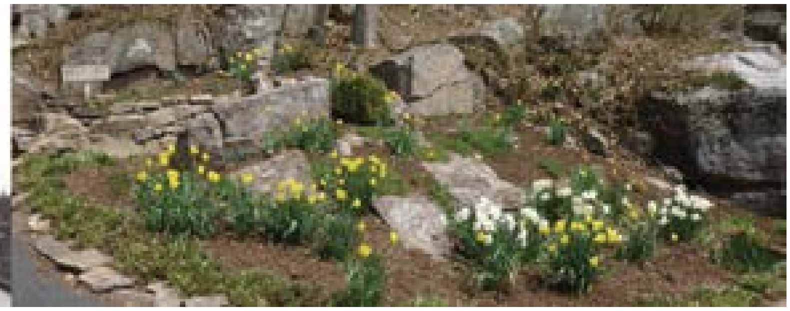


Stockton, New Jersey and the Stockton Formation

The Boro of Stockton, New Jersey

Stockton Boro is located along the Delaware River in Hunterdon County. It covers about 0.6 square miles and had a 2010 population of 538. In 1703, John Reading purchased the plot of land which is now Stockton. Over the next 100 or so years, people settled on and industrialized the property. In 1851, with the opening of its own post office, the boro was officially named Stockton after Robert Field Stockton. Construction of bridges, churches, schools, libraries, public buildings, work places and homes required building stone and led to the opening of several brownstone quarries (Naylor, 1998). In 1897, State Geologist Henry Kümmel investigated the rock at quarries and outcrops in the boro and named it the Stockton Formation (Kümmel, 1898).

The building stone produced at Stockton was highly valued, but there was no effective way to transport it to markets beyond the Stockton area. Transportation became available in 1834 with the completion of the Delaware & Raritan Canal. The canal was intended primarily as a water route between New York and Philadelphia, but included a 22-mile long feeder channel which passed through Stockton (NJ State Park Service, n.d.). Robert Stockton was influential in the completion of the canal, and invested $500,000 in its stocks. He also served as president of the Delaware & Raritan Canal Company for the last 11 years of his life (Encyclopedia Britannica, 2016). For almost a century, the canal was one of the busiest in America. Eventually, however, shipping moved to railroads and most canals closed. 1932 was the last shipping season for the Delaware and Raritan Canal (NJ State Park Service, n.d.).

Quarrying of the Stockton Formation

The opening of the Delaware & Raritan Canal led to the opening or expansion of many brownstone quarries in central New Jersey, with several in the Stockton area. Among these were the S.B. Twining, Raven Rock (fig. 1), De Flesco-Loveday, and William Ledger quarries near Stockton, and others in the historic Prallsville area (Zdepski, 2002). Quarrymen had to be strong, young men. Many were Italian immigrants (Saja, 2012). The 1880 census stated the average wage of a quarryman as $566 per year. Work was labor intensive and physically demanding, six days a week from dawn to dusk. The plug and feather method was the usual technique used to quarry the building stone. Workers drilled a series of holes where the stone was to be split. In the early days the holes were drilled by hand. Later, power equipment was used. Two semicircular rods, called feathers, were fitted into each hole. Then quarrymen used sledgehammers to wedge a "plug" between each pair of feathers (Zdepski, 2002). Due to natural perpendicular jointing, the rock easily split into blocks. After the rock was split, the loose blocks were buried in soil for about four months to season them and then were taken to a stoneyard for final preparation.

Figure 1. Raven Rock Quarry on May 19, 1932 as an active site (*photo from NJGWS Archives*).

Quarrying was a dangerous job and accidents were frequent, ranging from smashed fingers and toes to fatalities. In an historic accident, on May 19, 1888, James Wafer, a quarry boss for S.B. Twining, went to the powder magazine. Shortly after, about 300 small kegs of black powder and 50 cans of dynamite exploded leaving a deep crater. More than a dozen buildings were destroyed within a quarter of a mile of the blast, and houses up to a mile away had their windows blown out. The blast that killed James Wafer was said to be felt and heard in Trenton and as far away as New Brunswick (Saja, 2012).

