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Pennsylvania Geology

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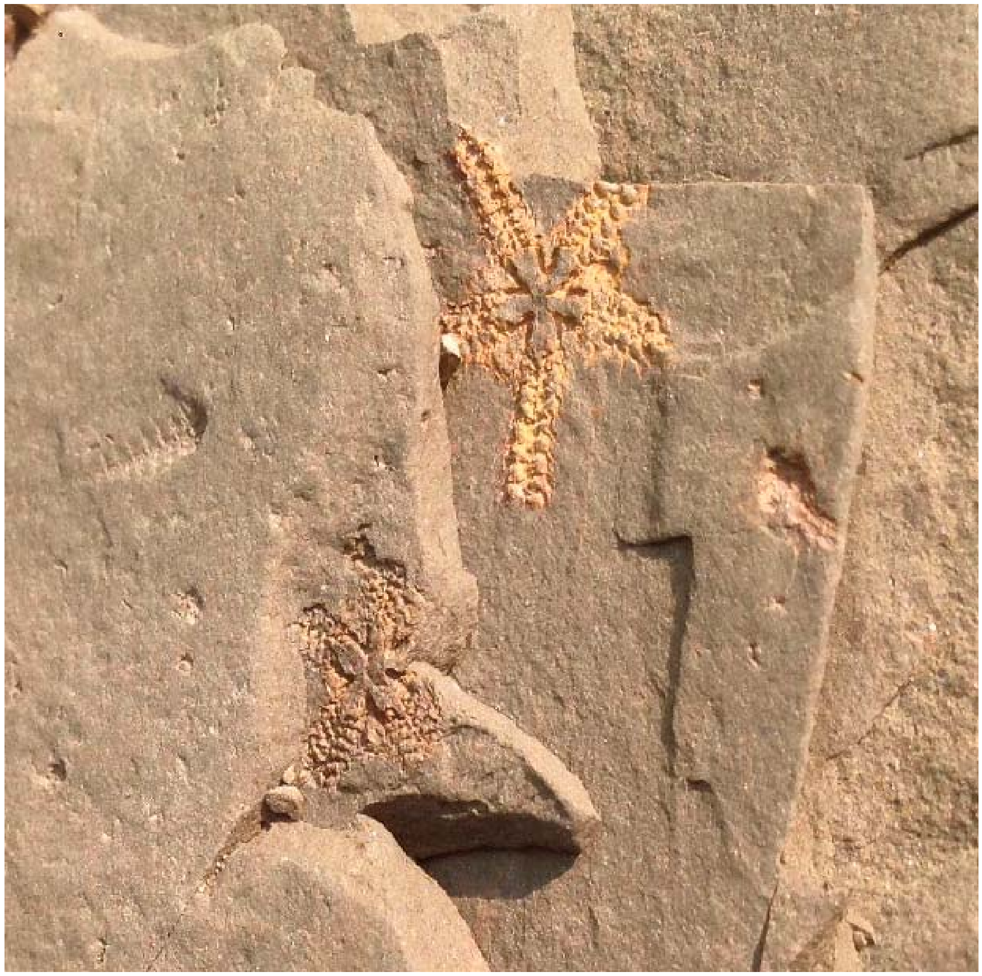

Brittle stars in the Ordovician Reedsville Formation from a borrow pit on Tussey Mountain near State College, Pa. (species identification is pending). Starfish are uncommon fossils in Pennsylvania, and they have not previously been identified in the Reedsville in Centre County. However, they have been found in the correlative Martinsburg Formation at Swatara Gap, Pa. Specimen collected and photographed by Anna Whitaker (a student at the Pennsylvania State University).

EDITORIAL

Holes in the Ground

Gale C. Blackmer, State Geologist
Pennsylvania Geological Survey

Geologists have an almost gravitational attraction to holes in the ground. From drill holes to construction excavations to quarries and mines, give us an opportunity to observe or go in, and we're there. Part of the attraction could be that we find it comforting to be surrounded by rocks. More practically, though, those holes in the ground provide large outcrops that are not naturally abundant in our beautifully verdant state. Drill holes can show us 1,000 feet or more of uninterrupted stratigraphy laid out in one continuous core and can provide a window into groundwater conditions and subsurface fracture populations. Quarries and mines give that same continuous view on a grand scale, commonly exposing fine stratigraphic or deformational detail and even adding a third dimension. The Rupp Quarry, described in this issue, allows the visitor to stand in the middle of a 480-million-year-old tidal flat, complete with individual storm deposits and algal mats that can still be seen in the rocks. And you never know when some nondescript borrow pit will yield a rare fossil.

Our colleagues in the Department of Conservation and Natural Resources tend to recoil in horror at the thought of opening holes in the ground. While as outdoor people and nature lovers we geologists can sympathize with them, we also like to pull out that often-overlooked bit of bumper-sticker wisdom: "If it can't be grown, it has to be mined." The new version of the *Directory of Nonfuel-Mineral Producers in Pennsylvania* is a reminder of why we need these holes in the ground. In 2011, the latest year for which data are available, the value of nonfuel-mineral production in Pennsylvania totaled $1.6 billion (that's billion with a "b"). Mineral production is an important part of our state's economy, and it provides raw materials essential to maintaining our way of life. The most common use of Pennsylvania minerals is in the broad category of construction aggregate. Quarries and mines also provide materials for dimension stone and a variety of industrial and agricultural uses. And then there is coal, oil, and gas, but that's another story.

It is important to realize that holes in the ground don't have to last forever. Certainly there are instances we can point to around the state where such holes have left scars on the landscape. But many more have been converted to other uses or have melted innocuously into the landscape. The Rupp Quarry now holds a parking lot. Many small quarries that once served as local sources of agricultural lime are now farm ponds, their origin completely unknown to new owners of the land. I have spent many days in the field searching in vain for evidence of quarries marked on maps from the 1920s that are now buried under housing developments and farm fields. One memorable "disguise" in Chester County was a kaolin clay pit now completely filled and hidden without a trace under a cornfield.

As we collectively move forward into what we hope is a more sustainable future, let's remember that holes in the ground have important uses. And once their minerals have been responsibly extracted, many of those holes can be made to fade into the landscape, after the geologists have had their fill of examining the rocks, of course!

Gale C. Blackmer

Carbonate Tidal-Flat Deposits in Rupp Quarry, Centre County, Pennsylvania

Charles E. Miller, Jr.
State College, Pa.

Introduction

For decades, an abandoned half-acre quarry (Figures 1 and 2) in State College, Pa., has been a field stop for Pennsylvania State University geology students. The Rupp Quarry exposes tidal-flat deposits in the Half-Moon Hill Member (Lees, 1967) of the Axemann Formation of the Lower Ordovician Beekmantown Group (Table 1). Included among the many sedimentary features seen here are the largest stromatolites in the local area. Despite partial backfilling and urban encroachment, this quarry still provides one of the best exposures of the Half-Moon Hill Member.

