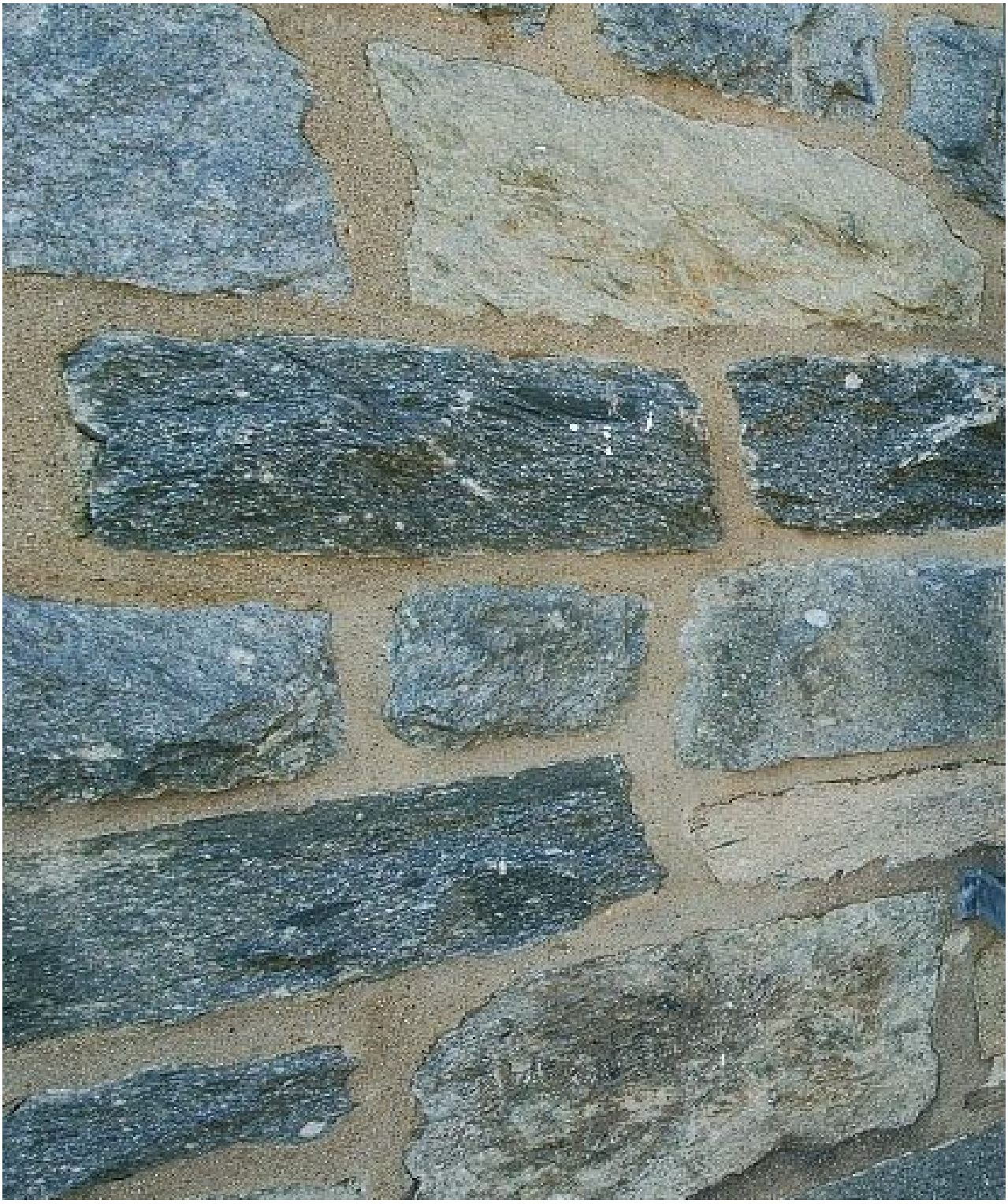
A Sketch of the Natural History of Tregaron and Vicinity

By Tony Fleming, Geologist



Potomac Bluestone in the Causeway. Part of the Sykesville Formation, this building stone was quarried along the Potomac Palisades in Arlington County from the late 1700's until 1938 and can be found in numerous historical structures in and around the District. Photo by Tony Fleming

Physical Setting and History: Tregaron and the adjacent Twin Oaks Estate occupy the upland between the two branches of Klingle Valley (figure 1). The two properties originally constituted one estate prior to Tregaron being split off from Twin Oaks a century ago. Tregaron is perched atop the ridge overlooking the confluence of the two branches, a dramatic and diverse physiographic setting that was exploited in the design of the estate. The deeply entrenched ravines are an integral part of the extensive landscape architecture, and many original elements made of local building stone are still visible today, most prominently the iconic stone bridge historically called "The Causeway" that leads into the property from Klingle Road (location #4 on figure 1). Most of these structures, including the bridge, are made of Potomac Bluestone (cover photo), the quintessential local building stone whose use dates to the late 1700's.

