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Pennsylvania Geology

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Brian Dunst, chief of the Petroleum and Subsurface Geology section at the Pennsylvania Geological Survey, examining bedrock and cave formations in Conodoguinet Cave, Carlisle, Pa. See article on page 3.

—Photograph by Katherine W. Schmid

EDITORIAL

On the Shoulders of Giants

Gale C. Blackmer, State Geologist
Pennsylvania Geological Survey

This is the first time that I write to you as the 12th State Geologist of Pennsylvania and Director of the Bureau of Topographic and Geologic Survey. What an honor it is to lead this group of talented and dedicated individuals, geologists and nongeologists alike. It is hard for me to believe that I have joined a line of historic figures well known to any student of Pennsylvania geology, such as Henry Darwin Rogers, J. Peter Lesley, George H. Ashley, and Carlyle Gray. And then there are the three most recent former state geologists under whom I have worked—Donald M. Hoskins, Jay B. Parrish, and George E. W. Love. Each of these men brought a unique perspective and set of skills to the job, and I have learned much from them. If you know them, you will not be surprised to hear that they continue to be free with their advice and assistance. As with all of our retirees, we welcome them into our midst.

You may have noticed that I am the first woman on the list of State Geologists of Pennsylvania. I purposely say "first" rather than "only," because you need look no further than the articles in this issue of *Pennsylvania Geology* and the staff listing on page 20 to see the increasing number of promising young women who are entering the field. Who knows? Perhaps one of the 5th-grade girls at the Drake Well Museum day camp will one day be writing this column. No matter how old we are or where we sit in our organizations, it behooves all of us to encourage and help the next generation of bright young women and men who will bring fresh perspectives to the science and will one day step into our positions.

Geology holds a unique position among the physical sciences as an "historical" science: our stock in trade is reconstructing past events at scales of time and space difficult even for us to comprehend. We like that historical space. As a group, we are comfortable with our traditional ways, and anyone who has seen a geologist's office can tell you that we keep everything. Sometimes that is a good thing—here at the bureau, we have drawers full of data and samples collected over the past 179 years. That's a lot of information that does not have to be recreated at great expenditure of time and money. Sometimes, though, we miss the opportunities presented by innovative new techniques because the way we do it now has always served us well enough. Sometimes it takes a body blow from one of those fresh perspectives to knock us out of the rut.

Many people have asked me where I plan to take the bureau. Following those who came before me, I plan to stay true to our mission of ". . . collecting, preserving, and disseminating impartial information about the Commonwealth's geology, geologic resources, and topography . . ." I do, however, want to see us leverage ever-advancing technologies to do that collecting, preserving, and disseminating in new, creative, and more effective ways that make it easier for us and for our customers to access, use, and analyze the information. This applies not just to data we are collecting now, but also to information assembled under all those state geologists who came before.

As the Survey begins this new chapter in its history, we will remember that we stand on the shoulders of giants, even while we launch fearlessly off those shoulders into the future.

Gale C. Blackmer

Conodoguinet Cave, Carlisle, Pennsylvania

Katherine W. Schmid
Pennsylvania Geological Survey

Introduction

I am a geologist at the Pennsylvania Geological Survey in the Petroleum and Subsurface Geology section. However, one of my lifelong interests has been the exploration and study of caves. I have explored caves in many U.S. states, including California, Idaho, Kentucky, Ohio, Pennsylvania, Tennessee, and West Virginia, as well as caves in a Central American country, Belize. I consider Conodoguinet Cave in Carlisle, Pa., to be a beautiful example of one of this state's natural features. Walking passages, nice formations, and Ordovician fossils can be found in this cave, as well as animals such as rare amphipods (small crustaceans), bats, salamanders, and frogs. This small cave has a long history of use and is found in an area having complex geology. It is also important in today's hydrologic regime.

Conodoguinet Cave is located in Cave Hill Park and Nature Center in the borough of Carlisle, Pa., near the Pennsylvania Turnpike (Figure 1). Figure 2 shows a map of the cave. Cave Hill Park was founded in 1963 after the construction of the Pennsylvania Turnpike to protect the land from future development (Cave Hill Park and Nature Center, 2013). According to Tom Metzgar of the Mid-Atlantic Karst Conservancy, Cave Hill Park was the first cave park created in the commonwealth. The cave was named after the Conodoguinet Creek. The cave entrance was about eight feet above the water level in the creek before the creek was dammed for the Carlisle Gas and Water Company in 1854 (Speece, 2013) and is at most only a couple of feet above the water level now. The cave has been gradually filling with mud since the construction of that and other dams, because the creek floods into the cave. The Conodoguinet Creek is one source of water for Carlisle.

