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Open-pit mine at Cornwall, Pa., in 1944 (from the Cornwall Iron Furnace photograph archives) (see article on page 3).

EDITORIAL

Our Work Continues

Gale C. Blackmer, State Geologist
Pennsylvania Geological Survey

Well, 2022 is almost in the books. We are able to travel and meet again, albeit carefully and not entirely without consequences. We have been happy to see many of you at various functions throughout the year. Here are some of the high points of 2022.

Staff turnover continues. Stuart Reese, Jim Shaulis, and Connie Cross left us for the greener pastures of retirement this year. We were joined by Emily Parkovic, Chris Oest, Hailey Filipelli, Ted Tesler, and Kyle Rybacki. We were fortunate to have three new positions added to our complement in this budget cycle, two in the Pittsburgh office to work on aspects of carbon storage and one in the Middletown office to act as grants coordinator. These positions are in various stages of the filling process, and we look forward to welcoming more talented folks into the fold.

Of course, the staff continued to do great work this year on all the projects you have come to expect from us: geologic mapping, subsurface geology, groundwater, elevation-derived hydrography, EDWIN (Exploration and Development Well Information Network [oil and gas wells]), PaGWIS (Pennsylvania Groundwater Information System), and distributing data and information to the public in a variety of ways. Carbon storage is really coming into its own with boosts from the federal government and rising interest from Governor Wolf, Governor-Elect Shapiro, and the legislature. Our bureau is part of the Midwest Regional Carbon Initiative, the 21st Century Power Plant project in southwestern Pennsylvania, and the CCUS (Carbon Capture, Utilization, and Storage) Interagency Work Group, led by Kris Carter. On the important front of protecting water resources, Pennsylvania is closer than it has ever been to establishing water-well construction standards, thanks to the diligent efforts of DCNR's (Department of Conservation and Natural Resources) Policy Director Nicole Faraguna and our own Sim Suter, with great help and support from an engaged group of stakeholders. Al Guiseppe and his GIS (Geographic Information Systems) team are charging ahead with pilot projects to develop 3D mapping methods while producing interesting datasets such as top of bedrock and other important geologic horizons in the subsurface, all toward a goal of building a 3D geologic model of Pennsylvania. The model will serve the needs of burgeoning interests in carbon storage, water resources, and mineral resources, and will contribute to U.S. Geological Survey goals to produce a 3D geologic model of the nation by 2030 through the U.S. GeoFramework Initiative.

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The Metals of Cornwall, Pennsylvania

Michael F. Weber[1]

INTRODUCTION

The Cornwall mines (see cover photograph and photograph on page 17), located in Cornwall, Pa., about 5 miles south of Lebanon, were an important source of iron for Pennsylvania and the nation for more than 236 years. From 1737 until 1973, miners produced an estimated 106 million tons of iron ore at Cornwall (Lininger, 1979). But did you know that in addition to iron, the Cornwall mines produced significant quantities of copper, silver, gold, and cobalt? A summary of the history of recovering these valuable metals at Cornwall is contained in this article.

The Pennsylvania Geological Survey provided the most authoritative description of the geology of Cornwall in the *Geology and Origin of the Triassic Magnetite Deposit and Diabase at Cornwall, Pennsylvania* (Lapham and Gray, 1973). Lapham and Gray built their definitive studies of Cornwall geology upon earlier work conducted by the Second Pennsylvania Geological Survey in the second half of the 1880s (Rogers, 1858; Lesley and d'Invilliers, 1886). Most of the available geologic literature focused on the iron deposit and mining, and relatively little has been documented about the beneficiation of the other metals at Cornwall.

Mining began at Cornwall in shallow trenches and pits on three hills—Big Hill, Middle Hill, and Grassy Hill. As mining progressed deeper into the ore deposit beneath Middle Hill, miners discovered significant quantities of copper ore. Miners dug trenches, tunnels, and shafts as deep as 30 to 40 feet into the iron ore to excavate veins and seams of copper ore. They found copper in its native metallic form (native copper [Cu]), an oxide form (cuprite [Cu_2O]), carbonate forms (malachite [$Cu_2(CO_3)(OH)_2$] and azurite [$Cu_3(CO_3)_2(OH)_2$]), a sulfide form (chalcopyrite [$CuFeS_2$]), and a few other minerals of lesser importance. Fine specimens of these copper minerals collected at Cornwall in the 1800s can be found in museum collections today at Cornwall Furnace, Lebanon County Historical Society, the Smithsonian Institution's Natural History Museum, the Museum of Natural History in New York City, and other museums such as the North Museum at Franklin and Marshall College in Lancaster.

Although early records are incomplete, the Cornwall Ore Bank Company and other sources reported that Cornwall produced more than 9,150 tons of copper ore between 1848 and 1885. Cornwall sent copper ore to Phoenixville, Pa., and Baltimore, Md., to be processed and refined. In addition, Benjamin Blewitt and C. M. Wheatley leased access to Cornwall to mine copper ore in the late 1800s (Lesley and d'Invilliers, 1886). Some of the copper was sent to the U.S. Mint in Philadelphia for use in minting coins.

At depths below about 40 feet, miners found that the copper only existed as the brassy-colored sulfide mineral chalcopyrite. In the 1700s and 1800s, chalcopyrite was much less attractive as an ore of copper due the expense and complexity of the steps required to extract and concentrate the copper from this mineral. Beginning in the 1820s and extending through the early 1900s, furnace operators roasted Cornwall iron ore to reduce sulfur content from the chalcopyrite and pyrite before loading the ore into blast furnaces. Cornwall Mines continued producing copper in the twentieth century by separating and concentrating the copper at concentration plants in Lebanon and Cornwall, Pa. (Peets and Olsen, 1970).

