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# LURKING IN THE DEEP FREEZE?

Climate change may release dangerous pathogens frozen for centuries in Arctic permafrost

By **Jon Cohen**

In 1733, an Inuit boy and girl who had been sent to Denmark for the king's coronation 2 years earlier sailed back home to Greenland. Both were in a “sickly state of health” during the trip, according to an account written a few decades later by a missionary, and the girl died on the way. Shortly after reaching his native land that September, the boy also died, of “a cutaneous disorder.” He had brought smallpox with him, and the disease raced around the island, killing Inuits and Europeans alike. Another missionary wrote of “houses tenanted only by the corpses of their former occupants, and dead bodies lying unburied on the snow.” The outbreak lasted until at least June of the next year, killing maybe half of Greenland’s already sparse population.

In the summer of 2022, a team of research-

ers visited Greenland to take soil samples from heaps of human and animal waste, or middens, dating from the smallpox epidemic and before. Their goal is to assess the risk that, as the Arctic warms and the permafrost thaws, long-frozen soil could release dangerous pathogens. Such “zombie viruses” are fodder for Hollywood, but they are not science fiction. Temperatures in the Arctic are rising twice as fast as in the rest of the world. And viable pathogens are clearly lurking in the soil, says Marion Koopmans, a virologist at the Erasmus Medical Center who runs a European consortium dubbed the Versatile Emerging infectious disease Observatory (VEO) that’s studying how northern-latitude warming might influence infectious diseases (see related story, p. 1402). “What you see

now is studies that find infectious viruses from permafrost.”

The odds are low that smallpox or anything comparably dangerous will spring from the soil after centuries in the deep freeze, says veterinary microbiologist Frank Aarestrup, who heads the VEO project with Koopmans and whose lab at the Technical University of Denmark has been screening the midden samples for DNA. “But it’s better that we should investigate it now rather than after something has been released.” Yet some scientists do worry that the effort itself could unleash a human pathogen.

Researchers from Aix-Marseille University were the first to isolate viruses from ancient permafrost, reporting in 2014 and 2015 that

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When archaeologists excavate waste piles, or middens, left centuries ago by Norse settlers on Greenland (left), microbiologists retrieve soil samples, which they store and later analyze for pathogens (right).

samples of Siberian soil frozen for 30,000 years harbored two large DNA viruses that could infect amoebae but posed no threat to humans. In the 18 February issue of *Virus*, the same team, led by genomicist Jean-Michel Claverie and materials scientist Chantal Abergel, revealed 13 more permafrost megaviruses that infect amoebae, one dating back 48,500 years.

A more alarming pathogen may have already emerged naturally from frozen ground. In the unusually hot summer of 2016, *Bacillus anthracis*, a bacterium that lurks in soil worldwide and causes anthrax, killed 2649 reindeer in Siberia. It also sickened 36 people, including a 12-year-old boy who died. But linking the outbreak and climate change is not easy, as archaeologist Alexander Volkovitskiy from the Russian Academy of Sciences noted at an international workshop on microbial threats in the Arctic held in 2019. More than a century ago, anthrax outbreaks repeatedly killed Siberian reindeer, which led the Soviet Union to begin to vaccinate the animals in 1930. The elimination of cases led the Russian government to end the vaccination program in 2007, which could have helped set the stage for the 2016 outbreak.

The Ukraine war has ended outside col-

laborations in Siberia, which holds much of the world's permafrost, making VEO's work in Greenland more important. "Permafrost in the rest of the Arctic is a substitute, and all studies and investments in this are valuable," says Birgitta Evengård, an infectious disease specialist at Umeå University who specializes in Arctic health.

The VEO team collected 360 soil samples during its visit in the summer of 2022, concentrating on the middens, where waste sometimes reached 3 meters in height. "They're kind of hot spots," Aarestrup says. The group's studies to date have found several bacteria from the genus *Clostridium*, including ones that cause food poisoning, toxic shock, and botulism. Many samples are still being analyzed.

The researchers take precautions to avoid infection. In the field, they wear protective gear and only visit sites where archaeologists are already taking samples. "We cannot say that nothing is going to be released [from the permafrost], but it should not be because of us," Aarestrup said. In the lab, the samples are studied under sterile conditions with strict biosafety protocols.

Claverie isn't reassured. He hopes the VEO researchers do not attempt to revive pathogens that might have the potential to cause

outbreaks in humans. Claverie says he chose to focus on viruses that infect amoebae for safety reasons, "thinking that 2 billion years of diverging evolution is a much better barrier against human accidental infection than the walls and safety protocols." Aarestrup and Koopmans note that they chemically treat samples to kill any organisms before studying them. "We are collecting a relatively small number of samples, by people who understand possible risks," Koopmans says.

There are also worries that permafrost pathogens could infect livestock—and then spill over into humans. The Norse brought sheep when they settled the island around 1000 C.E., but both the animals and the Norse were gone by 1450. "With climate change, Greenland expects to start having sheep farming again," Aarestrup says. "As a vet, this is something that you immediately start getting concerned about because this potentially is bringing a completely immune-naïve population of animals into an area."

If the VEO team does find dangerous pathogens, Greenland could close certain areas to tourists and stop archaeological excavations, Aarestrup says. "I don't think something will happen, but I do think that it's good to be prepared for it," he says. "You should never say never." ■



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