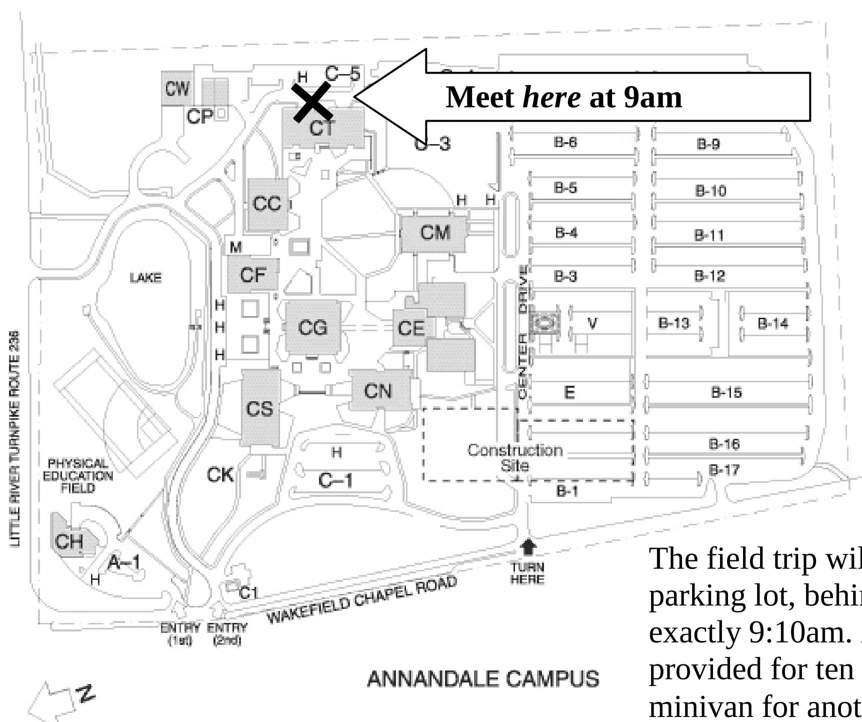
Geology of the Billy Goat Trail, C&O Canal National Historical Park, Maryland

Field Studies in Geology

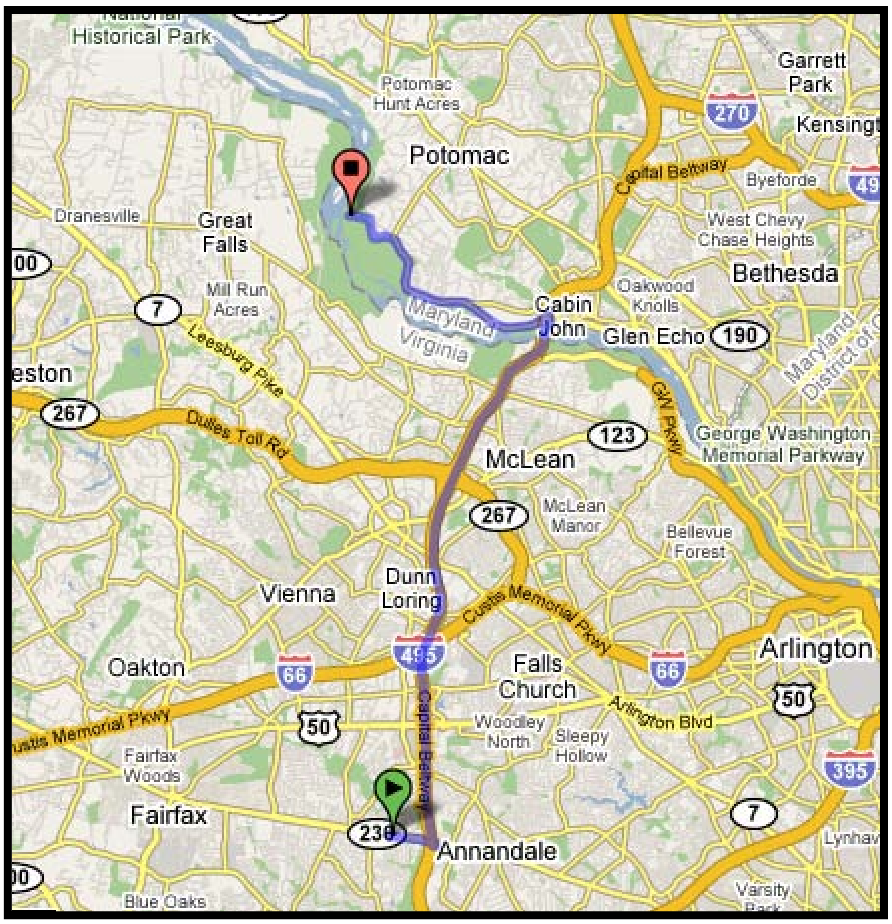
GOL 135 | Northern Virginia Community College, Annandale | C. Bentley