The entrance to Conodoguinet Cave is at the base of a cliff next to Conodoguinet Creek. There is a good-sized sinkhole on the surface on top of the cliff and above the cave's entrance that is about 500 feet

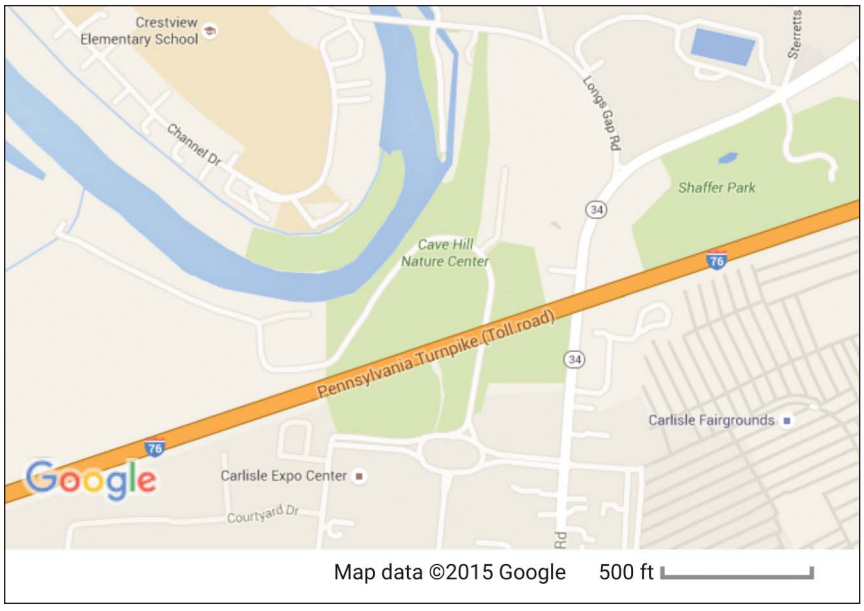

Figure 1. Location of Cave Hill Park and Nature Center in Carlisle, Pa. The creek northwest of the turnpike is the Conodoguinet. The park is located at latitude 40°13'18"N, longitude 77°11'22"W.

