

The Ice That Remembers

Two miles down, the snow that fell on a forgotten winter is still holding its breath.

7 min read

Before you read

- **core** — a long cylinder of material drilled out from below the surface
- **proxy** — something measured in place of what you actually want to know
- **isotope** — a form of an element that is slightly heavier or lighter than usual
- **compaction** — the squeezing of a material into a denser form under weight
- **stratified** — arranged in distinct layers, one on top of another
- **resolution** — the level of fine detail a record is able to show
- **abrupt** — happening suddenly, over a very short period
- **calibrate** — to check a measurement against something already known to be accurate



A core section is lifted from the drill barrel — snow that fell before the pyramids were built

¹ The Greenland ice sheet is, in places, more than three kilometres thick. It looks like a desert of white, featureless and still. It is in fact one of the most detailed historical archives on Earth, and it has been writing itself, without interruption, for longer than our species has farmed.

² The principle is simple enough to explain in a sentence, which is part of why it took so long to be taken seriously. Snow falls. More snow falls on top of it. The weight of everything above squeezes the layers below into ice, and because the ice sheet never fully melts, nothing is erased. Drill down, and you are

drilling backwards through time.

Reading a layer

³ A fresh core comes out of the barrel as a cylinder about ten centimetres across, cloudy near the top and startlingly clear further down, where compaction has driven out the air spaces. Held against a light board, the upper sections are visibly stratified: summer snow is coarse-grained and scatters light, winter snow is finer and darker. Counting those pairs is, near the surface, as straightforward as counting the rings of a tree.

⁴ It does not stay that straightforward. The deeper the ice, the more the weight above has thinned each layer, until a single year occupies less than a millimetre and the eye is useless. From that point, the layers are counted chemically rather than visually, and the record loses resolution — a core that can distinguish individual seasons at the top may only distinguish decades at the bottom.

What the ice is a proxy for

⁵ Nobody drilling in Greenland is primarily interested in the ice. They are interested in what the ice is a proxy for. Water molecules containing the heavier isotope of oxygen evaporate slightly less readily and condense slightly more readily than ordinary ones, and how strongly that difference shows up depends on temperature. Measure the ratio of heavy to light oxygen in a sample of ancient ice, and you have a thermometer reading from a year when nobody was holding a thermometer.

⁶ The air is better still. As snow compacts, it traps bubbles of the atmosphere that surrounded it. Those bubbles are not a proxy for anything; they are the sample itself, sealed and dated. A laboratory can crush a fragment of hundred-thousand-year-old ice and measure directly how much carbon dioxide the air of that year contained. There is no comparable archive for any other part of the climate system.

⁷ Dust, ash and sulphate complete the picture. A volcanic eruption large enough to put sulphur into the upper atmosphere leaves a thin acidic line in ice sheets on both sides of the planet. Where that eruption also appears in a written record — a Roman account of a dimmed sun, a Chinese court diary noting a failed harvest — the two can be matched, and the ice chronology can be calibrated against human history.

The uncomfortable finding

⁸ For most of the twentieth century, climate was assumed to change the way continents move: steadily, over thousands of years, far too slowly for any one generation to notice. The Greenland cores dismantled that assumption. Running up through the last glacial period, researchers found temperature swings so steep that they could not at first be believed — warmings of several degrees that appear to have taken a decade or two, not a millennium.

⁹ The first reaction was to suspect the equipment. The second was to drill a second core, hundreds of kilometres away, and check whether the same jumps appeared at the same depths. They did. The abruptness was in the climate, not in the instruments.

¹⁰ This is the quiet reason ice coring attracts the funding it does. A record that only told us what the past was like would be interesting. A record that tells us how fast the past was capable of changing is something else: it sets the speed limit we are entitled to assume for the future, and the cores suggest that limit is far higher than anyone expected.

¹¹ There is a deadline on the work. The oldest ice sits at the bottom, where the sheet is warmest and where meltwater can smear the layers into each other, and the surface layers of smaller glaciers are already melting and refreezing in ways that scramble the record. The archive is being edited while it is being read.

Part A Choose the best answer

Circle the letter next to the right answer.

