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A new water-well site at the bottom of the access road in the deep wooded area in Leonard Harrison State Park. See article on page 3.

—*Photograph by Victoria V. Neboga*

EDITORIAL

A Farewell

George E. W. Love, State Geologist
Pennsylvania Geological Survey

Four years ago, I wrote about the work that Stuart Reese and his group were doing regarding Pennsylvania's abundant natural resource, water. At that time our citizens were concerned about water consumption by the natural gas drilling industry. Today, we hear the news about drought in the agriculturally productive areas of California and heavy rains and historic floods in the stereotypically dry areas of Texas. Water continues to be a popular topic, not to mention one of the truly basic needs of humankind. In this issue, there is an interesting article on the efforts of Survey personnel to help the Bureau of State Parks provide this much-needed commodity to the visitors of two of the wonderful parks of the Department of Conservation and Natural Resources. This is an interesting read that provides insight into the application of basic geological principles coupled with intuition and rational thought to address a need. It is satisfying to see the Survey's knowledge and experience put on the line, and rewarding to see the efforts lead to the desired conclusion. Read the article entitled "A Search for Water" and judge for yourself. These are talented folks, and the citizens of Pennsylvania are the beneficiaries.



Also of importance, and an article I find both fun and heartwarming, is the Bureau News section highlighting Mark Brown and Aaron Bierly of our staff sharing geology with elementary students at a School Science Night. They showed the children that geology is fun. That's heartwarming. And the topic was economic geology. That's REALLY heartwarming! Of course I am biased, as I believe our society is based upon technology that moves forward as a result of the world's mineral abundance.

And finally, there is an interview with the current State Geologist, how he got to where he is, and where he is going. I use the third person reference as I find it difficult to believe that I am that person! As some of you know, Einstein's Theory of Relativity failed to include the statement, "The passage of time accelerates exponentially; the exponent being directly related to the distance, measured in years, between the date of one's birth and the date one begins to think about what one has done with one's life." For me, it can be summed up using the LOVE Method. This is a means of evaluating an idea, project, proposal, or in this case, an inevitable situation. And no, I did not create this method. So let's apply it to my recent retirement.

What's to **L**ike about approaching maturity? Plenty!

What have I **O**verlooked as I engaged in my life and career? Plenty!

What have I **V**alued in my life? Plenty!

How could I **E**xpand on this inevitable situation? Do all the things I put off for the last 40 years? Or was it 50 years? Maybe apologize for what I did do?

Perhaps it's best to state that being a geologist has been a great ride. I would not change my career choice. I think I would change some of the details, but if I did, what highlights of my life would I have missed? Would I have enjoyed smiling with amazement at those rare occasions when I made a correct prediction? Would I have learned to admit that I am wrong (more than occasionally) and that it is OK seek wise counsel? Would I know that my life has been immeasurably improved by the people I have met?

Thank you for allowing me to serve in the Bureau of Topographic and Geologic Survey.

A Search for Water

Victoria V. Neboga, Stuart O. Reese, and Michael E. Moore
Pennsylvania Geological Survey

The search for water requires extensive training, a plethora of maps, and sophisticated software.

Introduction

State park and forest facilities, commonly far from public water supplies, depend on water wells for an adequate yield of clean water. Finding that spot where a well will provide enough good-quality water is not always a “slam dunk.” In the past year, bureau geologists hoped to support two of their sister bureaus by finding a supply of that precious resource for old and new facilities, using both old and new techniques. First, Leonard Harrison State Park, located in remote Tioga County, has struggled for many years with a less than ideal situation for drinking water. Second, a new Buchanan State Forest facility in Fulton County could have been compromised if the water supply turned out to be of poor quality or had a very low yield. Both of these agencies turned to the bureau for help.

New Techniques and “Old School” Tools

In the past, geologists relied on printed maps, aerial imagery, and local topography to find a good location for a water well. The interpretation of aerial photographs is based on a thorough study of differences in color, tone, or the texture and sharpness of a photograph’s objects. Usually, aerial photographs are viewed as stereoscopic pairs, where some objects “stand out” in relief from the surface and certain topographic trends are more readily visible. This technique has been used by geologists for decades to look at fracture traces on the land surface. Fracture traces are natural linear features that appear as topographic, vegetational, or soil tonal alignment on aerial photographs. They are typically the surface expressions of fracture zones in the subsurface. A well located where two or more of these fractures intersect will have a better chance of producing more water. After finding these features in the photographs, the geologist can check their location on the ground as part of field verification. However, where surface indications are less evident, for example in heavily forested areas or areas of thick glacial cover, other factors should be considered during the photo interpretation, such as rock types, geologic contacts and faults, type of vegetation, land-use history, and an area’s climate and soils.

Modern technology has brought many additional tools to the geologist’s aid. High-resolution aerial photography and elevation data acquired by light detection and ranging (lidar) are available through the PAMAP program (Pennsylvania Geological Survey, 2014). Special tools in GIS (geographic information system) software convert the lidar-derived DEM (digital elevation model) data into hillshade views of bare earth (with trees and structures removed). This technique is widely used by bureau staff geologists to identify different geologic phenomena, such as sinkholes, glacial features (eskers, kettles, and buried valleys), bedrock outcrops, mine openings, landslides, and fracture traces. The high resolution of lidar imagery of 3.2-foot pixels enables the geologist to see many details on the ground previously hidden by vegetation or structures. A hillshade image showing an apparent fracture trace (yellow dashed line) mapped within Leonard Harrison State Park is shown in Figure 1.

Geology, the Grand Canyon of Pennsylvania, and the Rugged Path to the Well

Leonard Harrison State Park lies within the Deep Valleys section of the Appalachian Plateaus physiographic province and is situated in the upland area, deeply dissected and drained by Little