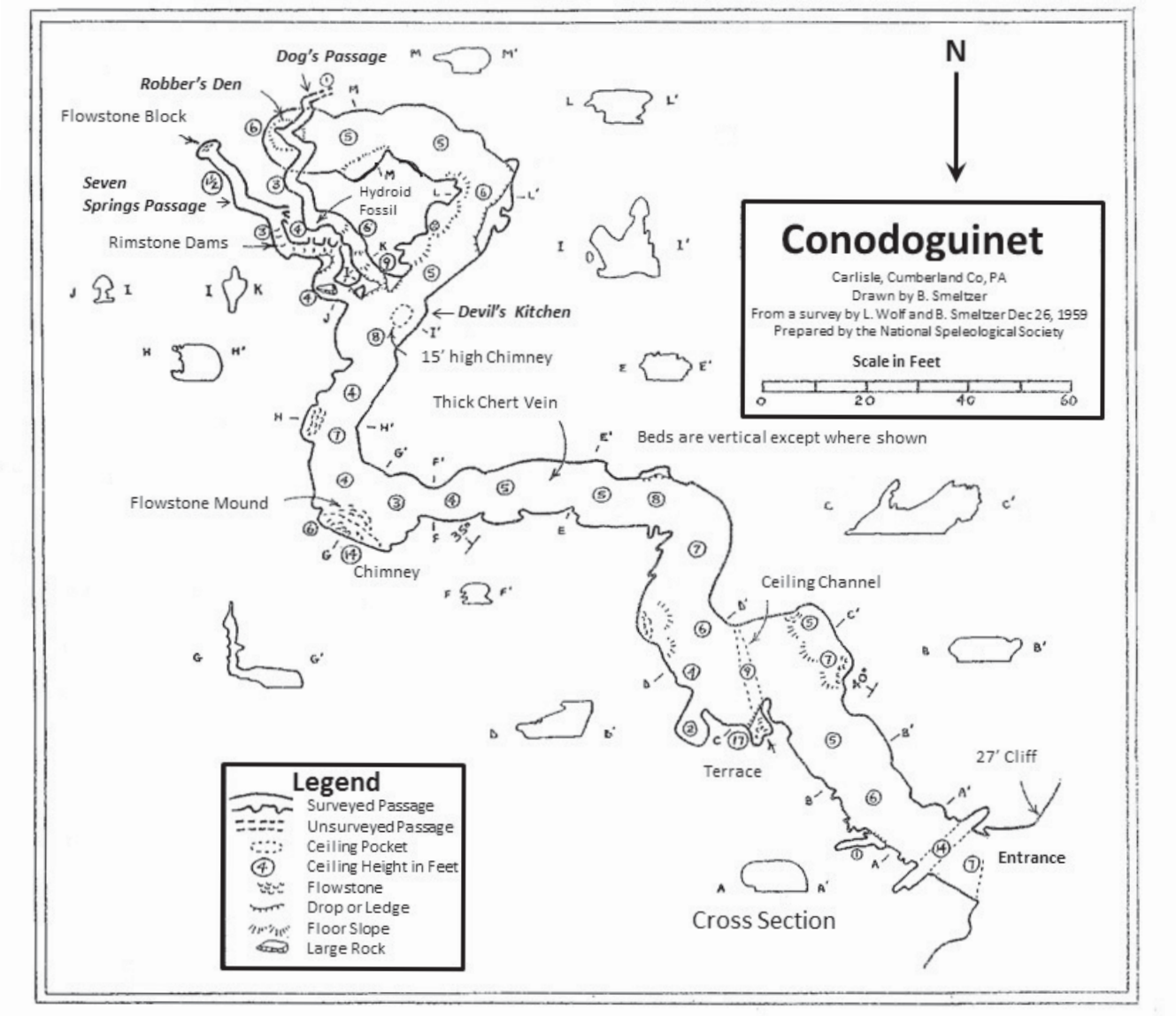

Figure 2. Map of Conodoguinet Cave created by Bernard L. Smeltzer in 1959. Names of rooms and passages in the cave are italicized. Used with permission.

in diameter. This sinkhole exists on topographic maps drawn before the turnpike was constructed. Numerous small sinkholes can be found in the large sink. One example is shown in Figure 3. This particular sink was taking water the day before I led a field trip to the cave during the Field Conference of Pennsylvania Geologists in October 2014. A U.S. Geological Survey stream gage downstream from the cave in the Conodoguinet Creek recorded how fast the water rose and that the water levels peaked on the day of the field trip (Figure 4). Fortunately, we were still able to get into the cave, although our feet got wet. That is the only time that I have seen water flowing out of the cave entrance.

History

People have been visiting this cave for centuries. Because of its cool air, the cave was very popular in times before air conditioning—it was a fashionable place for ladies to have their afternoon tea in the 1700s (Cave Hill Park and Nature Center, 2013) (Figure 5). Johann David Schöpf, a German geologist, included this cave on his geologic map of eastern North America in 1787 (Speece, 2013). General

Figure 3. Water flowing into a small sink (about 12 feet in diameter) within a larger sink near the cave on October 15, 2014. The water flow is toward the top of the photograph.

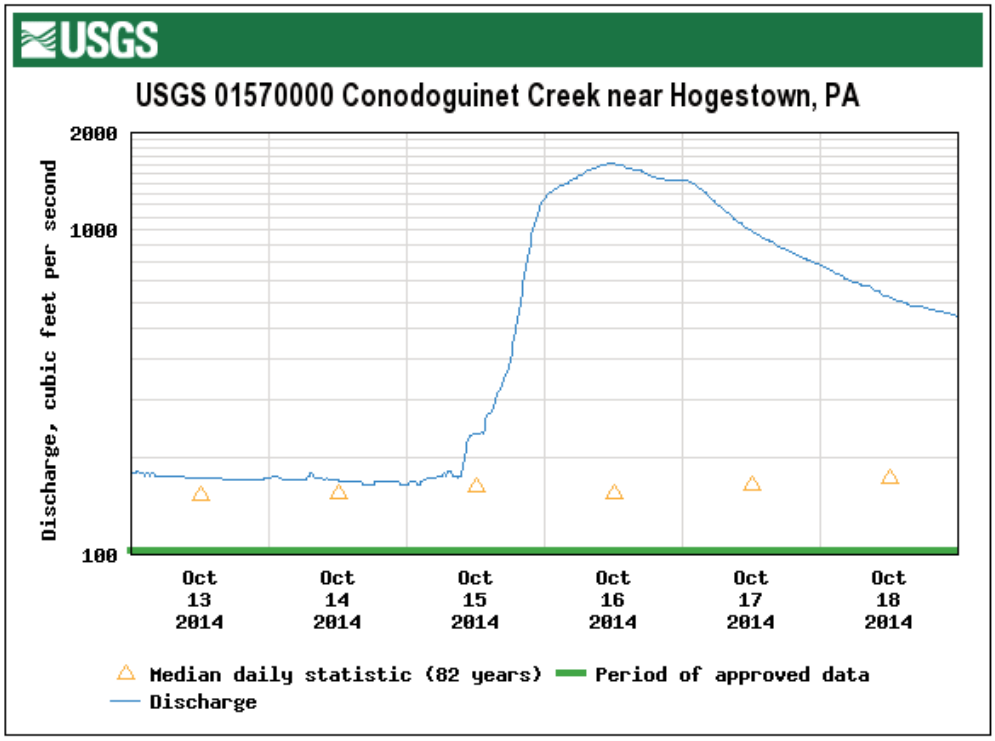

Figure 4. Discharge of the Conodoguinet Creek in October 2014, recorded on a U.S. Geological Survey stream gage. Data obtained from http://waterdata.usgs.gov/nwis/uv?01570000.

