THE NORTHERN VIRGINIA MINERAL CLUB INC

The Mineral Newsletter

Next meeting (tentative): February 6   Time: 7:30 p.m.

Dunn Loring Fire Station, 2148 Gallows Road, Dunn Loring, VA

Amblygonite

***from* Linópolis, Divino das Laranjeiras, Minas Gerais, Brazil**

Source: Mindat   *Photo: Rob Lavinsky*.

Volume 63, No. 1-2
January-February 2023
Explore our website!

Meeting Program:

No meeting in January

Details on page 7

In this issue …

Mineral of the Month
Amblygonite

by Sue Marcus

I'd heard of amblygonite and thought it might be interesting for us to study as our January Mineral of the Month. I almost dropped the idea when Mindat didn't have many interesting images. I looked a bit deeper and began learning that amblygonite may indeed be worthy of study—and possibly collection.

Amblygonite was originally described and named by August Breithaupt. The name comes from the Greek words for blunt and angle. The mineral cleaves easily and in four directions, though not at right angles (90^{o}). Amblygonite is also the name of a group of minerals, the Amblygonite Group; the group includes amblygonite and montebrasite, which form a solid solution series, along with natromontebrasite and tavorite. Montebrasite is the most common in this group of uncommon minerals.

Because the fluorine in amblygonite can be easily lost, some montebrasite (which is more abundant) might have originally been amblygonite. Other alteration products of amblygonite include fluorapatite and viitaniemiite. Natromontebrasite, also called natramblygonite, is the sodium-rich form of montebrasite but a distinct species. By contrast, hebronite is a variety of amblygonite, not a separate species.

Amblygonite occurs in lithium-rich pegmatites. This interesting rock type, which occurs worldwide but is rare, can host beautiful, unusual, and well-crystalized minerals. Pegmatites are often zoned due to changes in the mineral melt that forms them. The melt differentiates and crystalizes as the fluids cool and the pressure changes.

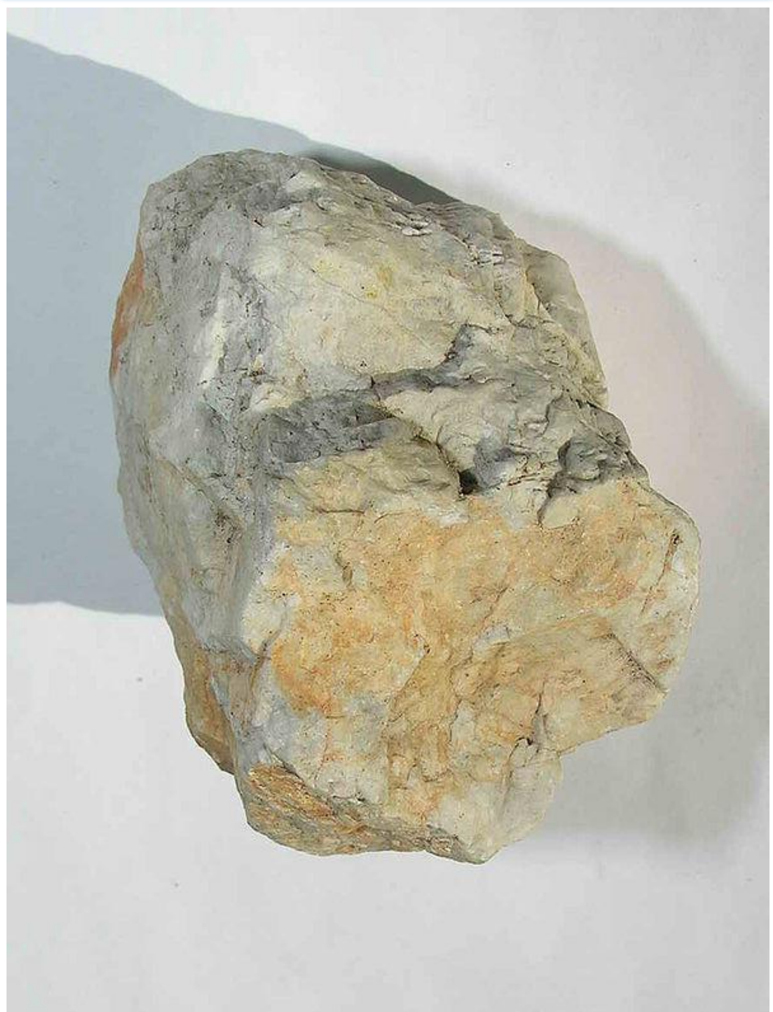
Unfortunately for mineral collectors, amblygonite rarely forms crystals. Instead, it exists mainly as part of the massive host rock for other mineral species. Few amblygonite localities are worth noting for well-crystalized specimens. Most amblygonite is white, forming a light-colored, fine-grained rock.

Pegmatites near Newry in Maine host many unusual minerals. Although amblygonite may have been reported from Newry, specimens are more likely to be montebrasite. Lovely montebrasite crystals, including euhedral colorless ones that would appeal to micromounters and white euhedral crystals up to about 2

Happy New Year!

Northern Virginia Mineral Club members,

Because we lack elected club officers (see the articles on page XX), the NVMC cannot meet for now. If club members volunteer, then the next meeting can be in person on February 6 at the Dunn Loring Fire Station, 2148 Gallows Road, Dunn Loring, VA. The fire station is next to Kilmer Middle School.



Amblygonite (no locality given). Source: Wikipedia; photo: Luis Miguel Bugallo Sánchez.

inches (5 cm) in size, are pictured on the locality's Mindat site.

Amblygonite from Hebron, ME, is shown on that locality's Mindat site. The Hebron material consists of opaque white cleavages. Analysis could determine the Hebron specimens to be montebrasite.

Rare euhedral crystals of montebrasite along with massive specimens have been found at several other Maine quarries. Since massive or opaque cleavages of montebrasite or amblygonite can be mistaken for albite, more of these unusual lithium minerals may occur in Maine.

Custer County, SD, is listed as an amblygonite locality. The single image on Mindat shows an opaque white chunk described as a "crystalline mass," mainly notable for indicating an unusual locality specimen. Amblygonite-montebrasite is also reported from New Mexico; a Colorado locality is also possible.

