As glaciers melt at an alarming pace, a geologist reflects on the legacy of ice ages and what the future may hold

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Jack Ridge uses a compass to show the direction of a series of glacial striations atop Waitt's Mount in Malden, Massachusetts. Credit: Alonso Nichols

With continued news of glaciers in Greenland, Antarctica, Alaska and

the Alps, as well as other parts of the world, melting far faster than predicted, Tufts Now turned to an expert on ice sheets and the last ice age to better understand the big picture.

Jack Ridge, professor and chair of the Department of Earth and Climate Sciences, has built a career studying the retreat of the last ice sheet that blanketed eastern North America. He has created detailed geologic maps of the nearby Middlesex Fells Reservation as well as areas of New Hampshire and central New York, created the North American Varve Project, and has taught and led field work at Tufts for nearly four decades.

Ridge shared how past glaciers shaped our landscape, why today's ice sheets are shrinking at a accelerated rate, and what concerns him most about the rapid melting of glaciers.

Tufts Now: Let's start by framing ice ages from the widest possible perspective. Throughout Earth's history, starting billions of years ago, there have been cold periods that allowed glaciers to form on the planet. The ice ages within the last 2.5 million years occurred in cycles of both very cold and warm intervals like we have today. Glaciers of the last ice age receded from New England about 10,000 years ago.

Jack Ridge: Past ice ages have shown themselves to be very cyclic. This is clear from long climate records, and we seem to understand the mechanisms responsible: Earth's orbital cycles that influence the amount of solar radiation we receive trigger changes in ocean and atmospheric circulations, the amount of carbon dioxide in the atmosphere, and the

amount of sea-ice cover near the poles.

The period we're living in now is the interglacial period of the Holocene, which technically began 11,700 years ago. Earlier, prior to the last major ice age, there had been another interglacial period at 135,000 to 90,000 years ago, when North America was significantly warmer than it is today, and sea level was six meters [20 feet] higher. Alligators lived as far north as the Ohio River valley, for instance.

Still, even in our own interglacial period, you will see records of smaller climate swings. The Little Ice Age, for which there is an historic record, impacted Europe and North America from about the year 1000 to the mid-1800s. In the 1600s London was cold enough to have frost fairs on the frozen River Thames.

Ice sheets seem to be juggernauts when it comes to shaping the landscape. They must have had incredible abrasive force.

A glacier is a powerful erosion agent not only because it's large and heavy, but because it moves, or actually slides, across the land surface. The ice sheet that once covered Boston was about a mile thick and, because the base of the glacier was wet, it slid rapidly across the land surface, probably at rates of hundreds of meters per year.

Ice sheets always move from where their surface has a high elevation toward the low elevation areas at the margin. This means that the ice that flowed across New England came from Canada. This is true even when the glacier gets smaller: the ice always flows outward from the center of the ice sheet. But during ice recession, or ice retreat, the rate of melting at lower elevations becomes greater than the flow rate, and so we see a net retreat.

The moving ice sheet scrapes the Earth's surface and gathers up deposits. At the same time, it rearranges drainage systems by carving valleys and creating lake basins. It basically reconfigures the landscape. The Great Lakes are the result of glaciers gouging out rocks, for instance, primarily near the edge of the ice sheet, where there are big lobes that move fast.

We can also see its action on the Tufts campus. What we call the Hill is a streamlined glacial deposit known as a drumlin. So, Ballou Hall is built on a pile of sediment dating back 35,000 to 17,000 years ago.

But the record left behind by deposits is not one of continuous retreat. I like to say it's nervous and jerky with times of rapid recession punctuated by short periods of glacier expansion, and then more retreat.

You take your students on field trips in the nearby Middlesex Fells. What are some of the visual signs you look for in that topography?

The Fells has some great examples of glacial erosion in the form of glacial striations, or scratches and grooves, and there are large boulders left behind in various places that were moved by the ice. We have also found evidence of moraines, piles of debris that were left behind at the margin of the glacier about 17,000 years ago while it was retreating.

