THE WISSAHICKON VALLEY IN PHILADELPHIA for the AEG Field Conference, 2024

Led by Natalie P. Flynn Ph.D., Earth and Environmental Science Department, Temple University

Enter from the Valley Green Rd parking lot, 0.1 miles from bridge 40.056493, -75.214290
https://maps.app.goo.gl/xHmSZo6HGVBSQYNX9
OR from Wises Mill Rd from Henry Ave. and the Valley Green parking lot.

Note all figures and content are cited from various experts on the Wissahickon or related regions. They are not this author's original research. See citation list for additional details.

NAME and LOCATION:

The word 'Wissahickon' comes from the language of the Lenni Lenape Nation. It is a combination of two words from their language: 'Wisauckisickan' which means yellow colored creek and 'Wisamickan' which means catfish creek (Gasiorowski, 1997). Currently the park encompasses 1,400 acres under the auspices of the Fairmount Park Commission. In 1868 it became the first piece of publicly owned land to be set aside for preservation of its natural beauty (Simon and Jaffe, 1995).

The Wissahickon valley is located in a northwestern section of Philadelphia, bordered by both urban and suburban neighborhoods. Chestnut Hill, Mr. Airy and Germantown are to the east and East Falls to the southeast. Roxborough and Manayunk are to the west. Lafayette Hills in Montgomery Co. is to the North (Figs 1, 2). The Wissahickon creek merges into the Schuylkill River and flows into the Delaware, eventually to the sea. The Wissahickon gorge is part of the piedmont plateau and consists of pre-Cambrian and lower Paleozoic rocks (West, 1998).

Figure 1. Location of Schuylkill and Wissahickon creek near Philadelphia, PA

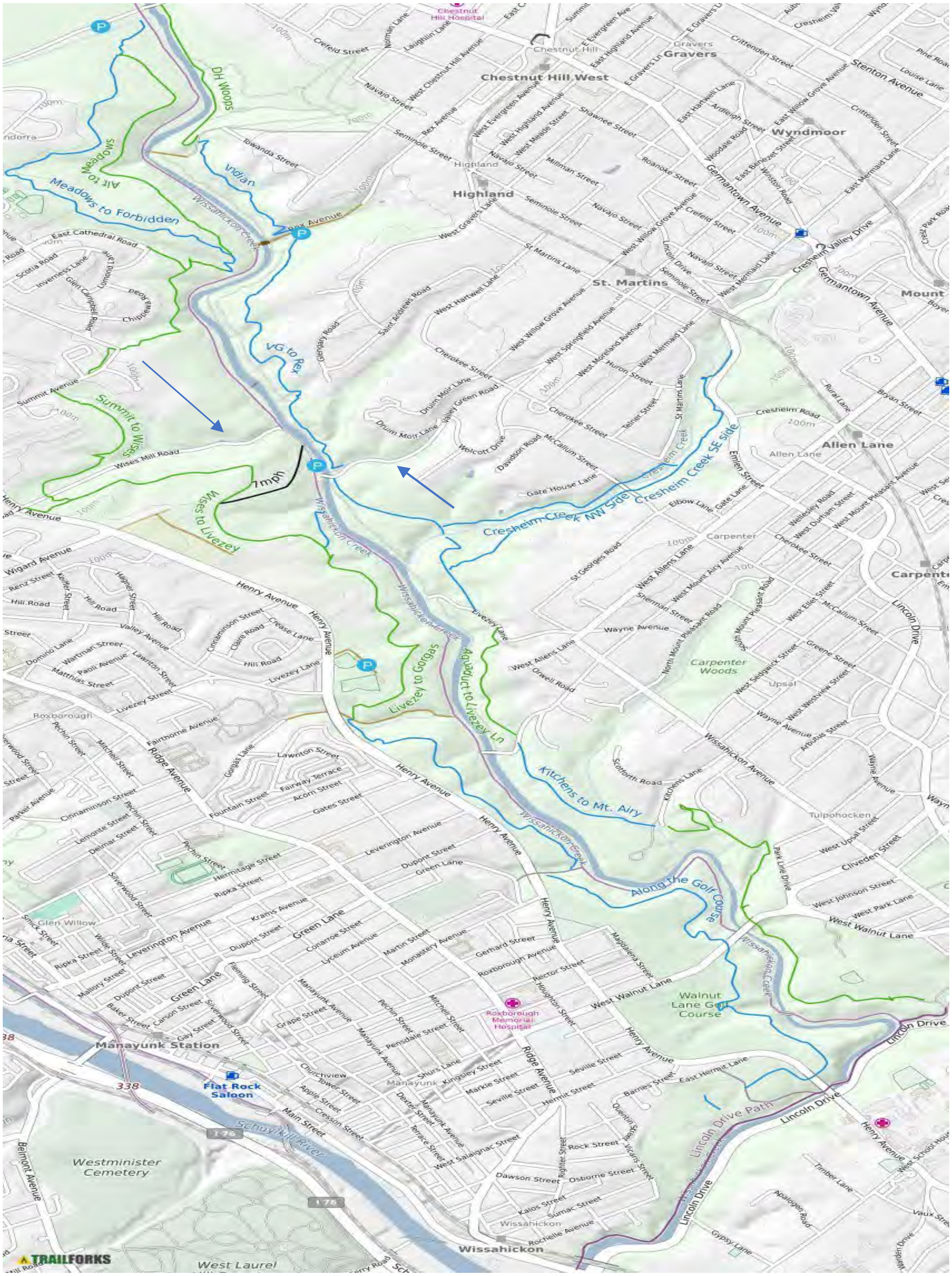


Figure 2. Street map of Wissahickon creek. **Note:** Wises Mill Road as access point from Henry, upper left. Valley Green Rd on the right. Blue arrows, 1/3rd from the top of map.

Geological Provinces of the Wissahickon Water Shed
(adapted from Ed Silcox)

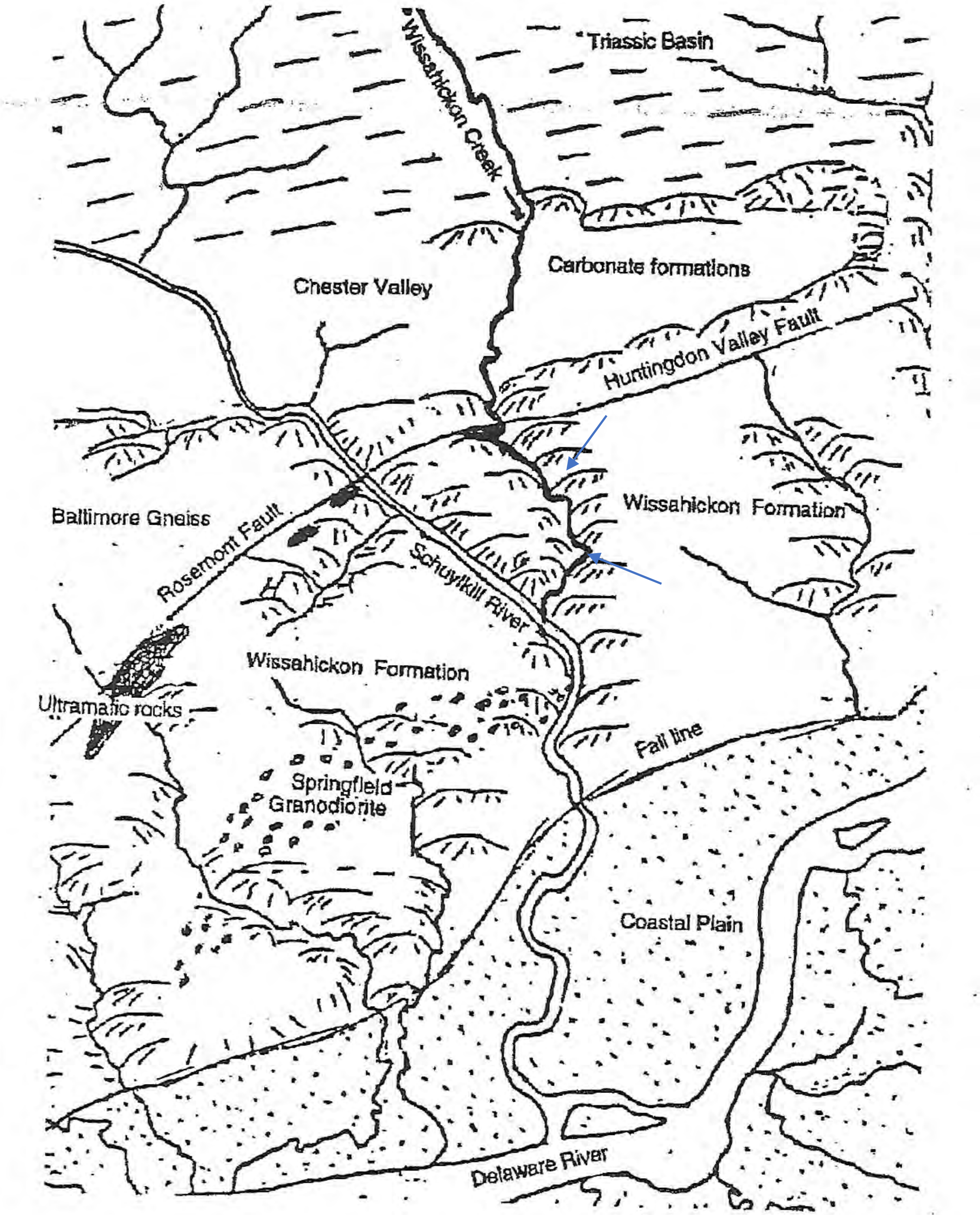


Figure 3: West, 1998, from Ed Silcox drawing of the provinces. Blue arrows show the approximate location of trip.

