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Evidence of a Prehistoric Pottery Kiln, Sebasticook River, Winslow, Maine



*View from prehistoric habitation site, lower Sebasticook River,
Winslow, Maine. Oct. 2009.*

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The art of ceramics was well known and widely used by the prehistoric people of Maine as shown by the large numbers of pottery shards found at prehistoric habitation sites in Maine. Independent dating methods show that the "Ceramic Period" in Maine roughly spanned from 2,800 B.P. to the arrival of European traders and settlers after the 1500s (Doyle 2008).

Yet while many shards of completed ceramic pots and vessels are known from Maine, little is known of where and how these pots were fired. It is presumed that the kilns used to fire these pots were "one time" kilns that were assembled for a single firing and then taken apart to gain access to the fired ware inside them. The materials used to make these kilns is not known, nor their shape and design (Bourque et al. 2001).

Because prehistoric people of Maine were frequent travellers, it is logical to assume they took their ceramic pots and vessels with

them as they travelled. This means that the site where a pot shard is found may not be the site where it was made and fired.

However, we do know that these pots had to be made and fired *somewhere*. What evidence or diagnostics can we use to identify a potential firing site?

One diagnostic would be a dense collection of shards from pots that failed to fire properly. Even today, potters frequently have pots explode or crack or shatter during the firing process. Once taken out of the kiln, these failed pots are relegated to a "shard pile" and are discarded. This means that a prehistoric kiln site that was used repeatedly would, over time, generate a good number of broken and failed pots. Unfortunately, most of the pottery shards found in Maine prehistoric sites are already very small and quite broken. This makes it very difficult to distinguish between a pottery shard from a finished, successful pot and a shard from a pot that failed during the firing.

A second diagnostic depends on an assumption that at least some prehistoric potters in Maine used clay as a building material in the kiln itself. The challenge in any kiln design is to ensure all of the ware reaches "bisque temperature," which is generally in excess of 1,100 degrees Fahrenheit depending on the character of the clay body. When clay is heated past this minimum temperature, a number of permanent physical and chemical changes occur to the clay body which make it hard, durable, non-porous and incapable of reverting back to a liquid form (Rhodes 1971). If the fired ware (or some areas of the ware) does not reach bisque temperature, the finished piece will dissolve and crumble once exposed to moisture.

Because all prehistoric Maine pottery was wood-fired, we have to consider what type of wood-fired kiln structure would allow for the efficient, reliable heating of pottery to bisque temperature. The simplest firing method is to dig a pit, place the pots in its bottom, fill the pit with firewood on top of the pots, light the firewood and continue feeding the fire until the pots in the bottom of the pit reach bisque temperature. Once the entire pit has burned out and cooled, the pots are dug out of the ashes.

A problem with this method is that the pots are in direct contact with burning wood and coals for the entire firing. This causes

some of the carbon in the pieces of burning wood lying in direct contact with the clay surface to migrate into the clay body. This results in "carbonization" of the clay surface which turns the clay surface completely black and/or covered with prominent black scorch marks. Examination of the finished prehistoric pot shards found in Maine shows very little signs of scorching or carbonization. Instead, most outer surfaces of the shards are very clean, uncarbonized, unscorched and carry the natural yellowish tan of the fully bisqued local clay used to make them. Because carbonization and scorching from direct, physical contact with burning wood and the clay surface is unavoidable and permanent (the carbon is actually incorporated into the bisqued clay body), it seems unlikely that most of the shards of prehistoric pottery found in Maine were made with this type of pit firing.

The clean and uncarbonized surface of most (but not all) prehistoric Maine pottery means that the kiln must have been designed in a way that prevented the burning wood from coming in direct, physical contact with the ware. This strongly suggests that prehistoric potters used some version of a "beehive" kiln. A beehive kiln consists of two structures: a sealed chamber which holds the ware with a chimney hole above the chamber, and a firebox attached to the ware chamber with an opening where wood is fed in and air can enter. The secret of a beehive kiln is that it forces the flames and heat from the burning wood to flow around and past the ware in order to exit through the chimney, but does not allow the burning wood to come in direct contact with the ware itself.

For prehistoric potters in Maine, the challenge of building a beehive kiln is finding a suitable material to build the beehive chamber which holds the ware. Stones will not work because they cannot be stacked in the necessary shape without falling apart and breaking the ware (this flaw is exacerbated by the fact that stones tend to shatter and crack when exposed to the intense, prolonged heat necessary to get the clay to reach bisque temperature). A teepee of woven branches and saplings would not work because the fire would quickly consume them. There is only one easily available material that is sufficiently fireproof and capable of being formed into the necessary beehive shape: clay.