Building stone was not the only material sought in the quarries. During the uranium rush of the 1950s, Vernon and Alvin Gatling believed they had found a potentially profitable uranium deposit at the abandoned Raven Rock Quarry (fig. 2). They created Gatling Brothers Mining and Development, established a corporate office, began work, and sold stocks for $0.25/share (Zdepski, 2002). The Gatling Brothers, however, did not own the land; Anton Schuck did. He believed that the brothers were Rutgers students doing research. The brothers claimed that they were given permission by Schuck, and filed a lease, which was never legally signed. After 18 months of operation, they were evicted from the quarry. Their

Figure 2. Sign on NJ Route 29 in Raven Rock stating the outcome of The Gatling Brother's find. *Photo by F. Rea*

checks bounced, their purchases were bought on unpaid credit, and their stocks were sold without knowledge of the Securities and Exchange Commission. The Gatling Brothers were in trouble, and as a last effort, they sued Anton Schuck for mining rights. The brothers had to confirm, with an expert's opinion, that the uranium could be profitably mined. In the end, the profitability was never confirmed, and a judge closed the case forever (Saja, 2012).

The Newark Basin

The Stockton Formation consists of sedimentary rocks and is the oldest of New Jersey's Newark Supergroup rocks. The formation reaches a thickness of 4,000 feet. It was deposited in the Newark Basin, a now inactive rift basin which extends from lower New York State across northern New Jersey and into Pennsylvania (fig. 3). The rifting, related to the breaking up of the supercontinent of Pangea into today's continents, began late in the Triassic Period and continued into the early Jurassic Period, roughly 200 to 220 million years ago (fig. 4). As the rifting progressed, a series of down-dropped rift valleys and upraised fault blocks formed along the eastern seaboard (U.S. Geological Survey, 2015). All of the rifts, with the exception of the rift that created the present day Atlantic Ocean, were eventually abandoned.

One of those abandoned rifts was the Newark Basin. It is bounded to the west by a series of large normal faults, the best known being the Ramapo Fault (fig. 3). Structurally, the east side of the basin has dropped downward and rotated westward, while the west side was uplifted. The uplifted side eroded, and the eroded sediment was carried into the basin by streams (U.S. Geological Survey, 2015). The erosion continued through the basin's history and, as a result, sediment was continually washed into the basin, filling newly available space created by the downdropping (Smoot, 2010).

