

Nittany Mineralogical Society Bulletin

Nittany Mineralogical Society, Inc., meeting in State College, Pennsylvania
Contact information on back page

April, 2023

Visit our web site: www.nittanymineral.org

Editor (see back page):

David C. Glick

April 19th meeting:

IN PERSON at BOAL HALL or via ZOOM:

How to study an Asteroid: Penn State's role in NASA's OSIRIS Rex Mission

presentation by Dr. Allison Baczynski
Penn State

Our April meeting will be held Wednesday the 19th in Boal Hall (Boalsburg Fire Hall), 113 East Pine St., Boalsburg, PA 16827. Maps can be found on our web site.

7:15 to 7:45 p.m.: Social "hour." We will serve some refreshments - snacks and a few beverages - or feel free to bring your own non-alcoholic beverage.

7:45 to 8:00 p.m.: Announcements, door prizes, sales about 8:00 p.m.: featured program

*The event has free admission and free parking (lot just east of Fire Hall along East Pine St.), and is open to all; **parents/guardians must provide supervision of minors.** Bring your friends and share an interesting evening.*

*We hope you will join us in person, but if you can't, the **Zoom link** will be e-mailed to all paid members who receive our e-mails. Others are welcome to request it by e-mailing <xidg@verizon.net>. We plan to record the presentation for later posting to our web site. -Editor*

Dr. Baczynski is one of three Penn State faculty selected to join the NASA Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer (OSIRIS-REx) mission to analyze samples from the carbon-rich asteroid Bennu. The NASA spacecraft collected a sample from the asteroid in 2020, and is returning to Earth in September 2023. Penn State will analyze its sample for isotopes in its molecules, using techniques developed at Penn State, with the hope of learning about the origins of these molecules. See <https://www.psu.edu/news/research/story/penn-state-faculty-join-nasa-mission-study-samples-asteroid-bennu/>

Junior Rockhounds Meetings Happening Now!

Students in grades 3-8
See page 2

Monday evenings 6:00 - 6:40 p.m.
April 17, 24; May 1, 8, 15, 22

Penn State

Night at the Museums

April 20

Many of Penn State's museums will be open special evening hours, free and open to the public, Thursday, April 20, 5:00-8:00 p.m. This includes The Earth & Mineral Sciences Museum and Art Gallery in Deike Building. Visit there and see NMS's fluorite display, as well as fossils, minerals, historic maps, and artworks depicting the mineral industries. See <https://museum.ems.psu.edu/event/night-museums>

NMS Recorded Presentations

David Glick

The majority of the NMS meeting Zoom presentations made during the pandemic were also recorded and may be viewed by using the links on the main page of our web site (scroll down to find them). The March program is now available. Others require more processing, which is in progress.

NMS 2023 Spring Schedule

May 17: Life in the Cambrian: Oxygen and Diversification

TBA: Geology Field Tour

Possible Mineral Garage Sale

David Glick

Any members who might be interested in selling their items at a 'Mineral Garage Sale,' please contact the president (see p. 12).



FEDERATION NEWS

Nittany Mineralogical Society, Inc., is a member of EFMLS, the Eastern Federation of Mineralogical and Lapidary Societies, and therefore an affiliate of AFMS, the American Federation of Mineralogical Societies. We encourage our readers to read their monthly newsletters. The AFMS News is linked from our web site, <<http://www.nittanymineral.org>>, found at <http://www.amfed.org/afms_news.htm>. The Eastern Federation now has its Newsletters on its web site (use Chrome if Firefox does not work). Back issues are also available; for the password, look on the web site or contact David Glick (see back page).

In the AFMS April Newsletter, President Cheryl Neary discusses balancing work, family, and travel to Federation Conventions! Junior Poetry Award Winners are published (see page 11 of this Bulletin). The AFMS Convention will be held August 3-6 in Billings, Montana, together with the Northwest Federation Convention; geology, geography, and history background is discussed. Historian Jennifer Haley encourages the preservation of photographs from club history. A Newsletter for Kids by Kids is announced by the Juniors Committee.

The Eastern Federation’s April Newsletter includes an update on many activities from president Bill Stephens. He renews his call for volunteers to chair various EFMLS committees. Advance Registration forms for the July EFMLS Convention are provided; this includes registration for the three field trips, notably the July 10 Herkimer “diamond” field trip to Mohawk Valley Mineral Mining (cost \$75). There’s more about Syracuse, site of the July 7-9 2023 EFMLS Convention.

Junior Rockhounds Meetings Happening Now!

The meetings have a different topic each week, such as minerals, fossils, gemstones, geology, and dinosaurs. They include fun hands-on activities and discussions with an expert. Parents stay with their children, and may get a lot out of the meetings too! You don't have to be a member to attend; please come out and see what it's all about.

WHO: You! Best for students in 3rd through 8th grades, WITH their parents.

WHAT: Junior Rockhounds Science Club – Rocks and Minerals Programs.

WHERE:
BOALSBURG FIRE HALL
113 E Pine St.
Boalsburg PA 16827

Google Map link and more at :
<http://www.nittanymineral.org/juniors.htm>

WHEN: 2023 Spring Schedule: 6:00 to 6:40 p.m.
(Mondays): April 3, 10, 17, 24; May 1, 8, 15,22

Cost: Free! (plus students get free mineral samples)

Parents: Please accompany your student! All materials provided free of cost. Students get specimens to add to their personal collection. Hands-on, messy, fun! Science, learning, and family fun!

Contact for any questions is:
Andrew A. Sicree, Ph.D.
aas132@psu.edu 814-867-6263

Geo-Sudoku by David Glick

The puzzle ar right contains the letters ABDEIORST. One row or column includes the topic of our meeting. If you’ve read this issue, you’ve seen it. Each block of 9 squares, each row, and each column must contain each of the nine letters exactly once. The solution is on page 12.

