Granite State Geologist

The Newsletter of the Geological Society of New Hampshire,
Spring Edition – March 2021 – Issue No. 112
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In this issue:

MESSAGE FROM THE PRESIDENT

In preparing this edition of the President's column, I really tried to shift focus away from the ever-present bad news of the COVID-19 pandemic. I really tried! In my last column, I focused on the mission of GSNH to promote geological education in New Hampshire. All educational institutions, including GSNH, continue to struggle with how to overcome the impacts of the pandemic as we enter our second year with COVID-19. I'd like to thank all who helped prepare for and participated in our January 21, 2021 virtual winter meeting.

Over the past few years I've noted that training in classical geology, so dear to many of us, is fading away. The University of Vermont has initiated the process to eliminate its geology program, citing COVID-19 as one of many factors in pursuing this action. Clearly, the pandemic did not initiate efforts by many universities and colleges to move away from classical geology course offerings toward curricula focusing on global environmental challenges; but the permanence of this shift has been made more clear. Given the current status of Federal and State support, institutions of higher education are forced to follow the money. Many colleges are engaged in downsizing or "rightsizing" of academic programs by faculty attrition or early retirement buyouts. At Keene State, admissions to the geology program were curtailed in Fall 2016 and the remaining Bachelor of Arts in Earth and Space Science program was dropped in the Fall of 2019.

My alma mater, the University of Buffalo, took steps several years ago to organize its graduate-level geosciences program into several specialty research centers. Among them are: climate

change; water and the environment; ecosystems and adaptation; computational geosciences and geo-hazards. Now gone from the UB Geology Bachelor of Science program are requirements for physical and historical geology courses. In their place are introductory climate change and natural hazards courses. The traditional ig-sed-met petrology sequence has been replaced by a single earth materials course. Classical geology requirements such as paleontology, structural geology, appear to be abbreviated with the addition of sedimentary geology and global tectonics to each of these offerings, respectively. I suspect that other universities are making similar changes in their geology programs. Distance learning, now a large part of our pedagogy due to COVID-19, will no doubt play an expanding role in the future of geological education. This will make higher education available to more, but I feel a bit saddened that many future geologists will not experience spending many hours staring down a petrographic microscope observing whether the Becke line goes in or out of a crystal when lowering the stage.

Geology things to look forward to:

- The Geological Society of America Northeast Section Meeting was virtual this year on March 14 and 15. The program and abstracts are available. I've reviewed many of the abstracts. I'm encouraged that field research in New England is still a significant component of training for many new geologists.
- The virtual 2021 New Hampshire Geological Survey Mapping Workshop is scheduled for April 8th. Participants will need to pre-register through the NHDES website to receive a link to the Webex presentation. Participants will receive a certificate for 3.5 hours continuing education when attendance is verified.

Stay safe and reach out to someone you haven't talked to in a while. Both of you will feel better!

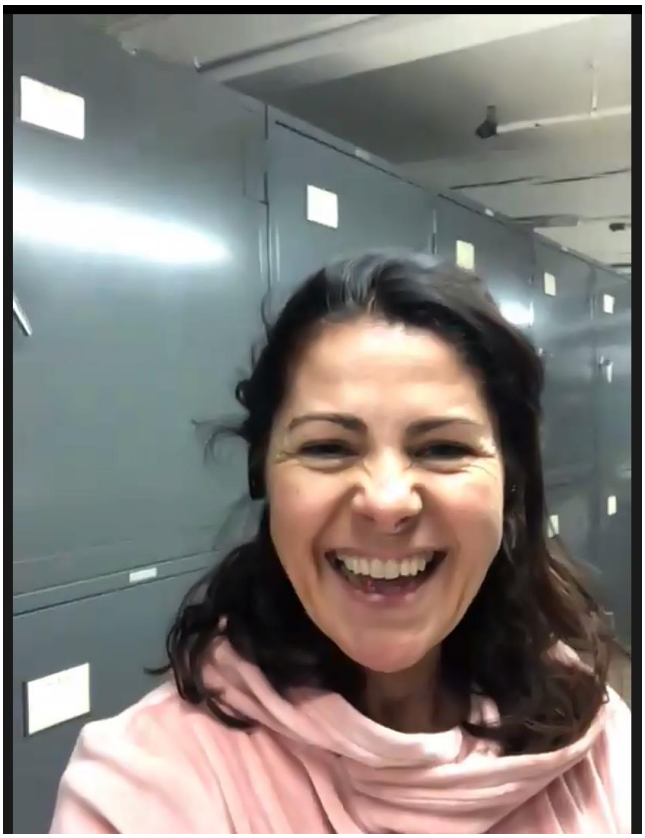
GSNH T-Shirts Available!

We have GSNH t-shirts available in size small, medium and large (sorry, sold out of extra large). T-shirts will be shipped to you – no need to wait until the next in-person meeting! See order form on second to last page (right before the renewal form).

Front (left photo) and back (right photo) of GSNH t-shirt.

January GSNH Meeting Recap

For our January meeting (held via Zoom on January 21), Dr. Raquel Alonso-Perez gave a behind the scenes virtual tour of Harvard University's Mineralogical & Geological Museum. The museum has a world-class collection of minerals, rocks, ores, meteorites, and gems, and Dr. Alonso-Perez was able show us some amazing specimens from "behind the scenes", including trays of gold specimens (see below) and tourmalines from Maine, the largest platinum nugget found in the U.S. (from Alaska), and a room full of flurorescent minerals.



Left: Dr. Alonso-Perez showing some of the many storage cabinets for speciments. Right: crystalline gold specimen. Much of the gold collection is from the late 1800s gold rush.

The group had a wide-ranging and lively discussion regarding favorite minerals, locally significant mines, using radioactivity to treat diamonds for color (and what to do about the now-radioactive result!), how the mineral collection started, special storage requirements, notable donations, and the work the museum is doing now.

Left: a recently-donated collection is being organized. Right: The Hamlin necklace, which was designed and commissioned by Augustus Choate Hamlin in the 1890s, is primarily comprised of tourmalines from Mount Mica, Maine. The necklace includes 18 removable pendants attached to a gold chain. Hamlin appears to have made the pendants removable, and the necklace has seventeen additional hooks. The 70 gemstones total 228.12 carats and range in size from 3 to 34 carats. (details from Dr. Alonso Perez)

Currently there are 5673 official known minerals. See the following for a listing of minerals and details of mineral classification: http://cnmnc.main.jp/

Have you Renewed Your Membership?

If you have already renewed your GSNH membership this year, thank you! If now, please consider renewing.

With membership, you get a discount on dinner meetings and field trips (which will happen at some point!), information on upcoming events of interest, voting privileges at Society business meetings, and automatic subscription to this newsletter. Membership dues also help to support important geological outreach for the greater community.

See last page of this newsletter for a membership renewal application.

Archive – Johnsondale Potholes

From Earth Science Picture of the Day, December 26, 2020.
Photographer and Summary Author: Tom McGuire
https://epod.usra.edu/blog/2020/12/archive-johnsondale-potholes.html

Each Sunday we present a notable item from our archives. This EPOD was originally published December 28, 2003.

This group of holes is on a granite outcrop in the southern Sierra Nevada Mountains at the former logging camp of Johnsondale. That is a milling station, the most common type of archaeological feature found in the Sierra Nevada. The individual cups are referred to as bedrock mortars. They were primarily used for pounding acorn into flour and could be used to process seeds and other nuts (e.g. pine nuts). The number of cups on a site can range from one to more than two hundred. A larger feature typically has a residential area associated with it, i.e. a midden with lots of obsidian artifacts.

Note: the caption has been updated December 2020.

Related Links:

- Johnsondale History
- A Virtual Tour of Mojave National Preserve
- Mano and Metate

The April Meeting will be Online

We will have another virtual (Zoom) meeting for our April GSNH meeting. The breakout room meet and greet will be from 6:30 to 7:00 PM, and the presentation will start at 7:00 PM.

Our speaker will be Charlie Kerwin, who will be giving a presentation entitled *NH geology and the Massabesic Gneiss Complex…What we know*: The rocks in New Hampshire tell a complicated story of accreting terranes and sedimentation during the convergence of plates that created a supercontinent. The presence of copious igneous rocks indicates that the present surface exposure was once buried deep within the crust. Among the granitoid exposures are (meta) sedimentary rocks that show various stages of anatectic melting, but, nowhere in the state did melting occur at the scale of the Massabesic Gneiss Complex (MGC). This talk will focus on the mapping, petrology and chemistry work done over a decade in the MGC to decipher what the rocks have been showing us.

Please watch for an email from Doug Allen providing presentation and registration details. You will need to register in order to receive the Zoom invitation for the meeting; you can register by emailing Sharon Lewandowski (Sharon.A.Lewandowski@des.nh.gov). Doug will send a zoom link to those who have registered a few days before the meeting.

What's Your Board Been Doing? Submitted by Shane Csiki, Secretary

The officers of GSNH met for its first quarterly meeting of 2021 on the evening of March 18th. As has become custom around the world of late, the Board met once again via Zoom. During the meeting, Board members expressed enthusiasm for the day when we can, once again, all meet in person.

The Board has confirmed and potential speakers for future dinner meetings lined up through next January 2022, thanks to the work of Lee Wilder and Nelson Eby. Our April "dinner" meeting will be virtual once again, with Charlie Kerwin as our speaker. GSNH was planning on partnering with the Friends of the Pleistocene (FOP) trip, planned for the Lakes Region, as its summer field trip for 2021. However, FOP has postponed that trip until 2022. As a result, the Board discussed the possibility of having some type of virtual event this summer for GSNH members in its place. Board members are going to raise this for discussion with everyone at our virtual meeting on April 15. If there is interest, the Board will work on putting a small program together for some time during the summer.

