GLACIOLOGY

Ice cores: Clues to past climates

CRREL

Langway removes an ice core from CRREL refrigerator.

Variations in the isotopic composition of glacier ice cores provide valuable clues to the earth's climatic history

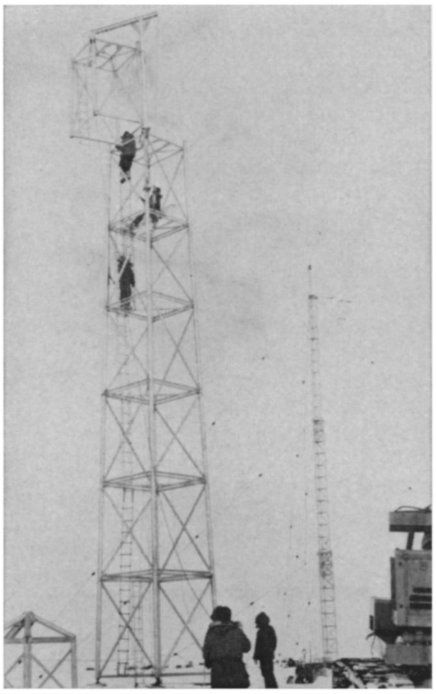
by Louise Purrett

To most persons glaciers symbolize just one kind of climate—cold. But to glaciologists they represent a comprehensive record of the whole range of past climate.

These scientists find clues to the earth's climatic history in the isotopic composition of the ice—the proportion of water molecules containing the heavy isotope of oxygen, O-18. This isotope is present in the atmosphere in concentrations that vary with temperature. The higher the temperature, the higher the concentration. When a cloud forms, its water molecules are synthesized out of the oxygen atoms in the surrounding atmosphere, and so will contain the heavy isotope in the same proportion. Then, because the molecules with O-18 are heavier than those with the more common O-16, they precipitate first. The relative concentrations of the two isotopes in an ice sample, therefore, indirectly tell scientists the atmospheric temperature at the time the ice was formed. The age of the ice sample can then be calculated from its depth within the glacier.

Samples of glacier ice are obtained in the same way as samples of ocean sediments—by extraction of cores. In 1966, the U.S. Army Cold Region Research and Engineering Laboratory, using a modified oil-drilling rig, penetrated through the entire thickness of the North Greenland ice sheet to obtain an ice core 1,390 meters long. Analysis of the isotopic concentrations at different levels in this core has provided a climatic record spanning 100,000 years.

This core is probably the most thoroughly studied chunk of ice in existence. Glaciologists from all over the world have requested samples. Among those who have examined it are Dr. Chester C. Langway of the CRREL and four Danish colleagues, Drs. S. J. Johnsen, Willi Dansgaard, H. B. Clausen and J. Møller, who have analyzed its isotopic variations over the 100,000-year extent of the core and determined in detail the climatic changes they represent. These researchers conclude that though the complete curve is valid primarily for the North Greenland area, it agrees with known and reported climatic changes in other parts of the world and with previous research using other methods.