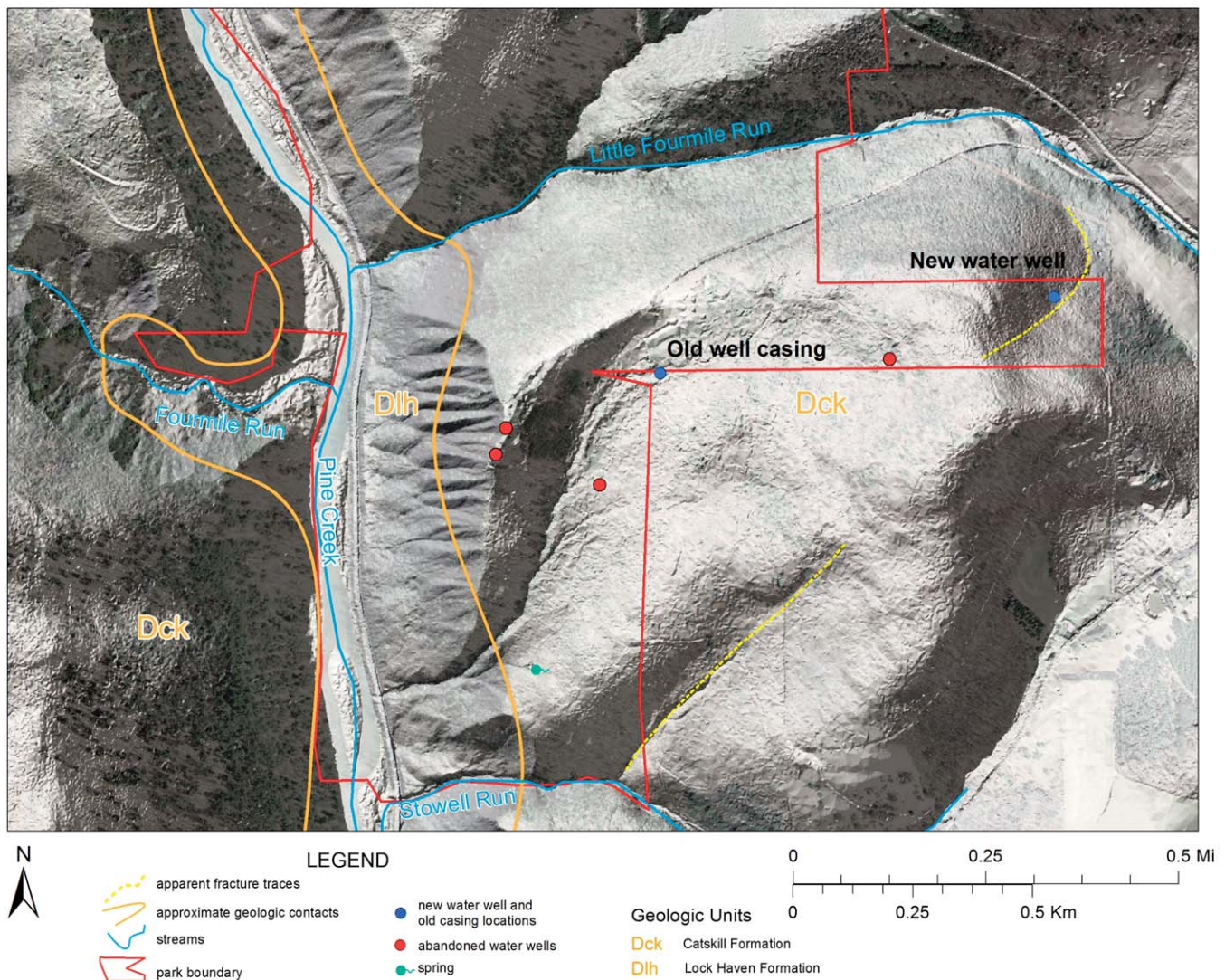


Figure 1. Aerial view of Leonard Harrison State Park showing the park boundary, geologic units, location of the old wells, new well, and fracture trace (yellow dashed line). The base map is PAMAP orthoimagery overlain by lidar bare-earth hillshade with 40 percent transparency.

Fourmile Run to the north and Stowell Run to the south (Figure 1). The park is famous for its spectacular view of Pine Creek Gorge, also known as the “Pennsylvania Grand Canyon,” having a descent of 900 feet to Pine Creek. This site is included in the Department of Conservation and Natural Resource’s Story Maps website (Pennsylvania Department of Conservation and Natural Resources, 2014), featuring the most beautiful geologic sites in Pennsylvania (<http://maps.dcnr.pa.gov/storymaps/geologic.html>). One result of this is that more people flock to the park every fall to see the spectacular forest foliage, and thus the need for more drinkable water is on the rise.

In August 2013, the Groundwater and Environmental Geology section of the bureau received a request from the Bureau of Facility Design and Construction to take a fresh look at possible sites to drill a water-supply well for Leonard Harrison State Park. For many decades, the park’s only source was a

small, low-yielding spring having an average yield of 1.8 gal/min (gallons per minute). The maintenance of the spring was rather costly and required constant monitoring of the cartridge filters, which had to be replaced more often during rainy periods. Several attempts at drilling wells had been made in the past. The PaGWIS (Pennsylvania Groundwater Information System) database includes the records of five wells drilled within the park since the 1930s and showed that none of them produced more than 2 gal/min. New facilities built in the park within the past decade, including flush toilets at the overlook, day-use, and campground areas, required more water. Based on a peak attendance of 12,000 people a day during fall foliage season, the current spring supply was not enough.

The most recent wells, drilled in 1999 and 2000, did not get an adequate yield and were abandoned shortly after completion (Figure 1). Bureau geologists assisted in an aquifer pumping test in May 2000 but had never been tasked with finding a suitable location for a water well. The oldest well drilled within the park (1935) had a measured yield of 1.5 gal/min. In a report published in 1939, Stanley W. Lohman stated, *“Insufficient supply. Original water level—333, dropped 18 feet after dynamiting, which did not increased yield”* (Lohman, 1939). An old casing, most likely belonging to this well, is still visible in the dry creek bed along the park’s southern boundary (Figure 2).

As a first step, two of the authors, Neboga and Moore, reviewed site topography, lithology, and geologic structure as three important controls of well yield. The bedrock of the park is primarily Catskill Formation of Upper Devonian age (359 to 385 million years ago). It consists of interbedded shale, siltstone, and sandstone, arranged in well-organized fining-upward cycles. Previous work described a pronounced system of joints at outcrops along Little Fourmile Run (Figure 1). Joints that cut through the rock are prominent features and serve as conduits for the groundwater. The Pine Creek valley is underlain by the Lock Haven Formation, which is composed of interbedded sandstone, siltstone, and shale. This rock unit is also Upper Devonian in age. In general, the Catskill Formation is less calcareous and coarser grained than the Lock Haven Formation (Williams and others, 1998).



Water-well data from 34 wells in PaGWIS and internal PaGWIS files were retrieved for the area within a 3-mile radius of the park. Statistics show that the average yield for wells in the Catskill Formation is 12 gal/min, which is close to the desirable number of 10 gal/min requested for the park’s needs. Most of the wells completed in the Catskill Formation yield water of the calcium bicarbonate type, which is moderately hard (61 to 120 mg/L as CaCO_3), and it may contain elevated concentrations of iron and manganese.

Figure 2. Old casing found within the dry creek bed in Leonard Harrison State Park.

The small park's area of 560 acres of rugged terrain limited suitable places for the future well. In these areas, a closer look at the geologic structure, including faults, folds, fractures, and other features, so-called "zones of weakness" in rocks, was needed. As mentioned previously, wells that intersect fractures will typically yield more water than those that do not. Neboga reviewed stereoscopic pairs of black-and-white photographs from 1952 and 1971. Fracture-trace analysis of the old aerial photos, new PAMAP color orthophotos, and lidar elevation data revealed one area that had potential in the park's eastern half. An obvious swale (a slight depression) going down the hill in a northeasterly direction could be seen on the photographs and was observed during a field visit in October 2013. Surface depressions commonly accompany underground fracture zones, which may contain one or as many as a couple of dozen separate fractures or cracks. Access to the site was extremely difficult and required construction of a new access road, but it was the only potential site for the new well (see cover photograph). It should be noted that the location of the well had to balance hydrogeologic preference with the justified costs to move water to the facility.

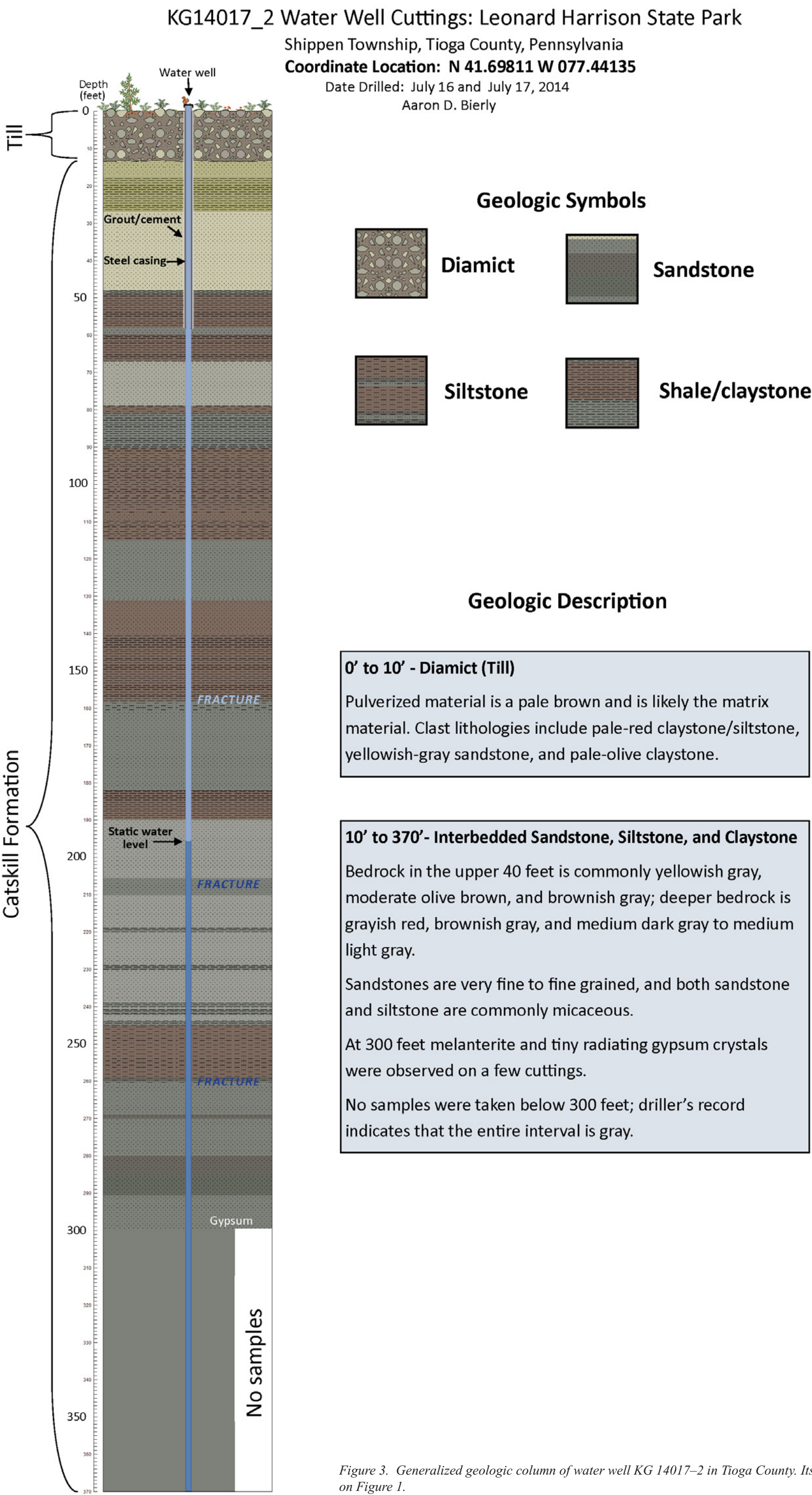
Bureau of Facility Design and Construction engineer Barry Eppley (retired) and Leonard Harrison State Park manager Chip Harrison agreed with the proposed location, and in the Winter of 2014 they started the contracting process to drill the well.

