UNEARTHING NEW JERSEY

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Department of Environmental Protection

MESSAGE FROM THE STATE GEOLOGIST

During the American War for Independence, no other colony experienced as many battles as New Jersey. The Battle of Trenton, which began with General George Washington's famous crossing of the Delaware River the night of December 25, 1776, is considered by historians to be the turning point of the war. Hessian colonel Johann Gottleib Rall, who commanded the British forces, ignored warnings of an American attack in favor of celebrating the Christmas holiday. It was a fatal mistake. In less than an hour the battle was won and Rall lay mortally wounded. The Trenton Barracks, which, prior to the battle, billeted Hessian soldiers, were located on the battlefield in Trenton City.

In this edition of *Unearthing New Jersey*, geologist Richard Volkert takes a closer look at the masonry of the Barracks. Once the largest building in downtown Trenton, the Barracks was constructed primarily of Chickies Quartzite. This is an excellent example of local rocks being used as building stones.

Other on-going programs at the New Jersey Geological and Water Survey (NJGWS) include mapping the geology and aquifers of the Coastal Plain. This work took place last Fall in Double Trouble State Park, Berkeley Township, Ocean County, with the drilling of a core hole. Don Monteverde and Peter Sugarman discuss their work mapping the Piney Point aquifer.

The story of New Jersey also includes a long history of mining. Copper was not one of New Jersey's more abundant ores, but for two centuries there always seemed to be someone who thought he could be the one to find the mother lode. In the third and final installment of his series on New Jersey copper, Larry Müller examines the copper mines of central New Jersey. Of particular interest in this discussion are mines which were discovered and in operation around the time of the War for Independence. Parts 1 and 2 of Copper in New Jersey can be found in the Winter 2010 and Winter 2011 editions of *Unearthing New Jersey* posted on our website.

Closer to home, and more recently, NJGWS has begun to use QR (quick response) codes on publications. We also have a new Assistant Commissioner, Michele N. Siekerka, Esq. who was appointed to head the Department's Water Resource Management program. Her experience in renewable energy supports ongoing NJGWS research on geothermal technologies and applications.

Karl W. Muessig
New Jersey State Geologist

The Trenton Barracks successively housed Irish, Scotish, British, Swiss, Hessian and American Continental soldiers, Trenton, Mercer County. *Photo by Z. Allen-Lafayette*

BUILDING STONES OF THE TRENTON BARRACKS

By Richard A. Volkert

TRENTON BARRACKS

Built in 1758 by troops from the Colony of New Jersey during the French and Indian War, the Trenton Barracks was, at that time, the largest building in Trenton. The Barracks are located adjacent to Petty's Run, a south-flowing stream, now covered over, between the Barracks and the State House. Today, the Barracks (fig. 1 and *above*) stand in stark contrast to the more modern look of buildings in the downtown area. Nevertheless, its significance is unquestioned.

Historic evidence in the form of structures such as the Trenton Barracks documents the early commercial use of

Figure 1. Rear view of the Trenton Barracks, showing original stonework, *left*, and restored stonework from 1915-1916, *right*. *Photo by R.A. Volkert*

local rocks as building stones in New Jersey. However, until recently, the geologic formation used in construction of the Barracks has remained speculative at best. Work by the New Jersey Geological Survey in 2009 sought to shed some light on this subject by identifying the bedrock for the sake of an accurate historical and scientific perspective.

CHICKIES QUARTZITE

The exterior walls of the Trenton Barracks are constructed almost exclusively of the Chickies Quartzite of Cambrian age (~540 million-years-old). The only other rock type seen in the Barracks consists of six blocks of reddish-brown sandstone of the Stockton Formation of Triassic-age (~200 million-years-old) that form an archway above an upstairs window in the original stonework.

Chickies Quartzite, named for the type section in Pennsylvania at Chickies Rock along the Susquehanna River, derives its name from the Lenape word “chiquesalunga” meaning “place of crayfish.” Near Trenton, outcrops of Chickies Quartzite are well exposed in the hillslope along the Delaware Canal, west of the Delaware River at Morrisville, Pennsylvania (fig. 2). Rock types here include 1) conglomerate and sandstone with rounded pebbles of blue quartz (fig. 3, *top*), 2) white to light-gray, vitreous, thin-bedded quartzite (fig. 3, *middle*), and 3) medium-grained, light-gray to light-greenish-gray quartz-sericite schist with disseminated, fine grains of black tourmaline (fig. 3, *bottom*), all of which have an estimated total thickness of about 730 feet. The pebbles of blue quartz indicate that sediment composing the Chickies was derived locally from Mesoproterozoic (Precambrian) gneisses more than 1 billion-years-old in which blue quartz is a characteristic feature.

The Chickies at Morrisville locally displays graded beds and tabular cross-beds that indicate orientation of bedding here is right-side-up and also confirm a sedimentary origin for the formation. The presence of fossils elsewhere in the Chickies of worm burrows from *Skolithus linearis* fixes its age as Cambrian (Bascom and others., 1909) and suggests that it is coeval with the Hardyston Quartzite Cambrian-age in the New Jersey Highlands. The texture, bedforms, burrows, lithologic characteristics, and compositional maturity of the Chickies, particularly the large amount of sand versus mud that make up the rock, indicate deposition of the precursor sediments in a marine environment, possibly estuarine, along a passive margin (Adams and Goodwin, 1975). The geochemical composition of the Chickies, especially its SiO_2 content (~88 wt. percent) and high SiO_2/Al_2O_3 ratio of 13.3, indicate mature sediment formed from the weathering of older, quartz-rich Precambrian rocks in a passive-margin type of