Board members have continued to work on putting together a website for geologic sites of interest. Members who have been working on this project include Wayne Ives, Lee Wilder, Abby Fopiano and Lea Anne Atwell. This is a work in progress, so stay tuned for further details.

The next GSNH Board meeting is planned for Thursday, June 17, 2021, virtually. As always, if you have any interest in attending a Board meeting, let any of the officers know.

More Protective Arsenic Standard Will Reduce Risk for Many

From Supply Lines with the Source, Newsletter of the NHDES Drinking Water and Groundwater Bureau, Fall 2020.
https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-fall-supply-lines.pdf

New Hampshire's s new maximum contaminant level (MCL) of 5 parts per billion (ppb) for arsenic in public water systems will take effect July 1, 2021. In May 2020, NHDES began contacting individual public water systems (PWSs) likely to be affected. New Hampshire is the second state, after New Jersey, to adopt an arsenic MCL that is more protective than the federal MCL of 10 ppb. NHDES has also adopted the same 5 ppb limit as an enforceable Ambient Groundwater Quality Standard (AGQS).

The change in the standards was far from sudden. The federal MCL of 10 ppb was controversial when USEPA adopted it in 2001, and the standard has been under review since 2003. In 2018, New Hampshire House Bill (HB) 1592 directed NHDES to conduct a review of the arsenic MCL and AGQS.

After NHDES recommended lowering the standards to 5 ppb, the Legislature enacted HB 261 in 2019 directing NHDES to adopt the more protective standards.

Naturally occurring arsenic contamination is widespread in New Hampshire groundwater. Over a third of our public water systems have arsenic in their untreated water and an estimated 25-30% of private residential wells have arsenic at 5 ppb or higher. With nearly half of New Hampshire residents using private wells at home, NHDES estimates that 116,000 private well users are drinking water with more than 5 ppb arsenic.

New Hampshire residents pay a heavy price for having arsenic in their water supplies. Arsenic is associated with increased risks of bladder, lung, and skin cancers, and New Hampshire ranks first in the nation for bladder cancer incidence. More recent research, some of it conducted at Dartmouth College and involving New Hampshire residents, has implicated arsenic – even below 10 ppb – in adverse birth outcomes, health problems during infancy, reduced childhood IQ, and increased death rates from cardiovascular disease.

The cost of complying with the new standards is also significant. NHDES estimates that approximately 310 PWSs (community and non-transient) will have to add or upgrade their treatment in order to comply, at a total capital cost of about one million dollars. The new AGQS will result in about twice that amount in capital costs for compliance at facilities with groundwater discharge permits.

Most of the affected water systems will need to add an adsorption system or replace the treatment media more frequently if they already use adsorption, while others will use iron-arsenic (greensand) filtration or anion exchange. Technical assistance with identifying and evaluating treatment alternatives is available from DWGB by contacting Cindy Klevens at cynthia.klevens@des.nh.gov.

NHGS Geologic Mapping Workshop

The NH Geological Survey (NHGS) is pleased to announce our 2021 Geologic Mapping Workshop, scheduled for Thursday, April 8, 2021, beginning at 9:00 AM. Unavoidably, this will be an online event, using the WebEx platform. All are invited to attend and 3.5 CEUs toward continued Professional Geologist licensure will be available to all attendees. Pre-registration is required. To register, email Shane Csiki at shane.csiki@des.nh.gov with your request and you will receive a link to the WebEx workshop. We hope you will join us for a morning of interesting presentations. A complete agenda with abstracts will be posted shortly on the NHGS website https://www.des.nh.gov/land/geology.

Agenda:

9:00 – 9:20	Welcome and NHGS Program Update, Rick Chormann, NH State Geologist
	Guest Speakers:
9:20 – 9:50	Sean Kinney, Lamont-Doherty Observatory – "*Causal implications of new geochronological constraints on Mesozoic post-rift magmatism in New England*"
9:50 – 10:20	Scott Bailey, Hubbard Brook Experimental Forest – "*Fluoride as a natural tracer of hydrochemical processes in New Hampshire's Jurassic Park (aka the White Mountain Batholith)*"
10:20 – 10:50	Andy Boeckeler, Nobis Engineering – "*Investigating and remediating abandoned hard-rock mines in the Vermont Copper Belt*"
10:50 – 11:10	Break
11:10 – 11:40	Greg Walsh and Peter Valley, U.S. Geological Survey – "*Tectonic implications of new U-Pb zircon ages in the Bronson Hill Arc, western New Hampshire*"
11:40 – 12:00	Dykstra Eusden, Department of Geology, Bates College – "*U-Pb Constraints on the Timing of Plutonism, Sedimentation, and Deformation in Northern NH-Western ME and their Implications for the Tectonic Evolution of the Northern Appalachians*"
12:00 – 12:20	Woody Thompson, Maine Geological Survey (retired) – "*Surficial geology of the Lancaster 7.5-minute quadrangle, New Hampshire*."
12:20	Questions and closing remarks, Rick Chormann, NH State Geologist
1:15 – 4:00	**Private Working Session for NHGS Mappers via WebEx**

The Disaster that Helped the Nation Prepare for Future Earthquakes: Remembering San Fernando – 50 Years Later, an Earthquake's Legacy Continues

USGS, February 4. https://www.usgs.gov/news/50th-anniversary-san-fernando

The San Fernando earthquake struck Southern California 50 years ago, killing 64 people and costing over $500 million in damages. The quake prompted federal, state and local action to reduce earthquake risks and bolster public safety.

At 6 o'clock in the morning on February 9, 1971, the reservoir keeper of the Lower Van Norman Dam in Southern California tried to get out of bed.

He couldn't. A magnitude-6.6 earthquake was shaking his home nestled at the bottom of the dam. After checking on his wife and child, he drove to the top of the dam to examine the damage. "It was hard to believe what I saw," he said.

The Lower Van Norman Dam, which sat above the San Fernando Valley in Los Angeles County, had nearly collapsed in the wake of the quake. “As wind-whipped waves chewed at the damaged lip of the 1,100-foot Van Norman Dam, police spread through a nine-square-mile area between the reservoir and the Ventura Freeway, warning residents to evacuate,” The Los Angeles Times reported on February 10, 1971. Approximately 80,000 people did evacuate as officials lowered the water levels in the dam.

North-Trending fracture pattern near the Sylmar Converter Station above the upon Van Norman Dam. The fracture was due to a landslide and the dam's setting in extensive fill material. Photo taken from a view looking northeast on Feb 10, 1971. (Credit: USGS. Public domain.)

The 1971 San Fernando, or Sylmar, earthquake was the worst to hit an urban area of California since the 1933 magnitude-6.4 Long Beach quake. It led to 64 deaths and more than $500 million in damage. It prompted Governor Ronald Reagan to declare Los Angeles County a disaster area and President Richard Nixon to send Vice President Spiro Agnew to inspect the area.

After the San Fernando earthquake, the State of California enacted the Alquist Priolo Act to limit construction along faults that likely caused earthquakes able to rupture the ground surface in the last 11,000 years.

On the federal level, Congress renewed its interest in earthquake safety, held hearings and introduced new bills to establish a national earthquake research program. Congress eventually passed the Earthquake Hazards Reduction Act of 1977, which led to the National Earthquake Hazards Reduction Program, or NEHRP, and was pivotal in helping establish what is now the USGS Earthquake Hazards Program.

Over the years, NEHRP agencies, including the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology, the National Science Foundation and the U.S. Geological Survey, made research and policy recommendations that in part contributed to the City of Los Angeles enacting an ordinance in 2015 to retrofit weaker first-story wood-frame buildings and non-ductile, or brittle, concrete buildings, which are both more vulnerable to collapse during strong shaking. In 2013, San Francisco enacted the Mandatory Soft Story Retrofit Program, which was based in part on work sponsored by NEHRP and on the aftermath of the 1989 Loma Prieta earthquake.

"NEHRP was founded on the belief that while earthquakes are inevitable, there is much that we can do as a nation to improve public safety, reduce losses and impacts and increase our resilience to earthquakes and related hazards," Gavin Hayes, the USGS senior science advisor for Earthquake and Geologic Hazards, said.

An unforgettable earthquake

An earthquake large enough to spur legislative action and help form new federal programs garnered much media attention.

"A Major Disaster," the New York Times printed on Feb 10, 1971. "Quake Cost in Death, Damages Staggering," the Valley News and Valley Green Sheet declared on Feb 11.

The latter newspaper printed an article that captured the quake's desolation in a paragraph. "The cities of San Fernando and Sylmar were left in shambles. Some destruction was reported throughout the Newhall and Saugus areas, 10 miles west of the quake's epicenter. And the destruction spread, almost like the ring on a pond after the rock's initial splash."

The earthquake was the first disaster in the United States to happen after the Disaster Relief Act of 1970, which directed federal agencies to provide assistance to state and local governments. At the time of the earthquake, FEMA did not exist.

The epicenter of the quake was about 8.7 miles (14 km) north of San Fernando in a sparsely populated area of the San Gabriel Mountains. It was 5.6 miles (9 km) deep and generally felt over approximately 80,000 square miles (208,000 square km) of California, Nevada and Arizona.

More than 200 aftershocks with a magnitude of 3 or more occurred over the next month. The upper San Fernando Valley, including the northern section of the City of Los Angeles, sustained the most severe damage to buildings and utilities.

Two fallen structurally separated stair towers and the collapsed basement at Olive View Hospital after the San Fernando earthquake in February 1971. View is north. (Credit: USGS. Public domain.)

There were 64 causalities directly related to the earthquake, with 49 people killed at the San Fernando Veterans Administration Hospital. Two of its buildings were completely destroyed by the quake. Others died at Olive View Hospital, under collapsed freeway overpasses and at other locations. At Olive View, four 5-story wings pulled away from the main building and three of them toppled.

Figure 5.48 Building 6, located east of the main buildings. This building which was constructed in 1925 was severely damaged.

