BUBBLE-BONE ICE

By Jim Spinosa

For the past few years, I have been trying to determine the sequence of events, which occur during the formation of an ice sheet over the rushing waters of brooks. There doesn't seem to be a clear explanation of this perplexing phenomenon–it appears no scientific consensus has been reached on this subject. On the other hand it is easy to imagine how ice can form on the still waters of a pond or lake, if the air temperature is below freezing. First, a thin film of ice will form over the surface of a pond or any other still body of water. Secondly, assuming nothing disturbs it, the thin film of ice will gradually build up until it is several inches thick. Lastly, the insulating properties of this thick layer of ice will takeover and these will keep the remaining water under the ice from freezing.

This method of ice formation cannot occur on the swiftly flowing waters of a brook because the flowing water would break up any fragile film of ice. I have read about a kind of ice called *anchor ice,* which is found on the bottom of unfrozen brooks and lakes. There, according to *Webster's Dictionary,* it often coats the stones, which rest on the bottom. That kind of ice might exist, but wouldn't being covered with water cause the ice to melt? How could anchor ice form in a streambed? The temperature of the running water would have to be below freezing.

With these questions and others in mind, I began to study the formation of ice on a swiftly flowing brook. I decided on Beaver Brook, a tributary of the Rockaway River, as my subject. The nearby ponds had been frozen over for weeks, yet the brook was still completely ice free except for some fringe ice or frost ice that stretched out along both banks at irregular intervals.

The Rockaway River and its tributaries have been flowing through what is now Morris County, New Jersey since the Wisconsin Ice Sheet retreated about 25,000 years ago. Geologically the region is known as the New England Upland, but it is most often called the Highlands. The landscape is dominated by flat-topped ridges that are often covered with various hardwood trees and occasionally stands of cedar. Many small lakes are embedded in between the ridges. Today, the Rockaway River courses through the county all but unnoticed by most of the residents. Barry Brantner, a keen eyed environmentalist, who has studied maps of the area, claims that several tributaries of the Rockaway River are named Beaver Brook.

For many days I observed how ice often formed around obstructions in the brook. Large, tangled rows of wild roses grew along both banks of the brook in many spots. At a sharp bend in the brook, about twenty stems from a tangled thicket of wild roses dipped into the water. A small, irregularly shaped sphere of ice would form on each stem about an inch or less above the waterline. I assumed that the brook's rushing water collided with the stems and produced minute droplets of spray, which coalesced into the ice spheres when the air temperature was below freezing. During a prolonged cold snap these ice spheres would enlarge and merge together until they formed a small, bumpy ice shelf. A few yards downstream was a still pool of water formed when a small streamlet merged with the brook where it made a right-angled bend. Here the water froze just as the water in a pond would.

As I examined the brook more thoroughly, I found an unusual ice formation. The brook often coursed through tangles of roots, sticks and dead leaves. The jumbled detritus that broke the water's surface was usually small in comparison to the tangled mass that spread out below. In some of these waterlogged tangles, a few of the sticks would oscillate. They would continually produce bubbles of various sizes like someone blowing through a straw in a glass of milk. As these bubbles floated downstream they were often captured by some obstruction. These were usually formed around a branch that had bent into the brook and had snagged some dead leaves and twigs. As the obstruction increased in size it would capture enough bubbles and foam for an effervescent island to form.

These bubble-islands would be shaped by the current until they looked like a bone shaped dog's chew toy. The bulbous downstream end, which butted against the obstruction, would be crowded as the bubbles piled up. The middle portion would be tapered since the current would peel off many bubbles. The upstream end's position allowed it to intercept the most bubbles, and as they lodged the end enlarged. The islands of bubbles and foam would freeze while the water all around them remained ice free. The bubble-ice had the color and texture of snow. It was lighter than balsa wood and so brittle that it was difficult to pick up even a small piece without it breaking up. A cross section showed a compact bubble structure like an empty honeycomb except that the cells were spherical, not hexagonal. The spheres averaged 1/4 inch in diameter.

The bubble-ice islands rose in a gentle curve from the water, the apex of which arched over a thickened middle section. There were narrow, light brown striations running the length of the islands, which looked like miniature replicas of the wrack lines left on a beach after high tide. I wondered whether the bubbles were naturally occurring or were they the result of household wastewater run-off that contained detergents.

Finally, the brook froze over. I didn't observe the actual freezing. The one day that I decided not to bother looking at the brook was the day when it froze over. The watched pot doesn't boil and the watched brook doesn't freeze. There hadn't been a significant drop in the temperature so that was n't a factor in the freezing of the brook. There had been a 2 or 3 inch drop in the water level, as though a faucet had been turned down. The water level had sunk abruptly while for the previous week or more it had been constant. I had noticed that often when a brook froze over there was a shelf of ice running along the edge of the brook that was 3 or more inches above the newly frozen ice. Exactly how this fringe ice shelf formed had never been clear to me. Now, it was apparent that the shelf of fringe ice represented the previous water level and was nothing more than the normally occurring fringe ice that forms along the banks of a brook.

