Nittany Mineralogical Society Bulletin

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

Editor (see back page):
April, 2017 ***Visit our web site:*** **www.nittanymineral.org** *David C. Glick*

April 19th meeting -

Applications of Mineralogy to Archaeology: Part IV. Visions of the Past

by **Barry E. Scheetz, Zachary Nelson, Guillermo Mata Amado and Antonio Prado**

Our April meeting will be held Wednesday the 19th, ***BACK IN OUR USUAL LOCATION, Earth & Engineering Sciences Building,*** *on the west side of the Penn State campus in State College, PA. Maps are available on our web site. We will met in* ***Room 116****, the smaller auditorium.:*

6:45 to 7:45 p.m.: Social hour, refreshments in the lobby
7:45 to 8:00 p.m.: announcements, questions, answers
about 8:00 p.m.: featured program

The event has free admission, free parking, and free refreshments, and is open to all; ***parents/guardians must provide supervision of minors.*** *Bring your friends and share an interesting evening! -Editor*

A chance find during an archaeological excavation of a Central American Mayan site resulted in the opportunity to examine in detail how early mirrors were manufactured. Mirrors have been used since 6000BC in Anatolia with the earliest record in the new world of 1925BC. Because of the rarity of suitable minerals for the manufacture of the reflective surface and the extreme craftsmanship necessary to polish the surface, ownership of mirrors was generally relegated to Royalty which place a great value on them. Mirrors came to be used in a spiritual way to connect the Royalty to the Gods. We report here on a different but nonetheless tedious method of making mirrors which most likely resulted in significantly reducing the cost of the object and making it available to the wealthy non-royalty members of the Mayan society.

ATTENDING THE APRIL MEETING?
Donations of **a few high quality, labeled door prize specimens** are invited.
Bring a friend!
WE ARE BACK IN E.E.S. BUILDING

Thank You to All for a Successful Minerals Junior Education Day

by David Glick, NMS President

Our 22nd annual Minerals Junior Education Day, held on April 1 2017, had increased attendance and went smoothly under the direction of coordinator Frank Kowalczyk. Nittany Mineralogical Society volunteers and their family members put in a great deal of effort in preparation, in publicity, and in presenting the event. Volunteers from our partner organizations did the same, and were absolutely essential in making the event a success; they were: the Bald Eagle Chapter of Gold Prospectors Association of America, Junior Museum of Central Pennsylvania, Penn State Earth and Mineral Sciences Museum, and Penn State College of Earth and Mineral Sciences students.

At the lapidary station, students learn about cutting, grinding and polishing rocks and minerals as gems, and receive an example to add to the collection they are building in their egg cartons. *D. Glick photo.*

We had 195 students, plus parents, participate this year. They visited eight stations which covered topics in earth and mineral science and related hobbies and crafts: gold panning (by GPAA), lapidary (cutting and polishing gemstones); grinding and polishing rock spheres; invertebrate fossils; vertebrate fossils (by PSU EMS Museum); ultraviolet fluorescence (glow in the dark); crystal structure, formation, and cleavage; and

Continued on page 2

constancy of crystal angles. At each station they received a labeled specimen or other item to remind them of the topic and what they learned.

Two stations covered a range of mineral properties related to their ordered atomic arrangement: crystal formation and structure, mineral cleavage, and constancy of crystal angles.
D. Glick photo.

We also had a sales table as a source of a variety of additional mineral, fossils and polished stones, at child-friendly prices. The $5 admission charge does not usually cover all of the costs of the event, so income from the sales table is greatly appreciated. Most of the material at both the sales table and the stations was donated, and Nittany Mineralogical Society is very grateful to those who have donated, both this time and through past years.

Students at the invertebrate fossil station recovered fossils from weathered rock, and also received two fossils from other locations.
D. Glick photo.

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 present brief summaries here in order to encourage readers to see the entire newsletters.

The **EFMLS Newsletter** is available through the link on our web site **www.nittanymineral.org**, or remind Dave Glick to bring a printed copy to a meeting for you to see. The April issue's President's note reports on discussion of improved use of email, social media and the Federation website for communication. The Wildacres Workshops are described and discussed; the fall session is September 4-10, the speaker in residence will be Dr. Tim Morgan, and a registration form is provided. The safety article from AFMS (see page 7 of this Bulletin) covers an important part of important collecting gear - the soles of our boots. Nominations for Club Rockhound of the Year are invited.