I	D			T				S
	A	O						R
	B	E	A	O	R	D	T	
	I			E	B			D
	O							
E		B		A	S	R	I	
O				B		S		
							D	
B		I	S			E		

THANKS to MANY for a Successful Minerals Junior Education Day

by David Glick, NMS President

Minerals Junior Education Day went smoothly at CPI on March 25, thanks to our many volunteers and attendees. Because of COVID, this was our first such event since 2019. We had about 90 young students, plus their parents, come through. We're still processing the finances, but it seems that despite the rather low attendance, we came out ahead. Coordinator Frank Kowalczyk made extensive arrangements over several months for the venue, the various stations, lunch for the volunteers, publicity, and more; we also thank his family for all of their help. John Dziak and Dr. Bob Altamura also worked on publicity. Special thanks go to several students from Penn State Department of Geosciences / Association for Women Geoscientists who solved our staffing shortage by filling in as needed at various places. At the nine stations, we thank the following, and anyone else who we may have missed:

- Lapidary: Dr. Bob Altamura, with assistance from Luke Laubscher of Creekside Rock & Gem, Bellefonte.
- Rock Spheres: Jim and Pat Garthe.
- Gold Panning: Volunteers from the Bald Eagle Chapter of Gold Prospectors Association of America.
- Caves & Karst: Personnel from Lincoln Caverns & Whisper Rocks, Huntingdon.
- Copper: Dr. Andrew Sicree, Dr. Duff Gold, and Dale Kephart, with specimens from Bryon Brookmyer.
- Fluorescence: Stuart and Ellen Bingham.
- Native Americans used rocks - Dr. Barry Scheetz and Sherman Stoltzfus.
- Stars & Stripes in Gemstones - Dr. Peter Heaney and students Dongyoun Chung and Marielle Reese.
- Fossils: Dr. Charles E. Miller Jr., Steve and Jackie Sywenski, Sigrid Byers, and Brady Clemens.

• Sales: Thanks go to the following who made donations of materials, their time and expertise, or both: Betsy Suhey, Dr. Bob Altamura, Dr. Shirley Fonda, Dr. Duff Gold, Dr. Andrew Sicree, Jim Van Fleet, Tim Holtz, Steve and Jackie Sywenski, Stuart and Ellen Bingham, Karen Harrington, the late John Passaneau, the late Pen Ambler, and the late 'Skip' Colflesh. ❄



Student Activities in Earth Science FOSSIL APPLICATIONS

Dr. Charles E. Miller, Jr.
State College, Pennsylvania

Introduction

On 2-16-22, the author spoke to the Nittany Mineralogical Society on "Applied Paleontology." That talk discussed some of the many ways fossils are used to interpret Earth's geological past. This article describes fossil applications as student activities for earth science or geology courses. The NMS Bulletin is distributed to other organizations, some of which might have members still involved in teaching. Presently, teachers compete with cell phones, videos, and social media to be interesting and relevant. The examples in this article may be a small contribution.

Using fossils to date sedimentary rocks

Before radiometric age dating, fossils were used for relative dating of sedimentary rocks. Relative dating is distinguished from absolute dating. The former determines relative time, linking fossils to a subdivision of geologic time, such as the Devonian, Ordovician, etc. It cannot determine absolute time, something that radiometric dating does. The technique uses fossil ranges that how long a fossil group lived. Fossil ranges are usually depicted on a geologic timetable (Figure 1), showing subdivisions of earth's geologic history. The ranges vary in length, reflecting successes and failures in adapting through time.

Ranges A-K of Figure 1 are for a typical fossil assemblage - a fossil group found together in rock layers (strata). Each fossil has its own stratigraphic

range. By comparing ranges, the sedimentary rocks can be relatively dated. This is best done using short fossil ranges. Long fossil ranges (A, Figure 1) are less helpful because they are not specific enough.

- Student Activity 1.

Using fossil ranges B-K (disregarding "A" because it is too long) of Figure 1, determine the relative age of this assemblage. Alphabetical letters identify fossils in lieu of scientific names. Begin with overlap of "C" and "K." This overlap gives oldest (Cambrian) and youngest (Jurassic) limits for the assemblage. Use ranges D-J to refine your answer (Table 1).

Radiometric age dating largely supplants fossils in dating sedimentary rocks. Nonetheless, geologists routinely use fossil ranges in their work. For example, a lay person may think they have discovered a dinosaur footprint in Ordovician (Figure 1) limestone. The geologist immediately knows this is misidentification because dinosaurs did not begin until the late Triassic (L, Figure 1), approximately 235 million years later. A real, albeit similar, example involves a geology field guide.

Question	Answer	Explanation
1. Can the assemblage be Cambrian or Ordovician?	No	Because H, I, and J are younger fossils.
2. Can the assemblage be Mississippian, Pennsylvanian, Permian, Triassic, or Jurassic?	No	Because older fossils (H, I and J) lived only in the Silurian. This leaves Silurian and Devonian as choices.
3. What is the age of this fossil assemblage?	Devonian	At the end of the Silurian, H, I, and J became extinct. The Silurian was over. Immediately, fossils D, E, and G began at the beginning of the Devonian.

