in the schists and the white coating of selenite on the rocks. About 10 feet north of the southern end of this first cut, the metabasalt comes in contact with the schists. Note the change in color from the bluish-gray schists to the dark-green metabasalts. Cleavage has become less distinct. Because the metabasalts are less resistant to erosion, the valley between the two cuts is underlain with this rock. The schists once again appear more resistant approaching the southern cut. Again, near the southern end of the stop, the schist-metabasalt contact occurs and the later underlies the valley to the south.

Because these rocks are metamorphic, we have to guess their origin. Because the two rock types are folded together, they are considered the same age. Studies over the years have indicated that the rocks are Precambrian in age (600 million years or older), but more recent studies have suggested a much earlier date within the Ordovician Period (520-450 million years). The high content of titanium and iron oxide may suggest a volcanic origin for a portion of the Wissahickon Formation, since these two elements are considered original constituents. The metabasalts are certainly volcanic in origin as they at one time were volcanic lavas. Minerals such as epidote, muscovite, and chlorite represent a low-level metamorphism versus where garnet is present suggests a higher grade of metamorphism.

What is meant by metamorphism and how does it occur? In this case, heat and pressure, produced during the intense folding changed the composition of these rocks. There is a decrease in metamorphism from southeast to northwest in this region. This process of folding and metamorphism took a long period of time, with the earlier metamorphism more intense than the later part. It is believed in these rocks, that at least two different episodes (and possibly three) of metamorphism occurred. Each more recent episode of metamorphism literally eliminated any evidence of a prior metamorphism event, making the real story of its geologic history more difficult for a geologist to decipher.

METAMORPHISM RANKING

SHALE - SEDIMENTARY ROCK COMPOSED OF CLAY

HEAT AND/OR PRESSURE INCREASE DOWNWARD

PHYLLITE - CLAY PARTICLES CHANGE TO MICRO MICA CRYSTALS
SLATE - MICA AND OTHER ROCK-FORMING MINERALS ALIGN THEMSELVES TO CREATE FLAT FOLIATION SO COMMON TO SLATE
SCHIST - LARGER MICA AND QUARTZ CRYSTALS FORM GIVING THE ROCK A COARSE-GRAINED APPEARANCE
GNEISS - LIGHT AND DARK COLORED MINERALS ZONE THEMSELVES. GIVING THE ROCK AN ALTERNATING DARK/LIGHT "LAYERING" APPEARANCE

OTHER SEDIMENTARY TO **METAMORPHIC ROCK** EXAMPLES:

SANDSTONE CHANGES TO **QUARTZITE** & LIMESTONE CHANGES TO **MARBLE**

STOP 3 - NEW OXFORD CONGLOMERATE ON ROUTE 194

HIGHLIGHTS HERE - The base of the Triassic Period; Start of the last rock-forming event in York County; Exposure of the New Oxford Conglomerate

The word "Triassic" is a geologic period that lasted from 225 - 180 million years ago. In Pennsylvania, the Triassic rocks are found in a 10 - 20 mile wide section through southeastern Pennsylvania. Of course, the rocks don't terminate at political borders but extend into surrounding states north into Connecticut and south into Alabama. Along this region and since the rocks don't follow strike continuously, each area is known as a "Triassic Basin". In this section of Pennsylvania, we are located is what is known as the Gettysburg Basin which extends from near Harrisburg into Maryland.

