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MESSAGE FROM THE STATE GEOLOGIST

The New Jersey Geological Survey is celebrating its 175th year of providing crucial earth science information to government agencies, the business community and the public. In a speech to the state legislature in October 1832, New Jersey Governor Peter D. Vroom stated: "I have no doubt that if a geological survey of our State, or parts of it, could be made, even upon a limited scale, it would result in most valuable discoveries." William Marshall, chairman of the Committee of the Assembly, reported favorably upon this portion of the Governor's message, saying such a survey "would tend to develop still further the wealth and resources of the State. It would have a tendency to advance the progress of science, to exalt the character of New Jersey, and to promote the growth and prosperity of her agricultural and manufacturing industry." On February 19, 1835, the New Jersey Legislature passed an act "To provide for a geological and mineralogical survey of the State of New Jersey."

Governor Vroom appointed Henry Darwin Rogers (1808-1866) as the first New Jersey State Geologist. His mandate was to perform a survey of portions of the State concluding with a written report of his findings. Rogers' work plan called for five transects that crossed many of New Jersey's geologic formations. He presented his 174 page report to the Governor in February 1836.

The early focus of the Survey on mineral resources for economic development soon evolved to include water and energy resources. Although the specific resource needs are different today, mineral (beach nourishment sands & construction), water (resource protection & use) and energy (geothermal & carbon sequestration) resources remain priority focuses for the Survey in collecting and analyzing reliable geoscience data.

The Survey welcomes your feedback on the content or format of the newsletter. Digital maps and reports are online, and printed maps and reports are available through DEP Maps and Publications (609) 777-1038, PO Box 402, Trenton, N.J. 08625-0402. Due to fiscal constraints, over-the-counter purchases are no longer available. Go to our website for more information. Publication prices are maintained on the Web. Unpublished information is provided at cost by writing the State Geologist's Office, N.J. Geological Survey, PO Box 427, Trenton, N.J. 08625-0427. Staff are available to answer your questions 8 AM - 5 PM, Monday through Friday by calling (609) 292-1185.

Karl W. Muessig,
New Jersey State Geologist

DEEP DRILLING AT LIMECREST QUARRY, SPARTA, NEW JERSEY: A GEOLOGIC PERSPECTIVE

By Richard A. Volkert

INTRODUCTION

The opportunity to examine rock from below the ground surface, especially from great depth, is exciting for every geologist. Quarries can provide an easy and excellent place to view subsurface material. However, most quarries in New Jersey are no more than a couple of hundred feet deep, which is a very limited amount of rock to observe. Geophysical techniques involving seismicity, magnetism, gravity, or electricity enable geologists to image the subsurface. Unfortunately, the results of these techniques are often ambiguous, and no actual rock samples are available for inspection. Drilling to retrieve rock core is the only reliable method to determine the type of bedrock below ground. It provides a precise record of the stratigraphic order in which the rock occurs, and the presence of faults or other structural features that may have affected the rock. The drill core is a permanent and tangible record of the subsurface geology that is available for current and future scientific study.

Most drilling in New Jersey is shallow, a few hundred feet or less. It is done mainly for water wells, environmental issues, or to locate abandoned mine workings and typically produces rotary cuttings of very small rock chips. These chips become mixed together during drilling and are of

Limecrest Quarry, Sparta Township, Sussex County, 2004. *Photo by R.A. Volkert*.

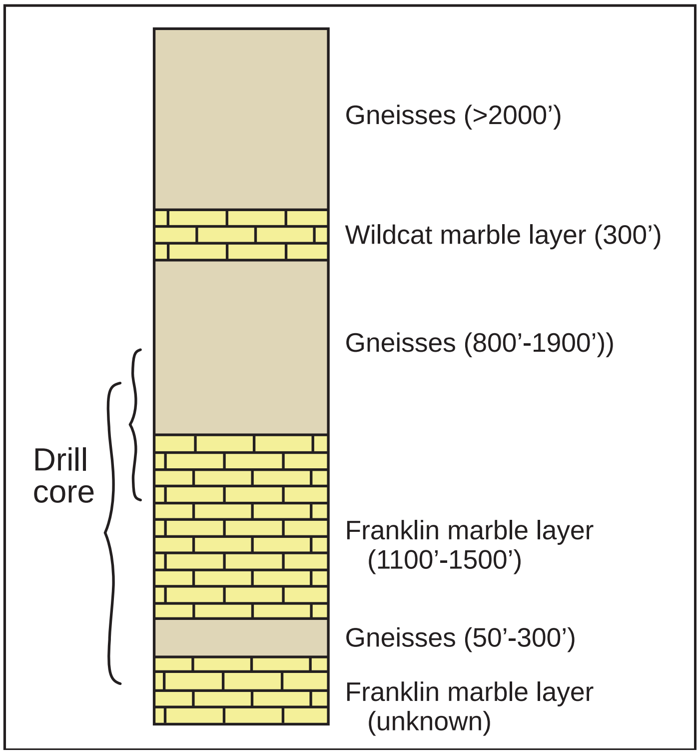

Figure 1. Stratigraphic column of Precambrian gneisses and marble from the area of the Limecrest Quarry. Rocks exposed at the quarry are within the short bracket and those penetrated by the drill core are within the long bracket. Thicknesses shown (Hague et al., 1956) are not true thicknesses of the rock units, but rather estimates based on calculated thicknesses from outcrop information (J.L. Baum, 2009, personal communication).

limited use unless the geology is uncomplicated and the rock is of the same type. Such is not the case in the New Jersey Highlands where the geologic relationships of the oldest rocks in the state are extremely complex and the rock types vary widely. Here rock cores are essential for understanding the subsurface although it is specialized and expensive work.