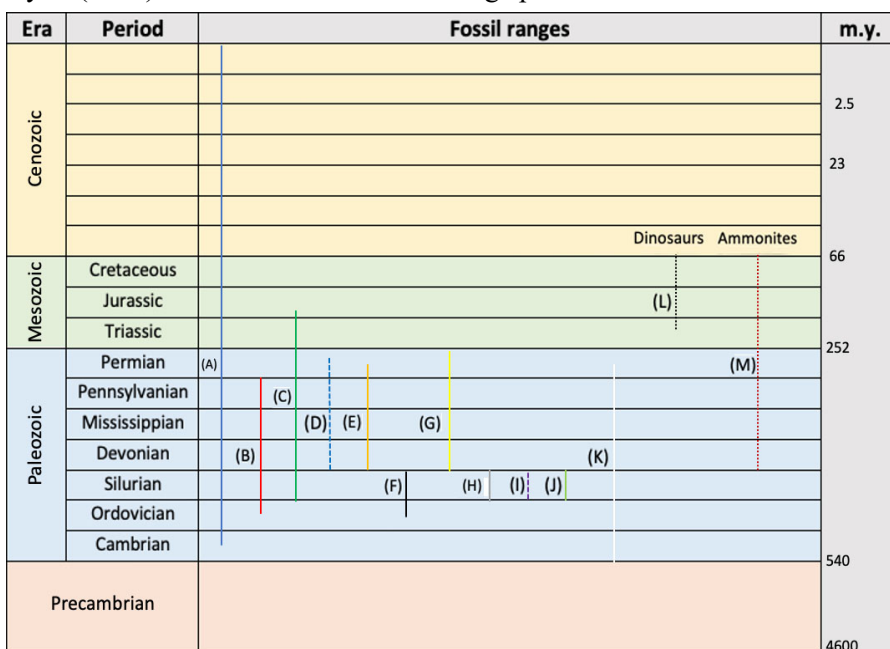


Figure 1: Geologic timetable showing ranges of selected fossil groups. m.y. = million years. (Absolute dates are from radiometric dating)

Four fossils were misidentified as ammonites in Ordovician (Figure 1) limestone. Ammonites did not begin until the Devonian (Range M, Figure 1).

Fossils and paleoclimates

Fossils provide information about ancient climates (paleoclimatology). We are interested in paleoclimates for multiple reasons. If you know the climate, you also know something about plants, wildlife, temperature, precipitation, and soils. In addition, paleoclimates are used to note climate change throughout Earth's history. For example, we know Earth has had at least four ice ages. Each reflects a climate different from what most of us experience today. Paleoclimatology assists in explaining tropical plant fossils in Alaska and Antarctica. These could not possibly grow there today. Obviously, a much warmer climate existed in those locations in the geologic past.

Some animals are proxies (indicators) of past climates. Examples include caribou, musk ox, collared lemming, and mastodon. Fossils of these animals have been found in central Pennsylvania. The animals reflect a colder climate 11,000 years ago in that part of the state. The first three now live in northern Alaska and Canada, in a much colder climate. Mastodons are extinct, but lived in a colder climate at that time. In conjunction with palynological (spores and pollen) data, these fossils are used to reconstruct paleoclimates in central Pennsylvania back to 16,000 years ago (Figure 2).

- Student Activity 2.

You are a geologist describing paleoclimates in central/southcentral Pennsylvania for the last 16,000 years. Using Figure 2, Table 2, and Table 3, describe/explain the climate change. For tasks 1-3 (Table 3), describe the climate in terms of average temperatures, vegetation, animals, comparison to present day, duration, etc.

- Student Activity 3.

The White River Group (Figure 3) consists of sediments 56-23 million years old. They are found in Badlands National Park, South Dakota (Figure 3a), and neighboring states. The world's

Table 2: Climate descriptions.	
Climate	Description
Temperate	Climate of central PA today: mixed conifer and broad-leaf forests. Mild to warm summers, cool to cold winters. Four distinct seasons. Ample precipitation. Average temperature: 49 degrees F.
Taiga	Forest of the cold, subarctic, just south of the Arctic Circle. It lies between the tundra to the north and temperate forests to the south. Soil contains permafrost. Thick coniferous forests. Typical animals: moose, bears, and lynx. This is the climate/setting in which mastodons lived. Temperatures are > those of the tundra but < those in a temperate zone. Average temperature: 23 to 41 degrees F.
Tundra	Treeless region presently located in the northern parts of Alaska and Canada. Very cold (avg. temp. -30-20 degrees F.), windy, scant rainfall. Soil is permafrost, covered with snow much of the year. It is too cold for most trees. Typical animals: Arctic foxes, polar bears, gray wolves, caribou, and musk oxen. This is the setting of the woolly mammoth when it was living. Vegetation: mostly grasses, mosses, sedges, and lichens.