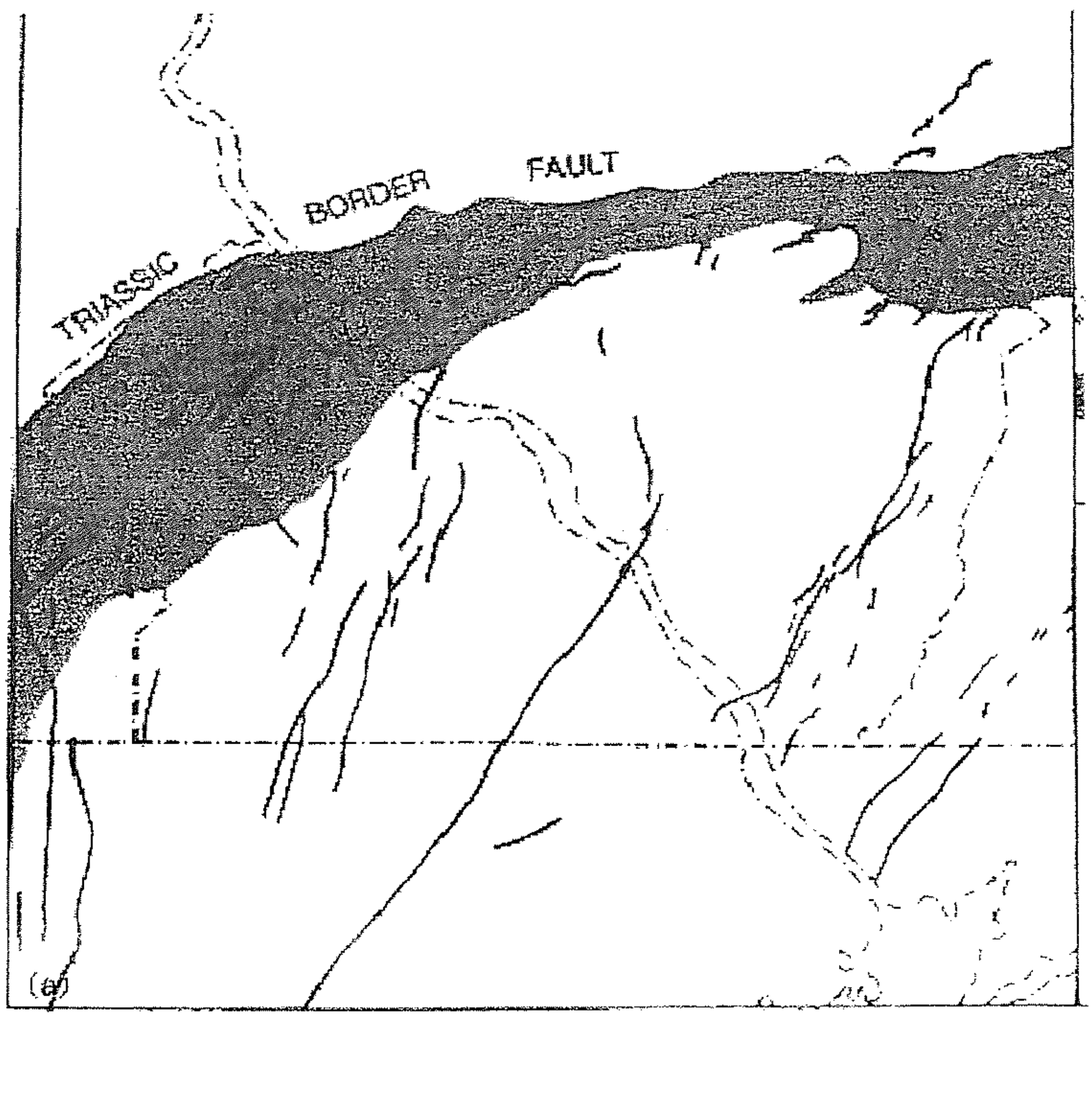
As you stand here and face northwest, imagine being here 220 million years ago. The climate then was compatible to that of the Everglades in Florida. Picture a swampy environment with abundate vegetation (ferns, water plants, etc) and trees (mostly palms an conifers). An occasional meandering stream, small tributaries and isolated lakes are also visible. Also, with a little luck, you might see a reptilian-type "dinosaur" walking through the swamp or feeding along a small beach (see Stop 5). This describes what the Triassic environment was like in Pennsylvania.

Because of the "Everglades" climate, there was also a large amount of rainfall, allowing a rate high of erosion form the surrounding highlands. The Triassic area was the lowlands at that time. Bordering the basin to the south in this immediate area were the Pigeon Hills, while the Blue Ridge Mountains and Appalachian Mountains bordered the basin to the north. The runoff carried weathered rock fragments into the basin.