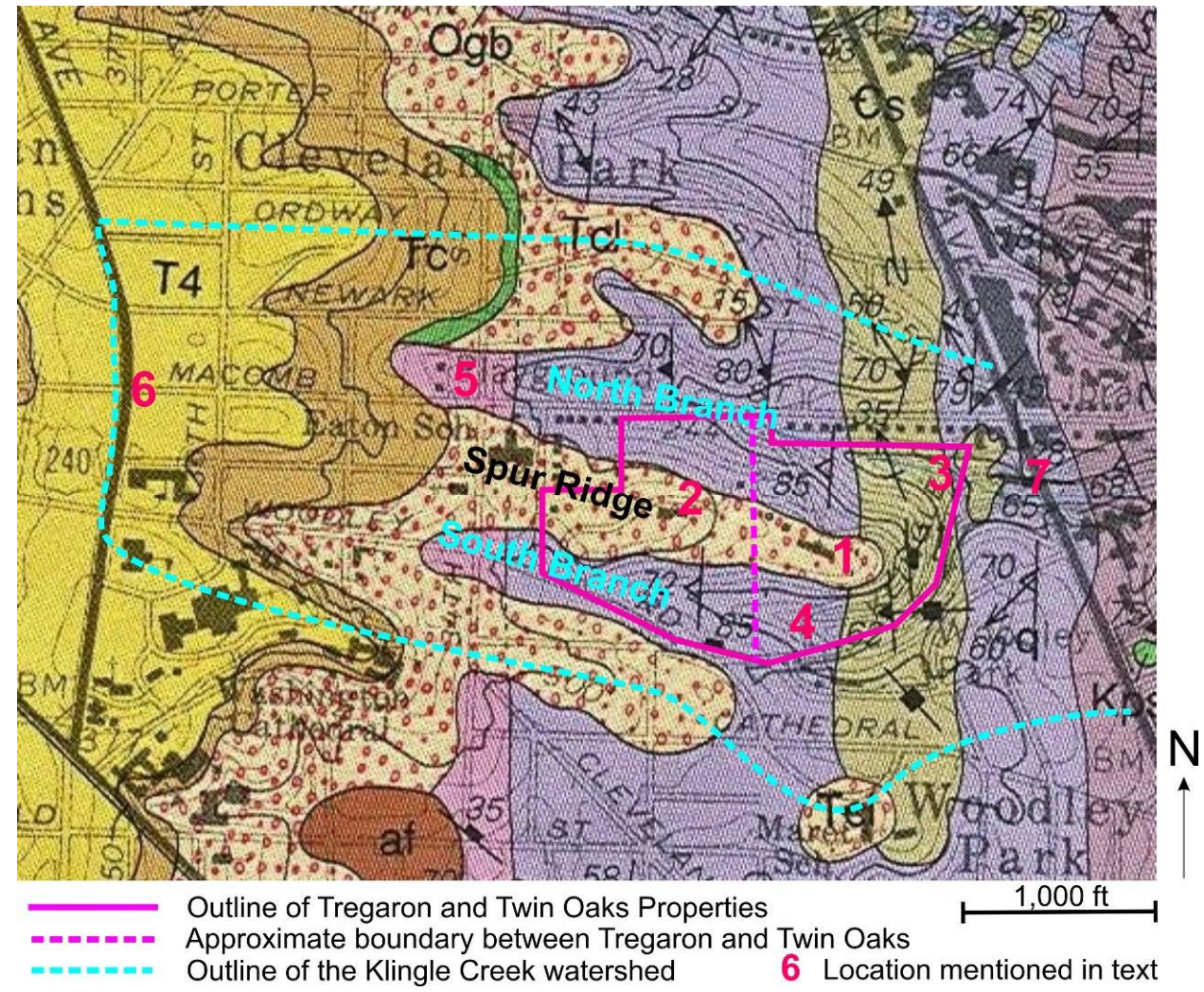
Tregaron adjoins a narrow extension of Rock Creek Park along Klingle Road and, at 20 acres, is one of the largest, privately-held, woodland properties in this part of the District. The Washington International School occupies about 6 acres near the summit of the ridge, while the Tregaron Conservancy encompasses the remainder, including portions of the two ravines, as well as the nose of the ridge that overlooks their confluence. Although modified by both intentional design (e.g., landscaping) and unintended consequences (invasive, non-native plant species), the wooded portion of the property still retains a relic old-age forest whose composition from place to place reflects the particular physiography and underlying geology. This sketch[1] highlights the major physical features of the property and their relationship to the natural communities that exist now or likely existed in the recent pre- or early-settlement past.

Geologic Setting: Washington, D.C. straddles the Fall Zone—the physiographic boundary between two major geologic provinces:

1) the Atlantic Coastal Plain, a mostly low-lying terrain that extends east to the modern shoreline and is underlain by unconsolidated marine and river sediments (sand, gravel, clay, shell beds) deposited along and near the coast as the shoreline fluctuated back and forth across the region. The oldest Coastal Plain sediments were deposited about 130-140 million years ago, but most are much younger, including the river gravel that caps the Tregaron upland, which is probably less than 5 million years old.
2) the Appalachian Piedmont, which forms a plateau-like upland that extends west to the Blue Ridge. The Piedmont is a complex terrane made up of crystalline rocks (metamorphosed volcanic, sedimentary, and intrusive rocks) that have been strongly deformed by several episodes of mountain building. The Piedmont rocks in the Washington area are part of a former volcanic island arc known as the 'Taconic Arc', which collided with North America about 450 to 475 ma. The Piedmont bedrock is exposed at the surface in the western part of D.C., within and west of Rock Creek Park, where the younger Coastal Plain strata have been eroded off.