NJGWS
1835

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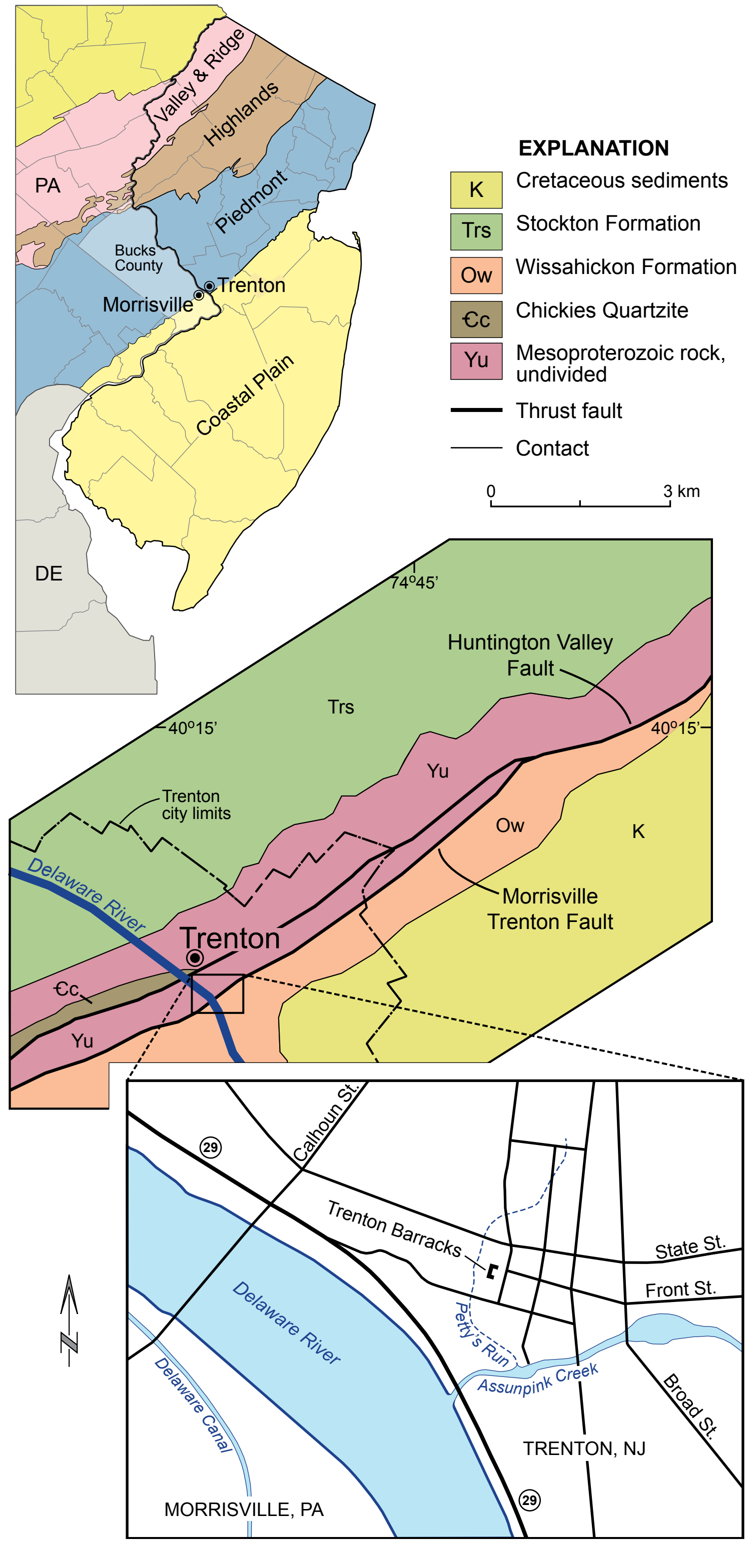

Figure 2. The index, *top above,* shows the physiographic provinces of New Jersey and eastern Pennsylvania. Bucks County, PA, Morrisville, PA and Trenton, NJ are also indicated. *Middle above*, a simplified geologic map of the Trenton area (modified from Volkert and Drake, 1993) showing the location and geologic relationships of the Chickies Quartzite to the surrounding lithology. Bottom *above*, a locational map of downtown Trenton, showing the Trenton Barracks, Petty's Run and the Delaware Canal.

Figure 3. Principal rock types making up the Chickies Quartzite include blue quartz-pebble conglomerate (*top*), quartzite (*middle*), and quartz-sericite schist (*bottom*). *Photos by R.A. Volkert*

tectonic environment, possibly similar to present-day coastal New Jersey.

EXTERIOR WALLS OF THE BARRACKS

Original building stones from the 1758 Barracks construction that are representative of the Chickies include mainly quartz-sericite schist, and less abundant conglomerate with small pebbles of blue quartz and relatively pure quartzite (fig 4). During restoration work on the Barracks in 1915 to 1916, craftsmen tried to match the replacement stone as closely as possible to the original. Although they used the Chickies, virtually all of the stonework consists of quartz-sericite schist, and was probably from a different quarry source in a more homogeneous facies of the Chickies than the original stonework. Although the blocks in the exterior walls of the Barracks clearly have been artificially shaped and sized, a thorough examination of the walls reveals an absence of tool marks on any of the blocks related to the quarrying process. Early quarrying methods often utilized the plug-and-feather technique (Gage and Gage, 2005) that left distinct vertical furrows on the face of the block. Perhaps the blocks used in the Trenton Barracks were quarried by a different method that instead utilized pry bars, or perhaps the craftsmen turned the blocks while constructing the walls so the imperfections faced inward instead of outward.

Figure 4. Close-up of exterior wall of barracks showing blocks of quartz-sericite schist (light gray) and blue quartz-pebble conglomerate (dark gray) of the Chickies Quartzite. *Photo by R.A. Volkert*

Because the Chickies Quartzite does not crop out east of the Delaware River (fig. 2), the source for the material in the walls of the Barracks must have been to the west, in the southeastern Pennsylvania Piedmont. Rogers (1865) recorded a laminated quartzose rock containing mica that is presumably a reference to the Chickies, indicating its very local use as a building stone in Trenton. Bascom and others (1909) also report that Chickies Quartzite was extracted from quarries at Neshaminy Falls, Janney, and Oxford Valley in southeastern Pennsylvania, principally for use as road metal, but they do not mention its use as a building stone. Nevertheless, the walls of the Trenton Barracks are unquestionably constructed from the Chickies Quartzite. Willard and others (1950) show nine quarries in the Chickies between Langhorne and Trevose in Bucks County, Pennsylvania. At Morrisville, Pennsylvania, near the Delaware Canal, a small abandoned quarry that was developed after 1950 is a reminder of the local importance of the Chickies as a building stone. This raises the total to 10 quarries in Bucks County alone. However, the exact site of the original material used in the Barracks walls within the outcropping belt of Chickies remains unknown.