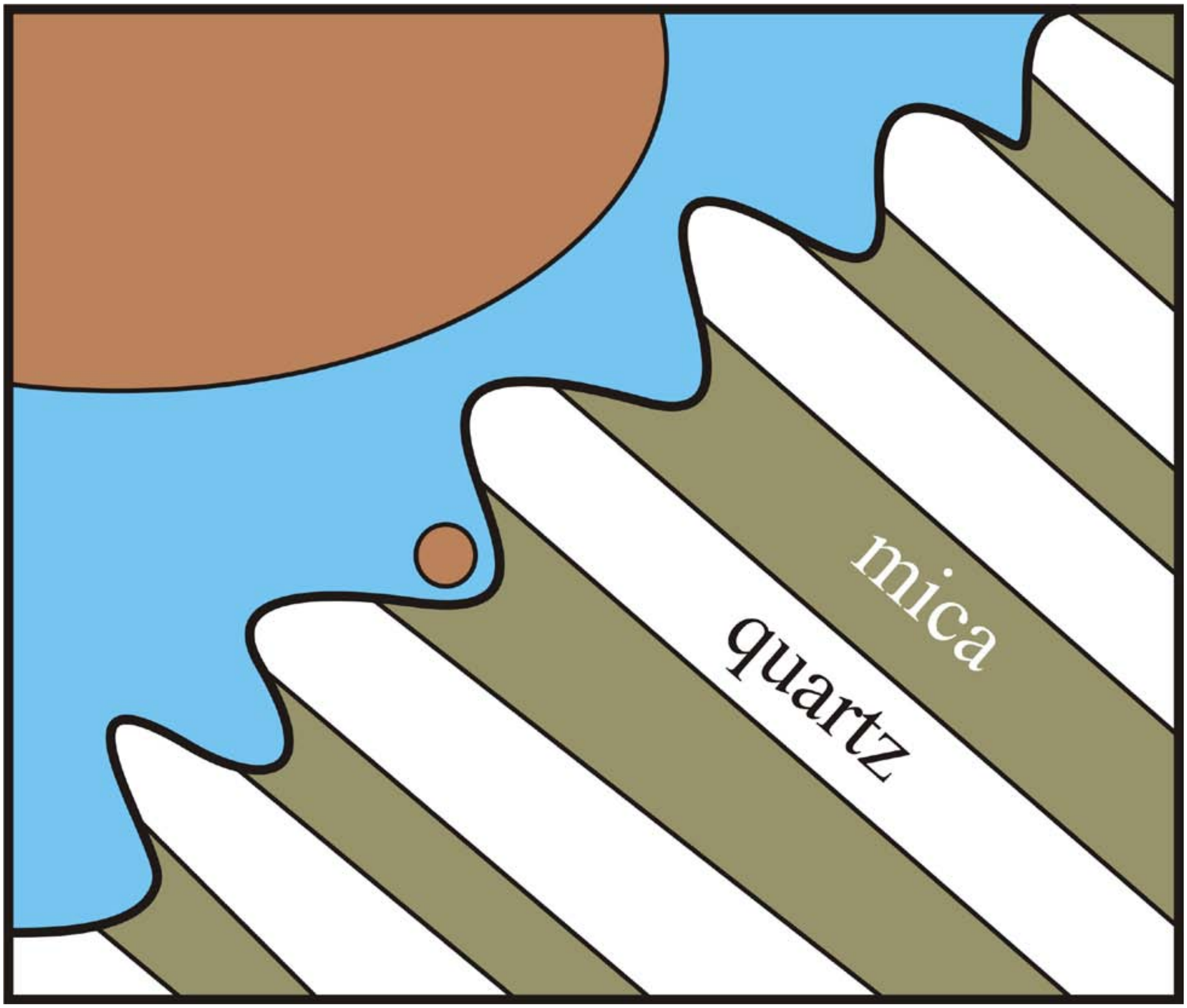


The field trip will depart from the C-5 parking lot, behind the CT building at exactly 9:10am. A van will be provided for ten (10) students and a minivan for another six (6) students Additional students will require additional vehicles to carpool. All park entrance fees will be provided for (a waiver form needs to be in each car). Please ensure that you are <u>on time</u> – we do not want to have to leave you behind!

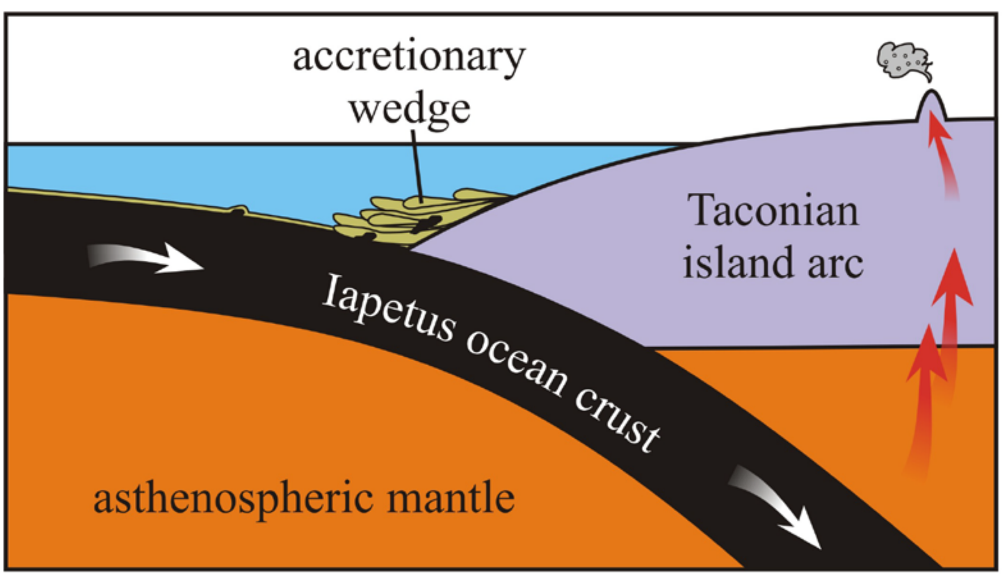
Driving directions from NVCC-Annandale to the Billy Goat Trail:

Instructions	Distance
1. Head east on Little River Turnpike/VA-236 E towards the Beltway.	0.8 mi
2. Slight right to merge onto Capital Beltway/I-495 N (inner loop).	10.4 mi
3. Cross the Potomac River on the American Legion Bridge. The first exit on the Maryland side of the river is the one we want. Take exit 41 toward Carderock.	0.3 mi
4. Bear left. Merge onto Clara Barton Pkwy. Drive past the David Taylor Model Basin on the right.	1.7 mi
5. Stop sign. Turn left at MacArthur Blvd.	3.4 mi
6. Another stop sign. Go straight, continuing on MacArthur Blvd. Pass Old Angler's Inn on the right. Keep going straight. On the left, you will see the sign for "Great Falls, Maryland." Turn left there, into C&O Canal National Historical Park. Long downhill drive to the park entrance booth. Present fee waiver there.	