The crystalline Piedmont rocks are harder and more resistant to erosion than the soft Coastal Plain sediments, ergo, the "Fall Zone" refers to the fact that streams typically descend rapidly as they cross this physiographic boundary on their journey to the coast, forming gorge-like valleys and steep ravines with rapids and small waterfalls. Rock Creek Valley and its tributaries, including Klingle Creek, vividly manifest this process, which has been enhanced in recent geologic time by differential uplift and tilting of the landscape from west to east, and by repeated lowering of global sea level by hundreds of feet during the Ice Age. Much of the incision of the local landscape has occurred quite recently by geologic standards. Klingle Valley, for example, is an artifact of the Ice Age, and the deepest parts of the ravines are probably less than 30,000 years old.

1 - The material presented herein is adapted from several geology walks led by the author in and around Tregaron, 2010-2016



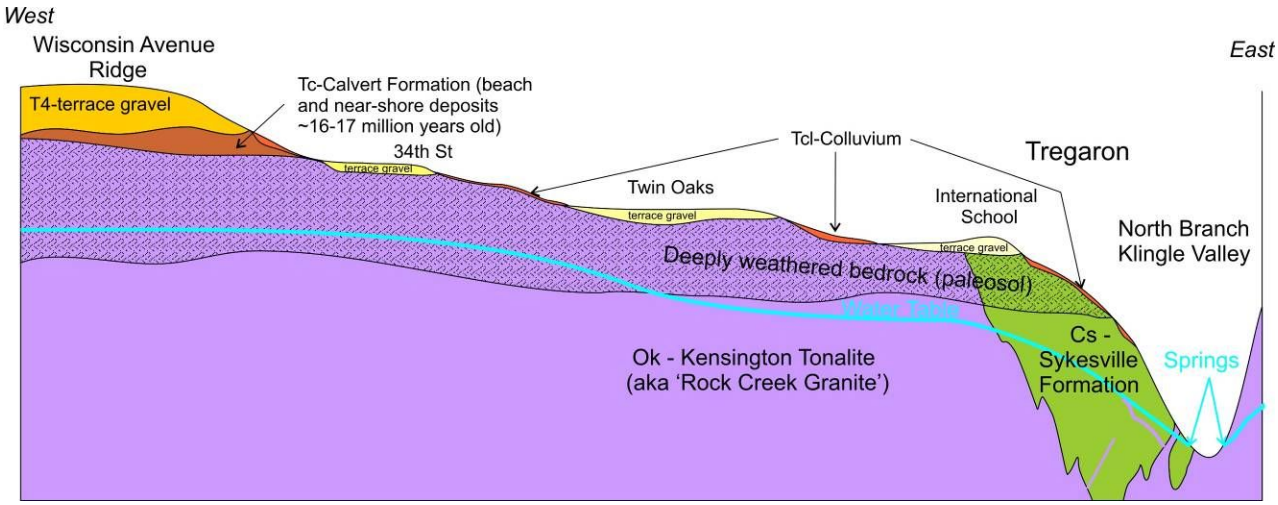
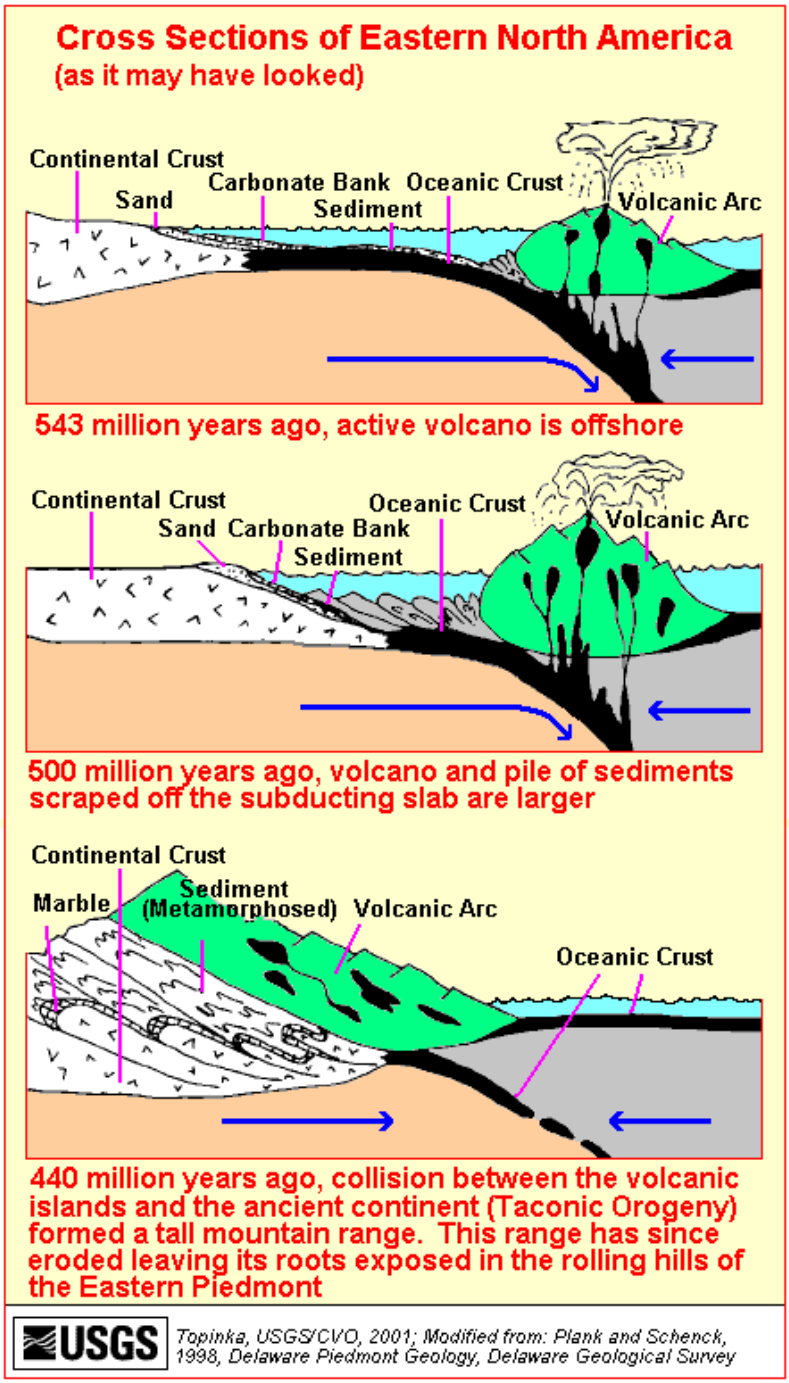