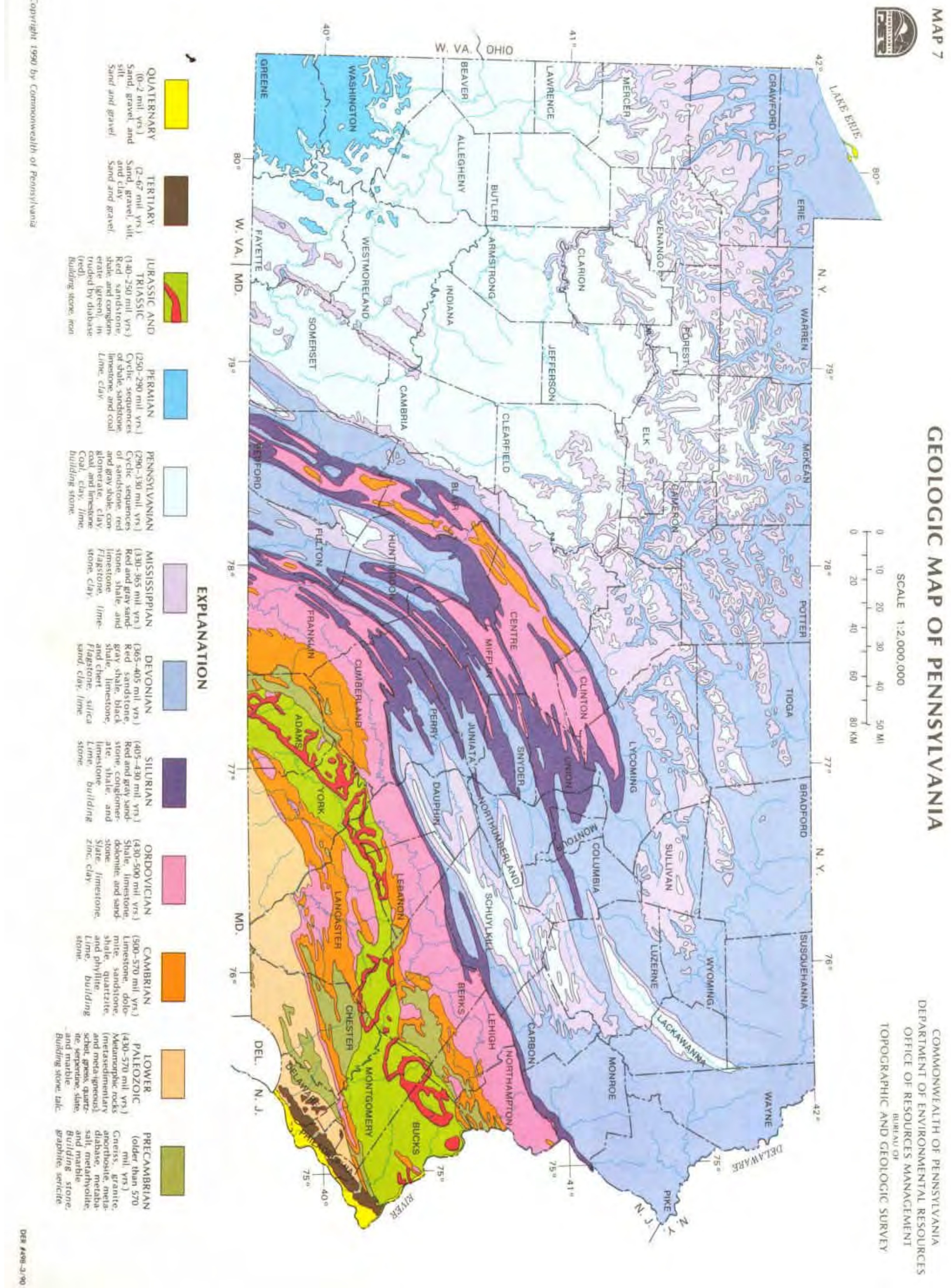


Figure 4: Generalized Geologic map of Pennsylvania DCNR. Free open access.

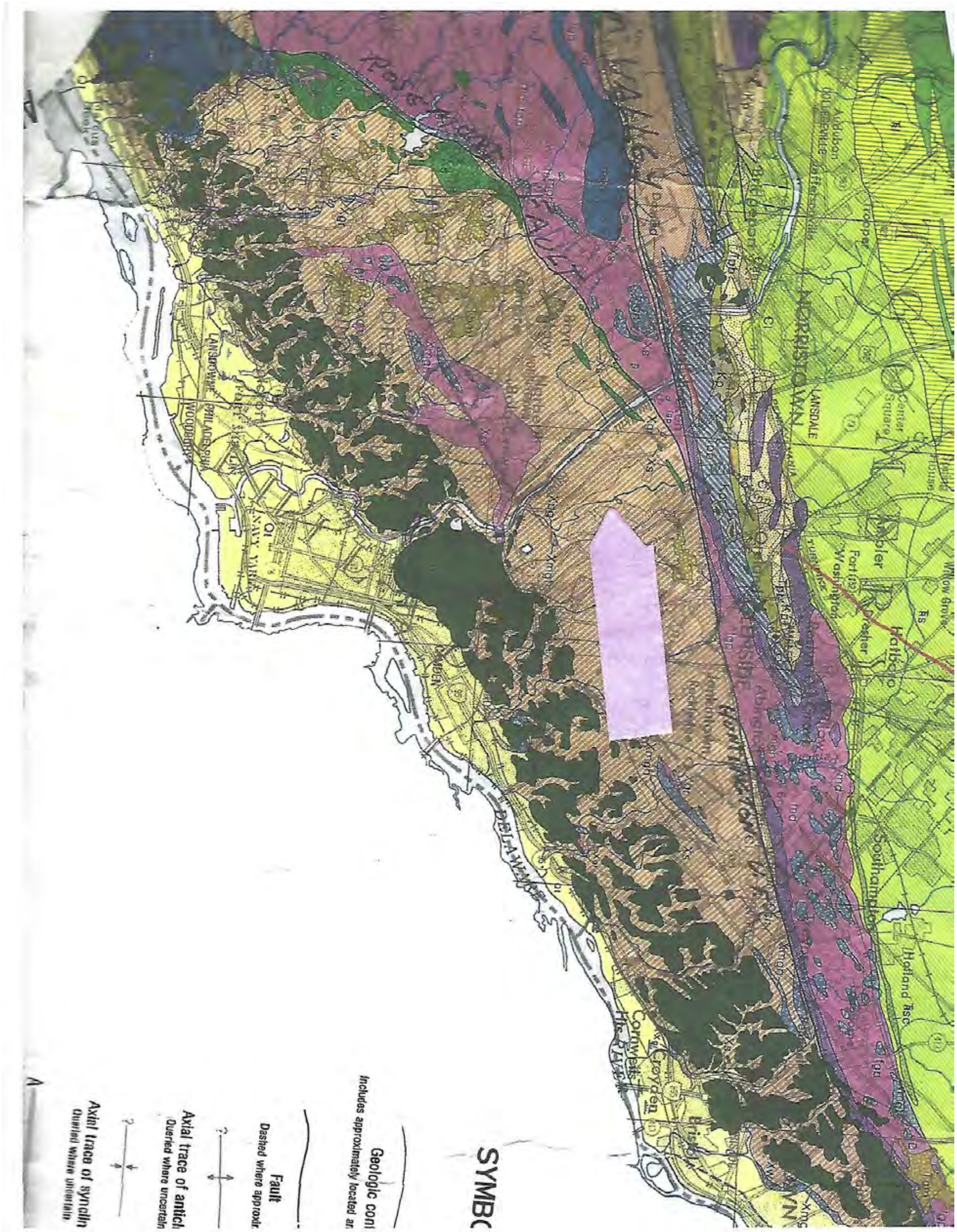


Figure 5: Small snip of the Pennsylvania geologic map. Commonwealth of PA free to download. Pink arrow shows trip location. Huntington Valley and Rosemont Faults are marked.

