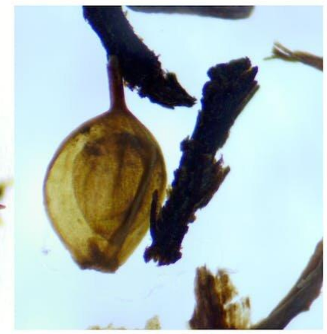
416,000-Year-Ago Glance at Greenland and Its Natural World

Norris Whiston norrisw@ns.sympatico.ca 8/19/2023 6:24 PM version. Thanks to Elise Bresnik and Dr. David Patriquin.
A hyperlinked version is at: NW Guides & Keys | Nova Scotia Wild Flora Society

[1] From 1960 to 1966, a core sample was drilled at Camp Century, in southwest Greenland. The scientists drilled 4560 feet down (1390 meters) into the ice and continued for an additional 12 feet (3.66 meters) into the frozen rocky soil below. The snow and the soil were then analysed and stored (Left photograph credit US Army photograph). A 1969 report was given about changes in the ice over Earth's most recent 125,000 years.

The soil portion of the Greenland sample vanished in the 1990s. In 2017, Danish scientists found the lost soil sample deep in a Copenhagen freezer. Under that deep snow and within the soil were moss, sedges, eight-petal mountain avens (*Dryas octopetala*), and willows. (Right photo Credit: Halley Mastro/U. Vermont)

A large international team of scientists was established to examine the soil, using tools that were not available in the 1960's. Tammy Rittenour, Utah State U. at Logan, used optically stimulated luminescence (OSL) on quartz grains to see how long the grains had been without the sun's light and, consequently, how long ago they had been buried. Dr. Justine Kemp, Griffith University, Australia, explains OSL in the 3:37 Youtube Optically Stimulated Luminescence – Archaeological Dating Methods.

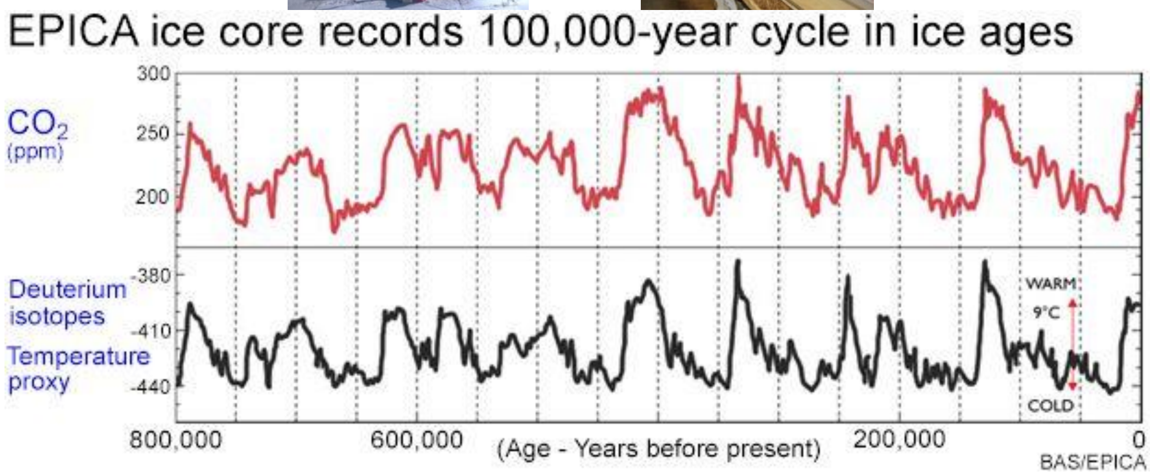
Paul Bierman, U. of Vermont at Burlington, at his lab, used specialized instruments to look for rare isotopes of aluminium and beryllium and noted their ratios of half-life to determine how long the soil had been exposed to the solar system's cosmic rays. Rittenour and Bierman's explanations are at EurekAlert.

