THE NORTHERN VIRGINIA MINERAL CLUB INC

The Mineral Newsletter

Meeting: March 28   Time: 7:30 p.m.

The meeting will be hybrid due to the coronavirus pandemic. Details on page 6.

Legrandite

Ojuela Mine, Durango, Mexico

Source: Wikipedia.   *Photo: Géry Parent*.

Volume 62, No. 3
March 2022
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March Meeting Program:

What meteorites tell us

Details on page 6

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Mineral of the Month
Legrandite

by Sue Marcus

Legrandite is an attractive, relatively rare, sunny yellow zinc arsenate mineral. It is our March Mineral of the Month. The original specimen was collected by a Belgian mining engineer, Louis C.A. Legrand, who died in 1920. The mineral was first described in print and named for him in 1932 by Julian Drugman and Max Hey.

Hey had merely two bachelor's degrees when he worked on this mineral. He later earned a doctorate degree and became a famous mineralogist. I wonder where the type specimen was between the year it was collected (1920) and when it was described (1932), but here's a clue: in their initial description, Drugman and Hey note that Drugman acquired the specimen from Legrand's widow.

That makes me think of all the no-longer-wanted mineral collections and the interesting specimens that may be discovered in them. What if Widow Legrand had just dumped her husband's minerals in the garden?

The describing authors, Drugman and Hey, graciously inform us that the type specimen came from the Flor de Peña Mine in Nuevo Leon, Mexico. This means that there is more information available about the type specimen than for many other minerals. Accurate location information helps professional and amateur geologists understand the environment that formed the mineral and therefore where to look for it in geologically similar locations.

The chemical formula deduced by Drugman and Hey was $Zn_{14}(AsO_4)_9OH \cdot 12H_2O$. That has since been modified to $Zn_2(AsO_4)(OH) \cdot (H_2O)$. The type specimen was small, and the early analytical techniques were destructive, which probably accounts for later, better specimens being used to refine the earlier data. Apparently, the amount of water—or, more precisely, the H_2O molecule—was difficult to determine due to the weakness or strength of the hydrogen bonds.

More specimens from a second locality in Mexico provided better material to analyze. Some of us remember Paul Desautels and possibly Roy Clarke of the Smithsonian Institution. They came up with the currently accepted formula of $Zn_2(AsO_4)(OH) \cdot (H_2O)$ and published their results in 1963. Other scientists throughout the world continued to examine the chemical composition of legrandite, deriving formulas with varying amounts of H_2O.

Köttigite and adamite, both arsenate minerals, are associated with legrandite. Different mineral localities, having roughly similar geological environments and histories, may sometimes be identified by the mineral associations specific to, or at least most common in, that location. These association, sometimes along with other physical characteristics, can

Happy St. Patrick's Day!

Northern Virginia Mineral Club members,

The November club meeting will be a hybrid meeting, both in person and via Zoom, on **March 28, 7:30 p.m.** Tom Kim has graciously permitted us to use his home for the meeting. The program will be on meteorites. See details on page 6.

Legrandite with adamite and limonite, Ojuela Mine, Durango, Mexico. Source: Wikimedia; photo: Parent Géry.

help collectors give a probable location for a specimen. Experiencing many specimens of the same mineral, whether at a museum, a mineral show, or online—even by looking at minerals for sale, without buying—can help us learn how to know our minerals and localities. Thanks for letting me learn by writing these columns.

Legrandite occurs at the [Sterling Mine](), Sterling Hill, New Jersey. The mineral, more of a novelty than a fine mineral from this locality, is the result of the diverse chemistry of the deposits there. The legrandite crystals are flattened, very rare, and mostly of interest to those who want a collection of all minerals found here. Although the deposits at Sterling Hill and Franklin are famous for their fluorescent minerals, legrandite does not fluoresce.

Mexico hosts the most renowned and probably the best localities for legrandite. When Louis Legrand examined the Flor de Peña property, he realized that arsenic in the deposit would make it difficult or impossible to exploit despite its ore-grade lead and zinc mineralization. During his probe of the location, he brought samples back to Europe. One of them, when described after his death, became the type specimen of the mineral that bears his name.

Although Legrand collected only one sample that contained this new material, collectors since then have found many more. Canary yellow legrandite forms lustrous, radiating sheafs and terminated individual crystals. The best of these have transparent areas within them but are mostly translucent. Crystals from this mine grow to at least 2.1 centimeters (0.79 in). Some images on Mindat show legrandite crystals of a more orange hue, though this may be due to the photographic conditions rather than the specimens.

Legrandite, Ojuela Mine, Durango, Mexico. Source: Wikidata; photo: Didier Descouens.

Legrandite on gossan matrix, Ojuela Mine, Durango, Mexico. Source: Wikimedia; photo: Rob Lavinsky.

Specimens are more common in gossan than those without matrix. Gossan forms from the oxidation and weathering of mineralized areas. The process of decomposing the original rock and forming the gossan also leads to mobilization of the chemicals that form secondary minerals like legrandite. The last reported specimen extraction that I found dates to the 1960s.