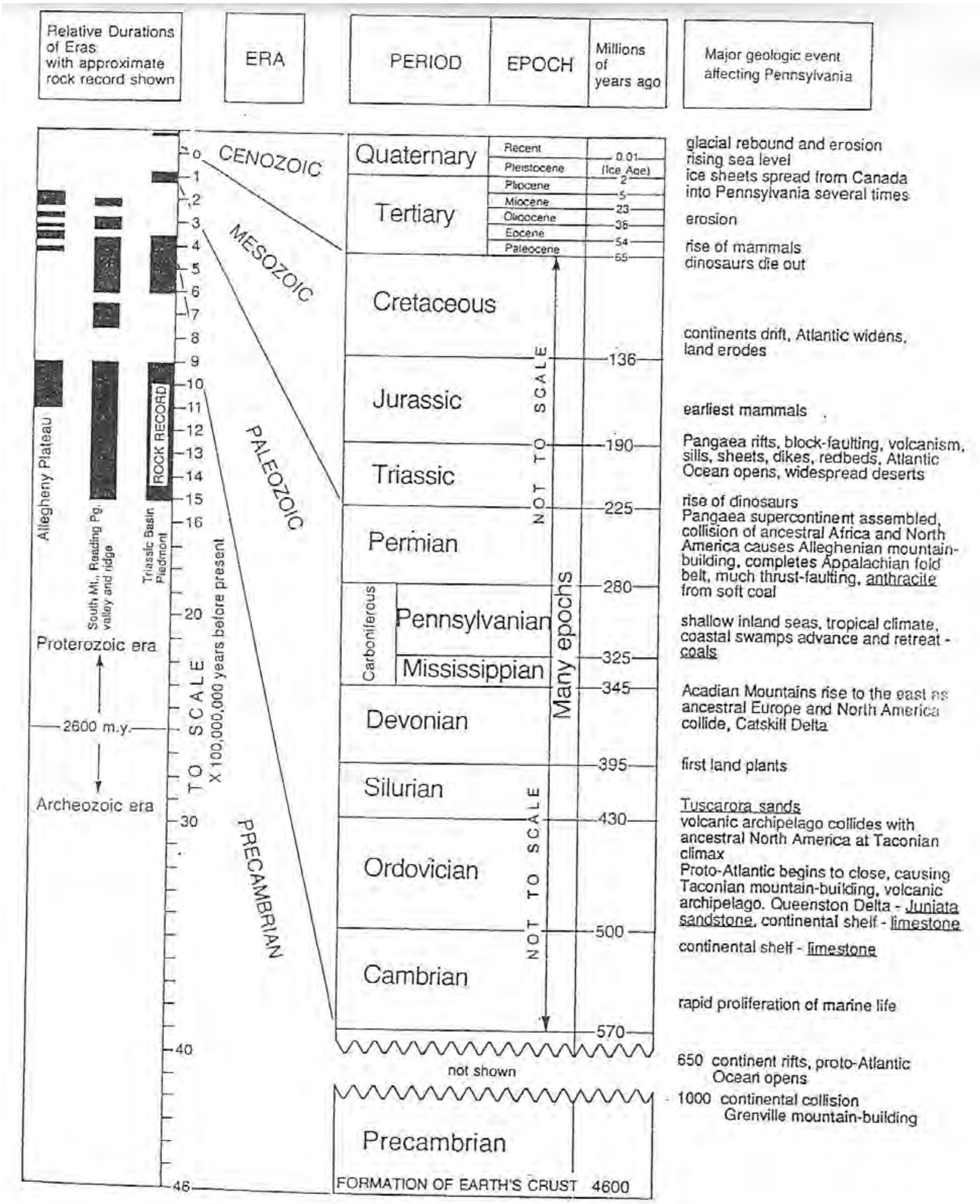


Figure 6. Geologic time scale. Specific time periods and events will be noted in the document. USGS free access document.

PLATE TECTONICS OVER TIME IN NORTH AMERICA

EAST NORTHERN COAST

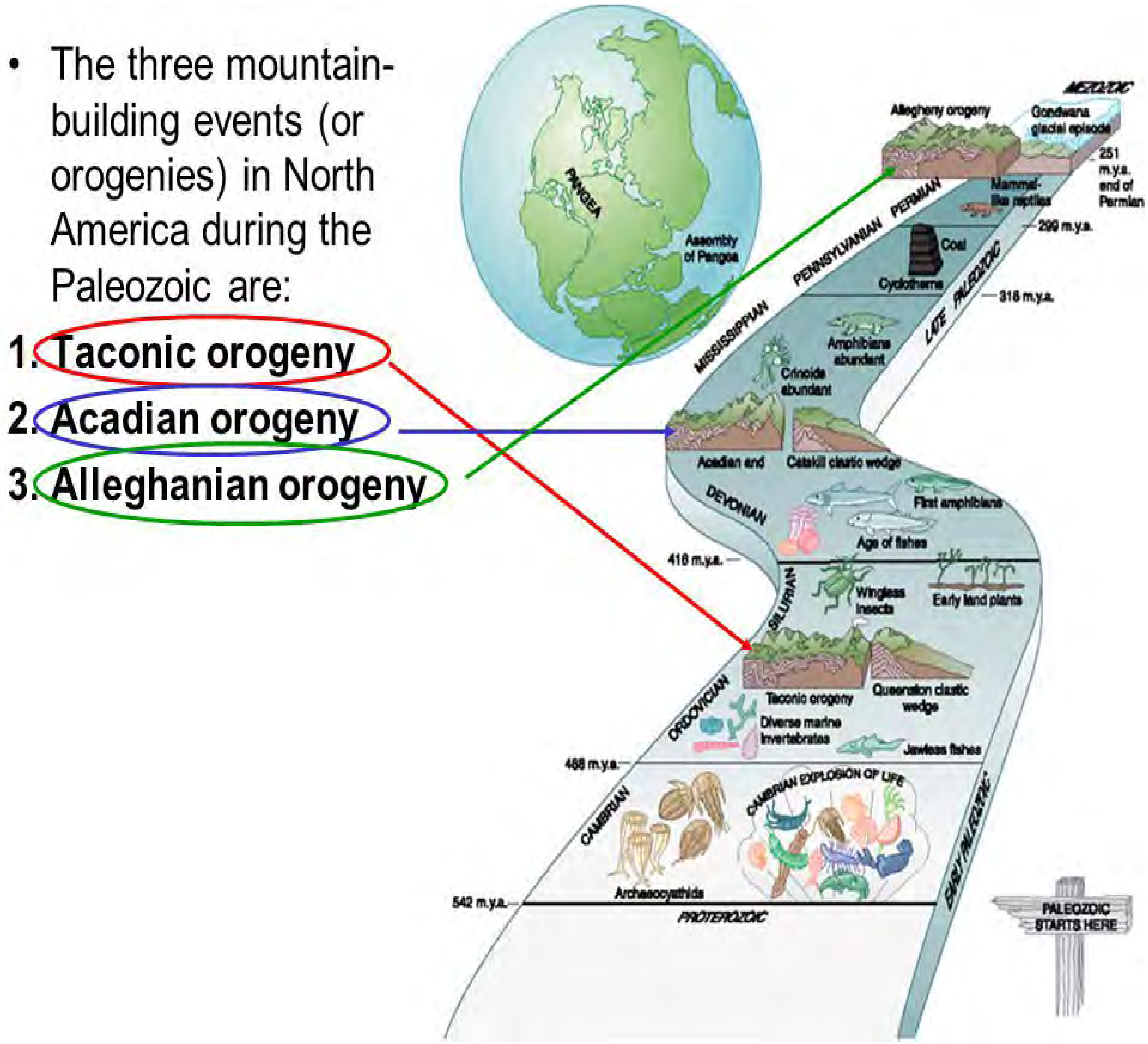


Figure 7. Representing the three main orogenic events that created the Appalachian Mountains in North America. The metamorphic rocks of the Wissahickon Formation were created during these orogenic events. Fabrics have been printed and overprinted in some sequences.

GEOLOGY in Eastern Pennsylvania over Time

The rocks that form the foundation of much of Pennsylvania began to form billions of years ago during the Proterozoic Eon. The Pennsylvania Piedmont is underlain by numerous Grenvillian basement blocks (Wagner and Crawford, 1975). During that time igneous rock in the form of continental crust formed large cratons. Around 1.1 billion years ago these cratons came together to form the supercontinent known as Rodinia. One section of Rodinia (Figure 8) - Laurentia contained the early formations of what would become the North American continent. The geological history of the rocks in the Wissahickon formation began when the state of Pennsylvania was but a small area of this super continent. During the period of accretion, considerable deposits of gneiss, serpentinite and meta-basalt formed in an area of the craton that would underlay the eastern coast of the United states. Of these early rocks, gneiss remains as the principal 'basement rock' of the state of Pennsylvania (Barnes & Sevon, 2016).