The Pala District in San Diego County, CA, is the source of many beautiful minerals, including some that contain lithium. Pala amblygonite is massive to coarsely crystalline. I hope an observant and lucky collector will find better specimens there. The Pidlite pegmatite near Taos, NM, is another minor amblygonite locality.

Manitoba, Canada, is the location of a large lithium-cesium-tantalum deposit, the TANCO or Chemalloy Mine near Bernic Lake. I was lucky enough to go underground in this mine when Roger and I lived in Manitoba in the early 1970s. Picture a mine with a large inclined ramp leading into the underground opening—and everything is white, including white massive amblygonite-montebrasite and white quartz, feldspar, pollucite, spodumene, and so on. Color was occasionally provided by tantalum minerals, lithiophilite, lepidolite, and micas. Rare crystals of amblygonite, up to 1.6 inches (4 cm) in size, were found there. Pale pink amblygonite (possibly montebrasite) was also reported from there, but these were probably intergrown with other minerals rather than being free-standing. A secondary phase of mineralization distributed more montebrasite. Fluorine is part of the chemically distinguishing zoning in the TANCO pegmatite.

Amblygonite-montebrasite pegmatites are also reported from the Yellowknife Pegmatite Field, part of the Slave Geological Province in Canada's Northwest Territories.

Amblygonite specimens from Minas Gerais, Brazil (with smoky quartz, bottom). Sources: Mindat (top), Wikipedia (bottom); photos: Doug Gardner (top), Rock Currier (bottom).

Some of the finest specimens of amblygonite come from several pegmatites in Minas Gerais, Brazil. The best of these are well crystalized, partly translucent, and pale yellow. A problem is that those shown on Mindat have apparently not be analyzed and could be montebrasite. Lovely photos of twinned, colorless to pale yellow specimens are labeled ambiguously as "amblygonite-montebrasite series." Analysis is needed to make the chemical determination; even then, this is an example of a solid solution series, so the results could place specimens anywhere on the

Amblygonite with turquoise from Montebras, Nouvelle-Aquitaine, France. Source: Mindat; photo: Pascal Ollic.

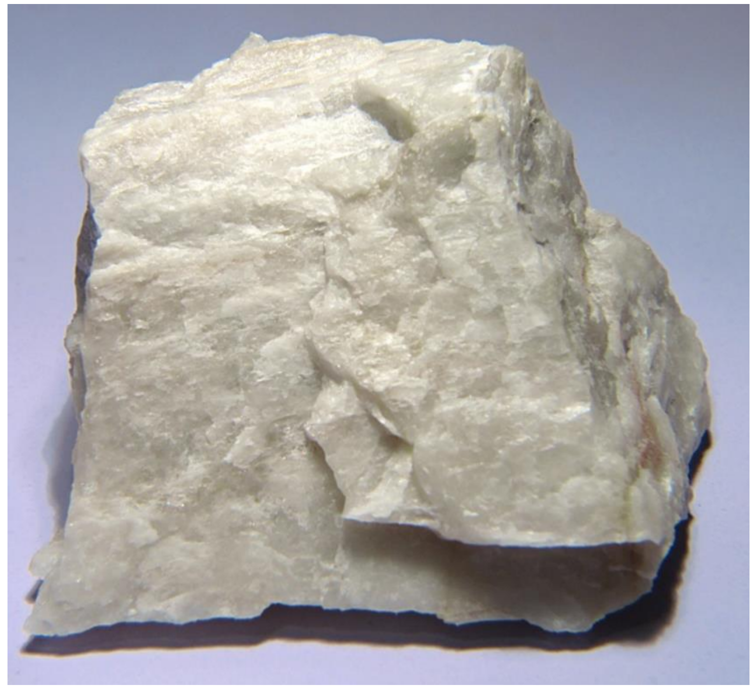
chemical continuum between amblygonite and montebrasite.

Amblygonite and montebrasite aren't reported on Mindat as coming from the Mina Morro Redondo in Minas Gerais, though a beautiful blue-green faceted stone claims that as its source. Amblygonite–montebrasite is reported from about a third of the pegmatites from the Divino das Laranjeiras-Mendes Pimentel pegmatitic swarm in Minas Gerais, Brazil. Low fluorine contents of the swarm imply that the montebrasite end of the chemical spectrum is more likely to occur.

In France, Montebras (the town) is the type locality and source of the name of montebrasite. Amblygonite is also found there, though in its fine-grained, massive form. Celts and Romans mined the deposits for tin, with current extraction occurring for feldspar used in ceramics.

Germany claims the type locality for amblygonite, from Chursdorf, near Mittelsachsen in Saxony. The coarse-grained, massive material from there would probably only interest those who collect specimens from type localities. Montebrasite is not reported from Germany, at least not on Mindat. Perhaps no one has looked for it or analyzed specimens for it.

Massive amblygonite is known from two localities in Sweden, a mica quarry near Norrö and a quartz quarry near Varuträsk. Mica was mined intermittently near Norrö, apparently in the 1940s. The sole Norrö amblygonite specimen on Mindat shows cleavages and appears to be translucent, though interlocked with other, more common pegmatite minerals.



Amblygonite from Varuträsk, Västerbotten County, Sweden. Source: Mindat; photo: Vik Vanrusselt.

The Varuträsk quarry was also intermittently active, working a lithium-cesium-tantalum pegmatite. The pegmatite is probably more economically valuable for those minerals than for quartz. The deposit produced four new minerals as the type locality for alluaudite, oxystibiomicrolite, stibersen (allemontite), and varulite. A large though repaired montebrasite crystal is shown on Mindat from the Varuträsk quarry.

Myanmar (Burma) and Brazil are the current sources of gem-quality amblygonite. The Myanmar localities seem to be even more closely held than the Brazilian ones. There are gem-bearing and lithium-rich pegmatites in Myanmar, though I could find no mention of amblygonite. Yet the faceted stones are found on numerous websites, sometimes with general location information like "Mogok." Searching for lithium pegmatites near Mogok brought no results that included amblygonite—so, readers, I hand off this research project to you. If there is gem rough, there are collectible amblygonite crystals somewhere in Myanmar!