That leads us into the rock located at this stop. Known as a conglomerate similar to Stop 1, this rock belongs to the New Oxford Formation. The type locality is found in a railroad cut in New Oxford, Adams County. This conglomerate was the first rock formed during the Triassic period and has been dated at 220 - 215 million years old. If you would walk northwestward across the basin, the rocks would become younger, as all of the strata within this area is tilted into the Earth at a gentle angle toward the northwest. Most of the pebbles within this rock are composed of rock fragments that originated from bedrock in the Pigeon Hills (quartzite, phyllite and basalt). It probably took at least two million years for this sediment (fragments and finer sand to lithify into a rock. By the way, the quickest that anything in geology can happen is about two million years.

This particular exposure is one of the best for the New Oxford conglomerate. Layering is easily observed. Each layer has a particular story to tell about the environment of deposition. For example, currents were able to transport larger sediment to form coarse-grained rocks. A slower water current could only transport fine-grained sediment. Compared with the conglomerate at Stop 1, these fragments are not nearly as rounded, indicating that the distance these have ben transported was considerably shorter here for the New Oxford conglomerate.

As we travel through the Triassic area north to the Dillsburg area, you will notice that the Triassic rocks produce a distinct greyish-brown sandy soil, easily marking the location of the Triassic Section.



VIEW OF GETTYSBURG BASIN IN PENNSYLVANIA
(FROM CHRASTINA AND JONES. 1989

STOP 4 - SITE OF JUNE, 1997 EARTHQUAKE CABIN HOLLOW ROAD, WARRINGTON TOWNSHIP

HIGHLIGHTS HERE - Site of first documented earthquake in southeastern Pennsylvania, west of the Susquehanna River; Gettysburg Formation with diabase

We have driven nearly across the width of the Triassic Basin in York County. To the north and west, the highlands of the Blue Ridge Province are obvious. This a great vantage point to see the sudden change in topography between the Triassic area and the Blue Ridge Mountains. We are now located within the youngest of the two geologic formations within this section, known as the Gettysburg Formation. The unit, named for its excellent exposures along the railroad west of Gettysburg, sandstone, shale, limestone and a fanglomerate (rock resembling a conglomerate but the pebbles are mostly angular in outline and probably formed on an alluvial fan environment), are found here. The unit is believed to be about 210 - 190 million years old. Slightly younger diabase intrusions occupy the higher elevations here due to their resistant to erosion and weathering. Along the contact between the sedimentary rocks and the igneous rock, formed iron deposits, rich enough to mine during the 19th century. The famed Cornwall Iron Mine in Lebanon County, formed in the same way. A cluster of mines were located about 1.0 mile west of Dillsburg and about 0.5 mile north of Wellsville, to our north and south respectively.

This location became a focus for several geologists in June, 1997, when residents reported three different episodes of earth vibrations within alittle more than a 24-hour period. Local sesimographs at Millersville University in Lancaster County and the Delaware Geologic Survey in Newark, recorded two of the "events". After Dr. Charles Scharnberger, of Millersville University, conducted resident interviews and prepared an isoseismal map showing the areas of degree of vibration felt, a theory on what really happened was developed. One possibility was that one of the abandoned iron mine shafts may have collapsed, creating the "tremors", but there were three different episodes. Also, an attempt to correlate the epicenter of the quakes and location of any known iron mines failed, as the epicenter plainly occurred well outside any known mining districts. Although Dr. Scharnberger's map was accurate, further interviews by Dr. William Kreiger of York College of Pennsylvania and the author, backed up the original findings. A questionnaire was placed in the *Dillsburg Banner* for area residents to complete and return to Dr. Scharnberger. About 70 residents took the time to complete the five questions, which did not reveal any new findings, but again, followed the pattern already placed on paper. Following is an article that was written for publication concerning the earthquakes and presented at the Seismological Society of America - Eastern Section Meeting in Quebec, Canada in October, 1997.