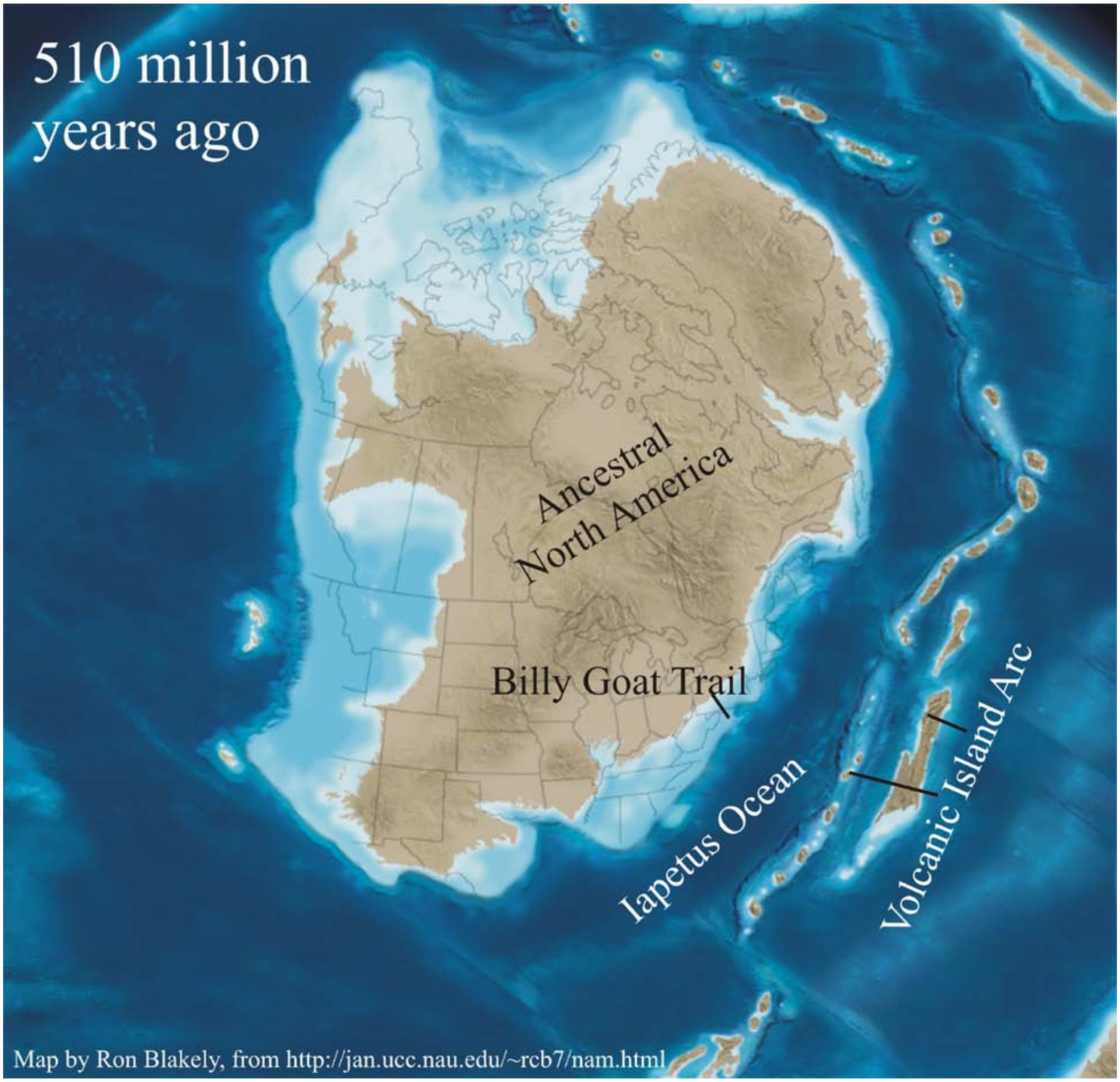




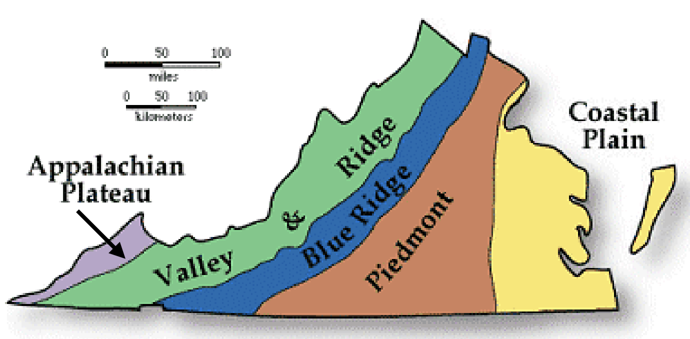
Texture of the interior of potholes reveals ridges of quartz in high relief and mica-rich layers in low-relief. Could a large cobble have hollowed out potholes with that sort of relief pattern? It is unlikely: cobbles are “too blunt an instrument” for etching that sort of relief. Only a small grain like sand or silt could fit in between the quartz layers to preferentially eat away at the mica strata.



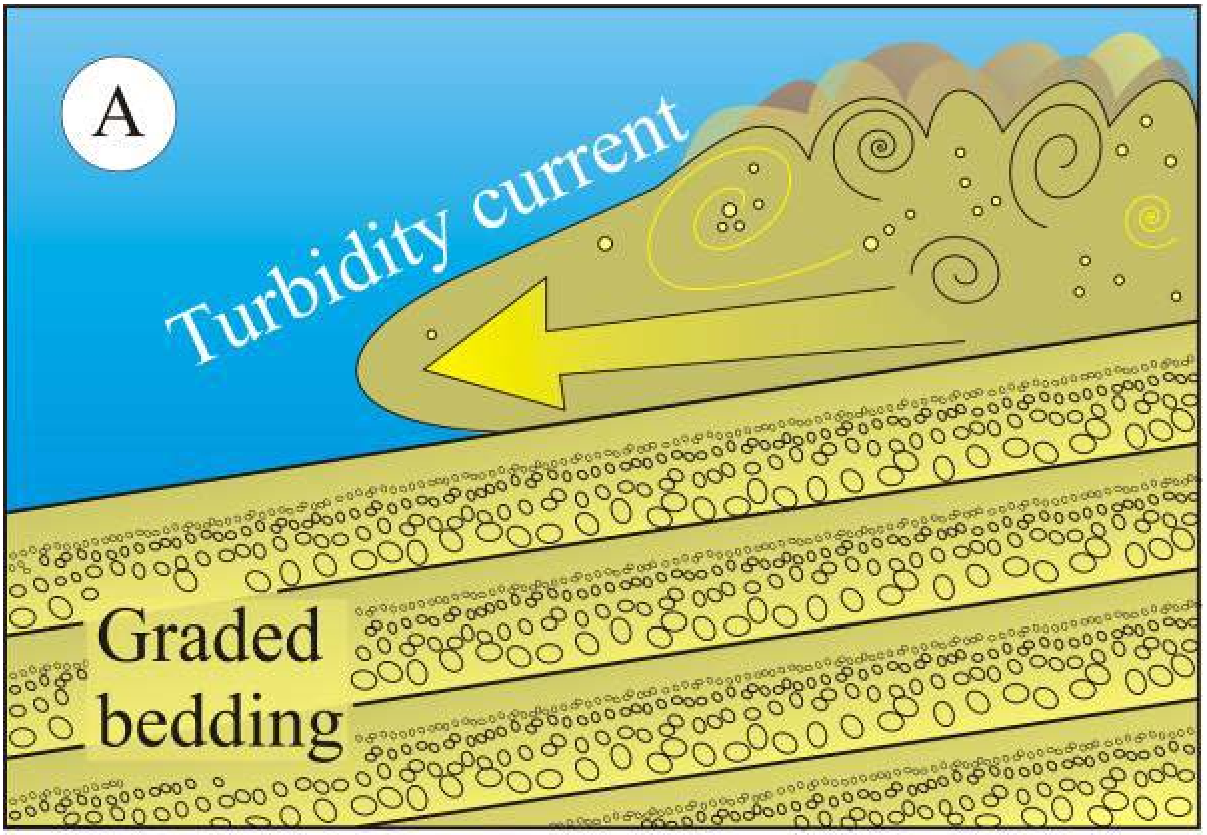
How the metagraywacke of the Iapetus Ocean got scraped off (along with a few chunks of the mafic oceanic crust) into a big, disorganized pile called an accretionary wedge. The Taconian volcanic island arc acted like a bulldozer as it moved closer and closer towards North America.