The **AFMS Newsletter** is available by the same methods; the April issue is not yet on the web site, but we do know that the AFMS Show & Convention will take place **June 9-11 in Ventura, California: "Ventura Rocks the Nation!"** Donations of specimens for the Endowment Fund drawing are invited.

Please see the web sites for the complete Newsletters. There's a lot there! *-Editor*

Geo-Sudoku

by David Glick

This puzzle contains the letters ABCEIMRTU. One row or column spells an individual organism which we find as a fossil on Earth. As usual, if you've read this issue, you've seen the word, or a variation of 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 8.

B	U		R					T
	T	M						R
	I						E	
		A	M		R		I	
E			A		C			U
				T	E			C
					B			
U		T		M				A
M	E				A	T	R	

Unconventional astronomical tools: fossils and rhythmites

Charles E. Miller, Jr.

Introduction

Solar-system astronomy often includes geology when discussing terrestrial planets, moons, asteroids, and meteorites. Geology's role in current Martian studies is familiar to most everyone. Less familiar are fossils and rhythmites as astronomical tools. Fossils (Figure 1) are remains, traces, or imprints of plants, animals, and bacteria preserved in rock. Rhythmites (Figure 2) are repetitious sedimentary rock layers of tidal origin. Both are unconventional approaches to better interpreting the Earth-Moon system through time. Like some other novel ideas in science, these have had their successes and failures.

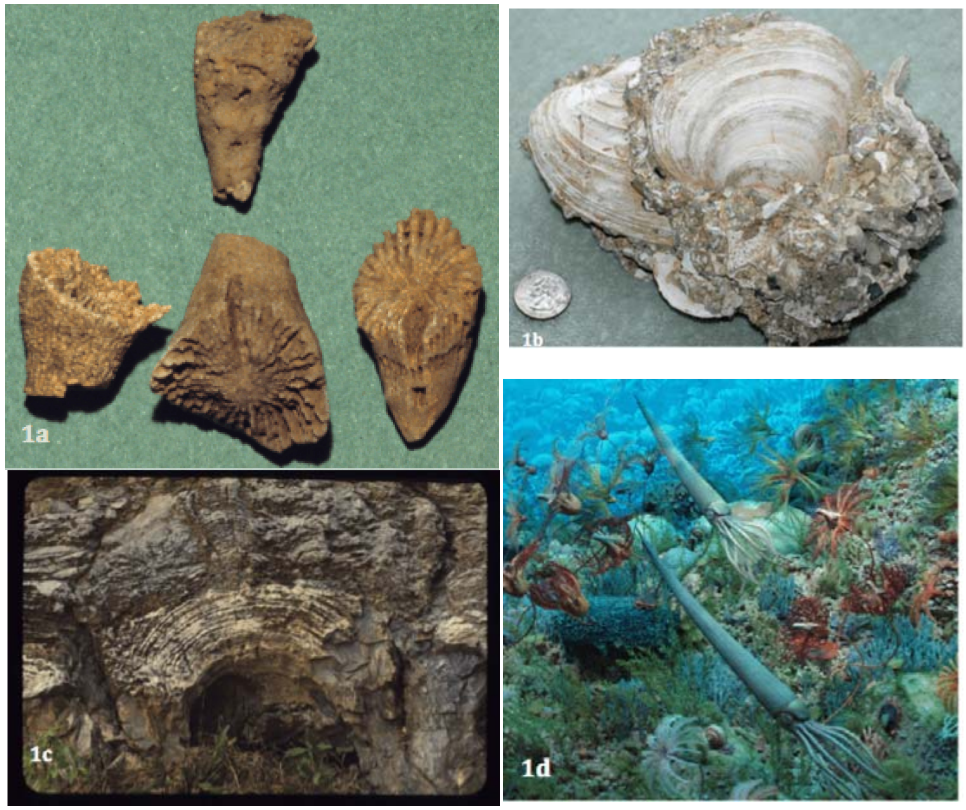

Figure 1: (1a) Devonian corals. (1b) Fossil clams. (1c) Intertidal stromatolites. (1d) Mural showing two straight-shelled mollusks (center). Images by the author.