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[1]Volunteer guide and researcher at Cornwall Iron Furnace

When mining began at Cornwall in 1737, the concentration of iron in the magnetite (Fe_3O_4) ore was relatively high, in the range of 60–65 percent by weight. The ore at and near the surface of Big Hill, Middle Hill, and Grassy Hill had been weathered for millions of years. Weathering had dissolved and removed minerals in the iron ore that were more susceptible to erosion. The magnetite in the ore was relatively rich in iron and resistant to erosion. Consequently, weathering of the surface ore increased the concentration of iron in comparison to unweathered ore. The weathering also produced native copper, cuprite, malachite, and azurite. The concentration of iron also varied naturally in the iron ore from the processes that formed the deposit and from differences in the structure and composition of the bedrock that hosted the ore.

As mining progressed on Big Hill and Middle Hill, the concentration of iron generally decreased in the ore with depth. In addition to the natural variations in the ore, the concentration of iron also decreased due to the incorporation of more waste rock (mostly limestone) that occurred while mining the ore in the surface pits. Miners boosted the iron concentrations in the ore somewhat by separating out or “cobbing” the ore from the waste rock. However, the miners could not do much to increase the concentration of iron in the ore itself beyond classifying the ores based on their grade or quality.

By the 1870s, the concentrations of iron in the ore were too low to be used directly in cold blast furnaces such as the Cornwall Iron Furnace. Furnace operators began blending Cornwall ore with more concentrated ores from other mines. The proprietors of the Cornwall Ore Bank Company consumed the best ore at the best prices in their furnaces. They sold comparable ore at higher prices or lower graded ores to competitors operating other furnaces (Cornwall Ore Bank Company, 1869). Several times during the 1880s and 1890s, the company considered processing the ore to increase concentrations of iron. However, the company took no action to do so even after conducting significant experiments that demonstrated the feasibility and economy of such processing.

By the turn of the twentieth century, the Pennsylvania Steel Company had acquired partial ownership of the Cornwall Ore Bank Company. In 1905, Pennsylvania Steel decided along with North Lebanon Furnaces to build and begin operating a “concentrator” plant in Lebanon (Figure 1). The plant concentrated the iron up to about 60 percent in a nodularized iron concentrate. Furnace operators fed these iron concentrates directly into blast furnaces (Peets and Olsen, 1970). After Bethlehem Steel acquired a majority share of the Cornwall Ore Bank Company in 1916, Bethlehem expanded and adjusted processing at the concentrator and, in 1920, changed the end product from nodularized iron concentrate to iron sinter (small, irregular nodules of iron mixed with small amounts of other minerals). By the time the concentrator plant moved to Cornwall in 1962, Bethlehem had replaced sinter with iron pellets as the final concentrated iron product.

The flow sheet in Figure 2 is a simplified diagram from 1945 of how the concentrator plant processed the Cornwall ore at Lebanon (Bethlehem Cornwall Corporation, 1955). Bethlehem Cornwall Corporation included this diagram in its annual report of 1954, which is today part of the collection of monthly and annual reports at the Cornwall Iron Furnace. The upper row of the flow sheet shows the sequence of processing steps used by Bethlehem Steel to concentrate the iron ore (from “crushed ore” on the left to “sinter plant” on the right). In the first step, the iron ore from Cornwall was ground to a very fine consistency, similar to the consistency of wheat flour. The plant then fed the ground or “milled” ore in a water solution through a series of magnetic separators, as shown in Figure 3. In this step, iron was attracted to the outside of rotating brass drums by powerful magnets inside the drums, while the rest of the solution flowed downstream. The separators scraped the iron concentrate off the drums and then agglomerated the iron in the form of nodularized or sintered iron by roasting it in furnaces. This series of steps concentrated the iron for use in iron and steel furnaces.

Figure 1. Aerial view of the concentrator plant in Lebanon, Pa., in 1958 (from the Cornwall Iron Furnace photograph archives, photograph B–3656).

As already mentioned, the mineral magnetite contained most of the iron in ore that was fed into the concentrator plant. So where were the other metals in the ore, the copper, silver, gold, and cobalt? The copper was present in chalcopyrite. Gold and silver at Cornwall occurred at very low or trace concentrations within the chalcopyrite. Another iron-sulfide mineral in the iron ore, pyrite (FeS_2, commonly referred to as "fool's gold"), contained trace amounts of cobalt (0.7 to 2 percent). Therefore, by concentrating chalcopyrite and pyrite in the iron ore, Cornwall produced mineral concentrates that were processed further to recover copper, silver, gold, and cobalt, in addition to iron (Figure 3).

The fine grinding and magnetic separation of the iron ore from Cornwall allowed Bethlehem Steel to process the residues that remained after the separation and recover other valuable metals from the Cornwall ore. In the early 1920s, Bethlehem Steel began experimenting with a variety of dry methods to extract and concentrate other metals from the ore. In 1927, Bethlehem added a series of additional wet processing steps on the back end of the concentrator plant. These steps occurred in the flotation plant (Figure 2, the third and fourth rows of the flow sheet) and were designed to separate and produce copper and pyrite concentrate.

