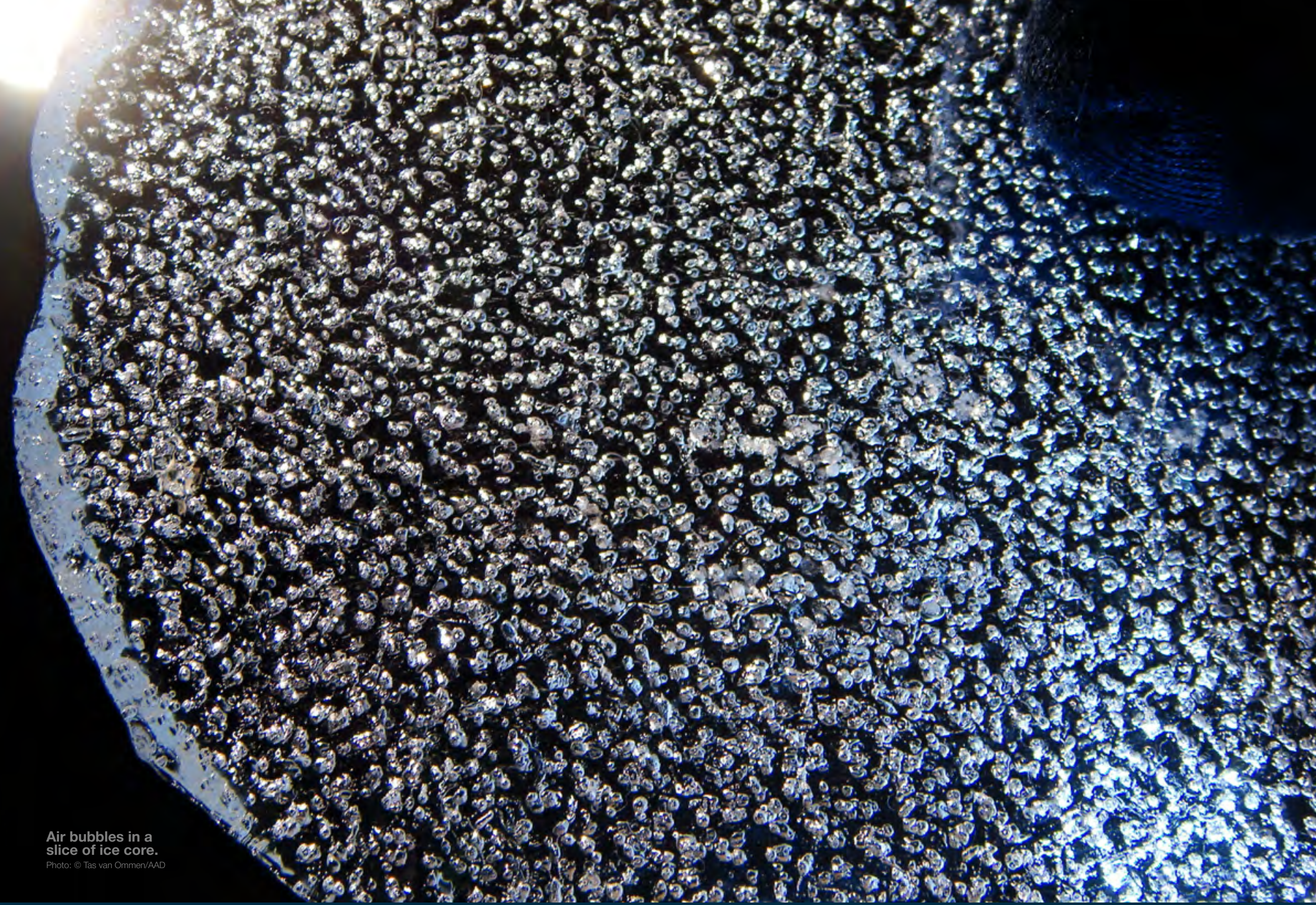

Air bubbles in a slice of ice core.
Photo: © Tas van Ommen/AAD

THE MEMORY OF ICE

WHY WE ARE HUNTING FOR ICE OVER A MILLION YEARS OLD

APRIL 2026

Earth has natural climate archives that preserve information about past environments, including tree rings, cave deposits, corals, ocean sediments – and ice cores. Ice cores are cylinders of ice drilled from deep in polar ice sheets and glaciers. Although difficult to get, ice cores are among the most useful and highest-quality climate recorders.