Figure 1. Geologic map (top) and cross section (bottom) of the Klingle Valley watershed between Wisconsin Avenue and Tregaron. Numbered localities on the map are features and places mentioned in text.: 1-International School, and 2-Twin Oaks mansion, both on the summit of the spur ridge, whose gravelly surface is denoted by the circle pattern on a light yellow background; 3- rock outcrops at bottom of Tregaron property along the North Branch of Klingle Creek. Sykesville Formation shown in olive green and Kensington Tonalite (aka 'Rock Creek granite') shown in light violet; 4-the Causeway; 5-Cleveland Park spring; 6-the Wisconsin Avenue Ridge, underlain by an ancient river gravel (unit T4), shown in the yellow color; 7- Connecticut Avenue. The cross section follows the spur ridge from Wisconsin Avenue to the bottom of Tregaron. Geologic map adapted from Fleming, Drake, and McCartan, 1994.

For millions of years prior to the Ice Age, most of the Washington landscape was a broad, alluvial plain with relatively modest topographic relief. A warm, humid climate prevailed during that time, and deep weathering profiles with thick soils developed on the bedrock and on the older Coastal Plain sediments. Ridge tops in Washington, such as the Wisconsin Avenue Ridge and the ridge upon which the International School sits, are erosional remnants of this earlier landscape—they now comprise isolated stream terraces that were once contiguous with other terraces at the same elevations—and are underlain by soil profiles tens of feet deep. Bedrock is generally exposed only in deep stream valleys where recent stream incision has stripped the soil and weathered material from the landscape, exposing the hard, fresh bedrock below.



Bedrock Geology: If you could have stood here early in the Paleozoic Era about 500 million years ago, you would have seen nothing but open ocean, because the east coast of (a much smaller) North America lay a hundred or so miles to the west, while the landmass that would eventually become the mid-Atlantic Piedmont lay hundreds or thousands of miles to the east. Over time, that landmass – an island arc similar to the modern Philippines or Japanese islands - approached the coast, being separated from the continent by a subduction zone and deep submarine trench that acted as a large basin (figure 2). A thick mass of sediment and volcanic debris accumulated in the trench at the base of the arc, while magma generated by melting of crust beneath the subduction zone rose up into the arc. The Taconic Arc eventually collided with North America between 450 and 475 ma, accreting the deformed remnants of the trench and the island arc onto the coast, thereby adding a sizable piece of real estate to the North American landmass.

Figure 2 (left) shows how the Mid-Atlantic seaboard may have evolved during the Taconic Orogeny. Diagram courtesy of the USGS.

The Piedmont bedrock beneath Tregaron consists of two rock units (figure 1) that originated during this event. The oldest is the Sykesville Formation (figure 3), which was deposited in the

submarine trench and consists of a mixture of sediment derived from the continent and pyroclastic debris ejected by explosive eruptions from the adjacent volcanic arc. A modern analog that may be familiar to some people is Mt. Vesuvius, which buried Pompei in volcanic ash and pumice with a single, spectacular explosion of its caldera, but in this case, the Sykesville Formation is several *miles* thick and undoubtedly contains the detritus from dozens or hundreds of large eruptions from the Taconic Arc as well as millions of years worth of sediment shed from the continent. The Sykesville Formation is probably about 475-500 million years old.

Figure 3. The Sykesville Formation in Klingle Valley. Some of the objects in the rock may be pumice and other volcanic material ejected from a vent or caldera. Photo by Tony Fleming.

The second rock unit is the Kensington Tonalite, an igneous rock similar to granite, which crystallized from magma intruded several miles beneath the surface. Zircons in the rock yield a crystallization age of about 462 million years, indicating the rock was emplaced at the height of the Taconic Orogeny. This rock has the classic salt-and-pepper texture of a fine building stone (figure 4), and was widely quarried in Rock Creek Valley and Cleveland Park during the 1800's and early 1900's; it was known in the building-stones trade as "Rock Creek granite", and it faces many buildings in northwest Washington. Unlike true granite, however, tonalite has a more basic composition, meaning it is somewhat richer than normal granite in base metals like calcium and magnesium, which is manifested by certain minerals seen in the rock. The more basic chemistry also produces a favorable substrate for many plants.