China is a huge country, so one would expect amblygonite to occur there. Regrettably, like many other amblygonite localities, little is known about amblygonite from China, nor are there evident crystals.

Amblygonite occurs in Namibia in masses up to several feet thick containing an estimate five tons of amblygonite. A 1946 source described the massive amblygonite near the village of Karibib. Namibia is also named as a significant source of gem-quality amblygonite, although I could not identify the specific mine or deposit.

Namibia's Erongo Region produces high-quality petalite crystals. Petalite is rare, with nice crystals prized by collectors. The Rubikon Mine produced gem-quality petalite. Mining began at the Rubikon property in the 1930s, with mining continuing at least intermittently though the 1990s. Amblygonite was mined there, and Rubicon could be the source of gem-quality amblygonite, although there are other amblygonite sources in Namibia.

The Uls property in Namibia was mined for lithium in amblygonite, spodumene, and petalite, and was active when a report was written on Namibian lithium in 2020. The Boris (or Soris) deposit is highly zoned, including an amblygonite zone.

Reports of amblygonite from other African pegmatites, including one in Rwanda, are probably true, though no crystals are known to have been produced. The Bikita pegmatite, in Zimbabwe, is one of the most famous pegmatites in the world for lithium and cesium. Amblygonite from this deposit seems to be like the amblygonite in Manitoba, yellow-white crystalline cleavages but not crystals.

Amblygonite, Capoeira 1 pegmatite, Parelhas, Brazil. Source: Mindat; photo: Paolo Neves.

Amblygonite, Ampandramaika pegmatite, Madagascar. Source: Mindat; photo: Michel Arliguie.

Amblygonite can be a source of lithium. Lithium is increasingly used in batteries, its primary use, and in ceramics and glass. Smaller amounts are used in a variety of other industrial applications. Most lithium is produced from brines, a significant technological change from the rock-mining techniques that produced collectible mineral specimens.

Recalling the origin of its name, amblygonite can be faceted, though it is not a practical or durable gemstone for use in jewelry. Stones of up to 7.09 carats are reported. Brazil and Myanmar are the main sources of gem-quality amblygonite, with colors usually greenish-yellow to pale green and pale blue. Sources vary on whether amblygonite is irradiated to enhance its color.

Amblygonite crystals are rare. My husband and I do not have an amblygonite specimen in our collection. A seller on Etsy was offering a 1.7-inch (4-cm) specimen with euhedral off-white crystals of "amblygonite montebrasite" from Brazil for $119. Since the seller was honestly stating that the specimen could be either and because it has nice crystals, this looks like a nice addition. A massive hunk of pale purple-and-white amblygonite from Brazil was offered by another seller for $396. Those with $7,500 to spend can purchase a lovely transparent to translucent euhedral amblygonite crystal from Brazil (2.2 inches (5.5 cm) in maximum dimension) from the irocks/Arkenstone website. Unset faceted stones in greenish blue to pale yellow are selling for about $200 (as of December 27, 2022).

Technical Details

Chemical formula..................$LiAl(PO_4)F$

Crystal form..........................Triclinic

Hardness...............................5.5-6

Specific gravity.....................2.98-3.11

Color....................................Colorless, white, pale shades of yellow/champagne, green, gray, tan, blue, orange-pink. Usually massive white opaque.

Streak ....White

Cleavage...............................1 perfect, 2 good, 1 distinct

Fracture ....Conchoidal to uneven

Luster ....Vitreous, greasy; pearly on cleavages

Amblygonite with lepidolite, Ognevka Ta deposit, Ulan, Kazakhstan. Source: Mindat; photo: Geoff Van Horn.

Acknowledgment

I appreciate Herwig Pelckmans's willingness to translate the original German in the Breithaupt source shown below. He graciously managed this request while enjoying the seasonal holidays with his family.

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Club Holiday Party—and Now, Unfortunately, We're Taking a Break

by Tom Kim, former President

It was wonderful to host this year's holiday gathering on December 20 together with the Micromineralogists of the National Capital Area. There were plenty of food and conversation and a wonderful festive spirit.

Unfortunately, there were no definite takers for the president or secretary positions in our club, although Craig Moore has volunteered to stand as vice president. Sue Marcus and I announced that the club will temporarily suspend activities until someone volunteers to be president. **There will, therefore, be no club meeting in January.**

Don't lose hope! There are rumblings of negotiations and rumors of activity. Perhaps we could have two copresidents until someone is ready to fully fill the position, and we have a possible volunteer.

But nothing is certain yet, and the opportunity for someone else to step up and volunteer is still wide open. If, as president, you would be interested in just keeping the club going (as I did) or if you've always been hoping that the club makes some changes—there's no better chance than now.

Sue and I are fully committed to supporting the transition to new leadership, so let us know if you'd like to step in and help out. ⛏

Club Officers Urgently Needed

by Hutch Brown, Editor

The NVMC will suspend activities until club members step up to volunteer for service as our next club President, Vice President, and Secretary.

We have many club officers (see the list on the last page of this newsletter), but only four positions are elected each year:

- The ***president*** presides over club meetings and coordinates club activities with others, such as auctions and the annual club show. The president is not solely responsible for and does not necessarily lead the activities.
- The ***vice president*** assists the president and coordinates programs and speakers for the monthly club meetings.
- The ***secretary*** takes minutes at club meetings for the newsletter and summarizes presentations at club meetings, again for the newsletter.
- The ***treasurer*** collects club dues, keeps records of club members, and handles all club financial transactions.

Roger Haskins has agreed to stand again as treasurer, but Tom Kim, Sue Marcus, and David MacLean have stepped down, respectively, as president, vice president, and secretary. All three are more than willing to support and mentor their successors, and Craig Moore has volunteered to stand as vice president.

We will not have a meeting in January, but Roger Haskins has found a new meeting date and place beginning in February. The new meeting date is the first Monday of each month; we will meet in person at our new meeting place, the Dunn Loring Fire Station at 2148 Gallows Road, Dunn Loring, VA. The fire station is next to Kilmer Middle School.