One of the easiest ways to make a beehive kiln from clay is to build a teepee structure from woven saplings and to stack rolled coils of

clay around the outside of this skeletal structure until it is completely covered with clay coils except for the chimney hole at the top. The stacked coils are then smoothed by hand to join and seal them to one another. Interestingly, because the coil-built technique is exactly how prehistoric Maine potters built their pots, these potters obviously were extremely familiar and well-versed with it. A second technique is to mix the structural clay with straw to give it additional strength. A third technique is to dip large leaves (like maple leaves) into a thick liquid slurry of clay and apply them on the skeletal surface or coils like wallpaper. This method is widely used today with newspaper dipped in clay slurry to make "paper kilns."

A key diagnostic of a prehistoric pottery kiln made as described above would be the presence of bisqued clay fragments from the kiln structure that were discarded when the kiln was dismantled after firing. In a beehive kiln partly or wholly made with clay, some of the clay, especially the clay surfaces directly exposed to the interior of the firing chamber, will reach bisque temperature along with the ware. This clay will survive for as long as the pots themselves. Unlike the finished ware, these clay fragments will not be kept by the potter. They will remain at the kiln firing site (or moved to a "rubble pile" depending on whether the potter is a neatnik). As such, the presence of rough, irregular fragments of bisqued clay at a prehistoric habitation site practically guarantees that a pottery kiln was made and used within a few yards of the site. Such an occurrence seems to exist along the Sebasticook River in Winslow, Maine.

The Sebasticook River Kiln Site

There is a large Ceramic Period habitation site on a flat bench on the south side of the Sebasticook River in Winslow, Maine approx. 1/4 mile below the outlet of China Lake Stream and 3/4 of a mile above the confluence of the Sebasticook River and the Kennebec River. Small shards of decorated prehistoric pottery are fairly common on the surface of the site, which until 2008 was covered by approx. 2 feet of water by the impoundment of the Fort Halifax Dam, located at the mouth of the Sebasticook. At the northern end of this bench is a small, curious array of large (12 inch dia.) stones that were obviously placed there, as the bench is relatively free of large stones. The stones are not arranged in a fire ring with a

central pit of soil, as you would expect from a recently made fire pit. Instead they are tightly clustered in a roughly square pavement with no central pit. Recent construction is unlikely because from 1908 to 2008 (the time from when Fort Halifax Dam was built to when it was removed) the site was underwater. And because the stone pavement lacks a central fire pit, it seems unlikely that 19th century residents of Winslow built it (for what possible reason?).



The "stone pavement" site along the Sebasticook River in Winslow, Maine. From 1908 to 2008 this site was under 2-4 feet

of water due to the impounding effect of the Fort Halifax Dam, approx. 3/4 mile downstream. The dam was removed in July 2008. The height of the impoundment can be seen as the base of the tree line on the opposite shore.



Flint scraper in between the stone pavement. Photographed as found. The scraper is the size of a nickel.



Highly weathered ceramic shard with small flint flake to the right. Photographed as found. The shard is thumbnail-sized.





Thumbnail sized flint flake, photographed as found. Flakes of this size are common on the surface in the area directly around the stone pavement pictured above, but require very close examination (hands and knees) to see.



Carbonized pottery rim shard with stamped decoration, photographed as found. Approx. 3/4 inch in width.

The most interesting artifact found at the stone pavement area is a two inch long piece of rough, highly irregular bisqued clay. At first when I found this piece I thought it was just a piece of hardened dirt, which is what it looks like. But when I scraped the "dirt clump" with my finger nail, I could not make even the smallest scratch in it. Upon closer examination, it became apparent the "dirt clump" was a piece of bisqued clay. But unlike the decorated pottery shards found nearby, this clump of bisqued clay was far too irregular and rough to have been part of a finished pot. Interestingly one side has a fairly smooth surface while the opposite side is jagged, pitted and extremely irregular.