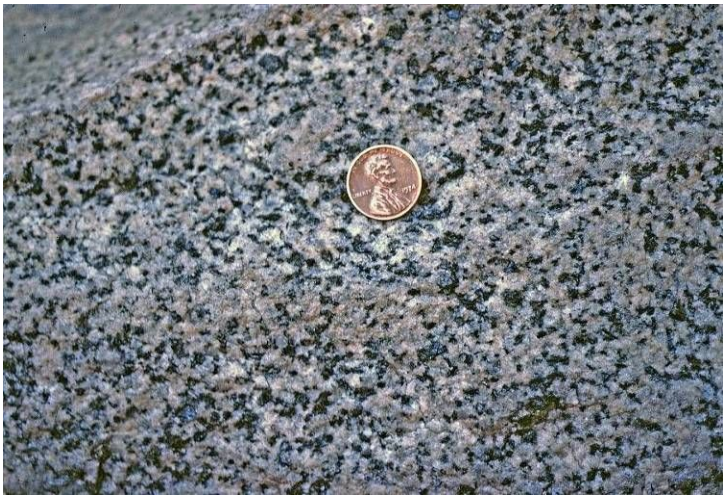


Figure 4. Outcrop of Kensington Tonalite in Klingle Valley, illustrating the classic "salt and pepper" appearance desirable in a building stone. Known in the building stones trade as "Rock Creek Granite", this rock was quarried for building stone during the late 1800's and early 1900's at several places in and near Rock Creek Park. Many structures in Cleveland Park are faced with rock quarried along Connecticut Avenue between Newark and Ordway Streets.

The principal bedrock exposures in and around Tregaron occur along the two branches of Klingle Creek, whereas elsewhere on the property, the bedrock is hidden beneath a thick mantle of soil, river gravel, and slope deposits. Bedrock crops out abundantly along the north branch between the Macomb Street entrance and Klingle Valley, and along the south branch after it leaves Tregaron and follows the east side of Klingle Road. The largest outcrops on the property are located along the north branch, just above Klingle Road (location #3 on map), and feature good examples of both rock units. Here, the Kensington Tonalite can clearly be seen to intrude the Sykesville Formation.

Impressive specimens up to several inches long of the minerals staurolite and hornblende can also be seen in these outcrops. Staurolite is an aluminum-silicate known for its unique twinned crystal form, which has led to the use of the names 'sawhorse twins' and 'fairy crosses' to describe this mineral (figure 5). This crystal form is well displayed at Tregaron. Staurolite also is a classic metamorphic index mineral, meaning that it acts as a 'rock thermometer' of sorts because it forms under specific temperature and pressure conditions during metamorphism, specifically 550-600^{o} C and depths of several miles. Hornblende is a greenish-black, calcium-rich form of amphibole found in igneous and metamorphic rocks. At Tregaron, it occurs along the contact between the Kensington Tonalite and the Sykesville Formation. Some of the specimens found along one horizon of the Sykesville Formation near the contact are unusually large and may be related to contact-metamorphic processes that allowed the crystals to grow to several inches in length. These exemplary exposures are readily accessible and could serve as an educational resource, possibly with an interpretive display or as part of a self-guided natural resources tour.

Figure 5. Twinned staurolite crystals in the Sykesville Formation in Tregaron, showing the classic sawhorse, or crossed, shapes. Photo by Tony Fleming.

Physiography: The fall zone of Klingle Creek is the dominant feature of the physical landscape at Tregaron. Nearly 125 feet of topographic relief separates the highest elevation on the property, at the school, from the lowest, at the bottom of the estate adjacent to Klingle Road. Both branches of Klingle Creek have deep, V-shaped profiles – the characteristic ravine shape of streams that are vigorously downcutting – and both ravines are floored by bedrock (figure 6). These streams have steep gradients: the north branch, for example, falls some 75 feet in the brief quarter mile it flows through the property, between the Macomb Street gate and Klingle Road. This is equivalent to a fall of 300 feet per mile, which is closer to the gradient of a mountain stream than your typical mid-Atlantic waterway. The result is the steep-sided valleys that dominate the lower elevations of the landscape: the grade approaches 50% (1 foot of rise for every 2 feet of lateral distance) on parts of the valley walls. All of this recent incision of the landscape is the handiwork of the fall zone, and nearly all of it has occurred in a few tens of thousands of years.

Figure 6. The south branch of Klingle Creek in its natural channel along the east side of Klingle Road adjacent to Tregaron. The stream falls sharply in this section, cascading down a flume-like channel floored by continuous rock outcrops within a narrow, V-shaped valley. In contrast, the higher section of the same stream that flows through Tregaron from the Lilly Pond to below the Causeway has a gentle gradient and a noticeably wider floodplain, indicating a more stable channel. The dynamic boundary between these two very different stream reaches is called a "knick point" and marks the upstream extent of the Fall Zone on Klingle Creek, where stream power is currently directed at eroding headward into resistant rock. The actual knickpoint lies near the point where the stream exits Tregaron and goes under Klingle Road in a culvert, which explains a great deal about why this particular location has been so problematic for the road over the last several decades. Photo by Tony Fleming.