AN EARTHQUAKE IN YORK COUNTY, PENNSYLVANIA

Dr. Charles K. Scharnberger, Millersville University
Jeri L. Jones, York County Department of Parks and Recreation
Dr. William Kreiger, York College of Pennsylvania

The Earthquake

A small but interesting earthquake occurred near Dillsburg, York County, Pennsylvania, in the early morning hours of June 16, 1997. The earthquake, with an estimated magnitude of 2.4, was recorded by the 1 hz vertical seismograph at Millersville University and by the Delaware Geological Survey in Newark, Delaware. The local time was 1:43 a.m., EDT. At least one aftershock was felt at 10:04 p.m. the same day and was recorded by Dickinson College in Carlisle. Its magnitude was estimated to be 1.6. Millersville University did not record the aftershock because the drum recorder was off line for approximately two minutes for the paper to be changed right at the time (Murphy's Law).

Some residents who live near the estimated epicenter of the main shock reported feeling possible small earthquakes around 9:45 p.m. the previous evening, June 15, and about 3:22 a.m. on June 16. A few residents claimed to have felt mild shocks over a period of months preceding June 16. A report of an additional aftershock came on August 3 from a person living near the inferred epicenter of the main shock.

The authors conducted an intensity survey through approximately 60 personal interviews with residents, supplemented by 16 returned survey questionnaires that were published in the Dillsburg Banner newspaper. Through these interviews and questionnaires, an isoseismal map was constructed using the modified Mercalli scale of earthquake intensities (Fig. 1). Our best estimate of the location of the epicenter is the center of the intensity IV zone, that is, 4 km. southeast of Dillsburg, at latitude 40.445 N, longitude 77.003 W.

An immediate speculation about the cause of the earthquake was that it was due to collapse of one of about 25 abandoned iron (magnetite) mines in the area. After completion of the isoseismal map and examination of the location of the mines, however, the authors concluded that the epicenter was located approximately 3 km, from the mines to the north, near Dillsburg, or those to the south, near Wellsville, and that no mines were known to exist in the immediate area of the epicenter (Jones, 1996).

Is there a Fault?

Although this earthquake was very small, it has several points of interest. First, this event confirms previous observations that seismicity in southeast Pennsylvania is associated with the margins of the Newark-Gettysburg Basin (Scharnberger, 1993). This is the first well-documented earthquake in the portion of the basin west of the Susquehanna River. It is unusual, however, in that the epicenter appears to lie within, rather than just outside, the basin.

The asymmetry of the intensity III zone suggests enhancement of intensity on diabase bedrock. On the other hand, interviews, conducted with persons living on diabase just west of Franklintown uncovered no one there felt any of the shocks. The 10:04 p.m. aftershock was felt on the diabase uplands only to the east of the inferred epicenter. The intensity III zone may be even more compressed on the west side than shown because few persons in Franklintown felt any of the events. The elongation of the maximum intensity zone, and higher intensities east of the inferred epicenter compared to the west, suggest movement on a roughly north-striking cross-fault associated with the Triassic border fault along the northwest margin of the Gettysburg Basin, with the east side being the relatively upthrown hanging wall of a reverse fault. This interpretation is consistent with the results of investigations of previous earthquakes in Lancaster and Berks Counties, and with what is known of the regional stress field (Armbruster and Seeber, 1987; Seeber and others, in press).

Field work conducted in July and August in the area of the shocks found evidence of a fault paralleling the intensity III zone pattern. Stose and Jonas (1939) mapped the area as belonging to the Gettysburg Formation and associated diabase sheets. In a new excavation for a housing development in the south end of Dillsburg, hornfels with pronounced slickensides was found. Another exposure of slickensides in the Gettysburg sandstone was located to the south-southeast in a stream cut. These two exposures, a new interpretation of the mapped contact between the Gettysburg Formation and the diabase in the Dillsburg area, interpretation of the aeromagnetic map of the area, and the pronounced linearity of the stream channel, combine to imply the existence of a fault striking approximately N20W (Fig 1.). Several other cross-faults near the Triassic border have been mapped previously (Wood, 1980).