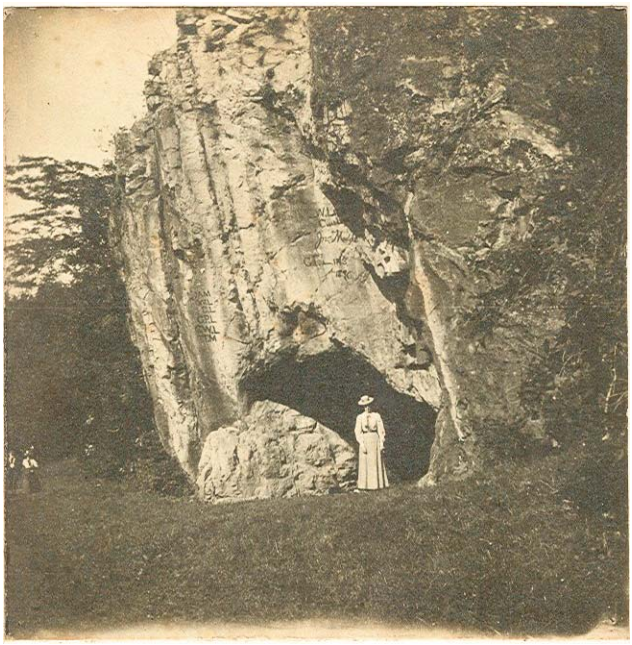

Figure 5. Historical photograph from the Cave Hill Park and Nature Center website (www.cavehillcarlisle.org). Used with permission.

Benjamin Lincoln, a general in the Revolutionary War from the Massachusetts Bay province, wrote about visiting this cave in 1782, and John Penn, the chief proprietor of Pennsylvania before the war, mentioned visiting it in a journal in 1788 (Ashbrook, 2013). Spencer Baird, a famous paleontologist from Dickinson College, visited the cave in 1848 and classified the bones of 18 different animal species. Baird believed some of these bones to be from extinct species, but this was disproved when Gerrit S. Miller, Curator in the Division of Mammals at the United States National Museum, reexamined the bones in 1940 (Speece, 2013).

Cave Features

Despite being used heavily by people for centuries, the cave does have numerous speleothems, including stalactites, flowstone, and rimstone dams. These formations are deposited as saturated waters come into contact with air that has a lower concentration of CO_2. **Stalactites** have the same morphology as an icicle. They begin as soda straws (thin-walled, hollow formations) that form as calcite crystals form around the edges of saturated drops of water on the ceiling. This soda straw forms the central canal of the stalactite. Simultaneously, the outside layers form as crystals build perpendicular to the walls of the soda straw because water flows down the outer surface of the speleothem (Hill and Forti, 1997). **Rimstone dams** have a stair-step morphology (Figure 6). They build up as

Figure 6. Rimstone dams in the Seven Springs Passage inside Conodoguinet cave.

barriers perpendicular to flow that obstruct cave streams or pools. They form as crystallization occurs at the water/ice/rock interface and commonly grade into flowstone as the gradient changes (Hill and Forti, 1997). **Flowstone** is a sheetlike deposit that has a crystal orientation that builds up perpendicular to flow (Figure 7).

Of course, this Ordovician limestone has very different types of fossils from those in the Mississippian and Pennsylvanian caves that I typically explore. A gastropod fossil found in the Dog's Passage is shown in Figure 8. In that same passage, there is also a stromatoporoid fossil (Figure 9). This fossil is labeled as a "hydroid fossil" on Smeltzer's map (Figure 2) but is now considered to be a reef-forming invertebrate classified as a sponge.

Geology

Conodoguinet Cave formed in the Chambersburg Formation of the Cumberland Valley section of Pennsylvania's Great Valley in an area having mapped faults and folds (Miles and Whitfield, 2001; Faill, 2011) (Figure 10). The Chambersburg Formation is Middle Ordovician in age and is composed of dark gray, thin- to medium-bedded nodular limestone and minor units of thin, even-bedded argillaceous limestone (Lindsey, 2005). The limestone in this area is very steeply dipping at approximately 80° (Figure 11), although there is some variation in the dip due to local folding (Speece, 2013).

Figure 7. An example of flowstone within Conodoguinet Cave.

Figure 8. Gastropod fossil (about 3 inches in diameter) (arrow) in the wall of the Dog's Passage in Conodoguinet Cave.

Figure 9. Stromatoporoid fossil (about 6 inches in diameter) in the roof of the Dog's Passage in Conodoguinet Cave.