Recently, the Riverbank Power Corporation in Toronto, Canada, selected a number of sites in the United States to evaluate for suitability of a below-ground alternative energy storage and power generation facility known as Aquabank™. For further information on this technology, the interested reader is referred to the Riverbank website. Following preliminary drilling at a site under consideration in Maine, the Limecrest quarry in Sparta, New Jersey, was chosen as the next site to be evaluated. If the bedrock beneath the quarry is deemed suitable, the Aquabank™ facility will be constructed at a depth of about 2,000 feet below ground surface and the water-filled quarry. Construction of an ambitious project of this scope requires a precise understanding of the bedrock and its engineering characteristics. The only way to acquire the necessary information is to drill a series of coreholes, each to a depth exceeding that of the proposed Aquabank™ facility.

NJGS 1835

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LIMECREST QUARRY

Limecrest quarry is located in Sparta Township, Sussex County, along the extreme western edge of the New Jersey Highlands. The quarry was first opened in 1906 as the Crestmore quarry by Thomas Edison for use as a source of high-calcium lime. It closed soon after, and remained inactive from 1908 until 1919 when it was reopened by the Limestone Products Corporation of America (Breskin, 1922). The quarry was then worked nearly continuously until 2003 when the pumps were turned off and it was allowed to fill with groundwater. Since then only the upper benches (areas of mining along the walls of an open pit) have been quarried.

Most of the Limecrest quarry is developed in rocks of Precambrian age, mainly Franklin Marble, although the upper quarry benches expose various gneisses that directly overlie the marble (fig. 1). The marble is white to light gray, medium to coarse grained, calcitic, and displays a mineral banding defined mainly by graphite and mica, but that also includes other minerals. Gneisses are quite variable in color and mineralogy, ranging from light gray or greenish-gray to grayish-black, are medium grained, and have a well-defined mineral banding. Dating of gneiss immediately above the marble at Limecrest quarry yielded an age of about 1299 million years (Volkert et al., in press) that provides an age for the time of formation of the gneiss as well as the marble. Rocks at Limecrest quarry older than 1050 million years were metamorphosed deep in the earth's crust at a temperature of about 1400°F (Peck et al., 2006). The youngest Precambrian rocks at the quarry are small bodies of coarse-grained granite known as pegmatite that are 998 to 989 million-years-old (Volkert, 2004). The pegmatites are undeformed and were intruded into the marble after it and the gneisses were metamorphosed.

Until now, the thickness of the Franklin Marble at Limecrest was unknown. Drilling of six 150-foot-deep coreholes beneath the quarry floor in 1997 to determine marble reserves provided only a minimum thickness for the marble of about 300 feet. Furthermore, the type and thickness of the bedrock beneath the marble at Limecrest has never been established with certainty. Based on geologic mapping of the Sparta area in Sussex County, Drake and Volkert (1993) interpreted faulted Precambrian gneisses south of the quarry that crop out from Andover nearly to Limecrest, to indicate that the Franklin Marble and gneisses at the quarry had been cut at depth by a thrust fault that transported the Precambrian rocks westward over younger, 500 million-year-old Paleozoic dolomite. Southwest of Andover, in Green Township, Baum (1967) similarly

Figure 2. Locations of coreholes DR1, DR2 and DR3 shown in relation to the present-day Limecrest Quarry in Sparta Township, Sussex County.

interpreted Precambrian marble and gneiss there to be thrust westward over Paleozoic dolomite based on drilling by the New Jersey Zinc Company. Baum (1967) named the fault intercepted in the drillhole the Tranquility thrust fault, and Drake and Volkert (1993) tentatively correlated the thrust fault at Limecrest quarry to the same fault. However, because Paleozoic rocks immediately west of the quarry appear to be in their correct stratigraphic order, and also because the Paleozoic rocks normally rest on top of the Precambrian rocks and not beneath them, the presence of the Tranquility thrust fault was questioned. Before drilling, it was hoped that a few deep coreholes at Limecrest quarry would provide some very important geologic information.