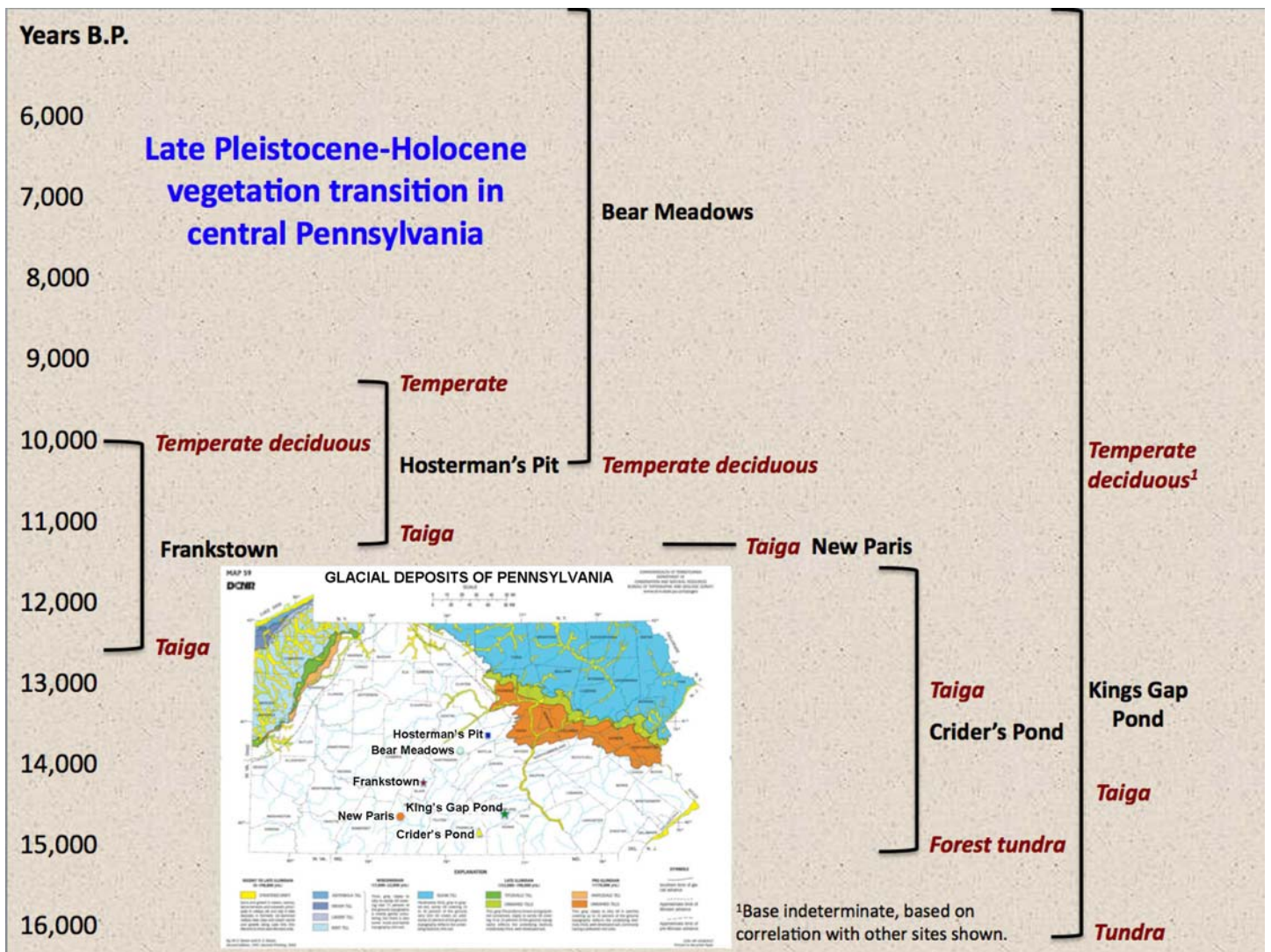


Figure 2: Vegetation transition in central Pennsylvania based on paleontological data from six sites. Years B.P = years before present. (Miller, 2019)

largest number of vertebrate fossils from this time are found in these sediments. White River fossils reflect climate over that time interval.

Figure 3b shows titanotheres and smaller herbivores living during Chadron time. Titanotheres stood eight feet at the shoulders (larger than today's rhinoceros). Figure 3c shows

formations (subdivisions) of the White River Group. The Chadron Formation is known as the "titanotheres layer." Provide an answer to Activity 1 of Table 4.

Fossils in forensic paleontology - Japanese Vengeance Balloon Bombs

Table 3:

Question/task	Answer	Description/Explanation
1. From 11,000 years ago to the present, identify and describe the climate.	Temperate	Climate central Pennsylvania experiences today: mixed forests of conifers and deciduous trees, four distinct seasons, ample precipitation. Temperature > tundra or taiga. Typical animals we see today in the study area.
2. From 15,000 to 11,000 years ago, identify and describe the climate.	Taiga	Coniferous forests with moose, bears, lynx, mastodon. Temperature > tundra < temperate.
3. From 16,000 to 15,000 years ago, describe and identify the climate.	Tundra	Treeless, cold, snow much of the years. temp. -30 to 20 degrees F (much colder than today). Typical animals: woolly mammoth, Arctic foxes, polar bears, gray wolves, caribou, and musk oxen. Low precipitation.
4. Is there a general (warming, cooling) trend in central Pennsylvania from 16,000 years to the present?	Warming	The warming trend from 16,000 to about 200 years ago was gradual. Once the industrial revolution began in the early 1800s, the warming trend increased dramatically. The present warming trend is the most rapid in the past 56 million years (Kump, 2011).
5. What was the vegetation where woolly mammoths lived?	Tundra	Grasses, mosses, sedges, and lichens. Virtually no trees.
6. What was the vegetation where mastodons lived?	Taiga	Conifer forests.
7. Did woolly mammoths and mastodons compete for food?	No	Mammoths had teeth adapted to eat grasses, as in a tundra. Mastodon teeth were adapted to eat tree leaves and branches.
8. What was the vegetation in central PA from 16,000 to 15,000 years ago?	Tundra	Grasses, mosses, sedges, and lichens. Virtually no trees.
9. What was the vegetation in central PA from 15,000 to 11,000 years ago?	Taiga	Conifer forests.
10. What was the vegetation in central PA from 11,000 years to the present?	Mixed forests	Mixed conifer and broad-leaf forests
11. At least six mastodons have been found in central PA. Describe the climate and vegetation at that time.	Taiga	Conifer forest of the cold, subarctic, just south of the Arctic Circle. Temperatures are > those of the tundra but < those in a temperate zone. Average temperature: 23 to 41 degrees F.

During WWII, Japan launched over 9000 balloon bombs. These were 33-foot-tall hydrogen balloons that included ballast sand, an antipersonnel bomb, and an incendiary bomb. The Japanese made use of the jet stream and the southwesterly prevailing wind belt. This combination sent most balloon bombs eastward, landing in Alaska, western Canadian provinces, and our western states (Figure 4).

The U.S. military suspected the balloons were launched from Japan. To determine launch sites, the ballast (beach sand) was sent to government geologists. The sand contained small fossils known as diatoms and foraminifera. The TV show "Forensic Files" aired episodes using diatoms in criminal investigations.

