BOLTON CONSERVATION TRUST

BOLTON LIMESTONE QUARRIES & KILN

A Brief Description of its History, Geology and Workings

The Bolton Conservation Trust thanks the Bolton Historical Society for the important historical information about the Limestone Quarries and Kiln.

BOLTON LIMESTONE QUARRIES & KILN

Background and History

Limestone was discovered by the Whitcomb family on the south side of Rattlesnake Hill between 1736 and 1738. Noticed as an outcrop of white rock on what was farmland (pasture) at the time, it was the second significant limestone deposit to be discovered in this area of New England, the first deposit having been discovered in Newbury in 1697.

Limestone was excavated from two quarries, the Hildreth Quarry to the south and the large Whitcomb Quarry to the north. Quarrying of the Hildreth Quarry, the older line of near-surface excavations, involved hand tools (star drills to drill holes to split rock with "feathers & wedges"). Consequently, when harder dikes of scapolite rock were encountered, they were left in place and the limestone was removed around them. The dikes are still clearly evident today.

Whitcomb Quarry

Hildreth Quarry with scapolite dike

The kiln used to convert the limestone to lime was set into the hillside to the east of the Whitcomb Quarry. In the 1950's the rock lintel to the doorway failed and the front face collapsed. The lime kiln was restored to its original configuration in 1976 on the basis of an old painting and a photograph in History of Bolton (1938) with funding through a Federal Government US Bicentennial Grant.

Lime Kiln – 1938 (History of Bolton)

Lime Kiln – 1976 (after reconstruction)

In the early 1800's the Whitcomb Quarry, largest and most recent, was begun at the top of a small hill south of Rattlesnake Hill. It was the first major (deep) attempt at following the limestone strata downward into the ground. Sometime in the mid-1800's the quarrying operation was discontinued because an underground waterway was inadvertently opened at the bottom of the quarry and the entire depression filled with water. It was rumored at the time that the quarry filled with water so

quickly that the ox that powered the device to lift limestone from the bottom of the quarry were drowned. The story was confirmed in 1937 when the quarry was pumped and all of the wrought iron shoes of the ox were recovered and given to Raymond Mentzer, the owner of the property.

In 1937 the lime quarrying operation was revitalized by Frederick Hazen of Somerville, MA, who leased it for the production of agricultural limestone. The effort was stopped shortly thereafter when the rock crusher was badly damaged in operation by the unusually hard Bolton limestone. No limestone has been commercially removed from the Bolton limestone quarries since that time.

Although the evidence of the quarrying operations now appears to be modest, it has been hidden under renewed plant growth and appears to be part of the natural landscape. Production was actually very significant, particularly for its time. The 1879 History of Worcester County noted that "Forty years ago, it turned out annually from fifteen to twenty thousand bushels of lime".

Bolton Limestone and "Boltonite" - Geologic Aspects

Limestone is initially deposited over long periods of time as a sedimentary rock and consists of pure calcite, $Ca\ CO_3$ and pure dolomite, $Ca\ Mg\ (C0_3)_2$ and other impurities. Depending on the size of the crystals the rock can appear like shale or slate (very fine crystals) or sandstone (more coarse collections of crystals). Bolton limestone tends to be more like sandstone in crystal size, but the crystals are very close together, making the rock very dense and less pervious to water.

Bolton limestone has undergone geologic processes that account for its unique characteristics of density and crystal size. These processes, forms of geologic metamorphosis, have occurred over relatively long periods of time and account for much of the twisting and folding of the rock that may seen on the east wall of the largest quarry.

The high pressures experienced by the rock during the metamorphism process, as well as deposition of other minerals in and around the limestone, have contributed to transforming the relatively soft sedimentary limestone into a much harder limestone, approaching marble. (In some cases the limestone in Bolton has been referred to as marble in the literature.) The Bolton limestone's metamorphosis has resulted in two important characteristics:

1. The very hard scapolite layers between the limestone deposits became vertical during metamorphosis, forming 'dikes' which were difficult for the early quarry workers to cut and consequently were left in place, the softer limestone being removed all around them. They may still be seen standing, appearing much like walls, in the older quarries.

2. Dynamic metamorphosis in which rocks are broken and ground without much hardness, density or crystal change. Cracks in the rocks (faults) may be seen in the east wall of the largest quarry.

One unique characteristic resulting from its metamorphosis: when broken, it emits a smell of sulfur for a few seconds.

Although Boltonite, a constituent of Bolton limestone, was considered for many years to be a unique mineral, it is now generally considered in the geologic community per the Mineralogical Society of America to be a local variety of fosterite. However, Boltonite is quite unique, the only other known location being near the slopes of Mt. Vesuvius in Italy.

The Bolton Limekiln: Producing Lime from Limestone

The Bolton Limekiln produced lime primarily for local wall plaster, mortar and whitewash (paint).

The kiln produced lime on an intermittent basis and employed the most primitive and least efficient method of producing lime, a method that was used back to Roman times.