Figure 3. Forage Mercier drill rig and the principal driller at corehole DR1, at the south corner of the quarry. *Photo by R.A. Volkert*

RESULTS

Three coreholes were proposed at Limecrest, each to be cored to a depth of 2,200 feet below ground surface. These included: DR1, on the south side of the quarry; DR2, on the west side; and DR3, on the north side (fig. 2). All of the drilling was performed by Forage Mercier of Val D'Or, Quebec, using a custom-designed drill rig (fig. 3). Drilling at DR2 took place from 7/24/09 until 8/3/09 to a total depth of 2,204 feet, and DR1 was drilled from 8/4/09 until 8/11/09 to a total depth of 1,997 feet The decision was made by Riverbank not to drill DR3 for reasons discussed later.

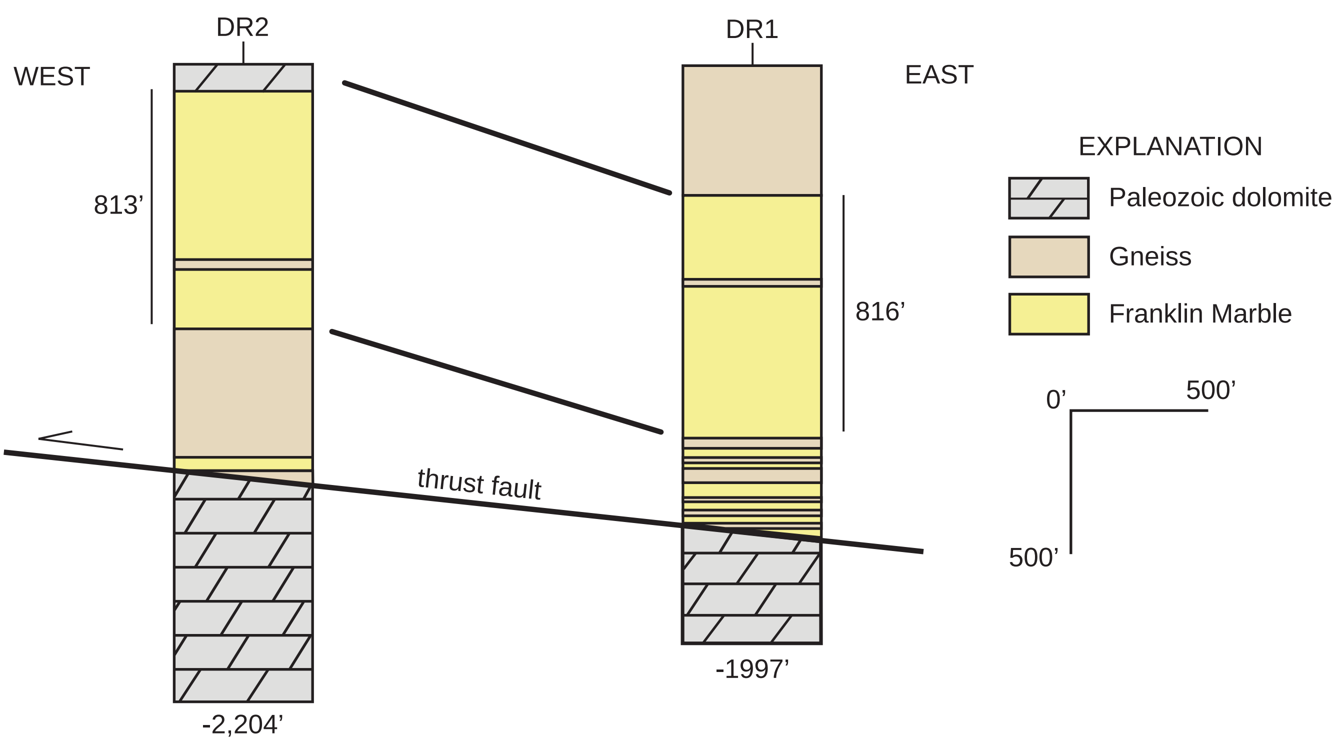

Figure 4. Generalized cross sections and drilling thicknesses of the bedrock penetrated in coreholes DR1 and DR2 at Limecrest Quarry. Sections were constructed from lithologic logs using the rock core from each drill hole. Arrow shows the westward direction of transport of the Precambrian rocks on the thrust fault.

Figure 5a, *above left*. Drill core of Precambrian Franklin Marble penetrated in holes DR1 and DR2. Figure 5b, *above right*. Drill core of greenish-gray granite pegmatite intruding Franklin Marble in hole DR1. Note the irregular contacts of pegmatite against the marble. *Photos by R.A. Volkert*

Detailed logging of drill core samples of Precambrian marble and gneiss from both holes was performed by the author and of Paleozoic dolomite by Don Monteverde, both of the New Jersey Geological Survey. The results of the core logging are shown in figure 4. Logging involved classifying the core by rock name and mineralogy, and then characterizing it using uniform standards for color, grain size, texture, rock fabric, structure (fracturing, faulting, folding), and other miscellaneous features. Corehole DR2 drilled (top to bottom) 80 feet of Paleozoic dolomite, and then Precambrian rocks that included 813 feet of marble (fig. 5a) and minor granite pegmatite (fig. 5b), 430 feet of gneiss (fig. 6), and 99 feet of interlayered marble and gneiss before penetrating a thrust fault (fig. 7) at a depth of 1422 feet. About 782 feet of Paleozoic dolomite (fig. 8) was encountered beneath the thrust fault. Corehole DR1 drilled (top to bottom) Precambrian rocks that included 495 feet of gneiss, 816 feet of marble and minor granite pegmatite, and then 282 feet of interlayered marble and gneiss before encountering the same thrust fault at a depth of 1593 feet. About 404 feet of Paleozoic dolomite was drilled beneath the thrust fault.