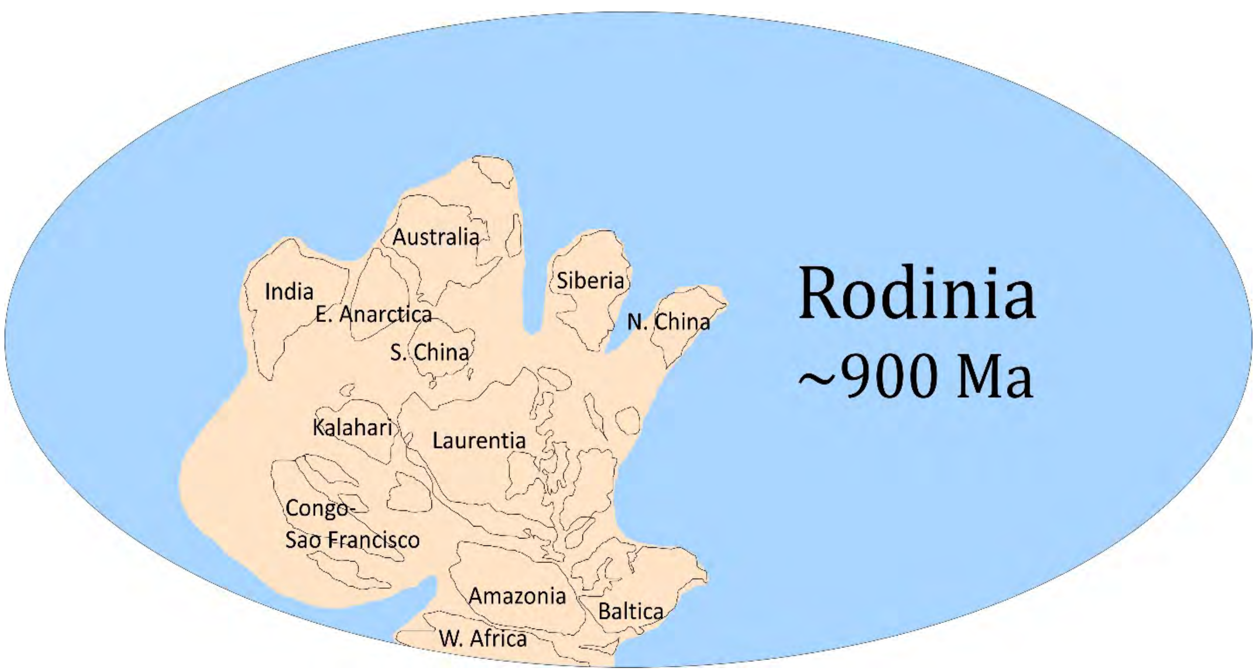


Figure 8. Proterozoic formation of the supercontinent Rodinia. Note the location of Larentia in the center as the location for the future Wissahickon Formation.
https://carnegiescience.edu/news/one-supercontinents-different-others-it%E2%80%99s-rodinia

Tectonic convection within the mantle would result in the breakup of Rodinia. As the supercontinent broke apart, rift valleys, basins and small seas formed at the margins of the separating land masses. Eroded sediments and volcanic ash were deposited in these areas forming a variety of sedimentary rocks: fine mud particles formed sandstones, coarser sediments formed sandstone, and volcanic ash dissolved in the early seas gave rise to carbonate-based rocks. Toward the beginning of the Paleozoic Eon (570-500 mya) the Iapetus Ocean formed to the east of Laurentia and the North American craton (Figure 9).

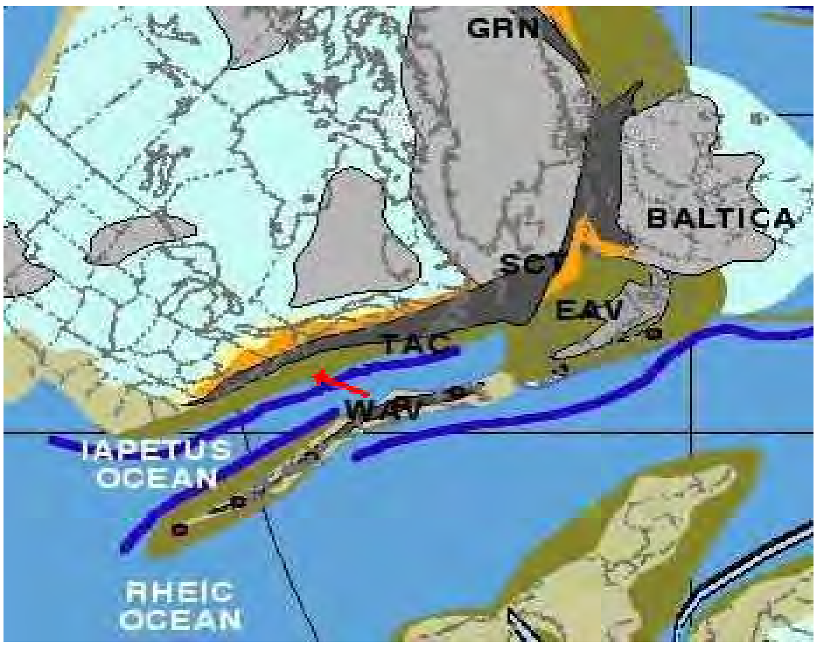


Figure 9. Formation of the Iapetus Ocean, proto-Atlantic. Note locate proto-Pennsylvania and the deposition of marine sediments. https://paleoportal.org/

During the Cambrian period water from the Iapetus Ocean covered much of the North American craton. Carbonates formed in the tropical water from the Iapetus Ocean covering much of the North American craton. Much of North America was located near the equator at this time. Early sediments such as mud, silt, and sand were deposited. These sediments would form mudstones, sandstone and shales, which would eventually become the schists quartzites of the area.

During the middle to late Ordovician period the Iapetus Ocean and a series of volcanoes to the east of North America collided with Laurentia (Figure 10). This convergence is known as the Taconic Orogeny. The newly formed Taconic mountains depressed the continent and a series of foreland basins formed (Gasiorowski, 1997).

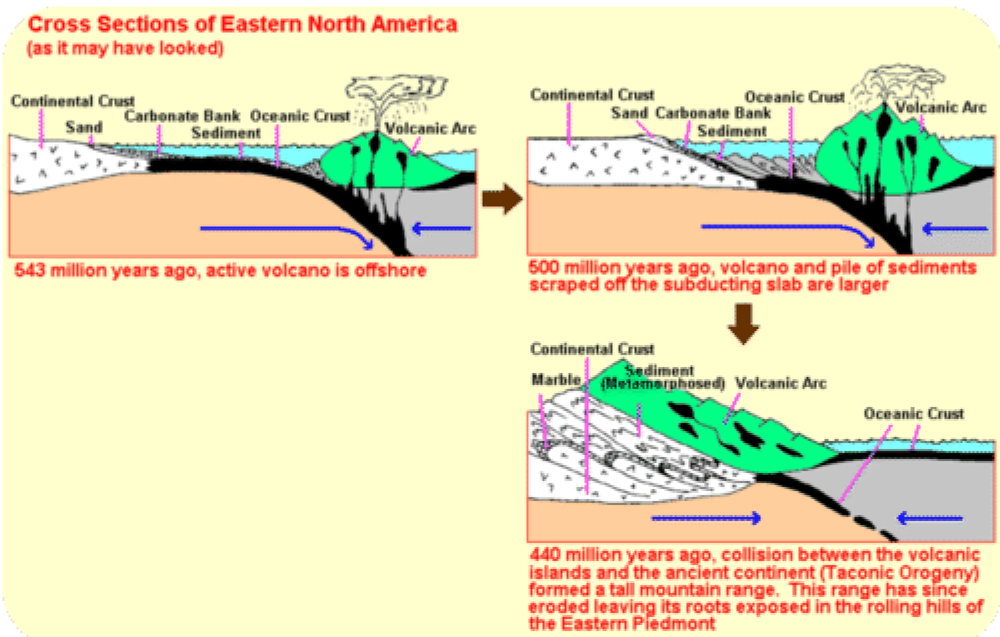


Figure 10. Early Paleozoic cross section of Eastern North America. (USGS doc.)

As the Iapetus Ocean began to close a proto-volcanic arc moved toward the North American plate and eventually closed which caused the volcanic arc to be thrust onto the continental crust as shown A, B, C, in figures 10 and 11. Once on the continent, the volcanic arc formed a larger mountain range called the Taconic mountains. During the Silurian Period (405-430 mya) the weight of the Taconic mountains caused the continental crust to subside creating a basin. Sediments washed down from the mountains collected in this basin and eventually formed rocks such as shale and sandstone. The shales and sandstones were eventually pushed into the crust and metamorphosed (Barnes and Sevon, 1996). This first orogeny produced the tight folding that is visible in the rocks of the Wissahickon.