Falling snowflakes trap dust and trace chemicals from the atmosphere. As snow gets buried and compressed, it forms layers of solid ice with trapped air bubbles. The layers correspond to years and seasons past, with the youngest ice at the top and the oldest ice at the bottom of the core.

With their archive of entombed air bubbles, particles, and trace chemicals, ice cores are a powerful tool to determine how the Earth's climate has varied in the past. When accurately dated, this information provides a long-term context for modern climate change and a testbed for climate models.

AAPP Australian Antarctic Program Partnership

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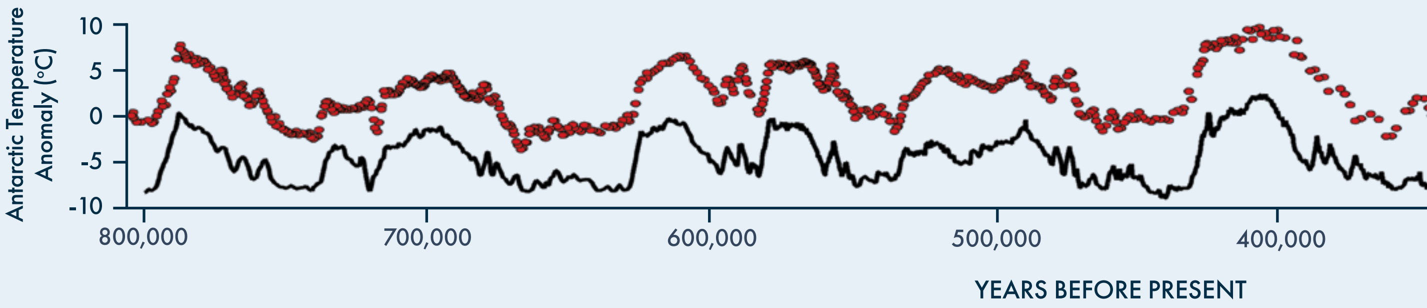
Existing ice core records show a close coupling of atmospheric carbon dioxide concentration (CO_2 in red) and temperature (in black) over the last 800,000 years.



The Australian-led Law Dome ice core and atmospheric monitoring stations capture and verify the steep rise in CO_2 since the Industrial Revolution, which is driving current increases in global mean surface temperature (also shown).

The oldest ice on the planet is found in East Antarctica where the ice sheet has persisted for millions of years. The oldest continuous ice core goes back 800,000 years and was drilled by a European consortium at Dome Concordia. This timespan offers views across eight glacial cycles (ice ages) and a clear picture of abrupt changes that occurred during the last ice age.

However, between 1.2 million and 800,000 years ago, something in Earth's climate system shifted.

The global climate was pushed into a new regime where the ice ages became longer, and the Northern Hemisphere ice sheets became larger. The shift is called the "Mid-Pleistocene Transition" (or MPT for short). The MPT marks a shift from ice ages with around 40,000-year durations to ice ages with 100,000-year durations. The cause of the MPT is a vexing and long-standing problem in paleo-climate studies, partly because it's just out of view from the 800,000-year-old ice core.

Old ice holds a memory of the ancient atmosphere. The Million Year Ice Core Dome C North borehole will eventually extend over three kilometres deep beneath the ice sheet to the Antarctic bedrock. Photo: © Joel Pedro/AAD

We're hunting for an ice core extending well beyond one-million-years-old to unravel the secrets of the MPT. This oldest continuous ice record will enable us to infer from past interglacial conditions what might happen in the future, as the world warms, and the implications for climate, sea-level rise, and ice-sheet stability.

Why do we care about past climate?

Compared to Earth's full history, the length of time where we have direct measurements of climate is extraordinarily short. For example, we only have direct measurements of carbon dioxide (CO_2) in the atmosphere since 1958. Since then, CO_2 concentration has risen by 37%, from 315 parts per million (ppm) to nearly 430 ppm (as of April 2026). This is useful for looking at recent changes, but we need to understand if that rise in CO_2 is abnormal in the context of Earth's past. Were there times in the past when CO_2 was this high? Is CO_2 concentration normally stable, or does it rise and fall naturally? And why?

To answer these questions, we can 'reconstruct' past climate from the atmospheric 'time capsules' in ice cores. These reconstructions allow scientists to study examples of climate change before humans had any influence. This allows us to characterise baseline conditions that existed before the intensification of fossil fuel combustion during the Industrial Revolution.