Because the marble and gneiss at Limecrest dip toward the southeast at an angle from horizontal, the drilling thickness is not the actual thickness of the bedrock. This is calculated from the angle of dip of the metamorphic banding (foliation) in the marble and gneiss. Measurements were recorded in drill core from 55 foliations each in holes DR2 and DR1, and their dip angles average 23^{o} and 36^{o}, respectively. Using these angles, the thickness calculated for the Franklin Marble at Limecrest is 745 feet to the west in DR2 and 655 feet to the east in DR1. No folding of the marble was noted in the drill core indicating that these estimates likely represent the actual thickness of the Franklin Marble layer.

Figure 6, *above left*. Drill core of strongly-banded Precambrain gneiss penetrated in hole DR1. Figure 7, *above center*. Close-up of thrust fault between Precambraian gneiss (top) and Paleozoic dolomite (bottom) in drill core from hole DR2. Fault plane in the core dips at an angle of about 60^{o}, but the dip becomes much gentler to the east of the corehole. Pencil tip points to the fault contact. Figure 8, *above right*. Drill core of Paleozoic dolomite encountered beneath the thrust fault in hole DR2. *Photos by R.A. Volkert*

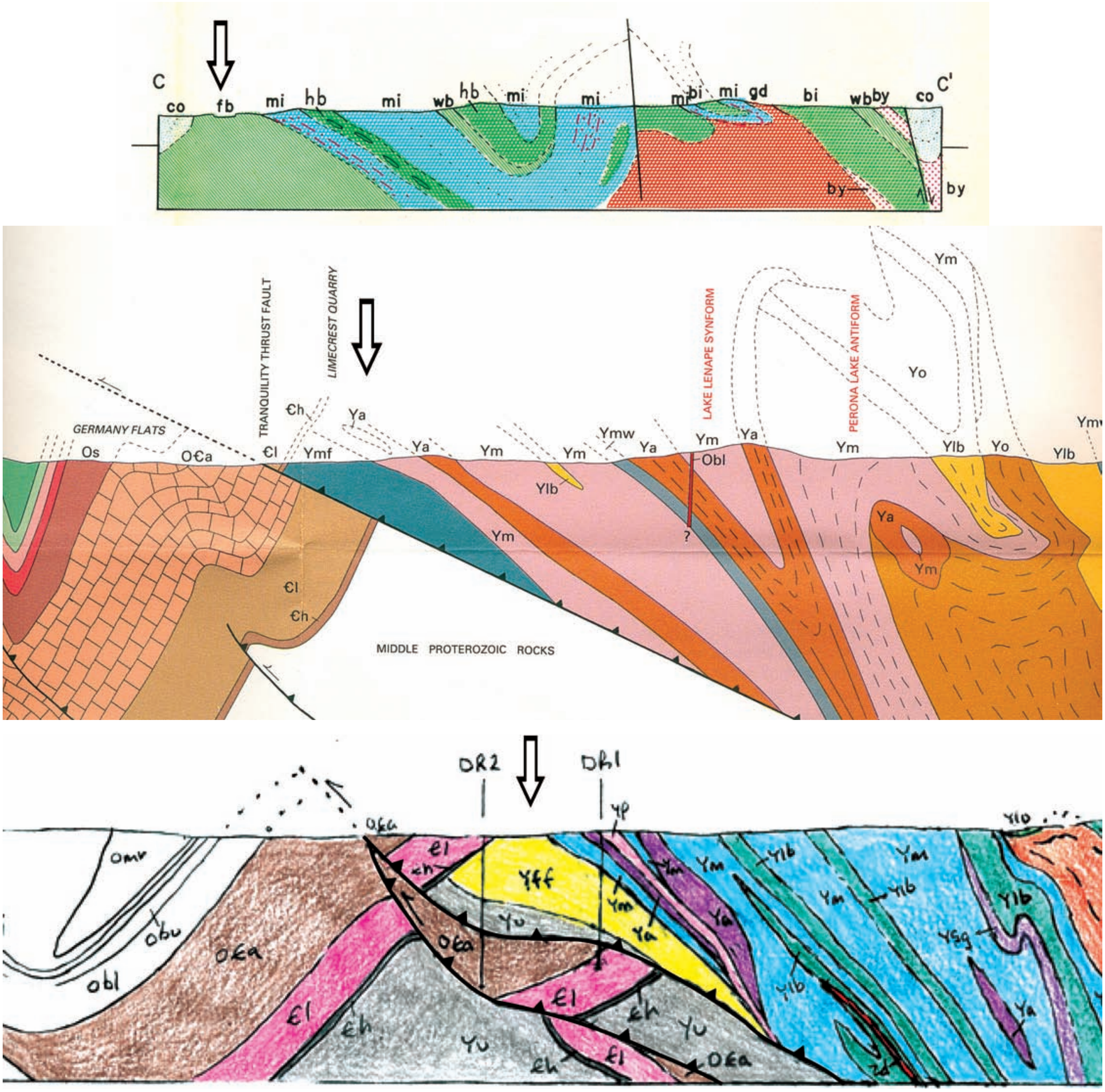

Figure 9. The evolution of geologic interpretations for Limecrest quarry as depicted in cross sections viewed with west to the left. Data sources are (top to bottom): Hague et al. (1956); Drake and Volkert (1993); and Volkert and Monteverde (2009). The latest interpretation emphasizes the importance of drilling in areas of complex geology. Arrow points to the surface location of Limecrest quarry in each cross section. Thrust faults are bold lines with barbs.

Drilling at Limecrest quarry ultimately confirmed the presence of a thrust fault at the western edge of the New Jersey Highlands as proposed by Baum (1967) and Drake and Volkert (1993). Moreover, the corehole data led to a better understanding of the bedrock formations and their structural relationships beneath the quarry (fig. 9) and regionally, resulting in a refinement of the interpretations shown on the updated bedrock geologic map of the Newton East quadrangle (Volkert and Monteverde, 2009). Projecting the drill core data from DR2 to DR1 (fig. 4) indicates that the Tranquility thrust fault beneath the quarry dips gently toward the southeast at less than 10^{o}. Because the dolomite formations drilled beneath the thrust fault in hole DR1 become older with depth, Precambrian gneiss and possibly more marble likely occur beneath the dolomite. However, the geology is further complicated by the interpreted presence of another thrust fault beneath the one that was drilled (fig. 9).