Upon inspection, it was noted the sand contained no coral fragments. Japan consists of a string of islands, some of which had offshore coral reefs. Through time, reefs erode, and fragments end up in beach sand. Absence of corals in the ballast sand eliminated those Japanese beaches with offshore coral reefs. This was a process of elimination. Based on fossil diatoms, geologists were able to recommend possible launch sites. B-29 bombers were sent, ending the balloon-bomb program. This is classic applied paleontology.

Interpreting dinosaur tracks

Thousands of dinosaur tracks have been discovered worldwide. These are important sources of information (Table 5). The following activities allow students to interpret trackways.

- Student Activity 4.

The Purgatoire River Tracksite in Colorado is the largest in North America, exposing 1200 footprints (Lockley, 1986). Figure 5 depicts nearly parallel dinosaur trackways five juvenile apatosaurus (brontosaurus) made on a former shoreline of a lake. (Figure 5 is

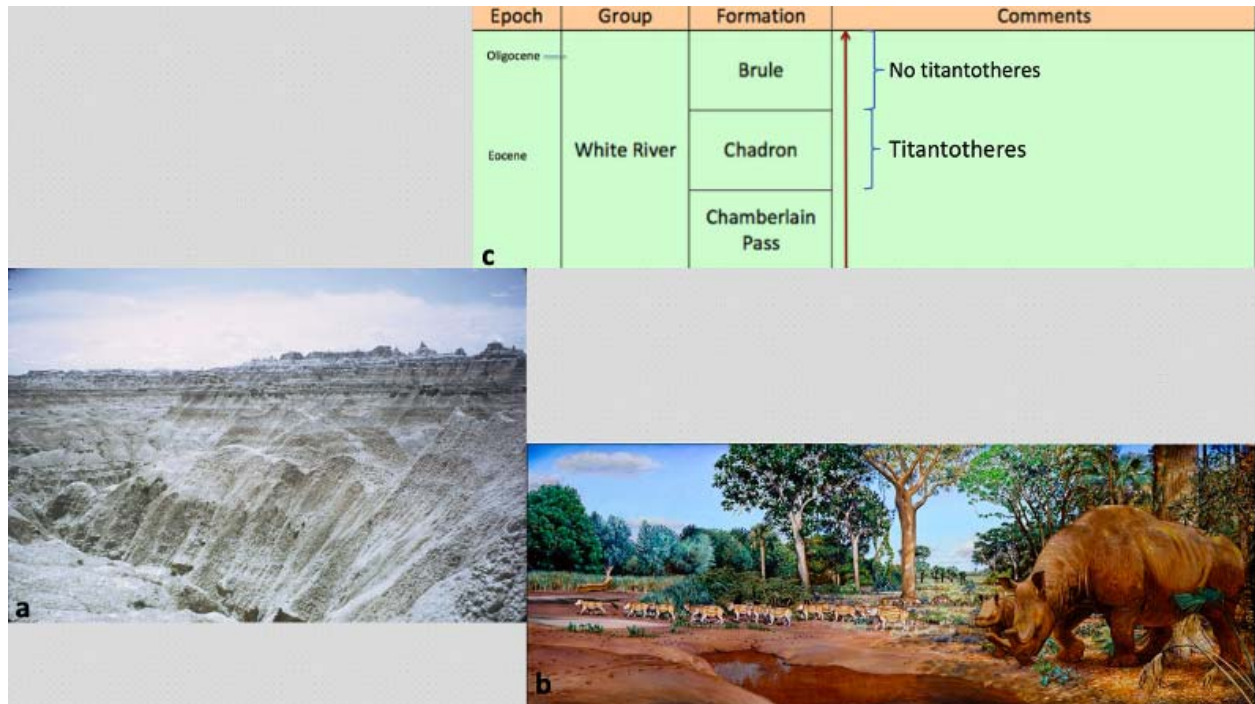


Figure 3: (a) White River Group; Badlands National Park, S.D.; image by the author. (b) Titantotheres and other mammals during Chadron time (Used with permission; Badlands Natural History Association.) (c) Formations of the White River Group.

Table 4 :	
Activity	Answer
1. Based on the theme "Fossils and paleoclimates," give a reason for titantotheres being abundant in the Chadron Formation but absent in the overlying Brule Formation. Hint: they did not die from disease, predators, or an asteroid.	1. Climate during Chadron time had plentiful precipitation, and vegetation for herbivores (Figure 3b). The climate was humid subtropical. Eight-foot-tall titantotheres ate a lot of vegetation. During Brule time, it was much drier, vegetation died, as did the herbivores that fed on it. The climate became semiarid, as it is today. Fossil evidence is very clear on this. In the Brule Formation, several spectacular fossil locations were excavated: the "Big Pig Dig" and "Bones Galore" sites. At the former, 19,000 fossils were found there. Both sites were waterholes around which animals congregated. These were last refuges for the animals as the land dried out.

a simplification for high-school Earth Science.) Shorelines experience rapidly changing conditions due to precipitation, evaporation, splashing waves, and animals walking on them. Therefore, the consistency and condition of shoreline sediments rapidly and constantly change. Sometimes these sediments were saturated and soupy. Other times, they were dry and firm, and/or disrupted from dinosaurs walking on them. The footprints of Figure 5 are

to the same depth, and are the same size. Were they made at the same time, as in a social group, or did dinosaurs at different times make the trackways, and coincidentally ended up nearly parallel? Use Table 6.

- **Student Activity 5:** One of the greatest stories in geology.....