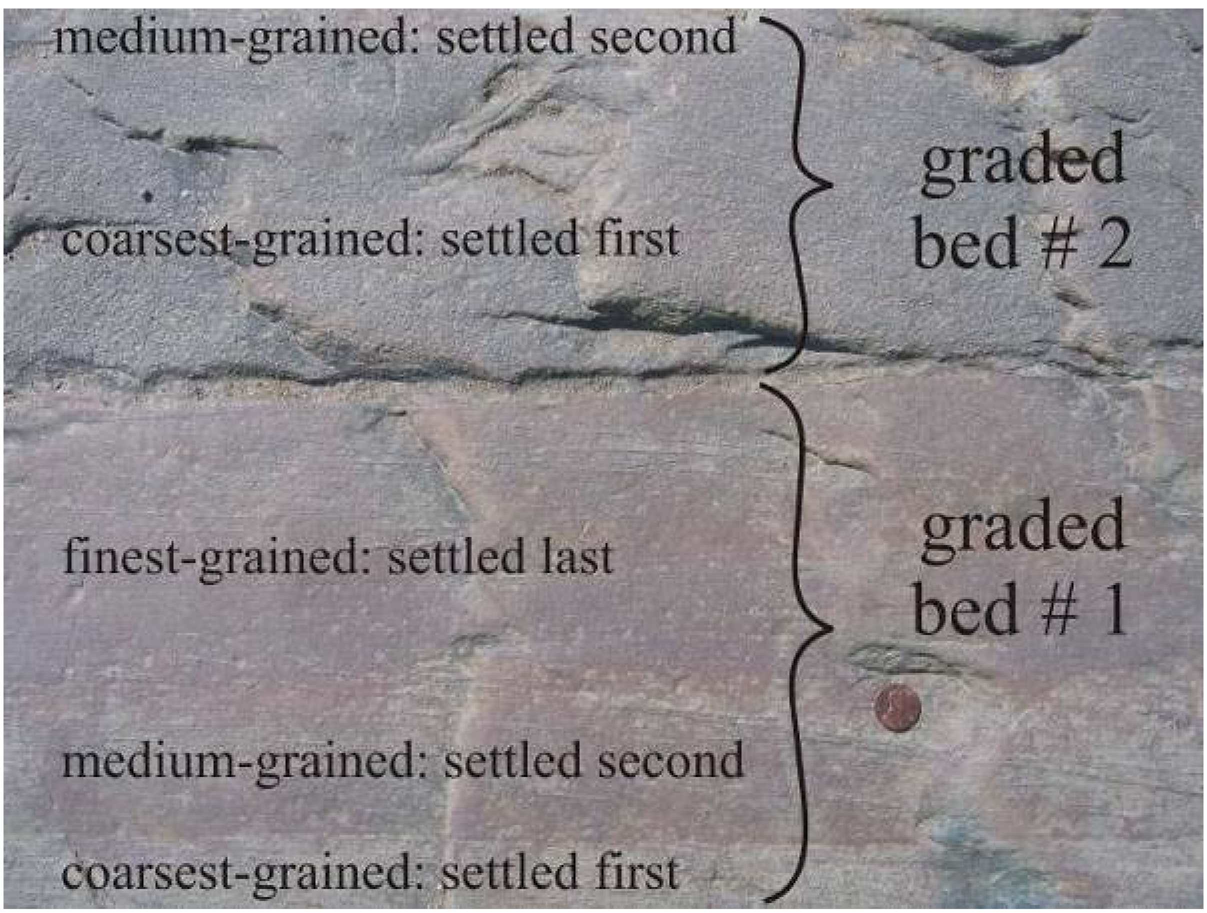


The **sedimentary environment** where the graywacke sediments (immature sand + mud) of Mather Gorge accumulated: an ancient ocean basin (the Iapetus Ocean), that no longer exists. It was closed in three stages: the Ordovician Taconian Orogeny (~460 million years ago), the Devonian Acadian Orogeny (~360 million years ago), and the Pennsylvanian & Permian Alleghanian Orogeny (~300 million years ago to ~260 million years ago).



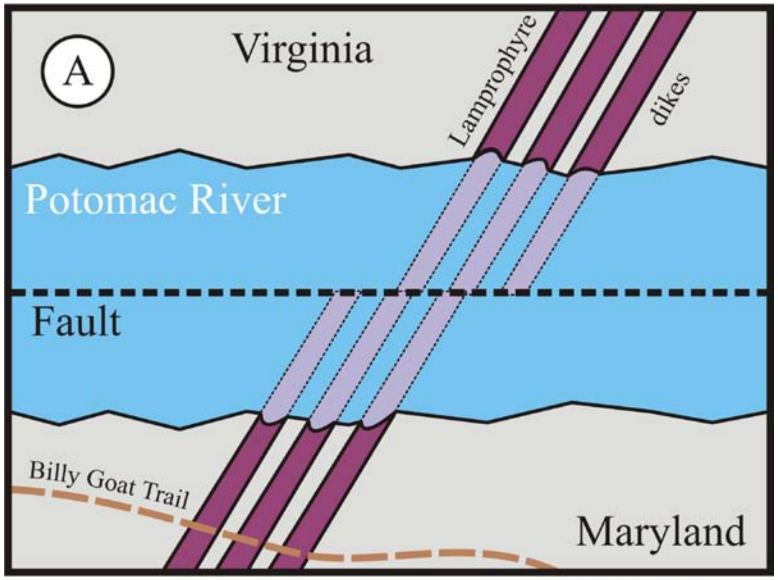
Physiographic provinces of Virginia. Great Falls is located on the boundary between the Coastal Plain and the Piedmont, a region called the Fall Zone. Image from http://www.wm.edu/geology/virginia