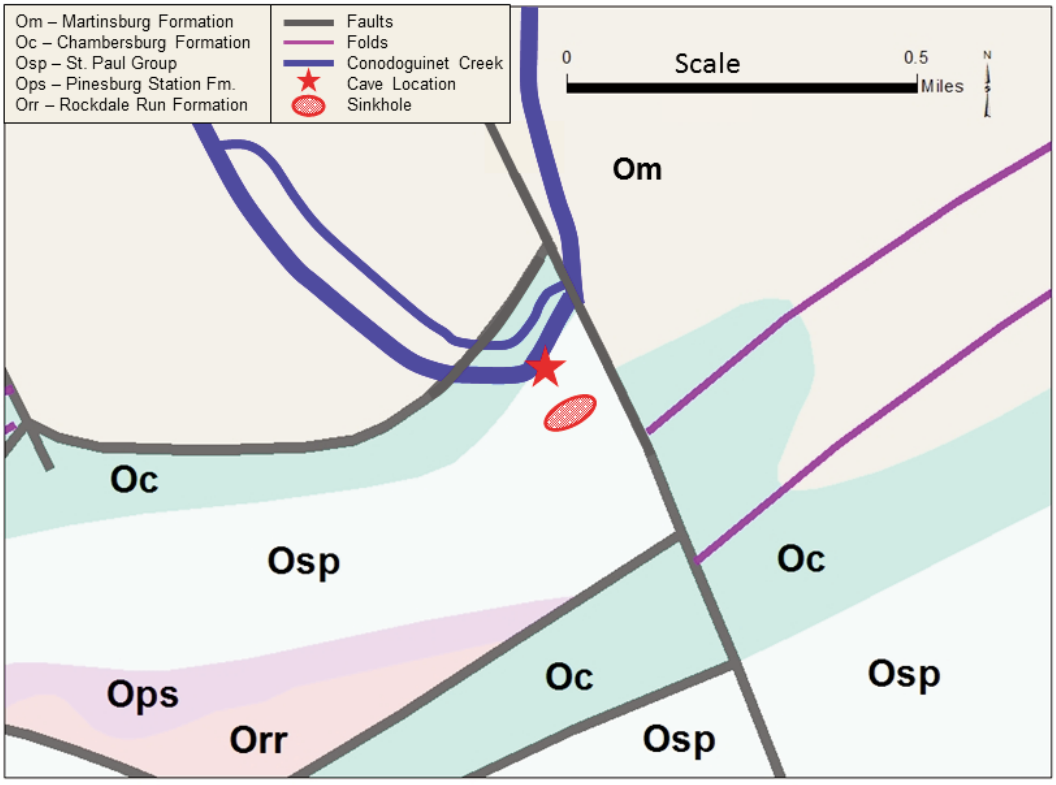

Figure 10. Geologic map of the area near Conodoguinet Cave, modified from Miles and Whitfield, 2001, and Faill, 2011. The cave is located at latitude 40°13'18"N, longitude 77°11'25"W.

After looking at the geologic map and reading some descriptions of the cave, I expected to see obvious effects from the faulting inside the cave, compared with all of the joint-controlled and fault-controlled caves in Kentucky, Pennsylvania, and Belize that I have helped map. Instead, these features are very subtle. The geologic map shown in Figure 10 does not show any folding or faulting directly at the cave, but this regional map was created at 1:250,000 scale, which does leave a lot of potential for error at this local scale. I would expect cave formation to be related to the fault as a result of increased water flow along the fault planes. An alternate path for groundwater flow that must be considered at this location is the near-vertical bedding.

I was able to make some observations on all of these influences after examining the cave. The overall trend of the cave's main passage is slightly west of the trend of the nearest mapped fault, and the orientation of a series of formations close to the entrance (cover photograph) is very close to the mapped fault orientation. In contrast, the speleothems hanging from the ceiling of the Devil's Kitchen farther in the cave are aligned with the dip of the bedding planes in this room. Evidence for folding can be seen in variations of the dip of bedding planes (Figure 12).

Summary

Conodoguinet Cave is an interesting cave for even inexperienced cave explorers to visit. Despite centuries of use, it still contains many examples of different cave formations. In addition to these formations, there are Ordovician fossils in the cave, including a few gastropods and a stromatoporoid. Subtle features in the cave reflect the region's complex geology. The fact that the cave is hydrologically

Figure 11. Steeply dipping bedding in the cliff above the cave, especially visible below the person on the right.

connected to the town's water supply needs to be taken into consideration when planning uses for the cave and the land above the cave. Please contact the park at www.cavehillcarlisle.org if you are interested in visiting this cave.

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Figure 12. Subtle folding in Conodoguinet Cave.