The next meeting will be on February 6 in Dunn Loring—*if* club members step up to volunteer for president or copresident for our club.

Don't forget: membership dues are due! See the last page of this newsletter for details. ⛏

Two Hawaii Volcanoes Have Stopped Erupting

by Jennifer Sinco Kelleher

Editor's note: *Adapted from an Associated Press report on December 13, 2022. Thanks to Sue Marcus for the reference!*

On December 13, 2022, scientists declared that two active Hawaii volcanoes—Kilauea and Mauna Loa—have stopped erupting.

Mauna Loa, the world's largest volcano, began spewing molten rock on November 27 after a quiet of 38 years. It was Mauna Loa's longest period of repose.

Lava viewers in Hawaii Volcanoes National Park were also able to see Mauna Loa's smaller neighbor, Kilauea, erupting at the same time. Kilauea had been erupting since September 2021. A 2018 Kilauea eruption destroyed more than 700 residences.

Mauna Loa lava didn't pose a threat to any communities, but got within 1.7 miles of a major highway that connects the east and west sides of the island.

For Native Hawaiians, volcanic eruptions have deep cultural and spiritual significance. During Mauna Loa's eruption, many Hawaiians took part in cultural traditions, such as singing, chanting, and dancing to honor Pele, the deity of volcanoes and fire.

It was unclear what connection there could be to the volcanoes stopping their eruptions around the same time. The volcanoes can both can be seen at the same time from multiple spots in Hawaii Volcanoes National Park near Kilauea's caldera.

Network of Magma Chambers Under Hawaii Volcanoes

by Robin George Andrews

Editor's note: *Adapted from the* Washington Post *on December 22, 2022. Thanks to Sue Marcus for the reference!*

Scientists have suspected that somewhere below Hawaii, a secret is entombed in stone. Now, with the help of almost 200,000 earthquakes and a machine learning program, a scientific team from the California Institute of Technology has finally unearthed it.

In a study published in the journal Science, the team revealed a previously hidden collection of magma caches. The discovery offers a possible solution to a longstanding mystery: How does magma from the Earth's mantle travel to the Hawaiian surface?

Like much of the planet, Hawaii would not exist without volcanism. Since time immemorial, a deeply rooted fountain of superheated rock known as a mantle plume has been torching the underside of the Pacific tectonic plate. As the plate has continued to drift, a succession of epic volcanoes has risen above the waves, creating the Hawaiian island chain.

Today, the chain hosts a small family of active volcanoes, including Mauna Loa and Kilauea, both on the Big Island.

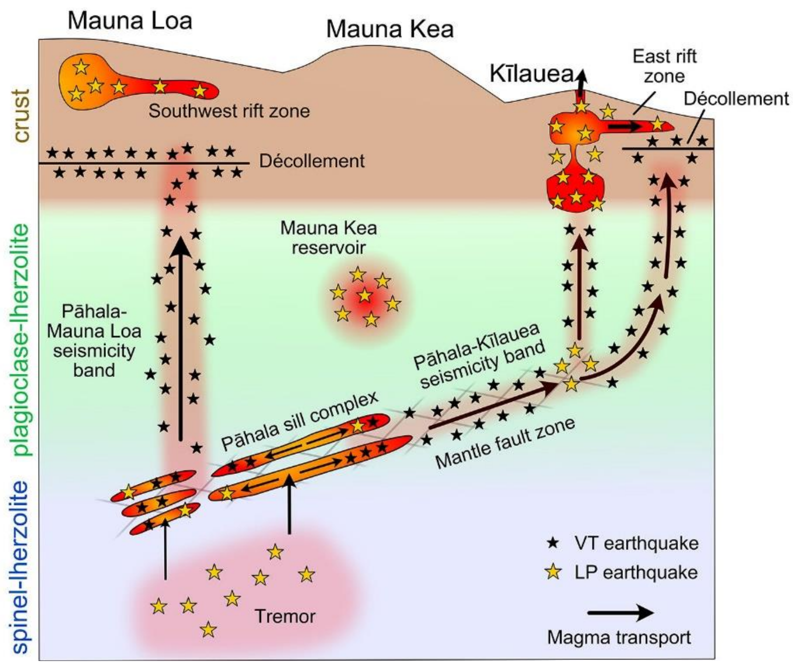
The shallow magma reservoirs that feed Hawaii's eruptions have been known for some time. This paper describes something new—a giant feature made up of several elongated chambers called sills. When eruptions drain magma from the shallow reservoirs above, these deep-seated sills seem to react. A cacophony of quakes signals when individual chambers begin to fill with molten rock at different times.

A persistent seismic rumble from an area southwest of Kilauea and 20 miles below ground had previously suggested that a collection of faults might exist there, creating pathways for magma to travel from the depths to the shallow reservoirs. And since the 1980s, special kinds of quakes suggestive of roaming fluids have hinted that magma has been churning about in the region. But until recently, the true nature of this underground labyrinth was based more on speculation than scientific truth.

What scientists needed was a sustained spike in quakes coming from that exact region, enough to strongly illuminate that shadowy zone. The team's lucky break came in 2018 when, after Kilauea had been erupting for 35 years, a grand-finale-style eruption sequence began. The event produced 320,000 Olympic-size swimming pools' worth of lava in just 3 months, draining the volcano's shallow magma reservoir and causing its summit to collapse dramatically.

In an exciting plot twist, geologists recorded a shocking spike in deep seismic activity in 2019 way below the town of Pāhala, which sits roughly 25 miles southwest of Kilauea. Surely, scientists thought, this cannot be happenstance.

From November 2018 to April 2022, the scientists logged around 192,000 quakes below Pāhala. Plotting the points on a map, the team was stunned to discover a collection of pulsing magmatic structures—the beating volcanic heart of southern Hawaii.



Eruptions at Kīlauea cause pressure gradients to change throughout the structure for transporting magma to the Pāhala Sill Complex. Magma is injected into the complex from the underlying magma-bearing volume; the sills are close to the plagioclase/spinel phase boundary and connected to Kīlauea and the detachment fault (décollement)/Ka'ōiki region within the Mauna Loa edifice along continuous bands of seismicity. VT = volcano tectonic; LP = long period. Source: nspirement. 2022. [Hawaii earthquake swarm caused by magma moving through sills](#).

