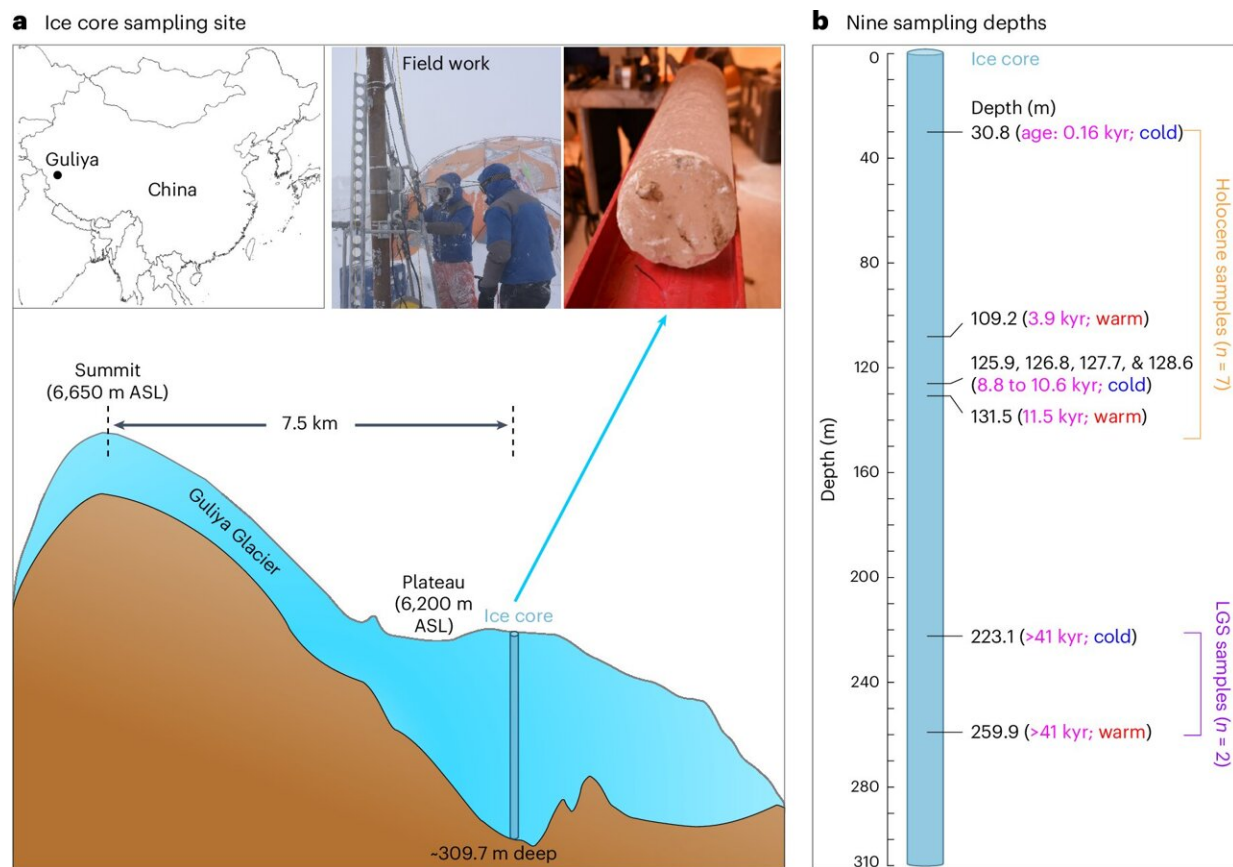


Ancient viral genomes preserved in glaciers reveal climate history—and how viruses adapt to climate change

September 1 2024, by Zhi-Ping Zhong, Ellen Mosley-Thompson, Lonnie Thompson, Matthew Sullivan and Virginia Rich



Glacier ice sampling. Credit: *Nature Geoscience* (2024). DOI: 10.1038/s41561-024-01508-z

As humans alter the planet's climate and ecosystems, scientists are looking to Earth's history to help predict what may unfold from climate change. To this end, massive ice structures like glaciers serve as nature's freezers, archiving detailed records of past climates and ecosystems—including viruses.