The presence of Paleozoic dolomite that was highly fractured (fig. 8) and weakened by faulting at the depth of the proposed underground Aquabank™ facility ultimately rendered the Limecrest site unsuitable for development of the project. Because dolomite is a permeable rock that does not have the same hydrogeologic or engineering characteristics as the Precambrian marble and gneisses, the ability to create a water-tight cavern beneath the quarry was unfeasible. Thus, Riverbank decided against the added expense of drilling a third corehole as originally planned. The fact that both coreholes intersected a thrust fault as postulated by previous geologic work highlights the importance of detailed and accurate geologic mapping in providing a solid framework upon which engineering and geotechnical decisions should be based.

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TRIPOD ROCKS AND GLACIAL ERRATICS

By Ted Pallis and Helen L. L. Rancan

It's an amazing occurence…balancing a huge boulder on three smaller rocks. Just think of it, the enormous force of nature, in the form of a moving glacier, depositing such an assemblage of rocks – a spectacle that remains for us to see 20,000 years later. New Jersey is home to several of these astonishing geologic features, generically called "tripod rocks". At some locations, they look perfectly symmetrical and well supported, at others, the boulder seems that it could topple at any moment, but doesn't. These groups of rocks are caused in one of three ways, the most common is from the deposition of glacial erratics.

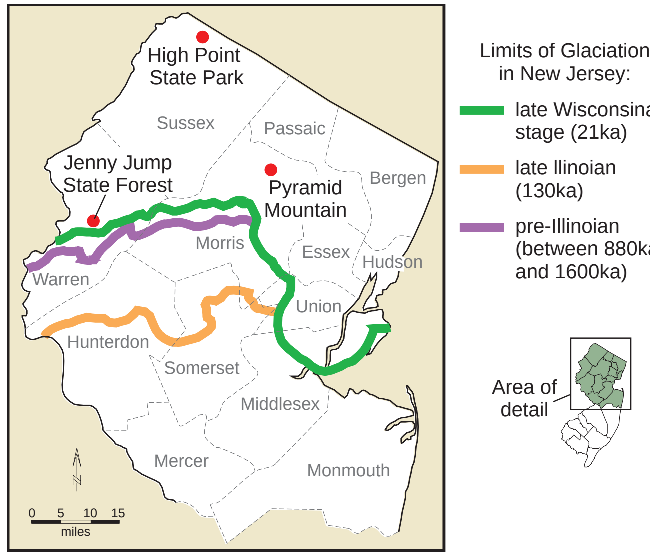

Figure 1. The trace of the late Wisconsinan limit in most places marks the position of the Terminal Moraine. High Point State Park, Jenny Jump State Forest and Pyramid Mountain all contain glacial erratics and tripod rocks. *Map after figure by R.W. Witte.*

Glaciers pick up, transport and deposit huge loads of debris as they advance and retreat across the land. As the Wisconsin Glacier moved over the Garden State 21,000 years ago (fig. 1), pebble to house-sized rocks called glacial erratics were often carried great distances from their original locations, sometimes miles away. Some of these erratics were laid down perfectly on top of smaller ones, commonly of an altogether different rock type.