The Paluxy River in Texas is famous for its dinosaur tracks. In 1938, the American Museum of Natural History (NYC) discovered spectacular dinosaur trackways in what is now Dinosaur Valley State Park. Most significant were sauropod and carnosaur trackways following the same general direction (Figure

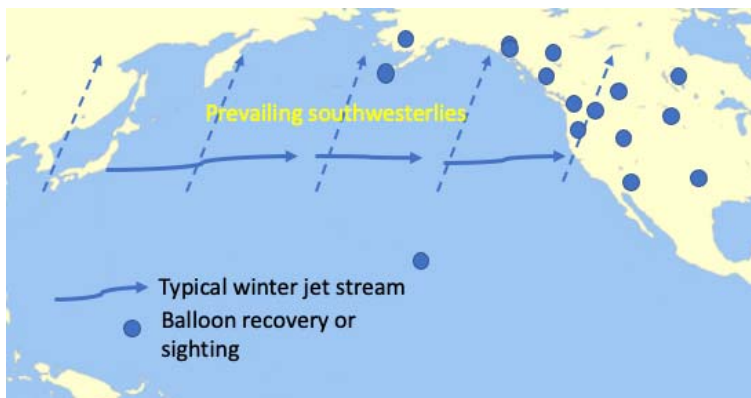


Figure 4: Map showing general sightings/landings of balloon bombs. Modified from a public-domain map.

Table 5: Information from dinosaur tracks and trackways.	
1.	Whether it was walking, trotting, running, or wading.
2.	Whether it was bipedal or quadrupedal.
3.	How fast it moved.
4.	How the tail was carried.
5.	Size and shape of the feet, number of toes.
6.	Details of soft anatomy of the foot.
7.	Geographic distribution.
8.	Paleoecology.
9.	Paleodepositional environment.
10.	Social behavior.

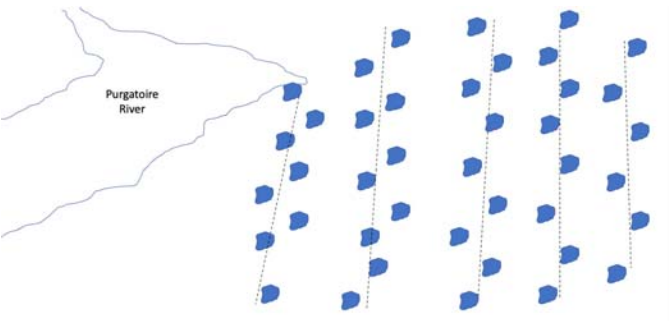


Figure 5: Five nearly parallel dinosaur trackways at the Purgatoire River Tracksite.

Table 6		
Question	Answer	Explanation
1. Were the five trackways made at the same time?	Yes.	If made at different times, trackways would be to different depths because shoreline sediments constantly change in consistency for reasons stated. Additionally, same-sized footprints suggest five juvenile apatosaurs walked the shoreline in a group. This is evidence of dinosaur social behavior.

Fossils and the Earth-Moon System

The most familiar Earth motion is rotation, producing day and night. Earth rotates once every 24 hours. As



Figure 6: Converging dinosaur trackways at the Paluxy River, TX. Apatosaurus (brontosaurus) on the right; three-toed carnivore tracks on the left. Convergence is near the top. (From Natural History, February 1941, copyright © Natural History Magazine, Inc., 1941)

6). At one point, a carnivore trackway (3-toed, left side, Figure 6) converges with the sauropod trackway (right side, Figure 6). It was inferred the carnivore attacked the sauropod. The "attack" interpretation of the converging dinosaur trackways is one of the "greatest stories in geology" (Bird, 1941). A brochure for Dinosaur Valley State Park illustrates the attack.

Compare Figure 6 to an internet video showing a lion attacking an adult elephant. These scenarios are similar. The carnivorous dinosaur was much smaller than the sauropod just as a lion is much smaller than an adult elephant. Refer to Table 7.

This activity demonstrates independent thinking as opposed to automatically accepting a prevailing idea. Good scientists challenge long-standing ideas.

time advances, its rotation slows down 1.4

Table 7		
Question	Answer	Explanation
1. Is there evidence an attack occurred ?	No	It is one of the greatest stories in geology...that never happened, as based on observations when the tracks were discovered. The story was perpetuated because it was sensational.
2. Is there evidence an attack did not occur?	Yes	There is no such evidence of an attack that can readily be seen from Figure 6. Videos of a lion attacking an adult elephant show change in gait, position, and posture of the elephant. Those changes in the sauropod tracks are not readily evident. The sauropod would not have stood still, allowing the carnivore to attack. The likely scenario is that a carnivore was tracking a sauropod. A more recent study cites putative evidence of an attack. That evidence is suggestive, and was not available when the tracks were discovered.

milliseconds (0.0014s) per 100 years due to tides (tidal friction). The reverse is true. As we go back in time, Earth's rotation progressively speeds up. From this, we

see that day length has varied through time. Fossils can provide evidence of this by preserving daily and annual growth lines. From growth lines, the number of days in a year when that organism lived is determined. For example, based on some corals, there were 390 days in the Devonian (Figure 1). These fossils are known as paleontological clocks.

- Student Activity 6.

Using information in the previous paragraph, complete Table 8 .

Lasers bounced off reflectors on the Moon indicate it is receding from Earth. This implies that as one goes back in time, the Moon was progressively closer to Earth. The distance the Moon is to Earth affects the latter's rotation much like a figure skater. When a spinning skater pulls extended arms to the chest, the spinning rate dramatically increases. The closer the Moon is, the faster Earth rotates. These observations are consistent with fossils as paleontological clocks.

- Student Activity 7: Answer Table 9.

Table 9		
Question	Answer	Explanation
1. As we go back in time, did Earth rotate faster or slower?	Faster	The Moon was closer to Earth, causing the latter to rotate faster. Think of the figure skater example.
2. Millions of years in the future, will an Earth day be longer or shorter?	Longer	Tidal friction is slowing Earth's rotation, making days longer. There will be fewer days in a year.