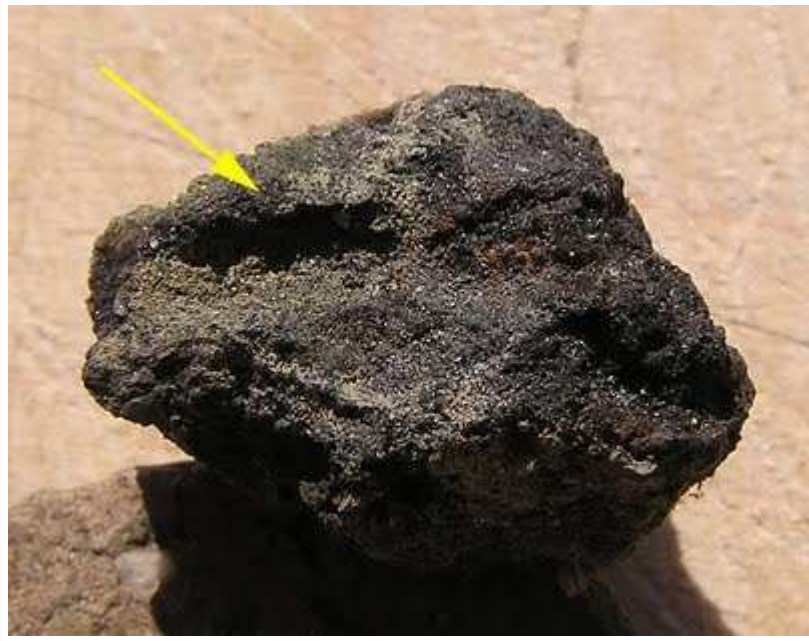
Rough, irregular side of bisqued clay "blob" found in between rocks of stone pavement. Piece is about 2 inches wide.



Rounded, flattened side of the same bisqued clay "blob." Note the lack of any angular quartz temper in the surface of the clay. All shards of finished, decorated shards of pottery at the site, even pieces 1/2 inch long, show prominent pieces of angular quartz in their cross-section and at their surface.

About two feet away from this piece I noticed a cluster of small blackened lumps embedded in the dirt. Prying them out of the soil, I noticed they were fairly heavy, with a tan colored "rind" and a jet black core. Like the piece described above, the rind of these lumps was extremely hard and could not be scratched, nor could the jet black interiors. After collecting about eight of these tiny,

blackened lumps, I noticed several were much lighter than the others. Close examination showed they were fragments of burned wood that had been reduced to charcoal, with a thin rind of bisqued clay on their exteriors. Later, at home, with a 20 power jewelers loupe, I discovered that one of the jet black bisque lumps had the clear impression of a twig in its center.



Small (1 cm) nodule of intensely carbonized bisqued clay. Arrow points to impression of twig or weed stalk encased in center of nodule.



1 cm nodule of charcoal, still showing original wood grain, surrounded by a rind of bisqued clay.

After making these two little discoveries, I spent the rest of the day on my hands and knees examining the soil surface around the stone pavement. Quite quickly I began to find numerous very small shards of prehistoric pottery near the pavement area. These shards were so small (thumbnail-sized) and so weathered and crumbled that they were nearly impossible to see. But a pattern emerged. The shards were all concentrated in an area around the northern side of the "pavement." As I extended my search in concentric circles farther and farther away from the pavement the number of shards fell off sharply.

That I found a concentration of small ceramic shards near a "hearth-like" stone pavement structure could be explained most simply by the fact that ceramic pots were used for food preparation, serving and cooking and the most likely place they would shatter, crack or be dropped is near the cooking area, so that's where the shards would tend to be concentrated, even today.



Red arrow shows location where carbonized nodules of bisqued clay were found, blue arrow is where "blob" of bisqued clay was found, yellow arrow where flint scraper was found.





Overhead view of stone pavement showing what appears to be its original rectangular structure trending from the bottom right to upper left. This is the only surface congregation of large stones in the entire 4-5 acre bench at this habitation site.