Use of fossils as astronomical tools began in the 1960s and rhythmite studies began in the late 1980s. Rhythmite data supplement those from fossils as astronomical tools. These tools provide information on Earth's paleorotation, paleotides, changing orbit of the Moon back to the Precambrian (before 540 million years ago, Ma), and early evolution of Earth's atmosphere.

In the search for life in the Solar System beyond Earth, no one expects to find fossils of larger organisms (macrofossils). However, living examples or fossils of microscopic organisms (microfossils), such as bacteria, are possible. On Earth fossil bacteria are found in rocks as old as 3.5 billion years ago (Ga). Of particular interest are extremophiles: microorganisms adapted to extreme living conditions. Such organisms and conditions are candidates for more complex life elsewhere in the Solar System, such as Saturn's moon Enceladus. Bacteria survivability in extreme conditions is known on Earth, for example, from hydrothermal vents at mid-ocean ridges. In 1969, Apollo astronauts recovered a camera from the Surveyor 3 spacecraft that landed on the Moon two and half years earlier. After returning to Earth, 50-100 bacteria were recovered. The organisms survived launch and space rigors such as vacuum, radiation exposure, deep-freeze, and no nutrient, water, or energy source.

Figure 2: Polished tidal rhythmites from central Utah. (Used by permission, Marjorie Chan)

Fossils as astronomical tools gained international attention in 1996 when NASA announced biological evidence in Martian meteorite ALH 84001. The putative evidence included globules, features that seemed to be fossilized remains of microbes, and mineral associations. Despite supporting arguments, consensus of the scientific community is the evidence was not compelling. Similar "fossil" features in the meteorite have been created in the laboratory without biological inputs.

Earth rotation and a receding Moon

Probably the most familiar Earth motion is rotation on its axis. This is one of the first astronomical concepts taught because Earth's rotation produces day and night. It is an easy concept to grasp and easy to distinguish from the other common motion – revolution. Earth presently rotates once in approximately 24 hours. However, Earth's rotation continues to slow down through time due to tidal friction. Rotational energy is slowly transferred to the Moon. This mechanism has worked since Earth's oceans first formed. Transfer causes change through time in day length, the lunar month, and receding of the Moon from Earth.

Early astronomers measured Earth's rotational deceleration by observing movement of the Sun, Mercury, Venus and the Moon across the sky over centuries. Egyptian archaeological astronomical data and Chinese and Babylonian records of total solar eclipses confirm the increase in day length.

Today, atomic clocks and Very Long Baseline Interferometry (VLBI) measure Earth's rotational deceleration. Atomic clocks, first used in 1955, show that a modern day is longer. VLBI observations use widely separated radio telescopes on Earth to observe a quasar at the same time. Earth's rotation speed is calculated using differences in microwave signal arrival times from the quasar. Approximately every 100 years, an Earth day lengthens 1.4 milliseconds, or 1.4 thousandths of a second. Conversely, as one goes back in geologic time, days become shorter. When the Moon was formed approximately 4.5 Ga, days were five hours long. Because those days were shorter, there were more days in a year than the 365.25 days we now have. Similarly, future days will be longer, resulting in fewer days in a year. Assuming deceleration of Earth's rotation is constant allows us to calculate the number of days in a year at various times in the past and future. An average in millions of years for geologic periods can be obtained from a geologic time table. For example, we can calculate the number of days in a Devonian (408-360 Ma) year and the number of hours in a Devonian day. An average of 400 Ma years for the Devonian Period is used. Each day was 14 seconds shorter per million years or 5600 seconds shorter. Converting 5600 seconds to hours gives 1.6 hours. The length of a day was 22.4 hours. A current Earth year has 8766 hours. If a Devonian day was 22.4 hours, then there were 391 days at that time.

Lunar laser ranging between Earth and the Moon accurately measures rate of the Moon receding from Earth. Reflectors Apollo lunar missions and Lunokhod 2 left on the Moon bounce laser beams back to Earth. This technique gives distance between Earth and the Moon to within 3 cm. This recession implies the Moon was closer to the Earth as one goes back in time. In keeping with conservation of angular momentum, Earth rotated faster when the Moon was closer and is now rotating more slowly as the Moon recedes. This is analogous to a figure skater spinning faster when arms are pulled in.