The bulk of the seismicity came from an area 22 to 27 miles deep. These volcano-tectonic quakes, the sort produced when a fault moves and rocks break inside a volcanic region, delineated near-horizontal sheetlike structures, some of them 4 miles long and 3 miles wide. The team surmised that these sheets were sills, magma pockets filled by molten rock rushing up from the lower fluid-filled region close to the mantle plume's peak.

The Pāhala Sill Complex appears to have several arteries branching from it. One major pathway, marked by rock-breaking quakes, appears to lead right into one of Kilauea's shallow magma reservoirs. During the 2018 eruption, Kilauea was drained of its shallow magma supply, causing a pressure drop; magma was sucked into the sills to equalize the pressure.

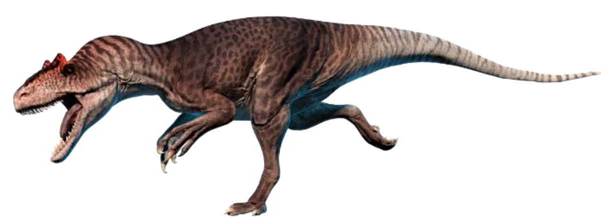
Further work may help resolve the controversial question of whether Kilauea and Mauna Loa, which are relatively close neighbors at the surface, are somehow connected at great depths. Much of the Hawaiian underworld remains unexplored, and more magmatic arteries may yet be located. ⛏

Meat-Eating Dinosaurs Were Terrifyingly Fast

by Mindy Weisberger

Editor's note: *The article is in LiveScience (December 9, 2021).*

Three-toed, meat-eating dinosaurs sprinted as fast as a car driving on city streets, new research shows. The finding comes from analyzing the footprints these theropods left behind as they dashed over squishy lakebed mud tens of millions of years ago.



Two sets of fossilized footprints at a site in La Rioja, Spain, show that the makers of the tracks were galloping along at speeds up to 27.7 miles per hour, reaching "some of the top speeds ever calculated for theropod tracks," according to the new study.

According to researchers, one dinosaur sped up steadily as it ran, while the other quickly changed its speed while still on the move. Together, these two sets of footprints from the early Cretaceous period (145 million to 66 million years ago) offer a unique snapshot of dinosaur mobility and behavior. ... *Read more*.

Prehistoric Footprints Place Humans in North America Earlier Than Thought

by Livia Gershon

Editor's note: *The story is adapted from* Smithsonian Magazine*, 24 September 2021.*

An analysis of fossilized footprints at White Sands National Park in New Mexico offers what some scientists say is the most conclusive evidence yet that humans lived in North America long before the end of the last Ice Age. The research, published in the journal Science, dates the prints to between 21,000 and 23,000 years ago.

"We'd been suspicious of the age for a while, and so now [that] we finally have that, it's really exciting," said study coauthor David Bustos, chief of natural and cultural resources at White Sands. "One of the neat things is that you can see mammoth prints in the layers a meter or so above the human footprints, so that just helps to confirm the whole story."

Scholars have long been aware of the tracks, which are known as "ghost prints" because they are only visible under particular weather conditions. But the new study is the first to clearly date them to such an early era. The researchers determined when the footprints were made through radiocarbon dating of dried ditchgrass seeds found in layers both above and below the impressions. ... *Read more*.

What Happens to Earth's Disappearing Crust?

by Yasemin Saplakoglu

Editor's note: *The article is in LiveScience (November November 19, 2021).*

Like a giant broken-up cookie with pieces floating on a sea of scalding milk, Earth's outer shell is made of rocky rafts that constantly bump into and dive beneath each other in a process called plate tectonics.

So what happens to those hunks of disappearing crust as they dive into Earth's superheated interior?

It turns out that they get weak and bendy, like a slinky snake toy; but they don't disintegrate completely, new modeling shows. The models also suggested that plate tectonics, at least in its modern form, likely only got going in the past billion years.

Plate tectonics drives earthquakes and volcanoes, creates mountain ranges and islands; it is the reason why Earth's continents, once joined together in a supercontinent, are now oceans apart. But there's still much unknown about how plate tectonics works, such as what happens when a plate slides beneath another (in an area called a subduction zone) and disappears into the mantle, the middle layer of the planet, which is composed of sizzling solid rock. ... *Read more*.

The Rocks Beneath Our Feet

The Potomac Water Gaps: Part 2

by Hutch Brown

Harpers Ferry, WV, is a picturesque town nestled between the Potomac and Shenandoah Rivers where they join to cut through the Blue Ridge (fig. 1). The Potomac's three water gaps are in ridges that trend from northeast to southwest and that span the width of the Blue Ridge geologic province.

The ridges rise more than a thousand feet above the river that cuts through them. How could a river carve such deep gaps in ridges of solid rock?

Harpers Ferry Rocks

The rocks that make up all three ridges are in a sequence typical for the entire Blue Ridge Province. You can find them all—almost every rock type in the Blue Ridge—either in or near Harpers Ferry (fig. 2).

To the west of town, the sequence begins with metamorphic rock types that originated in ancient marine sediments, starting with a band of Antietam quartzite (fig. 2, red). Next comes Harpers phyllite (fig. 2, orange), named for the town itself.

North and east of town (across both rivers), the Blue Ridge rises to almost 1,500 feet at Maryland Heights and almost 1,200 feet at Loudoun Heights. Both parts of the ridge are made up of tough Weverton quartzite (fig. 2, green), one of the hardest rocks in our area and extremely resistant to erosion.

To the east of the heights are exposures of Catoctin greenstone (fig. 2, dark green). The greenstone, a metamorphosed basalt, appears to be mostly covered by colluvial quartzite boulders from the heights (fig. 2, pale yellow).

Beyond the greenstone are granitic rocks (fig. 2, gray), the core of the Blue Ridge Province. The granitoids, heavily fractured by freeze-thaw cycles and by multiple mountain-building events over more than a billion years, are some of the most erodible rocks in the Blue Ridge (with exceptions like Old Rag Mountain).