Conclusion

This small earthquake near Dillsburg serves as a reminder of the relatively mild, yet persistent, seismicity associated with the Mesozoic rift basin of southeastern Pennsylvania. In fact, this event was followed five months later by a magnitude 3.0 earthquake south of the basin in Lancaster County on November 13, 1997. Whether a seriously damaging earthquake, one with magnitude as high as 6.0 or so, could occur in this region remains a matter of conjecture, but certainly is not out of the question. In fact, over the past 400 years, approximately 90 earthquakes of magnitude 6 or greater have occurred in regions of stable continental crust, two-thirds of them associated with crust that has been tectonically extended during Phanerozoic time (Johnston and others, 1994).

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STOP 5 - ZIONS VIEW TRIASSIC VERTEBRATE LOCALITY MANCHESTER TOWNSHIP

HIGHLIGHTS HERE - Exposure of the New Oxford Formation containing Triassic reptilian and amphibian fossils.

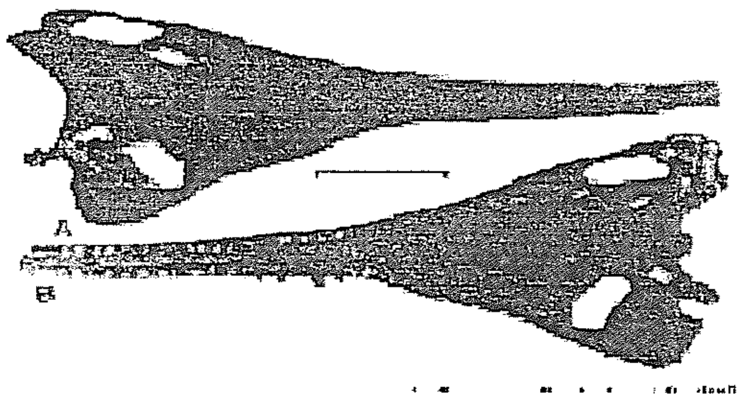
Dr. Robert Spangler Stahle discovered this site in 1909 after hearing of stories that "dinosaur" bones were found along the Little Conewago Creek near Manchester. Dr. Spangler continued his efforts here through 1912. A second round of research occurred at this site in the early 1970's under the supervision of The State Museum of Pennsylvania. Part of the collection accumulated by Dr. Spangler is now at Academy of Natural Sciences in Philadelphia, Princeton University Collection of Yale Peabody Museum in New Haven Connecticut. The collection made in the early 1970's by former Earth Science Curator, Don Hoff, of The State Museum, is at the museum in Harrisburg.

Fossils identified here include clam shrimp and unionid bivalves, which have not been studied. Isolated scales of bony primitive fishes as well as coprolites are common. What has really made this site significant is the finding of a group of crocodile-like reptiles known as phytosaurs and metoposaurs, an ancient amphibian. Some phytosaurs were as much as thirty feet long. All were predators who lived along the Triassic rivers and lakes (see Stop 3). A metopasaur looked something like a salamander, but sometimes grew to six feet long and believed to have been fish eaters.

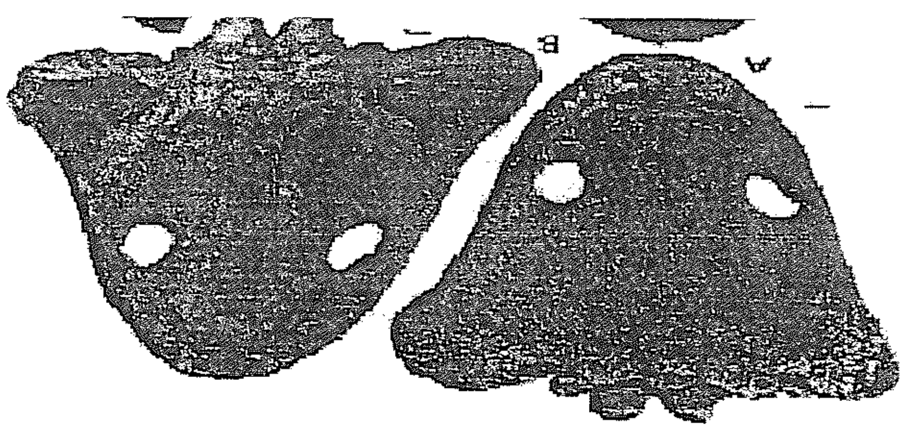
At Zions View, most of the vertebrate fossils belonged to the phytosaur, ranging from a assortment of isolated teeth and bone material, other than the skull and jaws. One of the most significant finds at the site actually was in 1995, when two researchers (Doyle and Sues) identified a phytosaur skull as *Rutiodon carolinensis*. A metopasaur amphibian skull was earlier identified as *Buettneria perfecta,*