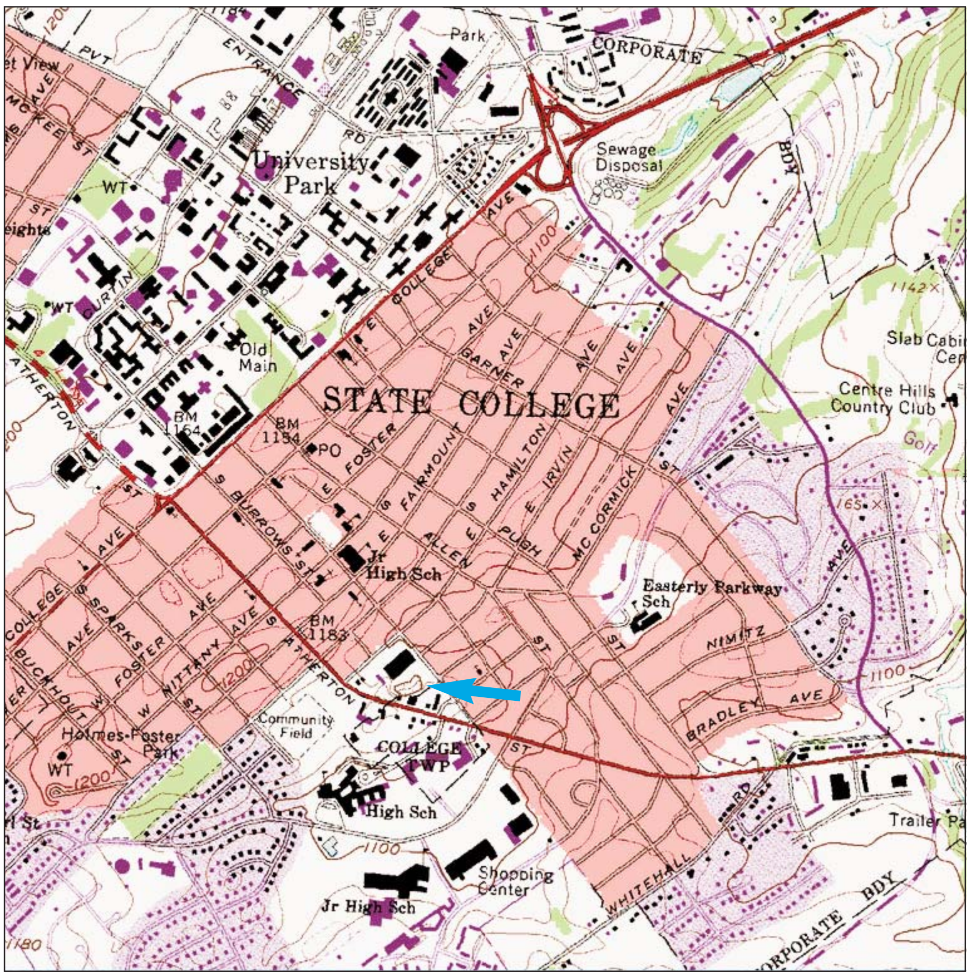

Figure 1. Location map for Rupp Quarry (colored arrow). Base from State College, Pa., 7.5-minute quadrangle, U.S. Geological Survey.

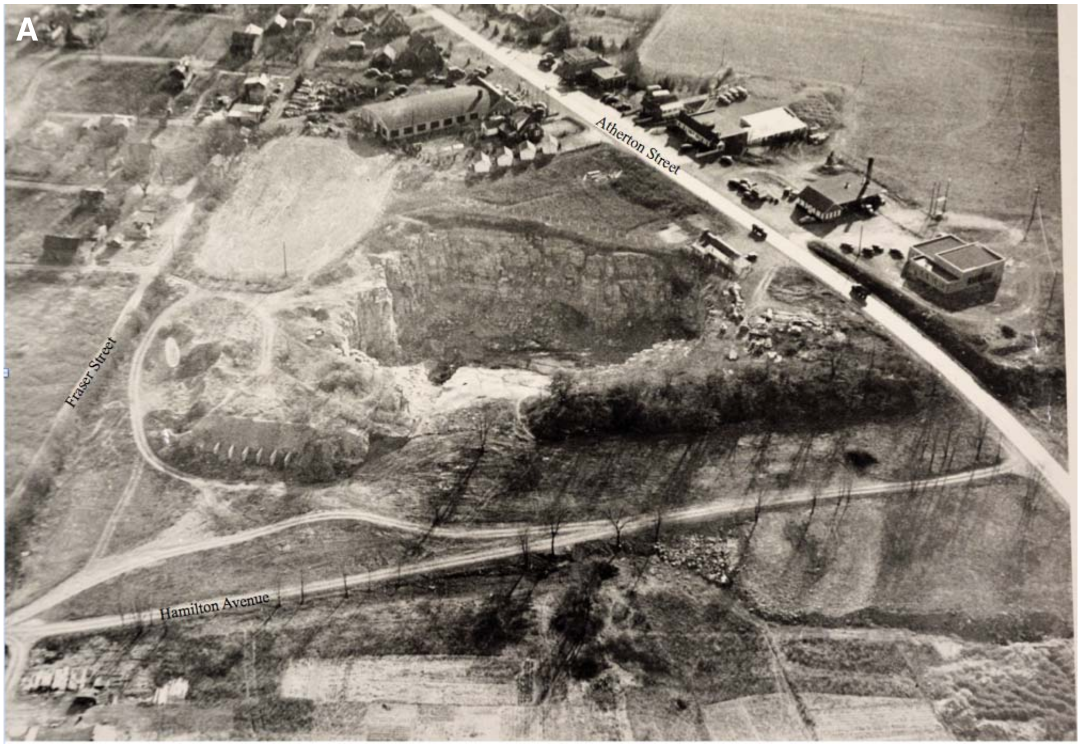

Figure 2. A, Oblique aerial view (circa 1938) of the Rupp Quarry (center) showing mining at an approximate maximum depth of 70 feet. B, Oblique aerial view (taken sometime between 1994 and 1997) of the Hamilton Square Shopping Center (number 1) and Rupp Quarry (number 2). By 1959, the quarry was backfilled to approximately 50 percent of its original total depth.

Table 1. Generalized Stratigraphy of the Lower Ordovician Beekmantown Group of Central Pennsylvania
(From Parizek and White, 1985)

System	Group	Formation	Member	Thickness (feet)
Ordovician	Beekmantown	Bellefonte (dolomite)		1,200
		Axemann (limestone)	Half-Moon Hill	400
			Rockview	
		Nittany (dolomite)		1,200
		Stonehenge (limestone)		600

Location and History

The Rupp Quarry, previously the O'Bryan (or William O'Bryan) Quarry (Rich Francke, personal communication), is located behind the Hamilton Square Shopping Center on Hamilton Avenue (Figures 1 and 2B). The quarry was active by 1911–12 (Frear, 1912) and was eventually excavated to approximately 70 feet (Figure 2A). Mining is thought to have ceased in the 1930s. By 1959, the quarry was backfilled to approximately 50 percent of its former depth. In that year, the shopping center was built, and the backfilled area became a parking lot. From 1994 to 1997, Championship Mini-Golf occupied part of the quarry. Since about 1999, Walk's Towing has used the same area for towed vehicles (Figure 2B). This section of the quarry is now fenced in, and permission must be obtained from Walk's to enter. In 2013, Cliffside Apartments was built above one abandoned highwall, covering the surface exposures.

Geologic Setting

The quarry is located in Nittany Valley, an anticlinal valley largely underlain by Cambrian-Ordovician carbonates. The Axemann (Table 1) is part of a local 7,000-foot carbonate sequence deposited on an early Paleozoic platform that fringed eastern North America. This great American carbonate bank represents 100+ million years of nearly continuous carbonate deposition (Demicco and Mitchell, 1982).