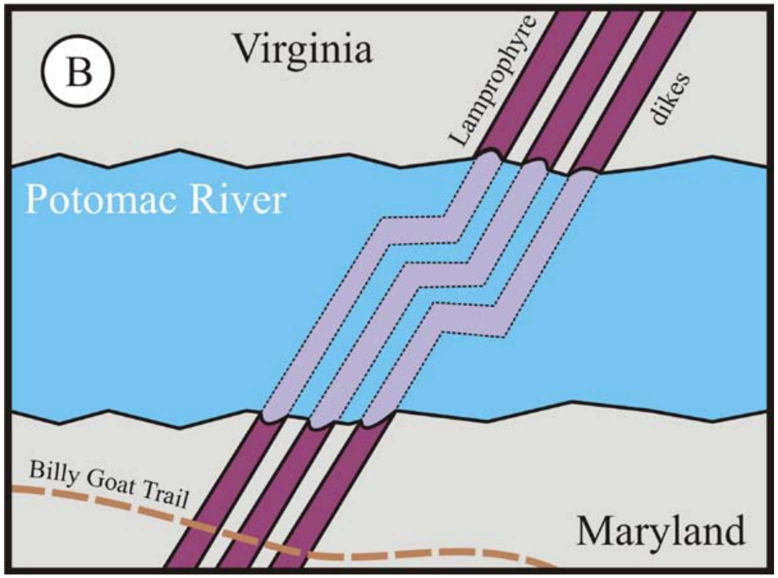

A
Turbidity current
Graded
bedding

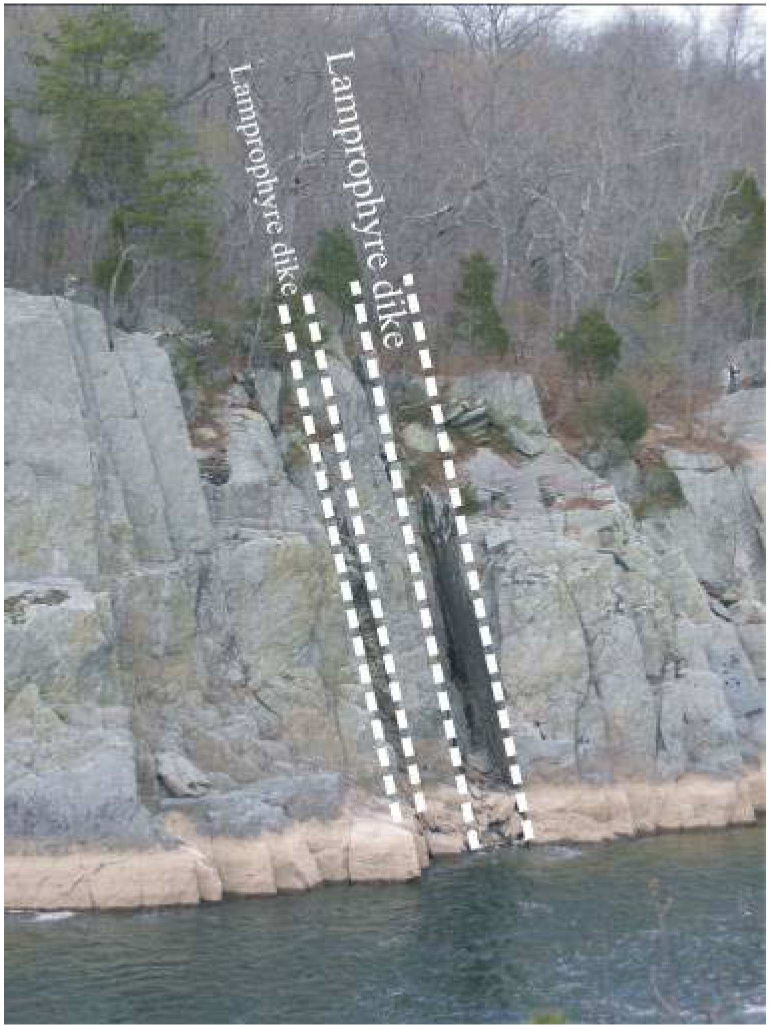

medium-grained: settled second
coarsest-grained: settled first
graded
bed # 2
finest-grained: settled last
graded
bed # 1
medium-grained: settled second
coarsest-grained: settled first

Aerial photograph of the Great Falls area, showing the wide, shallow river upstream from Great Falls, the location of the water diversion dam (start of the Washington Aqueduct, which leads to the Dalecarlia Reservoir in NW Washington, DC), the location of the Great Falls Tavern Visitor Center (MD), the falls themselves (whitish area shows main cataracts), the long, linear stretch of Mather Gorge, and the old, abandoned channel of the Potomac River utilized by the C&O Canal at Widewater.

Lamprophyre dikes





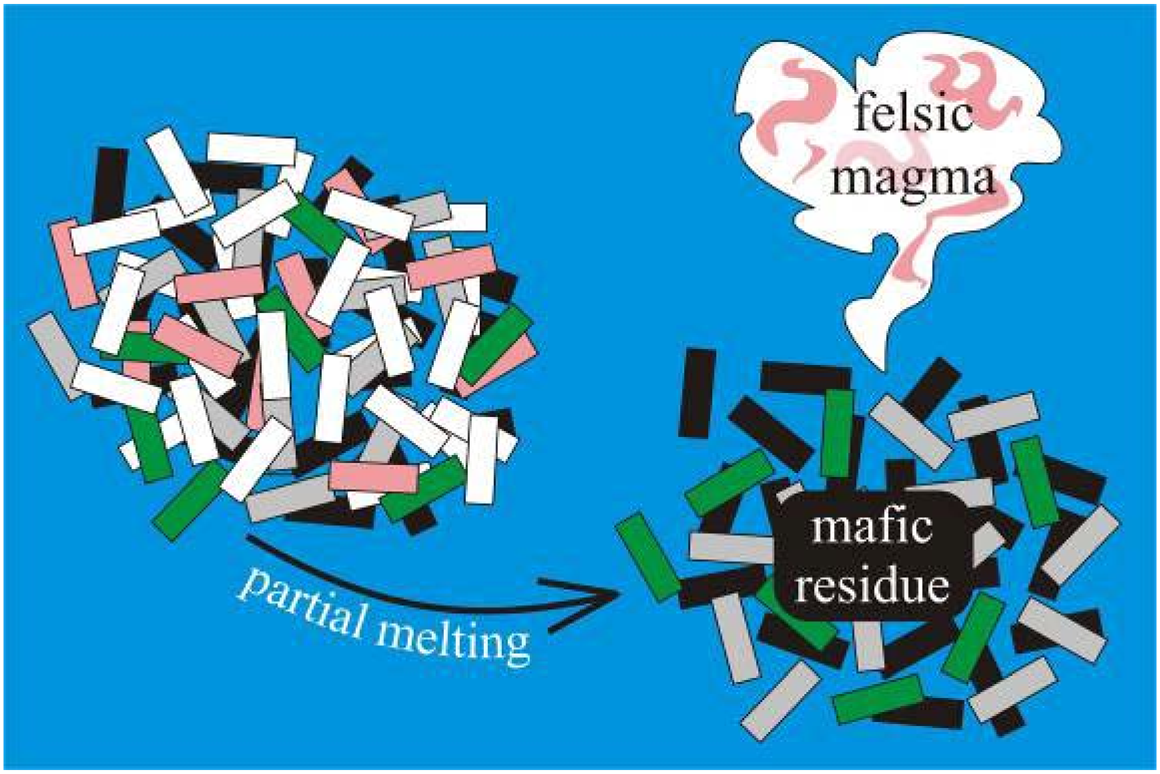


Dikes on the Virginia side of the river, as viewed across Mather Gorge from the Maryland side of the river.

