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FALL LINE FORMATIONS IN NORTHERN VIRGINIA

I swear upon my word of honor that I have neither given nor received any unauthorized help on
this assignment.

INTRODUCTION

In Northern Virginia, near the city of Fredericksburg, three geology formations meet: the Goochland Terrane, the Chopawamsic formation, and the Potomac formation. The intersection of these three formations is a microcosm of the Fall Line, the boundary between the Atlantic Coastal Plain and the Central Virginia Piedmont. The exposed portion of the Goochland Terrane in question is the Maiden's Gneiss, which is composed of metamorphic rock (Spears, et al., 2004). The Goochland Terrane is suspect in origin, and the metamorphism in the Goochland Terrane was caused when it accreted onto Laurentia during the Paleozoic (Spears, et al., 2004). The Potomac formation is sedimentary rock that was deposited by rivers during the Cretaceous, as a result of the flow of water being changed by the accretion of the Chopawamsic formation (Mixon, 2000).

The type of rock that these formations are composed of can have a direct effect on the success of agricultural and engineering projects in the region. Sedimentary rock is a poor base for many structures, as it is less stable than "hard rocks" (metamorphic and igneous rocks). Certain types of clay can be particularly difficult as they swell and shrink, causing damage to building on them and making them poor insulators for contaminants; on the other hand, certain types of clay are excellent for keeping waste from landfills out of the environment. Sedimentary

rocks composed of sand can be very permeable, where clay based sedimentary rocks absorb water, and metamorphic rocks are usually not particularly permeable.

METHODS

Three field sites across Northern Virginia were selected as suitable candidates for data collection. The sites were Meditation Rock, the outcrop at Alum Spring Park, and the exposure of the Po River metamorphic suite near Indian Punchbowl (see map for utm coordinates and bedding angle). All of these sites are located in or around Fredericksburg, Virginia. For this project, the outcrops at each site were examined and compared to the known geological formations in Northern Virginia. The sedimentary characteristics of the outcrops were then used to determine the environment that led to their formation, as well as which rock formation they were part of.

In the process of data acquisition, Brunton Compasses, adjusted for the 10° east magnetic declination in Fredericksburg, were used to take strike and dip, as well as to determine the orientation of outcrops. Forestry Suppliers 10 x 18 mm Loupe Magnifiers were used to analyze mineral content. Grain size charts and rulers were used to determine the size of minerals grains and clasts. Garmin eTrex 10 GPS units were used to take UTM coordinates of the field sites in the 18S datum.

The Kenmore Park and Alum Spring Park outcrops were sedimentary in origin, while the Po River outcrop was composed of metamorphic and igneous rocks.

RESULTS

The outcrop at Kenmore Park is a 12 foot wide, 9 foot tall sedimentary exposure on a hillside located at UTM Easting 284099, Northing 4242622, 18S. The exposure, called Meditation Rock, consists of layers of heavily weathered, gray, medium-grained sand, with beds of poorly sorted conglomerate interspersed throughout the rock. The exposed upper side of the outcrop has a heavy concentration of cobbles and pebbles. Weathering is particularly heavy on the sides of the outcrop, and less heavily weathered parts of the outcrop are light grey in color. The outcrop shows light crossbedding. The bedding of the outcrop has a strike of 025° and a dip of 26° south east.

The Alum Spring Park outcrop is a cliff face to the side of a hiking trail located at UTM Easting 282729, Northing 4240683, 18S; the outcrop is 22 feet high by 60 feet long. The exposure as a whole is sedimentary in origin, containing many grain sizes of sand, as well as pebbles, cobbles, and boulders. The lowest exposed layer is very thickly bedded, and composed of tan coloured fine sand and occasional cobble and boulder sized clasts, with some tree trace fossils in a dark brown matrix with very fine sand to silt grain sizes; this is followed by a layer of medium thickness made out of fine sand, however this layer contains many more clasts. The next layer is after a thinly bedded lens made out of fine sand to silt sized grains, and it does not contain larger clasts. Lenses similar to this layer appear across the outcrop face. The third layer is a sandy brown to dark grey color, and less weathered than previous layers, exposing fresh blue grey sediment. This layer is thickly bedded, and it is within this layer that heavy tree trace fossils appear (See figure 1). The highest layer that is still clearly visible from the path contains many tree trace fossils, but returns to the tan colour of lower layers. The outcrop continued past this layer, but was no longer clearly observable. The strike and dip of the main bedding of the exposure is $162^{\circ} 21^{\circ}$ south west. Faint crossbedding can be observed across the outcrop's

surface, the strike and dip of the crossbedding is $151^{\circ} 51^{\circ}$ south west. This outcrop displayed heavy weathering, especially near its base.

Of the Po River field sites, the first (PO1) is a roadcut adjacent to the punchbowl, and the second (PO2) is northwest of the first, on the bank of the Rappahannock River. PO1 is 7.5 feet high at its tallest point, and 32 feet long. The south east face of PO1 is dominated by a schist composed of coarse grained biotite and muscovite. The schist has a foliation orientation of $030^{\circ} 90^{\circ}$ NE. Turning to face south west from this face, a face composed of three separate igneous intrusions of granite is visible, two of which are metamorphosed and display foliation. The granite has a phaneritic texture and is composed of plagioclase feldspar, and quartz. A strike and dip taken from these layers read $318^{\circ} 79^{\circ}$ north east. The PO2 field site is north west of PO1, located at UTM Easting 283526, Northing 4244219. PO2 is a gneiss with colours ranging from dark grey to light tan, damaged by severe fractures, and containing many veins of igneous intrusions. The gneiss contained potassium feldspar, plagioclase feldspar biotite, hornblende, and garnet; the size of these grains ranged from fine to coarse. The metamorphosed rocks had foliation with a strike and dip of $222^{\circ} 89^{\circ}$ north west, and fractures with a strike and dip of $296^{\circ} 55^{\circ}$ north east. The igneous intrusions had a bearing of $011^{\circ} 03^{\circ}$ north west. and contained coarse grained quartz, potassium feldspar, and plagioclase feldspar. The effects of weathering on this outcrop are relatively minimal, possibly due to its hard rock composition.