Of course, fossils are very important to geologists of interpreting what the environment was like during a certain time. As mentioned in the introduction, a geologist can be viewed as a detective, collecting clues. Fossils can offer many clues and suggest answers to questions. At Zions View, the fossils suggest a freshwater lake as represented by the bivalves, clam shrimp and fishes. The thinly laminated shales of the New Oxford Formation correspond to thin layers of mud normally formed in lakes. Interbedded layers of shaly sandstone and conglomerate also suggest periodic flow of water, perhaps similar to what might occur on beaches or at river mouths along a shore. The phytosaur and metopasaur were water animals that lived in lakes and rivers and part on land (Lucas and Sullivan, 1996).

Triassic fossil finds in York County and adjacent counties are not common by any means, but important when they are found. Over the last 100 years, dinosaur footprints have been recovered from Yocumtown, New Cumberland and Goldsboro in York County; and York Springs and Gettysburg in Adams County. Matter of fact, there is a dinosaur footprint impression of one of the stone bridges on the Gettysburg Battlefield, as the rock used to construct the bridge came from the York Springs site. Localities producing other finds in York County include teeth from a primitive, bird-hipped dinosaur at the LeCron's Copper mine near Emigsville (Cope, 1878) and Wanner (1921) described fish and phytosaur fossils along the Little Conewago Creek near Manchester. Along with animal fossils in the Triassic of York County, there have been several localities described containing petrified wood and fern fossils within the New Oxford Formation in the Dover, Zions View, Manchester and York Haven areas. The plant remains support a tropical climate.



RUTIODON SKULL (FROM LUCAS AND SULLIVAN, 1996



BUETTNERIA SKULL (FROM LUCAS AND SULLIVAN, 1996)

STOP 6 - CODORUS STONE COMPANY QUARRY EMIGSVILLE

HIGHLIGHTS HERE - Exposure of the Vintage dolomite and view of typical quarry

Traveling back into the York Valley where we started our tour at Rocky Ridge County Park, this particular stop brings us to a mineral resource that has made this section of the Piedmont famous - its limestoneand dolomite. In York County, seven different quarries currently are active, removing the limestone and dolomite for a wide variety of uses. These include construction materials, fertilizers, agricultural products, road aggregate, cement, refractories and pet food. Here at Codorus, the stone is used entirely for road aggregate.

The quarry was incorporated by the Parthmer family of Mt. Wolf in 1954. Work progressed slowly until 1972, when the Susquehanna Quarries Company took over the quarrying operation. From 1984 to 1993, General Crushed Stone Company quarried the rock. Presently, Benchmark Company does the quarrying, while Codorus Stone Company is responsible for the sale of the stone. Today, five benches (or also known as levels or lifts), have been developed at a depth of approximately 160 feet. The quarry has been worked along the strike of the strata for a distance of over 2,000 feet with a width of about 500 feet. Excavations generally continue toward the east.

The rocks exposed in the quarry belong to the Vintage Formation, named from its great, continuous exposures in railroad cuts near Vintage, Lancaster County. The Vintage Formation is the oldest limestone/dolomite (from here referred to as carbonate) unit in the York Valley. Based on fossils, the formation is believed to be about 540 million years old. The contact between this formation and the older, underlying, Antietam Formation (sandstone and quartzite) is located about 300 feet north of the active quarry. Thickness of the formation could be as much as 1,000 feet, but probably about 650 feet.