The most prolific legrandite locality is the [Ojuela Mine]() near Mapimi in Durango, Mexico. Crystals up to 6.0 centimeters (2.4 in) in size have been reported. The crystals formed in vugs, often together with adamite, another zinc arsenate mineral. Hydrothermal fluids bearing lead, zinc, and arsenic replaced the limestone host rock. The primary ore minerals were oxidized, resulting in the formation of legrandite and other secondary minerals of interest to collectors, like scorodite, rosasite, and more.

The most productive period of specimen mining at the Ojuela Mine was in the 1960s–80s, although legrandite specimens were probably found later in smaller quantities. Crystals range from acicular micromounts to large, terminated crystals 3.2 centime-

Legrandite, Ojuela Mine, Durango, Mexico. Source: Wikimedia; photo: Rob Lavinsky.

Legrandite (the Aztec Club), Ojuela Mine, Durango, Mexico. Source: Mindat; photo: Jake Harper.

ters (1.3 in) in size. Unique, doubly terminated legrandite crystals were found at this locality. If, like me, you don't have one of these rarities, you can view them on Mindat's legrandite or Ojuela Mine websites. Smaller crystals are transparent and larger crystals translucent. Micromount collectors should be able to acquire excellent specimens.

The world's most iconic mineral specimens have names, possibly for marketing, although the names also help collectors refer these beauties in relatable ways. The Ojuela Mine produced two named legrandite specimens, the Aztec Sun and the Aztec Club. The Sun consists of crossed legrandite sprays measuring 18.7 centimeters (7.4 in) across. It was probably found by miners who, lacking regularly paying work in the 1970s when mines were closed or dormant, took to mining and selling mineral specimens to collectors. One of these men, Felix Esquevil, discovered the Sun in 1977.

The Sun and Club came to light in the United States when Jack Amesbury brought them to Tucson, where the Sun was offered to others before being purchased by Miguel Romero. The specimen is in now in the MIM Museum in Beirut, Lebanon. The Club, on display in the American Museum of Natural History in New York City, is a parallel group of crystals that reach 22 centimeters (9 in) long. Most of us have wished that we'd purchased a specimen rather than missing out on having it. Imagine the regret of professional mineral dealers on having declined to purchase what became an iconic mineral specimen. Romero liked specimens from the Ojeula Mine and had several stunning legrandites in his famous collection. Legrandite is reported by Mindat from two other localities in Mexico, both near the Ojuela Mine and probably related to it.

The Tsumeb Mine in Namibia is one of the world's most famous mines for beautiful mineral specimens and for the variety of minerals found there. The richly mineralized oxide zone of the orebodies contain legrandite. Tsumeb legrandite is not as abundant as in the Mexican mines, and most Tsumeb specimens are microcrystalline, though larger crystals were found in the Zinc Pocket in 1992. The specimens with larger crystals seem to be more orange than the usual canary- or lemon-colored crystals, with one Tsumeb specimen described as having a cherry-red streak. Mindat lists legrandite among the minerals found at the Sanyati Mine in Zimbabwe, though with no other information about its occurrence and no photos.

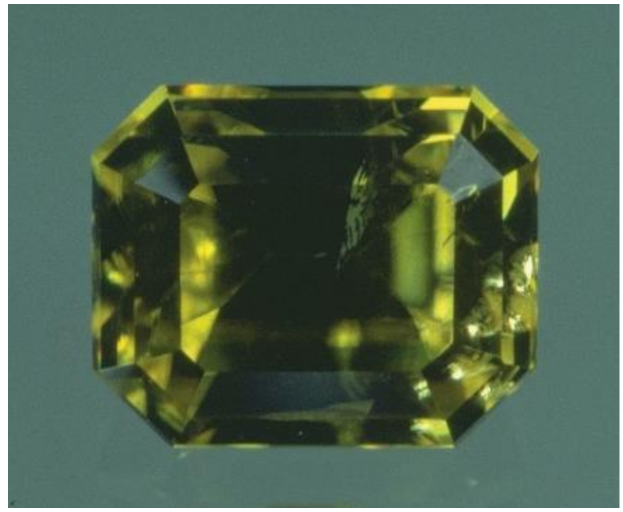
Anthony and others (2000) and Mindat note legrandite at a few other localities though nothing like the ones mentioned previously. The list of minerals from the Marie Mine near Willendorf, Germany, includes this mineral, though with no further information or photos. The Silbereckle Mine near Reichenbach, Germany, has köttigite and adamite along with legrandite. Since these minerals often occur together, perhaps more legrandite will be found there.

In the Boa Vista Pegmatite, Minas Geris, Brazil, legrandite was probably in the alteration zones associated with the pegmatite or in oxidized rocks related the pegmatite; it is quite unlikely to be a primary mineral formed with the pegmatite. Micromount-size crystals were found at the Toroku Mine in the Miyazaki Prefecture of Japan. The Ogibira Mine, in Japan's Okayama Prefecture, was reported to have minor legrandite as well.

Some people like a challenge, and apparently that includes faceters. I expected that no one would attempt to cut legrandite; after all, who wants to wear an arsenic mineral? I'm proven wrong again by a faceted 3.4-carat legrandite in the Smithsonian's gem collection.

Another, smaller faceted legrandite is shown on the Gemdat website; and the Gemsociety.org website mentions a possible 10-carat stone without further information. An attractive rectangular yellow faceted legrandite is shown on the Classicgems.net website. In late February 2022, while looking for legrandite mineral specimens for sale, I was surprised to find several faceted legrandites for sale on Etsy.com. Prices for the faceted stones ranged from about $170 down to $33. All faceted stones known to this author were cut from Ojuela Mine material.