DISCUSSION

The Po River exposure is part of the Goochland Terrane, and it showcases the order of events clearly at PO2 (Mixon, et al., 2000). At PO2 we can see that the igneous intrusion infiltrated before the metamorphism, as the igneous intrusion is foliated along the same lines as

the metamorphism, meaning that it must be younger according to the law of crosscutting relationships; this same law proves both of these events occurred before the fracturing, as the fracturing interrupts both the igneous rock and the metamorphic rock (See Figure 3). The metamorphism most likely occurred shortly before the fracturing and from the same event, where the rock was being compressed from the northwest and south east.

The Alum Spring Park outcrop is part of the Potomac formation, which the evidence suggests was formed by a braided river (Geolex, 2025). Crossbedding suggests the existence of a fluvial or marine environment, and as the flow of the river changed, bars of silt would have migrated across the river's width, while heavy clasts and branches would have been deposited during times of relatively low energy in the river (Rust, 1972). This appears likely because of the lenses of silt mixed in with sand, well rounded boulders and trace fossils from tree branches being carried by the river. The abundance of plant fossils in grey silt suggests that this outcrop is part of the upper Potomac formation (Mixon, 2000). The orientation of the trace branch fossils suggest that the river flowed to the north east, as this is the most common orientation of these fossils (see rose diagram).

The Kenmore Park outcrop best matches the lower Potomac formation as described in Mixon, et al (2000), with thick beds of sand as well as beds of conglomerate. This can be observed in figure 3, which displays both a thick bed of sand and conglomerate elements near the top of the exposure. The rock is most likely fluvial in origin, though it does not appear to have formed in a braided river. The crossbedding and large, well rounded clasts indicate that the paleoenvironment where it formed had flowing water that transported the rocks from farther inland, which suggests a river; however, the lack of trace tree fossils or silt lenses differentiate it from the Alum Springs outcrop, and specifically the latter indicates the river that formed

Meditation Rock was not braided. The Potomac formation, both lower and upper, were deposited after the Goochland Terrane had collided with Laurentia; specifically the Potomac formation was deposited during the Cretaceous, while the Goochland Terrane had accreted during the Paleozoic (Mixon, 2000; Spears, et al., 2004).

CONCLUSIONS

The Kenmore Park and Alum Spring Park exposures are from two levels of the same sedimentary rock formation, and both are mostly sand based. In terms of functionality, the Kenmore Park outcrop is sturdier than the Alum Springs Outcrop, and other parts of the lower Potomac formation are most likely a better choice for weighty construction than the upper Potomac formation. On the other hand, the upper Potomac formation is more suited to be used for agricultural purposes due to the lenses of silt increasing its ability to retain water. The Maiden's Gneiss exposure is poorly suited for agricultural purposes in areas where it is truly exposed, as igneous and metamorphic rocks do not absorb water well, and are harder for plant roots to take hold in. However, the crystal based rock here is significantly more stable when it comes to supporting structures, meaning that this soil is well suited to engineering purposes.

FIGURES



Figure 1: A trace fossil of a tree branch from Alum Spring Park with a 5 ½ inch pencil for scale.



Figure 2: An image of a foliated igneous intrusion that has been interrupted by a fracture, proving that the fracture is younger using the law of crosscutting relationships. A ruler is included in the image for scale.



Figure 3: A picture of the Kenmore Park outcrop with a ruler for scale, this figure displays both a thick bed of sand and a layer of conglomerate near the top of the rock. Please note that there is white and green graffiti discoloring the rock.

REFERENCES CITED

Geolex — Potomac publications NGMDB,

https://ngmdb.usgs.gov/Geolex/UnitRefs/PotomacRefs_3387.html (accessed November 2025).

Mixon, R.B., Pavlides, L., Po wars, D.S., Froelich, A.J., Weems, R., Schindler, J., Newell, W., Edwards, L., and Ward, L.W., 2000, Geologic map of the Fredericksburg 30' x 60' quadrangle, Virginia and Maryland:, doi:10.3133/I2607

Rust, B.R., 1972, STRUCTURE AND PROCESS IN A BRAIDED RIVER: *Sedimentology*, v. 18, p. 221–245, doi:10.1111/j.1365-3091.1972.tb00013.x.

Spears, D.B., 2004, The Goochland-Chopawasmic Terrane Boundary, Central Virginia Piedmont, *in* Southworth, S., Geological Society of America, and Geological Society of America (Eds.), 2004, *Geology of the National Capital Region: field trip guidebook ; joint meeting of Northeast and Southeast Sections, Geological Society of America, Tysons Corner, Virginia, March 24 - 27,2004*: Reston, Va, US Dep. of the Interior, US Geological Survey, U.S. Geological Survey circular, p.223-245.

AI USAGE STATEMENT

AI was not used in the production of this paper.