Isostatic Rebound

In high school, I learned that the Blue Ridge was the eroding remains of an ancient mountain chain, but that's impossible. Yes, the Blue Ridge rocks are the

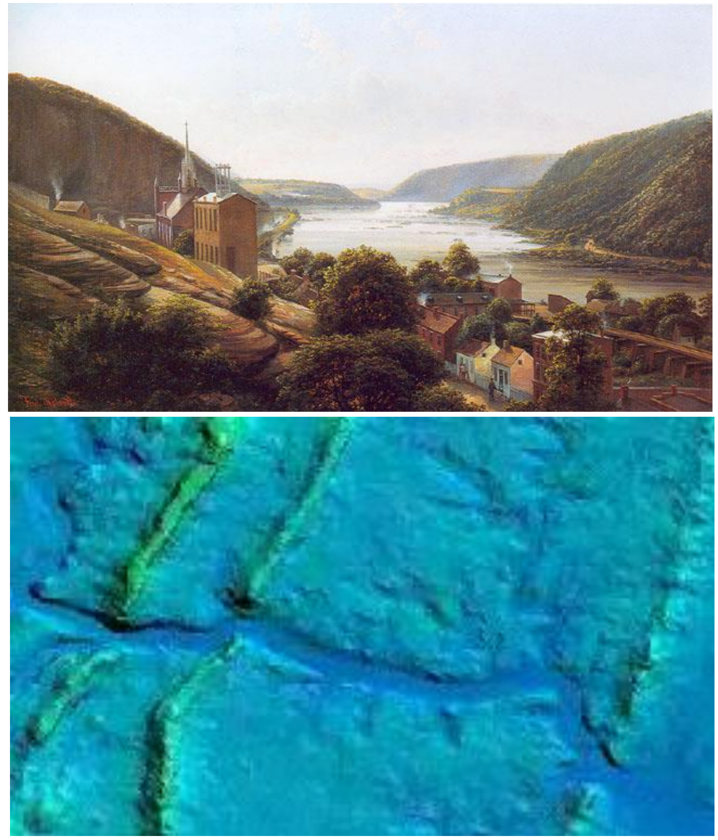


Figure 1—Top: View of the Potomac Watergap From Jefferson Rock, *a painting by Ferdinand Richardt (1857). The view is to the east, at the juncture of the Shenandoah and Potomac Rivers, with Harpers Ferry in the foreground. The water gap through South Mountain is visible in the distance.* **Bottom:** *LiDAR image of the three Potomac River water gaps. From left to right, the gaps are through the Blue Ridge at Harpers Ferry, South Mountain, and Catoctin Mountain. Sources: Fennell (2013), top; Grymes (2013), bottom.*

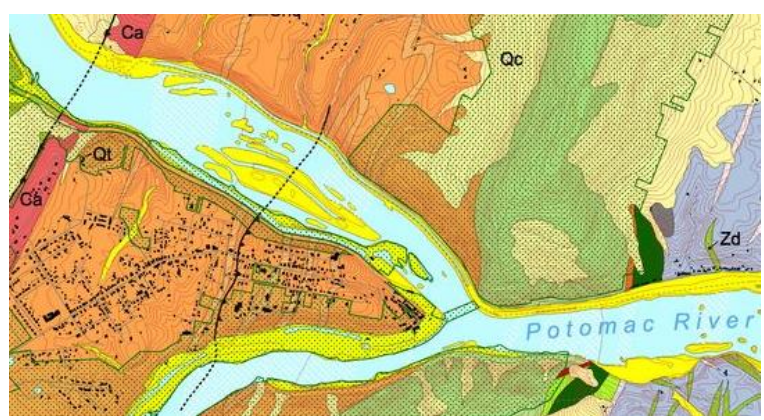


Figure 2—*Detail from a geologic map showing Harpers Ferry (black buildings); the two thin black lines crossing the river are faults. From left to right are Antietam quartzite (Ca, red); Harpers phyllite (orange); Weverton quartzite (green); colluvial quartzite boulders (Qc, pale yellow); Catoctin greenstone (dark green); and Grenville granite (gray). Source: Southworth and Brezinski (1997).*

roots of an ancient mountain chain, but mountains never last long in geologic time, and the ancient Alleghanian Mountains had peaked by about 280 million years ago and were already eroding away. Within a few tens of millions of years, they were gone.

The last major tectonic event in our area was rifting at the eastern edge of the Blue Ridge Province as the supercontinent of Pangaea split apart and the Atlantic Ocean began to form, with Africa separating from North America. Rifting took place about 220 million years ago, forming great rift valleys with rivers and lakes, much like the rift valleys in East Africa today.

By about 175 million years ago, our area had what geologists call a passive continental margin. Erosion had filled in the great rift valleys (including the Culpepper and Gettysburg Basins) and leveled the ridges that once loomed over them. From the Allegheny Plateau through the Blue Ridge to the Coastal Plain, our entire area was a flat and featureless plain.

About 5 million years ago, uplift began again due to what geologists call isostatic adjustment (or rebound). Uplift reached from the Allegheny Plateau to the Piedmont due to the aftereffects of Alleghanian mountain building 300 million years before.

During mountain building, brittle crustal rock builds up on the puttylike molten rock in the Earth's mantle (fig. 3). As the crustal materials pile up, forming mountains tens of thousands of feet high, the overlying weight displaces the mantle materials underneath. Much like an iceberg, only part of the mountain range is exposed: 90 percent of the material is underground.

As the mountain range erodes away, its weight decreases and the underlying mantle materials respond by rebounding, a process called isostasy. Whereas erosion is rapid and continuous, isostasy is slow and episodic. It affects our area today, even though mountain building stopped hundreds of millions of years ago. Ongoing gentle uplift is raising the ridges we see in the Blue Ridge Province, including the ridge that the Potomac River cuts through at Harpers Ferry.