Legrandite is relatively expensive because crystals are rare and nice crystals are even rarer. I found relatively cheap ($10–$25) splinters of legrandite for sale on Etsy.com, though I would not recommend them for any collector because they show nothing about the mineral. They don't have crystal faces, associated minerals, or matrix—they literally look like someone beat legrandite specimens to make chips. I found specimens for collectors beginning at $20, though most were more than $80 and prices can quickly climb to several hundred dollars. This is a mineral that you should buy if you see a nice one for a low price before someone else snaps it up.



Rectangular step-cut legrandite in the Smithsonian gem collection.

Technical Details

Chemical formula	$Zn_2(AsO_4)(OH)\cdot(H_2O)$
Crystal form	Monoclinic
Hardness	4.5–5
Specific gravity	3.98–4.01
Color	Shades of yellow, colorless in transmitted light*
Streak	White
Cleavage	1 fair to poor
Fracture	Conchoidal
Luster	Vitreous, resinous, waxy

* *Transmitted light is the light used in microscopy, when light passes though the mineral. The light is not reflected back into the microscope eyepiece; it is transmitted through the mineral.*

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Atlantic Micromounter's Conference

April 2, 1-5 p.m., via Zoom
(see website to join the conference)

Presentations:

Mineral Informatics: Visualizing the Amazing Mineral Kingdom by Dr. Robert Hazen (Senior Scientist at the Carnegie Institution for Science and Robinson Professor of Earth Science, Emeritus, at George Mason University)

Little Magnets, Big Geodynamics: Mineralogy as a Tool for Studying Earth's Magnetic Field and Tectonics In Deep Geologic Time by Alec Brenner (Ph.D. student at Harvard University)

March 28 Club Meeting
Hybrid Format

by Tom Kim

We're going to try another hybrid club meeting on **March 28, 7:30 p.m., at my own home,** 2301 Stokes Lane in Alexandria, VA. For the welfare and peace of mind of everyone there, we ask you to come in person only if you are vaccinated against COVID and are in good health. If you decide to join some of your fellow club members in person (masks on), come to my home in Alexandria. Greg Brennecka, our speaker, will be delivering his presentation remotely from California about what meteorites tell us (see more about him below). You can come in person or join us on Zoom; I'll send an email with the information. ⛏

March 28 Program
What Meteorites Tell Us
Dr. Greg Brennecka

Dr. Greg Brennecka will give a remote presentation to our club from his home in California. He will speak about meteorites and what they tell us.

Dr. Brennecka is a staff scientist and cosmochemist at Lawrence Livermore National Laboratory. In 2014, he received the prestigious Sofia Kovalevskaja fellowship from the Alexander von Humboldt Foundation to study the early solar system at the Institute for Planetology in Münster, Germany, where he led the Solar System Forensics Group for 5 years. His research has appeared in prestigious journals, including *Science*, *Nature*, and *Proceedings of the National Academy of Science*. ⛏

President's Collected Thoughts

by Tom Kim

This has been a busy month for the officers of the club. We have taken to heart the ideas and suggestions discussed at January's meeting and are working to follow through on them.

We've reached out to a number of clubs in the area as well as farther afield, hoping to collaborate on organizing field trips and events for our members. This has borne some fruit. We are organizing a group tour of the James Madison University Mineral Museum on April 9, and Roger Haskins is working out the details of an overnight trip to Fairy Stone State Park in southern Virginia. We are now reaching out to individual quarry owners and representatives for future trips. In fact, several clubs are working to reestablish old connections and make small in-person trips as club delegates to quarries and sites.

However, some sites remain closed to the public (including the Manassas quarry) or iffy in their availability. Even the SuperDiggg in New Jersey is a bit of a question mark right now because of the temporary closure of the Sterling Museum. Let's face it: facilitating these trips takes a lot of grassroots work that needs to be persistently maintained. If you're hungry to get out there and collect locally, we could use an official field trip coordinator at the club.

In the meantime, I'm looking forward to seeing you at my home or on Zoom. Let me know what the club can do for you ... and what you can do for the club!

Tom

South Mountain Rock Swap & Sale

May 14 & October 29, 2022
Central Pennsylvania and
Franklin County Rock and Mineral Clubs

Where: South Mountain Fairgrounds, west of Arendtsville, PA, on PA Rte 234; 615 Narrows Rd, Biglerville, PA 17307

When: 8 a.m. to 3 p.m.

Admission: $1

Info: tsmith1012@comcast.net; Tom Smith: 717-552-6554.

Collector Story

Lucky Find

by Milton Dye

Editor's note: *The story is adapted from Mindat, 22 January 2017.*

This happened about 50 years ago, when I was collecting fossils in an area of Alabama that was very secluded. This was just before I shipped out to South Korea.

The day before I flew to Korea, I visited the site and noticed a slab of limestone in a large flat area. This slab was about 3 feet thick and had a rough diameter of about 8 feet. On the exposed surface near the middle was a beautiful curved complete nautiloid standing out in relief that was some 8 inches long, and it was beautiful!