Photo of San Fernando Veterans Administration Hospital in Sylmar from the publication, "Engineering Aspects of the 1971 San Fernando Earthquake," published by the U.S. Department of Commerce's National Bureau of Standards in December 1971. The hospital's roof collapsed and the shaking caused damage to the vertical pillars at the corners of the building. (Public domain.)

In front of the San Fernando Valley Juvenile Hall facilities, railroad tracks were twisted, broken and displaced as much as 4 feet (1.2 m) from the intense shaking.

Major freeways and traffic arteries in the northern San Fernando Valley were closed following the earthquake because of pavement fissures and collapsed bridges blocking lanes.

Photo showing railroad track damage following the San Fernando Earthquake on February 9, 1971. (Credit: USGS. Public domain.)

The California Department of Transportation adopted seismic design practices using lessons learned from the San Fernando earthquake. The agency created a Post-Earthquake Investigation Team that examines damage to bridges after all earthquakes and makes recommendations. CalTrans creates and implements seismic design criteria for infrastructure across the state.

“I remember biking on the [not yet open] 210 freeway and seeing damaged bridges including near Foothill Boulevard, which had mushroomed columns,” Glenn Biasi, a scientist at the USGS, said.

Biasi’s home in Sunland, about 11 miles (18 km) from the epicenter, was damaged in the earthquake. He also recalled seeing people during the recovery phase salvaging used lumber from destroyed homes in San Fernando.

It was the cacophony of toppling and shaking appliances, dressers and other household items that Doug Given, a geophysicist with the USGS, remembers from the earthquake. Given, still in bed at home when the quake struck Glendale, pulled the covers over his head to drown out the noise. After

the 12-second temblor, Given biked to downtown Glendale and recalled seeing broken glass and tumbled bricks.

Oblique aerial view of collapsed highway overpasses and bridges at the interchange of the Foothill and Golden State Freeways after the San Fernando earthquake in February 1971. The principal highway link between northern and southern California was temporarily cut and traffic had to be re-routed for several months. (Credit: R. E. Wallace, USGS. Public domain.)

Eyewitnesses are valuable during an earthquake and can help scientists understand the intensity of the shaking for areas near and far from the quake's epicenter. Although people nowadays can easily submit "felt reports" to USGS through the Did You Feel It portal, which launched in 1999, in 1971, people would have sent in postcard surveys like the one below [next page] detailing their experience.

Form No. 9–3013

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
EARTHQUAKE REPORT

OMB No. 1028–0048
Expires 03/31/96

Please answer this questionnaire and return as soon as possible. Please refold and tape together at the top center for return mail. The Business Reply Mail side should be on the outside of the card.

1. Was an earthquake felt by anyone in your town near the date and time indicated on the opposite page?

☑ No ☐ Yes

Date _____ Time _____ ☐ AM ☐ PM ☐ Standard time ☐ Daylight time

Name of person filling out form Lorna

Address _____

City Same as addressed. County _____

State _____ Zip Code _____

If you felt the earthquake, complete both reports. If others felt the earthquake but you did not, skip the personal report and complete the community report. Check the appropriate boxes.

PERSONAL REPORT

2. Location at time of the earthquake was: Town _____ State _____ Zip Code _____

Did you personally feel the earthquake? ☐ Yes ☐ No

Were you awakened by the earthquake? ☐ Yes ☐ No

Were you frightened by the earthquake? ☐ Yes ☐ No

Were you at ☐ Home ☐ Work ☐ Inside ☐ Outside Other _____?

If inside, on what floor were you ? _____

Check your activity when the earthquake occured:

☐ Walking ☐ Sleeping ☐ Lying down ☐ Standing ☐ Driving (car in motion) ☐ Sitting ☐ Other _____

Did you have difficulty in ☐ Standing up ☐ Walking ☐ Maintaining balance

Vibration could be described as ☐ Light ☐ Moderate ☐ Strong

Duration of shaking ☐ Sudden, sharp (less than 10 secs) ☐ Short (10–30 secs) ☐ Long (30–60 secs)

Was there earth noise ? ☐ No ☐ Faint ☐ Moderate ☐ Strong

Can you estimate direction of noise ? ☐ North/South ☐ East/West ☐ Other _____

• Continue to next section which should include personal as well as reports from others •

520672

COMMUNITY REPORT

Town and zip code affected _____

DO NOT INCLUDE EFFECTS FROM OTHER COMMUNITIES OR TOWNS

554

3. The earthquake was felt by ☐ No one ☐ Few ☐ Several ☐ Many ☐ All

This earthquake awakened ☐ No one ☐ Few ☐ Several ☐ Many ☐ All

This earthquake frightened ☐ No one ☐ Few ☐ Several ☐ Many ☐ All

4. What indoor physical effects were noted in your community?

Rattled ☐ Windows ☐ Doors ☐ Dishes; ☐ Slightly ☐ Loudly

Walls creaked ☐ Slightly ☐ Moderately ☐ Loudly

Building trembled (shook) ☐ Slightly ☐ Moderately ☐ Strongly

Hanging pictures (more than one) ☐ Swung ☐ Out of place/tilted ☐ Fallen

Windows ☐ Few cracked ☐ Some broken out ☐ Many broken out

Small objects overturned ☐ Few ☐ Several ☐ Many

Small objects fallen ☐ Few ☐ Several ☐ Many

Glassware ☐ Dishes, ☐ Knicknacks broken? ☐ Few ☐ Several ☐ Many

Were ☐ Light furniture or ☐ Small appliances; ☐ Displaced ☐ Overturned ?

Were ☐ Heavy furniture or ☐ Heavy appliances; ☐ Displaced ☐ Overturned ?

Did hanging objects or doors swing? ☐ Slightly ☐ Moderately ☐ Violently

Items thrown from store shelves? ☐ Few ☐ Several ☐ Many

Continue on the reverse side

Survey sent in as part of postcard to report feeling the Northridge earthquake of 1994. These types of surveys predate the now online Did You Feel It portal. (Public domain.)

Even though the San Fernando quake was 50 years ago, 28 years before the invention of the Did You Feel it portal, more than 1,000 people have submitted retroactive electronic reports so far.

These felt reports help support critical USGS products like ShakeMap, which provides near-real-time maps of ground motion and shaking intensity following significant earthquakes, and the Prompt Assessment of Global Earthquakes for Response (PAGER) system, which provides fatality and economic loss impact estimates for significant earthquakes worldwide.

Measuring the quake

In addition to eyewitness accounts, scientists look to seismographs to determine the size, or magnitude, of an earthquake and the subsequent intensity of ground shaking. The instruments measure the shaking's amplitude, frequency and duration at various locations and distances from the earthquake, which gives scientists and decision makers an idea of ground and building motions, as well as potential damage, across an affected region.

There were more than 250 strong-motion seismographs around Southern California at the time of the San Fernando earthquake. Most of them were privately owned but maintained by the then-Seismological Field Survey unit of the National Oceanic and Atmospheric Administration's National Ocean Survey as part of a cooperative network.

These seismographs provided a wealth of data to better characterize the ground motion and help scientists understand how structures responded to the ground motion. The data points helped answer fundamental questions in earthquake engineering, such as how does local geology affect ground motion? What ground motion characteristics are most damaging to buildings, bridges, dams and other engineered structures?

The San Fernando earthquake was the first to record more than 1-g of acceleration in a horizontal direction, which happened on a seismograph at the abutment of Pacoima Dam. Before that point, the maximum thought reasonable was much lower. Since then, many higher recordings have been made, but in the history of strong motion seismology, San Fernando was a turning point.

Southern California has a tumultuous tectonic past dating back tens of millions of years. Its crustal movements are an ongoing part of a pattern of deformation ultimately responsible for the San Fernando earthquake as well as California's reputation as a shaky state.

Although most people think of the San Andreas Fault system when they think of a California quake, the San Fernando earthquake actually occurred on a less well-known fault system called the Sierra Madre Fault Zone, which runs along the base of the San Gabriel Mountains. The 1971 earthquake ruptured a subsection named the San Fernando Fault Zone, which extends from the western San Fernando Valley to Big Tujunga Wash, about 12 and a half miles (20 km) across.

The San Fernando Fault is a thrust fault, which means a section of land above the fault moved up and over a region below it. The earthquake was a single episode of ongoing crustal deformation, which, in a local sense, has pushed the San Gabriel Mountains up and south towards the broader Los Angeles Basin. In a broader sense, this motion is consistent with the plate boundary along the San Andreas Fault, where the plate to the west is moving northward relative to the plate on the eastern side at two inches (52 mm) per year.

During the quake, the mountains lurched as much as 5 feet to the south in a matter of seconds, damaging roadways, pipelines and other structures embedded in the ground, and leaving a discontinuous tear where the fault ruptured the ground surface across the mountain front.

Severe ground fractures and land sliding caused extensive damage in areas away from the fault itself, which is a common phenomenon for earthquakes of this magnitude. Landslides on very gentle slopes, known as lateral spreads and related to a process called liquefaction, happened in swaths of the northwestern San Fernando Valley. Though less visually dramatic, these caused significant damage to pipes and other infrastructure.

In steeper terrain, more than 1,000 landslides and rockfalls were identified and mapped from aerial images. They were concentrated in the foothills and mountainous areas of the San Gabriel Mountains. One of largest slides occurred on the east side of Schwartz Canyon and was approximately 600 feet (180 m) wide.

A path to earthquake legislation

Seven years before Southern California was rocked by the San Fernando earthquake, the most powerful recorded earthquake in U.S. history hit the state of Alaska. The magnitude-9.2 quake hit Prince William Sound on March 27, 1964, at 5:36 p.m. local time and ruptured for about 4.5 minutes. The quake triggered a major tsunami that caused death and destruction from the Kodiak Islands to northern California.