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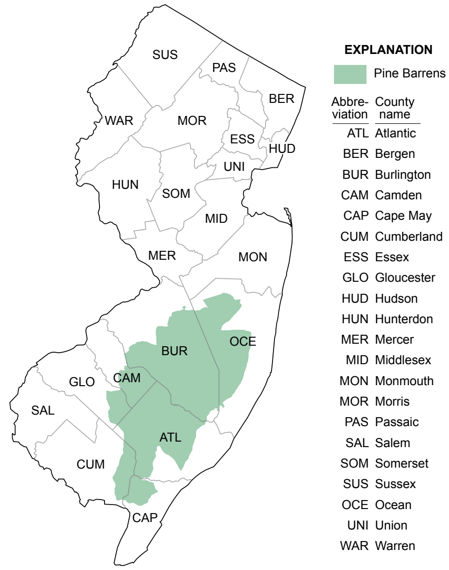

Figure 1. The Pine Barrens is a unique ecosystem of 1.1 million acres which extends into 7 counties.

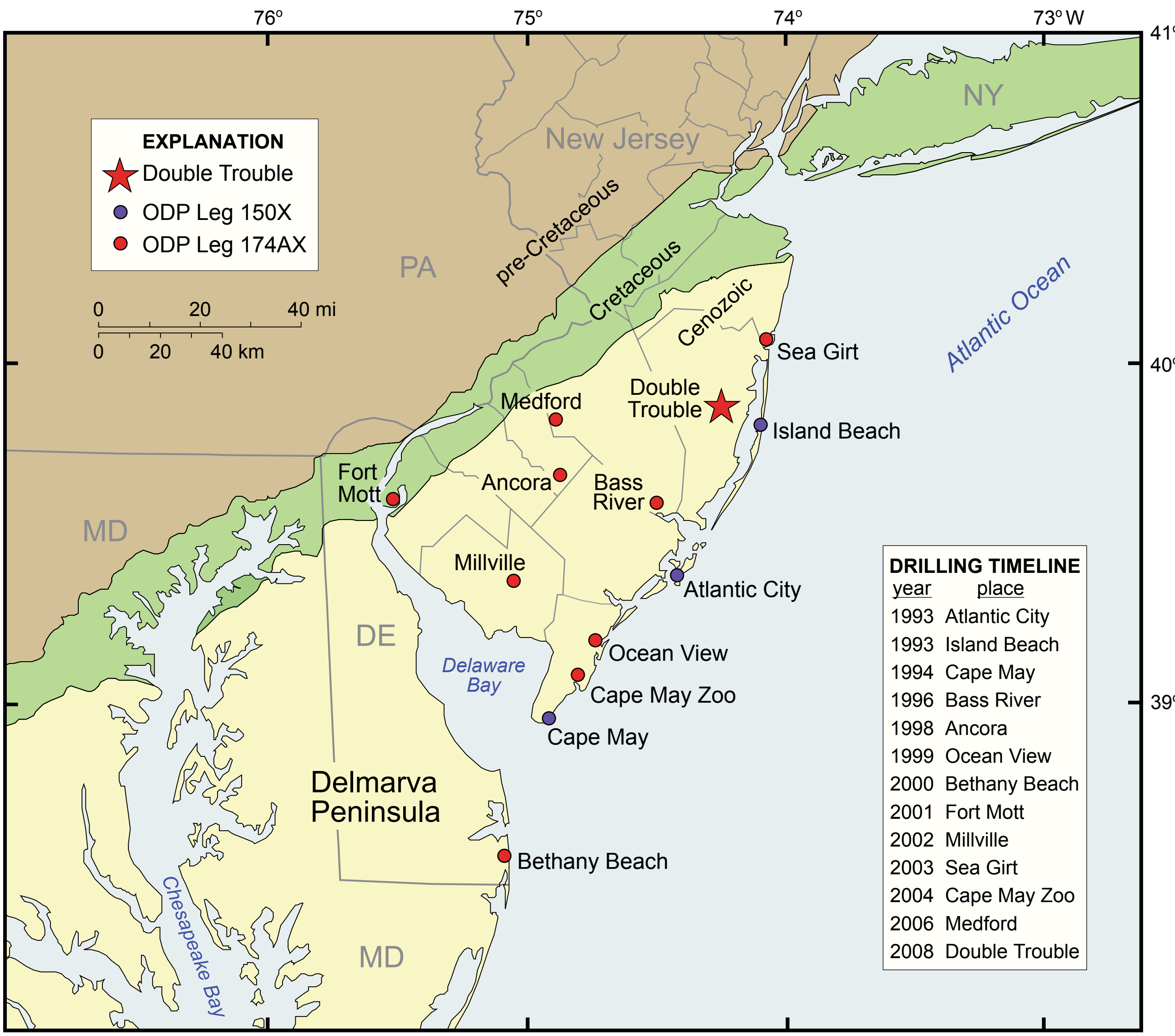

Figure 2. Location map showing the Double Trouble site, and Ocean Drilling Program coreholes drilled as part of the New Jersey Coastal Plain drilling project. Ocean Drilling Program (ODP) Leg 150X included drilling at Atlantic City, Cape May, and Island Beach, and was conducted from 1993-1994. ODP Leg 174AX included drilling at Ancora, Bass River, Bethany Beach, Cape May Zoo, Double Trouble, Fort Mott, Medford, Millville, Ocean View, and Sea Girt from 1996-2008.