The rock exposed in the quarry is a generally thick bedded, well stratified dolomite. Because the layers are dipping southeast, the younger dolomites are found in the southeast corner, while the oldest rocks are found on the north wall. The presence of layering is quite obviously as you look on the east wall. Upon close inspection, one can spot a difference between beds - layers magnesium rich are darker in color than those layers calcium rich, which are lighter. Also, some of the dolomite contain sub-angular rock fragments, making this rock a limestone conglomerate. Some of the fragments are up to 0.75 inches across. It is believed that this conglomerate may represent an underwater "landslide" in an ocean from which these sediments eventually formed these carbonate rocks.

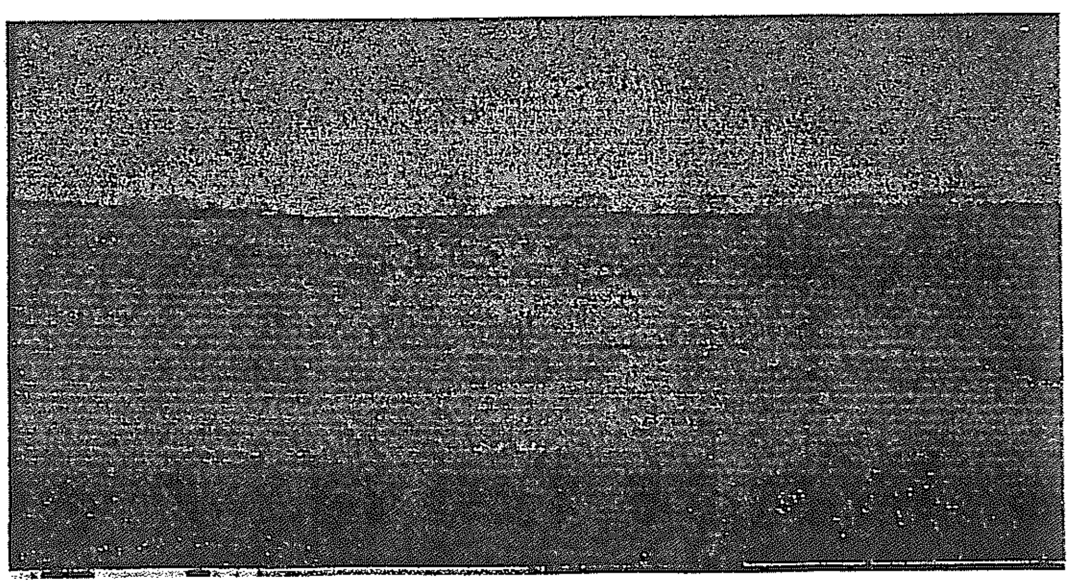
Within the quarry and so much typical of the York Valley, many faults disturb the strata. Several faults are evident on the south, north and east wall and are often times marked with calcite veins. One particular fault zone located on the top two levels of the quarry near the northeastern corner is well marked by numerous calcite veins, tightly folded carbonate rock and occasional slickensides (striations produced as two rock masses slide past each other). Other than the faults and consistent dipping of the strata toward the southeast, the rock is uniform throughout the operation.

Twenty-six minerals have been identified from this quarry. Although many of the minerals are microscopic and require a hand lens or microscope to see, several minerals have formed nice hand specimens. These minerals include calcite, quartz, flourite, and chalcopyrite. The red staining seen on the weathered surfaces of some of the dolomite is hematite.

Located near the southwest corner of the quarry on level four is what has become known as "York County's Niagra Falls". Struck in the late 1980's, this spring yields approximately 1100 gallons of water per hour. This "unwanted" feature within the quarry has created an extra headache for the quarry operators, as regular pumping is required to keep the water level controlled.

Another feature often seen in the York Valley with the carbonate rocks are sinkholes. The Vintage Formation is not as prone to sinkhole development due to its chemical composition (clay percentage). Several small cross sections of clay-filled sinkholes are seen on the upper level of the west wall. In other carbonate formations in York County, sinkhole and cave development is extensive. Several large caves are been uncovered and explored in these quarries. Quarries that have seen large caves include Medusa Minerals quarry and York Building Products both in Thomasville, and the York Building Products Company, Roosevelt Ave. quarry.