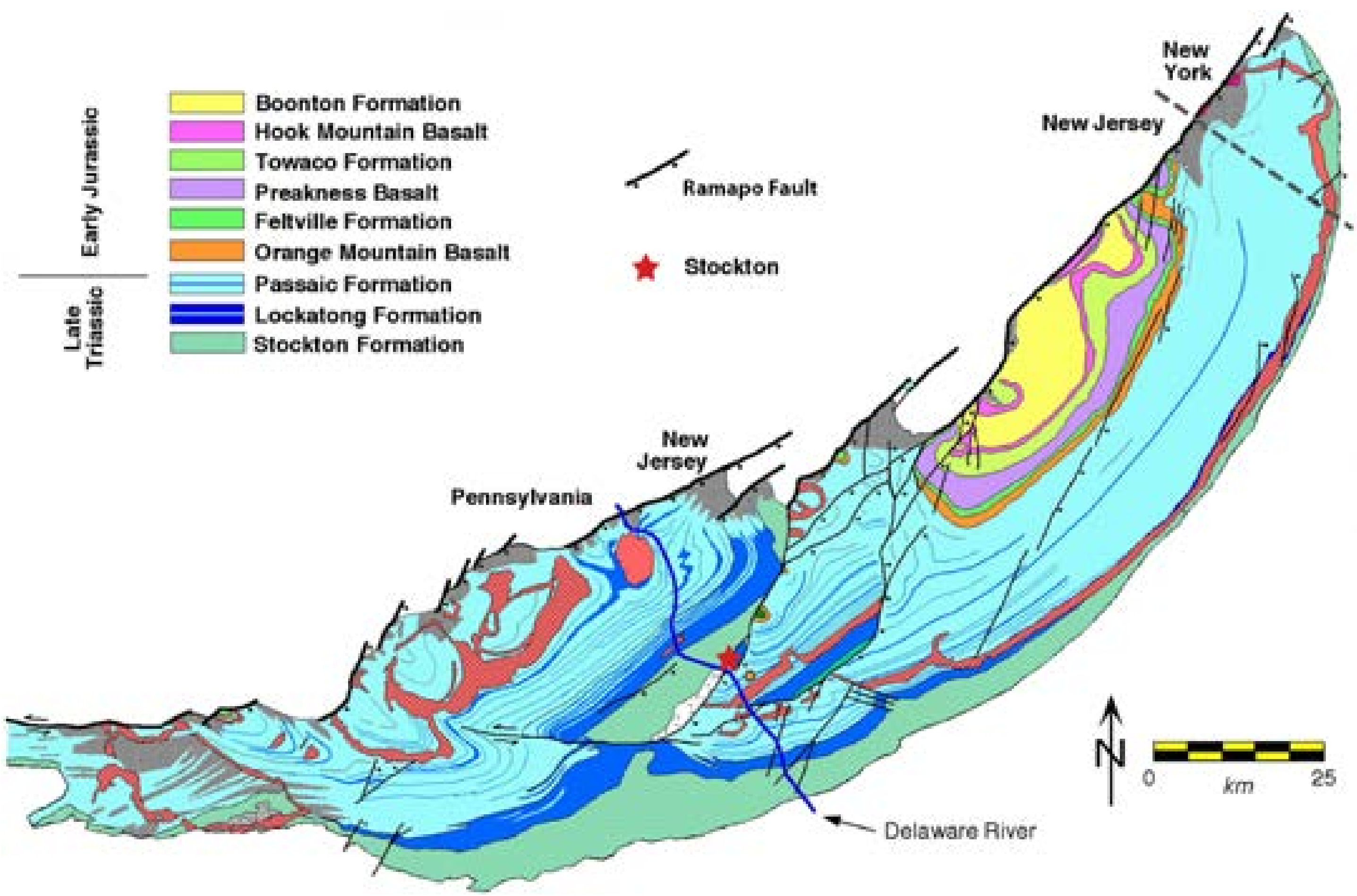


Figure 3. Map of the Newark Basin; specifically the placement of the Ramapo Fault and the Stockton Formation in relation to the Boro of Stockton. *Modified from Schlische, 2013*