GEOLOGIC AND AQUIFER MAPPING AT DOUBLE TROUBLE STATE PARK

By Peter J. Sugarman and Donald H. Monteverde

Double Trouble is a beautiful and historic state park located in Berkeley Township, Ocean County, just inside the eastern boundary of the New Jersey Pine Barrens (fig. 1, page 4). The park houses a historic village that contains a restored sawmill, and a cranberry sorting and packing house, as well as pristine woodlands and beautiful Cedar Creek. It is also the site of a geologic core hole drilled in October and November of 2008 to a depth of 858 ft, completed as part of the New Jersey Coastal Plain Drilling Project (fig. 2, page 4). It is the result of cooperation among the New Jersey Geological and Water Survey, the U. S. Geological Survey, Rutgers University Department of Earth and Planetary Sciences and Delaware Geological Survey.

The Double Trouble site (fig. 3) was selected to investigate Cenozoic sediments (65 million years ago to the present in age), including the Kirkwood-Cohansey aquifer system and the Piney Point aquifer which is not well understood; the age, distribution, and thickness of the Piney Point aquifer have been problematic to fully describe, and have required further investigation. In particular, the Piney Point has been dated as middle and late Eocene (Nemickas and Carswell, 1976), and late Oligocene (Olson and others, 1980), suggesting that it may consist of two distinct aquifers.

At the Double Trouble site, coring disclosed that the Kirkwood-Cohansey aquifer system includes a 94-ft-thick upper aquifer consisting of medium to coarse sand (fig. 4 and fig. 5) separated from a 70-ft-thick lower aquifer consisting of fine to medium sand by a 21-ft-thick leaky confining unit composed of >50 percent silt and clay (fig. 4). Deeper in the corehole lies the Piney Point aquifer, a 161.2-ft-thick unit (fig. 4), that is coarser at the top where it consists of coarse to very coarse sand with granules (fig. 5), and fines downsection to medium to coarse sand with granules. This aquifer is dated as middle Eocene, based on its dinoflagellate cysts. The Piney Point is an excellent aquifer in the Toms River and Double Trouble area, with installed pump capacity for various wells screened in this aquifer ranging between 160 and 1,900 gallons per minute. About six million gallons per day has been pumped from this aquifer during the last several years.

In summary, the Double Trouble core hole displays 858 feet of New Jersey Coastal Plain sediments that are critical in our understanding of the thickness and distribution of major aquifers used for water supply in the area. By establishing a firm correlation among geologic formations, aquifers, and geophysical logs, the drilling established a critical data point for regional correlation of the Kirkwood-Cohansey aquifer system, and the Piney Point aquifer. It will be especially useful in future studies of the Piney Point aquifer to determine if it is in fact a single aquifer, an aquifer system composed of possibly two aquifers, or two entirely distinct aquifers (one middle Eocene and one Oligocene).

The Double Trouble site (October-November 2008) is the thirteenth continuously cored borehole drilled as part of the New Jersey Coastal Plain Drilling Project (NJCPDP) and the tenth site drilled as part of Leg 174AX. Its main focus was mapping the Piney Point aquifer to better understand its regional distribution. A site report is available as a chapter within Ocean Drilling Program Volume 174AX Supplement Initial Reports (Browning and others, 2011).

Figure 3. Double Trouble scientific coring site showing U.S. Geological Survey's Eastern Earth Surface Processes Team drill rig and scientific trailer. *Photo by P.J. Sugarman*

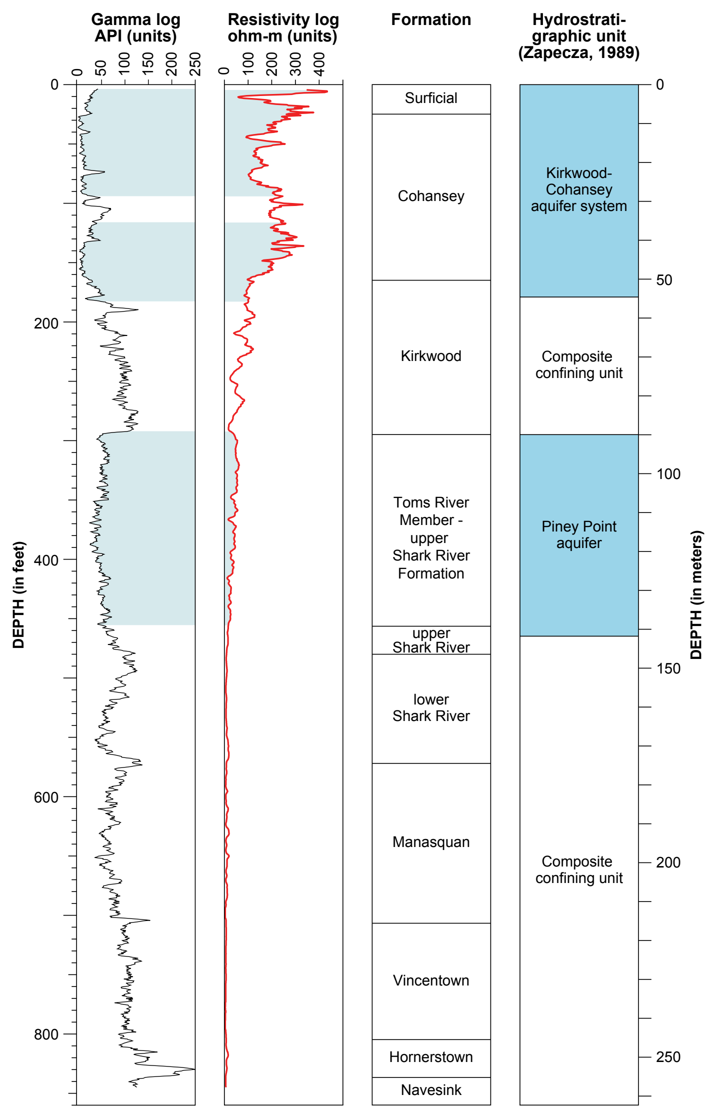

Figure 4. Lithology and hydrostratigraphy at the Double Trouble core hole. Blue shading in the gamma and resistivity log columns indicates aquifers.