Fossils as paleontological clocks

Fossils offer one alternative in discussing the Moon's recession from Earth. Paleontologists began using fossils as paleontological clocks in the early 1960s. Most of these studies involved corals and clams (Figures 1a and 1b, respectively); however, other fossils (Figures 1c and 1d) were also used, less successfully. This application is based on observations that certain living and fossil organisms display daily, monthly, and/or annual growth rings. Such growth rings are identifiable using microscopy. Dendrochronology, or tree-ring dating, is a similar application. With fossils, counting daily growth rings within annual rings indicates days in a year in the geological past. For example, a Devonian (419-369 Ma) coral might show 400 daily growth lines in a year, indicating 400 days in that time period. Similar counts of corals or other organisms in different geological periods show the number of days per year declines from then to the present. The implications of these data are the same as those using tidal friction calculations: the more days in a year, the faster Earth rotates. Another way of stating the same relationship is: the more days in a year, shorter are the days. Fossil studies also generally agree with tidal-friction computations that the Moon was 3 to 3.5 percent nearer Earth in the early Paleozoic (~ 540 Ma).

Fossils as astronomical tools are collaborations with astrophysical calculations and offer insights such calculations do not provide. However, these applications have caveats. One is observer subjectivity, particularly in identifying and counting growth bands. Excellent preservation is paramount. Misinterpretation of ambiguous patterns is possible. Sometimes random environmental disturbances or individual traumatic events cause organisms to skip daily increments, thus interrupting continuity of the record. In some instances animals deposit double increments in a 24-hour period. If those increments are interpreted as daily growth lines, an incorrect number is counted. Finally, there is the possibility of an unconscious bias. For example, a paleontologist working with Devonian corals may know a priori from tidal-friction calculations the number of days in a Devonian year. Does that information subconsciously bias counting growth rings? These difficulties led to a lull in working with fossils as paleontological clocks.

Fossils and Earth's early atmosphere

Earth's early atmosphere interests astronomers searching for habitable earth-sized exoplanets and for life in the Solar System beyond Earth, such as Saturn's moon Enceladus. It serves as a model to which comparisons can be made. The earliest atmosphere of Earth contained little or no free oxygen. Primitive microbes during this time were anaerobic. This slowly changed as free oxygen was produced. Evidence suggests free oxygen was present as far back as 2.8 Ga but it was not until about 2.0 Ga that oxygen concentrations increased markedly. It took approximately 1.7 Ga for free oxygen to be present in the early atmosphere and about 2.5 Ga for enough free oxygen for animal evolution.

Clues to Earth's early atmosphere come, in part, from stromatolite (microbial mats) fossils (Figure 1c). Stromatolites played a key role in our atmosphere's evolution. These blue-green algae or cyanobacteria are photosynethesizing organisms. They are largely responsible for oxygen in the early atmosphere. Fossil stromatolites date back to at least 3.5 Ga and living representatives exist today, such as in Shark Bay, Australia.

Fossils, rhythmites, and Earth's tidal ranges

Early in history it was realized Earth's tides relate to the Moon. This is despite the Sun exerting a far stronger gravitational force on Earth than does the Moon. The Sun's greater distance in combination with proximity of the Moon to Earth results in the Moon having the greatest effect on tides. As we have seen, tidal friction is responsible for deceleration of Earth's rotation. Because the Moon is largely responsible for Earth's tides and because the Moon was closer to Earth in the geologic past, average tidal ranges or amplitudes must have been greater at that time.

Stromatolite fossils (Figure 1c) are possible astronomical tools for quantifying tidal ranges in the geologic past. Such information would have implications on the Earth-Moon system. Modern and fossil stromatolites are most commonly found in tidal flat depositional environments – low-lying coastlines that tides affect. Tidal flats have three zones, one of which is the intertidal zone. This is located between high and low tide, defining the tidal range or amplitude. Stromatolites are found in each tidal zone and their different morphologies reflect those zones. Of particular importance to this discussion is the intertidal zone. Stromatolite tops are at the high-water mark in intertidal zones. These stromatolites are typically stacked hemispheroids forming domes, columns or club-like heads (Figure 1c). The shapes are usually distinctive enough that, in conjunction with stratigraphic interpretations of enclosing and adjacent strata, ancient intertidal zones are identified.