Although the mighty Alaska quake took place in a sparsely populated area, it demonstrated the potential for devastation in other parts of the country and started the conversation toward a coordinated federal program focused on earthquake risk mitigation and response.

The San Fernando earthquake revitalized those talks and helped push forward what eventually became NEHRP in 1977. The bill created an Office of Earthquake Hazard Reduction that eventually became the USGS Earthquake Hazards Program. The program works with partners to monitor and report earthquakes, assess earthquake impacts and hazards and perform research into the causes and effects of earthquakes.

Since NEHRP's inception in 1977, it has been reviewed and reauthorized by Congress many times. The four agencies that currently lead the effort, including FEMA , the National Institute of Standards and Technology, the National Science Foundation and the USGS, are each tasked with specific roles.

Most recently, NEHRP was reauthorized and signed into law in December 2018. This most recent bill expands its purview to bolster communities' ability to prepare for, recover from and adapt to earthquakes and publish maps of active faults and other seismically induced hazards. It also continues to support and develop the Advanced National Seismic System, including the ShakeAlert earthquake early warning system, which is now operational throughout California, Oregon and Washington.

Exogenic Fulgurites

From Earth Science Picture of the Day, December 29, 2020
Photographer and Summary Author: Mila Zinkova
https://epod.usra.edu/blog/2020/12/exogenic-fulgurites.html

The class of exogenic fulgurites refers to liquefied materials resulting from a powerful lightning strike (>100 GW) that are thrown into the atmosphere above the lightning's point of impact (i.e. they are ejected) and solidify in the air. Exogenic fulgurites feature an amorphous and often bubbly appearance due to the rapid manner in which the airborne, liquefied materials cool down. They are generally dark green in color (as a result of a moderate iron oxide content), differing from traditional fulgurites, which are typically carrot, brown or tan. In addition, they have a smoother, glassier texture than conventional fulgurites, which have a gritty, sandy feel to them. Photo taken November 12, 2020. [next page]

Photo Details: Camera: Apple iPhone 6; Software: Adobe Photoshop CS3 Windows; Exposure Time: 0.0009s (1/1163); Aperture: ƒ/2.2; ISO equivalent: 32; Focal Length (35mm): 35

Related links:

Fulgurite

Student links:

Petrified Lightning

Fulgurite – Lightning Fused Sand

Earth Observatory

Patterns of Lightning Activity

DATES TO REMEMBER

Please check online or the contact info below to confirm the status of these events. The list is current as of publication date but may change.

March 31 – April 1, 2021 – **Maine Sustainability & Water Conference** – online, virtual format for 2021. https://umaine.edu/mitchellcenter/event/2021-maine-sustainability-water-conference/

April 8, 2021 – **NH Geological Survey (NHGS) 2021 Geological Mapping Workshop** – online event using WebEx. Pre-registration is required. See pages 8-9 for details.
https://www.des.nh.gov/land/geology

April 9 and 10, 2021 – **Saving Special Places 2021** – online, virtual format for 2021.
https://savingspecialplaces.org/

April 15, 2021 – **GSNH Meeting** – this will be a virtual meeting; see page 6 for details. Charlie Kerwin will give a presentation on NH geology and the Massabesic Gneiss Complex.

April 17 -18, 2021 – **Southeastern New Hampshire Mineral Club Show** – 282 Durham Road (Dover Elks Lodge #184), Dover, NH.

May 17 – 19, 2021 – **Geological Association of Canada/Mineralogical Association of Canada (GAC-MAC) Joint Annual Meeting** – hybrid in-person (London, Ontario) and virtual meeting.
https://gacmac2021.ca/

June 17, 2021 – **GSNH Board of Directors Meeting** – location TBD

June 26-27, 2021 – **Gilsum Rock Swap & Mineral Show** – Gilsum Elementary School & Community Center, 640 Route 10. Decision on holding rock swap to be made by April 16.
https://gilsum.org/rockswap/

July 17-18, 2021 – **21st Annual Seek the Peak Hike-a-Thon** supporting the Mount Washington Observatory. https://secure.qgiv.com/event/stp2021/

Friends of the Pleistocene Summer Field Trip – **POSTPONED** to early June 2022. Look for more details in future issues.

Looking for some continuing ed credits? Some webinar series are below:

- clu-in.org compiles webinars of interest to EPA and the environmental community here: https://clu-in.org/training/#upcoming
- The geoscience online learning initiative (GOLI) has several webinars and short courses that are free, but do include an administrative fee for continuing ed credits: https://www.americangeosciences.org/workforce/goli

GSNH Education and Outreach Committee Update by Lee Wilder

This past summer (2020) your GSNH awarded a grant to Joel Kneisley. Joel is a current University of New Hampshire (UNH) Department of Earth Sciences graduate student (former undergrad also) doing his Masters Research in August (2020) in north central Vermont. Joel's Masters Thesis Proposal is described below. If GSNH ever gets back to having in person dinner meetings, Joel has said he would be glad to attend and meet all of us.

The Tillotson Peak Complex (TPC), located in north central Vermont, shows evidence of Taconic (Ordovician) metamorphism with Acadian (Devonian) metamorphic overprinting (Laird and Albee 1981). Prior research into the petrology of the TPC by Laird and Albee (1981) revealed the existence of symplectite textures outlining glaucophane and omphacite porphyroblasts. These symplectites are important in understanding the processes that occurred during metamorphism, burial, and subsequent exhumation. This study will gather field samples showcasing the symplectite texture and determine (1) chemical reaction(s) involved during the formation of the symplectites, (2) whether symplectite formation is caused by disequilibrium in prograde or retrograde metamorphism and (3) the depth of symplectite formation using pressure and temperature estimates. This study will also further the understanding of the complex geologic setting and timing of Taconic metamorphism and subsequent Acadian, or younger, overprinting in northern Vermont.*

As a reminder, we also have grants of up to $500 available for New Hampshire K-12 teachers who would like to add earth-science teaching materials to their curriculum. For additional information regarding classroom-enhancement grants and an application (available as a PDF and Word file), please see the GSNH website at http://www.gsnh.org/classroom-grant.html

* Laird J. and Albee A. L. 1981. High-Pressure Metamorphism in Mafic Schist from Northern Vermont. American Journal of Science V. 281 pp. 97-126. https://www.ajsonline.org/content/281/2/97

In Other Election News, Massachusetts Just Voted on a State Dinosaur

By Jessica Leigh Hester, Atlas Obscura. February 5, 2021.
https://www.atlasobscura.com/articles/massachusetts-state-dinosaur

While much of America rehashes the outcome and aftermath of a recent election, voters in Massachusetts have been electing another official. The job description is vague, the duties negligible. The gig is mainly as a figurehead, which is good, because the candidates aren't particularly revved up about representing their constituents. They demonstrate astonishingly little interest in local government. In fact, they've been dead for millions of years.

If Massachusetts Representative Jack Patrick Lewis has anything to say about it, his state will soon become the 13th to appoint an official state dinosaur. Lewis—a lifelong dino nerd who has traveled to several dig sites and brags about seeing every Jurassic Park movie on opening night—hatched the idea while noodling over ways to make paleontology accessible and engaging for his kid's Cub Scout den. Introducing a bill to name a state dinosaur struck him as a good way to get kids jazzed about both science and the legislative process. It also seemed really fun.

One dinosaur to represent the state—but which? "I initially assumed that there hadn't been dinosaurs discovered in Massachusetts," Lewis said at a recent webinar about the dinosaur election, hosted by Boston's Museum of Science. Not so—but not especially far off, either. Lewis tapped researchers to help brainstorm some potential nominees. The task "turned out to be relatively simple, because there are only two species of dinosaur whose bones have been found in the state," says Noel Heim, a paleobiologist at Tufts University who consulted on the effort.

During the Early Jurassic period, which lasted from about 200 million to 175 million years ago, the land that is now Massachusetts was semi-arid and probably monsoonal—drenched in some seasons, and dry in others, says Mark McMenamin, a paleontologist and geologist at Mount Holyoke College who also consulted on Lewis's initiative. The land was speckled with prominent lakes and stippled with juniper-like trees. Upland, large portions were barren and rocky. We know that several species of dinosaurs crossed this landscape because some of their tracks are preserved around the shores of those ancient lakes. But it's famously difficult to match a track with a track-maker, and there's still no consensus about which species' travels are recorded, for instance, in the rock at the Dinosaur Footprints site in Holyoke.

Across the state, finding an area of exposed prehistoric bedrock "larger than a typical parking lot is relatively rare," McMenamin says. Dinosaur Footprints is an exception. The same goes for some roadcuts along I-91 that reveal red-and-brown Jurassic rocks. The strata are visible in some parts of the Holyoke and the Mount Tom range, but "the exposures are really limited compared to what you'd find in a Western state like Colorado or Wyoming," McMenamin says. Out West, he adds, some fossils almost ask to be found. "There are vast stretches of land where you can see the bones sticking out of the ground."

Though some trace fossils, such as tracks, are in the collection of Amherst College's Beneski Museum of Natural History, scientists have only found bones of two species in Massachusetts. Joanne Rathe/The Boston Globe via Getty Images

So Lewis drew his candidates from a comparatively shallow pool. The only swimmers were *Podokesaurus holyokensis* and *Anchisaurus polyzelus*, the two species that scientists know to have left bones behind in Massachusetts. Both were extracted from the Hartford Basin.

Geologist, paleontologist, and professor Mignon Talbot discovered *P. holyokensis* near Mount Holyoke in 1910. Writing in *The American Journal of Science* in 1911, she described how a split "bowlder" yielded "the excellently preserved skeleton of a small dinosaur" with hollow bones and a "light and delicate" frame. Talbot's fossils were lost a few years later, when a fire razed the campus building that housed them. (She and her students sifted through the rubble, but couldn't recover the bones.) Casts remain, though, and scientists believe that the dinosaur was carnivorous and at least partially feathered, stretched between three and six feet long, weighed around 90 pounds, and scampered between nine and 12 miles an hour. *A. polyzelus* turned up in the 1850s, when armory crews blasted ground in Springfield. The fossils are in the collection of Amherst College, and the dinosaur may have been an ancestor of the *Argentinosaurus*, a genus of gargantuan sauropods that would hulk onto the scene millions of years later, during the Late Cretaceous.