The specific name for the upland that separates the two branches of Klingle Creek is a *spur ridge*, which refers to the fact that the ridge is an offshoot, or spur, of the main Wisconsin Avenue Ridge. The spur ridge gradually descends in elevation and narrows to a blunt point above the confluence of the two branches. Observation of the surface of the spur ridge between Wisconsin Avenue and Tregaron shows that it descends in a series of "steps", from a high point of around 400 feet near Wisconsin Avenue, to about 285 feet at the level summit where the International School sits. Each "step" is separated from the ones above and below by a short rise, or scarp, perhaps 20-25 feet high, which is analogous to the risers on a set of stairs. But unlike a set of stairs, which might be surfaced by carpet, the summit of the spur ridge is mostly covered by a veneer of gravel and cobbles deposited by ancient streams. Each step is thus a terrace—a remnant marking the various positions of the Potomac River (and later, Rock Creek) as they cut down through the landscape during the past several million years.

The Wisconsin Avenue Ridge is the highest and oldest terrace in the District (at least one even higher terrace is known from northern Virginia); it marks the position of the Potomac River during the late Tertiary period, and may be as old as 10-15 million years. As much as 30-40 feet of red, weathered, well rounded river gravel underlies the summit of the ridge. It is important to note that this broad, prominent upland was an alluvial bottomland when the gravel was deposited—that is, it was the low point in the regional landscape prior to the Ice Age—which attests to how much erosion has subsequently occurred. Stepping down from Wisconsin Avenue (see cross section in figure 1), the next terrace is much narrower and is visible as the level surface in the 3400 block of Lowell and Newark Streets. The next one below that is the broad surface upon which sits the Twin Oaks mansion (location 2 on figure 1), at about 310 feet above sea level. Highland Place occupies another remnant of the same terrace. About 25 feet below that is the terrace at the summit of Tregaron (location 1 on figure 1). The exact ages of these terraces are not known—no fossils are known from any of the upland river gravels that cap them—so we can only speculate about how long it took for them to form. What does seem clear is that the deep incision of the Klingle Creek ravines is a relatively recent feature associated with the latest in the series of glaciations that make up the Ice Age. This most recent glacial period, known as the Wisconsin Stage, occurred from about 20,000 to 70,000 years ago and provides an age range for the incision of Klingle Valley.

One consequence of the rapid valley incision in the Fall Zone is the production and down-slope transport of copious amounts of sediment. Most of the hillsides in Tregaron are mantled by loose gravel and smaller soil particles moving slowly down the sides of the valley towards the streams. The gravel is derived from erosion of the terrace at the top of the property, while the smaller particles come mostly from weathered bedrock that underlies the hillsides. This mixture of gravel and finer particles is called *hillslope colluvium*, or just *colluvium* for short.

Figure 7. Colluvium is particularly noticeable around the bases of trees, where the action of water runoff removes the finer particles, leaving a lag of gravel and cobbles. Photo by Tony Fleming.

Colluvium moves via a combination of frost heaving and gravity: each time the soil freezes, stones and smaller particles are lifted outward, perpendicular to the slope. When the soil thaws, the particles settle straight down, thereby migrating down slope a few millimeters each year. In this way, a large amount of colluvium is constantly being mixed and transported down hillsides to the ravines, albeit very slowly. Very little of it shows up in the bottoms of ravines, however: despite their small size, the steep gradient of the streams gives them considerable power, enabling them to easily flush out the sediment. An indication of the size of the sediment load moving through these ravines can be seen when the process is disrupted, as is the case along the south branch of Klingle Valley where it flows through Tregaron between the Causeway and Klingle Road. There, the small stone culvert (undersized to begin with) that formerly carried the stream under Klingle Road became plugged with debris about 30 years ago, blocking the passage of the stream and the sediment it carries. In only a few short years, several feet of gravel, sand, and mud was deposited in the small floodplain upstream of the culvert, a volume that clearly suggests the size of the sediment load moving down the adjacent hillsides.

Another important effect of rapid stream incision is on soil depth. The soil generally gets thinner, and fresh bedrock is increasingly close to the surface, as one proceeds downslope into the bottoms of the ravines, where the streams are actively cutting into rock. This has a practical effect on natural communities, because the substrate generally is moister, richer, less acidic, and therefore, more conducive to supporting more vigorous and diverse plant life in and near the bottoms of the ravines, whereas the soil is generally dryer, more acid, and less fertile higher in the landscape.

Urban Hydrology: Both branches of Klingle Creek are perennial streams, meaning they flow all the time, even during periods of drought, when they may be reduced to trickles. The flow in these streams comes from two sources: 1) overland runoff, which is water that runs directly off the surrounding landscape when the intensity of rainfall or snowmelt exceeds the infiltration capacity of the soil. Typically, this occurs during strong storms, or anytime the ground is either frozen or completely saturated; and 2) base flow, which represents the volume of water available all the time from the constant discharge of ground water into the streambed from soil and bedrock. Because the ravines are deeply entrenched, the streams remain in contact with the water table along most of their lengths, and thus maintain relatively robust base flow. Several small springs and seeps, for example, can be seen near the banks of the north branch of the creek in Tregaron. The base flow of both branches also is maintained by large springs at their heads: the historic Cleveland Park spring (location 5 on figure 1) lies at the head of the north branch, between Macomb Playground and 34th Street; whereas, one or more similar springs (no longer visible due to landscape alterations) on and near the National Cathedral grounds also feed into the south branch via underground pipes.