The highest layer of soil, in which water had moved moss, sedges, leaves and twigs, was dated to 416,000 years ago (ya). The soil had been exposed to the sky less than 14,000 years. This occurred within a longer-than-normal warm interglacial period now known as MIS 11, which took place between 424,000 and 374,000 ya. Within that era, atmospheric carbon "remained between from **265 and 280 parts per million** for about 30,000 years."

Paul Bierman and Tammy Rittenour published in The Conversation on July 23, 2023 a summary of the report's findings. They wrote at 416,000 ya, "Scrubby tundra basked in the sun's rays on Greenland's northwest highlands. Evidence suggests a forest of spruce trees, buzzing with insects, covered the southern part of Greenland. Global sea level was much higher then, between 20 and 40 feet [6 and 12 meters] above today's levels. Around the world, land that today is home to hundreds of millions of people, was under water."

"Today, our atmosphere contains 1.5 times more carbon dioxide than it did at MIS 11, around **420 parts per million**, a concentration that has risen each year. Carbon dioxide traps heat [1856 discovery shown in UN-approved Youtube Eunice], warming the planet. Too much of it in the atmosphere raises the global temperature, as the world is seeing now." The international team's report appeared in the journal Science on July 20, 2023.

[2] The graph to follow is reflective of Earth's changes in orbit, tilt, and wobble. Note the highs and lows and changes in direction of the graph. Earth's orbit changes, though on its grand scale relatively small, are significant when the orbit places the sun visibly closer to the northern hemisphere. The orbit causes the land-covered, heat-sensitive northern hemisphere to be its warmest every 100,000 years. The tilt changes the angle of exposure in summer for the northern hemisphere, which occurs every 41,000 years. Earth's degree of wobble changes every 26,000 years. Those cycles, now known as Milankovitch cycles, are explained in two short UN-approved Youtubes by Dr. Paul Merrell called How Ice Ages Happen: The Milankovitch Cycles and The Milankovitch Cycle Timeline: Where are we now? Dr. Dan Britt, U. of Central Florida, also explained Milankovitch's work in the UN-approved Youtube Orbits and Ice Ages – The History of Climate Change at 22:58.



Pictures and graph from BBC report Antarctic Quest to Find 'Oldest Ice' and originally from British Antarctic Survey (BAS) / European Project for Ice Coring in Antarctica (EPICA) under Dr. Robert Mulvaney. Antarctic snow was drilled down in 3.2 km / 2 miles thick snow and its ice cores were stored underground. The core's bubbles were measured for atmospheric CO_2 and air particles. The core's snow was measured for Deuterium isotopes as a temperature proxy.

Note within the graph, when atmospheric carbon dioxide - the red line - naturally went up mostly due to those cycles, the temperature - the black line - went up as well. Those vertical dotted lines in the graph are 50,000 years apart. Locate the Marine Isotope Stage (MIS) 11 era, 424,000 to 374,000 ya, on the graph. Imagining an extension to the scale at the left, locate July 2023's level, 420 ppm CO_2, above the far-right red point. At UCal San Diego's Keeling Curve site slide to the 800 K years tab and see how you did.

[3] Approaching 416,000 year ago, the orbit and tilt change would have set off the same succession of climate changes that the Earth and humans are currently witnessing. "Tipping points" were identified on November 11, 2021 in the State of the Planet by UN's Intergovernmental Panel on Climate Change (IPCC). On Sept. 6, 2022, a portion was explained in UN-approved Youtube by Prof. Tim Lenton, U. of Exeter, and Maiya May, science communicator for PBS, in What Will Earth Look Like When These 6 Tipping Points Hit?

[3a] For areas at the edge of ice sheets or glaciers in the poles and in the mountains, even one degree matters a lot and that ancient melting would have occurred there first. In those ice-tundra boundary areas, the warming 424,000 ya would have caused ever-broadening areas to have less reflective new snow and more heat-absorbent dark land and dark water.