Stratigraphy

In central Pennsylvania, the Axemann ranges from 200 to 700 feet thick. At Rupp Quarry, 80 feet of strata are exposed: 76 feet of Axemann and 4 feet of overlying Bellefonte dolomite (Table 1). Lees (1967) provided detailed stratigraphic descriptions of this measured section. In the State College area, the Axemann can be divided into two members: a lower Rockview Member and an upper Half-Moon Hill Member. Only the latter is represented at Rupp Quarry. The best estimate for total thickness of the Half-Moon Hill Member is 150 feet (Lees, 1967).

The general lithology at the quarry is calcilutite (composed of clay-sized and silt-sized carbonate grains) interbedded with dolomite (Table 2). Closer inspection shows a more complex bedding of different lithologies, including calcarenites (calcareous sandstone) and calcirudites (calcareous gravel or

Table 2. Generalized Lithology and Thickness of Units at Rupp Quarry
(Modified from Lees, 1967)

Unit	Thickness of unit (feet)	Cumulative thickness (feet)
Dolomite	4	80
Calcarenite, pelmatozoan. Fossils include straight-shelled cephalopods and *Ceratopea ankylosa,* a gastropod operculum.	.5	76
Dolomite	8.5	75.5
Calcilutite, somewhat calcarenitic; dolomite	6	67
Dolomite	4	61
Calcilutite, calcarenite, dolomite	6	57
Dolomite	2	51
Calcilutite, calcarenite	4	49
Dolomite	4	45
Pelmatozoan calcarenite, calcilutite, dolomite	11	41
Calcilutite, calcarenite, calcirudite	1	30
Dolomite	2	29
Calcilutite, dolomite	1	27
Dolomite	1	26
Calcilutite, calcarenite	2	25
Dolomite	3	23
Calcarenite	2	20
Dolomite	6	18
Calcilutite, dolomite, calcarenite	12	12

conglomerate), reflecting environmental changes. Small-scale interbedding of strata several inches thick or less indicates rapid environmental changes, such as those that happen during storms (Lees, 1967).

Rupp Quarry strata represent carbonate tidal flats, which can be divided (from top to bottom) into supratidal, intertidal, and subtidal zones (Figure 3). In modern carbonate environments, supratidal zones are subaerially exposed except during storm surges and spring tides. Supratidal deposits in the quarry include dolomite, algal mats (finely laminated dolomites), mud cracks, evaporites, teepee structures (formed by the buckling of a sedimentary layer), and very restricted or absent fauna. Intertidal zones range from high to low tide. Intertidal deposits include intraformational conglomerates (rip-up clasts), disarticulated fossils, and “cabbage-head” stromatolites. Subtidal zones are below wave base and are permanently covered with water. Subtidal deposits are predominantly calcilutites. Each zone produces lithologies, sedimentary features, and fossils distinctive enough to differentiate one from the other. See Miller (1971) for a review of carbonate environments.

Of the intertidal features, large three-foot-tall “cabbage-head” stromatolites (Figure 4) are striking. These fossils are blue-green algae (cyanobacteria). Stromatolite morphologies reflect their distribution in modern tidal flats (Figure 5). Supratidal forms consist of laterally linked hemispheroids (LLH) having continuous laminae. They are commonly associated with algal mats. Intertidal stromatolites, such as

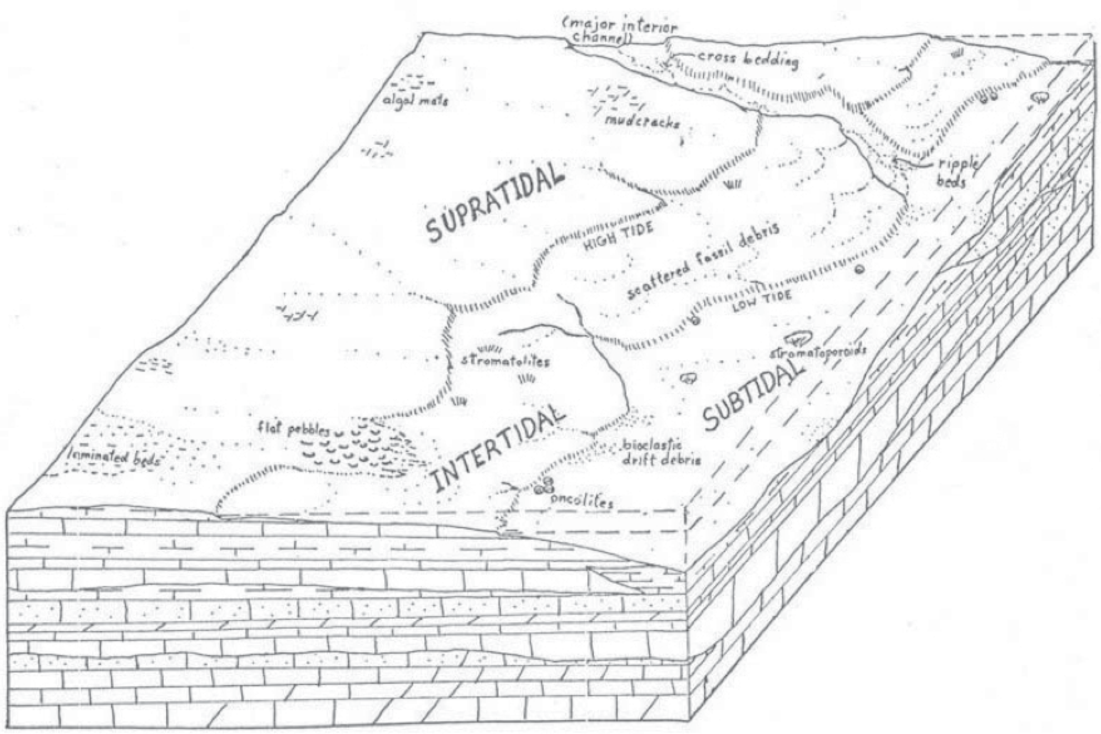

Figure 3. Block diagram showing the three zones of a carbonate tidal flat (Miller, 1971).

Figure 4. Three-foot-tall intertidal "cabbage-head" stromatolites at Rupp Quarry. These are the stacked hemispherical (SH) type. The folding knife is 4 inches long.