I began chiseling a trench around it to remove it but, try as I might, the cold and darkness drove me home after I had worked on the specimen for 3 hours. The next day, I left for Korea and was gone 18 months.

When I returned home I went back to the site and the large rock was gone! I looked around a while and noticed a pile of material a dozer had pushed into the woods about 100 yards from where I had last seen the slab.

Out of curiosity, I walked into the woods, and there was the slab still face up with the nautiloid still attached! I climbed onto the slab, took my hammer and chisel, hit the trench edge I had chiseled out just one time, and the entire specimen popped out on a nice display slab. I could hardly believe my eyes!

Fairy Stone State Park, VA

How the Fairystones Came To Be

by Roger Haskins

Fairy Stone State Park in southwestern Virginia is known for its staurolites, also called fairystones. Fairystones occur in the Fork Mountain Formation, where a staurolite-bearing mica schist underlies the northwest-trending ridges on the northwestern edge of the Smith River Allochthon (SRA). (The term allochthon refers to a large block of the Earth's crust that has been moved from its former location to its present position as a structural unit.)

Ranging from 8 to 10 miles in width, the SRA extends northeasterly for 100 miles. It consists of a large slice of crust 1 to 2 miles thick that was transported by nearly horizontal thrust faults, probably during the early stages of Appalachian mountain building. Along its northwestern flank lies a small thermal dome cut by the Fairystone Parkway at the Patrick and Henry County line; the dome contains the local collecting area. The Fork Mountain Formation's staurolites are typically amber, twinned, 1 to 7 centimeters (0.4–2.8 in) in size, and partially to completely altered to sericite pseudomorphs.

The presence of staurolite and sillimanite shows that regional metamorphism reached into the amphibolite grade of metamorphism, with temperatures ranging from 520 to 575 ºC. Peak pressures ranged from 2 and 3.5 kilobars (1 bar equals 1 atmosphere), which converts to 14 to 26 tons per square inch! The age of metamorphism of the Fork Mountain Formation is about 440 million years, as determined by the Rb/Sr whole rock method. Accordingly, the mica schist was formed in the Ordovician Period during the Taconian Orogeny. The Appalachian Mountains were upthrown in two stages, the Taconian and later Acadian events.

The mica schist is composed predominately of muscovite, biotite, quartz, garnet, and chlorite. Accessory minerals are plagioclase, epidote, clinozoisite, magnetite, and titanium-bearing minerals. Porphyroblasts of chloritoid, staurolite, kyanite, and sillimanite display complex prograde and retrograde events. (Prograde metamorphism occurs as rock reforms its mineral assemblages due to intense heat and pressure during burial; retrograde metamorphism occurs as the rock reforms again during uplift and cooling.)

Staurolite (27 mm by 15 mm) from Fairy Stone State Park, VA. Source: Mindat; photo: Rolf Luetcke.

The mica schist is believed to have begun as a pelite (siltstone or mudstone) on the basis of its mineralogy and grain textures. The prograde metamorphic mineral assemblages in the fairystone area are:

1. quartz + muscovite + biotite + garnet + staurolite + magnetite- ilmenite + rutile, and
2. quartz + muscovite + paragonite + plagioclase + garnet + staurolite + sillimanite + magnetite-ilmenite + rutile.

The Fork Mountain Formation slowly cooled from its peak event and rested for considerable geologic time at a lower pressure and temperature before reaching final stability. This retrograde event caused the existing metamorphic minerals to become unstable and reform into minerals that would be stable in the new pressure and temperature setting. The retrograde metamorphic mineral assemblages in the fairystone area are:

1. quartz + muscovite + chloritoid + chlorite, and
2. quartz + muscovite + staurolite + chloritoid.

In laboratory experiments, this reaction occurs at temperatures of about 540 ºC and 4,000 bars through about 560 ºC and 7,000 bars (fig. 1). Formation of staurolite from a pelite occurs as temperatures increase over the boundary from the greenschist into the amphibolite facies via the reaction chlorite + muscovite + staurolite + biotite + quartz + H_2O. The first occurrence of staurolite marks the transition from the greenschist to the amphibolite facies. The greenschist temperature boundaries begin at about 390 ºC and continue to about 510 ºC. The amphibolite facies continues to a temperature of around

Staurolites collected at Fairy Stone State Park, VA. Source: Mindat; photo: Mike Dennis.