After a significant fraction of the iron was removed from the ore, the flotation plant processed the solution with the remaining ore through a series of physical and chemical steps to concentrate the finely ground chalcopyrite. The solution was processed through rake classifiers, thickeners, and flotation cells. These steps are depicted in the flow sheet in the third (from the top) horizontal sequence of steps. Various chemicals, such as pine oil and flocculants, were added in this process to attract the chalcopyrite to stick to bubbles that floated on top of the solution. The bubbles were then scraped off the top,

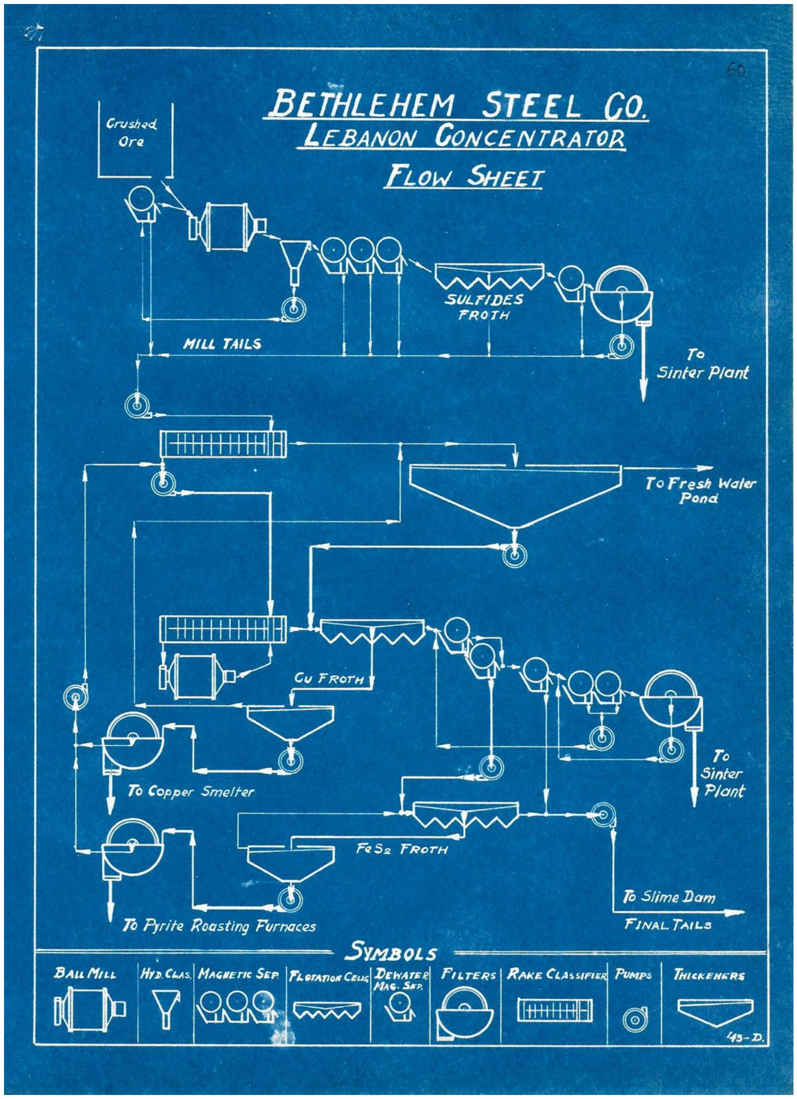

Figure 2. Flow sheet showing how the concentrator plant processed the Cornwall ore at Lebanon. See text for explanation.

thickened, and pumped into a filter press that separated the copper concentrate from the solution. The copper concentrate was then sent off-site to smelters in Arizona, New York, Michigan, Washington, and Canada for further processing, which included extraction and concentration of the gold and silver, as well as refining and smelting the copper.

In the 1920s, Cornwall modified the flotation plant to produce a pyrite concentrate. The process was similar to that used to produce copper concentrate, but pyrite concentration used different chemicals and sequences of steps. The pyrite concentration process is depicted in the flow sheet as the fourth and final horizontal row of steps. Cornwall shipped the pyrite concentrate off-site to Baltimore, Md., and Wilmington, Del., to recover and concentrate cobalt.

Finally, after the ore had been stripped of iron, chalcopyrite, and pyrite, the remaining solids, along with the solution that carried them, were discharged into large impoundments located near the concentrator plant in Lebanon (1905–62) and in Cornwall (1962–78). The solids and the solutions that

Figure 3. Six-drum magnetic separators used to separate magnetite ore from the other ore components (from the Cornwall Iron Furnace photograph archives, photograph B–1431).

remained after processing were called tailings, as seen in the photograph of the "old quarry" behind the concentrator in Lebanon (Figure 4). The removal of the tailings is depicted at the bottom of the flow sheet in the final discharge following the production of the pyrite concentrate ("To Slime Dam—Final Tails" on Figure 2). Once a year, the millers reprocessed the tailings in the quarry through the concentrator plant in Lebanon to recover additional iron, copper, and pyrite before the company discharged the tailings to a large impoundment on the north side of State Route 72 near the concentrator.

Figure 4. Removing tailings from the "Old Quarry" for reprocessing at the Lebanon concentrator plant in the 1950s (from the Cornwall Iron Furnace photograph archives).

The reprocessing occurred during a one- to two-week period in the summer months when the rest of the concentrator and the mines suspended production to conduct large maintenance projects. When the concentrator relocated to Cornwall in 1962, the millers stopped reprocessing the tailings and sent them directly to the large tailings impoundment located above Rexmont, as seen in Figure 5. Today you can view the embankment for the tailings impoundment from State Route 419 just east of Cornwall.