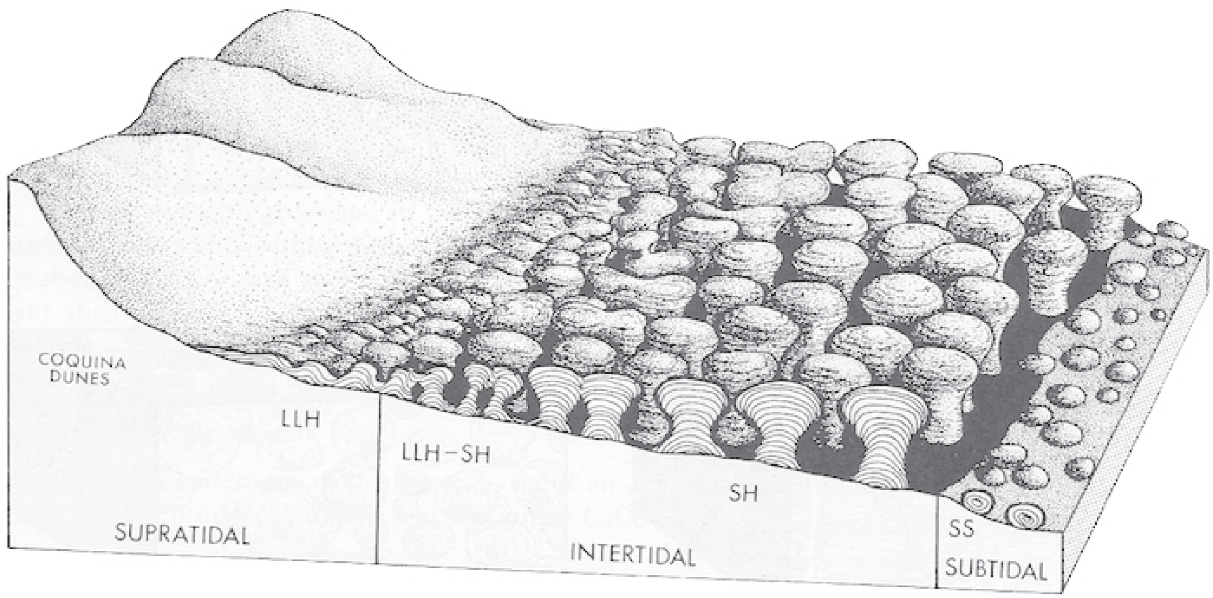

Figure 5. A generalized distribution of stromatolites in tidal flat environments (see text for explanation) (Anstey and Chase, 1974; used with permission).

those seen in the Rupp Quarry, develop larger, more distinct domes or hemispheroids, forming columns or clublike “cabbage heads” that are classified as stacked hemispherical forms (SH) and transitional LLH-SH forms. Subtidal forms, designated SS (for spheroidal structures), are not present at Rupp Quarry.

The height of intertidal stromatolites (the SH and LLH-SH types) has been considered as a paleotidal indicator (Cloud, 1970). This would be a valuable tool for determining tidal amplitudes in the geologic past. However, there are several caveats. The principal problem is misinterpretation of the preserved fossils as if they were large, treelike 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, one can see that the stromatolite top projected above the surrounding sediment surface by only inches, not feet. Additionally, shoreline configuration, water depth, and storms are some of the factors influencing the height and timing of tides at a locality. For example, the Bay of Fundy in 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 that the tidal range there was totally due to lunar influence. In addition, assuming that exceptionally high tides were an average for that geologic time period is equally erroneous. The caveats associated with intertidal stromatolites have led to geologists no longer using these features as paleotidal indicators.

Additional fossils found in the quarry include pelmatozoans (a type of echinoderm), gastropods, and cephalopods. Of these, the gastropod *Maclurites affinis* (now known as *Teiichispira affinis*) (Figure 6) is an index fossil for the Axemann. This means that the fossil ranges vertically through the formation and is not found in other local carbonates (Lees, 1967). As such, it is useful in identifying the Axemann. High-spired gastropods of the genus *Hormotoma* (Figure 7) are also found throughout most of the formation.

Figure 6. An example of Maclurites affinis *(approximately 1 in. wide) (used with permission from the Geology Department, University of Vermont, www.uvm.edu/perkins/DisplayW.php?fname=PGMFS461_001).*

In general, fossils are sparse. A paucity of fossils can reflect paleoenvironmental and diagenetic factors. Unfavorable environmental conditions might include reduced dissolved oxygen, increased salinity, subaerial exposure, and turbulence. The calcilutite-dominated stratigraphy may have been unfavorable for some marine macroorganisms but may have been conducive to algal growth, which in turn provided a substrate ideal for grazing organisms such as gastropods. Very fine grained lime mud may have been suffocating to the organisms (Lees, 1967). In contrast, pelmatozoan calcarenites reflect environmental conditions favorable to those animals. Dolomitization, a diagenetic process, destroys fossils in preexisting limestone. As well, the supratidal environment in which dolomitization occurs is not conducive to prolific fossils due to subaerial exposure. LLH stromatolites are an exception. Fossil distribution in the Axemann here mimics present-day observations in carbonate depositional environments. Marine life in these settings is not ubiquitous but exists where conditions are favorable.

The various carbonate lithologies—calcilutite, calcarenite, calcirudite, and dolomite—reflect different paleodepositional environments. Calcilutites are fine-grained limestones representing quiet-water (low-energy) settings, either below wave base (subtidal) or in shallower, restricted areas (such as subtidal lagoons behind barrier shoals, organic buildups, or exposed highs). Other than stromatolites, macrofossils are scarce in cacilutites. Calcarenites are carbonate sands deposited in shallow higher energy settings such as coastal sand dunes, beaches, and offshore bars and shoals. Some calcarenites are oolitic and others contain disarticulated pelmatozoans, both reflecting a higher energy environment. Calcirudites are coarse-grained or pebbly carbonates, also reflecting shallow higher energy deposition. These higher energy carbonates form in subtidal coastal settings where debris from the intertidal zone can accumulate. The presence of dolomite, in association with mud cracks, algal mats (the LLH type), the scarcity of other fossils, and possible teepee structures, may indicate a sabkha environment (an environment where supratidal mud flats form along arid coastlines).

Figure 7. An example of Hormotoma *(approximately 0.63 in. long) (from Hoskins and others, 1983).*

A conspicuous feature at Rupp Quarry is the repetitious pattern of limestone alternating with dolomite (Tables 1 and 2). This pattern represents carbonate cycles (Engelder, 2006). Each cycle is a shallowing-upward sequence, beginning with limestone deposited below wave base in the lower energy subtidal zone. The cycle ends with limestone penecontemporaneously altered to dolomite in the supratidal zone. The shallowing-upward cycle is the most common type of carbonate cycle (Engelder, 2006). The cyclicity is due to sea-level fluctuations relative to vertical land movements over thousands of years. These Rupp Quarry cycles occurred in a sabkha setting analogous to the Abu Dhabi sabkha in the Arabian Gulf today. Dolomite deposition within the cycles reflects more restricted conditions of greater-than-normal marine salinity. These more restricted conditions must have persisted for longer periods of time as younger and younger cycles developed. This can be seen in the increasing ratio of dolomite to other lithologies, going from lower to higher strata (Table 2). Dolomite represents 31 percent of lithologies in the lower strata, increasing to 50 percent in higher ones (Table 2). The observation that dolomite dominates in upper Axemann strata here contrasts with observations from elsewhere in the same formation. Doden and others (personal communication) reported that, elsewhere in the State College area, limestone predominates near the top of the Axemann. The difference may mean that the Rupp Quarry location was in a more restrictive carbonate setting than other Axemann locations.

Paleogeography

During Axemann time, State College was estimated to be at 25° south latitude (Laughrey and others, 2004), placing it in the tropics. This is consistent with most modern marine limestone being deposited in the tropics or subtropics. A shallow, warm epeiric sea covered Nittany Valley. Except for restricted areas, oceanic connections to the northeast and southwest maintained normal marine salinities (Schuchert, 1955). These marine waters were supersaturated with calcium carbonate (Lees, 1967). Carbonate deposition implies a low or distant sourceland for clastics. Based on present-day comparative models, the absence or paucity of allochthonous clastic sediment indicates that no local orogeny occurred for the duration of the Axemann. Water depth was probably less than 30 feet (Demicco and Mitchell, 1982). At times, substrates were subaerially exposed to desiccation, as inferred from the presence of mud cracks, evaporite vugs, and algal mats. Intraformational conglomerates (rip-up clasts) show that storms may have occasionally affected the tidal flats. In places, tides, waves, and/or currents were strong enough to winnow sediment and cause disarticulation of fossils.