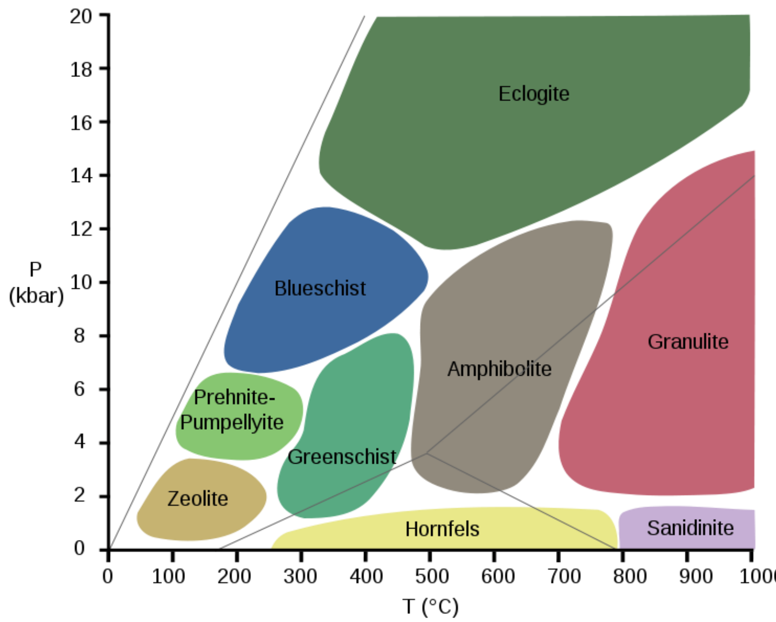

Figure 1—*Diagram of metamorphic facies in the Earth's interior, showing greenschist and amphibolite on the scale of increasing heat (Celsius) and pressure (kilobars). Source: Wikipedia, Woudloper (2008).*

670 ºC. In both facies, the minerals formed change with increasing pressures. At temperatures above 670 ºC, melting of quartz and feldspars begins. ⛏

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Physical Properties of Gems and Minerals

Specific Gravity

by Barbara Smigel

Editor's note: *Ever wonder that the "technical details" for a mineral mean? As part of her online course on gemology, the author describes some of them. This article, adapted from the original, examines specific gravity.*

Specific gravity, also known as relative density, differs widely among gemstones and is one of the most important ways of identifying them. Specific gravity is the ratio of the weight of one unit volume of a gem or mineral to the weight of the same unit of water. For example, a cubic inch of sapphire (corundum) weighs four times as much as a cubic inch of water, so it has a specific gravity of 4.0. Values for specific gravity range from 1.08 for amber—which has almost the same density as water—to 6.95 for cassiterite.

Why do specific gravities differ so much? The answer has to do with the chemical and structural makeup of gems and minerals.

Gems are made up of elements with atoms of different weights. Atoms of gaseous elements like hydrogen and oxygen are light, whereas metallic elements like aluminum and iron have heavy atoms. Chemists use "atomic weights" to describe elements; rounded off, for example, hydrogen = 1, carbon = 12, oxygen = 16, aluminum = 27, silicon = 28, calcium = 40, iron = 56, zinc = 65, and lead = 207.

Accordingly, a cubic-inch block of lead will weigh much more than a cubic-inch block of aluminum. So a gem made up of relatively heavy elements will have a greater specific than a gem made up of lighter ones.

Take calcite ($CaCO_3$) and smithsonite ($ZnCO_3$), for example. They have the same crystal structure in the orthorhombic system and the same chemical formula except for substituting one element for another. But because the atomic weight is 40 for calcium and 65 for zinc, their specific gravities differ—2.71 for calcite and 4.35 for smithsonite.

The second factor to consider is the structure: How are the atoms put together? Are they tightly packed or loosely arrayed? The interplay of chemical makeup with crystal structure determines specific gravity.

Light gems (top) have a specific gravity less than 3, including amber (1.08) and opal (2.10). Medium-density gems (center) range from 3 to 4 in specific gravity, including andalusite (3.16) and sapphire (4.00). Heavy gems (bottom) have a specific gravity greater than 4, including zircon (4.69) and cassiterite (6.95).

Take calcite and aragonite, for example. Both have the same chemical formula ($CaCO_3$), but calcite is in the orthorhombic crystal system and aragonite is in the trigonal crystal system. Both are made up of the same elements in the same proportions, but their building blocks are put together differently, so their specific gravities differ—2.71 for calcite and 2.94 for aragonite.

The Rocks Beneath Our Feet

Great Falls: How Did It Get There?

Part 3—The Falls and the Gorge

by Hutch Brown

Great Falls on the Potomac River is a spectacular series of falls and rapids, dropping 47 feet from the broad river valley above into the gorge below, with individual falls of up to 20 feet. At the falls, the river cuts through metagraywacke, a metamorphosed silty sandstone, then slices through more metamorphic rock (mica schist/gneiss, migmatite, and amphibolite) in the arrow-straight reaches of Mather Gorge (fig. 1). This article explores how.

Great Falls on the Potomac River. Source: National Park Service.

Weaknesses in the Rock

Metagraywacke (like quartzite) is relatively compact, nonporous, and resistant to weathering. Water will generally flow over, under, or around such rock, and even the heaviest flows won't break it unless it is already fractured—which it is (fig. 2). Subjected to tremendous tectonic heat and pressure during mountain building hundreds of millions of years ago, the ancient metamorphic bedrock in our area is full of joints, folds, faults, and fissures. A river flowing over it will find myriad weak points, wearing away at them with the help of scouring sands and gravels. Gravity and flow will ensure that the river then bears down on the deepening and widening fissures.