River Dynamics

The Potomac River basin has two pronounced characteristics (fig. 4). The river's headwaters follow ridges trending from southwest to northeast, the result of isostatic rebound from Alleghanian mountain building. The river then turns to cross the ridges at Harpers Ferry and flow towards Chesapeake Bay, paralleling

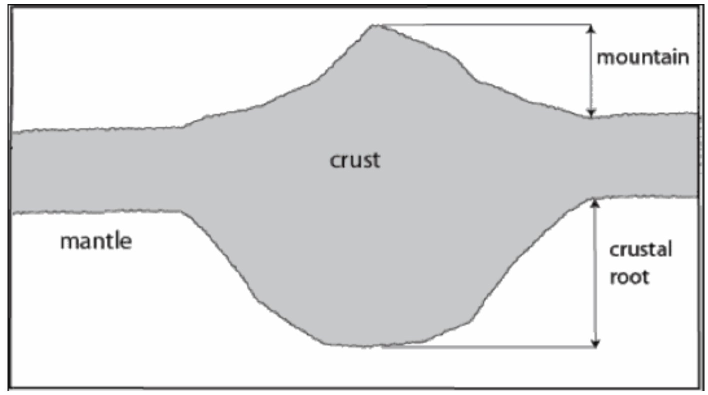


Figure 3—*Mountain building associated with accumulations of crustal materials over the plastic mantle rock. As the overlying mountains erode, the mantle rebounds, leading to the isostatic uplift we see in our area today. Source: Marx (2019).*

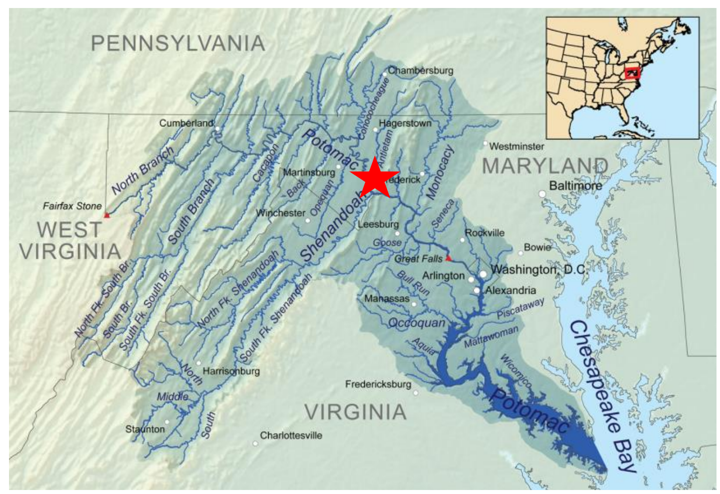


Figure 4—*Potomac River basin. Star shows Harpers Ferry, where the river system turns to the southeast. Source: Wikipedia.*

the southeasterly course of other major rivers across the Atlantic seaboard. Why does the Potomac cross the Blue Ridge and change directions at that particular place?

Rivers take the course of least resistance. In the Valley and Ridge Province, the valleys are in soft and erodible limestones and shales, whereas the ridges tend to be made up of erosion-resistant sandstones. They parallel the ridges made up of erosion-resistant metamorphic rock in the Blue Ridge Province.

Even erosion-resistant rocks have faults, fractures, and fissures, and rivers seek out such weaknesses. The ancient Blue Ridge rocks were all subjected to tremendous pressures during multiple mountain-building events, resulting in folds, faults, fissures, and fractures. Moreover, the extensive fields of colluvial

Potomac River rapids through Weverton quartzite below Harpers Ferry. Source: Wikipedia.

quartzite boulders on the flanks of Maryland Heights (fig. 2, Qc, pale yellow) attest to the erosive power of freeze-thaw cycles magnified by the onset of continental glaciation at the start of the Pleistocene Epoch about 2.6 million years ago.

Yet the geologic map in figure 2 shows no signs of the Potomac River following fractures in the rock. Instead, the river seems to cut straight through bands of rock, including two fault lines (fig. 2, black lines).

In a process called headward erosion, a stream gradually extends its channel above its point of origin. By steepening the terrain, uplift from isostatic rebound increases the downcutting power of streams in our area and their rate of headward erosion. If a river's flow is large enough, it can keep pace with the gentle uplift in our area through downcutting, even through tough bedrock like Weverton quartzite.

So the key factor in forming the water gaps through the Weverton quartzite in the Blue Ridge was not the nature of the bedrock but the downcutting power of the rivers. Gentle uplift from isostatic rebound increased their downcutting capacity in our area, as did Pleistocene freeze-thaw cycles by releasing tremendous volumes of frozen water in great floods during the short summer months.

But the most obvious contributor to the Potomac's downcutting power at Harpers Ferry is its confluence with the Shenandoah River. The Potomac's erosive force was (and still is) enormously boosted by the added volume of its largest tributary (figs. 4, 5).

In fact, the Shenandoah's amplification of the Potomac River's downcutting capacity is enough to explain all three water gaps. Faults and fractures in the rock contributed, with a bend in the Potomac at its confluence with the Monocacy River near Catoctin