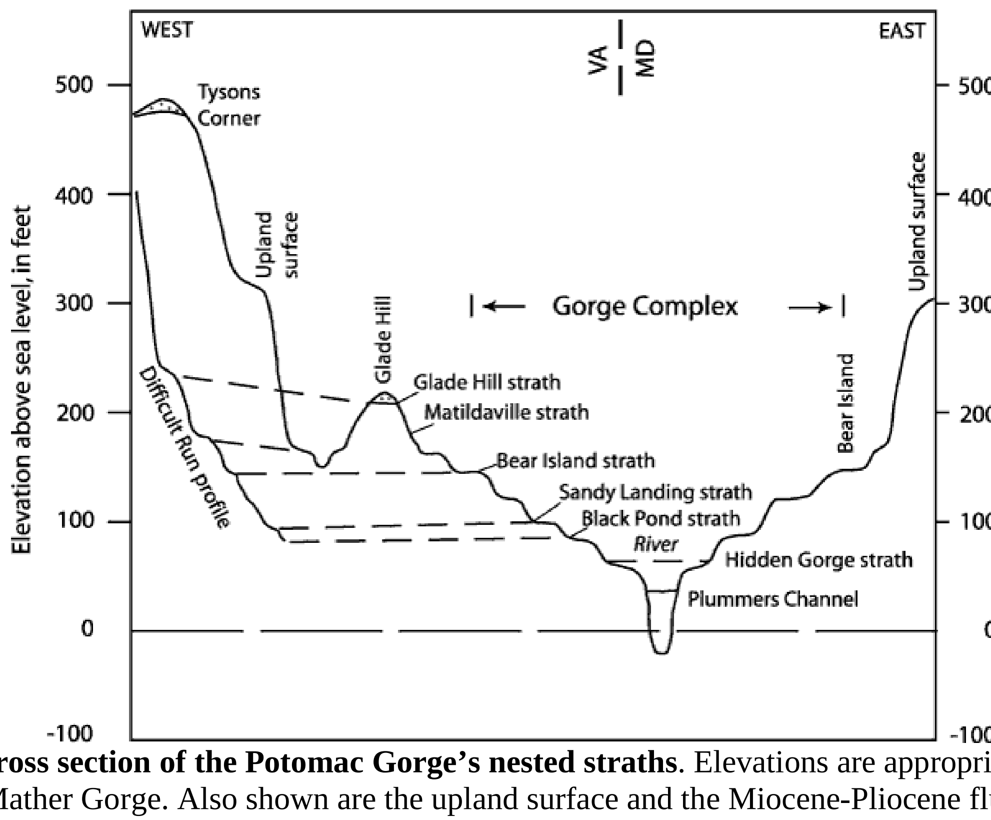
Rocks of the Great Falls area

Amphibolite, a metamorphic rock with a mafic igneous rock (basalt? gabbro?) for its protolith.

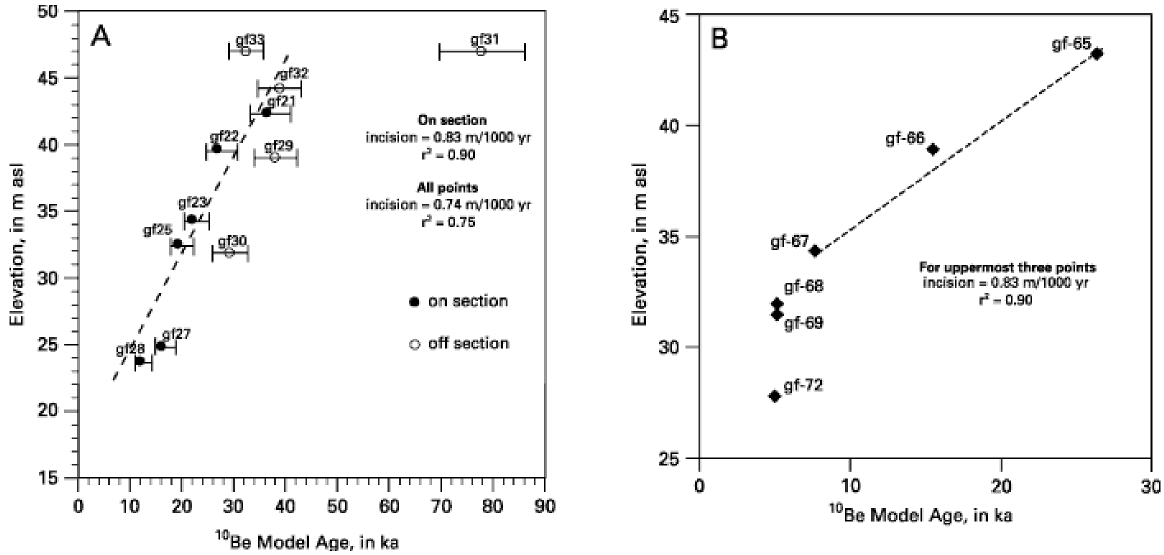
Migmatite, partially-melted meta-greywacke with "wisps" of granite in it.



Partial melting of rocks with a mix of minerals liberates the more felsic constituents (quartz, muscovite, potassium feldspar, Na-rich plagioclase feldspar) as liquid melt, leaving behind the more mafic constituents (Ca-rich plagioclase feldspar, hornblende, biotite, pyroxene, olivine) as a solid residue. *In general, felsic minerals have lower melting temperatures than mafic minerals.*



Schematic cross section of the Potomac Gorge's nested straths. Elevations are appropriate for the entrance to Mather Gorge. Also shown are the upland surface and the Miocene-Pliocene fluvial deposit sequence found at Tysons Corner. From "The Incision History of a Passive Margin River," Bierman, et al., Field Trip 6, *USGS Circular* 1264, 2004.

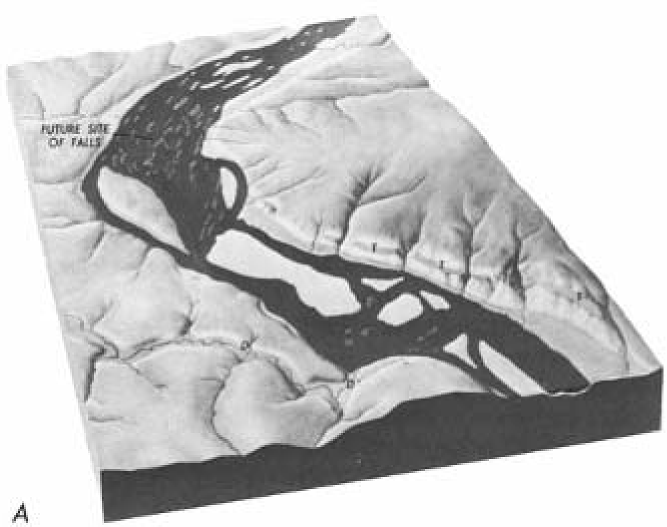


Cosmogenic Berylium-10 (^{10}Be) shows incision of the Potomac River increased about 10,000 years ago (10 ka). From "The Incision History of a Passive Margin River," Bierman, et al., Field Trip 6, *USGS Circular* 1264, 2004.