The bid was granted to Eichelbergers, Inc., who started drilling the well on July 16, 2014. During the first day they drilled 300 feet down and encountered at least three fractures at 158, 208, and about 260 feet bgs (below ground surface) (Eichelbergers, Inc., oral communication). The next day, Moore and Neboga went to the site and witnessed water gushing from the well as it was deepened to 370 feet, also encountering more fractures at 340 and 360 feet bgs (Figure 3). The measured well yield was 16.1 gal/min, much to the delight of the park personnel. An aquifer-pumping test (to evaluate the aquifer) was performed two weeks later and conducted for six hours. The discharge rate during this test was held constant at 11 gal/min. The water level declined from 196 to 258 feet bgs in the first hour of pumping and showed no significant drop for the remainder of the test. The water level recovered to 196 feet bgs within an hour after the test. Based on the test, it appears that the Catskill aquifer can supply the 10 gal/min target yield. A video of the water gushing from the well was recorded and can be viewed online at www.dcnr.state.pa.us/cs/groups/public/documents/multimedia/dcnr_20030782.mp4.

Water Quality of the Leonard Harrison State Park Well

Water-quality samples were collected in July 2014 and analyzed to characterize their physical and chemical quality. Samples were analyzed for 43 constituents and properties, including nutrients, major ions, metals, and trace elements. A review of the analyses revealed that water well KG 14017-2 produces water of excellent quality, meeting all primary and secondary maximum contaminant levels for public water supplies (Pennsylvania Department of Environmental Protection, 2006). Only the sodium concentration slightly exceeded the Environmental Protection Agency's health advisory level for sodium of 20 mg/L (milligrams per liter) (U.S. Environmental Protection Agency, 2003). The analysis indicated relatively hard water with 178 mg/L of dissolved solids. Most of the metals and trace elements in natural groundwater are leached from the soil or dissolved from the bedrock in minute quantities by circulating groundwater. Concentrations of major ions also were below maximum contaminant levels.

While describing the well cuttings, Aaron Bierly, a staff geologist, discovered white crystals on the sandstone cuttings from a depth of 300 feet (Figure 4). SEM (scanning electron microscope) analysis (Figure 5A) showed that the crystals contained calcium, sulfur, and oxygen, and probably constitute gypsum, CaSO_4 . John Barnes (another staff geologist), who ran this analysis, also found a small amount



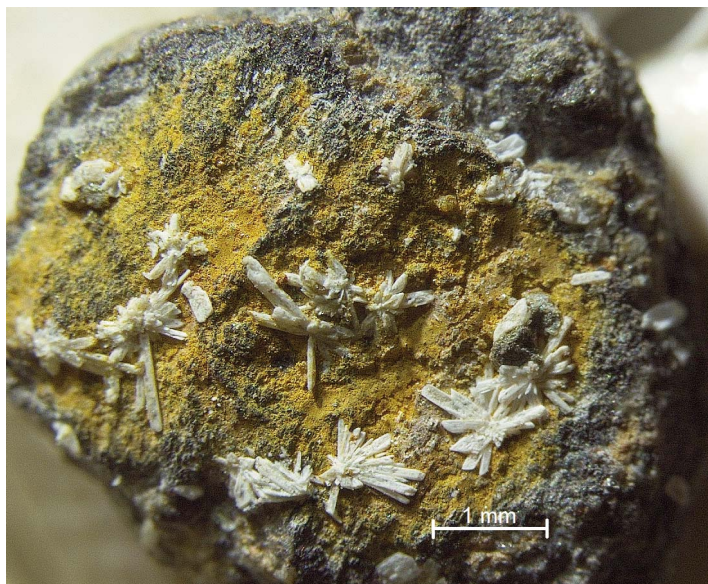


Figure 4. Cutting sample from the well KG 14017-2 in Tioga County showing white crystals of gypsum about 1 mm long. Photograph by Aaron Bierly.

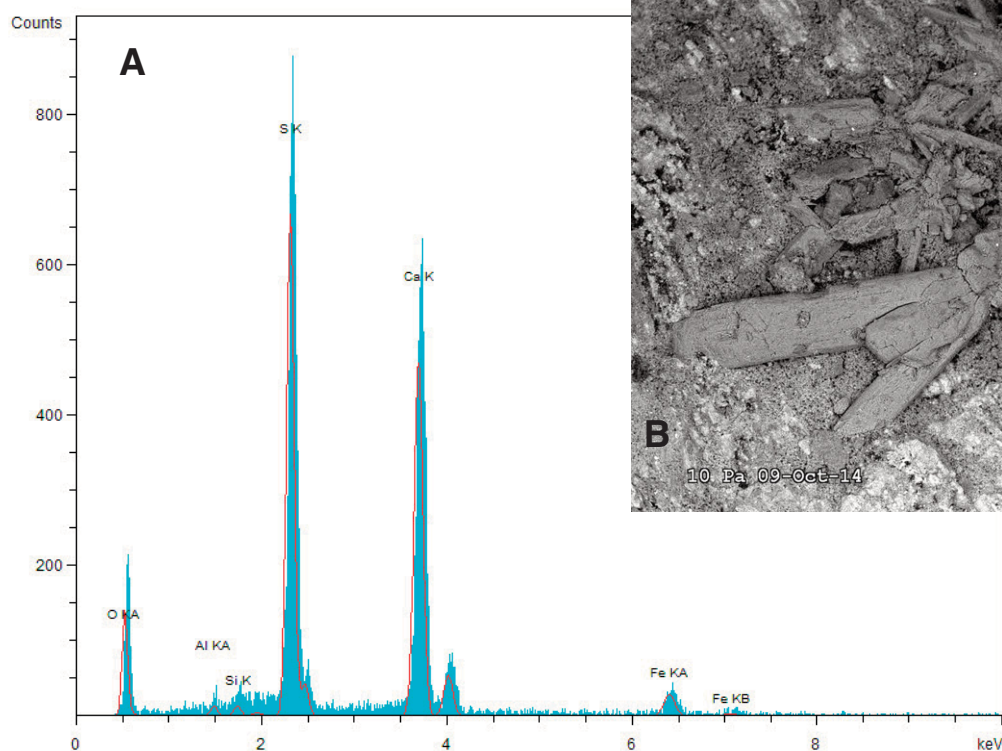


Figure 5. (A) EDS (energy-dispersive spectrometer) spectrum of one of the crystals shown in Figure 4, and (B) SEM photomicrograph showing radiating gypsum (CaSO_4) crystals and melanterite ($\text{FeSO}_4 \cdot \text{H}_2\text{O}$) patches above the letters "WD." Analysis and photograph by John Barnes.

of an iron sulfate mineral, most likely melanterite ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$) (Figure 5B). He also found a significant quantity of iron in the rest of the substrate, possibly as iron oxide.