Conclusion

The Rupp Quarry is an excellent field example of carbonate cycles occurring within the Half-Moon Hill Member of the Axemann Formation in the State College area. The upper strata of the Half-Moon Hill Member are exposed. The strata were deposited during the early Ordovician in a warm, shallow epeiric sea supersaturated with calcium carbonate. A sequence of calcilutite interbedded with dolomite also includes calcarenites and calcirudites. Varying lithologies, fossils, and sedimentary features suggest a shallowing-upward sequence of tidal-flat deposits in a sabkha setting. Higher energy normal-marine conditions occasionally interrupt calcilutite deposits formed in shallow, restricted, quiet water. These cycles may reflect repetitive changes in eustatic sea level.

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BUREAU NEWS

A Conversation With the New State Geologist

Editor's note: We thought it would be interesting to ask the new State Geologist, Gale Blackmer, about her background, as well as what she has in mind for the future of the Pennsylvania Geological Survey.

What first sparked your interest in geology? What subdiscipline of geology do you work in?

My mother claims that she knew from the time I was a little kid that I would be a geologist, because she always had to be careful to empty the rocks out of my pants pockets before she put them in the laundry. Although that sounds like 20/20 hindsight to me, I do recall sitting on my bedroom floor when I was 9 years old, reading pamphlets from the U.S. Geological Survey about careers in geology. And I spent so much time poring over the National Geographic magazines on plate tectonics and sea-floor topography that I knew all about plate boundaries before I even got to 6th grade Earth Science. I have no idea what sparked the interest; I must just be wired that way. Except for a brief childhood bout of wanting to be a nurse, which ended when I realized that sick people aren't all that much fun to be around, I've never wanted to be anything but a geologist. I have always loved history, too, and what is geology but history on steroids? Even though a circuitous career path led to field mapping, my greatest professional joy comes from turning those field observations and maps into big tectonic stories.

What was the path that brought you to the Pennsylvania Geological Survey?

If you polled any random group of geologists, most would probably tell you that their careers were what happened while they were making other plans (apologies to John Lennon). That is certainly true for me. Working at a state geological survey had never occurred to me until a string of acquaintances and temporary jobs got me to the right person in the right place at the right time, and I joined the bureau as a field mapper in southeastern Pennsylvania. What a great place to work! We get to do real science with

practical, and frequently immediate, applications. And carrying that Pennsylvania Geological Survey affiliation really opens doors. Other government agencies share interesting data and geologic questions that one wouldn't get to see from the "outside." With a few exceptions, we receive the same kind of treatment from colleagues in the consulting business and various geologic industries. They recognize the usefulness of our work, and in return they allow access to their quarries and surface mines, and take us on excursions into underground mines and even to the occasional drill site. People even volunteer to lead us on field trips! Those trips and excursions have been some of my favorite moments of my time at the bureau. What could be better than to be surrounded by rocks and people who love to talk about them?

What are some of the goals that you hope to accomplish as State Geologist?

Sustainability. Going forward, I want to focus the work of the bureau on sustainability. Admittedly, that is a fuzzy term that can carry different meanings for different people. I view sustainability as maintaining a comfortable quality of life in a manner that can be continued indefinitely. That means providing clean air, clean water, adequate food, warm houses, electricity, batteries, good roads, convenient transportation, and so on. In order to accomplish that, we must protect water supplies, extract energy and mineral resources in ways that have the least impact on the environment, and use all of these resources efficiently. The bureau has an important role in that kind of sustainability. I want the citizens of Pennsylvania 100 years in the future to be thankful every day for the groundwork we laid to help them continue to live sustainably.

Water. The current drought in California and neighboring states presages things to come. Many surface water supplies have dried up, and groundwater supplies are being depleted faster than they can recharge. We along the eastern seaboard are blessed with abundant water. It behooves us to understand and protect our surface water and groundwater systems before inevitable shifts in population, agriculture, and industry put more pressure on our water supplies. To effectively protect water, we must recognize that the source and storage area for drinking water is not only surface streams and lakes but also rocks in the shallow subsurface down to something like 1,000 feet below the land surface. The rocks that contain the water control the chemical elements present in the water and the pathways along which water and contaminants, both natural and man-made, can move. The bureau's work will improve our understanding of the water itself and the rocks in which it lives through a program of stratigraphic investigations, rock coring, and groundwater investigations. The types of products resulting from these investigations include geologic maps, reports on the stratigraphy of critical geologic units, reports on the geohydrology and water quality of fractured-bedrock test holes, regional groundwater flow models, and analysis of recharge areas. All underlying data, including geologic field observations, water chemistry, rock chemistry, and shallow-gas chemistry, will also be made available.

Extractive industries. We can't address water and sustainability without addressing the extractive industries. The fact is, we need energy and mineral resources to maintain our modern way of life, and Pennsylvania has those resources in abundance. The bureau's work is directed to enabling those resources to be extracted and used in an environmentally responsible manner. We conduct broad-based, more regional studies that form the foundation of localized work done by other government regulatory and nonregulatory agencies, conservation groups, and individual companies. Our maps, reports, and databases point companies to areas that are most likely to produce the resource they seek, reducing the expense and environmental disturbance of unnecessary exploration. Our groundwater and test-hole investigations provide transparent, publicly available data that can be used by all concerned to assess the impact of natural-resource extraction on drinking-water wells. The bureau partners with surrounding states, academia, and industry to do broad research on vital energy and environmental concerns such as carbon sequestration, subsurface brine and wastewater disposal, low-temperature geothermal energy potential, and assessment of potential for extracting rare earth elements from coal ash.

Seismicity and other geologic applications. The bureau currently partners with the Department of Environmental Protection on a contract with Penn State to maintain a network of seismic stations established by the Department of Conservation and Natural Resources (DCNR) over the past several years. Among other things, the data recorded by the seismic network can be used for assessing whether induced seismicity is an issue in Pennsylvania. I would like the bureau to become more involved with the rest of DCNR and other organizations in providing the geologic underpinnings for studies on landscape, biota, and the effects of climate change.

Land use. Part of building sustainable communities is learning to respect the impact of natural hazards on land use. The bureau should enhance its existing products on sinkholes and landslides to make them more comprehensive, accessible, and usable by geologists and nongeologists alike.

Data collection and sharing. In order to make all the work described above truly useful outside the bureau, we must create and maintain a data infrastructure that leverages current technology to constantly improve data collection, data analysis, and data distribution. I use the word "data" here to include the "hard" collections of rock core and cuttings, hand samples, fossil and mineral specimens, and thin sections, as well as information such as field observations, drilling logs, and analytical results now stored largely in analog form. The bureau is in the throes of major modernization efforts of our three flagship databases. The Exploration and Development Well Information Network (EDWIN; previously known as PA*IRIS/WIS) is Pennsylvania's official database of oil and gas well records reported to the state. Public access to EDWIN is either free or by paid subscription, depending on the desired level of service. The Pennsylvania Groundwater Information System (PaGWIS) is a public-facing database that holds water-well records. The Stratigraphic Database is an internal database that holds geologic data tied to specific outcrop or drill hole locations. All of these databases are being updated or rebuilt to take advantage of current web-based technology. The new versions should be up and running this summer, greatly increasing the efficiency of our work and the accessibility of the contained data. I look forward to the expansion of our web-mapping application, PaGEODE, to include current geologic mapping. As we press on into the future, I would like to see the bureau develop an interactive, three-dimensional geologic "map" of the state.