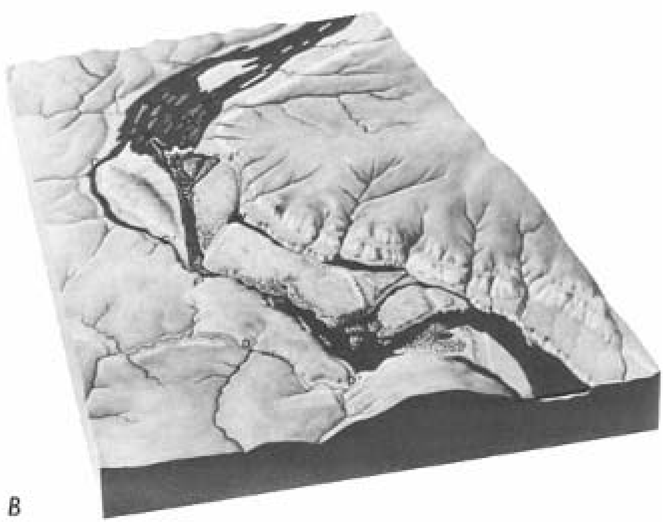
Also from "The Incision History of a Passive Margin River," Bierman, et al., Field Trip 6, *USGS Circular* 1264, 2004:

"Fieldwork along the Potomac River, in conjunction with many measurements of cosmogenic nuclides in samples collected from fluvially eroded surfaces, suggests that:

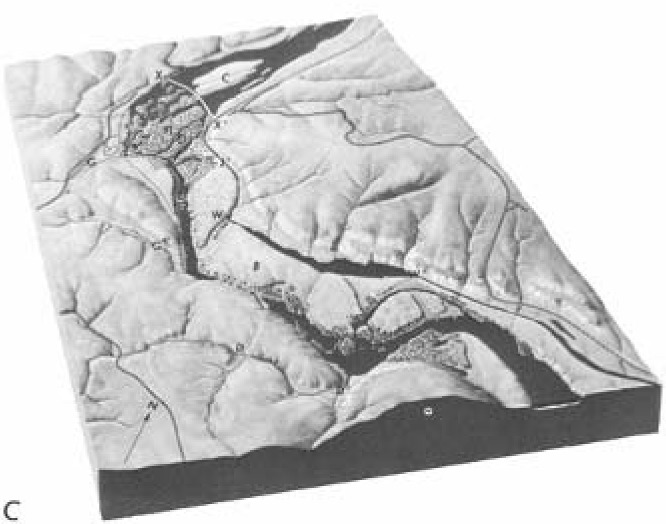
1. "The most distinct bedrock strath terrace bordering the Potomac River downstream of Great Falls is a time transgressive feature. Between Black Pond and Great Falls, this terrace surface, the Bear Island level, was first exposed about 38 ka, coincident with the onset of the latest Laurentide ice advance. Downstream of Black Pond, the same terrace surface is considerably older.
2. "Terrace formation and knick zone retreat appear to be episodic with long stillstands and rapid periods of retreat. Both field and cosmogenic data argue against steady knick zone retreat over time.
3. "Great Falls first formed between 25 and 30 ka as indicated by the exposure ages of several samples collected just above the knick zone.
4. "Two vertical transects of samples suggest that Mather Gorge was steadily incised at a rate between 0.5 and 0.8 m/1000 yr over much of the late Pleistocene."



A



B



C

STAGES IN THE CARVING OF GREAT FALLS. The area of the block diagrams covers about the some area as that shown on the map. Refer to the map for scale and names of geographic features.

A. The Great Falls area as it probably appeared before the Ice Age. The river occupies a broad valley, and the future site of the falls is marked by rapids and ledges of resistant rock. Gravel-covered benches *(T)* are remnants of an older, higher valley floor. Difficult Run *(D—D')* flows across a broad, flat flood plain to empty into the Potomac River.

B. The same landscape during a period late in the Ice Age. The lowered sea level has caused the river to cut deeply into the floor at its former valley. Floods at this time may have been even higher and more frequent than they are today because of greatly increased snowfall. The down-cutting has been relatively rapid in the slightly softer rocks below Great Falls and especially rapid where the rocks are broken along a fault *(F—F').* At *F* the river encounters a series of closely spaced fractures or joints. This zone of weakness has caused the river to cut laterally *(J—J').* Diversion of water into the deeply cut channels along the fault and fracture zone has caused the river to abandon several channels on the Maryland side, including the one now occupied by Widewater *(W—W').* The channel around Glade Hill *(G—G')* still carries water, but it is rapidly being cut off. Deepening of the river valley has caused Difficult Run to correspondingly deepen the lower part of its valley *(D—D'),* destroying its old flood plain and building a new lower one.

C. Great Falls today. Continued erosion along the fracture zone *(J—J')* has diverted all the water from the channel around Glade Hill *(G—G').* Channelways are now being cut upstream from the fracture zone, leaving Olmsted *(O)* and Falls *(Fl)* Islands above water level. Construction of the dam *(X—X')* to divert water into the Washington aqueduct has further modified the details of the landscape above the falls. Most of Conn Island *(C),* for example, has been built since the construction of the dam. The abandoned channel north of Bear Island *(B)* has been flooded by building dams at *W* and *W'* so that it could be used as part of the C. and O. Canal. Difficult Run *(D—D')* continues to deepen its valley so that its old flood plain survives only above the first rapids *(D).*

Images and text from *The River and the Rocks*, USGS, 1970.

Assignment

Write a short (3-5 page) paper about the geology of the Billy Goat Trail area. The paper is to be a synthesis of what you have learned on the trip. It should be based primarily on your field notes and the images and information in this document, but may also include additional research that you do after the day of the trip. Emphasize the rocks and structures that we observe in the field, and geologists' interpretation of those rocks and structures. If you use any outside sources, including the ones I have gathered for you here in this document, you must cite them in a **Bibliography** or **Works Cited** section.

The paper should cover: (a) the rocks which make up the bedrock of the Billy Goat Trail area, both sedimentary and igneous (b) modifications to those rocks (folding, faulting, jointing, intrusion of igneous rocks, partial melting, etc.) that occurred during the Taconian and Acadian Orogenies, and (c) the incision (cutting) of the Potomac River into that bedrock (including floods, pothole formation, and the possible influence of a fault running through Mather Gorge).

The report should be in standard **Times New Roman font** (like this page), **12-point** in size (like this page), and **double-spaced** (like this page). Figures, if included, should not be included in this page count – the "3 to 5 pages" are for text only. Figures can certainly be included (frequently, they are far better than words at expressing geologic relationships), but they are not required. You may draw figures yourself, or reproduce them from the published literature. Any figures you haven't drawn yourself need to be cited as sources.