The suspected area of melanterite is visible as a bright patch in the bottom center of Figure 5B, just above the letters “WD.” This figure is a backscatter image that was taken using the SEM. Bright spots in the upper right part of the image seem to be iron oxide. In a backscatter image, the brightness of an object is dependent on the atomic numbers of the elements that make up the object—the heavier the element, the brighter the object appears. The area of suspected melanterite is brighter because of the presence of iron (the heaviest element from the detected spectrum with an atomic weight of 55.84). The elements in gypsum are relatively light, so the gypsum crystals are rather dull in appearance.

Water Well in Buchanan State Forest

Bureau staff were also asked to investigate a possible well site near the proposed Resource Management Center in Buchanan State Forest, which looked promising for a good supply of groundwater beneath the slope of Little Scrub Ridge in the Appalachian Mountain section of the Ridge and Valley physiographic province. Many wells within a mile of the site had good yields of more than 15 gal/min. Swales observed on aerial photographs from the 1950s and 1960s were an indication that water-bearing fractures might cross the property. Bedrock at the site was steeply dipping limestone; mapped outcrop patterns to the west on the ridge top indicated that the rocks were likely fractured (Figure 6). Rock units include the Nittany Formation, Bellefonte Formation, undivided Salona Formation through St. Paul Group, Reedsville Shale, Bald Eagle Formation, Juniata Formation, and Tuscarora Formation. It should be noted that on the *Geologic Map of Pennsylvania* (Berg and others, 1980), separate terminology is used to differentiate carbonate units of central Pennsylvania as opposed

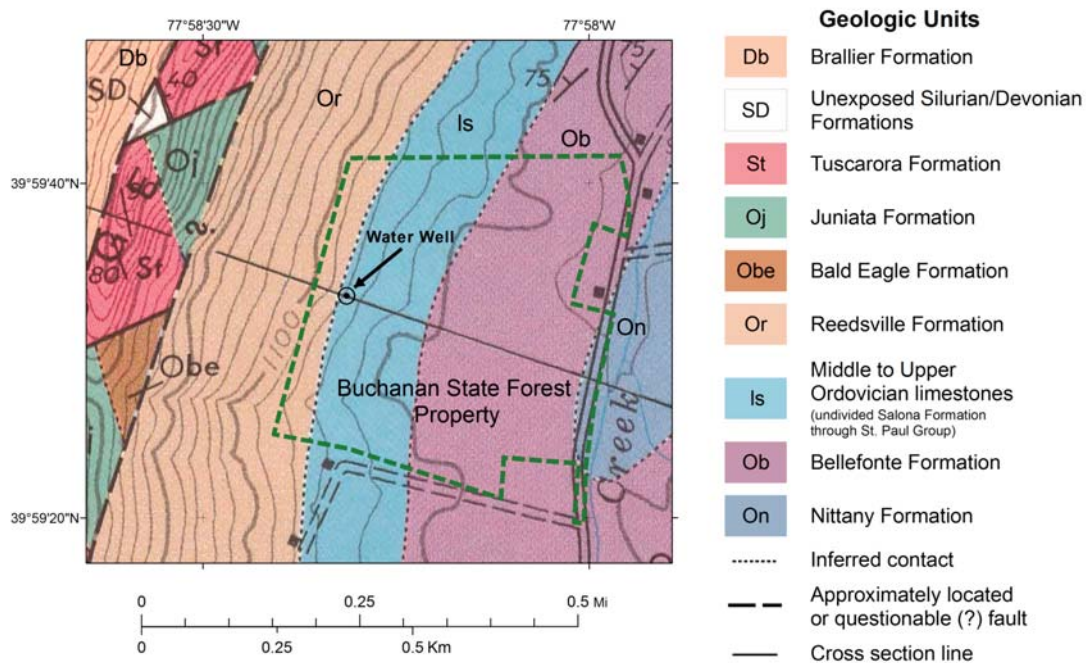


Figure 6. A modified section of the bedrock map of the McConnellsburg quadrangle (Pierce, 1966), showing the location of the water well. The cross section is not included in this article.

to those of the Great Valley province. Correlation with any particular formation is difficult. It can, however, be narrowed down to an interval somewhere between the Loysburg Formation and the Nealmont Formation (Map 1 units). In reality, this rock is probably transitional between the Great Valley carbonates and the central Pennsylvania carbonates, and further determination would be difficult without more geologic data. The age of this rock is approximately Middle Ordovician (458 to 470 million years ago).

The initial field visit did not answer questions. Dense brush and pines had covered the fields seen in aerial photographs from 30 and 40 years ago. Topographic subtleties were hidden; however, lidar DEMs supported the aerial photographs. Linear depressions matched up fairly consistently with apparent fracture traces on the photographs. Despite the thick vegetation, Stuart Reese (one of the authors) selected a tentative well site close to the proposed building location that had been staked. This was not the optimal hydrogeological location, because deeper, more substantial swales were mapped to the south; however, its proximity to the facility would lessen piping costs.

After the facility site was cleared of brush, a second field visit by bureau staff affirmed the location next to the proposed building site as a well site that could yield adequate water. A subtle swale could be seen at the proposed well site, which was located at the end of an east-west fracture trace. On July 16, 2014, Holt Drilling completed a 240-foot open-hole water well (Figure 7).

Staff geologist Bierly logged the borehole, which is shown in Figure 8. Despite a rather monotonous limestone lithology, closer inspection of cuttings showed secondary minerals calcite (CaCO_3) and pyrite (FeS_2) (Figure 9). Stylolites (irregular seams possibly caused by pressure dissolution and containing insoluble materials) were also present.

The driller estimated the well yield at 14 gal/min, which met facility requirements. Laboratory water-chemistry tests indicated hard water but of excellent quality.

Summary and Conclusion

Water is an essential mineral resource for everyone. Pennsylvanians use more than 1 billion gallons of groundwater every day. Despite the state's overall abundance of water, it is not always sufficiently available in areas where it may be needed. Geologists should consider all available tools and techniques when tasked to find enough groundwater for a particular need.



Figure 7. The drilling team (Holt Drilling Co.), preparing to add the 15-inch diameter drill. The top 20 feet of overburden was drilled at this diameter to set temporary surface casing. Photograph by Aaron Bierly.