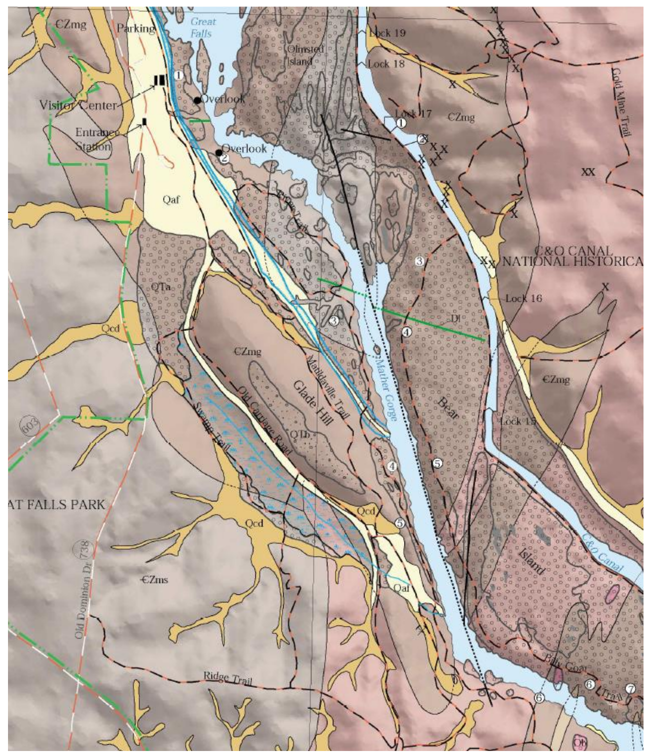

Figure 1—*Detail of a geologic map of Mather Gorge on the Potomac River, showing consecutive bands of metamorphic rock of various kinds. The river cuts through them all. Brown (CZmg) = metagraywacke; gray (CZms) = mica schist/gneiss; reddish brown (CZmm) = migmatite; tan lens (lower right) = amphibolite; patterns/yellow/gold = alluvial deposits; C = Cambrian; Z = Proterozoic. Source: Southworth and Fingeret (2000).*

Figure 2—*Metamorphic bedrock on the walls of Mather Gorge, showing joints, fissures, and fractures caused by tectonic pressures associated with ancient mountain building. Source: National Park Service.*

Gravity thereby escalates the downcutting power of rivers and streams in our area. Gentle regional uplift over the last 5 million years has uptilted the Piedmont region, increasing its slope and raising the speed of its waterflows. What was once a flat Piedmont plain is now rolling hills as streams have scoured valleys into the metamorphic bedrock. By 2 million years ago, the Potomac River had carved the broad Piedmont valley you can see today above Great Falls (fig. 3, top). The river there is wide and relatively shallow, with islands and channels bordered by ample floodplains and low terrace hills. The contrast with Mather Gorge below Great Falls is striking (fig. 3, bottom).

Figure 4 shows what the future site of Great Falls probably looked like 2 million years ago. The site was marked by riffles and outcrops of the metagraywacke visible at the falls today. Below the riffles, the river was broad and relatively flat, with islands and channels, much like you find upstream today.

The Potomac River would have been much the same downstream throughout our immediate area. The flat gravel-covered terrace that visitors use to reach Great Falls on MacArthur Boulevard past Old Anglers Inn in Maryland was once part of the Potomac riverbed, which was 50 to 60 feet higher than today. A boulder of diabase weighing 4 tons sits on the Virginia side of the river far above Mather Gorge; it must have floated downstream on Pleistocene ice from a Triassic-basin source in what is now Loudoun County.

Figure 3—*Contrasting landscapes.* **Top:** *The Potomac River at Riverbend Park upstream from Great Falls. The river is broad and shallow, up to 1,000 feet wide and with occasional islands and riffles along with floodplains and low hills on each side.* **Bottom:** *Mather Gorge, where the river narrows to 100 feet and flows between sheer rock walls up to 60 feet high. Source: National Park Service.*

Pleistocene Changes in the Landscape

During the Pleistocene Epoch, continental glaciers advanced and retreated at least 20 times, including 4 times within the last 400,000 years. For tens of thousands of years at a time, our area not only got more precipitation than today but also was locked in ice and snow for most of the year. The relatively brief summer thaws would have released great torrents of water blocked by ice floes, giving rivers and streams far greater downcutting power than today. During each period of glaciation, tremendous seasonal floods wore away at the Potomac riverbed, year after year.

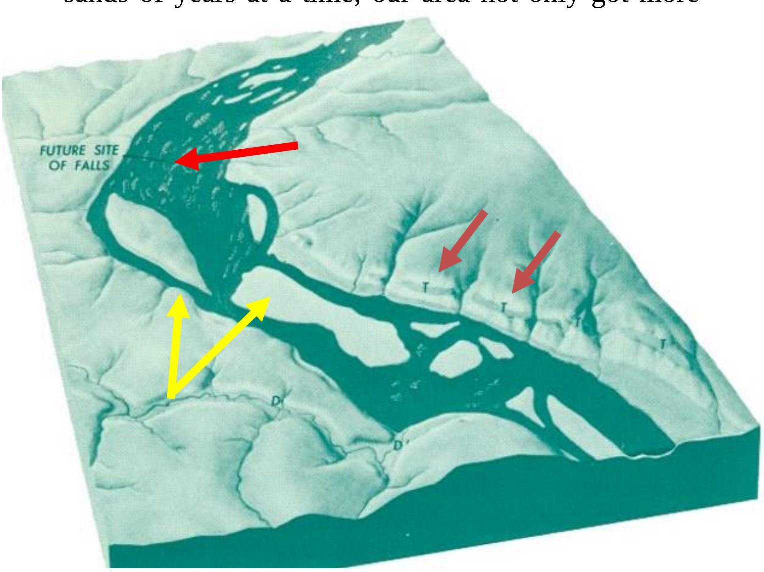

Figure 4—*The future site of Great Falls (red arrow) about 2 million years ago. The river was broad, with islands and channels (yellow arrows). Maroon arrows mark terraces from older riverbeds. Source: Reed and others (1980).*

Riverine downcutting tends to start downstream and work its way upstream in a process known as headward erosion. The lower Potomac Gorge upstream from where Key Bridge is now located would have worn away first; the river still forms a deep and narrow valley there. In places such as Little Falls, the river found myriad points of weakness in the rock, forming the rapids you can see there today. The weaknesses are especially prominent at Great Falls and in Mather Gorge, where heavy bedrock erosion was much more recent.