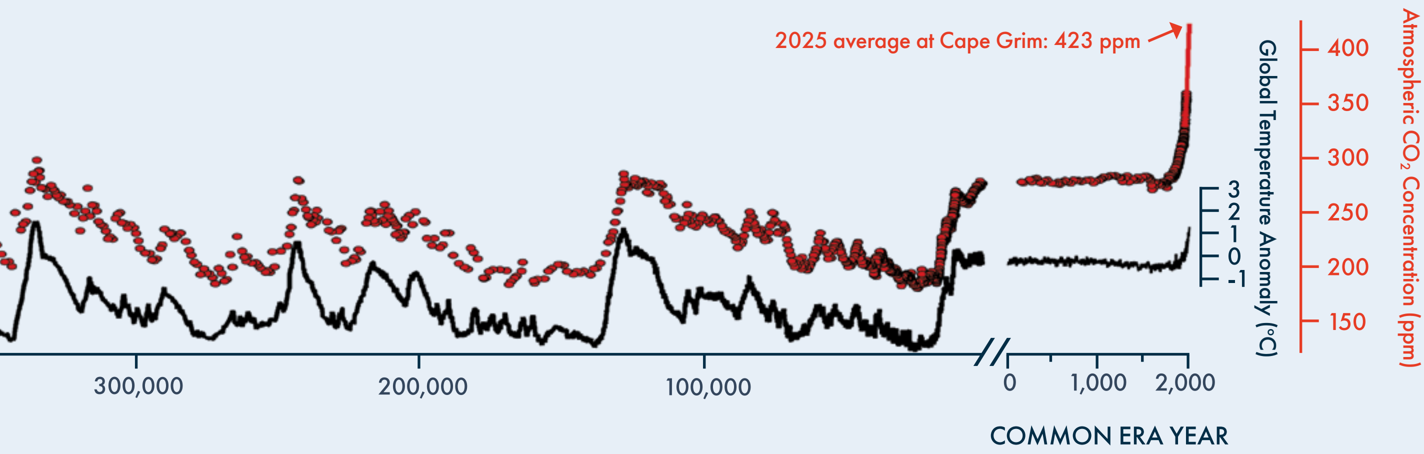
Ice cores also capture natural changes in climate that occurred in the past, like the transitions between ice ages and warm periods. These transitions offer valuable examples of climate change that provide insights into the current changing climate.

Understanding the processes that drive climate change is crucial for building good models that predict future trends. It is also key to unravelling how much humans are contributing to modern global warming, relative to natural processes.

Extending the ice core record to over one million years ago will make it possible to study what caused the Mid-Pleistocene Transition and help validate climate and earth system models in different background states.

How do we collect a Million Year Ice Core?

Million-year-old ice exists very deep in the Antarctic ice sheet. Getting a core involves overcoming significant logistical challenges. The Million Year Ice Core (MYIC) project, led by the Australian Antarctic Program, is drilling an ice core to 3,000 metres depth in three-metre segments, and returning the cores in pristine condition to Hobart, Tasmania.



Data Sources: Bereiter et al., 2015; Parrenin et al., 2013; Rubino et al. 2019; CSIRO/Australian Bureau of Meteorology Kennaook/Cape Grim Baseline Air Pollution Station, Neukom et al. 2019, PAGES2k Consortium 2017, www.berkeleyearth.org (figure: Andy Menking)

MYIC Dome C North drill camp in November 2025. Photo: © Damien Beloin/AAD

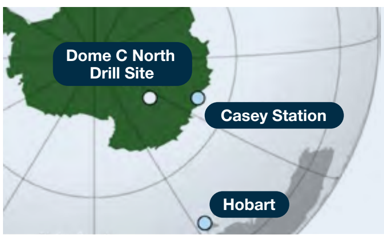
To do this, the Australian Antarctic Program has developed new tractor-traverse capabilities to tow equipment 1200 km from Casey station to the drill site, and adopted new drilling technology. The project has also invested in the design and manufacture of specialised insulated boxes to keep cores frozen during transport.

Scientists have worked both domestically and internationally to select the optimal site where there is a high chance for recovery of old ice – at Dome C North. In the summer of 2024-25, the MYIC team established a deep-field camp at the site. The field camp includes the drilling infrastructure, accommodation for researchers and traverse staff, and storage for equipment and ice cores.