In the 1960s it was suggested intertidal stromatolite heights relate to tidal range or amplitude. The larger the tidal range, the taller the intertidal stromatolites. Such fossil evidence might demonstrate and quantify tidal ranges in the geologic past. It was also observed that average size of intertidal stromatolites diminishes through geologic time to the present. If correct, this proved the Moon was closer to Earth in the geologic past. Since these ideas predated lunar laser ranging of the 1970s, intertidal stromatolites are important as some of the first clues of a closer Moon.

There are a number of caveats when using intertidal stromatolites as described. The principal problem was misinterpretation of the preserved fossils as if they were large, tree-like structures during life, standing free high above the bottom. Instead, by carefully tracing individual laminations from the stromatolite interior, out into the layers in the surrounding sediment, it was shown that the stromatolite top projected above the surrounding sediment surface by only centimeters/inches, not meters/feet. Thus, the initial inference of very great tidal ranges was seriously in error. Additionally, shoreline configuration, water depth, and storms are some of the factors influencing height and timing of tides at a locality. The Bay of Fundy at Nova Scotia has the highest tidal range in the world. These exceptionally high tides are largely due to a funnel-shaped coastline that shallows toward the upper part of the bay. This combination forces incoming tides higher up onto the shores. If such a coastal setting is preserved in the ancient rock record, it is misleading to assume the tidal range there was totally due to lunar influence. In addition, assuming these exceptionally high tides to be an average for that geologic time period is equally erroneous. The caveats associated with intertidal stromatolites led to no longer using them as paleotidal indicators.

Since the 1980s, rhythmites (tidalites) have provided information on the Earth-Moon system and have largely supplanted stromatolites as paleotidal indicators. Rhythmites are repetitious sedimentary rock layers of tidal origin. They provide information on diurnal, monthly, and seasonal cycles, tidal range or amplitude, and rate of the Moon's retreat from Earth. Dark and light bands correspond to neap and spring tides, respectively (Figure 2). Neap tides occur during quarter moon phases, producing lower high tides and thinner deposits. Spring tides occur at full and new moon phases, producing the greatest tidal range during the month and relatively thicker deposits. Tidal rhythmites from 620 Ma show that over hundreds of millions of years the Moon receded at an average rate of 22 mm per year and the day lengthened at an average rate of 12 microseconds per year, both about half their current values. At this time a day was 21.9 hours, and there were 13.1 synodic months per year and about 400 solar days per year.

There are also caveats when attempting to interpret tidalites. Chief among them is that tidal currents, ebbing and flowing, often erode or scour and remove a few recently deposited layers over which they are running. Similarly, meteorological storms often interrupt normal tidal sedimentation patterns. As a result, determining how many layers were in the original deposit becomes impossible, and so does any inference about the time involved. Sedimentary geologists consider these caveats and use a variety of approaches to elicit paleoastrophysical data from the tidalites.

Why use fossils and rhythmites in astronomy studies?

Fossils and rhythmites as astronomical tools provide collaboration between astronomy and geology. Despite numerous caveats, such pursuits should continue. They provide insights into the Earth-Moon system that tidal-friction calculations do not. Those calculations assume a constant rate the Moon is receding from Earth. However, fossils and rhythmites offer possibilities of seeing changes. For example, lunar laser ranging measures a current rate of the Moon receding from Earth at about 3.8 cm per year (about 1.5 inches per year). In comparison, rhythmites indicate an average recession rate of the Moon between the Precambrian (> 540 Ma) and now of 2.17 cm per year, about half the present rate. Tidal-friction calculations cannot indicate when the Moon separated from Earth. Fossils and/or rhythmites can possibly document that event. The Moon's greater gravitational influence due to its proximity to Earth in the geologic past should be reflected in certain fossil growth bands and in tidal deposits (rhythmites). These unconventional approaches provide evidence for presence of the Moon as far back as 1 Ga. Fossils and/or rhythmites may also provide clues about past ice ages. At least five ice ages have occurred through geologic time. In each of these, melting ice caused ocean levels to rise significantly, resulting in increased tidal friction. Conversely, expansion of glaciers caused a drastic decline in sea level, resulting in decreased tidal friction. These significant fluctuations in sea level and resulting changes in tidal friction should have affected Earth's rotation. Fossils and/or rhythmites may provide evidence of this. These, then, would be further proof that Earth's deceleration is not a constant rate.