FUL057_0345 Water Well Cuttings: Buchanan State Forest District Office

Todd Township, Fulton County, Pennsylvania

Coordinate Location: N 39.99210 W 077.97072

Date Drilled: July 14 and July 16, 2014

Aaron D. Bierly

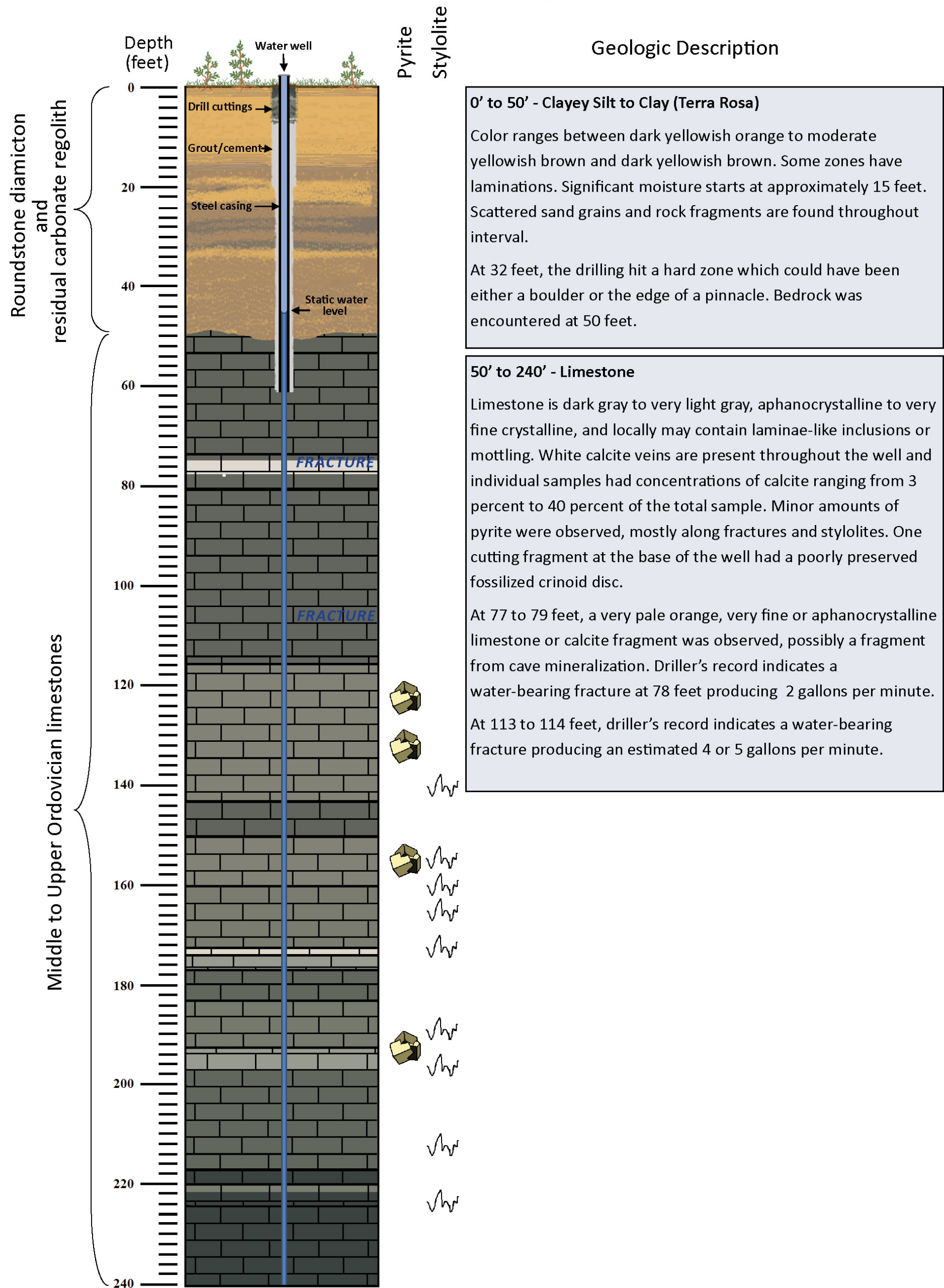


Figure 8. Generalized geologic column of water well FUL057–0345 in Fulton County. The location is shown in Figure 6. The dip of the bedrock is not horizontal. Based on previous mapping, it is likely dipping 75° to 80° to the northwest.

Acknowledgments

We would like to thank Aaron Bierly for describing the cuttings in both wells and constructing the geologic columns of the water wells. John Barnes kindly ran SEM analyses of the crystals to identify their mineralogy.

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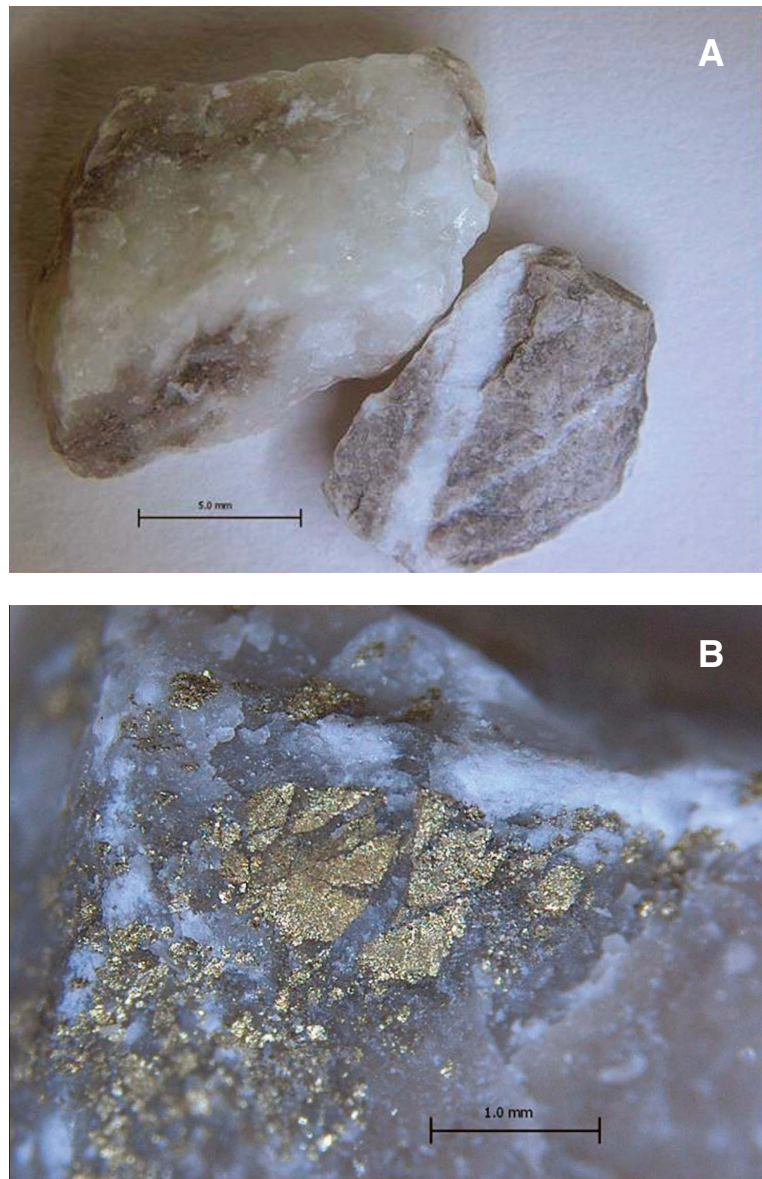


Figure 9. Photomicrographs of (A) calcite and (B) pyrite (noted in Figure 8).

An Interview with Outgoing State Geologist George Love

Editor's note: On May 29, 2015, State Geologist George Love will retire. He has provided many years of successful service to the commonwealth, and we wish him well in his retirement. We recently asked him about his background and his experiences as State Geologist of Pennsylvania.

What first sparked your interest in geology?

My desire to never return to New York City! I first went to college (Drexel Institute of Technology in Philadelphia) to study physics. The program was a 5-year deal—9 months for freshman year, the summer off, then 4 years of 6 months at school and 6 months as an intern. Rather than have the initial summer off, I was asked to go to New York and work for the then Atomic Energy Commission. After 6 months I was told I would be returning to fulfill my 6-month internships. As a kid from a farming community, I decided I would never return to “that place.” And as my choices were to return or quit, I decided to quit, and spent a year working in construction, which involved lots of ditch digging. I thought being a geologist would allow me to work outside, away from cities, and I could dig holes in things I found interesting. Young and naive! So off to Penn State I went.



The three most recent State Geologists. From left to right: Jay Parrish (2001–2010), Donald Hoskins (1987–2001), and George Love (2010–2015).

What did you do initially as a geologist?

Following my M.S. degree in geology, I was fortunate to receive a job offer in Pittsburgh to work for an engineering firm that was involved in engineering geology projects. The concept interested me as numbers and calculations had a role in the execution of the geologic work. As you know, geologists are almost as ambiguous as lawyers! Engineering geology offered an opportunity to use geology and apply some measurable values such as bearing strength, abrasion resistance, rock quality designation (RQD), density, and the like. That led to a multi-year career in the construction of dams, large industrial facilities, and tunnels. I almost fell from grace by working toward an M.S. in civil engineering with an emphasis on soil mechanics. What saved me? At the same time, I was involved in exploration for industrial minerals and any other natural material that my boss Mel Robinson of Dravo Corporation could think of. From aggregates to gold, he sent me off to look at deposits and to talk to every con man (no women, as they are too honest) who thought he had the world's largest deposit of you-name-it. Someday I'll tell you about my platinum experience. That whole combination of geology and numbers “naturally” led into mining. What geologist doesn't want to be first into the blasted area to see what pops up, or got blown up, or what leaked in, or see whether his calculation of reserves is anywhere close to the multi-millions of dollar value he guessed at?

Your recent career in the mining industry was working with phosphates in Florida and high calcium limestone in the eastern half of the United States. What led you to choose a career in those industries?

Once again it was an unnatural love of numbers. Mobil Corp. had a position as Geology Manager in Florida at its phosphates mines—and the travel requirements were FAR less than an exploration guy with a wife (Cheryl) and three children had been experiencing. Since I had earthmoving experience, had learned the value of a dollar, and could spell geology, they asked me to come to Florida and deal with the reserve position in the mines. Interestingly enough, the definition of reserves includes the concept of dollar value—real dollar value. Can you extract this raw material economically; can you beneficiate this raw material; do we have enough raw material to warrant a large investment to get a rate of return on the investment that will satisfy the investors? Because these questions interested me, I decided to combine my geology degrees with a degree in business administration, focusing on the finances surrounding mining operations. I had a lot of fun with that.