Drilling operations commenced in early 2025 with the successful extraction of the first 150 metres of ice, and widening of the borehole, ready for installing a casing. Deep drilling commenced in the 2025-26 season and reached 400m depth at the end of that season.

Due to the extreme cold and remoteness of the Antarctic plateau, drilling can only continue during the Antarctic summer from late November to January. The team expects to reach bedrock in the 2028-29 season.

Australia is not alone in hunting for the oldest ice. Other efforts include the European Beyond EPICA Oldest Ice project, the Japanese Third Dome Fuji Project and the American Center for Oldest Ice Exploration.



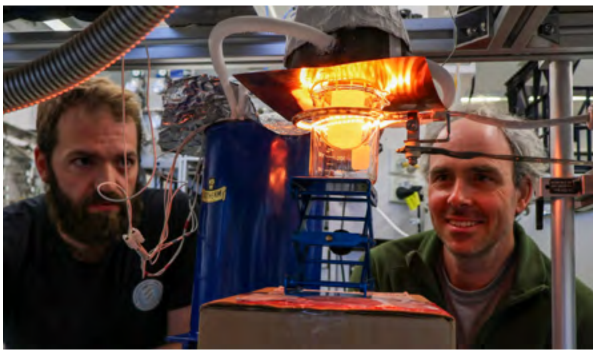
Location of MYIC Dome C North drill site, 1200km inland of Casey station

There are also similar projects proposed by the Chinese, Korean, and Russian Antarctic research programs. Multiple records are important to replicate and verify the climate and atmospheric records from the very oldest ice.

There are places in Antarctica with non-continuous layers of ice that are several million years old. These give useful complementary data that are snapshots of past climate, but are difficult to date and do not provide the time-continuous record that our three-kilometre ice core is targeting.

What will we measure?

There has been significant investment by the Australian Antarctic Program to improve laboratory capabilities in advance of obtaining the Million Year Ice Core. The core laboratory is operated as a partnership between the Australian Antarctic Division (the Department of Climate Change, Energy, the Environment and Water) and the University of Tasmania. It specialises in ice core analysis, using instruments that measure different chemical components in the ice. This state-of-the-art lab, supported by the Australian Antarctic Program Partnership, is one of only a few of its kind in the world.



Ice core gas lab. Extracting gas from air bubbles by sublimation, whereby ice is turned directly into vapour without melting. Photo: © Mark Horstman/AAPP

Expected data products include high-resolution greenhouse gas records, climate-sensitive indicators such as water isotopes, and chemical composition of the ice including major ions, trace elements, and dust particles.

The full suite of data products will allow us to study the role of greenhouse gases in forcing the Mid-Pleistocene Transition (MPT), as well as changes in Antarctic climate, the atmosphere, and biogeochemical cycles in the 40,000-year versus 100,000-year worlds.

Ice core in drill.
Photo: © Joel Pedro/AAD

What will a Million Year Ice Core tell us?

The Million Year Ice Core will provide key information about Antarctica, global climate, and the stability of ice sheets and global sea level, beyond the window viewable with existing ice cores. The MYIC will:

- **Improve** our understanding of the natural climate variability that led to our current climate state.
- **Enable** better assessment of the likely course our climate will take in the next few centuries to millennia in the absence of human interference.
- **Quantify** numerous examples of the natural (pre-Industrial Revolution) relationship between greenhouse gases and climate, allowing us to deduce the underlying physical rules.
- **Resolve** key questions about the timescales and processes that control the exchange of carbon dioxide (including excess CO_2 from human activities) between ocean, land, and atmosphere reservoirs.

A 1.5-million-year ice core record will shed new light on the remaining uncertainties in understanding the ice ages – namely, how and why glacial cycles end, the role of ice sheet instability, and the relationship between climate and the carbon cycle.

Australia's effort is one of several to get a continuous ice core through the MPT. The international ice core community has long recognised that we need more than one record to extract the best information and confirm results.

Loading ice cores, 2026. Photo: © Joel Pedro/AAD

To be cited as: Menking, A., Baggenstos, D., Pedro, J. and Horstman, M. (2026) **The memory of ice: Why we are hunting for ice over a million years old.** Antarctic Program Partnership and Australian Antarctic Division, Hobart Australia

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