PYRAMID MOUNTAIN NATURAL HISTORIC AREA, MORRIS COUNTY

In New Jersey, the largest and most striking of these tripod rocks is fittingly called "Tripod Rock" (fig. 2). It is located on Pyramid Mountain, Morris County (near

Figure 2. Tripod Rock, Pyramid Mountain, Morris County. *Photo by Z. Allen-Lafayette*

Figure 3. The Solstice Stones, Pyramid Mountain, Morris County. For scale, note the rock hammer in front of the left side stone. *Photo by Z. Allen-Lafayette*

40.9658ºN 74.3826ºW), weighs an impressive 160 tons and sits 920 feet above sea level. This natural rock sculpture is the best known tripod rock in the New Jersey and is one of the largest in the Eastern United States. The glacier probably carried this erratic 10 to 20 miles before depositing it on a rock ledge. Approximately 50 feet from Tripod Rock are two smaller tripod rocks named the "Solstice Stones" (fig. 3). They sit side-by-side facing a valley in an intriguing configuration. They appear to be in alignment with the sun on the summer solstice. It has been suggested that the Solstice Stones were formed not by nature, but by Native Americans for use in ceremonial purposes.

A quarter-mile west from Tripod Rock lies "Bear Rock". While not a tripod rock, Bear Rock is one of the largest glacial erratics in the state.

Pyramid Mountain Natural Historic Area is located along Route 511 (Boonton Avenue), near Taylortown Reservoir, just south of Fayson Lakes Road, Kinnelon.

JENNY JUMP STATE FOREST, WARREN COUNTY

The unnamed tripod rock in Jenny Jump State Forest (near 40.9139ºN 74.9145ºW) is along Summit Trail but can still take some effort to locate because the 4,200-acre forest is littered with glacial erratics. Jenny Jump is located near the forward (southern most) advancement of the late Wisconsinan glacial ice sheet that is known as the Terminal Moraine. Here the glacier dropped its immense load of boulders and sand as it retreated north. As a result, this area is littered with countless boulders of every size. One, the tripod rock (fig. 4), is a fine example of nature's powerful forces leaving behind a huge balanced boulder. Most of the glacial erratics along Summit Trail come from local gneiss, providing a generally homogeneous rock display. But the tripod rock consists of hard, banded quartzite and is probably a Lower Paleozoic dolomite. It is not like the other boulders and looks out of place on top of the mountain. The tripod rock is found at the second overlook along the Summit Trail. Jenny Jump State Forest is accessible from Shiloh Road off of Hope-Johnsonburg Road (Route 519), just north of Hope.

Figure 4. An unnamed tripod rock in Jenny Jump State Forest, Warren County. *Photo by T. Pallis*

HIGH POINT STATE PARK, SUSSEX COUNTY

Like many undeveloped areas in northern New Jersey, High Point State Park is littered with glacial erratics. Across Route 23 from High Point Monument, lies a tripod rock (near 41.2949ºN 74.6637ºW). However, it is unlike those described above because it appears not to be a glacial erratic. This unnamed structure (fig. 5) is not found on an exposed ridge line, but rather near a meltwater channel, a small valley or ravine cut by streams discharging from the melting ice sheet. Rather than an erratic haphazardly balancing on top of three smaller rocks, here it is the result of erosion and sediment transportation. This is evident because the rock outcrop immediately adjacent to the site appears to have been broken off, perhaps by the force of meltwater, in the same pattern as the surface of the tripod rock. Also, it is evident that the layering of sediment within the tripod rock matches the color and width of that found in the main outcrop. It is the weathering of a softer layer down to just three points of contact with the harder rock surface above that has caused this interesting rock sculpture. Of note, too, are adjacent rock shelters used by Native Americans for protection against the elements. This tripod rock is within High Point State Park, approximately seven miles north of Sussex, on the southbound side of Route 23.

Figure 5. This tripod rock, not a glacial erratic, is the result of erosion and sediment transportation, High Point State Park, Sussex County. *Photo by H.L.L. Rancan*

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COPPER OF THE NORTHERN NEW JERSEY PIEDMONT

By F. L. Müller

Miners from Cornwall and Wales, tunnels under the Passaic River, profitable deposits of copper, large investments of time and labor, sales of mining stock, ore bearing silver and gold: all of these are part of the lore of copper mining in the New Jersey Triassic-Jurassic rocks. Since the Seventeenth Century reports have existed of metals in the redbeds and igneous flows from these formations.

The longest lasting and perhaps most profitable deposit of copper ore was discovered by a slave on the property of Arent Schuyler in the area of present day Bellville and Arlington. The discovery was some time shortly before 1719 and records indicate that ore was shipped to Holland for smelting in April 1721 because the Dutch offered a better price than the British. When the British Trade Commission learned that this copper ore was profitable, and that they were losing an investment opportunity, they began to tax the ore heavily and ordered the ships to stop in Britain before continuing to Holland. The colonials found a way to circumvent the tax by using different shipping routes. For their own benefit the British were forced to lift the tax; after this the ore was sent to Bristol, England for smelting. The Bristol Copper and Brass Works, the major buyer, reported that 6,933 casks of ore had been accepted by 1731. Slaves worked the mine, and in those days, yielded about 100 tons of dressed ore per year. The primary mineral ore that was mined was chalcocite.