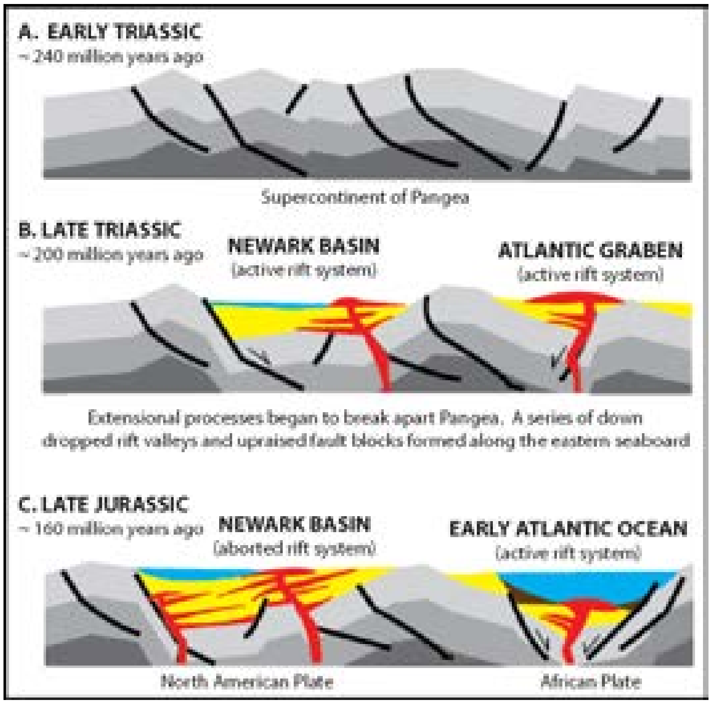


Figure 4. Diagram showing a simplified timeline of the formation of the Newark Basin. *Modified from U.S. Geological Survey, 2015*

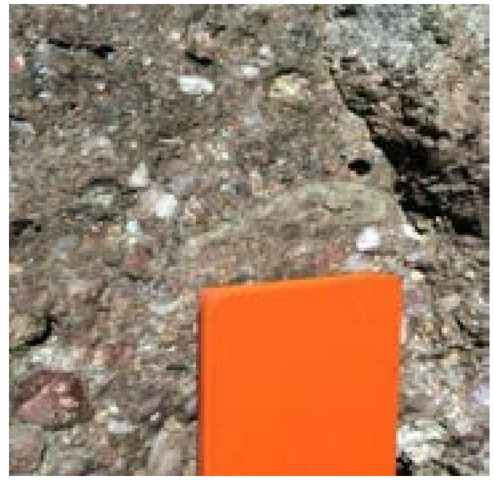
Facies of the Stockton

A facies is a group of related rocks with characteristics representative of the depositional environment. According to Smoot (2010), the Stockton can be broken up into three facies based on grain size and sedimentary structures. The oldest facies, conglomerate and conglomeratic sandstone, lies at the base of the formation (fig. 5A). The rock consists of pale, yellow-brown sandstone with pebble- and cobble-sized grains throughout. It occurs in layers stacked in repeating sequences 7 to 20 feet thick. In each sequence, the sediment is coarser grained towards the bottom and finer grained towards the top. This sequences are separated from those above and below by sharply bounded, thin mudstone and siltstone layers. Trough cross-bedding is common in beds near the base of the formation (Smoot, 2010). Climbing ripple cross bedding is present higher up in some of the sequences.

The second facies, arkosic sandstone, is younger and stratigraphically higher. An arkose is a sandstone in which at least 25% of the grains are feldspar. The Stockton arkose consists of layers of purple to tan sandstone with red sandstone alternating with red mudstone and siltstone (fig. 5B). As with the first facies, the arkosic sandstone occurs stacked in sequences separated by mudstone and siltstone beds. The sequences are 32 to 49 feet thick. Within a typical sequence, the grain size grades upward from the base from coarse sand occasionally containing small pebbles to fine-grained sand at the top. The beds are usually heavily jointed parallel to and perpendicular to strike. As in the conglomeratic facies, trough cross-bedding is present toward the bottom sequences but is replaced by climbing-ripple cross-lamination upward in the finer sandstones (Smoot, 2010).

The third facies consists of micaceous sandstone, siltstone, and mudstone. Rocks of this facies occur interbedded with rocks of the conglomeratic sandstone and arkosic sandstone facies (fig. 5C). The rock is red or purple, very fine grained, and usually heavily bioturbated by roots. The roots have decayed, but they left networks of tubes that have filled with sediment (fig. 6). Ripple cross-lamination and mudcracks are common, but are often disrupted by the roots and unrecognizable (Smoot, 2010).