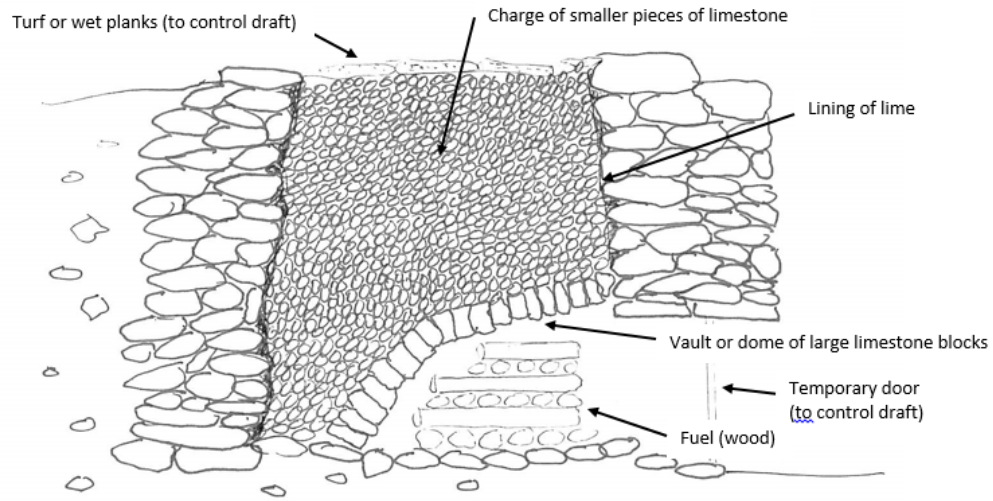
From a paper by the Vermont Archeological Society (1990), the construction of the kiln and its use to convert limestone to lime:

> "Ruins of 19th-century intermittent type lime kilns were all constructed of stone, most of which came from the same quarry that provided the stone which was eventually burned inside the kiln. Although this sounds like a peculiar practice, the insides of these kilns soon glazed over from the heat of burning, and the glaze protected the kiln walls from further heat effects. The glaze also helped seal the kiln from unwanted outside drafts, keeping the heat inside and reducing fuel consumption."

Note that the glazing is still evident on the inside of the Bolton kiln.

> "In charging the kiln, the largest pieces of limestone were first selected and formed into a rough dome-like arch about 5 to 6 feet high, leaving openings around the stones for upward draft. Above this arch, the kiln was filled to the top with limestone fragments with the larger fragments toward the bottom. A wood fire was started under the dome, and the heat was gradually raised to prevent sudden expansion and rupture of the dome. After a bright heat was reached throughout the mass of stone, it was maintained for 3 to 4 days. Complete burning was indicated by a large shrinkage in volume of the contents, the choking up of spaces between the fragments, and the ease that an iron rod could be forced down into the mass from the top of the kiln. The fire was allowed to slowly die out, and the lime was gradually removed from the bottom. The process was simple and cheap, the main expense being for quarrying the stone and preparing the fuel. One or two kilns supplied a 17th- and 18th-century neighborhood for a year, operating for a week or two, and remaining idle for the remainder of the year."

A cross-section of the kiln ready for firing is shown below. Note that the draft to assure proper heating was controlled at the top of the charge with wet boards, turf, or some other method. The draft at the bottom was controlled with a temporary door or a partial dry stone wall.



The product produced by the kiln was "quicklime", a very caustic substance which had to be hydrated (slaked) with water to be used. The water source to slake the lime was not taken from nearby Great Brook as might be expected, but taken from a dedicated stone-lined well slightly to the southwest of the kiln door. Prior to the slaking process, the lime was stored in and sold from a lime house, the foundation of which is still evident about 100 ft. east of the kiln and was shown in the Silas Holman 1797 and 1831 maps of Bolton.

For those interested in the chemistry of the lime firing and slaking processes, the chemical transformation from limestone to quicklime is:

limestone	heat	quicklime	carbon dioxide
$CaCO_3$	$\longrightarrow$	CaO +	CO_2

And the transformation from quicklime to slaked lime is:

quicklime	water	slaked lime
CaO +	H_2O $\longrightarrow$	$Ca(OH)_2$

It is interesting to note that when the slaked lime is mixed with other constituents for use, e.g., sand, and is exposed to carbon dioxide in air for long periods of time, it reverts to the original limestone, thereby providing a very hard and durable “manmade” limestone as the matrix for mortar, concrete and “plaster” in structures.

slaked lime	carbon dioxide	“limestone”	water
$Ca(OH)_2$ +	CO_2 $\longrightarrow$	$CaCO_3$ +	H_2O

Although the intermittent lime kilns were very effective for the needs of the time, the lime they produced inevitably also contained the ashes from the fire, an unwanted impurity. Present day lime production uses continuous closed furnaces that contain heat more efficiently than the lime kiln and don't mix ashes with the lime. They are generally externally fired by oil or gas.

Much of the mortar and plaster in older houses in Bolton came from this kiln. The mortar was formed by combining slaked lime, sand and water. Plaster was further reinforced by mixing wool, horsehair or cow hair with it.

Selected additional information sources:

1. http://www.townofbolton.com/pages/BoltonMA_HistComm/surveys/quarry
   Bolton Historical Commission (1998): Whitcomb Lime Quarry
2. https://www.mindat.org/loc-3824.html
   Detailed mineralogical discussion and list of minerals at the quarries. Also an extensive reference list.
3. History of Worcester County, Massachusetts. 1879
   (https://archive.org/details/historyofworcest04marv)
   Good summary of Bolton from earliest settlement to 1879. Descriptions of quarries and kiln.
4. *About Bolton,* Whitcomb, Esther Kimmens (1988). Bowie, MD: Heritage Books, Inc.
   Summary of the Bolton Quarry and Kiln.
5. *History of Bolton, 1738-1938*, Whitcomb, Esther Kimmens (1938), no publisher
   Earlier history of Bolton; more and different information than the 1988 book.
6. Report on the Geology, Botany and Zoology of Mass., Edward Hitchcock, Amherst College, 1833
   Excellent detailed description of the Bolton limestone.
   https://ia802608.us.archive.org/20/items/reportongeologym00massrich/reportongeologym00massrich.pdf
7. Report on the Geology, Botany and Zoology of Mass., Edward Hitchcock, Amherst College, 1841
   Excellent description of the economic uses of limestone and the details of lime kilns (pgs. 160-178).
   https://archive.org/details/finalreportonge00hitcgoog/page/n7

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