In time the mine passed to Schuyler's descendants, and Colonel John Schuyler brought miners from Cornwall and Wales to augment or replace the slave labor. At various times steam driven pumps were brought from Britain to combat water problems. The earliest of these engines was one of the first steam pumps in North America. It was placed in the sump of what came to be called the Victoria Shaft—which ultimately reached a depth of 347 feet (Lewis, 1907). Later labor problems, sabotage, accidents, fires and the Revolutionary War hampered mine operation. Through these difficulties the mines operation was sporadic, and operated by a number of companies through the Eighteenth and the Nineteenth Centuries. For example, in 1859 the Consolidated

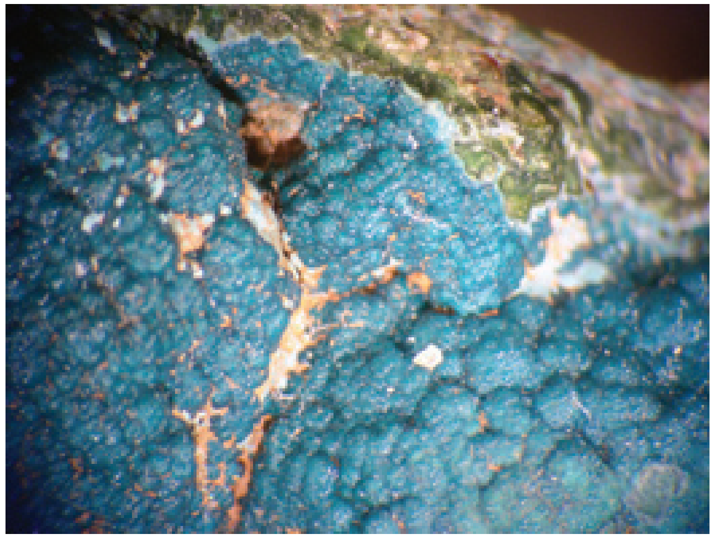

Figure 1. Pseudo-malachite, malachite and chrysocolla, magnified 14 times. This sample, collected from the tailings pile of the Schuyler Mine, is characteristic of the ore minerals found in the mine. *Photo by J.H. Dooley*

Mining Company employed 200 miners and sunk one shaft 275 feet below surface where they claimed there was a significant amount of ore. However, water became a major problem (Woodward, 1944, p. 54). The Arlington Company began their operation of the mine in 1900 by which time the area was riddled with workings. Arlington's mining engineers reported that "the dimensions of the mine chambers are indeed tremendous; one, especially, is 75 feet wide with a length of 300 feet and varies from 12-30' in height. Most of the chambers are found above the drain tunnel" (Woodward, 1944, p. 58-59). Woodward states that many of the tunnels and chambers are not far below ground surface. Some of the drain tunnels were hundreds of feet long. One legend posits a tunnel extending under the Passaic River to the basement of the Reformed Dutch Church. One theory says the tunnel was used to smuggle silver from the mine because the British claimed ownership of "Royal Mines"--meaning gold and silver. Some of the assays of the Schuyler ore and the ore from the adjacent Westlake Sandstone Quarry showed both gold and silver. Westlake Quarry ore was purported to be as high as $12.00 per ton silver (Woodward, 1944, p. 55). "It is of interest in this connection to note that a blowpipe assay of a rich specimen of ore from this mine (Schuyler) made in the Mineralogical Laboratory of Rutgers College by Mr. Harry R. Lee, yielded 4.4 oz. of silver per ton and a gold bead that was distinctly visible" (Lewis, 1907, p. 143). Now, despite all the invested capital, labor and exploration, little financial success was enjoyed with the exception of that of the Schuylers'. Discounting an occasional slump caused by the collapse of an adit or chamber, (in 1892 one company robbed ore from supporting pillars, [Woodward, 1944]), there is scant evidence on the surface today of more than two hundred years of active mining.

The source of Schuyler ore is likely traced to the Palisades and Arlington Sills and the various dikes and veins which are associated with them. At places the Arlington Sill is the foot wall of the tunnels. A discussion of numerous theories of the paragenesis of the ores can be found on line at the New Jersey Geological Survey web site, for example, Woodward, 1944, and Lewis, 1907.

