

ties did not allow for commercialization. Sanger administrators agreed they would need to gain permission from their partners, according to the emails. But these records also indicate that Sanger was eager to buy the arrays before Thermo Fisher's price guarantee expired at the end of 2018. In October 2017, Sanger and Thermo Fisher went ahead with a press release announcing the commercial launch of the gene chips, and Sanger ordered its chips in December 2017 without permission from all its partners. "The way it was done, we were in breach with ethics and many of these legal agreements," says one whistleblower, who wishes to remain anonymous for fear of retribution in her career. The institute planned to consult with partners and get the required permissions if Thermo Fisher were to publicly sell any of the chips, spokesperson Steve Palmer says.



The Wellcome Sanger Institute ordered 75,000 gene chips without the consent of all its partners.

In March of this year, Stellenbosch University demanded Sanger return about 100 samples donated by the Nama people, as its MTA did not permit commercialization. "This conduct of the Wellcome Sanger Institute raises serious legal and ethical consequences," wrote Vice-Rector Eugene Cloete. The University of KwaZulu-Natal in South Africa, which had gathered DNA from 100 people of Zulu descent, has also expressed concerns.

Ciara Staunton, an expert in the governance of genomic data at Middlesex University in London, says manufacturing and purchasing the chips, even for internal use, is commercial and should be consistent with MTAs and participant consent. "To do otherwise is hugely concerning, and legally and ethically questionable," she says.

Sanger disputes the whistleblower allegations, which were first reported by *The*

Times on 14 October. The institute says intellectual property lawyers who reviewed the whistleblowers' complaint found no breach of contract or infringement of intellectual property. "There was no commercialization of the arrays," Palmer says, adding that the institute never sold the arrays and has not received any payments in connection with them. Ron O'Brien, a spokesperson for Thermo Fisher in Waltham, Massachusetts, also claims the company did not commercialize the array.

The Thermo Fisher chip would have been cheaper than another gene chip created for African populations in 2017 by Illumina, researchers say. Researchers involved in Human Heredity and Health in Africa (H3Africa), a collaboration funded since 2010 by the U.S. National Institutes of Health (NIH) and the Wellcome Trust, have already used the "H3A" chip to screen 60,000 Africans to find gene variants linked to disease. Ambroise Wonkam, a medical geneticist at the University of Cape Town, is using them to study 2000 people with sickle cell anemia to learn about genes that favor survival. "The H3A chip is already helping a lot," he says.

That chip was developed with a different set of African donor DNA. The donors' consent did not restrict commercial use, says de Vries, who chaired the H3Africa ethics committee. She and others worry the Sanger affair could jeopardize the trust the collaboration has built with African institutions and people. "I do not want the fallout to start to have effects on H3Africa," says Charles Rotimi, a member of the H3Africa steering committee and a genetic epidemiologist at NIH's National Human Genome Research Institute in Bethesda, Maryland. "We are just gaining traction with genomics on the African continent."

After the whistleblowers filed their complaint, the Wellcome Trust's subsidiary that oversees Sanger asked an external lawyer to investigate. A summary of the lawyer's report, which Sanger released in October 2018, addressed a separate complaint about alleged bullying by senior Sanger management, concluding that no wrongdoing took place. Regarding the gene chip work, it found there was "no wrongful exploitation of scientific work."

All four whistleblowers have since left Sanger. One says she was fired in June for bringing Sanger "into disrepute" for writing emails to colleagues about the issue. Sanger declined to comment on personnel. The 75,000 gene arrays, stored at Sanger, have not been used and will expire in December. ■

With additional reporting by Sarah Wild.

ANCIENT CLIMATE

Mud in storied ice core hints at a thawed Greenland

Dirty base of Camp Century ice core warns of future ice sheet retreat

By **Paul Voosen**, in Burlington, Vermont

In one of the Cold War's oddest experiments, the United States dug a 300-meter-long military base called Camp Century into the ice of northwest Greenland in the early 1960s, powered it with a nuclear reactor, and set out to test the feasibility of shuttling nuclear missiles beneath the ice. A constant struggle against intruding snow doomed the base, which was abandoned in 1966. But Camp Century has left a lasting, entirely nonmilitary legacy: a 1.3-kilometer-long ice core drilled at the site.

The core, extracted by a team that included glaciologist Chester Langway, yielded a record of past temperatures that helped kick off studies of Earth's ancient climate. And last week, dozens of scientists met here at the University of Vermont (UVM) to take stock of another gift from the core: mud from Greenland's ancient land surface, serendipitously discovered in archived samples. New analyses of the mud suggests Greenland's massive ice sheet was largely absent in a warm period during the past million years when global climate was much like today's. The samples likely have more stories to tell, UVM geochemist Paul Bierman said at the gathering, which he organized to discuss recent results and plan further analyses. "There is a lot of new data, 90% of which seemed to be generated in the last 48 hours."

The Camp Century core was largely forgotten by the mid-1990s, and Langway was eager to retire from the University at Buffalo (UB), part of the State University of New York system. He contacted longtime colleagues in Denmark, asking them to take his ice. Either that, the story goes, or it was going to end up in Lake Erie. Soon enough, 20 crates and two shipping containers full of ice arrived in Copenhagen, says Jørgen Peder Steffensen, a glaciologist at the University of Copenhagen and the curator of



A 9-meter rig in Camp Century's secret ice tunnel drilled a core that is still yielding discoveries.

its ice core repository. “We knew we should hang on to the ice because you never know when it becomes valuable.” But at the time, the Danes were busy with their own drilling, and some of Langway’s boxes were left unopened—and eventually forgotten.