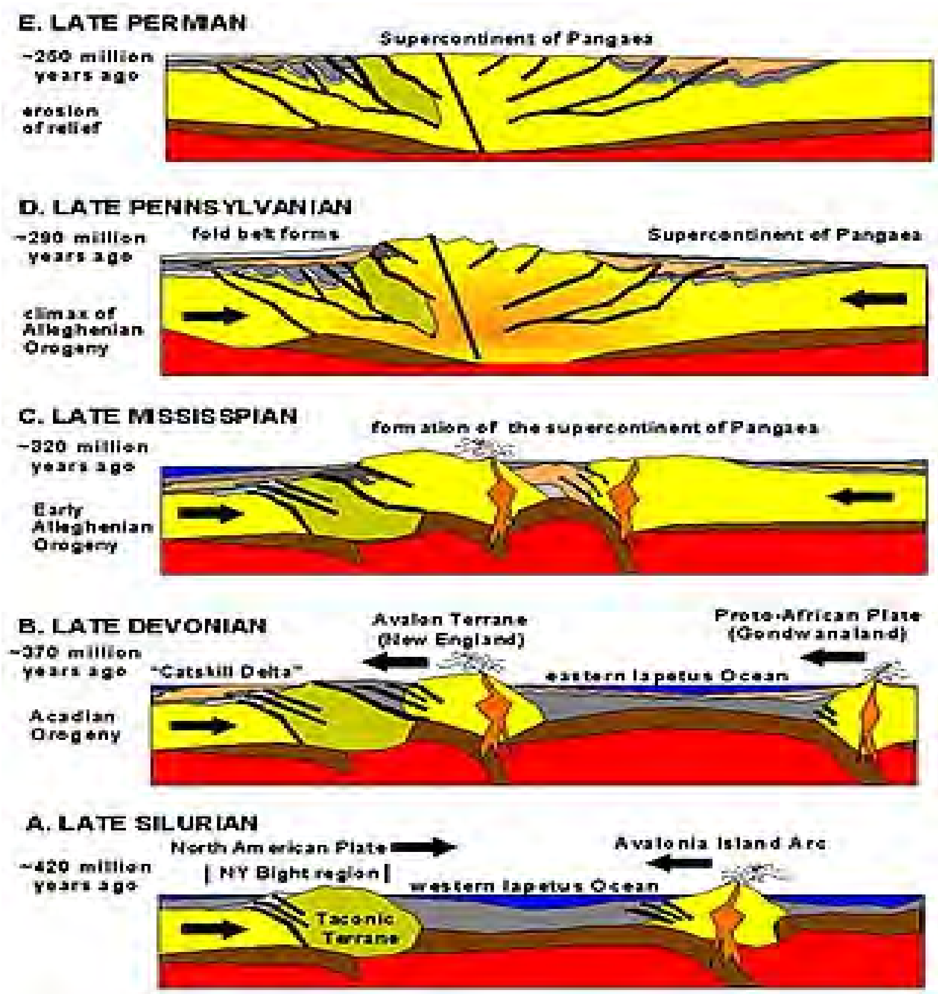


Figure 11. Paleozoic closing of the Iapetus (Proto-Atlantic). Accretion of Avalonia Island – a proto volcanic arc. (Image USGS).

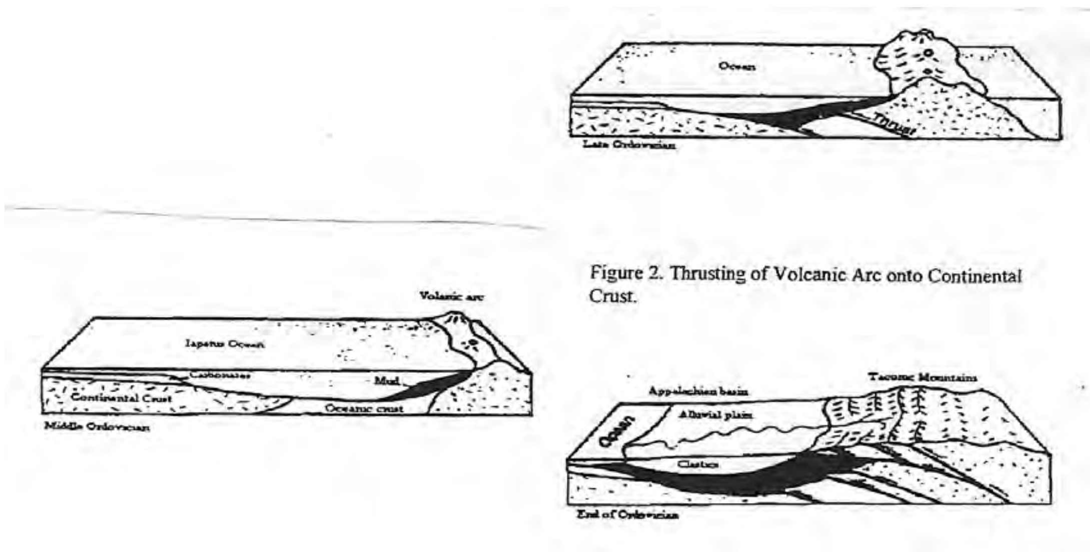


Figure 12. Ordovician formation of the Taconic mountains (West, 1998).

The second period of mountain building is the Alleghenian orogeny (250-290 mya) during the Permian. A four-way collision between Europe, North Africa, South America and North America created the Appalachian Mountains. (Barnes and Sevon, 1996). The rocks with the tight folding formed in the first orogeny were thrust up by this collision changing the direction of the folds and creating broad open folds throughout the Valley (West, 1993). The mountains eroded and deposited large amounts of sediment into the basins, resulting in layers of shale and sandstones. During the Devonian Acadian orogeny Avalonia, Europe, andNorth American cratons converged to form the supercontinent Euramerica (Figures 12 and 13).

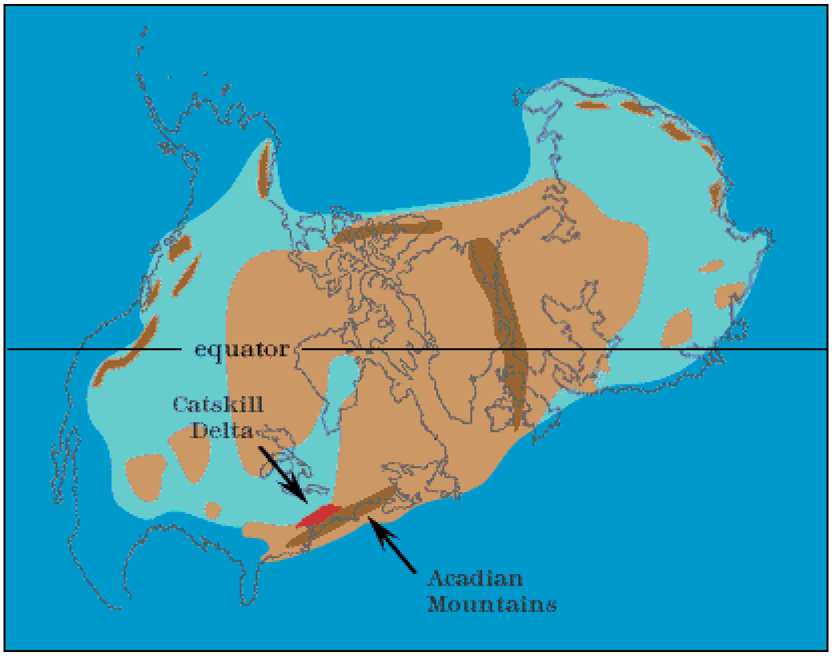
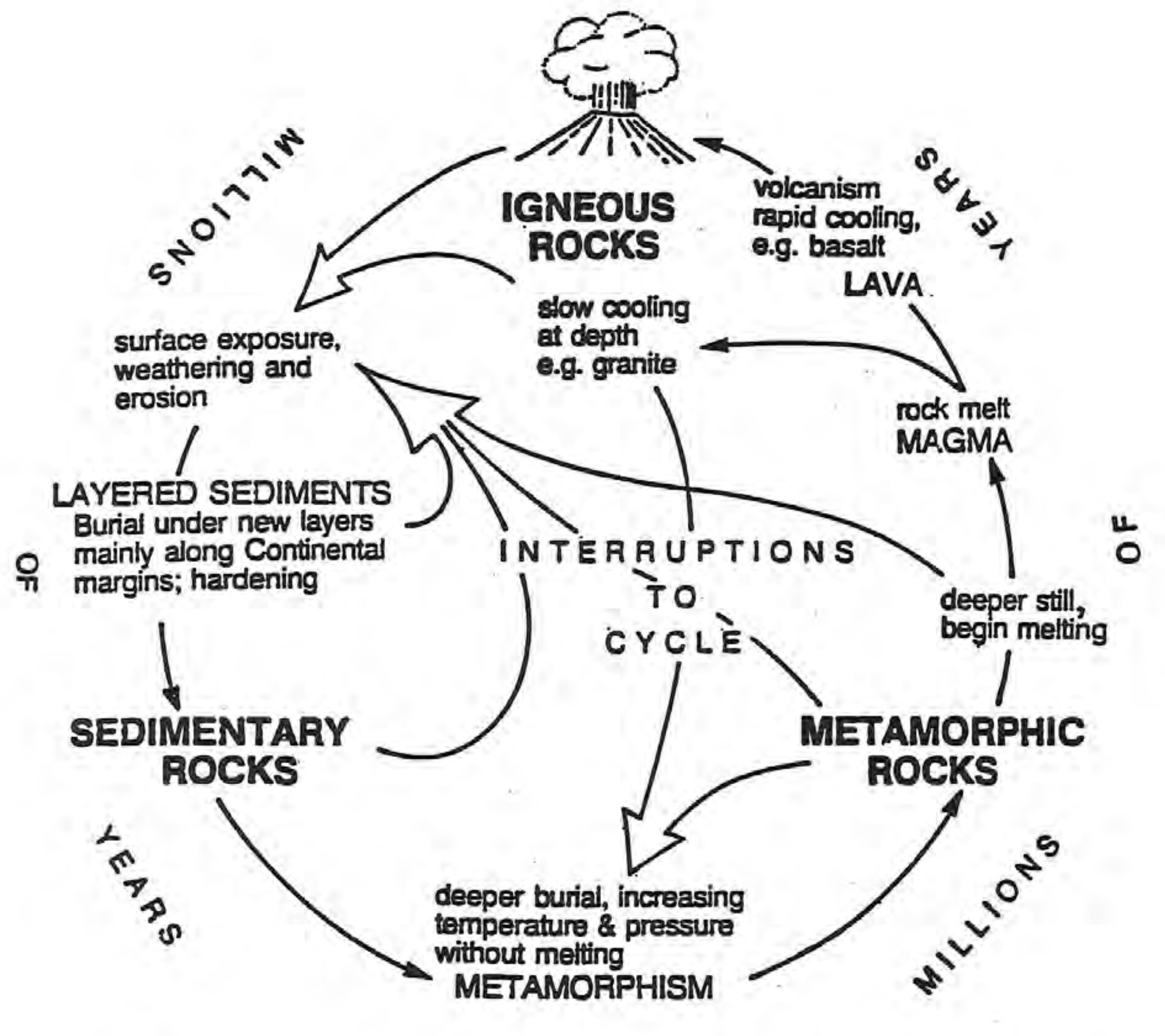