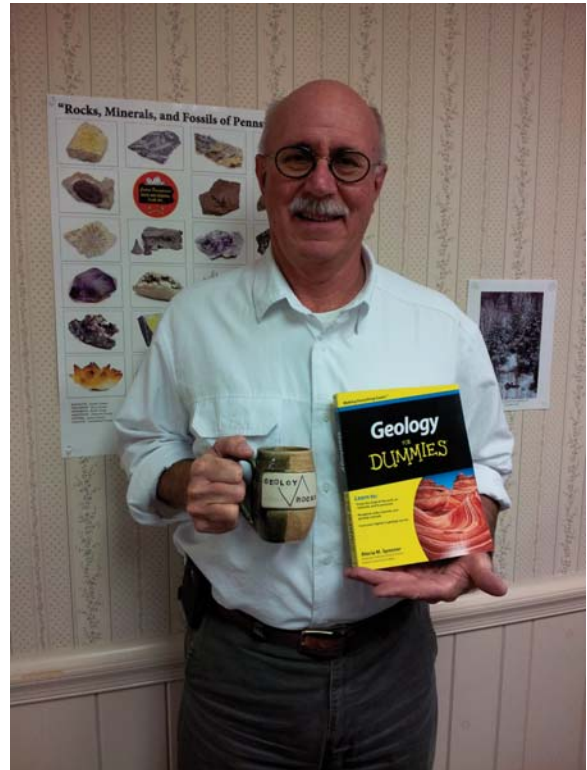
The migration into limestone resulted from a desire to get into colder climates (yes, it really was). Mobil decided to sell its Florida Operations unit to Cargill in 1996. I was asked by Cargill to run their Florida mining operations; my wife and I gave it about 12 seconds of consideration. We said no thanks and I promptly retired (for the first time!). Although Florida has its fair share of wonderful attractions, heat is the evil common denominator. The central Florida landscape (where phosphate mining occurs) is livable from about mid-November to late March. At least that was our opinion.

Too young to REALLY retire, I started looking around for opportunities. One in California, mining diatomaceous earth for kitty litter, caught my eye. The company asked me for references, so among those I contacted was an old Dravo friend. Unknown to me, he had become CEO of Dravo Corporation. He refused to give me a reference until I came to Pittsburgh to talk to him. Once in his office, we chatted for 15 minutes about old times, then he offered me a job. As my wife and I had lived in the Pittsburgh area before (and loved everything but the weather), and we knew the company, I took the job without asking for Cheryl's permission. And that is how I returned to limestone mining!

I don't think I consciously chose either of those opportunities for the sake of mining the specific commodities; I think they were the vehicles that allowed my family and me to do interesting things in an environment that sounded attractive. I joke about being migrant labor, but change and different opportunities to learn have always attracted me.

What were some interesting experiences that you had in the mining/geology sector?

Geology is a fascinating science. Yes, some people don't think it is a science, or even fascinating for that matter, but what do they know? Experiences I can *remember* and share involve bats, open stopes,



George Love is a modest person, and he is no dummy, but, if the coffee mug is any indication, maybe he does have trouble with spelling.



George was always interested in going into the field, no matter the task . . .

caisson inspections, dangling from ropes on high walls, walking into someone's "private growing area," crawling into abandoned mines, getting shot at, backfilling very old dumps, blowing up rocks, the list goes on. BUT, my most interesting experiences have always revolved around the people I have dealt with. Geologists and others who are related to, or who are circling around, our profession are fascinating. I do not know of another profession so filled with occupants that range from cynics to dreamers, mentors to bores, with a few paleontologists thrown in.

I will share three experiences. In Mexico, I was looking at an old mine as a possible investment target. My team had to go into old drifts (tunnels) that were filled with sleeping bats. As

we walked hunched over (in a very confined space) toward the ore vein, the bats took flight. I discovered that there is a maximum density to flying bats contained in a restricted space. Once that density is reached, they turn and fly into your face! I recommend, should you find yourself in this situation, DO NOT drop to the floor. That is the spot where many years of bat guano has accumulated, and cockroaches thrive on the material.

The second involves a person. I was sent to look at a mining property in Nevada. The owner welcomed me into his office, which was an old school auditorium. All the seats had been removed, save for one folding chair. The gentleman told me to sit down; he walked up the stairs onto the stage where his LARGE desk was situated. We negotiated, he on the stage, me on the floor in the small folding chair. I do not recall what his property was claimed to have, but we never came to a satisfactory agreement, and I did not get to see the rocks. I did get a cupcake and a glass of water from a woman who came into the "office" from some unknown portal!

The final involves a whale. In Florida phosphates, mining is strip mining. A large machine removes 30 to 60 feet of overburden—soil, sand, and muck—and then mines



. . . or how small it made him seem.

the orebody, which commonly ranges from 5 to 30 feet thick. The operations generally run 24/7—24 hours a day, 7 days a week. One mine I ran had 240 employees and produced 2 million tons of finished product per year so lots of money was spent each day. While mining, we encountered the skeleton of a baleen whale in the highwall. It was so unusual, and in such good shape, that the Florida Department of Environmental Protection (their name has changed but they were the regulators) asked to see/excavate the skeleton. I gave permission for a group of geologists and paleontologists to excavate much of the beast. I nearly lost my job because I shut down the operation for about 5 days. I doubt many folks in the mining business can blame a whale for missing their production quota!

How do you compare working in that industry to working for a government agency?

They are, in many regards, very similar. Both involve people—interesting but strange people. The work itself, from my perspective, is also similar—meeting objectives and managing costs. Some days are boring and some are filled with new and exciting events. In industry I complained about regulations, lack of funds, tight deadlines, and unrealistic requests from my superiors. Working in government I can reflect on the same constraints: policies vs. regulations; unfunded mandates issued by well-meaning but

ill-informed politicians; the need to rapidly complete some work assignment so someone can present some report to some group of people who will probably not use the data. I guess I sound bitter, but that is not the case. I can say, without reservation, that there are very positive aspects to working for the Department of Conservation and Natural Resources (DCNR). The mission is more altruistic and the people are dedicated to service. I have not worked in any other government entity so the answer is specific to DCNR.

Was there anything that especially surprised you about working here?

Yes! The people in DCNR are wonderful and dedicated. I had come into the initial DCNR job after my second retirement. Ten years with Dravo and its successor Carmeuse was enough. In all honesty, as an “industry person,” my impression of state workers was negative based upon my experience with regulators and watching highway road crews standing around. Now I know it is wrong to judge people by appearance, or to extend



George is a lifelong learner, always ready to study something new.

a bias to a large group based upon little to no information, but let’s face it, perceptions drive conclusions. I do not mind saying I was wrong on many levels. The quality of people, both professionally and on a personal basis, far exceeded my expectations. The DCNR folks are dedicated and engaged. I have said, and truly mean it, that were I still in private industry and needed the talents that I see here, I would do my darndest to hire them away. I also believe I would fail, as they are dedicated to the mission. So is this a surprise? Yes. Does it apply to government in general? I do not know.

Are there any experiences here that especially stand out?

You mean aside from the fact that I have completely failed at my original intention of becoming a geologist and learning to map?

The project the Survey conducted to collect data for the Carbon Sequestration project comes to mind. Then-Governor Rendell gave the Survey almost 7 million dollars to conduct a study of the potential for long-term geologic storage/disposal of carbon dioxide. That project allowed us to do some work that might never have been done otherwise. The seismic data collection operation was continuous, no weekends off. The seismic lines were run in western Pennsylvania in Indiana County and southeastern Pennsylvania in Lebanon and Lancaster Counties. The staff at the Survey never quibbled about the work schedule. If one was assigned to a Sunday afternoon standing along the roadside, they did it. Life is always better with a team of colleagues who pitch in as needed.

While nothing significant has as yet occurred as a result of the study, the issue of carbon sequestration remains. And for Pennsylvania, the Survey has gotten recognition as a group knowledgeable on the parameters that need to be evaluated for this type of effort. And most importantly, all the data collected are available to the public.

The other experience that impressed me is the PAMAP effort, a project that was underway when I joined the Survey. What I saw was the Survey, under the leadership of my predecessor Dr. Jay Parrish, moving forward on a truly groundbreaking effort to gather statewide orthophotography and then statewide lidar coverage that was current, seamless, and most impressive, free to the public. This effort cost more than 20 million dollars, funded by DCNR and a consortium of other groups such as Pennsylvania county governments and the U.S. Geological Survey. I think the real credit for this effort must go to the Survey personnel, the then current senior leadership of DCNR, and Dr. Parrish. His tireless efforts are hard to underestimate.