1. Why does the ice sheet preserve a continuous record?

- A Because snow falls there in every season
- B Because it never fully melts, so earlier layers are not erased
- C Because the ice is clearer at depth than at the surface
- D Because volcanic ash seals each layer in turn

2. According to the passage, what happens to the record as depth increases?

- A It becomes more detailed because the ice is clearer
- B It stops entirely below three kilometres
- C It loses resolution, because the weight above thins each layer
- D It can no longer be dated by any method

3. Which of these does the writer say is NOT a proxy?

- A The ratio of oxygen isotopes
- B The grain size of summer and winter snow
- C The air trapped in bubbles
- D The thickness of a single annual layer

4. Why are volcanic sulphate layers useful to researchers?

- A They show how warm a particular year was
- B They can be matched to dated human records, calibrating the chronology
- C They prevent meltwater from smearing the layers
- D They mark the boundary between glacial and warm periods

5. What does the writer mean by saying the archive 'is being edited while it is being read'?

- A Researchers disagree about how the data should be interpreted
- B Earlier findings have had to be withdrawn and corrected
- C Melting is degrading the record at the same time as it is being studied
- D Drilling destroys each core once it has been measured

Part B Write your answer

Answer in two or three sentences, using the passage as your evidence.

6. Explain, in your own words, how a ratio of oxygen isotopes can act as a thermometer for a year nobody measured.

7. The writer says the principle behind ice coring is 'simple enough to explain in a sentence, which is part of why it took so long to be taken seriously.' What is being suggested about how new scientific ideas are received?

8. Researchers responded to the surprising temperature swings by drilling a second core hundreds of kilometres away. Explain why that was the right response.

9. Why does the writer argue that knowing how **fast** climate has changed matters more than knowing what past climate was like?

Part C Think deeper

There is no single right answer here. Say what you think, and say why.

- 10. The passage says the cores 'set the speed limit we are entitled to assume for the future'. How far can a record of the past reasonably be used to predict what is possible next? Give one reason for and one reason against.**

- 11. Ice-core research is expensive, slow and carried out in conditions that are difficult and costly to sustain. Make the strongest case you can for continuing to fund it, then state the strongest objection you can think of to your own case.**

- 12. The researchers' first reaction to an unexpected result was to suspect the equipment. Is that scepticism a strength or a weakness in a researcher? Use the passage, and an example of your own, to support your view.**

Answer key

For parents and teachers

Part A

1. **B** — Because it never fully melts, so earlier layers are not erased | 2. **C** — It loses resolution, because the weight above thins each layer | 3. **C** — The air trapped in bubbles | 4. **B** — They can be matched to dated human records, calibrating the chronology | 5. **C** — Melting is degrading the record at the same time as it is being studied

Part B

6. Water containing heavy oxygen evaporates less readily and condenses more readily than ordinary water, and the size of that difference depends on temperature. Measuring the ratio preserved in the ice therefore reveals the temperature when the snow fell. Accept any answer that connects the isotope ratio to temperature through evaporation or condensation; do not require both.

7. That a simple-sounding idea can be underestimated, or dismissed as too obvious or too crude to be reliable. Accept answers noting that science resists claims that seem too easy, or that simplicity is mistaken for a lack of rigour.

8. A single core cannot distinguish a real climate signal from a fault in one drill site or one set of instruments. Finding the same jumps at the same depths in a distant core rules out local error — the result is independently replicated. Credit any answer reaching the idea of checking or replication, even without the term.

9. Because the rate of change, not the absolute temperature, is what determines whether systems — ecosystems, agriculture, societies — have time to adapt. The cores show change can be far faster than was assumed, which raises what we must plan for. Accept answers that get to speed as the thing that determines risk.

Part C

These answers vary. Mark the reasoning, not the answer.

10. A strong answer handles both directions: the past is the only direct evidence we have of what the climate system can do, but conditions today (atmospheric composition, land use, population) differ from any past period, so past behaviour sets a floor on what is possible rather than a forecast. Weak answers assert that the past either does or does not predict the future without engaging with the limits of the comparison.

11. The skill under test is self-criticism. The case for: no other archive provides directly sampled ancient atmosphere, and the record is being destroyed. The objection should be genuine — opportunity cost against other research, or the diminishing return of further cores. Mark down answers whose 'objection' is weak on purpose.

12. Either position can earn full credit. Strength: scepticism prevents instrument error from entering the literature as fact. Weakness: it can delay acceptance of correct but unwelcome findings — which is close to the point the writer makes about simple ideas in paragraph 2. Reward answers that notice the tension between those two paragraphs.

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