That changed late last year. Steffensen and Dorth Dahl-Jensen, a glaciologist at the University of Copenhagen who has led many large European drilling efforts in Greenland and Antarctica, unearthed 30 glass jars containing the Camp Century core’s bottom 3 meters of sediment. This was a rare haul: Only a few drilling efforts have penetrated Greenland’s ice to the land beneath. The Danes told two leading geochemist detectives about their find: Bierman and Joerg Schaefer at Columbia University.

Both are experts at analyzing the trace amounts of radioactive isotopes created when cosmic rays strike exposed rock and soil, which provide clues to when currently ice-covered terrain was last exposed. Several years ago, the two worked on dirt and rock recovered from the bottom of the GISP2 ice core from central Greenland, where drilling finished in 1993. Schaefer found that the existing ice sheet could not have covered the site at a time

more than 1 million years ago. But that was one pinprick in a vast ice sheet. So, the researchers couldn’t believe their luck when they visited Copenhagen this spring to see the Camp Century “cookie jars,” as Steffensen calls them. What they held could double existing knowledge. “It would cost tens of millions of dollars to get a sample like this,” Bierman says.



Dirt from the core’s base was once exposed at the surface.

He and his colleagues set out to tease every bit of information they could from the recovered dirt. Some 800 grams of samples, representing the top and bottom of the muddy layer, arrived at Bierman’s lab in the middle of July. Drew Christ, a geochemist in the lab who prepared the samples, says when the jars were opened, the room grew pungent with a smell from more than 60 years ago: the diesel fuel that was pumped

into the hole to keep it open.

Christ sent thawed samples to the lab of Eric Steig, a glaciologist at the University of Washington in Seattle, who measured ratios of oxygen isotopes to tease out past temperature. He also sent pieces of frozen muck to Tammy Rittenour, a geologist at Utah State University in Logan who specializes in luminescence dating: blasting rocks with light to

dislodge electrons that record when the rocks were last exposed to sunlight. The early results suggested the site may have been free of ice as recently as 400,000 years ago, she says, during a warm period between ice ages.

A day before last week’s meeting, Bierman’s group got results on cosmic ray isotopes that point to a similar conclusion. His group measures and compares two radioactive isotopes, aluminum-26 and beryllium-10. The aluminum isotope forms seven times as fast as the beryllium, and, once cut off from the surface by ice, decays twice as fast; the declining ratio between the two isotopes serves as clock.

Bierman expected Greenland’s cold northern part—where Camp Century was located—would have been a stronghold of ice for millions of years, perhaps since the beginning of the Pleistocene 2.6 million years ago, when a gradually cooling Earth tipped into its current cycles of ice ages. Instead, the clock suggested ice has covered Camp Century for at most 1 million years—matching the GISP2 results. “It could be less, but a million years is the maximum,” Bierman says. “So you can’t argue for full Pleistocene stability at either site.”

“Camp Century is sort of a litmus test,” Steffensen adds. If you can say it was ice free, “that actually points at a severely reduced Greenland Ice Sheet.” Sea level would have been many meters higher than today, even though the climate 1 million years ago was similar to today’s greenhouse-warmed climate. “This stuff is really scary,” Schaefer says.

Bierman adds that it is also very preliminary. Evidence from marine cores and elsewhere also suggests a large fraction of the ice sheet disappeared 400,000 years ago. And DNA found at the bottom of several ice cores is from plants that would have thrived at summer temperatures of 10°C—although its age is uncertain. Yet in what may be a contradictory finding, ice at the bottom of a different ice core, called GRIP, has been dated at 1 million years old. “The old data and the new data seem to support each other in being difficult,” Dahl-Jensen says.

There is one scenario that could match the conflicting evidence, says Jason Briner, a geologist at UB. “Maybe the Greenland Ice Sheet vanished and reformed many times until 1 million years ago.”

The 28 cookie jars left from the Camp Century mud likely hold more secrets. Scientists are hunting through microfossils, leaf wax, mineral types, noble gases, and much more to answer questions about what Greenland’s ancient landscape looked like when it was last exposed. But they must choose their targets wisely, Bierman says. “There’s less of this stuff than there is Moon rocks.” ■

Science

Mud in storied ice core hints at a thawed Greenland

Paul Voosen

Science **366** (6465), 556-557.
DOI: 10.1126/science.366.6465.556

ARTICLE TOOLS

<http://science.sciencemag.org/content/366/6465/556>

PERMISSIONS

<http://www.sciencemag.org/help/reprints-and-permissions>

Use of this article is subject to the [Terms of Service](#)

Science (print ISSN 0036-8075; online ISSN 1095-9203) is published by the American Association for the Advancement of Science, 1200 New York Avenue NW, Washington, DC 20005. The title *Science* is a registered trademark of AAAS.

Copyright © 2019 The Authors, some rights reserved; exclusive licensee American Association for the Advancement of Science. No claim to original U.S. Government Works