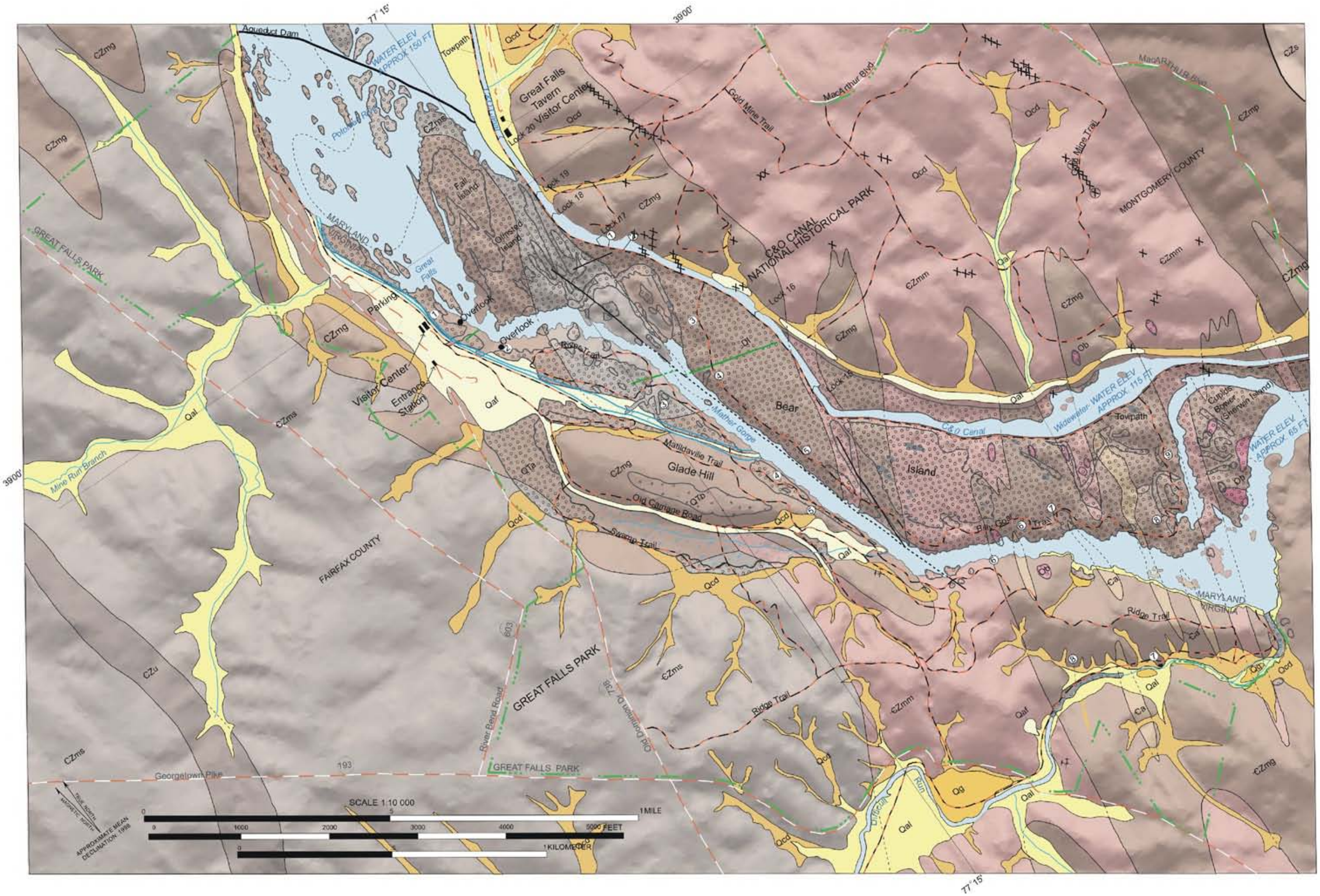
NOTE: **Title pages** are not necessary. I consider them to be a waste of paper.

To help you avoid some of the most common mistakes in writing a paper of this sort, proper formatting guidelines are online at:

http://www.nvcc.edu/home/cbentley/gol_135/formatting.htm

There's lots of useful information available online for you at the course website:

http://www.nvcc.edu/home/cbentley/gol_135/billy_goat


Aqueduct Dam
WATER ELEV APPROX 150 FT
Potomac River
Towpath
Great Falls Tavern
Lock 20 Visitor Center
Lock 19
Lock 18
Lock 17
Lock 16
Lock 15
Fall Island
Olmsted Island
MARYLAND
VIRGINIA
Great Falls
Parking
Overlook
Visitor Center
Entrance Station
Mather Gorge
Bear
Island
C&O Canal
Widewater- WATER ELEV APPROX. 115 FT
Cupids Bower (Sherwin Island)
WATER ELEV APPROX. 65 FT
Glade Hill
Matildaville Trail
Old Carriage Road
Swamp Trail
Ridge Trail
C&O CANAL NATIONAL HISTORICAL PARK
Gold Mine Trail
MacArthur Blvd
MONTGOMERY COUNTY
FAIRFAX COUNTY
GREAT FALLS PARK
Mine Run Branch
River Bend Road
Old Dominion Dr. 738
Georgetown Pike
Difficult Run
603
193
77°15'
39°00'
SCALE 1:10 000
1 MILE
5000 FEET
1 KILOMETER
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1996

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Qaf — **Artificial fill and ground disturbed by construction**

Qal — **Alluvium (Holocene—present to 10,000 years old)**
Unconsolidated clay, silt, sand, gravel, and cobbles in valley bottoms

Qg — **Alluvial gravel-bar deposits along Difficult Run (Holocene and late Pleistocene—present to 100,000 years old)**

Qcd — **Colluvium (Holocene and late Pleistocene—present to 100,000 years old)** —Cobbles, boulders, and debris in slope hollows

QTa — **Unconsolidated clay, silt, sand, and gravel deposited on level surfaces called terraces (Holocene and Pliocene—10,000 to 5 million years old)**

QTb — **Boulder deposit on crest of Glade Hill; is remnant of highest and oldest terrace (Holocene and Pliocene—10,000 to 5 million years old)**

OLDER IGNEOUS ROCKS

Dl — **Lamprophyre dikes (Late Devonian-about 360 million years old)**—Dark-colored, biotite mica-rich tabular intrusions that cut across the surrounding rock

Ob — **Bear Island Granodiorite and pegmatite bodies (Ordovician-about 470 million years old)** —Light-colored, muscovite mica-rich, elliptical intrusive bodies and small tabular intrusions

Ꞓa — **Amphibolite sills (Early Cambrian-about 540 million years old)** —Dark-colored, hornblende-rich tabular intrusions, emplaced parallel to the bedding of the surrounding rock

METAMORPHOSED SEDIMENTARY ROCKS

(Lower Cambrian and (or) Late Proterozoic—about 600 million years old)

Sykesville Formation

ꞒZs — **Melange**—Gray, fine-grained mixture of quartz and feldspar, with pebbles of white quartz and blocks of greenish-gray phyllonite; originally deposited on the ocean floor

Mather Gorge Formation

ꞒZms — **Quartz-rich schist and mica gneiss** —Greenish-gray rocks with different textures; schist is finer grained, more planar, and less massive than gneiss

ꞒZmg — **Metagraywacke and metasiltstone schist** —Well-bedded, gray, dirty sandstone interbedded with siltstone; originally deposited in submarine turbidity currents on the ocean floor

ꞒZmm — **Migmatite** —Complex, light- and dark-gray rock formed when rocks of different ages were melted together

ꞒZmp — **Phyllonite with vein quartz** —Shiny, greenish-gray, fine-grained sheared rock with pods and veins of white quartz

OLDER IGNEOUS ROCKS

ꞒZu — **Ultramafic rocks** —Dark-green igneous rocks consisting of serpentinite, soapstone, and talc schist; occur as sedimentary blocks and fragments in the Mather Gorge Formation