Editorial

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Melting ice core archives

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Urgent efforts are needed to collect and preserve ice cores from mountain glaciers before these archives are lost.

Layers of ice within mountain glaciers dating back hundreds to thousands of years represent a rich historical archive for palaeoclimatologists. Proxies abound for reconstructing environmental change from these layers, from water isotopes that track temperature and precipitation shifts to a myriad of trapped gases and particles that reflect factors like the chemical makeup of the atmosphere. Although not as continuous or as old as records cored from polar ice sheets, the wide geographic spread of mountain glaciers, including in the tropics, make them especially useful. Precise correlation of ice core records has constrained global climate patterns extending back to the last glacial period tens of thousands of years ago, providing an invaluable baseline for understanding the modern Earth system.

The survival of these icy archives is, however, far from guaranteed. Ongoing anthropogenic climate warming is especially acute at high elevation and is increasingly destabilizing mountain glacier systems. Ice core collection from these dwindling mountain glacier archives and their careful storage need to be prioritized before these precious archives are degraded or lost entirely.

The growth and decay of glaciers largely represents a balance between precipitation – both rain and snow – and temperature. Careful assessment of the net influence of these factors on mountain glaciers is key to understanding how they might fare in the future. As highlighted previously in *Nature Geoscience* by Yulan Zhang and Schichang Kang, recent climatic changes are causing pervasive melting across the Tibetan Plateau, a region that contains most of the world's lower latitude glaciers[1]. Ice loss is focused in lower elevation areas with high snow accumulation rates, which are the most suitable for coring efforts due to the continuity and detail of their ice records. Cores from the Tibetan Plateau region only started to be collected in the late 1980s and are crucial to understanding how these glacial systems will respond to future climate perturbations. Researchers will have to increasingly shift coring activities to more dangerous higher elevations, where generally thinner ice cover will mean shorter and more complex core records.

Melting can also have detrimental effects on the fidelity of ice cores long before a glacier disappears. Ice cores contain a record of atmospheric aerosols – particles sourced from forest fires, pollution, and dust – that track the anthropogenic impacts on ecosystems and are difficult to measure in other archives like speleothems or lake sediments. In a Brief Communication in this issue of *Nature Geoscience*, Margit Schwikowski and colleagues show how just two years of warming has made the reconstruction of atmospheric aerosols from a Swiss glacier core untenable. They find that a large portion of aerosols have been removed from the upper part of the core, either washing away in surface runoff or migrating deeper into the glacial ice and contaminating the older record. The loss of relatively modern aerosols from the ice core means it is difficult to assess how well the sampled ice represents aerosols in the atmosphere, which in turn makes reconstruction of the past uncertain. Some proxy systems are less sensitive to melting, such as water isotopes, but melting is limiting the scientific potential of ice cores.

Dedicated efforts are underway to core the world's most vulnerable mountain glaciers. For instance, ice cores were collected a decade ago from the rapidly retreating glaciers of Papua New Guinea[2]. Although these ice records extend back only to the mid-twentieth century, these are the only ice core records detailing climate variability in the equatorial western Pacific. These glaciers will likely not persist much longer, but the collected cores will persist in lab freezers. Elsewhere in the tropics, initiatives like the Ice Memory Foundation are helping to coordinate international efforts to collect ice cores from the world's most vulnerable glaciers.

Continuing funding of ice coring efforts as well as the repositories that can indefinitely store the collected ice – often at considerable cost – and make it available for research will be critical in the next few decades as mountain glacier melting accelerates. Where damage to glacial ice records has already been done, there is some promise that reliable past climate information can still be measured from unconsolidated snow patches; the likely fate of many current glaciers[3]. New analytical techniques that allow for the extraction of new or more detailed information from old cores will also help extend the scientific potential of the ice cores we are able to harvest. With time running short, we need to save what ice we can to continue to unravel the stories trapped within it.

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References

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