When a brook freezes over the ice sheet has many small variations in it. The interactions between ice, flowing water and streambed result in a harmonious landscape of sights and sounds held in a shivery balance. Much of the ice was an inch or more thick–almost strong enough to hold my weight without cracking.

The next day a powerful storm deposited 2 feet of snow. I didn't return to the brook for about one week. By that time the ice was beginning to melt because of a slight rise in the temperature. There seemed to be fewer bubbles in the brook than before and there seemed to be no ready explanation for this. Most of the ice had melted, and what was left had shrunken back to a band of fringe ice along both banks.

Farther upstream there was a straight portion of the brook about 100 feet long. At the midpoint of this section a cluster of trees spread their bare branches across the brook. The branches were crowded together so thickly that despite their leaflessness they formed a patch of shade. The way the long branches arched over the brook brought to mind several lines of a poem:

> The river's tent is broken: the last fingers of leaf
> Clutch and sink into the wet bank. The wind
> Crosses the brown land, unheard. The nymphs are departed.

With those three lines, "The Fire Sermon" begins, which is the title of the third section of T. S. Eliot's *The Wasteland*. The poem's protagonist is viewing an autumnal Thames as it flows through London.

Where I was walking the trees actually formed a tent over the brook when in leaf, and the branches at this particular spot grew so densely intertwined that even in the middle of the winter they formed a tent albeit a leafless one, which shaded the brook.

As it flows under London Bridge the Thames is 250 yards wide, and further east at Gravesend it is 700 yards wide. The word, *Thames* is probably derived from a Celtic word, which means broad river. The trees along the banks of the Thames as it flowed through London would not form a tent because the river is much too wide.

Possibly, a tent of leaves could be formed in another way. The fallen leaves could gather on the river's surface in such profusion that they would form a carpet covering the water. Once, I had seen this happen to Beaver Brook during a fall in which there had been almost no rain. Even when the brook was as thickly carpeted with fallen leaves as the forest floor, I saw the reflection of the moon under the upturned corner of a leaf. I have never seen the Rockaway River covered with leaves, and it is only 1/10 the width of the Thames so it is unlikely fallen leaves could cover the Thames.

Tent has a second meaning, which is less well known, it refers to a plug of gauze inserted into a wound or opening to dilate it or keep it open. The broken tent that T. S. Eliot mentions could be a plug that keeps open a passageway to a magical and mysterious Thames where nymphs reside. In the modern world that tent has been broken and the passageway has been closed, and we are left with only the materialistic Thames.

Back here, the brook's winter tent provided a small portion of the melting ice with shade allowing it to maintain a remnant of its original form. An expanse of exposed water–enclosed by the melting ice on three sides–was stagnant, and it formed an elongated *V*. The melting ice was thin, gray and waterlogged. Despite its diminished state the ice managed to span the width of the brook at the bottom of the *V* , and thus the stagnant water was separated from the flowing water by the ice. When the ice reached the center of the brook, it was only a narrow dam, 1 inch wide, weak and gray. On one side of the flimsy dam, stagnant water stretched out upstream. On the other side of it, the brook resumed its sinuous flow. The dam was weak, it was only durable enough to stop the surface flow of water. The waning ice had formed a cul-de-sac that trapped bubbles and foam. If I were to break the dam, perhaps with a long stick, the stagnant pool of bubbles and foam would drain downstream. If I were to try to keep the ice dam from reforming by placing small sticks along the edges of the narrow channel, I had just contemplated forming, I would have constructed a tent, though not of gauze.

A flotilla of trapped bubbles and foam covered the stagnant water. They had formed ever decreasing, concentric arcs of white froth as they descended down the elongated *V* until finally they came to rest on the still water. The white arcs decorated the smooth surface of the water. A few feet in front of the large mouth of the *V* a thin, black line was barely visible. At this boundary line, the water seemed to slip under itself. This thin, black line performed a frenzied dance, back and forth, across the width of the brook as if it were whipped by an unseen gale. The bubbles and foam suddenly lost their momentum as they crossed this line. They decelerated to an almost complete stop. Then I realized the water wasn't running under itself; instead, it was sliding under a thin film of detergent. The bubbles began losing their momentum as soon as they no longer rested on the water and instead floated on the stagnant film of detergent.

This suggested that the ice-bubble islands were made from detergent bubbles. Detergent has the property of smoothing out swiftly flowing water. This would give detergent bubbles an advantage over naturally occurring bubbles in the formation of ice-bubble islands. Waterways have not been polluted with detergents until recently. Bubble-ice is ephemeral by nature since it is engulfed once the familiar ice sheet is formed. Taking these two facts into consideration, bubble-ice may not have been described before. However, there is a type of hail know as graupel that consists of brittle, white ice particles with a structure like snow.