Figure 13. Euramerica Devonian Acadian orogeny. Note: most of North America is located south of the equator in warm tropical waters.

Sediment from the Acadian mountains filled the Appalachian basin fine; clay and muds would form the mudstones and shales known today as the Marcellus shales (Barnes & Sevon, 2016). Pangea would later once again form a supercontinent in the Alleghenian Orogenic event.

North America begins its movement northward away from the equator, Pangea begins to break apart. During the 250 million years of activity along the convergent boundary numerous small microcontinents, including ancestral Wissahickon formation formed from the early location and became welded to the eastern North American coastline (West, 1998).



The rock cycle, showing the three major classes of rocks, how they form, and how they interrelate.

Figure 14: ROCK CYCLE: Note the connections between rocks by tectonic and surface processes.

Metamorphic cycles and index minerals specific to Wissahickon schist

The Wissahickon schist does not refer to a single type of rock, but it is a classification of rock. Within the valley there is an array of schist types of rock, each with a distinctive composition and geologic history. The Wissahickon Formation is composed of interlayered pelitic and semi-pelitic schist, with rare amphibolite layers (Valentino et al 1999). A regional schistocity pervades the Wissahickon Formation and is genetically related to the regional metamorphism (Crawford and Crawford, 1980, Valentino et al, 1995).

The predominant rock types found in the Wissahickon are metamorphic quartzites, schist, gneiss, amphibolite and igneous pegmatites. The quartzites formed from siliceous rich sandstone deposits. The schists contain a variety of index minerals such as chlorite, muscovite mica and biotite mica along with tourmaline, garnets and staurolite. The high-grade metamorphic gneiss is primarily feldspar amphiboles from former granites and schists. Pegmatites are also present in the form of migmatites. The presence of pegmatites, which consist of large albite feldspars, quartz and mica, indicates a high temperature and fluid presence. The fluid concentration allows for faster and larger scale ion migration, as well as reduced melting temperature of the lower Bowen's sequence minerals.

There are alternating layers of quartzite and dominant schist. The schist has dominant micas and garnets and, in many locations, wavy crenulations. The micas layers due to their phyllosilicate structure forming perpendicular to the dominant stress direction. Lichen cover much of the outcrops surface. Look for fresh surfaces. Many of the larger outcrops show unloading expansion fractures or joints. There is no movement along the joints – relative to each other. Inclined and overturned beds are common. Thin veins of quartzite have formed.

The unique combination of index minerals present in the Wissahickon schist is as follows: biotite mica, garnet, staurolite, kyanite and sillimanite (Crawford, 1987). Minerals of this sequence indicate metamorphic conditions at a depth of 20-25 km (12-16 miles). The gneisses are indicative of even greater depth and pressure temperature conditions. Their presence at the surface provides evidence of great tectonic forces that uplifted and eroded the overlying layers. Patterns of folding and faulting are indicative of these forces. The quartzites respond to heat and pressure but can maintain their geometric orientation when stress is applied and thus will fold in the direction of the applied stress. Mica minerals however tend to recrystallize in linear layers that are aligned perpendicular to the applied stress (Gasiorowski, 1997). Different minerals are favored to grow under different conditions. Biotite mica begins to form at 400^0C, garnets at 500^0C and kyanite at 600^0C. Depth equivalent of pressure is also recorded in the formation of index minerals. Kyanite remains stable (not converted to the higher-pressure polymorphic phase of sillimanite), if pressure remains below 20 km. Therefore, a significant volume of overburden has been eroded to expose rocks formed at great depths. Folds occur when tectonic forces occur in hot or pliable rocks. When the rocks are brittle faults and joints occur.

The Sillimanite zone indicates a greater depth and is not present in this location of the Wissahickon Formation. The uppermost amphibolite facies gneiss of the Wissahickon contains the assemblage biotite-sillimanite-garnet-potassium feldspar-plagioclase-quartz-ilmenite muscovite which according to Alcock, (1989) places them above the sillimanite isograd. These units are noted to the north and west along the shear zones. See later structural comments.

Locations: South of the Valley Green road toward Cresheim Creek: (notes modified from the GS of NJ field guide, 1991).

Initial rock exposures show the typical Wissahickon Formation garnet-mica-kyanite schist. Approximately 0.5 miles along the path a unique anthophyllite-talc exposure is present. Notice how differently the rock is weathered. It is pitted and lacks the schistose layering common in the Wissahickon schist. The minerals present are a combination of anthophyllite and talc. Notice the silky, soft feel. This outcrop is unique as it represents the metamorphism of an ultra-mafic protolith rich in iron and magnesium silicate resulting from possible pieces of the upper mantle/oceanic crust. This differs from the typical pelitic protolith of the schists. Near this site is a chlorite rich vein produced from hydration metamorphism.

Locations north of the Valley Green Road parking lot.

We will see metamorphic index minerals from mica, garnet, tourmaline, staurolite, kyanite. A deviation from the main path will be taken to see an amphibolite outcrop. We will then continue to a migmatite outcrop.