The upper Klingle Creek watershed (above Connecticut Avenue; see figure 1) encompasses about 175 acres; it extends west to the summit of the Wisconsin Avenue ridge, south to approximately Cleveland Avenue and Woodley Road (near Maret School), and north to the ridge defined by Highland Place and Newark Street. All of this area feeds overland runoff and ground water into the two branches of the creek. Urbanization of the watershed has fundamentally changed the hydrology by partially replacing what was once an entirely forested landscape with impervious and poorly pervious surfaces, such as rooftops, streets, gutters, and lawns, all drained by a system of storm sewers that commonly discharge into nearby ravines. This has the practical effect of increasing runoff and reducing ground-water recharge during any given storm, which in turn increases the size and power of floods while diminishing base flow at other times because reduced ground water recharge results in a lower water table. This more extreme ‘urban hydrology’ is typical of the entire Rock Creek watershed (figure 8) and can lead to more frequent and severe flood damage, gully-like stream profiles, and less moisture availability at other times to plants and animals that occupy or depend on the ravines.

These urban impacts are mitigated considerably along the north branch of Klingle Valley (and to a lesser extent, the south branch) by the presence of large tracts of mostly forested land (Tregaron and Twin Oaks), large leafy residential lots that bound the ravine along Macomb and Newark Streets, and because the stream flows directly on solid rock as it passes through Tregaron, which limits both flood damage and the rate of channel downcutting by the stream. The impacts of urbanization are more pronounced along the south branch, the upper reaches of which are contained in an unnatural underground pipe from its headwaters near the Cathedral to its outfall near the Woodley Road gate of Twin Oaks. Storm water draining off of the Cathedral grounds and adjacent streets and neighborhoods discharges into the south branch, turning what is normally a small, placid stream into a raging torrent during a heavy thunderstorm.

The impacts of this urban hydrology regime are most evident along the now closed Klingle Road, where the south branch has repeatedly undermined the road at several places. In part, this reflects the fact that modern flood volumes simply overwhelm the limited capacity of the antiquated water-control structures that were built at the turn of the century when this watershed was mostly in large, leafy estates rather than moderately dense urban neighborhoods. It is also because "Klingle Road" basically follows (and is named after) the historical 18th century wagon trail that led through this precipitous, V-shaped valley on its route from Georgetown to the Klingle Estate (aka Linnean Hill). Despite these issues, the sections of both branches of Klingle Valley in Tregaron are still largely natural, mostly stable, and function reasonably normally in a hydrologic sense. They require minimal intervention or restoration, consisting mainly of removal of trash from the stream beds, and control of invasive plants such as ivy that may choke stream banks and topple trees across the bottoms of ravines. Both streams are a valuable educational resource and provide major ecological and aesthetic amenities to the property.

Figure 8. Storm sewer outfalls and gullied stream channels are common features around the headwaters of tributary streams in Rock Creek Park. Photo by Tony Fleming.

Natural Communities: Natural communities are defined as distinct associations of plants and animals that recur in specific places within a landscape in response to a specific set of physical conditions. Climate, geology, and water are among the dominant variables that interact to determine which natural communities occupy which parts of the landscape. For example, the gravelly hilltop where the International School is located is fundamentally different than the deep ravine occupied by the north branch of Klingle Creek, and the two locations can reasonably be expected to host distinct natural communities. By virtue of its hilltop position, which promotes direct exposure to sun and wind, and its gravelly soil, which is well drained and droughty, the hilltop is a distinctly hotter and drier site. In contrast, the northeast-facing ravine is sheltered from direct sun and wind, and remains moist and cool most of the time from the discharge of ground water along the bottom of the slopes. The contrast between the two sites illustrates the concept of microclimates (figure 9), which are defined as landform-induced adjustments in temperature, moisture, and sun exposure. Thus, even though both sites have the same regional climate, they differ substantially in the details. On a hot summer day, the shady ravine is likely to be about 10-15 degrees cooler than the exposed hilltop. This example shows that climate, geology, and water are not independent of one another; rather, geology (in the form of topography) affects both of the other two.