In the vicinity of the Schuyler Mine in the Triassic-Jurassic formations, there were several mines and prospects east of the First Watchung, now known as the Orange Mountain Basalt. They were not near any known extrusive flow or sill or dike (Woodward, 1944, p. 69). The mines and prospects were located along the Second River, Wigwam, and Toney Brooks, and were largely worked in Colonial times. The Dod Mine, discovered in 1720, along the Second River operated until mid Eighteenth Century. The company shipped the ore to England. The mine had tunnels as long as 800 feet, an entrance a horse and wagon could enter, and one chamber as large as half an acre according to Woodward (1944). Once again, the ore was chalcocite in veins and voids in the sandstone. The Glen Ridge, another Colonial mine, was excavated along Bloomfield Avenue and is thought to be a northeast extension of the Dod deposit. It was largely a prospect located approximately a mile from the Dod Mine on the east bank of Toneys Brook. Several tunnels and drifts were dug, one approximately 700 feet long. Woodward (1944, p. 73) reports that the roof of one may be as close as 40 feet from the surface. At the end of the Nineteenth Century quarrying in the area of Bloomfield Avenue and Hillside Avenue exposed a previously mined tunnel with a vein or pod of ore 20 feet wide and 12 inches thick at the east end and about 4 feet thick at the west end. It was rich ore containing 79 percent copper and a little silver (Woodward, 1944, p. 74). In the tunnel quarrymen found mining tools, a pump, and a powder horn which were donated to the New Jersey Historical Society. The main ore, similar to the Schuyler Mine, was chalcocite and chrysocolla. The Wigwam Brook Mines were a little more than a half mile from the Dod Mine. These shafts, deep and debris filled when rediscovered in the mid 1800's, were likely worked in the late Eighteenth Century or early Nineteenth Century.

Figure 2. This specimen is typical of the ore veins at the Schuyler Mine, North Arlington Borough, Bergen County. The primary ore mineral is chalcocite (blue-black); it is covered by carbonate minerals (blue). *Photo by J.H. Dooley*

There is scant record of any owner or investor gaining the great wealth they anticipated. Detailed discussion of these mines can be found on the New Jersey Geological Survey website. The next issue of *Unearthing New Jersey* will review the copper mines of the central and western Piedmont.

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NEW PUBLICATIONS

OPEN-FILE MAPS (OFM)

NEW MAP. OFM 77, Surficial Geology of the Plainfield Quadrangle, Middlesex, Union and Somerset Counties, New Jersey, Stanford, Scott D., 2009, scale 1 to 24,000, size 36x44, 2 cross-sections, 17-page pamphlet. $10.00

NEW NJGS EARTHCACHE

EarthCaching is a form of Geocaching, an outdoor adventure game played by several hundred thousand people worldwide. In Geocaching, folks use a handheld Global Positioning System (GPS) receiver to find packages (or "caches") hidden by other players. NJGS has created a new EarthCache, entitled "Artifacts and Inchnofossils". Here, visitors will explore a rock shelter used by Lenape Indians during the Archaic Period (8,000-1,000 BC), as well as examine approximately 400 million year old trace fossils, formed by soft-bodied wormlike marine organisms.

Bevans rock shelter is the destination for a new NJGS EarthCache called "Artifacts and Inchnofossils." Photo from NJGS archives, photographer unknown.

CROSSWORD ANOMALIES

Commonly called “Bear Rock,” this glacial erratic is one of the largest in New Jersey, Pyramid Mountain, Morris County. *Photo by Z. Allen-Lafayette*

ACROSS

2. Accumulation of unsorted drift deposited by a retreating glacier
8. Banded texture in a metamorphic rock
9. Horizontal passage from the surface into a mine
10. Cylindrical sample of rock obtained through drilling
11. Name of last glacier to cover northern New Jersey
14. Tabular igneous intrusion that parallels bedding
15. Cu
16. Characteristic association of minerals
17. Sun is the greatest distance north or south of the equator
18. Low-angle reverse fault
19. Open workings for the extraction of stone
20. Melt or fuse in order to separate metal
21. Rock fragment carried by glacial ice

DOWN

1. Limestone or marble, rich in magnesium carbonate
3. Bedrock covered only by surficial deposits
4. Copper carbonate
5. Metamorphic rock with a banded texture
6. Calcite and/or dolomite metamorphic rock
7. Boulder balanced on three smaller rocks
12. Consolidated equivalent of sand
13. Large mass of ice
17. Vertical mine tunnel

Glaciers are delicate and individual things, like humans. Instability is built into them.

--Will Harrison, geophysicist--

Copper salts, such as copper chloride and copper sulfate are soluble in water and at low concentrations can function as antifungals and astringents, however, at high concentrations they can be poisonous to humans and other mammals. Ironically, copper is a trace metal found in many foods, and the human body needs it to be healthy.

Banner photographs by J.H. Dooley

CROSSWORD PUZZLE ANSWERS. Across: (2) Moraine, (8) foliation, (9) adit, (10) core, (11) Wisconsinan, (14) sill, (15) copper, (16) paragenesis, (17) solstice, (18) thrust, (19) quarry, (20) smelt, (21) erratic. **Down:** (1) Dolomite, (3) outcrop, (4) malachite, (5) gneiss, (6) marble, (7) tripod, (12) sandstone, (13) glacier, (17) shaft.