THE 2015 FIELD CONFERENCE OF PENNSYLVANIA GEOLOGISTS

The 80th Annual Field Conference of Pennsylvania Geologists (*Conglomerate, Coal, and* Calamites—*Geology, Mining History, and Paleontology of "The Region"—Schuylkill, Northumberland, and Columbia Counties, Pennsylvania*) met in October near Pottsville, Pa. Retired Pennsylvania Geological Survey geologist Jon Inners organized a wonderful trip that had 12 stops, including a stop at famous (or infamous) Centralia, where an underground mine fire has been burning for more than 50 years. Also included was a visit to the type section of the Pennsylvanian Pottsville Formation along Pa. Route 61 just south of the city of Pottsville. This site features an exposure of the underlying Mississippian Mauch Chunk Formation. Amphibian trackways (foot traces) were originally discovered in laterally equivalent Mauch Chunk rocks in nearby Mount Carbon in the middle 1800s by Isaac Lea.

This conference was truly a mix of geology, mining history, and paleontology (Figures 1 and 2), and included visits to three active strip mine operations, two abandoned mines, and two active quarry operations in Schuylkill, Northumberland, and Columbia Counties. It has been nearly 30 years since the Field Conference visited this area of the Anthracite region. This year, there were 172 attendees, including 22 students. Many of these attendees also chose to participate in one of the eight pre-meeting trips, which included a walking tour of historic Pottsville, fossil collecting at Sweet Arrow Lake County

Figure 1. Photograph of Field Conference participants examining a tight synclinal fold in the Llewellyn Formation on the base of the Mammoth coal bed at the Logan West pit. Photograph by Jon D. Inners.

Figure 2. Fossil plants from the St. Clair area. Photograph by Yuri Neboga.

Park, a visit to the Ashland Pioneer Tunnel coal mine, a visit to Bear Valley and the "whaleback," and an examination of geohazards associated with cropfalls on Sharp Mountain. A special *In Memoriam* chapter was included in the guidebook to commemorate and remember two individuals, Dr. Richard P. Nickelsen, Professor Emeritus at Bucknell University, and Dr. Rodger T. Faill, Pennsylvania Geological Survey, who did so much to increase our understanding of the structural geology of Pennsylvania. They were also ardent supporters of the Field Conference and will be greatly missed.

Thank you to everyone who made this year's Field Conference a great success. If you would like to learn more about the Field Conference, or to download any of the guidebooks, including this year's, please visit the Field Conference website at www.fcopg.org.

—Leonard J. Lentz

BUREAU NEWS

Pittsburgh Office 2015 Summer Interns "ROCK!"

Catherine Bert and Priscilla Clark
Pennsylvania Geological Survey Interns

The Pittsburgh office of the Pennsylvania Geological Survey hired six interns this past summer (Figure 1). Each individual brought a different educational background, which gave the office a diverse environment. Their majors ranged from strictly geology to environmental study, and each intern was able to approach work differently and offer insight to the others, providing the opportunity to learn and grow as students. In addition, the opportunities that the Department of Conservation and Natural Resources provided to us will be crucial to our future careers and prospects. From learning new software and computer skills to field work and networking, the experiences we had will play into our futures.

Unlike many other internships available to students, these internships allowed us to directly work on a major project that involved collaborations with other states. Since 2003, the bureau has been a member of the MRCSP (Midwest Region Carbon Sequestration Partnership). Ongoing work includes investigations into potential rock strata that might be used to store waste carbon, and determining whether this byproduct can be used to enhance oil and gas production. This summer, all of the interns assisted staff geologists in an important part of the project. The bureau geologists revisited formation

Figure 1. Summer 2015 interns who worked in the Pittsburgh office of the bureau (from left to right): Priscilla Clark, Sarah Haralam, Anna Lesko, Catherine Bert, Matthew Magill, and Luke Fritz.

Figure 2. The fossil display in the lobby of the Pittsburgh office.

tops and bottoms for the Hamilton Group and other organic-rich shales using software known as PETRA©. The interns were assigned counties in Pennsylvania and began looking at geophysical logs from wells scattered throughout these counties. Using cross sections as well as guidance from other interns and staff, formations were determined on geophysical logs and compiled in PETRA©. This information was shared with different states within the MRCSP and used to further research on carbon capture use and storage potential.

In addition to working on specific projects, interns also performed day-to-day tasks that the Pittsburgh office manages. These tasks included processing oil and gas wells in the Wells Information System, geophysical log processing, and sorting logs and finding missing API numbers (numbers assigned to each well drilled for oil and gas). There was never a shortage of work at the bureau!

Along with individual work, group collaborations were also a big part of the internships. The interns came up with a new theme for the display case in the building lobby (Figure 2). This year, the topic of Pennsylvania fossils was selected. Each intern chose a fossil, researched facts about it, and found images depicting how the organism may have appeared. Sample fossils were borrowed from the Middletown office of the bureau, courtesy of staff geologist Kristen Hand. A poster was printed and hung in the display case, and fossil images were placed on a time-scale background. Fossil specimens were placed on shelves in the display case. The interns also researched historical oil and gas wells and reconstructed their history and significance. Lastly, the interns organized and planned a lunchtime picnic party for the Pittsburgh staff (Figure 3). They chose a theme using geology puns, and we can all promise you that it was a really GNEISS time!