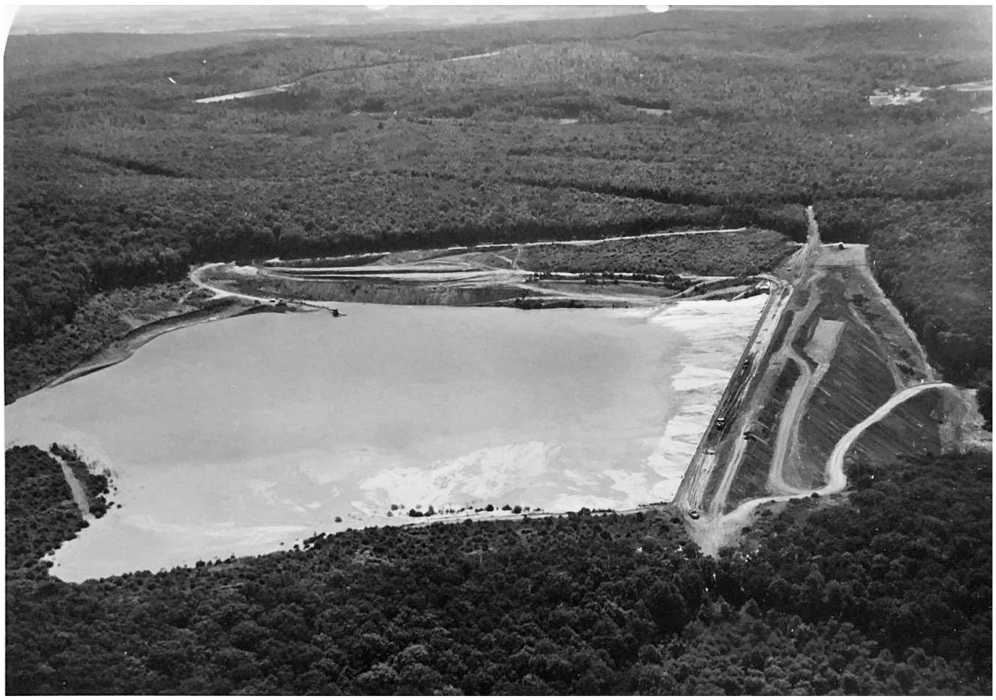

Figure 5. The tailings impoundment above Rexmont, near Cornwall, Pa., in 1966 (from the Cornwall Iron Furnace photograph archives, photograph C–3429).

The gold and silver at Cornwall were highly disseminated in the chalcopyrite, which itself was present at low concentrations in the magnetite ore (generally less than 0.5 percent). After the iron had been removed from the ore and the chalcopyrite further concentrated into "copper concentrate," the gold generally occurred at 0.1 ounce per ton of concentrate and the silver at 0.6 ounce per ton (Smith and others, 1988). Gold and silver were not found in their native metallic forms at Cornwall (no flakes, wires, nuggets, or powder). Consequently, mineral collectors at Cornwall have been disappointed by not being able to collect specimens of gold or silver or to find these metals in placer deposits by panning nearby Furnace or Snitz Creeks.

Although the amounts of copper, gold, and silver produced by Cornwall were small by comparison to the amounts produced by much larger mines throughout the United States, the total amounts produced were significant and valuable as byproducts from iron mining (see, for example, Pennsylvania Department of Internal Affairs, 1944). In fact, Cornwall was the only commercial producer of gold and silver in Pennsylvania, and produced over 426,000 troy ounces of silver and more than 62,000 troy ounces of gold from 1922 to 1973 (based on a comprehensive review of the monthly operations reports of the Cornwall Division on file at the Cornwall Iron Furnace). This amount of gold would have been enough to make about 155 standard gold bullion bars at 400 troy ounces each. By using the price of gold in the New York market for this period, the total value of gold produced at Cornwall was worth over 2 million dollars (unadjusted).

In addition to the gold, silver, and iron, Cornwall also produced more than 163,000 tons of copper and more than 8,300 tons of cobalt. Cornwall became the most important domestic source of cobalt and developed the cobalt extraction technology just in time to help defend our nation before and during World War II and the Korean conflict. The cobalt was included in steel alloys used for armor plate and armaments, as well as specialty alloys used in manufacturing aircraft engines. For many years, Cornwall was and has remained a strategic source of cobalt in the United States ([The] Pennsylvania State University Center for Critical Minerals, 2020). The importance of cobalt in society today is increasing again because cobalt is used in manufacturing lithium-ion batteries and other electric components, in addition to high-strength alloys.

Although Cornwall Mines' production of copper, silver, gold, and cobalt was known by the Cornwall community, local residents did not generally understand the amounts produced and how the metals were recovered. In fact, between 1940 and 1966, the Cornwall Monthly Operations Reports omitted documentation of the gold and silver recovery and minimized discussion of the recovery of cobalt from the pyrite concentrate. As a result, many stories arose and were shared among the miners and millers about the recovery of these precious metals at Cornwall. Fifty years after the closure of the mines, historical research helps us separate fact from myth and reveal the history of the recovery of valuable metals at Cornwall.

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Editor's Note. The following section was added after the original article was accepted for publication, as it was deemed desirable to supplement the discussion of the metals at Cornwall with an explanation of the formation of the deposit.