In carbonte areas, due to the inconsistent weathering of the carbonate rocks, the contact between the bedrock and soil is not flat, but appears irregular in profile. These is known as karst topography. This irregular contact often makes building construction difficult to find the depth of bedrock.



VIEW OF EAST WALL AT CODORUS QUARRY

GEOLOGIC HISTORY OUTLINE OF POSSIBLE EVOLUTION OF SOUTHEASTERN PENNSYLVANIA

MYA - MILLIONS OF YEARS AGO *BYA - BILLIONS OF YEARS AGO*

DATE	PERIOD	COMMENTS
1 BYA	PRECAMBRIAN	ALL LANDMASSES JOINED TOGETHER ONE SUPER CONTINENT, POSSIBLY LOCATED NEAR SOUTH POLE
820 MYA	PRECAMBRIAN	SPLITTING OF LANDMASS BEGINS CREATING RIFTING AS SEEN BY METABASLTS IN PIGEON HILLS AND HELLAM HILLS AND SOUTH MOUNTAIN.
600 MYA	PRECAMBRIAN	IAPETUS OCEAN BEGINS TO MIGRATE ACROSS STATE FROM EAST TO WEST. POSSIBLE BARRIER ISLANDS PRESENT OF COAST AS REFLECTED FROM BY ANTIETAM FORMATION. LIMESTONE DEPOSITS IN YORK VALLEY BEGIN TO FORM AS WELL AS THE CHICKIES FORMATION. VOLCANIC ISLANDS FORMING OFF OF EAST COAST.
440 MYA	ORDOVICIAN	VOLCANIC ISLANDS COLLIDE WITH NORTH AMERICA FORMING PIEDMONT REGION NEAR BALTIMORE AND PA-DE-MD AREA. ROCKS IN THE SOUTHEASTERN UPLANDS SECTION MAY BE CONTINENTAL SHELF DEPOSITS FROM EITHER THE CONTINENTAL CRATON OR VOLCANIC ISLANDS. CREATES METAMORPHISM AND MOUNTAIN BUILDING PROCESSES
350 MYA	MISSISSIPPIAN	MAJOR COLLISION BETWEEN AFRICA AND NORTH AMERICA OCCURS CAUSING MAJOR CRUSTAL DISPLACEMENT AND METAMORPHISM. PRESENT

		APPALACHIAN MOUNTAINS FORMED AND THOUGHTS ARE THAT THE CRUST WAS PUSHED SOME FIFTY MILES TO THE NORTHWEST FROM ORIGINAL LOCATION. IAPETUS OCEAN MIGRATING MORE INTO WESTERN PENNSYLVANIA.
230 MYA	PERMIAN	ALFRED WEGENER'S SUPER CONTINENT PANGAEA BEGINS TO SPLIT APART WHICH WILL EVENTUALLY FORM THE EARTH AS WE KNOW IT TODAY.
225-180 MYA	TRIASSIC	RIFTING CONTINUES AS AFRICA ANNORTH AMERICA SPLIT APART FORMING THE ATLANTIC OCEAN. TRIASSIC "REDBEDS" ARE DEPOSITED IN EVERGLADES ENVIRONMENT. THE TRIASSIC BASIN WAS A RIFT THAT WAS ATTEMPTING TO TEAR AWAY FROM NORTH AMERICA. IF THIS RIFT WOULD HAVE BEEN SUCCESSFUL, WE TODAY WOULD BE A PART OF NORTHWEST AFRICA.
200-170 MYA	TRIASSIC & JURASSIC	WITH RIFTING CONCLUDING, MAGMA MIGRATED TOWARD THE SURFACE IN FISSURES. ALTHOUGH VOLCANOES NEVER OCCURRED AT THIS TIME, THE MAGMA COOLED MAYBE ONE MILE BENEATH THE SURFACE AND LATER FORMED THE ROCK DIABASE: EXAMPLE AS IN DEVIL'S DEN AT GETTYSBURG.

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