5A



5B

5C

Figure 5A. The conglomerate and conglomeratic sandstone facies showing pebble to cobble sized grains (6-inch-long field book shown for scale) off of NJ Route 29 in Stockton. **Figure 5B**. The arkosic sandstone facies displaying jointing parallel to and perpendicular to strike (person shown for scale) at an abandoned quarry off Worman Road in Stockton. **Figure 5C**. The micaceous sandstone, siltstone, mudstone facies showing weathered very fine sandstone- siltstone interbedded between prominent fine sandstone (pencil shown for scale) off NJ Route 29 in Raven Rock. *Photos by F. Rea*

Depositional Environment and Newark Basin Development

Each of the Stockton facies represents a different past environment. Based on sediment grain size, sedimentary structures, and the sequence of the facies, geologists infer that the formation was deposited by rivers. The conglomerate and conglomeratic sandstone facies represents deposition in a braided river system (fig. 7). As in modern braided rivers, stream slopes were steep and stream energy was high. This allowed large quantities of sediment including pebbles and cobbles to be transported into the basin. The coarsest material was deposited in bars in the deepest parts of channels and is preserved towards the bottoms of sequences. Finer material was deposited higher up on the banks, frequently on floodplains, and is preserved higher in the sequences. Trough cross-bedding is common in the channel sediments towards the bottoms of sequences and less common in river bank sediments higher up (Smoot, 2010).

The arkosic sandstone facies is inferred to have been deposited in meandering rivers (fig. 7). The slope and transport energy of the streams had decreased from when the conglomeratic facies was deposited, and cobbles and large pebbles could not be transported beyond the basin margin. In meandering rivers, sediment is eroded along the outsides of curved channels, creating a steep cut bank, and deposited on the insides of the curves, forming point bars. Upward fining of sequences in this facies is the result of shingle-like overlapping of sloping point bars, each point bar deposit being coarser-grained towards the channel bottom and finer upwards towards the bank (Smoot, 2010).

The third facies consists of micaceous sandstone, siltstone, and mudstone. Unlike the previous two facies, this facies does not represent an environment predominant at a particular time in the history of the basin. Instead, it represents floodplain and low energy environments which were present throughout the history of the basin but separate from the river channel environments of the first and second facies. In events known as evulsions, rivers commonly cut through their banks and spread fine-grained sediments of this facies widely across the land. These became the sandstone, siltstone, and mudstone of this third facies.

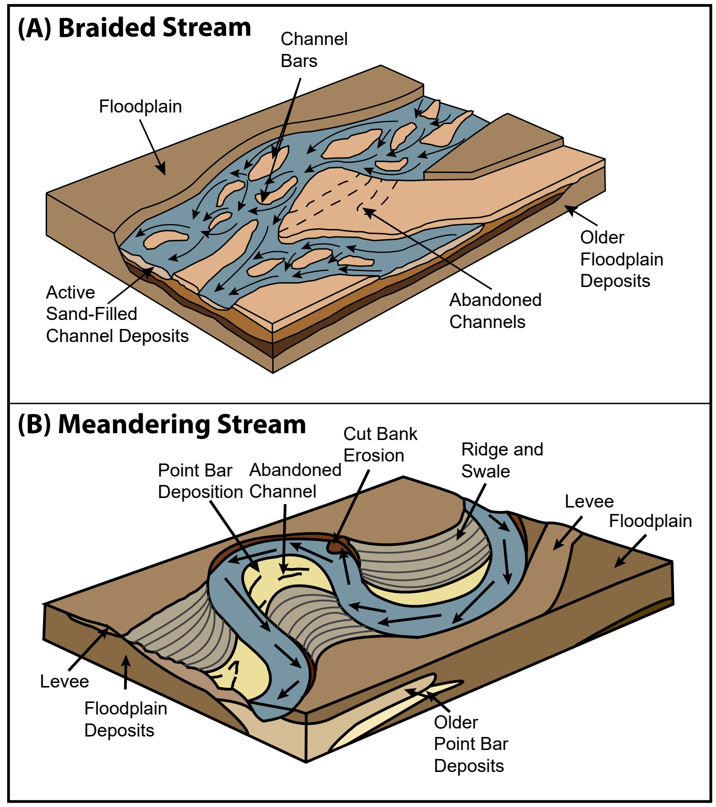


Figure 7. Diagram showing the river channel of a braided river system and meandering river system. *Modified from Schieber, 2007*