Those Weird Lumps of Bisqued Clay

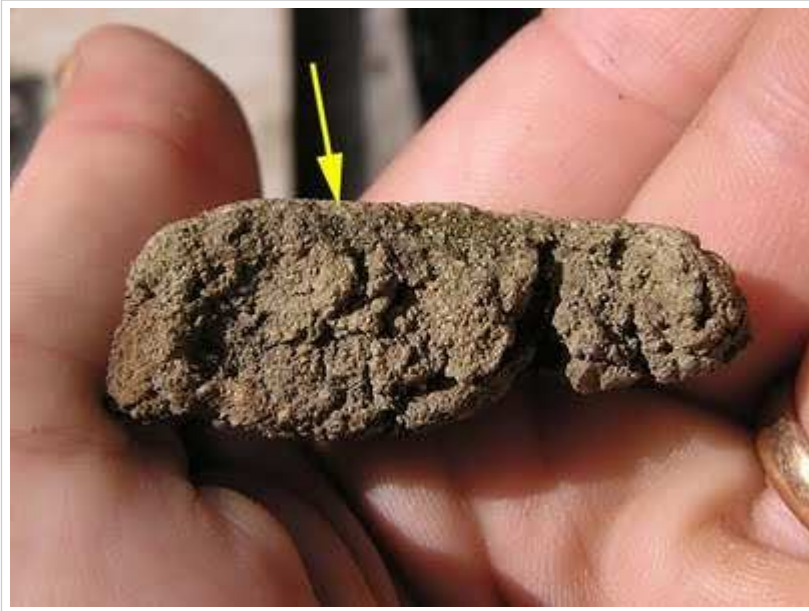
Of all the 30+ tiny pieces of bisque clay that I found on the surface of this habitation site, nearly all were parts of finished, decorated fired pots that had broken at some time in the past and were in a highly weathered and fragile state. The two anomalies were my first two finds directly around the pavement area: the odd two inch irregular lump of bisqued clay and the small "nodules" of bisqued clay with a tan rind and jet black cores. Examination of their fine particle composition with a 20X loupe shows these lumps are made of bisqued local clay of the same type.

What struck me about these lumps is they were made of bisqued clay but were obviously never part of a finished pot. So how and why did they get bisqued? The most logical reason seems to be that these lumps of clay were remnants of the kiln structure itself and reached bisque temperature because of their proximity to the firing chamber. When the kiln was taken apart after firing to retrieve the ware, these lumps were cast aside and ended up on the ground near the kiln. All of the other clay parts of the kiln structure which did not reach bisque temperature quickly dissolved with the first rainstorm after the firing. All of the wooden parts of the kiln were consumed by the heat of firing or were discarded with the lumps of clay.

It then occurred to me that the small nodules of clay with tan rinds and jet black interiors were highly carbonized clay. This was reinforced by the fact that one of the nodules was actually a small piece of carbonized wood, with grain structure still apparent, coated with a very thin but tough rind of bisqued clay. The final

hint occurred when at home I split one of the nodules in half with my fingernail and found its cross-section contained a clear, hollow impression of a branched twig. It then seemed obvious that the source of the carbon for the intense jet black core of these bisqued lumps of clay was small tree branches, and the nodules were created when clay was packed around the branches used to support the kiln structure, the heat of the kiln completely burned the wood and its carbon was absorbed into the clay packed around it.

Further examination of the two inch irregular piece of clay showed several things. First, it had an obvious blackened scorch mark on one end. Second, a view along its cross-section showed a clear "rind" about 1/4 inch wide surrounding a much coarser clay body.



Edge on view of bisqued clay "blob" showing rind along the rim with much looser clay in the center. Rolling clay into a loose coil causes the clay molecules at the edge to align themselves in a parallel direction to the direction of pressure with a discontinuity toward the center of the coil. Note the lack of any pieces of angular quartz temper in the clay.

My wife, Lori Watts, who is a professional potter, suggested the overall shape of the fragment resembled a large, loose coil of clay, and that part of the kiln structure was made by stacking thick, long coils of clay. Because clay minerals have a platy, flat crystalline structure, the act of rolling out a coil of clay causes the clay molecules near the surface to align in a parallel structure, while the clay molecules in the core retain a haphazard, random

alignment. As such, she hypothesized, the 1/4 inch thick rind could represent the effect of loosely rolling out a coil of clay by hand. And because a clay coil used to build the wall of a kiln chamber would tend to reach bisque temperature only on the side facing the interior the kiln and would not reach bisque temperature on its outer side, the extremely jagged, creviced and "pebbly" nature of the opposite side of the fragment would represent the exact boundary between where the clay in the coil hit bisque temperature and where it did not. And now, after 1,000 or more years of being exposed to the elements, the only part of the coil fragment left is that which was bisqued. The other wall and the rest of the interior of the coil dissolved in the first rainstorm after the firing in which it was used.

Two Kinds of Clay?