By about 400,000 years ago (fig. 5), headward erosion along the Potomac River had reached Mather Gorge, deepening the channel and narrowing the river. At the head of the channel, the river found a zone of fractures in the rock and began to form falls (fig. 5, circled). Below the falls, the river followed a faultline in the rock (double arrow), cutting a straight channel at the top of what would become Mather Gorge.

As the river poured into its deepening central channel, its side channels dried up and its islands disappeared. By about 9,500 years ago, the channel around what is now Glade Hill (fig. 5, maroon arrow) was gone. Wetlands are all that remain today, along with terrace gravels and potholes cut by the ancient river into rock along the trail overlooking Mather Gorge.

During the four glacial periods over the last 400,000 years, the Potomac River finished sculpting the falls and gorge as we know them today (fig. 6). At the head of Mather Gorge, the river cut new channels and islands into the metagraywacke, enlarging the zone of falls and rapids (fig. 6, circled). People have turned the relict channels north of Bear Island on the Maryland side into parts of the C&O Canal (fig. 6, yellow arrows).

The river twists and turns in Mather Gorge, following faultlines in the bedrock hidden by the swift and deep currents. At a Virginia overlook in the rocks above Mather Gorge, you can see three nearly vertical lamprophyre dikes on the Maryland side. The counterpart dikes on the Virginia side are 100 feet upstream—evidence of what geologists call a strike-slip fault: tectonic forces sheared away the bedrock on the Virginia side and moved it well to the north of the bedrock on the Maryland side. The river used such long lines of weakness in the rock to carve major stretches of Mather Gorge (fig. 6, double arrows).

A side stream kept pace with Potomac downcutting. Difficult Run (fig. 6, maroon arrow), once a meandering creek, has carved its own deep gorge above its confluence with the Potomac River.

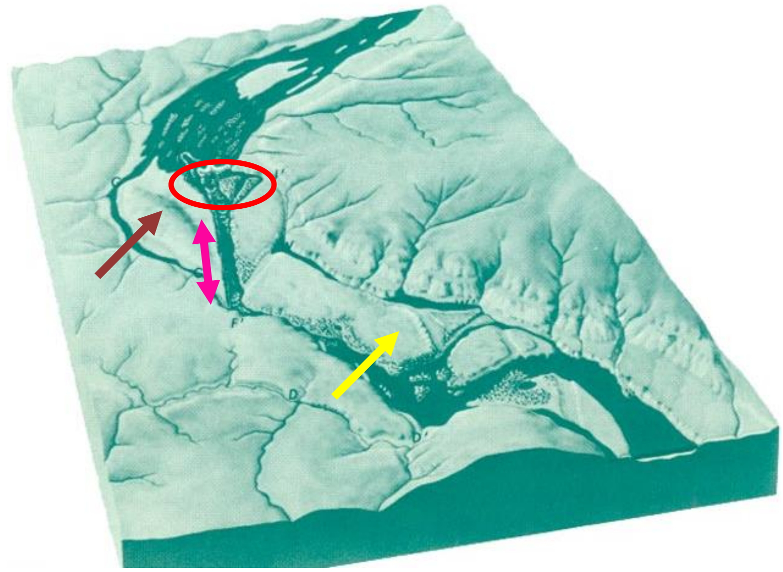

Figure 5—*Great Falls (circled) forming about 400,000 years ago. Below the falls, the river cut a straight channel into the bedrock along a faultline (double arrow), the beginning of Mather Gorge. Islands such as Glade Hill and Bear Island (arrows) were no longer cut off by the river's vanishing side channels. Source: Reed and others (1980).*