Paleontology provided the first means demonstrating change in day length, number of days in a year, and proximity of the Moon to Earth through geologic time. Archaeological records indicate change in day length, but the data extend back only a few thousand years. Atomic clocks, first used in 1955, showed a lengthening Earth day but it was not known if the deceleration rate was constant or variable through geologic time. Related to Earth's deceleration is recession of the Moon from Earth. Fossils as paleontological clocks predated VLBI measurements of the mid-1960s and lunar laser ranging of the mid-1970s. Tidal friction calculations could be projected back through geologic time but those assume a constant rate of deceleration for Earth.

Conclusion

Fossils and rhythmites are unconventional astronomical tools. Geology and astronomy are replete with examples of novel or unconventional approaches, some more successful than others. An example in geology is the history of continental drift and plate tectonics. The scientific community, particularly in this country, rejected early supporting ideas. In time, as additional studies were completed, those earlier ideas were accepted.

Currently, there is a lull in using fossils as astronomical tools. Despite shortcomings, their early use provided valuable insight into the Earth-Moon system at a time when VLBI data were not available. Future fossil studies involving larger populations and different techniques may provide additional insights into the Earth-Moon system. Similarly, as work with rhythmites continues, refinement of their use is anticipated and missing gaps in the geologic record could be filled in.

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SAFETY MATTERS: GOT A GOOD SOLE?

by Ellery Borow, AFMS Safety Chair

from EFMLS News,
Volume 64, number 6, April 2017

Yes, that is "Sole" and not a typo of "soul". Over the years I have seen a great many not so pretty soles out there on the footwear of rock, mineral, and fossil enthusiasts as they enjoy their collecting trips. I have also seen plenty of worn out, torn, missing and broken laces, as well as floppy bottomed footwear in use.

If you will permit me, I'd like to back up a bit here and mention that proper footwear is an important segment of having a good collecting experience. Having sufficient footwear for the effort is highly recommended -- as recommended as utilizing safety glasses, gloves, protective clothing and sun screen.

One of my primary footwear concerns is when I see shoe soles that are worn down to the point of treadlessness. Smooth soles do not work as well as treaded soles in keeping people upright. Although a case could be made for smooth soles on the footwear of some folks who shuffle rather than walk simply because lugged soles do grip significantly better than flat ones, and may thus be a tripping hazard for some. However, that said, I rarely see folks shuffle along in quarries and pits because shuffling can be dangerous.

Another consideration with having tread on the sole of a boot or shoe is the direction or pattern of that tread. If the primary tread patter is from right to left, or left to right, such a pattern would be excellent for walking or down a slope because the tread would be perpendicular to the direction of travel. But, what if one moves across the slope inn either clockwise or counter-clockwise motion? In such a case that same tread pattern would be parallel to the direction of slope and thus not have anywhere near as much gripping power. When traipsing in either a clockwise or counter-clockwise motion on a slope it would be better to have a pattern of ridges that ran from toe to heel, and thus, again be in a perpendicular orientation to the direction of the slope. If one were similar to most of us and find the need to not just move up and down, but also right and left on a slope it would be rather impractical to change shoes for the different directions.

Thankfully, most manufacturers offer patterns that are practical for all applications. While most manufacturers offer a pattern suitable for any occasion, I still see patterns that are biased to be better in one direction rather than all directions.

Another important consideration is the flexibility and resilience of the sole material. A softer material will have significantly greater gripping power than a hard material. However, a softer sole material will not last as long as a hard sole material -- especially as these boots and shoes are used on very abrasive surfaces. Again, most manufacturers realize their products will be worn in varying environments and so have selected a compromise material, a material that will wear well on wood floors as well as quarry bottoms.

Another sole consideration is water. Many of the wanderings through the woods I do when seeking lost or forgotten quarries brings me into contact with brooks, creeks and streams - all of which are wet. I frequently have occasion to walk on, over and through wet slippery rocks. If one has ever experienced such situation, one will no doubt recall the slipperiness of slick, bio-film, and moss covered rocks. Even a superior lugged sole can loose its grip on rounded slippery rocks. So, in such instances, having a soft sole with great gripping power is most helpful. The salient point when working in wet environments is to try and keep one's feet dry.