Unlike all of the finished pot shards at the site, the intensely carbonized nodules and the "blob" are notable for their lack of large, angular pieces of quartz in the clay body. Examination of the 25+ shards of finished pottery pieces shows they contain a temper of angular quartz of 0.5-2 mm in diameter. Small pieces of feldspar attached to some of the quartz fragments indicate the source rock was granite, which is common in highly weathered cobbles along the riverbank. However, the highly carbonized nodules and the 2 inch "blob" of clay noticeably lack this quartz temper material. This lack of quartz temper suggests these clay nuggets were made from the same body of raw clay as was used to make the finished pots, but quartz temper was not added to it. This suggests the existence of two separate clay preparations at the site: one clay preparation (with added crushed quartz temper) to make the finished pots and a second clay preparation (without quartz temper) to make and seal the kiln itself.

Putting ourselves in the place of the prehistoric potter for a moment, it is clear that a firing operation would use a separate clay preparation than that used for making the ware itself. Finished pots (called "greenware") must be completely dry before firing or they will shatter, crack and explode. If finished greenware is allowed to dry too quickly (such as by leaving it in the direct sun immediately after its completion), it will develop surface cracks before it is fired. Greenware must be dried gradually and slowly to ensure survival during firing. This controlled drying process

normally takes several days, or more if the weather is wet and humid. This means there would be a 2-5 day lag between when the pots were made and when they are ready for firing and therefore when the potter would need to make the kiln to fire them. If the prehistoric potters on the Seabasticook used clay to make their "one-time" kilns, as proposed here, the amount necessary to build the kiln would require a second load of fresh clay to be brought from its source. But, unlike the clay gathered for making the pots, this clay is not used for making finished pots. and would not require the addition of crushed quartz temper to make it usable for building and sealing the kiln. Instead, raw clay (with some sand added as temper) would do the job fine.

The Use of Large Quartz Temper

Rhodes (1971) describes the utility of large temper to assist in the successful bisque firing of pots:

"Drying is greatly facilitated by the presence in the clay of any sort of non-plastic particles. Such particles tend to take up much less water than clay and are, therefore, more easily dried out. Non-plastic particles also furnish open pores or channels through which moisture can escape toward the surface. Clays which contain a large percentage of non-clay particles, especially if these particles are relatively large, are called 'open' bodies."



Weathered pottery shard (2 cm wide) with surface spalled off, showing a profusion of angular white quartz added by the potter to

shooting projection of angular white quartz added by the potter to the raw clay to increase firing success. Photographed as found.

Putting the Pieces Together

From the evidence above, it seems likely the Sebasticook River site where these ceramic fragments were found was the site of a prehistoric pottery kiln; and the very irregular bisqued pieces of clay found at the site are fragments of the kiln. I reach this conclusion because there is no other explanation for the specific character of these bisqued clay fragments. While prehistoric people undoubtedly carried their finished pots with them when they travelled, they certainly did not carry along with them the scorched and broken parts of the kiln. Those were left at the kiln site. And for the same reason, prehistoric potters did not bisque fire rough, irregular oddly shaped lumps and blobs of clay for the fun of it. The highly carbonized lumps of bisqued clay with twig impressions in their core further suggest that the kiln was made with a combination of clay and saplings, twigs, branches, etc., with the wooden elements used to provide a skeletal structure which supported the clay coils stacked outside them.

A particularly pleasing endpoint to this research came when I walked 1/4 mile up the Sebasticook River from the habitation site to the mouth of China Lake Stream. Very near the mouth of the stream I observed its channel cuts through an enormous lens of very pure blue marine clay. This deposit would have provided prehistoric potters at the site with an endless source of clay for pots and for kiln-building in a location that is only a 5 minute ride by canoe. A single canoe load of clay from this bank to the habitation site (downstream, no less) would be enough to build a kiln.





Fifteen foot thick bed of blue marine clay at mouth of China Lake Stream, 1/4 mile upstream of the prehistoric habitation site. Most of the lower 1/2 mile of China Lake Stream flows through this marine clay deposit.



Photo taken at habitation/firing site showing location of marine clay deposit at mouth of China Lake Stream.



Photo taken from marine clay deposit at mouth of China Lake Stream looking downstream to habitation/kiln site.

How big were these kilns?

One of the engineering issues in building a kiln of clay/branch /straw is that the structural integrity of the kiln is inversely proportional to its size, which tends to favor small kilns.

Prehistoric Maine potters seem to have made only one size pot: big. Nearly all prehistoric pots found in Maine had capacities of four quarts or more, finished heights of 15-20 inches and mouth diameters of 10-12 inches. Given that bisque fired clay undergoes significant shrinkage during firing (10 percent or more), some of these pots as made and fired were up to 2 feet tall. Three of these vessels, arranged in a triangle, could be fired in a "beehive" kiln of 36 inches in diameter and 36 inches in height.