Figure 3. Geologic puns featured at the Pittsburgh office picnic.

The students also traveled to the Middletown office of the Pennsylvania Geological Survey. Catherine Bert worked in the lab there, gaining experience using some of the more sophisticated equipment. Priscilla Clark and Luke Fritz spent time in the core library, comparing rock samples to geophysical log signatures from the MRCSP project, and helping to identify formations. Appropriate intervals were selected for analysis.

Figure 4. The Drake Well Museum.

A few interns were able to take advantage of unique opportunities. The work that Catherine was involved in included preparing samples from the rock cuttings of two different wells. Horizontal and vertical samples were taken and ground down using a mortar and pestle. These samples were later taken to Middletown to create plugs (a mix of powdered rock and plastic) to be analyzed by petrographic analysis under the microscope. Luke had the chance to visit the landslide site in Allegheny County that is being monitored by the U.S. Geological Survey, where he helped to reposition the equipment because of previous instrument failure. Priscilla visited the Drake Well Museum (Figure 4) (see the article on the next page) and talked to 4th and 5th grade day campers about geology and mapmaking. Finally, Sarah, Priscilla, and Catherine attended the release of information about the Utica oil and gas play at the Utica Playbook Workshop (Figure 5). They also helped the facilitators during the event. This was a great opportunity to gain knowledge that is crucial to more than one aspect of geology. It was also a good networking experience for the interns.

Even though the interns came from different educational backgrounds, they proved to be essential to the Pittsburgh staff. Their internships gave them not only work experience but also a valuable education that is not often taught in classes. The bureau office in Pittsburgh is a great place to have an internship. It was with great sadness that we realized that the summer was over, and it is a fact that the interns' smiling faces and jovial personalities will be missed by all who work in the Pittsburgh office.

Figure 5. Interns Priscilla Clark, Catherine Bert, and Sarah Haralam at the Utica Playbook Workshop.

EARTH SCIENCE TEACHERS' CORNER

"It's All About Oil"

Renee Speicher and Robin Anthony
Pennsylvania Geological Survey

"It's All About Oil" day camp is one of the many annual events held at the Drake Well Museum and park in Titusville, Pa. (Figure 1). The museum educator, Sarah Goodman (from another commonwealth agency, the Pennsylvania Historical and Museum Commission), sought out one of our expert geologists, Robin Anthony, for a presentation to 4th through 6th graders. Robin was assisted by support staffer Renee Speicher and Priscilla Clark, one of the bureau's 2015 summer interns (see the previous article).

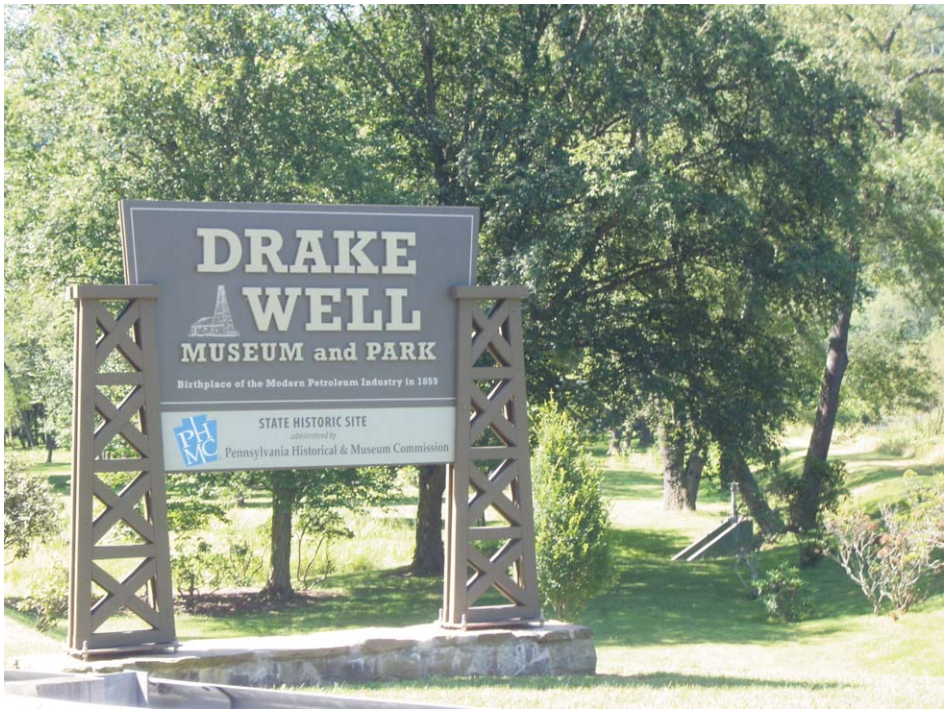

Figure 1. Entrance to the Drake Well Museum and park in Titusville, Pa.