What do you think are the geological challenges facing Pennsylvania in the foreseeable future?

What a question! The challenges are many, and they can be broken into many compartments, but I think at the root is education, specifically the lack of education on and recognition of the value of geology. Now that is not to say we Pennsylvanians are special in our lack of understanding. On the contrary, recent testimony by Dr. P. Patrick Leahy of the American Geosciences Institute, to the U.S. Senate Subcommittee on Interior, Environment, and Related Agencies, states:



George likes to be just one of the crowd. Here he is at a recent field trip for the Field Conference of Pennsylvania Geologists.

“Minerals and their materials form the basis of critical infrastructure and advanced technologies upon which we rely. The United States is the world’s largest user of mineral commodities. Aggregates for bridges and roads, metals for pipelines and transportation, and elements for computers and defense systems contribute to our national security, economy, and overall global competitiveness. Despite our dependence on these materials, the U.S. has not invested the necessary funds in programs to identify and characterize our mineral wealth and quantify the domestic and global supply of, demand for, and flow of minerals and mineral materials. The nation lacks the infrastructure necessary to support advanced mineral forecasting, leaving important supply chains susceptible to disruptions. Increased federal investments in minerals science and research are necessary to overcome this liability.”

Many people think that once an area is mapped, the geologic work is done. I can say this as it was a question I struggled with early in my career. Today, the geologic challenges are not simply “rock” questions; they are much broader but are directly impacted by geology. A challenge is to have decision makers/policy writers recognize this fact. For example, Pennsylvania has a long history of property rights independence. If I own 500 acres in the Palmyra area and wish to sell those acres for a development, I can do so. Some congestion or building height or development density issues may be problematic from a zoning perspective, but there are no controls on development in karst-prone terranes (read: sinkholes). Real estate agents, land developers, and mortgage institutions in the immediate area surely know about the potential problems and should share this information. Yes, I know this might infringe on owners’ rights, but there are too many times where this information should be shared because the buyer is unaware. The Latin expression *caveat emptor* is not fair in these types of situations. Who is looking out for the uninformed homeowner who winds up with one or more of the following: a sinkhole in their yard or under their house; a landslide dampening the beautiful view from the edge of a hill; or radon gases trapped in their basement leaking into the children’s bedrooms? These are “geologic” issues. They do not preclude development; they just require that thought be given to how development occurs. Yes, until people are educated to realize that these types of natural hazards exist and can be dealt with, much complaining will be heard from those who feel their rights have been trampled upon.



George in his office, ready to do battle with uninformed decision makers.

Of course there is always the matter of sterilization of natural resources. Developing a neighborhood, then complaining when a quarry wants to open nearby to provide the resources that were critical to the development of their neighborhood is another example of the failure to educate the public about where that item or energy or resource came from.

Currently, we Pennsylvanians are confronted with the development of the Marcellus shale. This shale and other similar organic-rich horizons are producing an energy resource that we all want and want cheaply. The problem is that its development and extraction come at a price. We must look at the problems that accompany this development and rationally address them. The contamination of groundwater and existing groundwater wells is not a geologic problem in the academic sense; it is related to man’s activities that are exacerbated by a failure to understand the geologic parameters. Sure, failures to perform to code, or spills, or disregard for safety occur, but they are not geologic in nature. So the need to educate the public on the value of the geologic resources and how they are required to maintain our standard of living IS a geologic challenge.

Aren't you sorry you asked? Perhaps I should have simply said, "The uninformed making decisions."

What role do you see for the Survey with regard to these challenges? Do you see its role changing anytime soon?

The Survey's role is well described in its Mission Statement:

"To serve the citizens of Pennsylvania by collecting, preserving, and disseminating impartial information on the Commonwealth's geology, geologic resources, and topography in order to contribute to the understanding, wise use, and conservation of its land and included resources."

What is not appreciated is the need for resources to accomplish the task, and the will to accept some of the outcomes of the work. We must continue our efforts to describe the resources we have here in Pennsylvania, to be aware of the new replacement resources that are required to maintain our standards, and to look for the mineral resources that will become important in the future. Those are standard thoughts anyone can blurt out. But what is required to make them meaningful? We need more information about our commonwealth. Some examples are: Where are the aggregates we need for tomorrow's transportation infrastructure and how do we protect them? What geologic issues might hamper development at this spot? Why is an abundant commodity such as groundwater worthy of protection?

From the purely geologic standpoint, we need to gather more information on what is happening at depth in our state. The U.S. Geological Survey is updating its Seismic Risk Map to include projections on potential seismic events within a shorter than 50-year term. This in theory will address injection wells and their unholy prodigy, anthropogenic events. We need to gather more information on the abundant groundwater resource that is sustaining our population, both urban and rural. This state has an enormous number of private wells servicing a fair part of the population. An overabundance of a natural resource is a good reason to be protective of it; taking water for granted may prove to be problematic in the next few decades. And of course, if we continue to develop our land at today's rate, geohazards must be recognized and addressed. The blind eye attitude some have merely pushes the costs and inconvenience down the road. Does this sound familiar?

We Survey employees must wear two hats. The "geology" hat is obvious—work on those projects that address the Survey mission. The other is, or can be, less comfortable. Engaging in outreach by making public presentations, writing understandable reports, spending some time in a grade school classroom, all are part the marketing of the Survey. We exist because someone saw value in our work. The Survey must continue both the geologic work and marketing effort. That sounds a like a self-serving comment, and it most definitely is! Given the competition for state funding, if we stop pointing out our value, no one else will step in except to take our meager dollars.

You have combined family with your work, for example bringing your grandchildren to the office when they are visiting you. What is the role of your grandchildren in your "next" career?

As a young geologist, I spent a lot of time on the road. Being a good employee ready to cover whatever need was important to my employer seemed critical to me to advance my career. The sacrifice was family time. Upon reflection, I missed some important aspects of my family life. Maybe I am smarter now? At any rate I want to spend more time with those people who are important to me. My grandchildren are a big part of that goal. So perhaps the answer is that my career has allowed me to get to the point where I can share time with important people—my wife, my children, and my grandchildren. The role of my grandchildren in my career? They are the catalyst for spending my remaining years focused on sharing what I have learned, and learning about and enjoying what others

think is important. A far cry from my super-red personality—I know what is right/important, so you had best get going to meet MY objectives!

If you had not chosen geology as a career, what other path do you think you would have taken?

That is a very hard question. I know many people who have a cause for which they volunteer, or a hobby they enjoy, such as music, carpentry, or cooking. Asking them this very question over the years, I have heard them talk passionately about those things they enjoy or have a talent for, and what they might have done. Many things interest me, but my terribly short attention span has not driven me toward anything in particular. If I had completed my original education in physics, I have no idea where or what I might be. Had I not gotten pushed into mine management, I have no idea if I would have remained in geology. Maybe my love of numbers would have led me into the actuarial profession. Sitting alone in a windowless room using someone else's data to determine what people should pay for life insurance to guarantee a profit for the company. Maybe THAT is where I would be.

Many retired Survey staff members never completely go away. They continue to make contributions as volunteers. Do you plan to join them? What do you plan to do?

YES! It's about time I "do some geology," whatever that may be! I see myself tagging along behind a geologist, asking questions and carrying rocks; working for John Neubaum in the core library and driving the hand truck; doing Jody Smale's bidding by scanning old photos; filling Aaron Beirly's HCl bottle so he can hose down the outcrops; and eventually mapping the Columbia West quadrangle after I learn what a pelite is, and why ophiolite is such a handy word to describe a bunch of random stuff that is hard to describe!

My wife and I are moving to Delaware for a few years before returning to reside locally. During my Delaware years I will be volunteering with the Delaware Geological Survey's advisory committee for StateMap projects and hanging out hoping to get a ride on their oceanographic vessel. Periodically we will return to the local area. Those will be the times I will be doing whatever some kind and sympathetic soul at the Pennsylvania Geological Survey will allow me to do.

This is a great place to work, and it has interesting and talented folks. I can only hope I will be allowed back in the door!



As George heads on down the road to his future, we wish him a long and happy retirement.