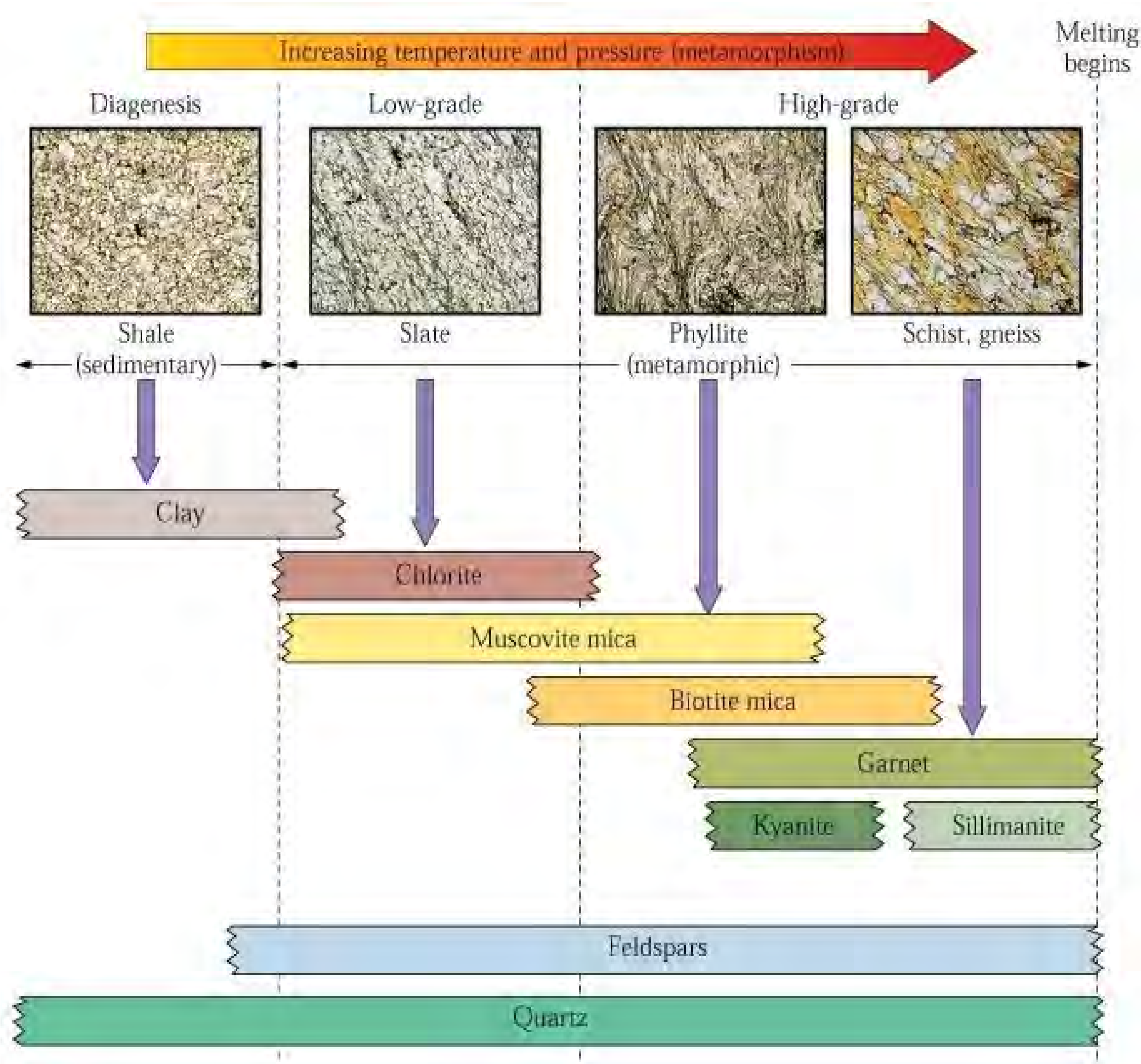


Figure 15: Index Mineral Formation sequence. As the level of pressure and temperature increase, pelitic protolith material from the above know sequence of minerals to accommodate the changing conditions. The initial micas form and

align their phyllosilicate structures perpendicular to the dominant direction of stress.

Garnet Minerals

Mineral	Composition	Specific Gravity	Hardness	Colors
Almandine	$Fe_3Al_2(SiO_4)_3$	4.20	7 - 7.5	red, brown
Pyrope	$Mg_3Al_2(SiO_4)_3$	3.56	7 - 7.5	red to purple
Spessartine	$Mn_3Al_2(SiO_4)_3$	4.18	6.5 - 7.5	orange to red to brown
Andradite	$Ca_3Fe_2(SiO_4)_3$	3.90	6.5 - 7	green, yellow, black
Grossular	$Ca_3Al_2(SiO_4)_3$	3.57	6.5 - 7.5	green, yellow, red, pink, clear
Uvarovite	$Ca_3Cr_2(SiO_4)_3$	3.85	6.5 - 7	green

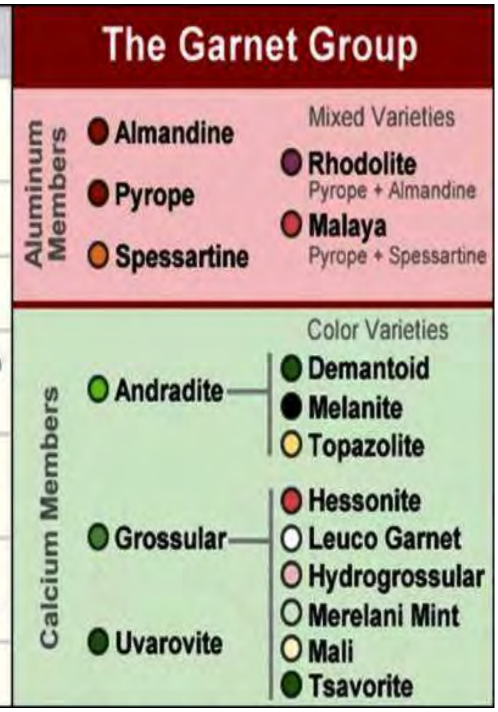


Figure 16: Garnet variety and details. Image: https://www.geologyin.com/2018/03/garnet-group-colors-and-varieties-of.html

Garnet group: The Wissahickon garnets. $X_3Y_2\ (SiO_4)^3$. There are two broader groups of Garnets: Pyralspites the Aluminum bearing group (Al_2) Pyrope, Almandine and Spessartine, and Ugrandites the Calcium (Ca_3) bearing group Uvarovite, Grossular and Andradite. Most of the Wissahickon garnets are Almandine – The Fe-Al member. The garnets from the Wissahickon Formation exhibit textural and chemical zoning that results from changing metamorphic conditions and mineral reactions during garnet growth allowing them to be used as a geo-thermometer (GA of NJ, 1991 field guide). The GASP (garnet, KAS, plagioclase, quartz) barometer indicates pressures of 5 +/- 1 Kilobar for the highest-grade gneiss garnets, which are located north.

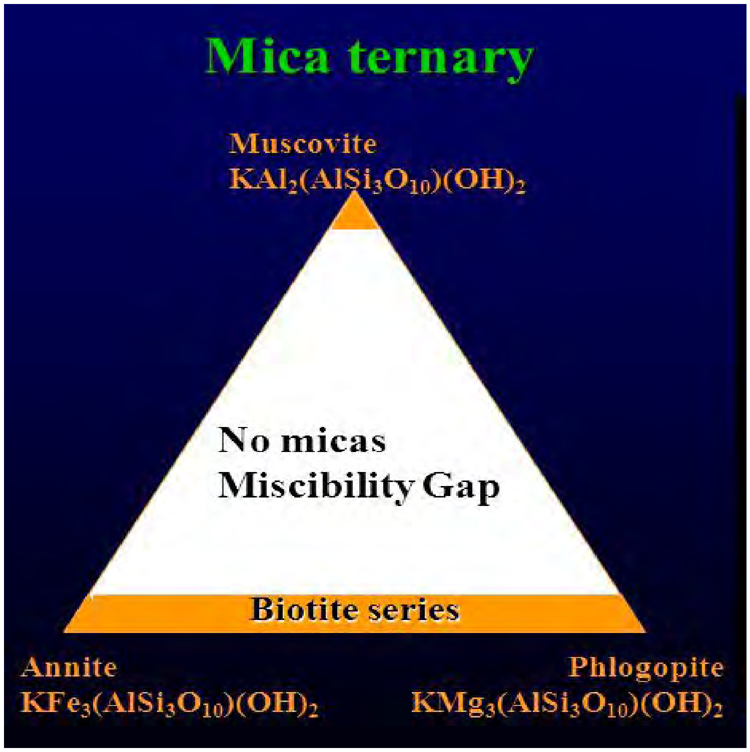
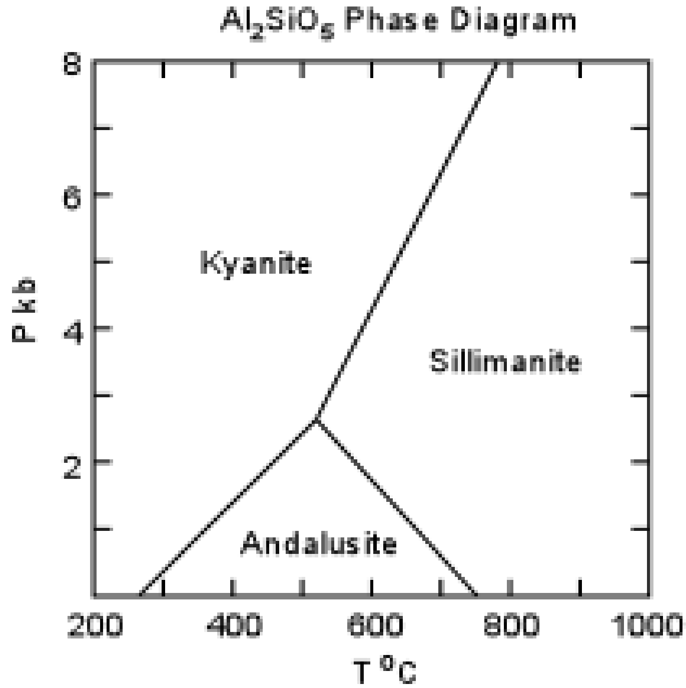


Figure 17: Mica group Minerals. Muscovite micas dominate in the Wissahickon Formation. Note there is no solid solution between the Aluminum rich muscovite group and the Magnesium-Iron biotite series. Phlogopite is unique to ultra-mafic igneous rocks.