Outreach and education. Woven into all of this work must be an element of outreach and education. Working for the bureau gives us unprecedented opportunities to talk to people. We knock on their doors to ask permission to look at rocks in their backyards or fields, they stop to question us as we work along roadsides, we encounter them at professional meetings and general-interest lectures, and they seek us out at educational workshops and programs for kids. I have come to realize that many people are truly interested in the earth and what they see around them in the landscape. But that interest is out of step with a general lack of understanding of the impact of geology and geologic resources on our daily lives. The bureau must make it our business to educate the public so that they can make intelligent decisions about natural-resource use and protection.

Any final thoughts?

Throughout it all, we can never lose sight of the fact that the bureau is essentially a service organization for DCNR, other state agencies, and the people of Pennsylvania. We must strengthen those bonds and always be responsive to the changing needs of those audiences.

NEW RELEASES

Watermarks

With the completion last fall of the depth maps for Lake Tobyhanna at Tobyhanna State Park and Pinchot Lake at Gifford Pinchot State Park, the Bureau of Topographic and Geologic Survey's bathymetry efforts reached a significant milestone: half of the state parks with lakes have lake-depth maps! On these maps, in addition to lake-depth contours, fish habitat is shown, including porcupine cribs and vertical post clusters (artificial habitat structures) (Figure 1). These data are taken from the Pennsylvania Fish and Boat Commission's fish habitat improvement maps. The lake-depth maps also show park amenities of interest to boaters and anglers, including boat launches, marinas, restrooms, bait stores, and telephones.

Not known to rest on their laurels, bureau staff recently released two new lake-depth maps: Glendale Lake at Prince Gallitzin State Park **(Open-File Report OFMI 16–01)** and Lake Wilhelm at Maurice K. Goddard State Park **(Open-File Report OFMI 16–02).** Both are very popular with boaters and anglers. The bureau plans to complete four lake maps each year until the task is completed in 2021. Maps can be accessed from each park's web page or from the bureau's website at www.dcnr.state.pa.us/topogeo/publications/pgspub/openfile/Geology-Lake-DepthMaps/index.htm.

—Rose-Anna Behr

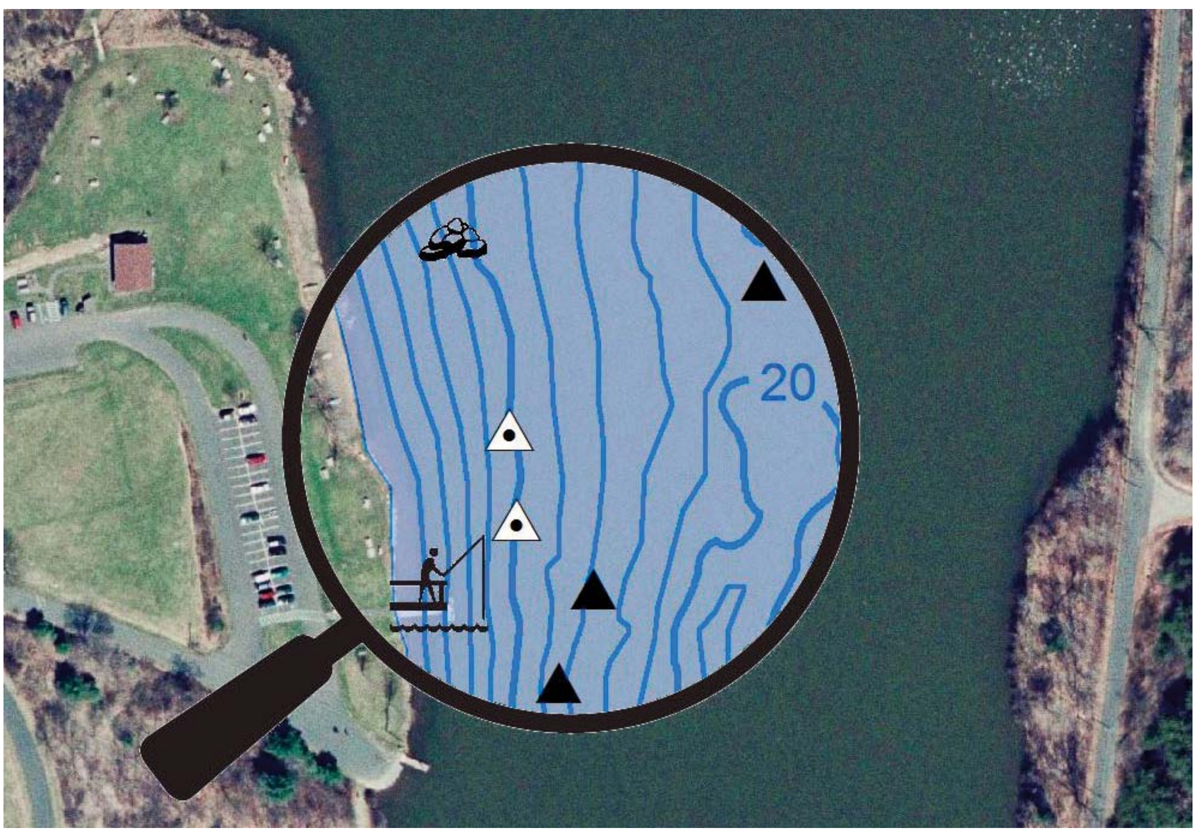

Figure 1. The lake-depth maps show depth contours, fish habitat improvements, and park features of interest to boaters and anglers. These features are overlain on aerial photographs for ease of use. In this case, the magnifier is focused on part of Francis Slocum Lake and reveals a fishing pier, porcupine cribs (shown as triangles), and a rock pile.

Directory of Nonfuel-Mineral Producers in Pennsylvania

An updated version of the *Directory of Nonfuel-Mineral Producers in Pennsylvania* has been released as **Open-File Report OFMR 15–01.** This is the most recent version of a report that has been updated many times since its initial release fifty years ago (O'Neill, 1965).

The present version of the directory contains information about the operations of 230 producers of nonfuel-mineral products, including the name, address, telephone number, and other contact information for each company, the names and locations of their operations, the products that they market, and the stratigraphic name and lithology of the rock that is being mined. The companies listed range from corporations that operate many large quarries to small, family-owned quarries or gravel pits. This directory is not a complete listing of every mineral-producing operation in the state because it includes only the companies that voluntarily responded to questionnaires that were mailed to them during the summer of 2015 and indicated that they wanted to be included.

The nonfuel-mineral industry is important to Pennsylvania, both in its contribution to the state's economy and in providing essential commodities, without which many things that we take for granted, such as paved roads, sidewalks, and brick or stone buildings, would not exist. In 2011, the most recent year for which data are available, Pennsylvania ranked 13th in the nation in the value of nonfuel-mineral production, having a total value of $1.60 billion (U.S. Geological Survey, 2015). In addition to construction aggregate, the nonfuel minerals produced in Pennsylvania have various other uses such as for acid neutralization in soil and as a fluxing agent in steelmaking. Dimension stone is an important product in some parts of the state, including the Allentown area, which has long produced slate that is used for such things as roofing shingles and billiard-table tops, and northeastern Pennsylvania, the site of many quarries that produce bluestone, a type of sandstone that is used for stair treads and walkways. Other specialized products include decorative stone for landscaping and, from one company, a blend that is marketed for use as "baseball infield mix."