ADDENDUM—GEOLOGIC ORIGIN OF THE IRON ORES

Robert C. Smith, II, Pennsylvania Geological Survey, retired
Kurt Friehauf, Kutztown University of Pennsylvania

The metal recovery processing in Cornwall, Lebanon County, Pa., described above, developed there because Cornwall is host to iron ores that are the type locality of "Cornwall-type iron deposits." Although this type of iron deposit was originally described from the Newark and Gettysburg basins in Pennsylvania, they are now recognized as far away as China (Hou and others, 2013). The largest publicly reported deposits in Pennsylvania are located at Cornwall and Morgantown in the east-west connection between the Gettysburg and Newark aulacogen (failed rift arm) basins, where 201.509 ± 0.035 million-year-old York Haven Diabase (Blackburn and others, 2013) contact metamorphosed adjacent Cambrian and Ordovician limestones and dolomites (Eugster and Chou, 1979). Smaller economically important iron-copper deposits were also found where the diabase encroached on Precambrian marbles at French Creek, Jones Mine, and Pine Swamp. Smaller deposits were also mined at York Haven Diabase contacts with *Mesozoic* carbonates near Boyertown, Dillsburg, and west of Gettysburg.

Although mafic magmas contain very significant volatiles (indeed, dissolved gases flooding Earth's atmosphere from the mafic magmas of the Central Atlantic Magmatic Province may have initiated the end-Triassic extinction [Davies and others, 2017]), and mafic magmas host some of the world's largest *orthomagmatic* chrome, titanium, platinum, nickel, and copper deposits, the circulation of *hydrothermal* waters that originate from mafic magmas do not typically form large ore deposits. For this reason, the formation of Cornwall-type mineralization also required crustal thinning, which not only yielded the hot diabase magma to accomplish the initial contact metamorphism, but also increased regional heat flow of deep groundwater enough to set up hydrothermal cells which were several townships across and lasted for at least tens of thousands of years. These hydrothermal circulation cells appear to have stripped iron and trace copper from hematitic coatings in red beds within the Mesozoic basins and deposited the metals in the contact metamorphic zones. Because salty waters are more effective at dissolving and transporting metals, the leaching of metals from red beds would have been enhanced by dissolution of evaporite beds in the rift basin strata (Barton and Johnson, 1996).

Although no quantitative data are known, it was generally acknowledged by the geology and mining engineering staff that small amounts of palladium were recovered in the process of recovering copper from the chalcopyrite concentrates. Some tentative support for this became available when David Gottfried of the U.S. Geological Survey (USGS) recognized that palladium might be piggybacking on chalcopyrite at the somewhat-related York Haven Diabase ferrogabbro at Reesers Summit, York County (Gottfried and Froelich, 1988). Harvey E. Belkin of the USGS reported a microscopic-sized Pd–Bi–Sb mineral in the ferrogabbro (Harvey E. Belkin, personal communication, March 2, 1989), and Smith and Barnes (2009) identified sudburyite (PdSb) and others. Mazdab (2001) documented pyrite from Cornwall that contained up to 2.78 weight percent cobalt, and pyrite from the French Creek and Grace deposits that contained up to 0.17 weight percent cobalt. Because palladium and cobalt are siderophile elements (having a weak affinity for oxygen and sulfur) not typically concentrated in oxidized sedimentary red beds, but which do occur in trace concentrations in mafic magmas, palladium and cobalt may have been leached from the diabase. Cornwall-type deposits therefore draw and concentrate metals from two sources: iron from sedimentary red beds, and palladium and cobalt from mafic igneous rock (diabase).

Further information on various aspects of these types of deposits may be found in the following publications:

1. For information on how the immense Morgantown deposit was discovered, see Wharton (2003).
2. For the geology and the entirely underground operation of the Grace Mine deposit, see Sims (1968).
3. For the favorability of the area for additional Cornwall-type deposits in Pennsylvania, see Rose (1972).
4. For technical information about the Cornwall-type deposit, see Rose and others (1985).
5. For the locations of some other Mesozoic copper deposits in Pennsylvania, see Smith and others (1988).
6. For how some *claim* that the York Haven Diabase and General John Buford won the Civil War, see Smith and Keen (2004).

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Editorial—continued from page 2

Perhaps our biggest coup this year was the receipt of $6 million from DCNR for construction of a new rock-sample storage facility (in case you missed the press coverage, here is a link to one of the stories: “Pa. core samples to get new, $6M home”—Pennsylvania Capital-Star [https://www.penncapital-star.com/energy-environment/pa-core-samples-to-get-new-6m-home/]). Between our own drilling work and some large donations of core and cuttings received over the last several years, the facility in the basement of the Middletown office is full. Secretary Dunn and her executive team understood the importance of these samples to progress on climate change mitigation, water security, economic development, and scientific investigations, and gave us the resources to pursue additional purposefully designed space for our collections. We are working with the Bureau of Facility Design and Construction to develop initial schematics to enable us to look for appropriate locations in the Harrisburg area.

We look forward to more exciting developments next year. In the meantime, we hope that all of you had a safe and joyous holiday season, and we wish you a happy 2023.

Gale C. Blackmer

A Fossil New to Science Discovered in York County, Pennsylvania

Jeri L. Jones[1]

Chris Haefner, a seasoned fossil collector from Lancaster County, loves to investigate the Cambrian-age Kinzers Formation in Lancaster and York Counties, Pa. In 2014, he visited the City View Community Church in Manchester Township, York County. The church, constructed in 2001, sat on a hill underlain by the Kinzers Formation. Chris spent more than four years excavating on the property, and he found multiple specimens of trilobites (including *Tuzonia*), *Camptostroma Roddyi* colonies, *Lepidasistis*, structural algae, and others. In the spring of 2017, he found a specimen that he did not recognize, and he knew that he should keep it (Figures 1 and 2, next page). Thirteen months later, Chris found a second specimen of this unknown 510-million-year-old fossil (Figure 3, next page).

