The Magic 9% (Water Drops Get Pointy When They Freeze)

Have you ever thought about exactly what happens when the ice is pebbled? The idea behind pebbling of course is you want to reduce the surface area of the stone that is in contact with the ice. So you lay down a fine layer of pebbles that the running band of the stone can rest on, which reduces the friction and makes the ice faster. But hold on; I think we can all picture what happens when a drop of water falls on the floor. It forms into round bead, but the bead is not really a nice plump round hemisphere that sticks up off the floor. It spreads out and kind of flattens down a bit. It still holds some of its round shape due to surface tension but it is still quite flat - and then you run the nipper over it and it has got to flatten out that pebble even more.

So why does pebbling actually work? (in reducing the surface area that we play on)
There is something else going on. And it is quite simple. Most substances contract when they freeze. Water does not. Water expands. In fact, water is the only known non-metallic substance that expands when it freezes; it expands in volume by about 9%. And that is where the magic comes in.

When that water droplet falls on the ice, the droplet holds its rounded shape because of surface tension (just like it would if it fell on the floor), but the very bottom layer of the droplet freezes in place fairly quickly so now the footprint of that pebble is fixed. So now the pebble is attached to the ice surface and it is freezing. But it has to expand as it freezes. The contact area with the ice is fixed, so it can't expand outward. It has to expand upward. And that is exactly what happens. When the pebble hits the ice it forms a flattish kind of bead. But as it freezes it actually grows up and forms a much more obviously conical shape. (See Pictures.)

Don't take my word for it. Some scientists (at the University of Twente) in the Nederlands did the experiment. They dripped tiny beads of water on a frozen metal plate and took some pictures; pictures in infra-red so you could see what happens as the pebble freezes. Liquid water is red in the photo and ice is green. The starting shape in the top left is a flat hemisphere (4mm x 2mm) but as the drop freezes it grows upward and becomes quite perky.

Now you can imagine the nipper coming along and it is cutting only the very top off this pebble so the reduction in surface area is quite limited. Nip the first one and get 2-3 mm wide. Nip the frozen one and you get only 1 mm wide. So this is the magic of pebbling: Reduced surface area, reduced friction, faster ice.

Another interesting thing they found was that when they leave the pebbles, the sharp tip of the pebble actually attracts water vapour out of the air and you get ice crystals growing out of the top of the pebble. This is strong evidence I think for a few things that we regularly observe in practice.

1. Ice that has not been played on develops a layer of frost that actually grows out of the top of individual pebbles;
2. Nipping is effective because it actually nips off that point so the ice crystals take longer to form and when they do form they do not form so much on the top of the pebble which of course would cause the ice to slow; and,
3. Think about the ice outside of the nip line: it is unnipped ice that sits there for an hour growing frost out of the top of the pebble and this can be going on the whole time you are playing your game. And you know when you have to make that draw out in the weeds towards the end of the game, that ice is going to be slow. (Unless your sweepers are smart enough to be cleaning in front of the rock.)

One last point: These top four photos were taken over a period of 18 seconds so that is a first estimate of how long it takes for pebble to freeze after it is applied. Except the surface here is being held at -20C, whereas our ice surface is much warmer. Our ice is only kept at about -5 or -6C, and it is even warmer at the surface, so it will obviously take much longer than 18 seconds to freeze the pebble. The point is you really need to wait a good 60 seconds or so for these beautiful perky pebbles to grow before you run the nipper.