I also take them to Waitts Mountain in Malden. The whole top of the hill is exposed rock, much of it marked with beautiful glacial striations and grooves. I always tell them to put their hand on the rock and then I say: "Now there's nothing between you and the last ice age."

A recent study revealed that Greenland's melting ice sheet will likely contribute almost a foot to global sea

level rise by the end of the century, and ice shelves surrounding the Antarctic coastline are retreating rapidly. Scientists with the British Antarctic Survey reported that 'we should expect to see big changes over small timescales in the future, even from one year to the next.' Can you comment on the rapidity of this loss?

The melting and retreat of glaciers has always depended on how much a glacier is out of equilibrium with the existing climate. Over the eons, melting has happened whenever the Earth's temperature rises to a level where ice simply cannot be sustained.

But since the Industrial Revolution, humans have been steadily raising Earth's temperature through carbon emissions, and today we're experiencing the planet getting warmer at a much faster rate. As a result, the planet's glaciers are more and more out of equilibrium.

That imbalance gets especially complicated where the glacier ends in the ocean. Floating fronts of glaciers, or ice shelves, are lifted by rising sea level, which further destabilizes them, creating huge icebergs by a process called calving. Calving causes even faster recession, and warming of sea water around the edge of an ice cap will further contribute to the glacier's collapse.

Where are you most concerned?

I worry most about ice recession in Antarctica and Greenland where ice caps are very large. Here, ice melting is happening at a faster rate than expected, and it continues to accelerate every year. Ice sheet melting is likely to dramatically raise sea level and lead to possible changes in

atmospheric and ocean circulation, which can alter climate in many areas and perhaps trigger extreme weather events around the planet.

In Antarctica, where the ice sheet is nine times larger than in Greenland, large icebergs are forming on the coast—especially on the Antarctic Peninsula, where smaller glaciers are currently destabilizing. And around the corner to the west, the Pine Island Glacier is also experiencing accelerated calving.

It is hard to grasp just how big some icebergs are in Antarctica. The largest we've seen in the past 50 years or so was two and a half times the size of Connecticut. It was a big chunk of ice. If the entire Antarctic ice sheet melted, it would raise sea level 65 meters, or about 200 feet. That would cover the whole state of Florida.

So scientists are watching ice loss in Greenland and Antarctica closely as they are the leading contributors to rising sea levels; they have the potential to reconfigure all coastlines and island nations, and that is certainly a cause for quickening how we plan to adapt for that uncertain future.

But the rising levels of carbon dioxide in the ocean, which cause ocean acidification, are to me even more of a concern. Climate change is changing the ecosystems in the ocean, with serious consequences for marine life and, of course, for the ocean as a supply of food. In my way of thinking, this is probably the biggest problem we're going to face.

We haven't seen this kind of shift happen in other interglacial periods because we have currently gone way beyond the carbon dioxide levels that occurred in other interglacial periods over the past 2 million years.

There is considerable debate when it comes to

predicting the next ice age. Some climate experts say that human activity will override any shifts in the Earth's orbital cycles. Do you have thoughts on the timing of the next ice age?

It appears that modern global warming, as it becomes more extreme, and if it is sustained, will have the ability to offset cooling trends that might occur. However, when we are predicting ice ages, we are looking 10,000 years or more into the future, and that makes climate trends more difficult to predict.

For example, if our current climate disaster were to become extreme, possibly lowering human populations by increasing pandemics or drastically reducing human food supplies, we might end up producing lower carbon emissions.

We should also consider that, on the scale of thousands of years, we may run out of fossil fuels, and lower emissions will be forced on us. In this case, the climate may revert to a condition closer to its natural state, and ice ages might continue as they did over the last half million years.

It will be hard to predict how climate changes in the next couple of centuries will impact an ice age 10,000 years into the future. In my opinion, we should worry about the impact of warming on the next few centuries. Worrying about distant ice ages right now, although interesting, seems to me like a distraction and we should focus more on the current crisis.

Provided by Tufts University

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