A 36 x 36 inch beehive kiln with a skeleton of saplings and sticks and a coiled and plastered clay exterior would fire 1-3 pots of the size typically found in Maine, take a skilled potter and assistant a few hours to build and would reach bisque temperature in 5-8 hours. The "one-time" construction of such a kiln (you have to rip it apart to get at the ware) would mean its use would leave very few long-term traces, except fragments of bisqued coils and wall clay. However, because such a kiln construction technique requires lots of clay, they would always be sited very close to a substantial natural clay deposit because nobody likes lugging giant masses of wet, sticky, gooey clay hither and yon if they can avoid it.

My assumption is that the prehistoric Maine potters, after much trial and error and experimentation, devised a happy medium ratio of kiln size to ware capacity. Given the documented size of prehistoric Maine pots, a kiln that could fire one 20 inch tall vessel could at best fire an additional one or two pots without causing a significant increase in kiln width and height. By exceeding this number, you would be required to stack pots on top of each other, increasing the risk of breakage and requiring a much taller kiln. This would create trend of diminishing returns because it would actually be easier to make two kilns side by side firing three pots each rather than one kiln that could fire six pots. This is because these kilns were one-fire and were taken apart after the firing. The economies of scale do not reward a high capacity kiln design unless the kiln structure itself can be re-used.

Because the success of a firing depends on reaching full bisque temperature on all surfaces of the ware, it is better to fire in smaller amounts and get consistently good pots than fire in one

large kiln and risk losing some or all of them due to inadequate temperature or kiln collapse and failure. Or, following this same rule, prehistoric potters may have tended to "play it safe" by firing one large pot at a time. This would minimize the amount of work to make the kiln, increase kiln efficiency, decrease fuel use and decrease firing time. Bisque firing with wood is an "all or nothing" enterprise in the sense that unless the firing process is a complete success, all of the previous work in making and decorating the ware and building the kiln is gone to waste if the pot is not fired properly. The large pots made by Maine potters required great skill to make (especially given their thin walls) and many probably did not even survive the greenware stage (due to unseen flaws and uneven drying) to even make it to the firing stage.

How Long was the Firing Process?

Even thoroughly dried "greenware" contains significant amounts of water trapped in between the particles of clay and temper. Unless this water migrates out of the ware before the firing temperature gets past the boiling point of water, the trapped water will turn to steam and explode and shatter the pot. For this reason, all potters must use a "candling" period where low, steady heat is applied to the ware to drive out and evaporate the pore water from the piece. In a small beehive of the type proposed here for prehistoric Maine potters, this candling would have been done by building a very small fire (with twigs and sticks) just outside the firebox of the kiln and letting the heat move past the ware and out the chimney. If only 1, 2 or 3 pieces were being fired this candling process would take at least 3-4 hours. Because excess candling cannot hurt a pot, but insufficient candling can quickly destroy it, prehistoric potters most likely candled a bit extra, since it requires minimal wood fuel, just to be safe with their ware.

The ability of a newly made pot to be sufficiently dry to be fired is dependent on the relative humidity of the atmosphere. In 100 percent relative humidity, pots will not dry out. In very low humidity, pots dry quickly. Prehistoric potters in the southwest desert of the United States live in practically ideal conditions for air-drying of newly made pots: high heat, very low relative humidity and little or no chance of rain. In contrast, prehistoric Maine potters were faced with a climate of much higher humidity, frequent rains (even in summer), and high air temperatures in conjunction with high humidity ("muggy" days). All of these

conjunction with high humidity (muggy days). All of these factors made the candling process critical for the success of firing a large, thin-walled pot in Maine, and may explain why for a distinct period Maine prehistoric potters deliberately added large amounts of coarse pieces of crushed quartz as temper in their pots, as this would greatly assist in the drying of the ware and fewer explosions in the firing process due to water trapped in pore spaces in the clay.

For the type of small, clay-lined beehive kilns proposed here, the actual firing time required for a well-candled large pot (or two) would be in the range of 4-6 hours. This suggests that the entire firing sequence took 8-12 hours. If the beehive kiln was completed in the morning, candling began at 10-11 a.m., firing began at 4 p.m., the entire process would be done by mid to late evening. Or, as an alternative, kiln construction may have been done the day before, with candling begun in early morning the next day, finished by noon, with firing completed at dusk.

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