Chris, feeling that the specimens were scientifically significant, placed the photographs on Facebook as a way to look for help in identification. Dr. Samuel Zamora, Researcher at the Spanish Research Council and the University of Zaragoza, saw the post and contacted Chris. Chris donated two specimens to the London Museum of Natural History so that Dr. Zamora could identify them. Dr. Jeffrey Thompson and Imran Rahman of the United Kingdom Museum of Natural History also assisted in their identification. The species was new to the science world. Belonging to the class of modern starfish and sea urchins known as edrioasteroids, it was named *Yorkicystis haefneri,* dedicated to the finder of the specimen. This class of animal had a disc-shaped body with five arms and a central mouth. What makes this species special is that, unlike most members of this class, *Yorkicystis haefneri* did not have a skeleton surrounding most of its body.

Dr. Zamora said the following about its discovery:

> "This is a major discovery with important implications for understanding the history of echinoderms, the animal group that includes starfish, sea urchins, brittle stars and their relatives. *Yorkicystis* represents the oldest example of an echinoderm that has secondarily reduced the skeleton. We were surprised to see this had happened so close to the origins of the group over half a billion years ago" (Zamora and others, 2022).

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Figure 1. (Above) Photograph of Yorkicystis haefneri *showing body parts. Photograph by Samuel Zomora, Spanish Research Council.*

Figure 2. (Right) Yorkicystis haefneri *found in 2017. From the Chris Haefner collection.*

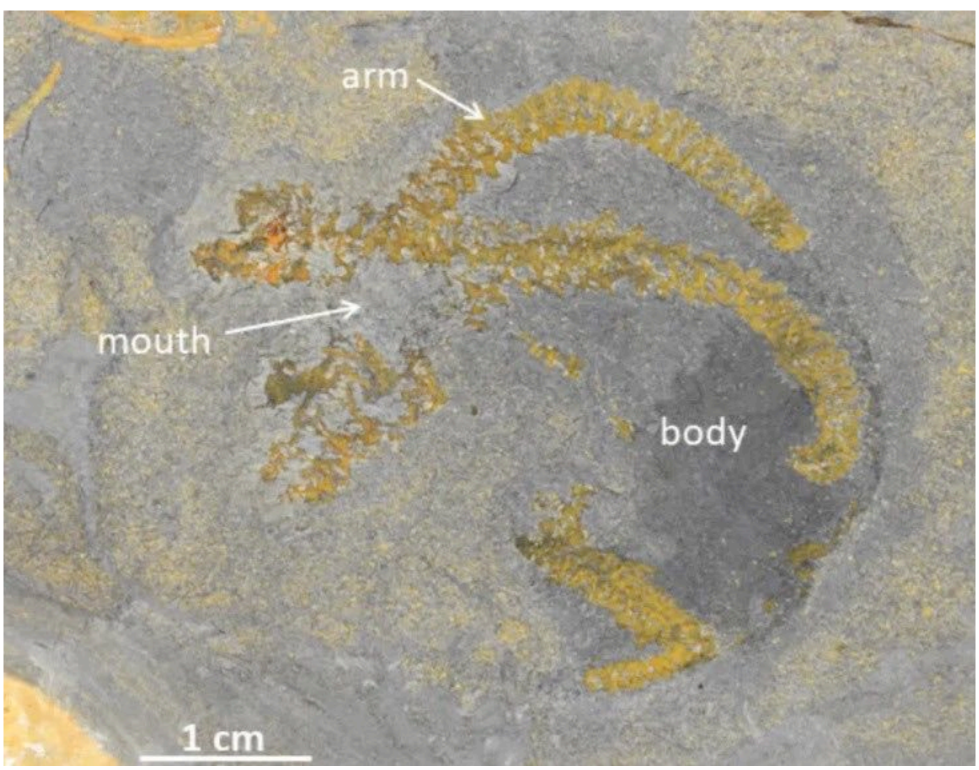


Figure 3. (Left) Yorkicystis haefneri *found in 2018. The dark area is the body. From the Chris Haefner collection.*