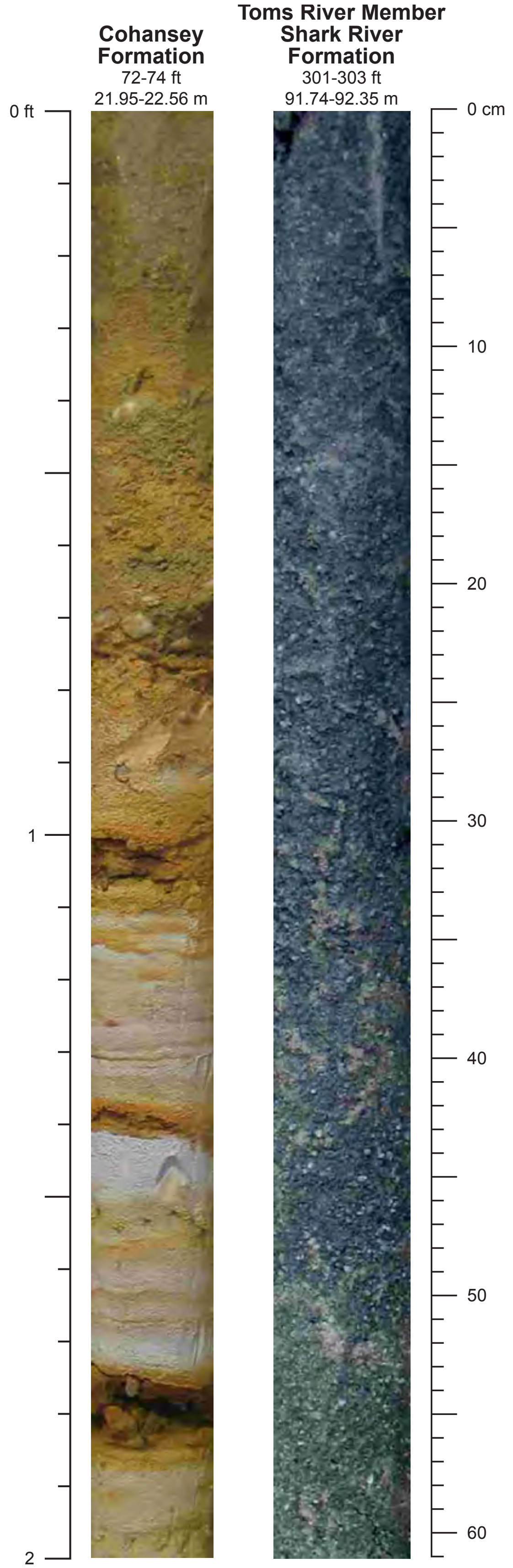

Figure 5. Photographs of cored intervals from 72-74 feet of the Cohansey Formation (Kirkwood-Cohansey Aquifer System), *left*, and 301-303 feet of the Toms River Member of the upper Shark River Formation (Piney Point Aquifer), *right*, both indicating nearshore sand deposits. The green color in the section on right is from transported glauconite sand. *Photos by P.J. Sugarman*

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MOBILE MARKETING AT NJGWS

By Helen Rancan

Recently, the New Jersey Geological and Water Survey began to attach QR codes to its published maps (fig. 1). QR or “quick response” is a matrix or two-dimensional code, invented by the Toyota subsidiary Denso Wave in 1994 to track vehicles during the manufacturing process, and it is fast becoming a world-wide standard for storing and retrieving information due to it’s fast readability and large storage capacity. Barcodes are not just for grocery store check out lines anymore. The information stored on QR codes can be phone numbers, web addresses, email addresses or just plain old text. With the advancements of technology, advances in product codes have kept pace. QR codes are now used on anything and everything from which a user might want information, including now in New Jersey, geological maps.

Figure 1. This quick response (QR) code is NJGWS’ uniform resource identifier.

At NJGWS, we have implemented mobile marketing. Users with a camera phone or smart phone equipped with a QR reader can scan the code. Our QR codes represent our uniform resource identifier (URI), better known as the string of characters that will bring a person to our website. For example, snapping an image of the QR code on the *Bedrock Map of the Bound Brook Quadrangle Open-File Map (OFM) 89* map will direct the user to our website. Here, users can explore all of the information available to the public, including how to purchase publications.

Scan the QR code above and be directed to our online publications page, where previous editions of this publication can be found.

A BRIEF HISTORY OF CENTRAL NEW JERSEY COPPER

By F.L. Müller

When the Dutch, the Swedes and British explorers moved up the Raritan River and settled northeast of what is now New Brunswick (fig.1) and south of the Watchung Mountains, they found scattered fragments, nodules, and sheets of copper. Phillip French had a farm a quarter of a mile from New Brunswick. In 1748, when several lumps of elemental native copper were plowed up, Elias Boudinot leased the mineral rights on the French farm. He organized a mining company and prospected for copper, sinking the first shaft in 1751 approximately 300 yards from the river. His men found sheet copper in the sandstone and some scattered grains of copper and a few larger nuggets of copper. They built a stamping mill near where Rutgers University now stands and prepared several tons of copper ore which was shipped to England for smelting because smelting was not permitted in the colonies. In the tunnels they found an ore body at a depth of 50 to 60 feet containing "sheets of copper as thick as 'two pennies' and three feet square" (Woodward, 1944, p.101). They expanded the workings sending adits in several directions that "some said, extended beneath the river" (Woodward, 1944, p.101). Water in the mine proved to be a problem and the venture ended.

A much later attempt at mining was made in 1840 at a site three miles southwest of New Brunswick. Known as the Raritan Mine, it had a shaft 160 feet deep with a short tunnel. Water in the mine became a problem and that, coupled with the low grade of the ore, made the endeavor unsuccessful. Nearby farms, the Randolph and the Politica, reported finds of cuprite, tenorite, chrysocolla, and some native silver flakes. None of these finds brought economic success. Copper minerals continued to turn up in this area; for example, along the canal copper carbonate ores were said to be found. In the twentieth century during construction in the Rutgers University area, copper ores, largely carbonates, were uncovered.