Stromatolites and the Earth-Moon System

Stromatolites are one of the oldest and most important fossils. They consist of concentric layers in columns or domal masses (Figures 7a,b). When living, stromatolites are made of photosynthesizing bacteria (cyanobacteria). The most important aspect of stromatolites can be seen in Figure 8. Earth's early

atmosphere was anoxic, with little or no oxygen. The oldest stromatolites are about 3.4 billion years old. For the next billion years, photosynthesizing bacteria produced oxygen. Not until the Great Oxidation Event at 2.45 billion years ago was atmospheric oxygen concentrated enough for complex organisms to evolve.

- Student Activity 8.

In the previous discussions on "Fossils and the Earth-Moon System," there were references about day length through geologic time. Using those observations and Figure 8, refer to Table 10.

Table 8		
Question	Answer	Explanation
1. As we go forward in time, will there be (more, less) days in a year?	Less	Days are getting longer because tidal friction is slowing Earth's rotation.
2. As we go backward in time, will there be (more, less) days in a year?	More	The farther back in time we go, the less time tidal friction had to slow Earth's rotation. This means as we go back in time, Earth is rotating faster, creating shorter days, and, therefore, more days in a year.
3. Were days shorter or longer during the Devonian (Figure 1)?	Shorter	There were 390 days in a year, so they had to be shorter.
4. How long was a Devonian day (400 million years ago)?	22.4 hrs.	<ul style="list-style-type: none"> - Earth's rotation slows $0.0014^s/100$ years - $400,000,000$ yrs./100 yr. = 4,000,000 100-yr. increments. - $4,000,000$ 100-yr. increments X 0.0014 seconds/100 yrs. = 5600^s - $5600^s/60^m/\text{minute} = 93^m$ - $93^m/60^m/\text{hr} = 1.6^h$ - Since we are going back in time, days are shorter. - 24 hrs/day (presently) – 1.6 hrs (due to tidal friction) = 22.4^h in a Devonian day.
5. If tidal friction is slowing down Earth's rotation, are days getting longer or shorter as time moves forward?	Longer	Tidal friction is slowing Earth's rotation, creating longer days.



Figure 7a: Stromatolites as slender columns. Image by the author.



Figures 7b: Stromatolites as domal masses. Image by the author.

geological history. Some activities cross pollinate by incorporating paleontology, astronomy, meteorology, and climatology. From this, students see how different sciences are complementary.

Aspects of these activities were successfully used in the author's classes. No special materials are needed; activities are amenable to individual and group learning; they can be done remotely; and little, or no, additional information is required. The activities do not have a high level of difficulty.

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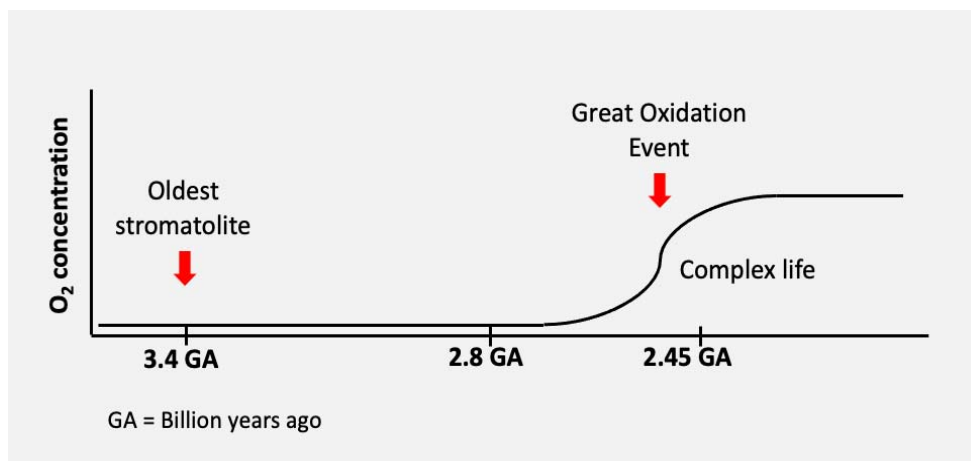


Figure 8: Oxygen concentration of Earth's early atmosphere.

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Conclusion

A series of activities allows high-school Earth-Science students to use fossils as geologists. Each activity is an example of "cause and effect." Students make observations and apply concepts to interpret Earth's

Table 10		
Question	Answer	Explanation
1. Were the days at 3.4 GA (Figure 8) shorter or longer than those today?	Much shorter	The Moon was much closer to Earth. Like the spinning figure skater previously mentioned, Earth rotated much faster at that time. Correspondingly, days were shorter.
2. Why did it take a billion years before atmospheric oxygen concentrated enough for development of complex life?		Days were 17-18 hours long; half was daylight, half was nighttime. Photosynthesis occurs in daylight. Shorter daylight hours slowed the concentration of atmospheric oxygen.

2022 Junior Poetry Award Winners

Linda Jaeger, AFMS BEAC Chair
from AFMS Newsletter — April 2023

Kudos to Celia Churchill, editor of Ventura Gem & Mineral Society, and her juniors for sweeping the top spots in the Junior Poetry Category of last year's AFMS Bulletin Editors Contest. Enjoy these reads from the eyes and pens of the younger set!

I Love Them All Big and Small!

Lucia H. (11)

Rocks, fossils, gems, and minerals. I love them all. Each time I go collecting I always bring home quite a haul. They're all so neat and interesting even the ones that are very small. If I had to pick a favorite I couldn't. Because I would pick them all.

1st Place AFMS Junior Poetry 2022. *Rockhound Rambling, 11/2021.*

Tide is Low, Time to Go!

Valerie C. (6)

What washed up today?
Red and yellow jasper,
White quartz,
One swirly agate.
It's getting dark,
My feet are wet and cold.
My bag is full. Let's go home.