We are a team of [microbiologists and paleoclimatologists](#) that studies ancient microorganisms, including viruses preserved within glacier ice. Along with our colleagues [Lonnie Thompson](#), [Virginia Rich](#) and other researchers at the [Ice Core Paleoclimatology group](#) at The Ohio State University, we investigate interactions between viruses and their environment archived in ice cores from the [Guliya Glacier on the Tibetan Plateau](#).

By linking the genomes of ancient viral communities to specific climate conditions preserved in glacier ice, our newly published research offers insights into how these [viruses have adapted to Earth's shifting climate](#) over the past 41,000 years.

Reading history in viral genes

We primarily [used metagenomes](#)—collections of genomes that capture the total genetic content of all microorganisms present in environmental samples—to reconstruct viral genomes from nine distinct time intervals within the Guliya ice core. These time horizons span three major cold-to-warm cycles, providing a unique opportunity to observe how viral communities have changed in response to different climatic conditions.

Through our analyses, we recovered the genomes of the [equivalent of 1,705 virus species](#), expanding known glacier-preserved ancient viruses more than 50-fold.

[Only about one-fourth](#) of the viral species we found shared species-level

similarities with any of the viruses identified in nearly 1,000 metagenomes previously captured in global datasets. Most of these overlapping species were also from the Tibetan Plateau.

This suggests that at least some viruses preserved in the Guliya Glacier originated locally in the region, but it also spoke to the relative lack of glacial viruses in available databases.

Using these new reference genomes, we attempted to "read" their stories.

One key finding was that [viral communities varied significantly](#) between cold and warm climatic periods. The most distinct community of viral species on the glacier appeared about 11,500 years ago, coinciding with the major transition from the Last Glacial Stage to the Holocene.

This suggests that the unique climate conditions during cold and warm periods profoundly influenced the composition of viral communities. We hypothesize that these influences were likely due to viruses from other places being blown in by changing wind patterns and subject to selection pressures from changing temperatures on the glacier.

Digging deeper, we next determined how viruses interacted with their hosts. To do this, we used computer models to compare viral genomes with the genomes of other microbes also found in this environment. We found that viruses [consistently infected Flavobacterium](#), a lineage of bacteria commonly found in glacier environments.

We also learned that viruses on the Guliya Glacier must "steal" genes from their hosts to manipulate their metabolisms. Encoded within the viral genomes were 50 auxiliary metabolic genes related to metabolism, including the synthesis and breakdown of vitamins, amino acids and carbohydrates. Some of these genes were abundant across all nine time intervals studied, suggesting that they help microbial hosts cope with the

harsh conditions on glacier surfaces and thereby improve viral fitness.

Thus, viruses not only infect and kill cells, but they likely also alter the fitness of their hosts during infection, in turn influencing their capacity to survive in the extreme conditions of glacier environments.

Climate change over time

Our findings offer a novel perspective on how life, in the form of viruses, has responded to climatic changes over tens of thousands of years.

Understanding these ancient interactions provides a unique opportunity for future research in both virology and climate science. By studying how ancient viruses responded to past climate changes, researchers can gain valuable insights into how viruses adapt to ongoing global climate change.

We believe that glacier ice, by capturing information on microorganisms and their ecosystems over time in each layer, remains a critical resource for unraveling the history of Earth's climate and the life it has supported—especially as [glacier ice](#) reserves rapidly diminish.

More information: Zhi-Ping Zhong et al, Glacier-preserved Tibetan Plateau viral community probably linked to warm–cold climate variations, *Nature Geoscience* (2024). [DOI: 10.1038/s41561-024-01508-z](#)

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