To the south a more ambitious enterprise took place before the Revolutionary War in Franklin Township, at a mine known as the Griggstown or Franklin. "The Pennsylvania Gazette of January 16, 1753 reported the presence near Griggstown of a valuable 'copper vein of six foot square', mining shares were offered for sale about 1765" (Woodward, 1944, p. 109). A relative of the first mine manager, Captain Rule, said that about 160 Welsh miners were employed there (Woodward, 1944, p.109). Mining ceased at the start of the American Revolution, and the mine remained idle for the next 40 years. Reports stated that the mine was in ruins. Before the Civil War, however, there were several small-scale attempts to work the mine. This activity ceased by 1868. In 1901 the main shaft was again opened and cleared by Isaac Gabel and Robert Dixon. They cleared passages to the 100-foot level and claimed that the mine contained copper, gold and silver. The deepest shaft was cleared by 1906. The mine consisted of several shafts and stopes and a 1600-foot drainage tunnel. Nevertheless, it did not last long. With the rise of copper prices in 1916 during World War 1, a new copper venture began with Mr. Robert Labaw of Hopewell as superintendent (Woodward, 1944, p. 111). He pumped out the water, cleared tunnels, and opened the mine for review. Despite a few favorable reports, Professor Phillips of Princeton University, after reviewing the mine, would say only that the owners would not like to hear what he thought (Woodward, 1944, p. 113). However, stock was sold, and a few bags of ore were sent to Perth Amboy. After a few months the mine closed. Woodward (1944, p. 113) concluded that the main thrust of this endeavor was stock sale rather than copper ore production.

The ore which is seen in the tailings piles is cuprite, chalcocite, malachite, azurite, chrysocolla, and some native copper. Gold and silver have been found in specimens reputed to be from the Griggstown Mine. "Owners of the property in the period from 1900-1905 were insistent that the gold and silver occurred in workable quantities in the mine, and were in possession of a number of assays to bear out this contention. One of these reported $212 of gold per ton, another $26 of silver per ton. An independent assay of rich ore of this type was requested by the New Jersey Geological Society, and this test showed 0.01 oz. of gold and 0.03 oz. of silver per ton" (Woodward, 1944, p.116). The rock in which the ore is found (country rock) is a pink to gray hornfels. A

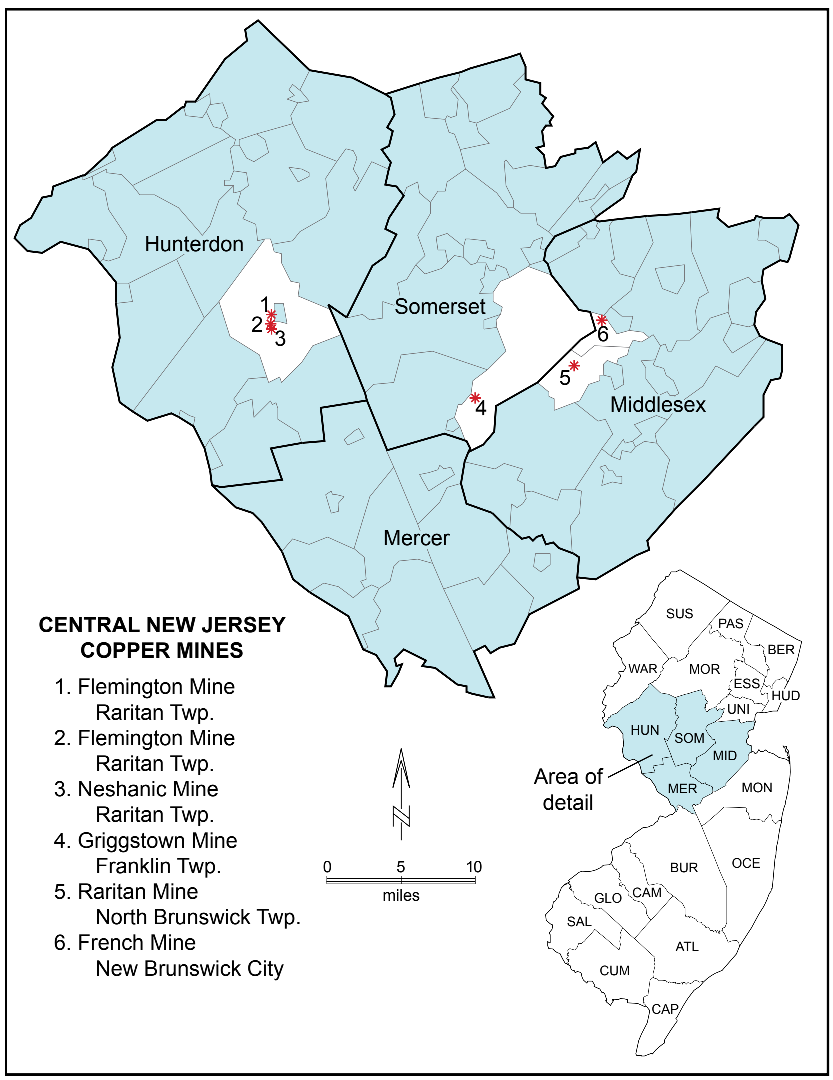

Figure 1. Location of central New Jersey copper mines.

blue-gray diabase dike is cut by one of the tunnels. Several diabase dikes and apophyses are nearby. Accessory minerals are chlorite and feldspar which are abundant, and minor tourmaline, calcite, epidote, magnetite, and hematite.