Science

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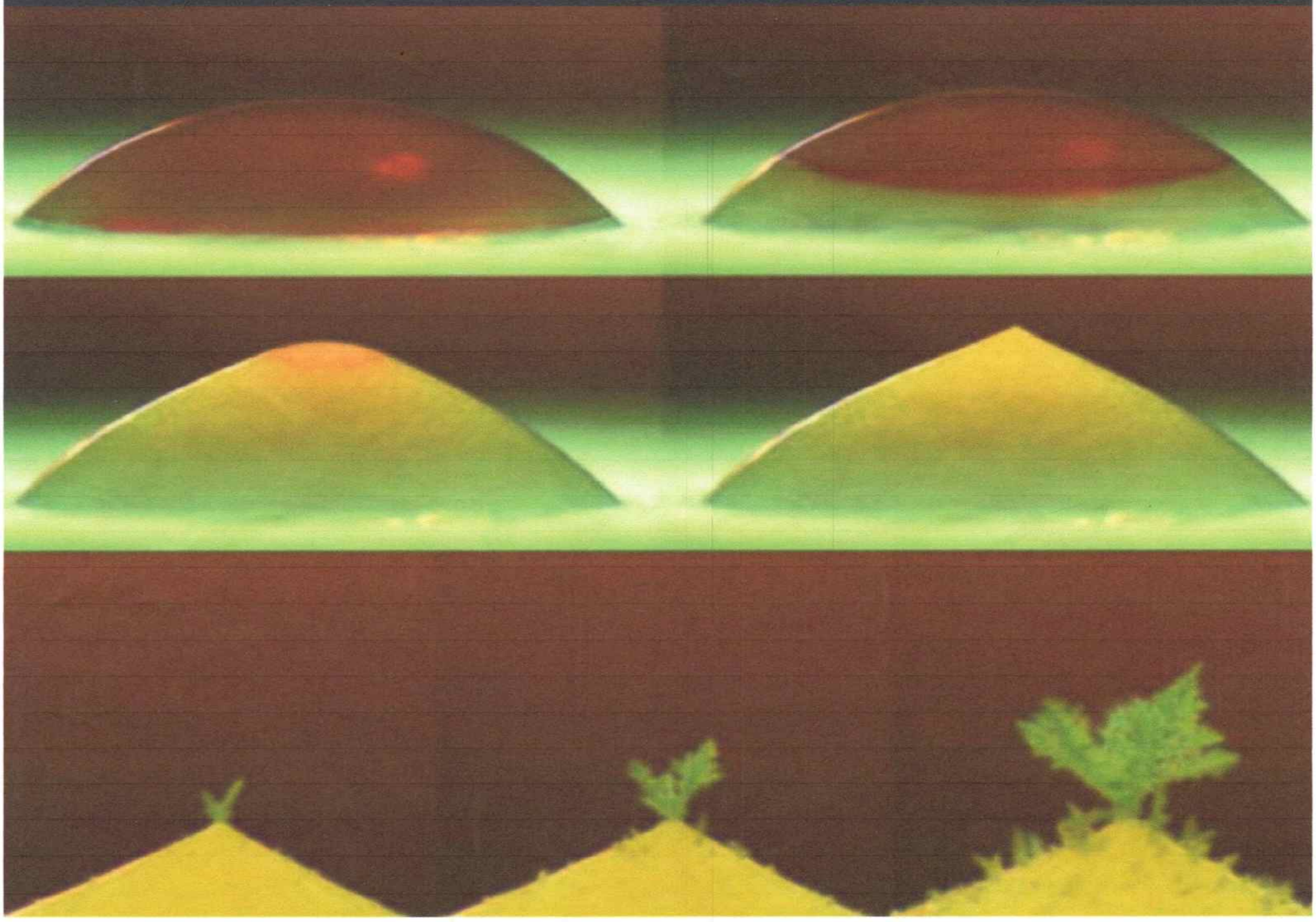

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Frozen water droplets take on a whole new shape when they freeze: Instead of staying round, they form a pointy tip, and eventually sprout a tiny forest of ice crystals on their surface. In order to observe these effects, researchers dripped tiny beads of water on a plate kept at a chilly -20°C. In the 18 seconds that it took the 4-millimeter-diameter droplets (top row) to solidify, researchers snapped photos of the water freezing from the bottom up. During the final stage of freezing, the ice drops developed a pointy tip (middle row), which continued to grow and eventually formed delicate ice crystals on the surface, the team reported last month in *Physics of Fluids*. Researchers believe the unusual pointy tip is caused by the vertical expansion of the ice combined with the surface tension on remaining liquid. Once frozen, the sharp tip of the drop attracts water vapor from the air, and produces treelike ice crystals (bottom row).

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