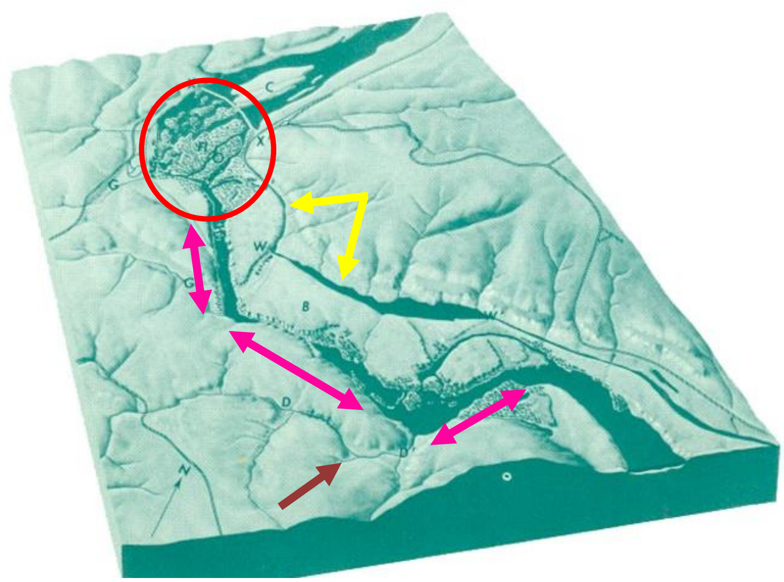

Figure 6—*Great Falls (circled) today comprises a large zone of falls, rapids, and rocky islands. The river's original side channels are gone; remnants north of Bear Island (yellow arrows) are now part of the C&O Canal. The sharp turns and straight channels in Mather Gorge (double arrows) demarcate hidden faultlines in the bedrock. Difficult Run (maroon arrow), a sizable stream that joins the Potomac at the lower end of Mather Gorge, kept pace with Potomac downcutting by forming its own narrow gorge. Source: Reed and others (1980).*

The Upshot

To sum up: Great Falls culminates a long history of riverine downcutting. The edge of the continental slope off Virginia's Eastern Shore has traces of a Pleistocene river valley carved by the Potomac; the river's massive downcutting over the past 2 to 3 million years covered a distance of more than 100 miles, from the continental shelf to Great Falls, gradually working its way upstream through headward erosion.

The downcutting started with gentle regional uplift 5 million years ago. Mountain-building events hundreds of millions of years before had left the metamorphic bedrock in our area full of joints, folds, faults, and fissures; the Potomac River found the weaknesses and wore away at them, keeping up with the slow rise of the land.

But the faults, fissures, and fractures in the rock had been there all along. What made much of the difference was a changing climate in connection with continental glaciation during the Pleistocene Epoch beginning about 2.6 million years ago. A useful analogue is flooding at Great Falls today.

Today, the Potomac River narrows at Mather Gorge, creating floodwater backups that all but drown Great Falls. Given the annual summer breakups of river ice during the many millennia of Pleistocene glaciation, similar floods would have lasted for weeks or months at a time, year after year, for tens of thousands of years.

Under such conditions, the Potomac River scoured away its riverbed to far greater effect than today—and continuously over long periods of time. At and below Great Falls, the river exploited zones of weakness in the bedrock, shaping the contours of both falls and gorge as we see them today.

In short, gentle regional uplift under arctic conditions during periods of glaciation in the last 2 to 3 million years exponentially increased the force of riverine downcutting in our area. Nothing else can explain Great Falls, Mather Gorge—or, for that matter, the deep valleys carved by Potomac tributaries such as Difficult Run. ⛏

Great Falls on the Potomac River on a usual summer day (top) and during a flood in January 2014 (bottom). Pleistocene meltwaters and ice blockages during periods of glaciation would have produced similar deluges year after year for weeks or months on end, exponentially increasing the river's downcutting capacity. Source: Wikipedia.

Sources

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March 2022—Upcoming Events in Our Area/Region (see details below)

Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1	2 MSDC mtg	3	4	5
6	7	8	9	10	11	12
13 Daylight savings	14 GLMSMC mtg	15	16	17 St. Patrick's Day	18	19 Show, Gaithersburg, MD
20 Show, Gaithersburg Spring begins	21	22	23 MNCA mtg	24	25	26
27	28 NVMC mtg	29	30	31		

Event Details

2: Washington, DC—Mineralogical Society of the District of Columbia; info: http://www.mineralogicalsocietyofdc.org/.

14: Rockville, MD—Gem, Lapidary, and Mineral Society of Montgomery County; info: https://www.glmsmc.com/.

19–20: Gaithersburg, MD—Annual show; GLMSMC; Sat 10–6, Sun 11–5; Montgomery Co Fairgrounds, Bldg 6, 16 Chestnut St; $6 adults, kids 11 and under free.

23: Arlington, VA—Micromineralogists of the National Capital Area; info: http://www.dcmicrominerals.org/.

28: Arlington, VA—Northern Virginia Mineral Club; info: https://www.novamineralclub.org/.

Disclaimer

All meetings/shows are tentative during the coronavirus pandemic, and club meetings might well be remote. Check the website for each organization for more information.

2022 Club Officers

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Vice President: Vacant
Secretary: Vacant
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The Northern Virginia Mineral Club

Visitors are always welcome at our club meetings!

PLEASE VISIT OUR WEBSITE AT:
http://www.novamineralclub

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RENEW YOUR MEMBERSHIP!

SEND YOUR DUES TO:
Roger Haskins, Treasurer, NVMC
4411 Marsala Glen Way, Fairfax, VA 22033-3136

OR

Bring your dues to the next meeting.

Dues: Due by January 1 of each year; $20 individual, $25 family, $6 junior (under 16, sponsored by an adult member).

Club purpose: To encourage interest in and learning about geology, mineralogy, lapidary arts, and related sciences. The club is a member of the Eastern Federation of Mineralogical and Lapidary Societies (EFMLS—at http://www.amfed.org/efmls) and the American Federation of Mineralogical Societies (AFMS—at http://www.amfed.org).

Meetings: At 7:30 p.m. on the fourth Monday of each month (except May and December).* (No meeting in July or August.)

**Changes are announced in the newsletter; we follow the snow schedule of Arlington County schools.*

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