West of Griggstown in southern Hunterdon County several copper mines have been operated. In the vicinity of Flemington, at the former Capner and the Dvoor Farms near Mine Brook, several mines, (collectively known as the Flemington Mine) were dug. Another about a mile and a half south of these on the Rockafellow property came to be known as the Neshanic Mine (Woodward, 1944, p.104). All of these were discovered and first operated prior to the Revolutionary War. The first workings were presumably small because "a report in 1834 describes the mine as abandoned" and it is worth noting that it is not always certain which one was indicated (Woodward, 1944, p.105). The Neshanic Mine was incorporated in February 29, 1836 with an investment of $100,000. The original backers of the mine were Joseph Case, William Sloan, Samuel Hill, and John Capner (Woodward, 1944, p.105).

A series of owners tried mining in the 1840's. The Central Mining Company of Flemington sank three shafts and although it found good copper, it was not abundant enough to be profitable. The Hunterdon Copper Company operated in the middle of the 19th century. Professor Montroville W. Dickson wrote a report in 1861 and directed it to the company. He surveyed the mine holdings of this company and based it largely on the Gay Shaft. He showed that the shaft reached a depth of 200 feet in five levels with drifts extending hundreds of feet from the shaft. Encouraged by what he saw, he recommended that the depth be extended to 300 feet. There is no report that this was done.

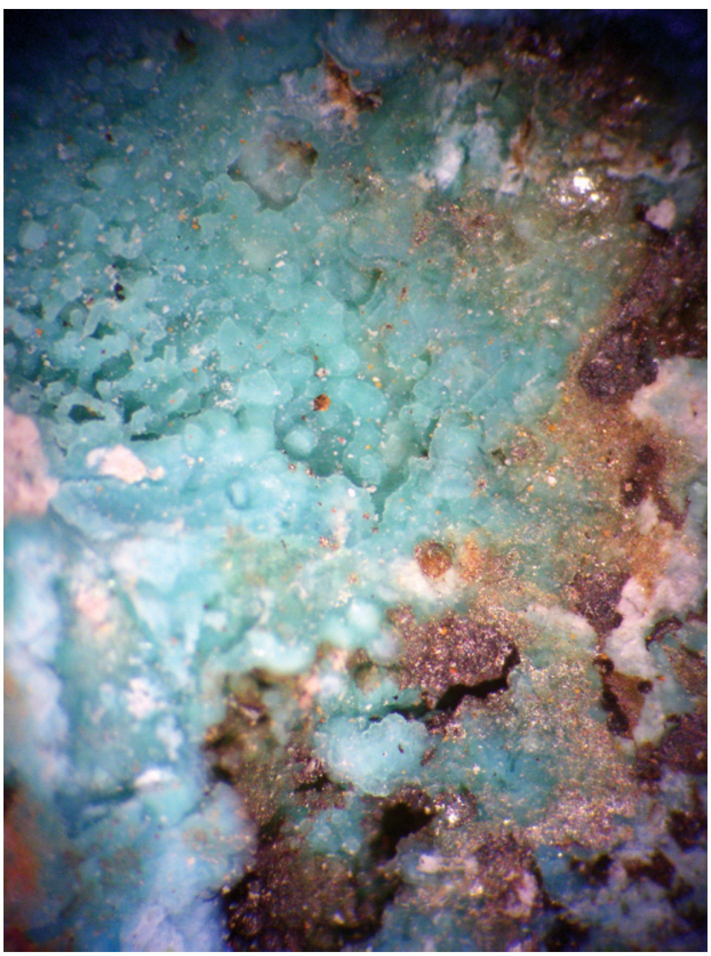

Figure 1. Chrysocolla is typical of the copper minerals found in central New Jersey mines. The blue-green color was one of the qualitites which attracted early prospectors to this mineral. *Photo by J.H. Dooley*

Elias Vosseller in his pamphlet "A Sketch of the Copper Mining Enterprise Near Flemington, New Jersey" recounts the stormy history of the early local mining endeavors through the mid-1800's. He describes many of the early mining companies' attempts (11 or more) and delineates the various stock sales and promotions, as well as the construction of mining buildings and equipment. Vosseller vividly recalls the rollicking life of the miners. For example, when a new mine captain replaced the well-liked captain Girardeau, the new captain replaced many of the miners. The miners revolted and rode him out of town on a rail. The sheriff was brought in to deal with the riot. The miners locked up both the sheriff and the captain. The town's citizens had to be called in to help the sheriff. The riot act was read and the miners scattered. Some 11 miners were fined but no one was seriously hurt. The mining efforts brought scant profits. The citizens of the town were concerned about the character of the miners: the whole effort was demoralizing to the town. Although it brought in some good citizens, it brought in many of a very rough character. There was a great deal of carousing, and Saturday nights in particular were made hideous, with brawls and drunkenness (Vosseller, 1891, p.22). Evidence of the old mining efforts in Flemington are occasionally seen when construction reveals the face of an old adit or a pond is discovered near Mine Brook.

Recently the Courier News of October 26, 2002 ran a story about a construction project in Raritan Township which broke into an old shaft and adit of the Neshanic Mine. Engineers surveyed the workings and stabilized the area. In the publication of their 1846 survey, Richard C. Taylor and David Stengel describe the activities of the Neshanic Mining Company. They quote local lore that says the mines were worked before the Revolutionary War and that a large amount of good ore was sent to England. By 1846 the mine was brought back to life. Shafts were cleaned and adits were dug, and they penetrated a copper-containing vein. In a letter of July 11, 1846, William F. Clemson, who mined the Neshanic for about a year, describes the shafts, tunnels and chambers together with the geology. The vein, he states, in places was 3 to 12 feet wide. The ore was a sulfide, gray in color. He remarked about the water problem and the need for pumping. In addition to the main ore mineral chalcocite, there was malachite, cuprite, and some azurite.

These mines never justified the investments of time, money or labor. What remains of this industry now is all on private property and one may not trespass. In times of low water in Mine Brook one might catch a glimpse of the blue or green which led these early speculators to try for the mother lode.