Mignon Talbot (second from left) and students sifted through the debris of a burned building in an effort to recover fossils. Courtesy Mount Holyoke College

Massachusetts residents cast ballots online throughout January. *P. holyokensis* trounced *A. polyzelus* in the polls, winning more than 60 percent of the 35,000 votes. (“I’ve been rooting for this one since the beginning,” Lewis said while announcing the winner at the Museum of Science webinar, sporting a tie with a jumble of dinosaurs on it.) On February 4, Lewis introduced two bills seeking to appoint *P. holyokensis* the official dinosaur of the Commonwealth.

Given his Holyoke home base, McMenamin also voted “for the local candidate,” he says. Now that his pick has clinched victory, the scientist has set his sights on another goal: stoking this enthusiasm for paleontology and trying to mobilize support for more digs. “Vertebrate paleontologists would just

salivate if we could get more material," he says. "We have some work to do to figure out who else is in the cast of characters." He hopes that more excavations will soon be in progress around the state, and that more dinosaurs will surface. "There's no question that they're down there," he says. "We know they're there. They're just hiding."

This creature, Podokesaurus holyokensis, is primed to be Massachusetts's future official dinosaur. Funkmonk (Michael B. H.) / CC-BY SA 3.0

The Merrimack: River at Risk Documentary

From the Society for the Protection of New Hampshire Forests: https://forestsociety.org/riveratrisk

The Merrimack River is the birthplace of the Industrial Revolution in America. During the 19th century, mills in cities such as Manchester, New Hampshire, and Lowell, Massachusetts, harnessed the power of the river to become the largest manufacturing plants in the world. Like many rivers in America, the Merrimack was heavily polluted as a result of industrial growth. But, thanks to the Clean Water Act of 1972, the Merrimack has been cleaned up considerably over the last 50 years. Remarkably, more than 80 percent of the Merrimack watershed is still undeveloped and largely forested. However, in 2016, it was named one of the most endangered rivers in the United States by the nonprofit American Rivers.

Hosted by conservationist and New Hampshire native Leah Hart, the documentary spotlights the threats the river and the watershed face now and in the future. From water treatment professionals to river guides to community builders, Hart interviews people who know what's at stake if towns and communities don't work together to protect the river and the forests that surround it. It's through these compelling interviews and Jerry Monkman's visually stunning cinematography that viewers will come to appreciate the often forgotten resources the Merrimack provides thousands of people every day and why it's so important to protect them.

The documentary is located on youtube here:
https://www.youtube.com/watch?v=w4UuEhMK-1Q&feature=emb_imp_woyt

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Half of Earth's Nitrogen May Be Homegrown

By Lakshmi Supriya. From Eos, March 3, 2021.
https://eos.org/articles/half-of-earths-nitrogen-may-be-homegrown

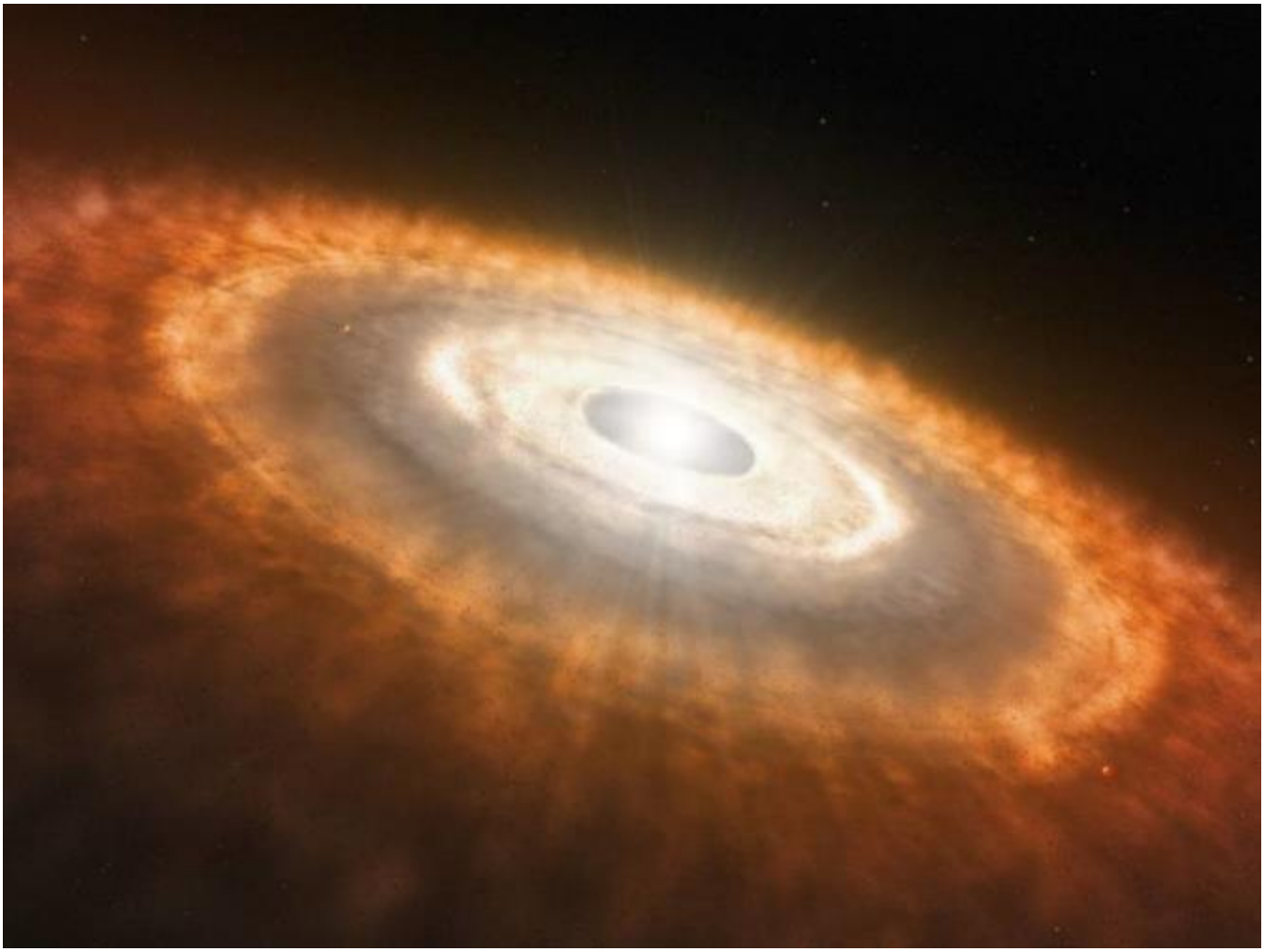
Nitrogen, carbon, and water—the key ingredients for life—are generally believed to have come to Earth from the outer reaches of the solar system. Researchers now have found evidence that as much as half of Earth's nitrogen could have come from much closer to home. This finding may change the way we look at how life formed in our solar system—and how it may form in others.

Our solar system began as clouds of gas and dust in a swirling disk. At the center of the swirl, most material formed the Sun. Farther out, matter accumulated and formed the nuclei of the planets we know today. Volatile elements like nitrogen and carbon have traditionally been thought to have condensed in the outer reaches of the disk, beyond the orbit of today's Jupiter, and to have been carried to the inner planets by meteoroids.

In the past decade, scientists figured out that Earth's meteorites can be separated into two distinct categories: those that came from the inner part of the solar system and others that came from beyond Jupiter. Further analysis revealed that isotopes of nonvolatile elements (like molybdenum and tungsten) in these meteorites are also split between "inner" and "outer" categories.

Damanveer Grewal of Rice University, lead author of a new study on the origin of nitrogen on Earth, was considering the fate of volatile elements in the early solar system when he came across data for nitrogen isotopes in iron meteorites. Iron meteorites are remnants of protoplanets—the undeveloped cores of planets that never fully formed. They formed within 300,000 years of the origin of the solar

system, as the planets were just starting to nucleate. Grewal thought iron meteorites could serve as a proxy for the seeds of today's planets and help him tease out clues about how life-essential elements fared early on.