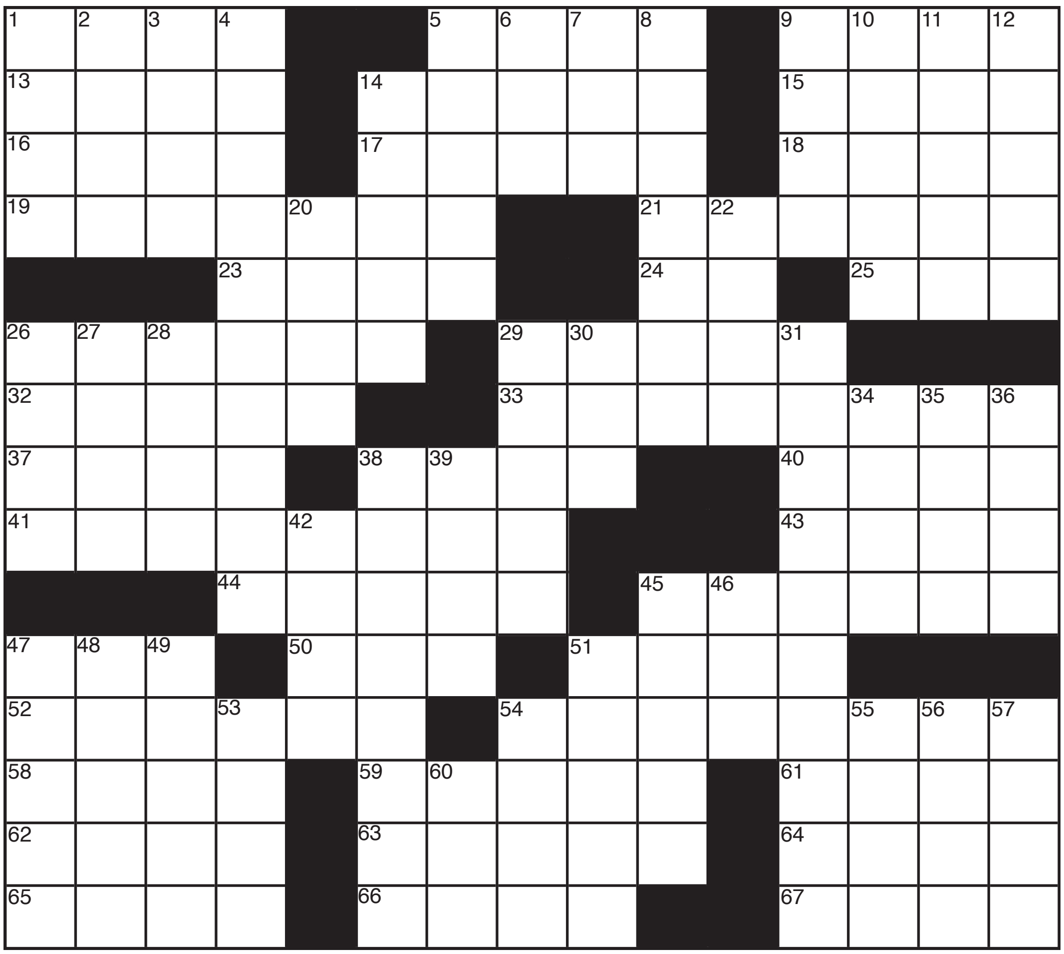
GEOPUZZLE

Geopuzzle Number 2

(Solution on page 18)

Stuart O. Reese
Pennsylvania Geological Survey, retired

For Geopuzzle Number 1, see Pennsylvania Geology, v. 46, no. 1, Spring 2016.



ACROSS

1. Principal
5. Info
9. Large lake fish
13. One time only
14. Stores
15. Publication prep
16. Thick soup
17. Spooky
18. Lacking substance
19. Attached like bryozoans
21. Puppy and its siblings
23. Ollie's partner
24. Jupiter moon

ACROSS *(Continued)*

25. IRS ID (abbr.)
26. Tattletale
29. Flora and fauna
32. Pentateuch
33. Not used; like the Marcellus before 2004
37. Terrible Russian czar
38. Dog's trick
40. Thin pocket bread
41. Aimlessly
43. Related (to)
44. Rock hammer chipping
45. Kingly home
47. Expired on loc.
50. E.g.: Constitution, Missouri, Arizona (abbr.)
51. Bonkers, moonstruck
52. 15-across might include this
54. Not to blame
58. Current flows (abbrs.)
59. Forelimb bones
61. Unit of time
62. In between child and adult
63. Canonsburg's Como
64. In the direction of
65. Snowshoe is a Pa. variety
66. Growth medium for plants
67. Aide (abbr.)