BUREAU NEWS



Paxtonia Elementary School Science Night



Mark Brown and Aaron Bierly represented the bureau on February 6, 2015, at Paxtonia Elementary School's 15th annual science night. This year's geology theme focused on economic geology. An educational display having multiple mineral samples and products demonstrating the raw geologic materials industry uses to make many of our daily household items was available, as was some rock core and drilling bits.

However, the real fun was when the students (miners, not minors) got to experience mineral extraction first hand by mining the chocolate chip "ore" from a cookie. All the miners were given \$10 in play money, with which they purchased land (the cookie) and mineral extraction tools (paper clips and two types of toothpicks) to quarry out the chips. The task was not easy, as only the tools could make contact with the cookie. Broken tools could not be reused, and a reclamation fee took away from the miner's profits. After five minutes Mark and Aaron evaluated the quantity and quality of each miner's work and paid them accordingly so they could purchase prizes (Pennsylvania Geological Survey temporary tattoos).

The activity was a simplified version of one from the Earth Science Week website. The more detailed version can be found at www.earthsciweek.org/classroom-activities/cookie-mining.



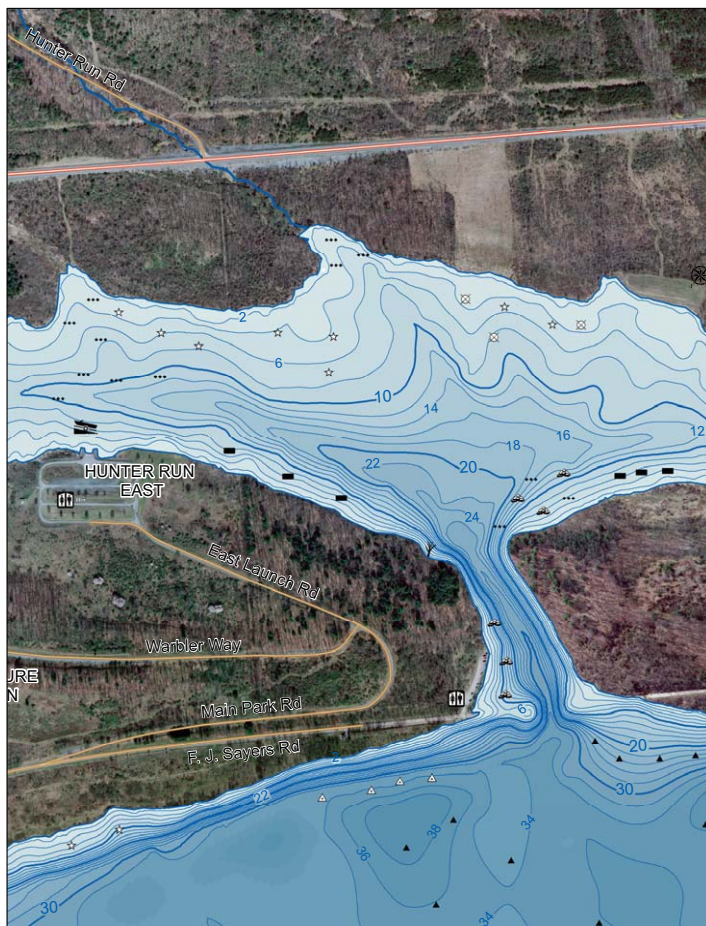
Mark Brown explaining the mining activity to a group of students.

Bathymetric Maps Now Available

Have you done any fishing or recreational boating in our state parks? The Pennsylvania Geological Survey has just released bathymetric (water-depth) maps for 19 state park lakes that should be of interest to all the anglers and boaters out there (see the figure below for an example). The maps, part of the Survey's Open-File Miscellaneous Investigations, are the result of data gathering that began in January 2005. They were created in large part through the efforts of staff geologist Rose-Anna Behr.

Depth and location readings on the lakes were obtained with a Garmin 3006C integrated depth finder and GPS. Back in the office, the data were imported into an ArcGIS file geodatabase, and ArcMap was used to create contour maps of lake depths. PAMAP orthoimagery was the base map for most of the surveyed areas.

In addition to water depths, the maps display fish-friendly structures such as stumps or downed trees, and amenities such as boat ramps, concessions, and restrooms. Please keep in mind that although the maps are meant to assist boaters and anglers, they were not designed for navigation. Lake depths can change due to drawdown, flooding, and siltation, and fallen trees and other debris may have moved since the data were first collected.



The 19 park lakes having published maps are listed on the next page and also on the bureau's web page titled ***Bathymetric Maps for Lakes in Pennsylvania State Parks.*** Published maps can be downloaded from the Pennsylvania Geological Survey's website. Click the report title link where it is listed under Open-File Miscellaneous Investigations. An article on the bureau's foray into bathymetry, associated field techniques, and the initial purpose of the research can be viewed in *Pennsylvania Geology*, v. 35, no. 1, p. 10–12.

Portion of lake depth map showing park amenities and fish habitat improvements at Bald Eagle State Park.

RECENT PUBLICATIONS

Open-File Miscellaneous Investigations (clicking on a link below will result in a download of the report): **(April 2015)**

- [Water depth of Hills Creek Lake—Hills Creek State Park, Tioga County, Pennsylvania](#)
- [Water depth of Canoe Lake—Canoe Creek State Park, Blair County, Pennsylvania](#)
- [Water depth of Holman Lake—Little Buffalo State Park, Perry County, Pennsylvania](#)
- [Water depth of Kettle Creek Reservoir—Kettle Creek State Park, Clinton County, Pennsylvania](#)
- [Water depth of Keystone Lake—Keystone State Park, Westmoreland County, Pennsylvania](#)
- [Water depth of Raccoon Lake—Raccoon Creek State Park, Beaver County, Pennsylvania](#)
- [Water depth of Chapman Lake—Chapman State Park, Warren County, Pennsylvania](#)
- [Water depth of Memorial Lake—Memorial Lake State Park, Lebanon County, Pennsylvania](#)
- [Water depth of Lake Jean—Ricketts Glen State Park, Luzerne and Sullivan Counties, Pennsylvania](#)
- [Water depth of Lyman Run Lake—Lyman Run State Park, Potter County, Pennsylvania](#)
- [Water depth of Frances Slocum Lake—Frances Slocum State Park, Luzerne County, Pennsylvania](#)
- [Water depth of Whipple Lake—Whipple Dam State Park, Huntingdon County, Pennsylvania](#)
- [Water depth of Laurel Hill Lake—Laurel Hill State Park, Somerset County, Pennsylvania](#)
- [Water depth of Kooser Lake—Kooser State Park, Somerset County, Pennsylvania](#)
- [Water depth of Doubling Gap Lake—Colonel Denning State Park, Cumberland County, Pennsylvania](#)
- [Water depth of George B. Stevenson Reservoir—Sinnemahoning State Park, Cameron County, Pennsylvania](#)
- [Water depth of Shawnee Lake—Shawnee State Park, Bedford County, Pennsylvania](#)
- [Water depth of Marsh Creek Lake—Marsh Creek State Park, Chester County, Pennsylvania](#)
- [Water depth of Foster Joseph Sayers Lake—Bald Eagle State Park, Centre County, Pennsylvania](#)

GEOFACTS

The Peculiar Habits (and Observations) of Geologists

Thomas G. Whitfield
Pennsylvania Geological Survey



Geofact 44

Lacking pack mules (interns), staff geologist John Neubaum utilizes the “Jacob Marley” technique for transporting a geophone array. Photograph by Michael E. Moore.

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 be seen in full on our website at

www.dcnr.state.pa.us/topogeo/publications/pageonline/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.

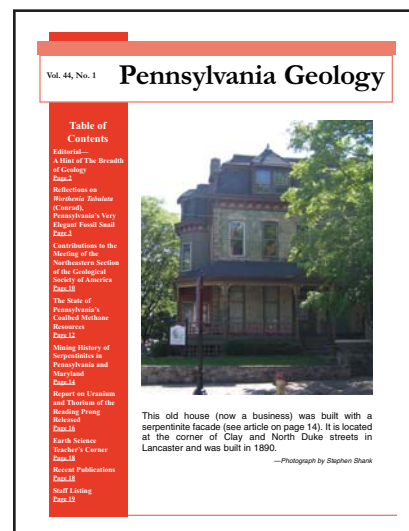
Earth Science Teachers’ Corner: Articles pertaining to available educational materials, classroom exercises, book reviews, and other geologic topics of interest to earth science educators should be 1 to 2 pages in length and should include illustrations where possible.

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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