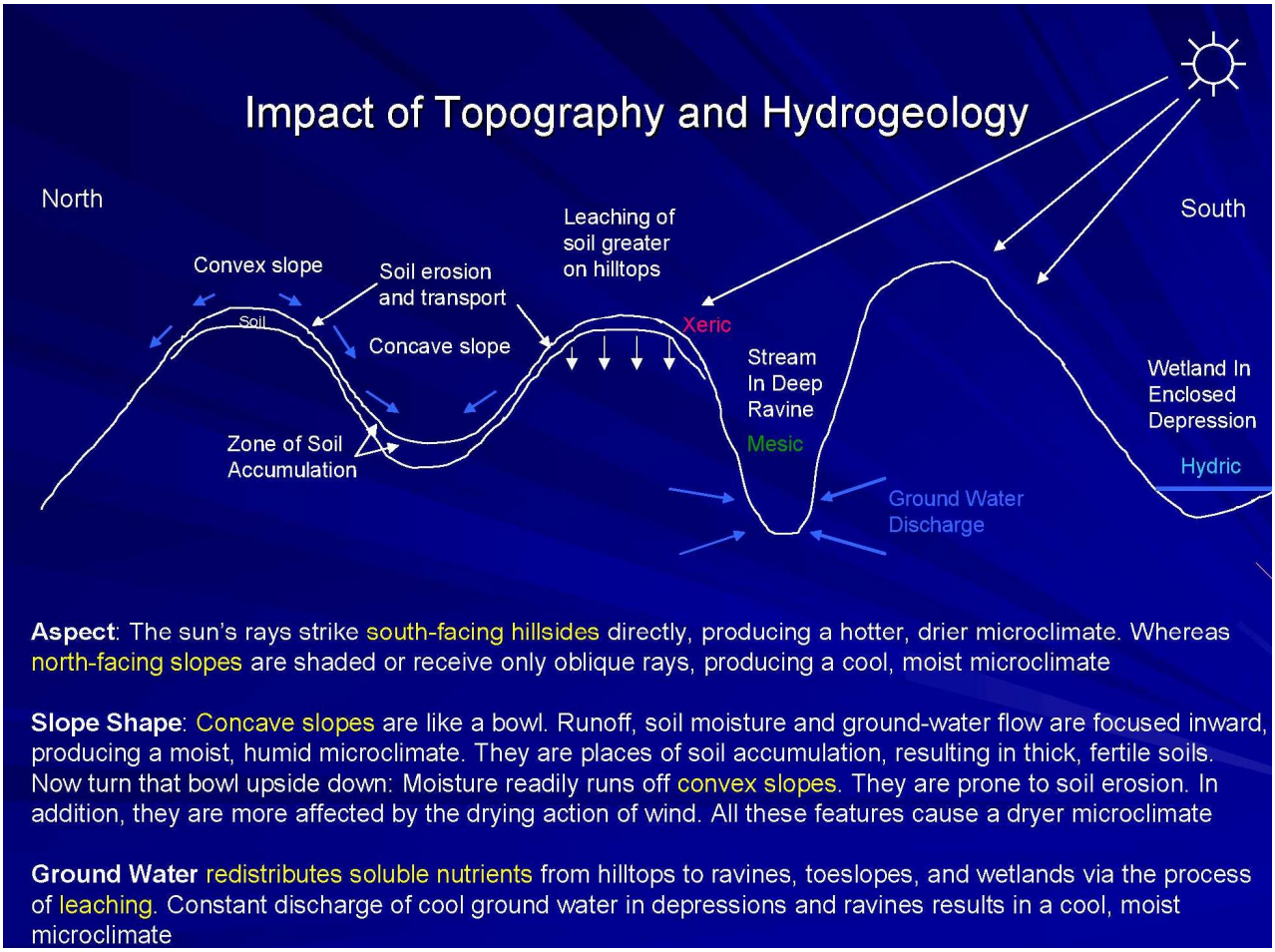


Figure 9. Why does this plant grow here, but not there? This diagram depicts some of the physical processes that influence the distributions of plants and natural communities in the local landscape.

The natural communities present at Tregaron, or that were likely present prior to settlement, reflect these environmental differences and are similar to those documented in Rock Creek Park (NatureServe, 2015). Much of the original vegetation on the hilltop was altered by clearing for the

estate, but relic enclaves suggest that it was populated by a dry *oak-hickory* and/or *oak-heath forest* composed of chestnut, white and black oaks, mockernut and pignut hickories, and, on the driest sites, heaths such as mountain laurel and low-bush blueberries. All of these plants are acid tolerant and well adapted to the seasonal dry spells associated with a gravelly hilltop. Below the hilltop, the upper slopes host a *mixed mesophytic forest*, with a greater proportion of beech, tulip tree, and dogwood, at least on the north- and east-facing slopes. However, white oak dominates the south-facing slopes on the south side of the property, closer to Woodley Road, suggesting a somewhat hotter microclimate. In contrast, the north branch of Klingle Creek has a cool, moist microclimate, and fresh bedrock with a modestly basic composition is close to the surface, producing a relatively rich substrate for plants. This ravine, and the slope above it, host the best remaining example of an original natural community on the site. This location contains (or formerly did, before being invaded by English ivy and other alien plants) a diverse herb layer with many wildflowers. Jack-in-the-pulpit, mayapple, Soloman's seal, and several types of ferns are a few examples. There is also a greater diversity of tree and shrub species. Northern red oak and tulip tree are among the dominant canopy species in this setting, as they both adapt well to moist, cool slopes and ravines. White ash, basswood, bitternut hickory, spicebush, and paw-paw are examples of other tree and shrub species found in this *basic-mesic ravine forest*.

As noted above, parts of the woodlands are infested with non-native invasive plants, many of which proliferated in the decades prior to the establishment of the conservancy. English ivy, Japanese knotweed, purple winter creeper (euonymus), Japanese honeysuckle, and garlic mustard are a few of the more prominent ones. These aliens thrive under the same favorable environmental conditions that promote the diverse native community. When I was growing up, the hillsides along the ravine had abundant wildflowers, and English ivy was limited to a small number of places, mainly around the more intensively landscaped areas close to the estate. Today, the opposite is true: English ivy and other invasive plants form widespread carpets that smother the native herb layer. The forest canopy itself remains intact, however, and forms the cornerstone for future restoration efforts. Removal of ivy from shrubs and trees is a high priority in terms of protecting the existing forest resource. Removal of ivy and other invasives from the forest floor throughout the property is an important long-term goal, and one that could be addressed at least in part through community participation. In some local jurisdictions, invasive plant removal efforts serve both as an educational tool and a community-building exercise, and a similar approach may be well suited to Tregaron.

Annotated Bibliography

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http://www.explorenaturalcommunities.org/parks-places/rock-creek-park
This well-illustrated website contains detailed information about the natural communities, soils, geology, landscape, and related aspects of Rock Creek Park, and contains many images of native plants

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