Additional footwear considerations also come to mind. If one is prone to dropping rocks, perhaps such folks should consider using strong or safety toe footwear. If one were to crawl among the rocks or walk on or over tough and abrasive surfaces, folks should consider using strong or safety toe footwear. Folks should also consider safety toe footwear if walking through biting insect or critter inhabited areas or areas of unknown danger.

Do you see a pattern forming here? Yes, I do suggest wearing good and appropriate footwear -- footwear suited for the occasion.

As I like to say, it is not that the sole makes the man, it is that the sole makes the man, or woman or entire family safe.

The takeaway here is that your foot safety matters...even if it sometimes becomes a wet foot. ❄

Some Upcoming Shows and Meetings

Our web site http://www.nittanymineral.org has links to more complete lists and details on mineral shows and meetings around the country. See www.mineralevents.com for more.

April 22-23, 2017: Gem, Mineral and Fossil Show, by Monongahela Rockhounds. West Mifflin Volunteer Fire Co., #4 Skyview Hall, 660 Noble Drive, Pittsburgh, PA 15122 (Near Century III Mall & Allegheny Co. Airport). Sat 10-6, Sun. 10-4. http://www.monongahelarockhounds.org/events.php

April 29-30, 2017: 45th Annual Gem & Mineral Show with Outdoor Swap, by New Jersey Earth Science Ass'n. Franklin School, 50 Washington Ave., Franklin, NJ 07416. Sat. 9 a.m. - 5:30 p.m.; outdoor swap 8 a.m. - 5 p.m. Sunday 10 a.m. -. 5 p.m.; outdoor swap 9 a.m. - 5 p.m. Contact: Sterling Hill Mining Museum, (973)209-7212 http://www.njesa.org/spring-mineral-show.html

May 6, 2017: South Penn Rock Swap, by Central Penn & Franklin County R&M Clubs. South Mountain Fairgrounds, west of Arendtsville PA on Rt 234. For GPS use 615 Narrows Rd, Biglerville PA 17307. Contact: tsmith1012@comcast.net

May 6-7: Treasures of the Earth Show, by MSNEPA. St. Joe's Oblates, 1880 Hwy 315, Pittston, PA. Sat. 10-5, Sun. 10-4; Admission $3, Children under 12 free; Minerals, fossils, crystals, jewelry and gems. contact Linda Williams, (717)-319-8334; e-mail: Lwilliams@excaliburinsmgmt.com

May 13, 2017: Annual Earth Science Show and Sale, by Rock & Mineral Club of Lower Bucks County. Christ United Methodist Church, 501 Wistar Road; Fairless Hills, PA

May 20-21, 2017: 49th Annual "World of Gems and Minerals" Rock, Mineral, Fossil and Jewelry Show, by Berks Mineralogical Society. Leesport Farmers Market, Leesport, PA.

May 20-21, 2017: Spring Show, by Cape Atlantic Rockhounds. 2641 Cologne Ave., Mays Landing NJ (between Routes 322 & 30). Sat & Sun 9-5. Free parking and admission. www.capeatlanticrockhounds.com/

June 3, 2017: Spring Mineralfest by PESA, Macungie, PA. Sat. only 8:30 -3:00. http://www.mineralfest.com/

June 16-17, 2017: Annual Show by Lancaster County Fossil and Mineral Club, Solanco Fairgrounds, Hoffman Building; 172 South Lime St.; Fri. 12-8, Sat. 10-5.

October 21-22, 2017: EFMLS Convention & Show, Bristol, Connecticut.

Geo-Sudoku Solution

B	U	E	R	I	M	C	A	T
A	T	M	C	E	U	I	B	R
C	I	R	B	A	T	U	E	M
T	C	A	M	U	R	E	I	B
E	M	I	A	B	C	R	T	U
R	B	U	I	T	E	A	M	C
I	A	C	T	R	B	M	U	E
U	R	T	E	M	I	B	C	A
M	E	B	U	C	A	T	R	I

Visit us at www.nittanymineral.org

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!

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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:

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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 (TIF, or good to highest quality JPEG files, about 1050 pixels wide, are preferred). Please provide captions and name of photographer or artist.