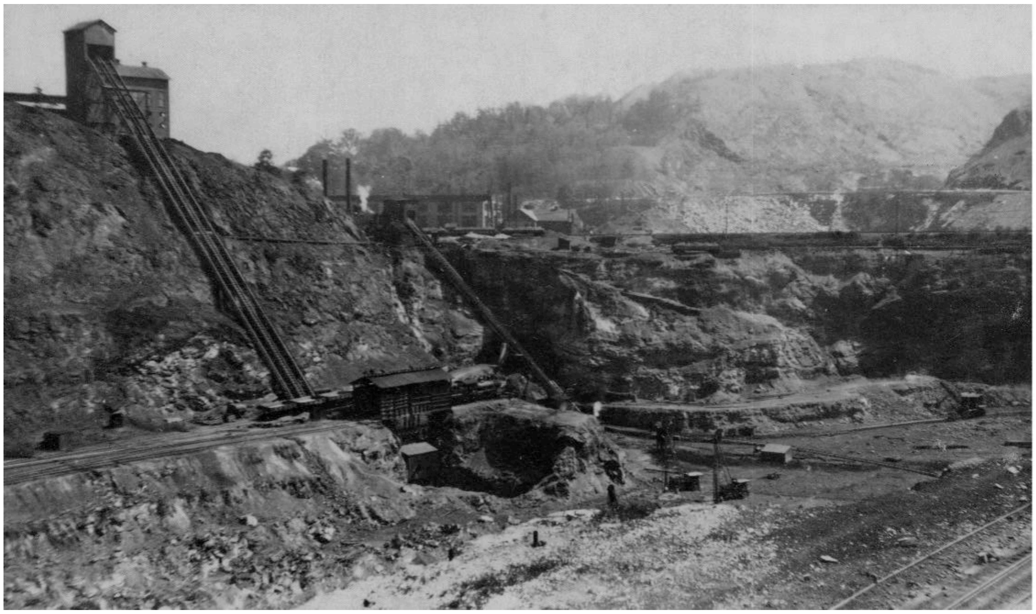
DOWN

1. Spore-bearing, nonvascular land plant
2. Gambler's stake
3. Pa. sign: "bridge ____ before road"
4. City corner relics of the past?
5. Oil on water?
6. High crag
7. U.S. Petrol. Inst. (abbr.)
8. American poet
9. Orogenic zone of deformation
10. Tunnels into mines
11. Locations
12. Severe; forceful
14. Psalms' pause
20. Consistent desire
22. Teeny tiny amount
26. Mix
27. New-born star
28. Arid western Asia country
29. C_4H_9—one H+ shy of butane
30. Goes with "outs"
31. Pre-plate tectonics "borderlands" term; Eastern USA cultural region
34. Small rabbitlike mammal of the Rocky Mountains
35. Relating to cultural analysis from an outsider's point of view
36. Hails from Odense
38. Demolition derby results
39. Afflictions
42. Grand musical work
45. Garden flower of viola descent
46. "A long, long time ____"
47. Life's end
48. "____ _ puzzler, always a puzzler"
49. Viper
51. Knotty bump
53. Bane of 62-across
54. Tennis Hall of Fame loc., maybe?
55. Phanerozoic and Proterozoic
56. Pine and walnut
57. Easy run
60. Sky lion

The unwritten rule for working crossword puzzles is that the puzzler isn't to rely on any outside assistance but only on their wits while using the easier clues to sleuth out the more challenging blocks. My advice is that you allow yourself three "lookups." No one will consider it cheating.

Thanks to Raymond Rizzo and Daniel Reese for their early helpful reviews, and to editor Anne Lutz.

A Look Back in Time



Former State Geologist (from 1919 to 1946) George Ashley took this photograph of the Cornwall ore bank on May 23, 1925 (see the article on page 3). In 1910, a skip hoisting incline was built, "increasing production by reducing the rail haul" (shown here on the left side of the photograph).

To see more photographs of the Cornwall mines and more photographs from the bureau's archives, please visit the library's Historical Photographs collection page.

To learn more about the Cornwall mines and the geology of Cornwall, please see the following resources, which are available online or in the bureau library:

- Gray, Carlyle, and Lapham, D. M., 1961, **Guide to the geology of Cornwall, Pennsylvania:** Pennsylvania Geological Survey, 4th ser., General Geology Report 35, 18 p.
- Lapham, D. M., 1972, **Cornwall—the end of an era:** Pennsylvania Geology, v. 3, no. 5, p. 2–9.
- Lapham, D. M., and Gray, Carlyle, 1973, **Geology and origin of the Triassic magnetite deposit and diabase at Cornwall, Pennsylvania:** Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 56, 343 p.
- Lininger, J. L., 1979, **A farewell to Cornwall—April 21–22, 1979:** A conference and field trip sponsored jointly by the Pennsylvania chapter of Friends of Mineralogy and the Mineralogical Society of Pennsylvania, Lancaster, Pa., 25 p.
- Reese, S. O., and Weber, Michael, 2020, **Outstanding geologic features of Pennsylvania—Cornwall Mines, Lebanon County:** Pennsylvania Geological Survey, 4th ser., Trail of Geology 20–120.0.
- Spencer, A. C., 1908, **Magnetite deposits of the Cornwall type in Pennsylvania:** U.S. Geological Survey, Bulletin 359, 102 p.

—Jody Smale, Librarian

Solution to Geopuzzle Number 2

M	A	I	N			S	T	A	T		B	A	S	S
O	N	C	E		S	H	O	P	S		E	D	I	T
S	T	E	W		E	E	R	I	E		L	I	T	E
S	E	S	S	I	L	E			L	I	T	T	E	R
			S	T	A	N			I	O		S	S	N
S	N	I	T	C	H		B	I	O	T	A			
T	O	R	A	H			U	N	T	A	P	P	E	D
I	V	A	N		S	I	T	S			P	I	T	A
R	A	N	D	O	M	L	Y				A	K	I	N
			S	P	A	L	L		P	A	L	A	C	E
D	O	A		U	S	S		G	A	G	A			
E	N	D	A	S	H		I	N	N	O	C	E	N	T
A	C	D	C		U	L	N	A	S		H	O	U	R
T	E	E	M		P	E	R	R	Y		I	N	T	O
H	A	R	E		S	O	I	L			A	S	S	T

Calling All Authors

Articles pertaining to the geology of Pennsylvania are enthusiastically invited.

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 jpg files. Ensure that black and white drawings are not saved as color images.

Articles should be submitted as Microsoft Word files. Feature articles will be reviewed by at least one bureau staff member. It is the author's responsibility to obtain approval for use of any illustrations that are copyrighted, including those taken from the Internet.

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.

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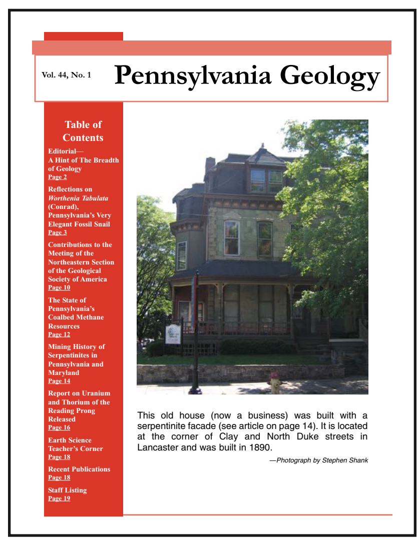

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This old house (now a business) was built with a serpentinite facade (see article on page 14). It is located at the corner of Clay and North Duke streets in Lancaster and was built in 1890.

—Photograph by Stephen Shank

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