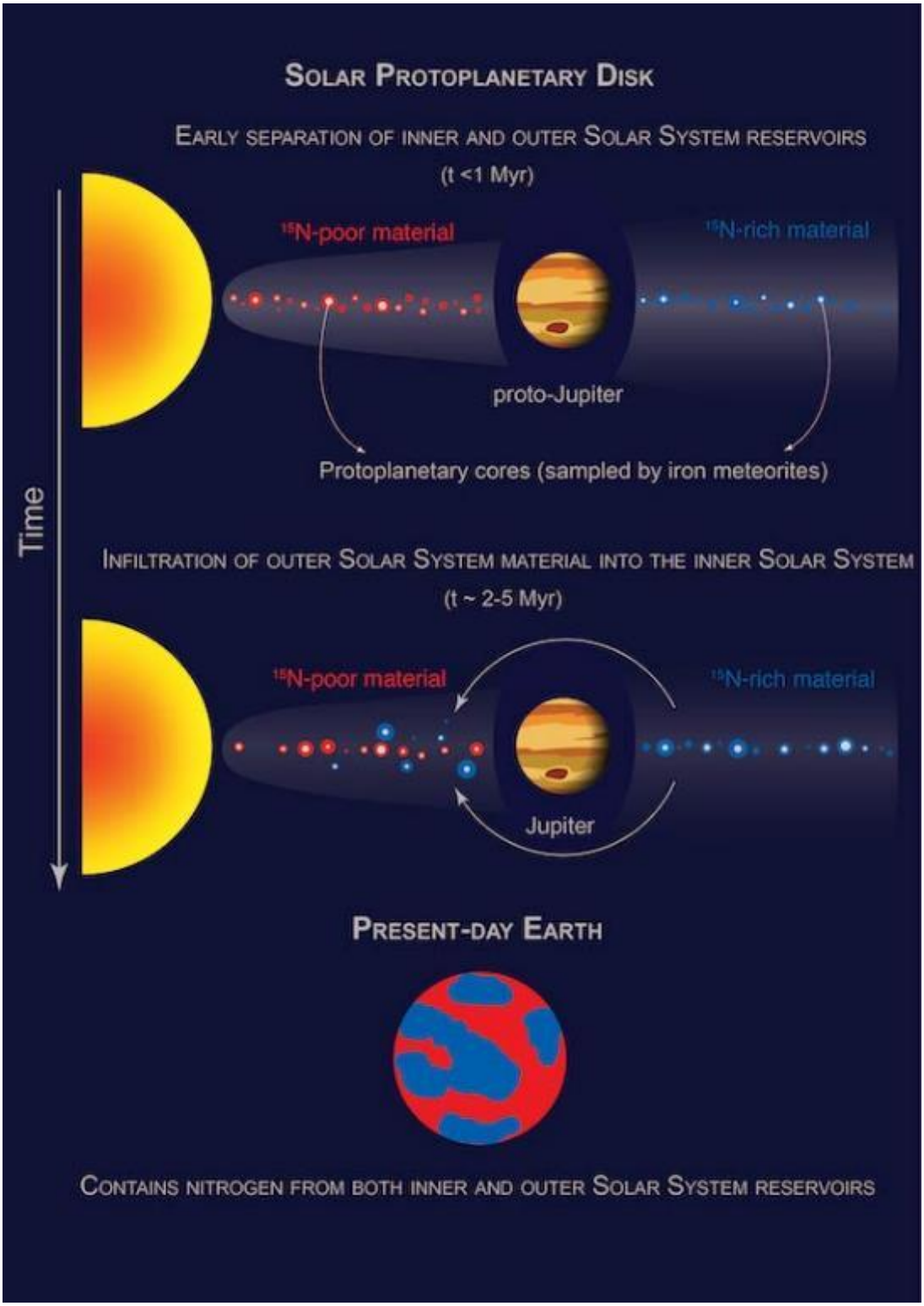
Nitrogen may have been present in the protoplanetary disk much closer to the young Sun than previously thought, new research indicates. Credit: ESO/L. Calçada, CC BY 4.0

Tracing Nitrogen's History

Grewal analyzed the nitrogen isotope data in the meteorites. "What I found at this stage was extremely shocking," he said: The meteorites' nitrogen isotopes fell into the same inner and outer categories as the nonvolatile elements. "This was too good to be true."

The iron meteorites from the outer part of the disk were rich in the nitrogen-15 isotope, and those from the inner part were rich in nitrogen-14, implying that nitrogen was present in the inner part of the disk when Earth was young. This suggests that not all of Earth's nitrogen came from the outer solar system, Grewal and colleagues reported in their paper published in *Nature Astronomy*.

“So the seeds of the protoplanets never started volatile-free; they always had volatiles in them,” said Grewal. It’s likely the nitrogen was present in some type of organic material with high temperature resistance.)



This illustration shows how nitrogen isotopes have been distributed in the solar system from its origins to the present day. Credit: Amrita P. Vyas

These findings challenge the traditional idea that volatiles like nitrogen and water were brought in from the outer solar system, said Sebastiaan Krijt, an astrophysicist at the University of Exeter not involved in the study. Because Earth's nitrogen isotope ratio falls between that of the inner and outer solar system reservoirs, "this suggests, in fact, [that] as much as half of Earth's current nitrogen budget may have been sourced locally in the form of nitrogen-bearing organics and/or dust."

Krijt said that understanding whether the processes responsible for bringing the ingredients for life to Earth were just a lucky chance or commonplace, as this study suggests, is important. "It sheds light on how often we expect similar conditions to arise on rocky planets in other planetary systems."

Citation: Supriya, L. (2021), Half of Earth's nitrogen may be homegrown, Eos, 102, Published on 03 March 2021.

Did Woolly Mammoths Overlap With First Humans in New England?

By Amy Olsen, Dartmouth News, March 4, 2021

Woolly mammoths may have walked the landscape at the same time as the earliest humans in what is now New England, according to a Dartmouth study published in Boreas. Through the radiocarbon dating of a rib fragment from the Mount Holly mammoth from Mount Holly, Vt., the researchers learned that this mammoth existed some 12,800 years ago. The humans in the Northeast are thought to have arrived around the same time.

"It has long been thought that megafauna and humans in New England did not overlap in time and space and that it was probably ultimately environmental change that led to the extinction of these animals in the region, but our research provides some of the first evidence that they may have actually co-existed," says co-author Nathaniel Kitchel, the Robert A. 1925 and Catherine L. McKennan Postdoctoral Fellow in anthropology.

The Mount Holly mammoth, Vermont's state terrestrial fossil, was discovered in the summer of 1848 in the Green Mountains during the construction of the Burlington and Rutland railroad lines. One molar, two tusks, and an unknown number of bones were excavated from a hilltop bog near Mount Holly. Over time, the specimens became scattered across several repositories, as they transferred from one collection to the next. A rib fragment from the Mount Holly mammoth became part of the Hood Museum of Art's collection, and some of the other skeletal materials are now housed at the Museum of Comparative Zoology at Harvard University and the Mount Holly Historical Museum.

Replica of a woolly mammoth (Mammuthus primigenius) in the Royal BC Museum in Victoria, British Columbia, Canada. The display is from 1979 and the fur is muskox hair. (Image by Flying Puffin, Creative Commons Attribution-ShareAlike 2.0 Generic license – cropped from original)

Kitchel stumbled across the Mount Holly mammoth rib fragment last December at the Hood Museum's offsite storage facility, as curators had invited him to take a look at some of their artifacts from New Hampshire and Vermont. He came across a large bone (approximately 30 cm. long) that was stained brown in color from age. He had a hunch that this was the remains of a mammoth and when he looked down at the tag, it read, "Rib of fossil elephant. Mt. Holly R.R. cut. Presented by Wm. A. Bacon Esq. Ludlow VT." This was serendipitous for Kitchel, as he had recently delivered a talk at Mount Holly's Historical Museum for which he had read up on the Mount Holly mammoth.

To appreciate the significance of the Mount Holly mammoth remains, including the rib fragment, it is helpful to understand the paleontology of the Northeast. During the Last Glacial Maximum around 18,000 to 19,000 years ago, when glaciers were at their maximum extent, the ice began to retreat, gradually exposing what is now called New England. During that period, it is likely that the glaciers probably sufficiently ripped up whatever soil might have been preserving fossils, reducing the likelihood of fossils remaining intact. These changes, combined with the Northeast's naturally acidic soils, created inhospitable conditions for the preservation of fossils. While Kitchel had discussed the complicated paleontology of the Northeast in the past with colleague and co-author Jeremy DeSilva,

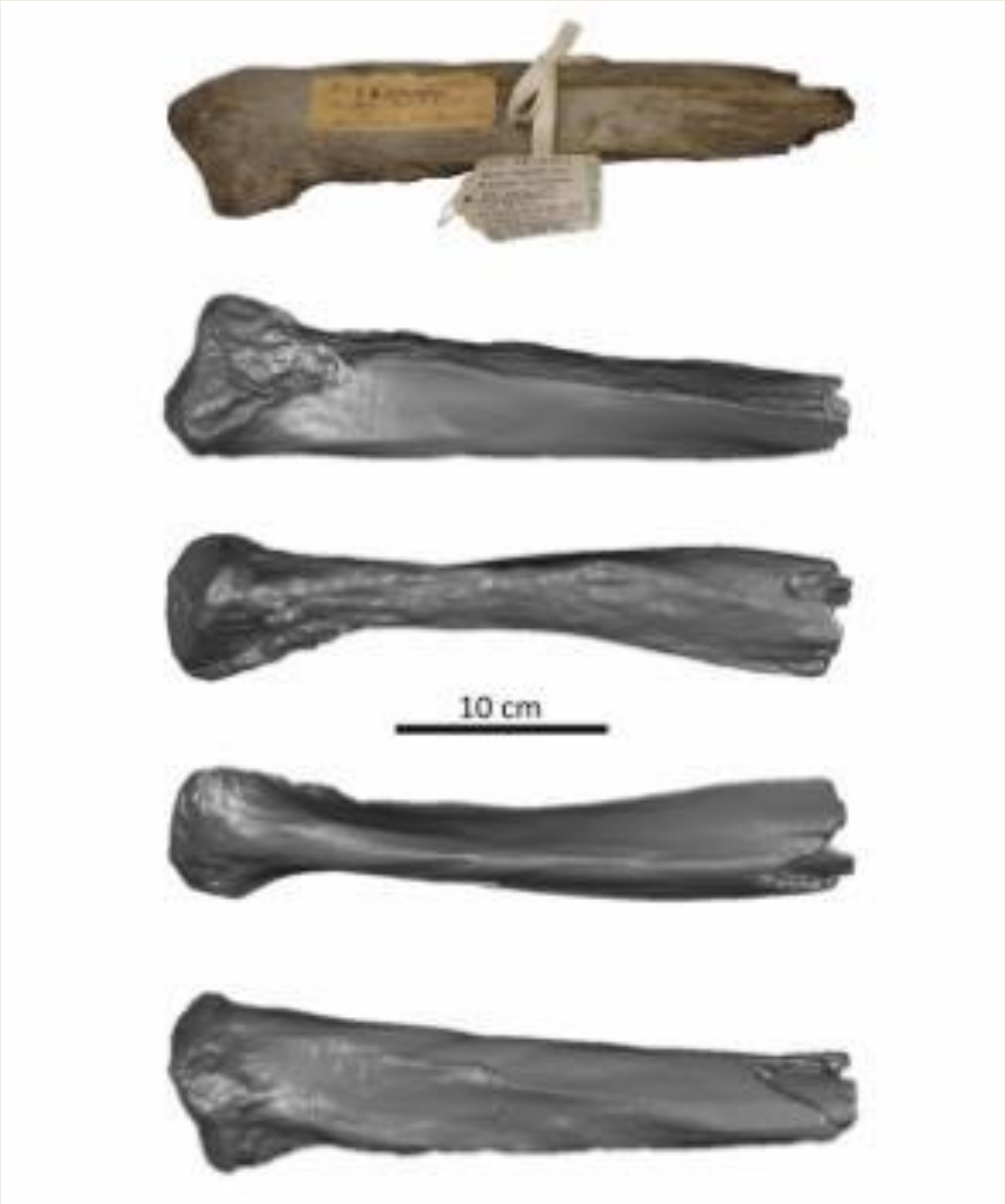
an associate professor of anthropology, he never thought that he would have an opportunity to work on it.