The directory can be accessed in two formats: as a tabular listing and as an interactive web mapping application. The tabular listing is organized alphabetically by commodity category, rock type, and county. The interactive map allows searches on each of those categories (Figures 1 and 2) or by outlining an area of interest. For each operation, it is possible to see a close-up aerial view (Figure 3) and get driving directions to the location.

Both formats of the directory are available online at www.dcnr.state.pa.us/topogeo/publications/pgspub/openfile/mineral_resource_directory/index.htm.

References

O'Neill, B. J., Jr., 1965, Directory of the mineral industry in Pennsylvania: Pennsylvania Geological Survey, 4th ser., Information Circular 54, 85 p.

U.S. Geological Survey, 2015, The mineral industry of Pennsylvania, *in* U.S. Geological Survey, 2010–2011 Minerals Yearbook, Pennsylvania [Advance Release]: http://minerals.usgs.gov/minerals/pubs/state/2010_11/myb2-2010_11-pa.pdf (accessed January 29, 2016), 9 p.

—John H. Barnes

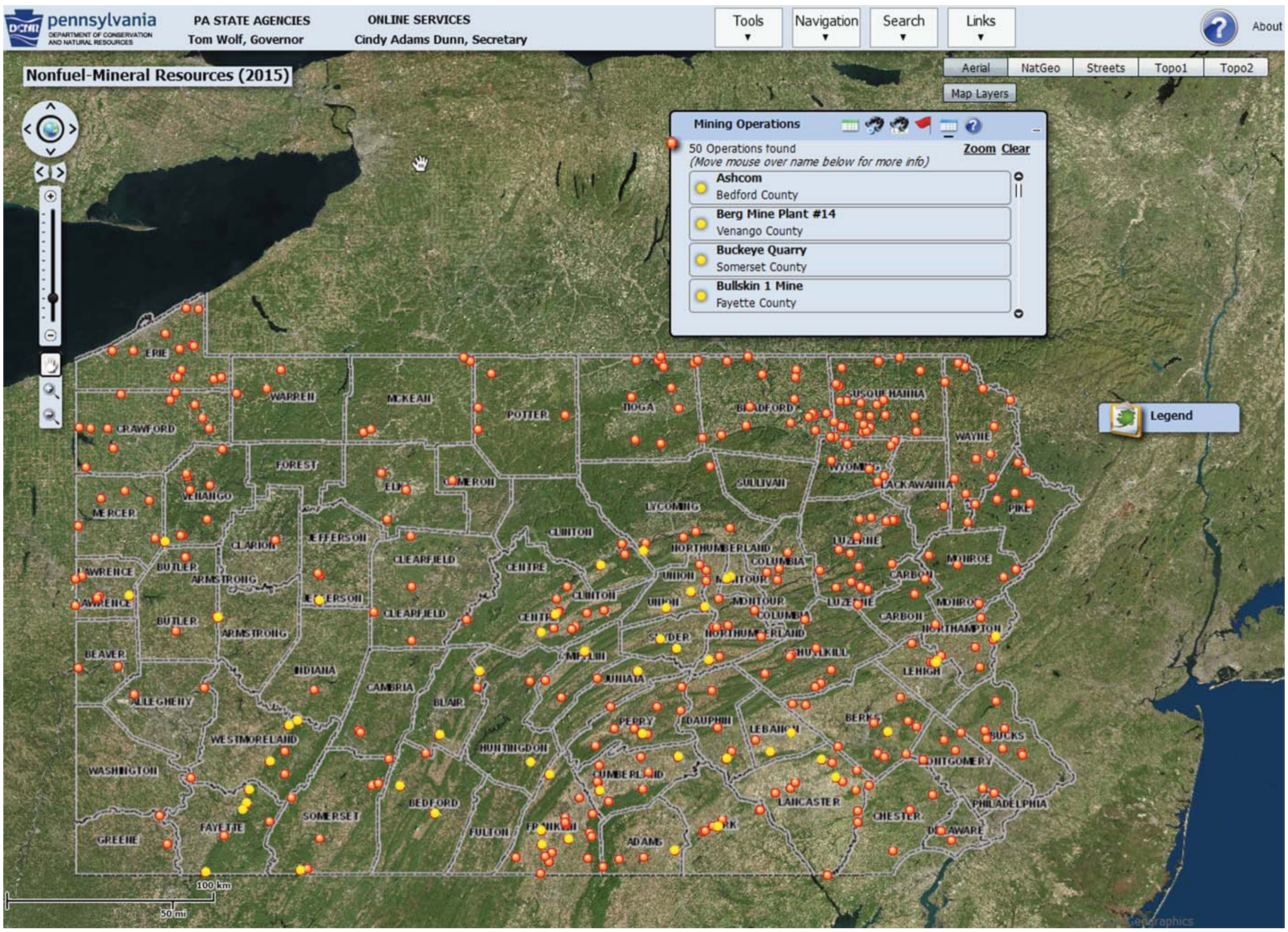

Figure 1. A display showing search results for quarries that produce coarse aggregate from limestone statewide. All such quarries are indicated by yellow dots. The orange dots represent industrial mineral operations that do not meet the requested selection criteria.