While sedimentary features help us understand the depositional environment, the geologic history of the Newark Basin better helps to explain the sequence of facies. Early in the basin's history, it was narrow and its margins were steep. This allowed for steep, high energy, braided rivers that could transport cobbles and pebbles across the width of the basin. As extension continued,

Figure 6. Bioturbated fine sandstone tubes backfilled with sediment (pen shown for scale). *Photo by F. Rea*

Figure 8. Trace of an old plug inserted into the rock face (6-inch-long field book shown for scale) at an abandoned quarry in Stockton. *Photo by F. Rea*

transport distance increased, and stream slopes decreased. With the shallower gradient, meandering rivers replaced the braided rivers, and fine sand became the dominant sediment. Eventually, slopes became too shallow to sustain river dynamics. Evulsions leading to widespread standing water and sediment deposition in low-energy flood plain environments became characteristic (Smoot, 2010). With still more extension, the basin became too wide to fill with the limited amount of sediment coming in from rivers. Downdropping continued, though, and the downdropped area became a closed basin with permanent lakes. As a result, deposition of river sediments of the Stockton Formation ceased and deposition of lake sediments of the overlying Lockatong Formation began (Smoot, 2010).

The Stockton Formation brought a lot of attention to the area in the past. Even though the brownstone quarries are abandoned and the canal no longer carries goods, many traces of Stockton's rich history remain today. Quarry walls and cuts are still recognizable in many places (fig. 8). The Delaware and Raritan Canal is now preserved as a state park. Prallsville is under the care of the Delaware River Mill Society. Many buildings constructed of the Stockton stone, including the Stockton Presbyterian Church and the Stockton Borough School, are still in use today.

References

Encyclopedia Britannica Online, 2016, Robert F. Stockton, website accessed April, 2016.

Kümmel, H.B., 1898, The Newark System -- Report of Progress: in Geological Survey of New Jersey Annual Report of the State Geologist for 1897, p. 23-160.

Naylor, I.H., 1998, Stockton, New Jersey -- 300 Years of History: Albion Printers: Stockton, NJ, 68 p.

NJ State Park Service, [n.d.], Delaware & Raritan Canal State Park: pamphlet.

Saja, B., 2012, Quarrying in Raven Rock: in Chinnici, R.C., ed., Stories from Raven Rock, New Jersey, The History Press, Charleston, SC, p. 132-135.

Schieber, J., 2007, River Systems: Recycling the Earth's Crust, website accessed April, 2017.

Schlische, R.W., 2013, Newark Basin Geology -- Maps and Cross Sections: Geology of the Newark Basin, website accessed April, 2017.

Smoot, J., 2010, Triassic Depositional Facies in the Newark Basin: in Herman, G.C., and Serfes, M.E., eds., Contributions to the Geology and Hydrogeology of the Newark Basin, NJ Geological Survey Bulletin 77, p. A4-A104.

U.S. Geological Survey, 2015, Mesozoic Basins: Geology of National Parks, 3D and Photographic Tours, website accessed April, 2017.

Zdepski, M.J., 2002, The Brownstone Quarrying Industry in New Jersey, presented to The Society for Industrial Archaeology, Roebling Chapter, 22nd Annual Drew Symposium, Drew University, Madison, NJ.

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Prepared by

Francesca A. Rea*

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Comments or requests for information are welcome.
Write: NJGWS, P.O. Box 420, Mail Code 29-01,
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Banner Photos, *left to right*:

Stockton Boro sign on NJ Route 29, Stockton Boro, Hunterdon County. *Photo by K. Vandegrift*

Tow barges on the Delaware & Raritan Canal. *Photo courtesy of NJ State Park Service*

The Stockton Formation at Stockton Boro School, Stockton Boro, Hunterdon County. *Photo by K. Vandegrift*