After seeing this mammoth material in the Hood's collection, Kitchel and DeSilva decided to obtain a radiocarbon date of the fragmentary rib bone. They took a 3D scan of the material prior to taking a small (1 gram) sample from the broken end of the rib bone. The sample was then sent out to the Center for Applied Isotope Studies at the University of Georgia for radiocarbon dating and a stable istotopic analysis.

Nathaniel Kitchel, the Robert A. 1925 and Catherine L. McKennan Postdoctoral Fellow, left, and Jeremy DeSilva, associate professor of anthropology, did research to determine the estimated age of the Mount Holly mammoth rib fragment. (Photo by Eli Burakian '00.)

Radiocarbon dating enables researchers to determine how long an organism has been dead based on its concentration of carbon-14, a radioactive isotope that decays over time. Stable isotopes however, are isotopes that do not decay over time, which provide a snapshot of what was absorbed into the animal's body when it was alive. Nitrogen isotopes can be used to analyze the protein composition of an animal's diet. The nitrogen isotopes of the Mount Holly mammoth revealed low values in comparison to that of other recorded mammoths globally while also reflecting the lowest value recorded in the Northeast for a mammoth. The low nitrogen values could have been the result of these mega-herbivores having to consume alder or lichens (nitrogen-fixing species) during the last glacial period, when the landscape was denser due to climate warming.

"The Mount Holly mammoth was one of the last known occurring mammoths in the Northeast," says DeSilva. "While our findings show that there was a temporal overlap between mammoths and humans, this doesn't necessarily mean that people saw these animals or had anything to do with their death but it raises the possibility now that maybe they did."



Photograph showing the affixed tags and 3D model of the Mount Holly mammoth rib fragment housed at the Hood Museum of Art. (Image by Nathaniel R. Kitchel and Jeremy DeSilva.)

The radiocarbon date for the Mount Holly mammoth overlaps with the accepted age of when humans may have initially settled in the region, which is thought to have occurred during the start of the Younger Dryas, a final pulse of glacial cold before temperatures warmed dramatically, marking the end of the Pleistocene (Ice Age).

While other research on mammoths in the Midwest suggests that humans hunted these animals and buried them in lakes and bogs to preserve the meat, there's little evidence that early humans in New England hunted or scavenged the animals.

The researchers are intrigued by the Mount Holly mammoth. The rest of its rib and other bones could be waiting to be discovered. Or, through time, they could have broken apart, dissolved in the acidic soil, or a scavenger could have run off with the bones. There are still a lot of unknowns, but the team has already begun further research using modern and more sophisticated archaeological techniques to explore what may still be underground at Mount Holly.

Current Geologic Mapping in New Hampshire

From Joshua Keeley and Rick Chormann, New Hampshire Geological Survey

Every year, the New Hampshire Geological Survey (NHGS) engages in new geologic mapping across the state in cooperation with the federal STATEMAP program. Last year, we were successful in producing 6 7.5-minute geologic maps, and the Surficial Geologic Map of the Lowell 30x60-minute sheet. New 7.5-minute surficial quadrangles include Mount Carrigain, the southern half of Berlin, and the northern half of Tamworth. New bedrock 7.5-minute bedrock quadrangles include North Grantham, Pittsburg, and the southern half of Berlin.

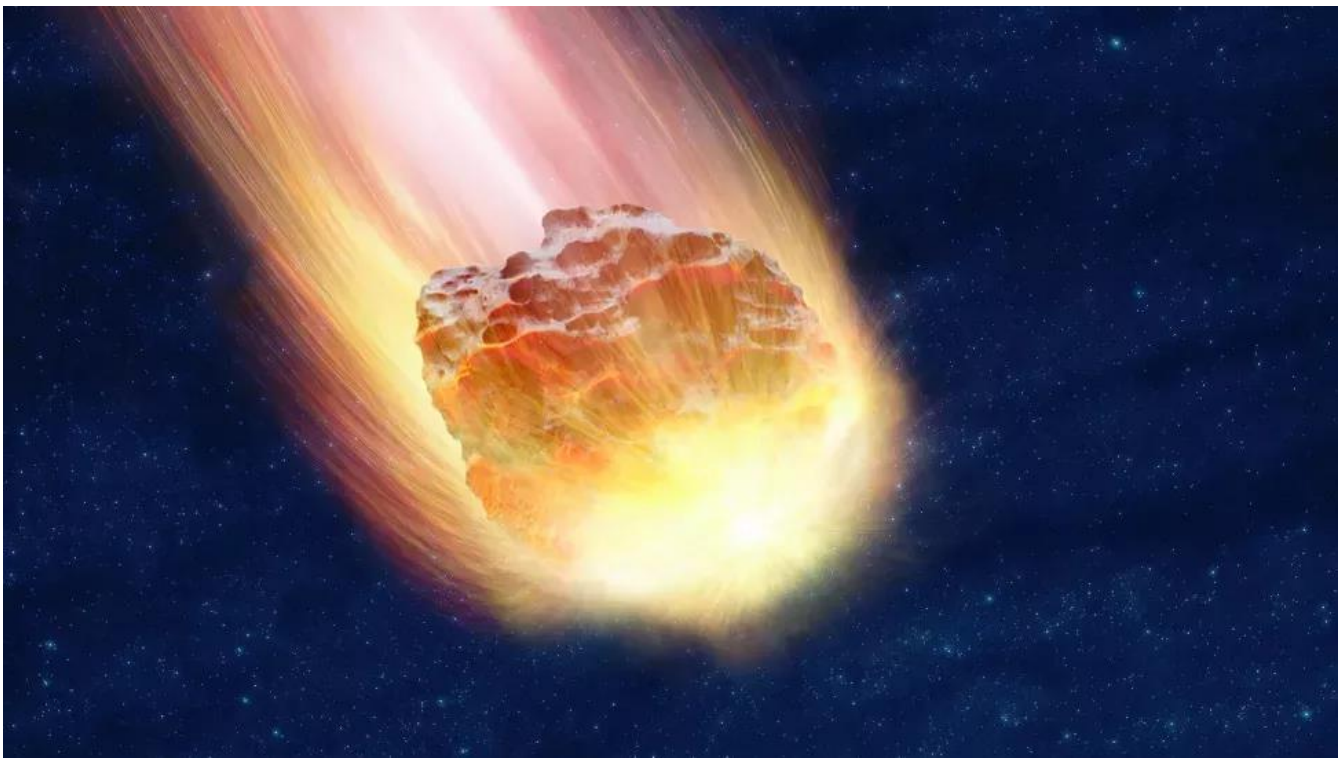
This year, Mike Prentice, Ph.D., P.G., will be mapping the surficial geology of the NH portion of the Winchendon quad, and will thereby complete the last remaining piece of the Keene 30x60-minute sheet along the borders of Massachusetts and Vermont. Brian Fowler, P.G., will be mapping the surficial geology of the southern half of the Mount Tripyramid quad, and in the process will be taking the penultimate step to finish a large swath of surficial mapping in the White Mountains. Dan Tinkham, M.S., P.G., will be mapping the surficial geology of the southern half of the Tamworth quad and John Brooks, Ph.D., P.G. will be mapping the southern half of the Tuftonboro quad—both of which will complete the surficial mapping of the Lake Winnipesauke basin. David Converse, B.S.E., PhD., and Wally Bothner, Ph.D., P.G., will be mapping the bedrock geology of the Lake Francis quad as part of a larger mapping effort in the Indian Stream area in northernmost NH. Peter Thompson will be mapping the bedrock of the southern half of the Mt. Moosilauke quad, which expands his recent bedrock mapping along the western border of New Hampshire into the White Mountains.

Meteor Explodes Over Vermont with the Force of 440 Pounds of TNT

By Rafi Letzer, Live Science. March 8, 2021.
https://www.livescience.com/vermont-meteor-explodes.html

A meteor streaked through the night sky over Vermont on Sunday (March 7), creating a spectacular light show and causing Earth-shaking booms as it burned through the atmosphere.

The meteor's explosive passage through the atmosphere released the equivalent of 440 pounds (200 kilograms) of TNT, suggesting that the meteor was likely 10 pounds (4.5 kg) and 6 inches (15 centimeters) in diameter, according to NASA Meteor Watch.



An illustration shows a meteor passing through the atmosphere. (Image credit: Michael Dunning/Getty Images)

The space rock smacked into the atmosphere at about 42,000 mph (68,000 kph), according to NASA. It appeared over the northern part of the state as a bright fireball at 5:38 p.m. EST, just before sunset.

Local news station WCAX3 reported calls from all over the state after the event, with Vermonters describing a "loud boom and body-rattling vibration" as the meteor passed overhead.