2nd Place AFMS Junior Poetry 2022. *Rockhound Rambling, 11/2021*



Spring Mineralfest

mineral, fossil, and gem show

Over one hundred tables loaded with minerals, fossils, crystals, geodes, gemstones, and gemstone jewelry from six continents and outer space

Saturday, 3 June 2023
8:30 AM to 3:00 PM

Macungie, Pennsylvania
Macungie Memorial Park – 50 N. Poplar Street

FREE ADMISSION and free parking
Rain or shine - over 50 vendors indoors, outdoor tailgate section weather permitting
Family oriented - younger attendees encouraged
Fluorescent mineral exhibit by courtesy of the Franklin Mineral Museum

Sponsored by the
Pennsylvania Earth Sciences Association
a 501(c)(3) nonprofit educational organization

PESA is a Lehigh Valley based group of mineral and fossil collectors, gemstone and lapidary artisans, and other earth science enthusiasts.

mineralfest.com   [facebook](https://www.facebook.com/mineralfest)



FRIENDS OF MINERALOGY - Pennsylvania Chapter SYMPOSIUM November 11, 2023 Johnstown, PA FIELD TRIP November 12

Symposium for mineral collecting enthusiasts

Friday evening Nov. 10: Meet & Greet - bring your mineral specimens to talk about.

Saturday Nov. 11: Hybrid Symposium - **ONLINE** or **IN PERSON**

8:30 a.m. to 5:00 p.m. at University of Pittsburgh - Johnstown

Talks by knowledgeable **SPEAKERS** on **Pennsylvania Mineralogy and Geology**

Expanded Sales by Select Dealers - Silent Auction - Give-away Table - Conversation

Professional Geologists: Five Professional Development Hour credits available for full lecture attendance

Sunday Nov. 12: **Field Trip** to New Paris Quarry. Open only to symposium registrants.

Watch for details, **registration form**, changes and updates on our **web site:**

www.rasloto.com/FM or Friends of Mineralogy Pennsylvania on Facebook

For newsletters and field trips during the year, please join our chapter!
See "Join FM" on the web site

UPCOMING EVENTS

Confirm details of events before attending.
<https://efmls.org/events/list/>

See other show calendar links on our web site.

April 21-23, 2023: 50th Rochester Mineralogical Symposium. <https://rasny.org/mineral-section>

May 6 - 7, 2023: Treasures of the Earth Annual Mineralogical Soc. NE PA/Scranton Gem & Mineral Show, St. Joseph's Oblates, Rt. 315 Yatesville PA (outside Pittston).

See <http://msnepa.org/gem---mineral-show.html>

May 13, 2023: South Mountain Rock Swap, by Franklin County R&M Club. South Mountain Fairgrounds, 615 Narrows Rd., Biglerville PA (near Arendtsville). Sat. only, 8:00 - 3:00. See Facebook.

June 3, 2023: Spring Mineralfest, by PESA. Sat. only, 8:30 a.m. to 3:00 p.m. Macungie Memorial Park, Macungie, PA. <https://www.mineralfest.com/>

July 7-9, 2023: EFMLS Annual Convention in Syracuse, NY hosted by Gem & Mineral Society of Syracuse, NY.

July 22-23, 2023: Gem, Mineral and Fossil Show, by Monongahela Rockhounds. West Mifflin Vol. Fire Co. #4, 660 Noble Dr., Pittsburgh PA 15122. Sat. 10-6, Sun. 10-4. <https://www.monongahelarockhounds.org/events-shows>

July 22-23, 2023: Christmas in July Extravaganza, by Lancaster County Fossil and Mineral Club. Farm and Home Center, 1383 Arcadia Rd, Lancaster, PA. See facebook LancasterFossilandMineralClub

August 3-6, 2023: AFMS and Northwest Federation of Mineral Societies Annual Convention, Billings, Montana.

Nov. 10-12, 2023: Friends of Mineralogy- PA Chapter Symposium, Johnstown, PA. Symposium for mineral collecting enthusiasts. Fri. eve. Meet & Greet; Sat. Hybrid Symposium - Online or In Person; Sun. field trip. See page 11 and <https://rasloto.com/FM/whats-new/>

Geo-Sudoku Solution

I	D	R	B	T	E	O	A	S
T	A	O	I	S	D	B	E	R
S	B	E	A	O	R	D	T	I
R	I	A	O	E	B	T	S	D
D	O	S	R	I	T	A	B	E
E	T	B	D	A	S	R	I	O
O	E	D	T	B	I	S	R	A
A	S	T	E	R	O	I	D	B
B	R	I	S	D	A	E	O	T

INVITE A FRIEND TO JOIN THE SOCIETY

The Nittany Mineralogical Society prides itself on having among the finest line-up of speakers of any earth sciences club in the nation. Everyone is welcome at our meetings. If you'd like to be part of our Society, dues are \$20 (regular member), \$7 (student rate), \$15 (seniors), \$30 (family of two or more members, names listed). Those joining in March or later may request pro-rated dues. Your dues are used for programs and speakers, refreshments, educational activities, Bulletins, and mailing expenses. Please fill out a membership form (available at www.nittanymineral.org), make checks payable to "Nittany Mineralogical Society, Inc." and send them in as directed, or bring your dues to the next meeting.

We want to welcome you!

CONTACT INFORMATION

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 Penna. Furnace PA 16865

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The Bulletin Editor will welcome your submissions of articles, photos, drawings, cartoons, etc., on minerals, fossils, collecting, lapidary, and club activity topics of interest to the members. Please contact:

David Glick E-mail: xidg@verizon.net
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 Bellefonte, PA 16823-9762

Newsletter submissions are appreciated by the first Wednesday of the month. Photographs or graphics are encouraged, but please do not embed them in word processor files; send them as separate graphics files (good to highest quality JPEG files, about 1050 pixels wide, are preferred). Please provide captions and name of photographer or artist.

Visit us at www.nittanymineral.org