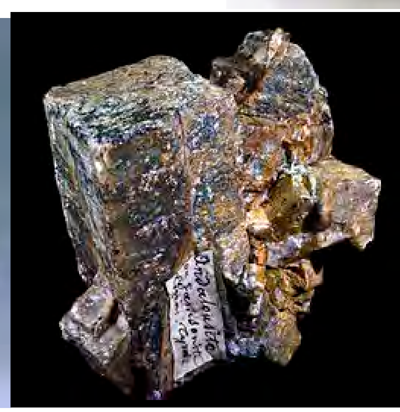


Figure 18: K-A-S Alumino-silicate group. Polymorphic phase changes can be used to indicate metamorphic conditions. The Wissahickon contains Kyanite and Sillimanite.

Tourmaline-boro silicate (left) AND Staurolite-Fe silicate (right).

Structural details to the general area – and to the North

Rocks of the Wissahickon are separated from the ancestral mountains by the Huntingdon Valley shear zone and the Rosemont fault. See figures below. Near Philadelphia, the Piedmont Province is cross-cut by numerous strike-slip shear zones. Of apparent late Paleozoic age (Valentino et al., 1995). These shear zones bound and cross-cut the Philadelphia structural block including the Wissahickon formation, Wilmington complex, and ultramafic and granitoid bodies. Valentino et al (1994, 1995) have completed research on the Rosemont shear zone to the northwest, Armstrong (1941) has conducted research on the Huntingdon Valley shear zone to the north, along with M. Ketterer 1995 (master's degree colleague of mine). The Crum creek shear zone is an apparent antithetical strike-slip fault conjugate to the Rosemont zone, crosscuts older structures and metamorphic zones of the Wissahickon Formation (Valentino et al., 1995). Note: much of this is to the north and west of today's field view.

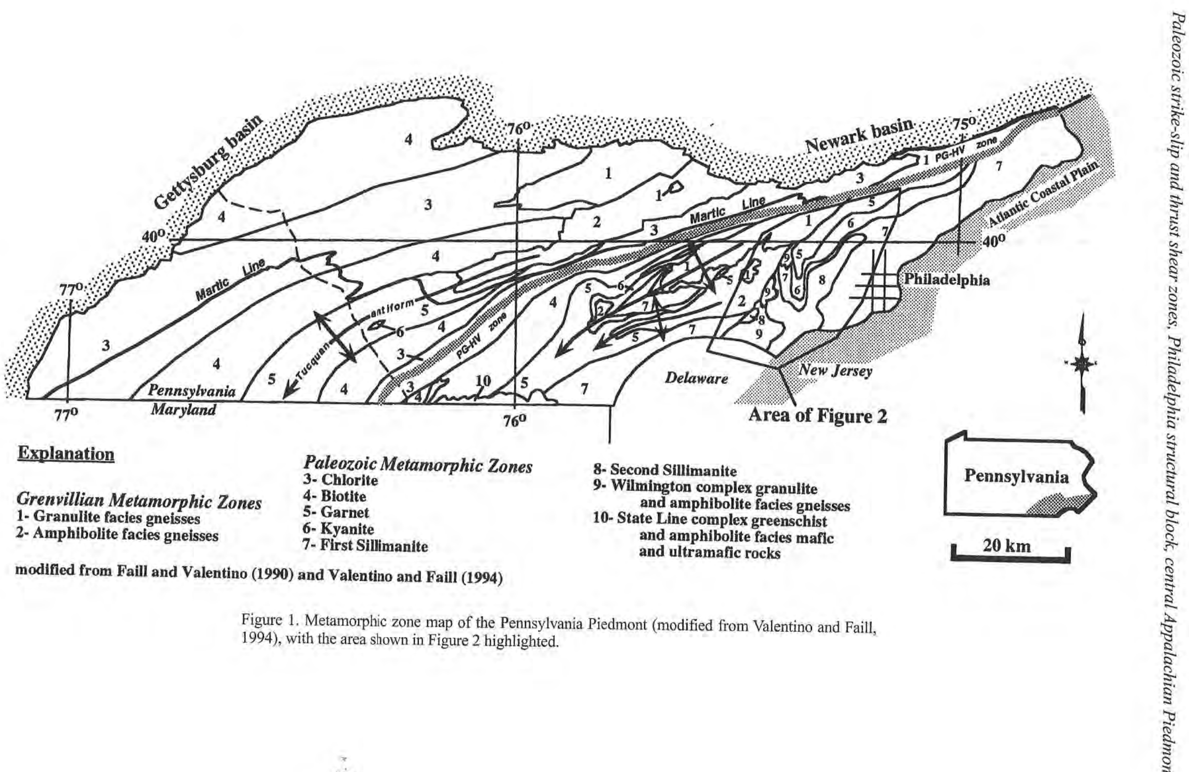


Figure 19: Metamorphic Isograds. Zone map of Pennsylvania Piedmont (Modified from Valentino and Faill, 1994)

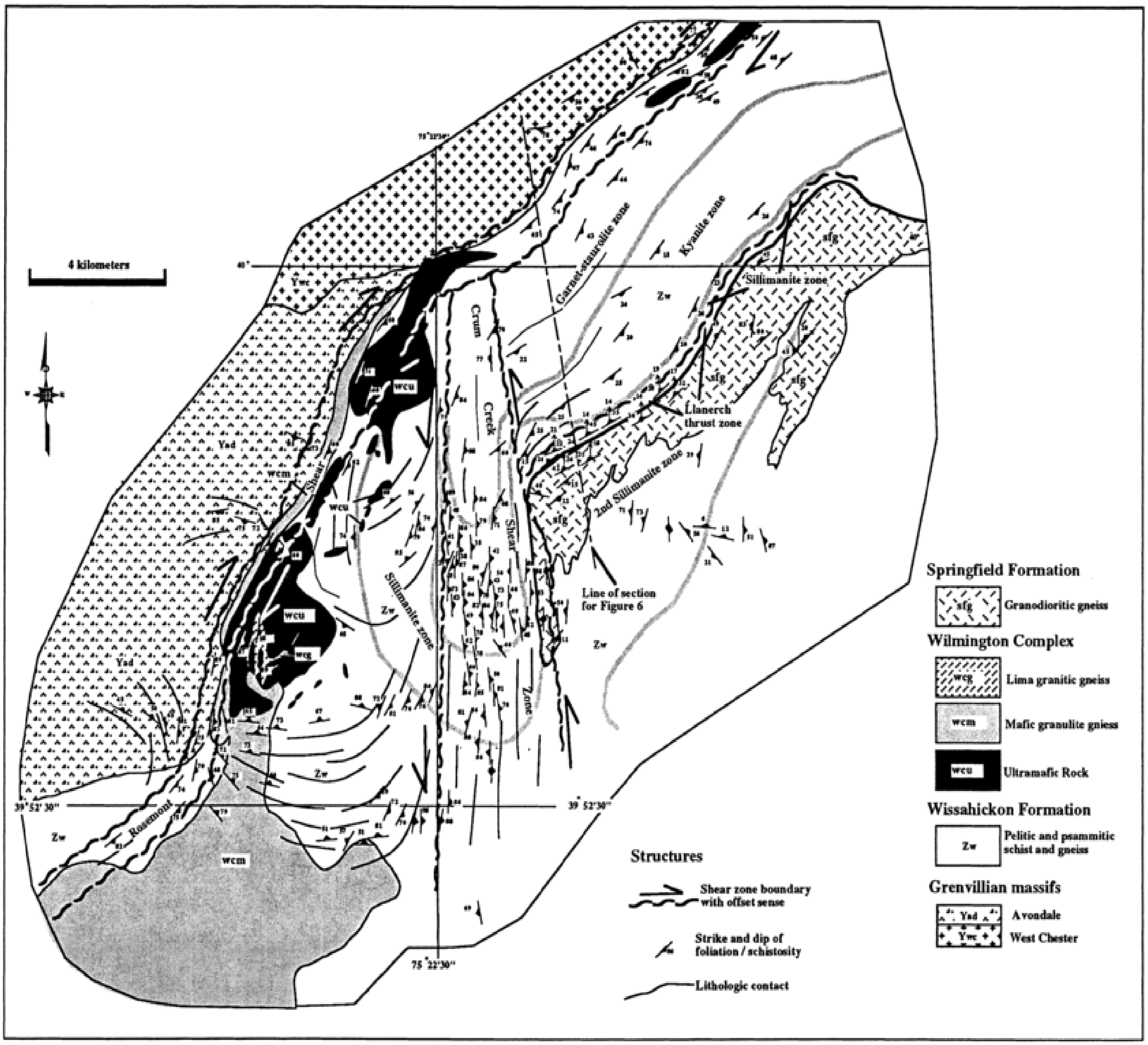


Image Uploaded from David Valentino

CITATIONS and other references. Note: Many images are from a creative commons license on line or citations below. This document is not meant for publication.

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WISSAHICKON EAST PROJECT REGIONAL CONTEXT MAP