

When the ground freezes... what happens?

Winter's cold freezes the soil... what's going on?!



By Katharine Fletcher

When winter arrives and temperatures plunge below zero, the country road outside my farmhouse changes.

First, with the cold come frost heaves, making ripples and bumps in the road's surface. Second, however, old fence-posts marking an old property line appear. Yes: they protrude perhaps a centimeter and a half above the asphalt!

When winter comes, we think about the science of snow and ice... But the mere fact of the ground freezing is really interesting, too.

What is frozen soil?

When the soil temperature falls below zero degrees Celsius, ground that contains water freezes.

Are there different types of frozen soil?

Yes! According to the University of Colorado at Boulder, "One-fourth of the land in the Northern Hemisphere has an underground layer that stays frozen all year long. Ground that stays frozen for at least two years in a row is called **permafrost.**"

However, here in Ottawa, the ground thaws when spring approaches, as does roughly half of the land in the Northern Hemisphere.

This type of frozen ground is called **seasonally frozen ground** – and that's what we experience in the National Capital Region.

What is pore ice?

The ground can freeze solid only if there is moisture – water – in it. After it freezes in soil, rocks, and pebbles, the frozen water is called **pore ice**.

And when the pore ice melts, the ground thaws.

What is the difference between melt and thaw?

Technically, scientists don't use the word "melt" to describe what happens when soil warms up and the pore ice thaws. This is because soil, rocks, and pebbles are solids. The word "melt" is only used to describe when a solid turns to liquid.

Therefore, we say the **ground thaws** in spring, not melts.

What is heaving?

A weird thing happens when water freezes to ice: it expands.

Therefore, when the ground freezes, the moisture that has turned to pore ice takes up more room, and the ground heaves, or buckles. This is why roads become bumpier in winter.

Experiment for fun

Try an experiment outside to demonstrate the expansion of ice when it freezes.

Fill a yoghurt container completely full with water and carefully put the lid firmly on. Then fill a second yoghurt container of exactly the same size half full and put the lid on. Before taking it outside, mark the level of water on the outside of the container.

Leave both containers outside overnight when the temperature outside is below freezing.

What happens? When the water in the absolutely full container freezes, it will pop off the lid, demonstrating how ice takes more room than water. When the water in the other, half-full container freezes, you'll notice that the ice is higher than the mark you made.

Is this why rocks split?

Yes. Freeze-thaw action will eventually split solid rock. That's because boulders, cliff faces, and pebbles break apart with the forces of expansion (freezing) and contraction (thawing).

How come ice floats?

It seems counter-intuitive, doesn't it, that ice floats in a glass of water... or that ice floats in a lake – or an iceberg floats in the ocean?

Scientists use the word density to describe water, which is more dense than ice. That means that ice, being less dense, floats on water.

Do all underground layers freeze at once?

No. During winter, the surface of the soil that is exposed to the -0 degree Celsius temperatures freezes solid. Layers under it, however, freeze more slowly. The lower the depth of soil, the longer it takes to freeze, because lower layers are insulated by the top, frozen earth.

Do sand and clay freeze?

Both very different types of soil will freeze. But they freeze at different rates.

Sand is loose with large particles. Kids play in sandboxes and play on sandy beaches, and it's easy for children to remember how sand can be poured – through your fingers or from a pail. Clay, however, is dense and its fine, almost flour-like particles are firmly packed.

The different textures mean that there is lots of room between the particles of sand for moisture to build up – and thus, sand will freeze easily. In contrast, there is little room in densely packed, hard clay, and as a result, it does not freeze as easily. (It still feels hard and cold, though!)

The next time you head out with your children to walk on frozen ground, you'll have lots of science to talk about!

Want to learn more? Go to www.ccin.ca and click on the Kids link!

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National Capital Region at bookshops and outdoor stores throughout the Ottawa Valley.

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