"I was fortunate to hear and see it by the Missisquoi River at the Missisquoi Wildlife Refuge in Swanton, VT, just before sunset," wrote Chris Hrotic, a commenter on NASA's initial post about the

event. "No loud boom as reported by others, but a rushing sound that made me look up at just the right moment. It was extremely bright and absolutely spectacular!"

Based on eyewitness accounts, NASA estimates that the fireball first appeared 52 miles (84 km) over Mount Mansfield State Forest just east of Burlington, the state's largest city. It then progressed 33 miles (53 km) northeast toward the Canadian border, disappearing 33 miles (53 km) above the ground south of the town of Newport.

According to NASA, the shock wave was a result of the meteor fracturing due to atmospheric pressure. As the bowling ball-size chunk of a larger parent asteroid moved at nearly 55 times the speed of sound through the atmosphere, pressure built up in front of it and a vacuum formed behind it. Eventually, the stress of that differential caused the rock to explode.

A NASA map shows the approximate path of the meteor over Vermont on March 7, 2021. (Image credit: NASA Meteor Watch)

In comments on NASA's initial Facebook post about the incident, people claimed to have seen the rock from as far west as Saratoga, New York, as far north as Quebec, and as far east as Watertown, Massachusetts.

A Little River in a Big Drought: A Brief Snapshot of Drought and Recovery

From Joshua Keeley, New Hampshire Geological Survey

Little River drains an area of about 7 square miles in the towns of Strafford and Barnstead. It flows northwest over a sizable sand and gravel aquifer toward Barnstead and joins Big River before flowing into the Suncook Reservoir. Every month, someone from the New Hampshire Geological Survey (NHGS) comes to measure the overburden well located a few tens of feet from this spot, in Barnstead, as part of its Groundwater Monitoring Network, one of 31 wells statewide. NHGS monitors groundwater levels to support the efforts of multiple partners in managing drought.

These pictures tell the story of how low rainfall over the spring and summer months led to low-flow conditions in September, and how below-average rain in October through November led to insufficient recovery. This portion of river reach never went dry during the drought as so many small streams across the state did, but the groundwater here got about as low as it has in other drought years on record. Short-term drought relief came when New Hampshire got a flashy boost in mid-December when rain fell on snow, leading to abundant meltwater. However, in the process, the state lost vital snowpack that is needed to sustain groundwater and streamflow throughout the spring and summer. Another such event in January led to a second boost of snowmelt, which flooded this reach beyond its banks.

As of late February, the groundwater level in this Barnstead well is still high. Unfortunately, many wells in the network are not experiencing such conditions. Moderate drought persists in the Connecticut River Valley and abnormally dry conditions persist in the southern Merrimack basin and Seacoast Region. Although groundwater levels had peaked in December across much of the state due to rain events and snowmelt, groundwater has been in steady decline in the northern and western portions of the state. Groundwater level trends are mixed in the Merrimack River basin and Seacoast Region.

NHGS will be continuing our monitoring of the wells to support the state's ongoing efforts to monitor the drought. If you're interested in our monthly reports, we post our groundwater reports here: https://www.des.nh.gov/resource-center/publications.

August 31, 2020

September 21, 2020

October 26, 2020

November 23, 2020

December 23, 2020

January 25, 2021

March Legislative Committee Report by Tom Fargo

Below is a list of 2021 NH General Court (House and Senate) Bills that are potentially relevant to members of the Geological Society of New Hampshire. This table lists bills identified by keyword searches completed on March 1, 2021.

Bill No.	Title	Bill Description	Legislative Action – Bill Status
Key Word "**Environ**"			
HB141-FN	requiring the Department of Environmental Services to maintain a public registry of where certain fire suppressants have been used	This House bill requires the Department of Environmental Services to maintain a public registry of where certain fire suppressants have been used. Note: The FN designation indicates the bill contains a fiscal note describing the impact of the bill on the State budget. In this case the cost was described and an indeterminable increase in expenses. This bill is a re-introduction of HB-1569 from 2020.	Public hearing is scheduled for March 8 in the House Executive Departments and Administration Committee
HB-256	adding members from Londonderry to the commission to investigate and analyze the environmental and public health impacts relating to releases of perfluorinated chemicals into the air, soil, and groundwater in Merrimack, Bedford, and Litchfield.	This House bill amends RSA 126-A:79-a, that in 2019 established a commission to study the impacts of emissions of PFAS chemicals in the vicinity of the Saint Gobain Performance Plastics facility in Merrimack. Without an extension, the commission's activities conclude with issuance of a final annual report by November 1, 2024.	Full House voted ought to pass on 2/24/2021
HB-398	making an appropriation to the Department of Environmental Services for funding eligible wastewater projects	This House bill appropriates to the Department of Environmental Services the sum of $5,735,248 for the fiscal year ending June 30, 2022 and $6,919,115 for the fiscal year ending June 30, 2023, which shall be nonlapsing, for the purpose of funding eligible wastewater projects under RSA 486	The House Finance Committee was scheduled to vote on this bill on 2/16/2021. Results of that vote are not yet listed on the General Court website.
HB-412	making an appropriation to the Department of Environmental Services for the purpose of funding public water system projects	This House bill appropriates to the Department of Environmental Services the sum of $500,000 for the fiscal year ending June 30, 2022 and $500,000 for the fiscal year ending June 30, 2023, which shall be nonlapsing, for the purpose of funding public water system projects under RSA 486-A..	The House Finance Committee was scheduled to vote on this bill on 2/16/2021. Results of that vote are not yet listed on the General Court website.

SB146-FN	adopting omnibus legislation relative to the environment	This Senate bill aggregates proposed legislation regarding: I. Establishing the coastal program administered by the Department of Environmental Services. II. Establishing a statewide solid waste disposal reduction goal. III. Prohibiting incineration of PFAS in New Hampshire. IV. The prevention of zoonotic disease transmission. V. Tidal waters. VI. Establishing a surcharge on certain saltwater licenses and establishing a fund for derelict fishing gear and coastal cleanup. VII. The acquisition and preservation of agricultural land for food producing in the land and community heritage program. VIII. Class 2 obligations under the electric renewable portfolio standards. IX. Public use of coastal shorelands.	Senate Energy and Natural Resources Committee held a remote public hearing on this bill on 3/1/2021.
Key Word "**Water**"			
HB-135	requiring parties responsible for pollution of a drinking water supply to be financially responsible for certain consequences of that pollution.	This House bill the polluter, as determined by the Commissioner of NHDES, to connect the water user to a municipal system or to provide water filtration and to pay for that corrective action.	The House Judiciary Committee is scheduled to vote on this bill on 3/2/2021
HB-235	relative to community small groundwater withdrawal	This House bill requires Community Water Systems with groundwater withdrawals less than 57,600 gallons over any 24-hour period from a new source to meet many of the requirements for large groundwater withdrawals as specified in RSA 485-C. Note this bill appears to be in response to groundwater withdrawals in the Town of Hampstead that resulted in private wells running dry.	The House Resources, Recreation and Development Committee was scheduled to vote on this bill on 2/3/2021. Results of that vote are not yet listed on the General Court website.
HB-265 and HB-335	requiring bottled drinking water sold to the public to meet the same maximum contaminant levels established for public drinking water.	These two identical House bills require bottled water manufactured and sold in NH to meet state drinking water quality standards	The House Commerce and Consumer Affairs Committee is scheduled to vote on both HB-265 and HB-335 on 3/3/2021.
HB-271	relative to standards for per and polyfluoroalkyl substances (PFAS) in drinking water and ambient groundwater.	This House bill establishes in Statue the maximum contaminant levels and ambient groundwater quality standards for four PFAS compounds previously adopted in rules by NHDES.	The House Resources, Recreation and Development Committee held a public hearing on this bill on 2/3/2021.

HB-478	relative to treatment of PFAS contaminants in the drinking water of the Merrimack Village Water District.	This House bill requests Saint Gobain Performance Plastics commit to provide for the design, installation, operation, maintenance and monitoring of all water treatment system(s) necessary to effectively treat and remove PFC contamination from all affected public water systems to meet NHDES standards and to pay for the required upgrades.	The House Resources, Recreation and Development Committee will hold a remote a public hearing on this bill on 3/5/2021.
HB-611-FN	abolishing fluoridation in water	This House bill amends RSA 194.3 relative to school districts, and repeals five existing RSAs relative to public water systems, to abolish the addition of fluoride to drinking water in New Hampshire. Note that this or similar bills have been introduced in each General Court session for decades. The fiscal note describes the impact of the bill on the State budget as an indeterminable increase in expenses.	The House Resources, Recreation and Development Committee held a public hearing on this bill on 1/27/2021.
Key Word "**Waste**"			
HB-413	establishing a solid waste working group on solid waste management planning and relative to compost.	This House bill establishes a solid waste working group on solid waste management planning and also requires the Department of Environmental Services to make certain rules regarding compost. The working group would include sixteen members listed in the proposed statute and designated by the Commissioner of NHDES. The working group shall issue reports on November 1, 2021 and 2024.	On 3/11/2020 calendar Resources Recreation and Development Committee vote on 3/5/2020 was split 11-9. Majority Ought to Pass with Amendment; Minority: ITL
Key Word "Professional" as potentially related to Geologists			
SB-58	relative to the administration of occupational regulation by the office of professional licensure and certification	This bill makes amends RSA 310-A:1-d relative to actions of the Office of Professional Licensure and Certification. Changes proposed for the Board of Professional Geologists include: 1. Designation of Board Members by the Governor and Council 2. Requirements for recordkeeping and applications for licensure would be in accordance with policy established by the Office of Professional Licensure and Certification	A remote hearing by the Senate Executive Departments and Administrative Committee was held on 1/27/2021.

Key word searches with no returns: **geology, mineral, rock, soil**

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