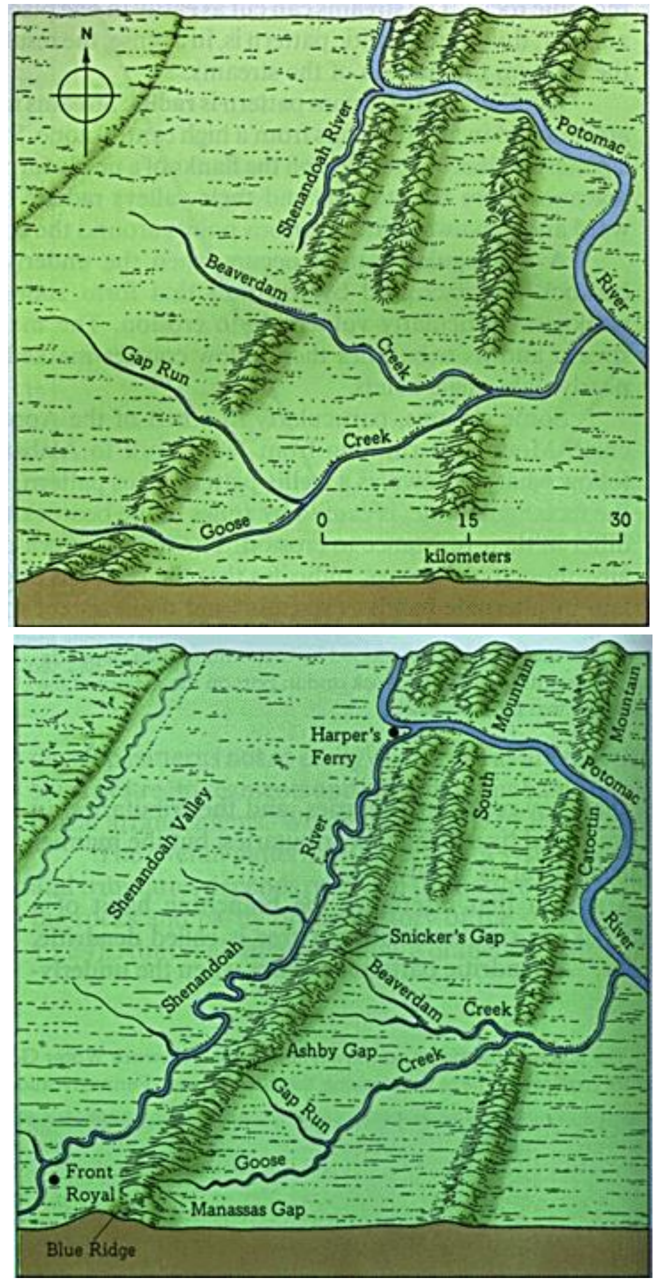


Figure 5—*Before (above) and after (below) images of Shenandoah River stream piracy through headward erosion west of the Blue Ridge. Source: Judson and Kauffman (1990).*

Mountain suggesting a possible weakness in the rock there (fig. 1, bottom); but the Shenandoah's added water volume alone, boosted by summer meltwater floods during the Pleistocene, is enough to account for the water gap at Harpers Ferry; and the Potomac appears to flow with relative ease through its next two water gaps as well.

So what made the Shenandoah River so voluminous?

Stream Piracy

The deeper a stream's channel, the farther it can push its valley uphill above its original bed through headward erosion. As the Potomac and its tributaries cut deeper into the bedrock, they extended their reach southwestward (fig. 5), deepening their valleys along the parallel ridgelines.

In particular, the Shenandoah River worked its way up the western side of the Blue Ridge (fig. 5). What were originally water gaps as various streams cut through the Blue Ridge (at Snicker's Gap, Ashby Gap, Manassas Gap, and elsewhere) are today called wind gaps because the Shenandoah River captured the streams in a process called stream piracy, diverting their flows into its own deeper channel. The captured tributaries followed a new course into the Potomac, adding to its volume and thereby increasing its downcutting capacity.

Over millions of years, the Shenandoah River's South Fork gradually worked its way up Page Valley between the Blue Ridge and Massanutten Mountain to the west, capturing streams as it went. As the process continued, the Shenandoah captured every one of the Rappahannock River's headwaters (fig. 6).

Figure 6—*Major watersheds in north-central Virginia. Through headward erosion, the Potomac River and its tributaries extended their reach to the southwest, capturing every tributary of the Rappahannock River west of the Blue Ridge and thereby adding to the Potomac's flows. Source: Judson and Kauffman (1990).*

As the land continued to rise due to isostatic rebound, a new watershed boundary formed between the Potomac and Rappahannock basins. A series of wind gaps resulted in the Blue Ridge, ranging from Snicker's Gap in the north to Rockfish Gap in the south. The water gaps remained, but today they carry nothing but wind.

The Upshot

So the Potomac water gaps are due to a combination of factors going back more than a billion years to the origins of the Grenville granitic rocks and the overlying metamorphic rocks (such as Weverton quartzite). Alleghanian mountain building emplaced the rocks and formed the Blue Ridge Province, and isostatic rebound within the last 5 million years resulted in uplift, shaping the Blue Ridge as we know it today.

The downcutting power of the Potomac River at its confluence with the Shenandoah River was enough to keep pace with the uplift, despite the tough Weverton quartzite at Harpers Ferry, South Mountain, and Catoctin Mountain. Fracturing of the rock by multiple mountain-building events and by freeze-thaw cycles, especially during the Pleistocene, also contributed, as did the short Pleistocene summers with their huge meltwater floods.

However, stream piracy by the Shenandoah River through headward erosion west of the Blue Ridge made all the difference. Stream capture added the volumes of water needed to give the Potomac its exceptional size and downcutting capacity.

Acknowledgment

Thanks go to Sue Marcus for reviewing and improving this issue of the newsletter, including this article.

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January 2023—Upcoming Events in Our Area/Region (see details below)

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1 New Year's Day	2	3	4 MSDC mtg	5	6	7
8	9 GLMSMC mtg	10	11	12	13	14
15	16 Martin Luther King Day	17	18	19	20	21
22	23 *No NVMC meeting*	24	25 MNCA mtg	26	27	28
29	30	31				

Event Details

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

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

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

Note: Show dates listed by *Rock & Gem Magazine* for January and February 2023 (as of December 29, 2022) did not indicate any shows in the mid-Atlantic area. However, the following might be of interest in February 2023:

9-12: Tucson, AZ—Annual show; Tucson Gem and Mineral Society, Inc; Tucson Convention Center, 260 S. Church Ave; Thu 10-6, Fri 10-6, Sat 10-6, Sun 10-4; ticketed event, open to the public; info: Tucson Gem and Mineral Society, Inc., 520-322-5773, email: tgms@tgms.org, website: www.tgms.org/show.

Netherlands Stamp: Which Side Is Up?

In 1962, the Netherlands issued a semipostal stamp featuring an ammonite. If you rotate one of the stamps 180 degrees so that it is upside down, you see an interesting optical effect. The upside-down stamp on the left looks like an external cast. However, when the stamp is viewed right side up, it looks like an internal mold. Both clearly show the outside of the fossil ammonite, but they certainly look different.

This stamp was part of a five-stamp set commemorating the International Congress of Museum Exports in July 1962 in Amsterdam. For those who are not stamp collectors, a semipostal stamp means that the second denomination on the stamp (in this case 4 ct) is a donation by the postal service on behalf of the purchaser of the stamp to a charity.

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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.*