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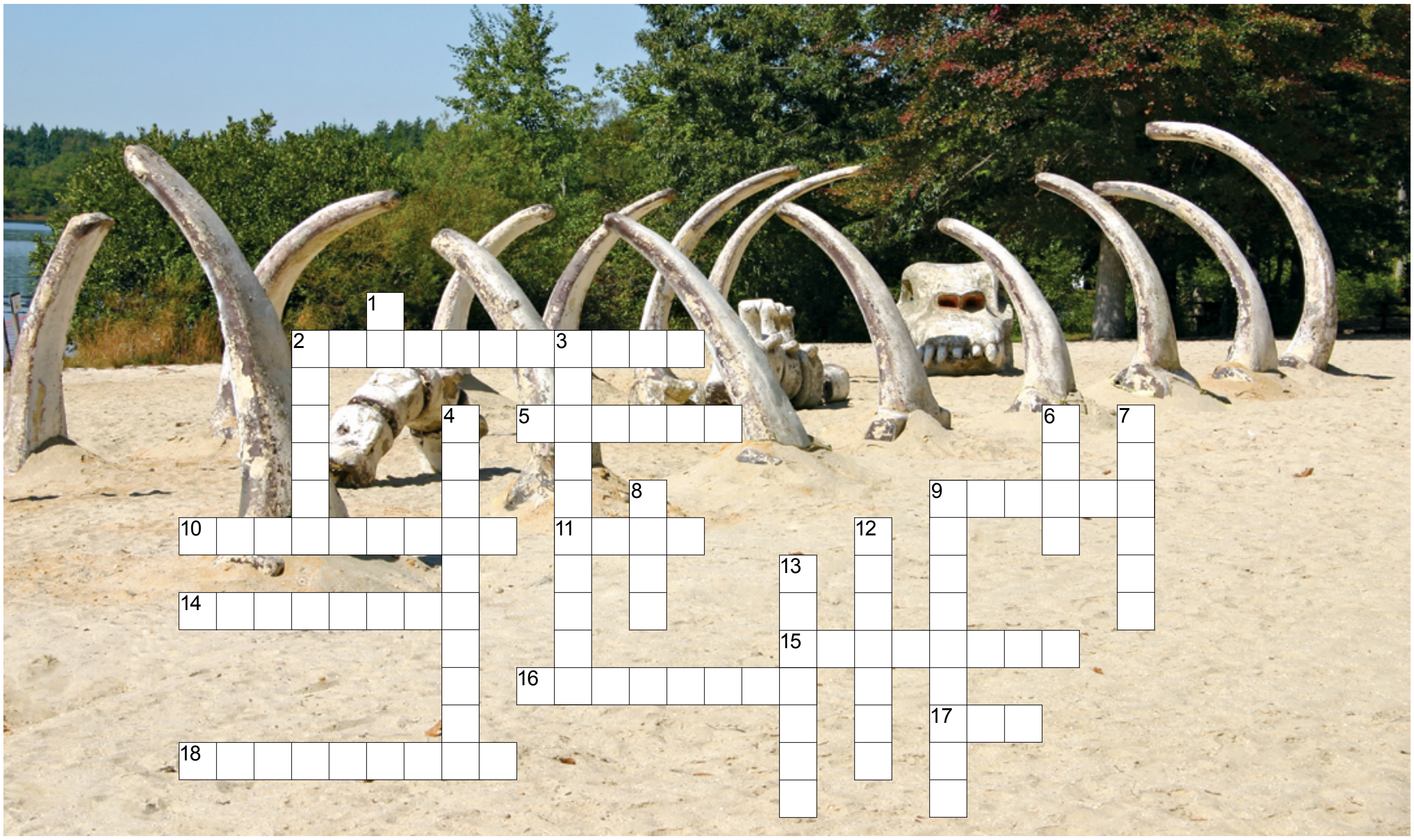
LET'S PLAY: GUESS THE MINERAL

Here it is:

$$CuSiO_3 \cdot nH_2O$$

If you think you know what this mineral is, send your answer to njgsweb@dep.state.nj.us.



Fossil dinosaur sculpture on the beach at Parvin Lake, Parvin State Forest, Salem County, 2005. Since this photo was taken, the sculpture has been removed from the beach. *Photo by Z. Allen-Lafayette*

CROSSWORD BONES

ACROSS

2. Show correspondence in character and stratigraphic position
5. Open mine workings
9. Strongly foliated crystalline rock
10. Unmetamorphosed sandstone
11. Horizontal passage from the surface into a mine
14. Circular hole made by drilling
15. Geologic period with its threefold lithologic division in the rocks of Germany
16. Geologic period characterized paleontologically by the abundance of mammals
17. Material from which a mineral can be extracted
18. Description of rocks

DOWN

1. Quick response code
2. Cu
3. Buergerite, elbaite and dravite are in this mineral group
4. Destructive processes by which rocky materials are changed by exposure to atmospheric agents
6. Fissure in rock filled with mineral matter
7. Endemic
8. Tabular igneous intrusion that cuts across the bedding
9. Clastic sedimentary rock
12. Water bearing stratum of permeable rock
13. Part of geologic formation appearing at the surface

CROSSWORD PUZZLE ANSWERS. Across: (2) correlation, (5) quarry, (9) schist, (10) quartzite, (11) adit, (14) borehole, (15) Triassic, (16) Cenozoic, (17) ore, (18) lithology. **Down:** (1) QR, (2) Cu, (3) tourmaline, (6) vein, (7) native, (8) dike, (9) sandstone, (12) aquifer, (13) outcrop.

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Chrysocolla is a hydrated copper silicate. It is a mineral of secondary origin, produced by the oxidation of copper minerals formed in oxidation zones around of copper ore bodies. Chrysocolla can take form as amorphous, non-crystalline structures, but it is more typically found as botryoidal (grape-like) masses or bubbly crusts. It is associated with malachite, azurite, cuprite, native copper, and other secondary copper minerals.

Banner photos by J.H. Dooley

This T-Rex *adipiscing metalli dinosaurum,* spotted near Sea Bright, Monmouth County, is a reminder of the long history of fossil exploration in New Jersey and the fact that these magnificent beasts once roamed what are now our suburbs. *Photo by Z. Allen-Lafayette*