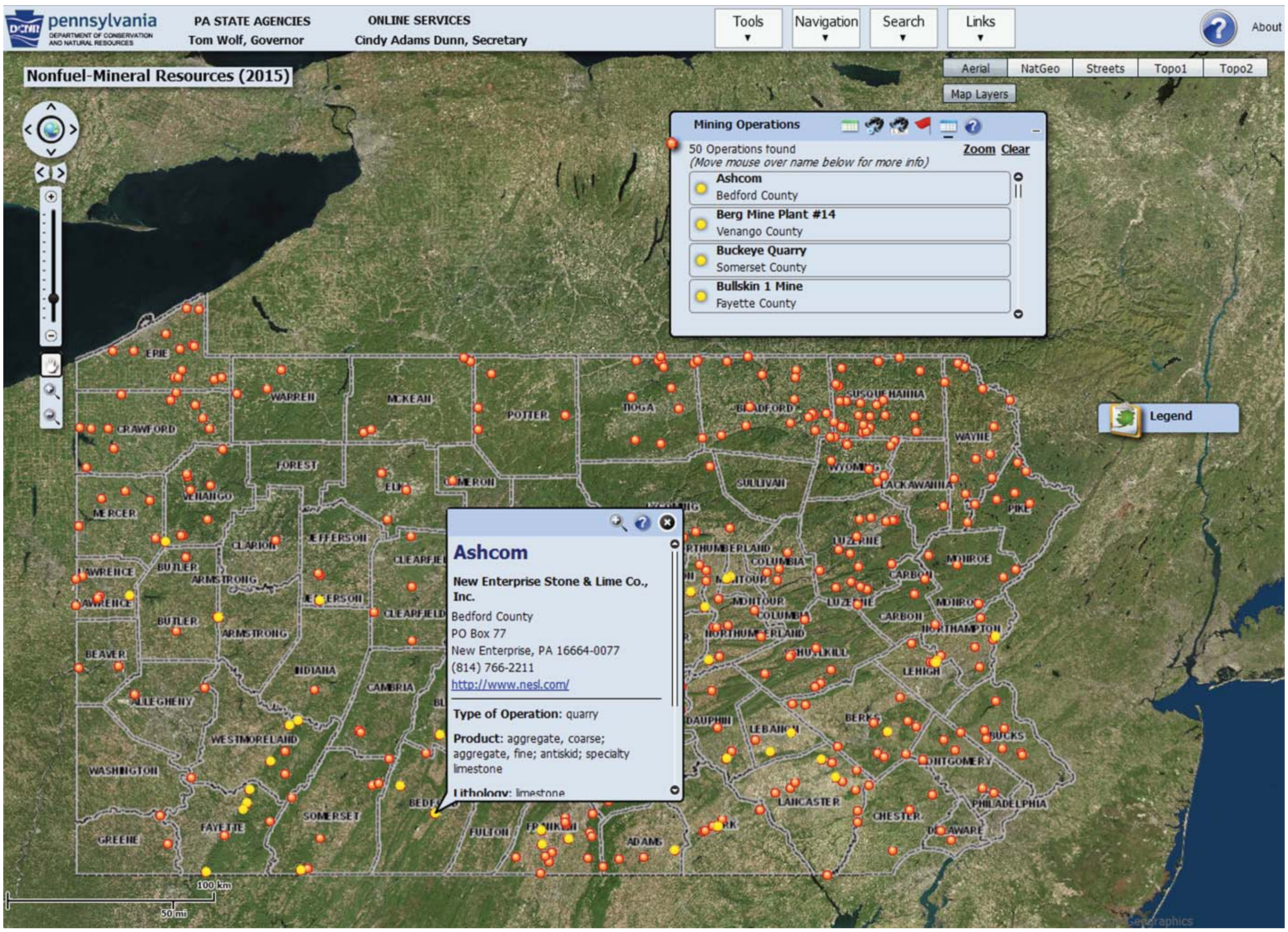

Figure 2. Clicking on the name of a quarry in the table of search results shows its location and information about it.

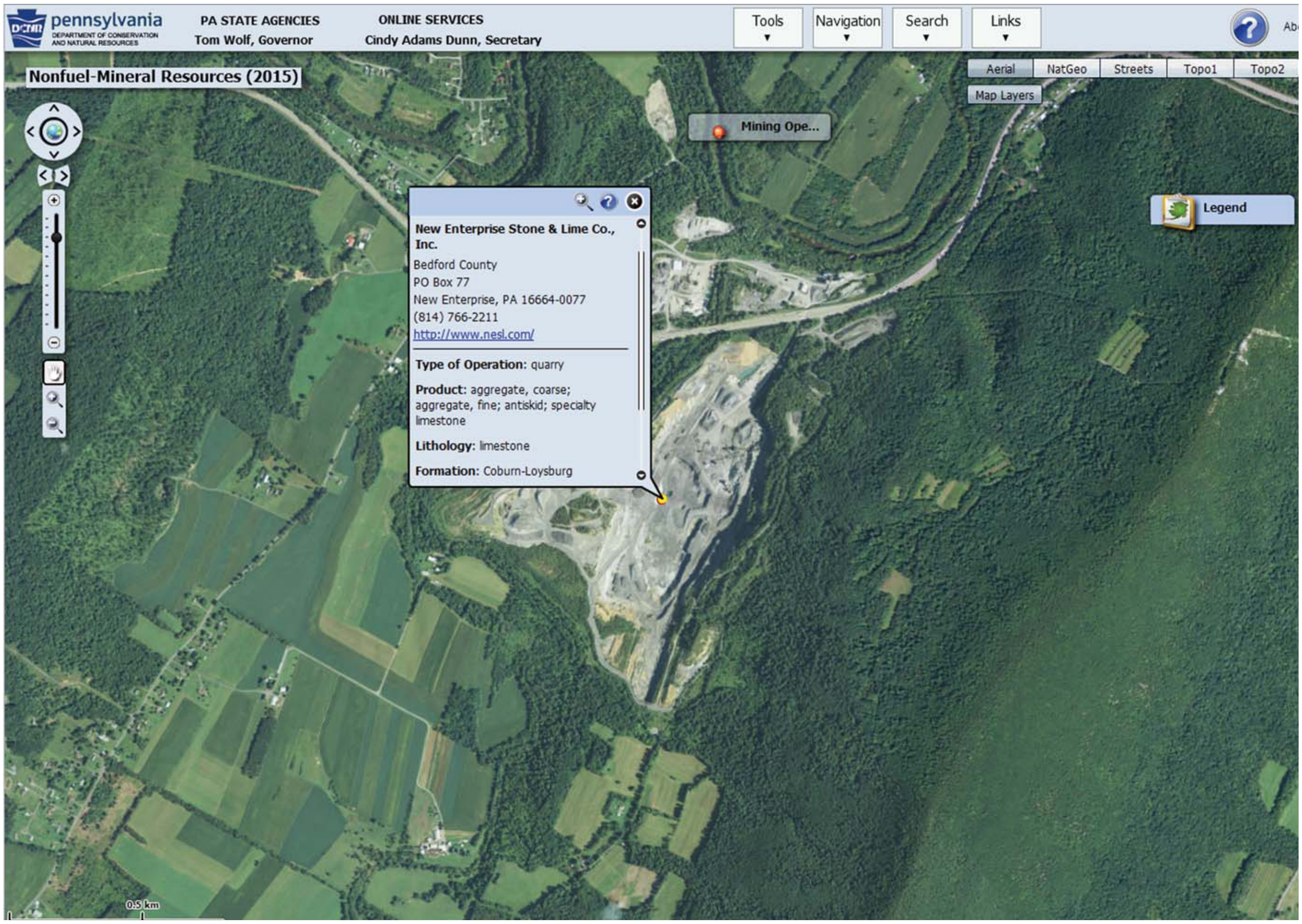

Figure 3. A zoomed-in view of the quarry of interest, obtained by clicking on the magnifying-glass icon in the quarry description box.

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Open-File Miscellaneous Investigations **(January 2016)**

- Water depth of Glendale Lake—Prince Gallitzin State Park, Cambria County, Pennsylvania
- Water depth of Lake Wilhelm—Maurice K. Goddard State Park, Mercer County, Pennsylvania

Open-File Mineral Resource Report **(December 2015)**

- Directory of nonfuel-mineral producers in Pennsylvania

Open-File Miscellaneous Investigation **(December 2015)**

- Geohydrologic and water-quality characterization of a fractured-bedrock test hole in an area of Marcellus shale gas development, Tioga County, Pennsylvania

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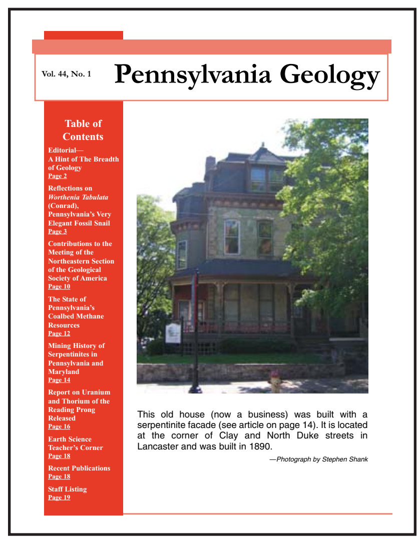
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This old house (now a business) was built with a serpentinite facade (see article on page 14). It is located at the corner of Clay and North Duke streets in Lancaster and was built in 1890.

—*Photograph by Stephen Shank*

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