[3b] Back then, uncovering the snow over the frozen tundra would have affected its permafrost, which, when warmed, would have exposed previously frozen soil carbons to be naturally processed and sent as CO_2 and methane (CH_4) into the atmosphere. In our present era some such former permafrost areas have already contributed greatly to Earth's atmospheric gases.



The **resin** on a white spruce, Old Barns, Nova Scotia, a **resin-covered** pine tree cone, Park Street, Truro, NS (Credit Norris Whiston), and an Alberta 2009 forest fire (Wikimedia Commons). When touched on their cones, bark, and in other places, one can feel the spruce, pine, and fir's gooey resin. The conifers' resin makes it far more combustible than deciduous trees.

[3c] Further from the ice-tundra boundary area, the warming would have caused resin-filled coniferous boreal forests and their soils to heat up and dry out. Once the resin-packed spruce, fir, and pine forests experienced heat and long droughts, wildfires would have been more easily started by lightning strikes and more easily spread by winds. Those wildfires would have sent additional CO_2 into the air. Bared soils would also have lost their long stored carbon.

In recent years, millions around the world have tragically experienced heatwaves, drought, consequential wildfires or indirectly experienced the wildfires as toxic smoke.

[3d] For MIS 11, that atmospheric carbon level, lasting a while, would melt much of Greenland's ice, stream fresh water southward in the seas along both sides of Greenland and empty into the North Atlantic. That fresh water, which was warmer, less dense, less salty, and less prone to sinking than colder North Atlantic salt water, changed periodically the ability of AMOC (Atlantic Meridional Overturning Circulation) to turn over.

In more recent history, since Earth's last ice age ended, Earth's warming appears to have caused the AMOC to also slow or halt several times. This included major warming to be followed by coolings of the Older Dryas around 14,700 ya, the Younger Dryas around 12,900 ya, the Northgrippian Age around 8300 ya, and the Little Ice Age around 600 ya. In 2023 Earth is seeing the **AMOC** affected again.

424,000 ya, the melting of Greenland's ice, along with mountain glaciers, ice sheets near the poles, and the snow over the Antarctic continent, would also raise the levels of the Earth's oceans.

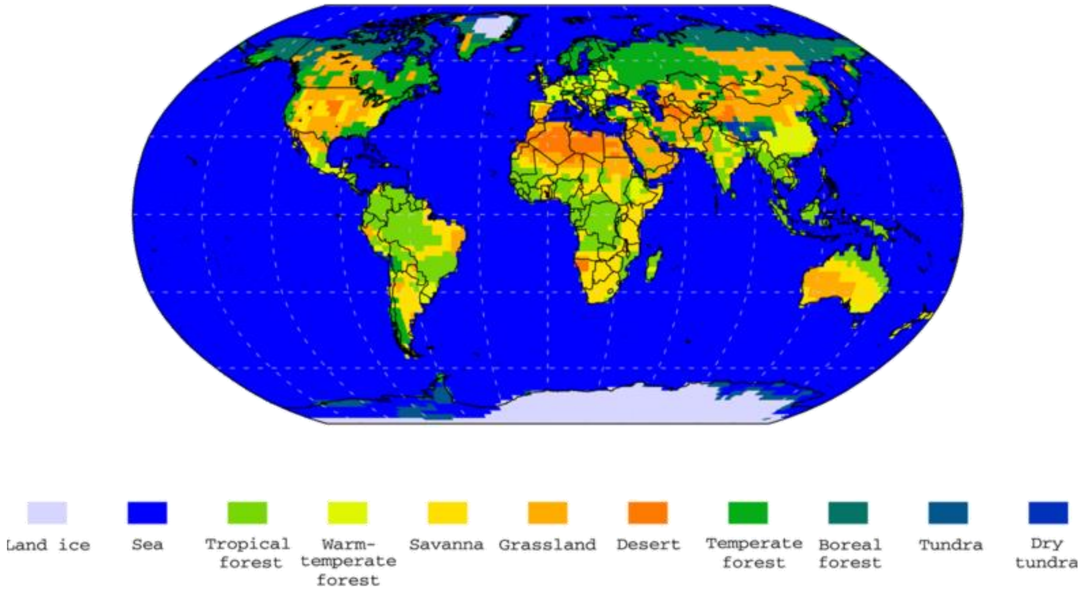
[3e] With the poles being warmer, ocean currents, the El Niño-Southern Oscillation (ENSO), the jet stream, and heat domes were set on unusual paths and had stronger intensities and longer durations. Each successive occurrence would cause the Earth to get even warmer and drier in places and wetter in others. 416,000 ya that warming was everywhere, especially the waters within the North Atlantic, which were periodically affected, then not affected by the AMOC. Currently heatwaves, storms, and floods caused by these climate events are literally affecting everywhere.