Priscilla honed her public speaking skills when talking to the campers by explaining her desire to study geology and how her love of computers is helping in this technical field. She showed the children how mapping has evolved from historical hand-drawn maps to the varied collection of printed, hand-drawn overlay, and computer-generated maps that we use in our office today. Since these kids knew what a global positioning system (GPS) device does, they quickly became absorbed in other advancements Priscilla showed them, such as layered information that can be presented on maps using Geographic Information System (GIS) digital technology.

Through a slide show, rock samples, fossils, fun facts, and quizzes, our bureau staff presented the basics of geology. Robin then discussed petroleum geology by showing subsurface rock correlations,

and Renee showed them how we help people. The kids learned just how many different subjects are under the geology "umbrella," and got a feel for all the different careers available to geologists.

Take-home information was distributed to the students who wanted more in-depth information. Each child left with a box of rock samples and trilobite transfer stickers. Armed with this information, our future geologists then let Priscilla lead them outside "in the field," where they inspected the collection of landscaped river rocks around the building (Figure 2). Finally, Robin "The Rock" left the children smiling with excitement as she exclaimed, "Geology is FUN!"

Figure 2. "It's All About Oil" day camp attendees inspect the river rocks located around the building with bureau intern Priscilla Clark (aqua shirt) and bureau staff geoscientist Robin Anthony (beige shirt).

RECENT PUBLICATIONS

Open-File Miscellaneous Investigations **(November 2015)**

- Water depth of Tobyhanna Lake—Tobyhanna State Park, Monroe County, Pennsylvania
- Water depth of Pinchot Lake—Gifford Pinchot State Park, York County, Pennsylvania

Educational Series **(October 2015)**

- Second edition of Sinkholes in Pennsylvania

Open-File Oil and Gas Report **(October 2015)**

- Using geophysical and remote sensing techniques to evaluate deep geologic formations in Indiana County, Pennsylvania—Well data

Calling All Authors

Articles pertaining to the geology of Pennsylvania are enthusiastically invited. The following information concerning the content and submission of articles has been abstracted from "Guidelines for Authors," which can been seen in full on our website at www.dcnr.state.pa.us/topogeo/publications/pageolonline/pageoolguide/index.htm.

Pennsylvania Geology is a journal intended for a wide audience, primarily within Pennsylvania, but including many out-of-state readers interested in Pennsylvania's geology, topography, and associated earth science topics. Authors should keep this type of audience in mind when preparing articles.

Feature Articles: All feature articles should be timely, lively, interesting, and well illustrated. The length of a feature article is ideally 5 to 7 pages, including illustrations. Line drawings should be submitted as CorelDraw (v. 9 or above) or Adobe Illustrator (v. 8 or above) files.

Earth Science Teachers' Corner: Articles pertaining to available educational materials, classroom exercises, book reviews, and other geologic topics of interest to earth science educators should be 1 to 2 pages in length and should include illustrations where possible.

Announcements: Announcements of major meetings and conferences pertaining to the geology of Pennsylvania, significant awards received by Pennsylvania geologists, and other pertinent news items may be published in each issue. These announcements should be as brief as possible.

Photographs: Photographs should be submitted as separate files and not embedded in the text of the article.

Submittal: Authors may send their article and illustrations as email attachments to RA-pageology@state.pa.us if the file sizes are less than 6 MB. For larger sizes, please submit the files on CD–ROM to the address given below. All submittals should include the author's name, mailing address, telephone number, email address, and the date of submittal.

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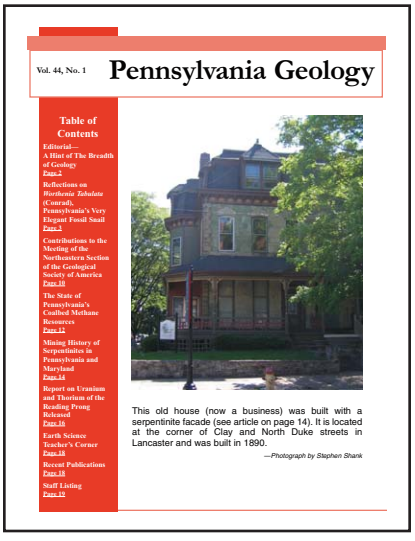
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This old house (now a business) was built with a serpentinite facade (see article on page 14). It is located at the corner of Clay and North Duke streets in Lancaster and was built in 1890.

—Photograph by Stephen Shank

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