[3f] 416,000 ya along the shore, shallow waters around the world would have heated up as they are doing currently, noted recently in Australia, Florida, the Caribbean, Atlantic Canada, and other places worldwide. Those warming waters bleached shore-protecting coral reefs and made rain storms and hurricanes longer in duration and more intense. The storm's floods would have washed the wildfire-exposed soil's accumulated nutrients downstream and out to the bays, affecting vegetation on land and in water.

[3g] Back between 424,000 and 374,000 ya these actions were repeated over and over, moving the tree line further and further north, but also moving the boreal – temperate forest line, and, perhaps more worrisome, the temperate forest - dry land line further north. All these events again accelerated global warming, sharpened those upward curves, and caused animals and plants to adapt, migrate or go extinct.

[3h] The decay of the AMOC also affected the Earth's monsoons, changing their timing, location or their strength.

The graph's zigzags show the effects of these various occurrences. Back 416,000 ya, as a consequence, instead of dipping, the CO_2 highs basically leveled off high as can be seen in the graph.



Pliocene megabiome from Wikimedia Commons

[4] With those melted conditions the megabiome of the 416,000 ya Earth would have resembled the Pliocene megabiome seen here. There would have been far less of an ice cap in the Arctic, and glaciers in higher altitudes would have shrunk or vanished. With global seas between 6 and 13 meters higher, there would have been a direct connection between the Atlantic and the Pacific Oceans. Islands, peninsulas, and coast lines would have changed or disappeared. Far to the north of where they are currently, the microbiome would have had a boreal - temperate tree line. The world would also have had larger swaths of drier lands, such as savannas, grasslands, and deserts. On the map, look for your homes, your far away relatives' homes, and your migrant friends' homelands.



Ending the era included having ground-covering, soil-binding white reflective crustose lichens, white reflective and sun-tolerant deciduous shrubs trees such as alders and birch with betulin, and the well-known sugar maple and yellow birch with their beloved sugar-filled **non-flammable water**. (Credit Norris Whiston)

[5] At the end of the MIS 11 era, finally turning things around for the better were changes for the northern hemisphere in the Earth's orbit away from the sun, its tilt, its wobble, and new reflective snow. Also turning things around were expanding reflective ground cover lichen, carbon-sequestering moss, ferns, and sedges. Forests transformed from flammable coniferous to more fire-resistant and carbon-sequestering birch, aspen, and their collaborative and coevolved species [Youtube Tom Wessels, Antioch U.]. After a time, those forests would become even hardier, mixing with oak, beech, elm, & maple. As they aged, returning to longer-lasting hardwood forests allowed, from May to October, for cooler environments, more atmospheric carbon to be sequestered and increased water recycling to make interior ecosystems further from the shores wetter and more alive. Peter Wohlleben explains trees transpiring water and condensing as rains beyond their locations in "*The Power of Trees*" 65-71.

416,000 ya, the Earth's atmospheric carbon was only between **265 and 280** parts per million unlike this week with carbon being around **420** parts per million. Turning things around has gotten challenging.