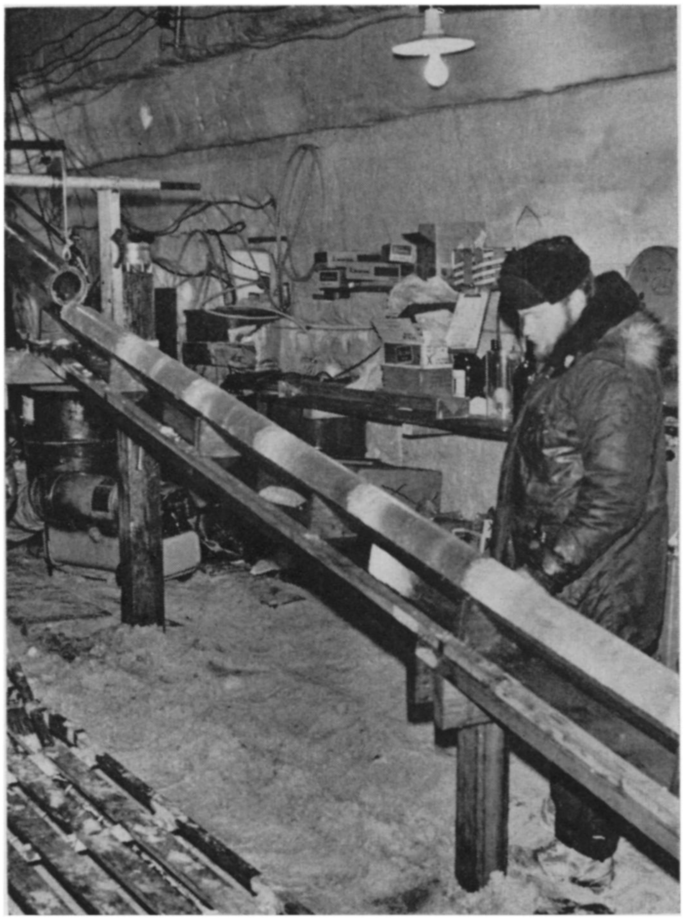
U.S. Navy

Engineers erect Antarctic coring rig.

It shows, for instance, the well-known climatic optimum about A.D. 1930 and the Little Ice Age of 1600 to 1730. At about 10,000 years ago, the isotopic concentrations fall off rapidly, corresponding to the final stages of the last glaciation. Two peaks at 11,900 to 11,100 and 12,500 to 12,100 years ago coincide with the Alleroed and Boelling interstadials—halts in the movement of a glacier—that are well-known from European climatic records. This was the first suggestion of the occurrence of these interstadials in the Western Hemisphere. The scientists also discovered a low of long duration in the 15th century, which they feel might help explain the mysterious abandonment of the Norse settlements in Greenland.

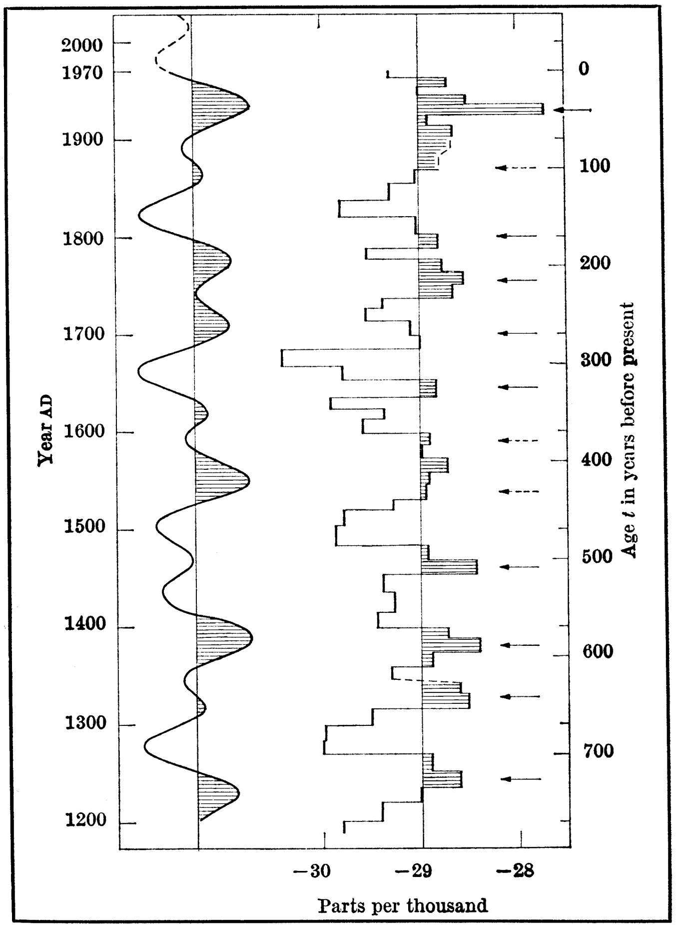
During the last 1,000 or 1,400 years, the scientists note, there is an apparent oscillation in the isotopic concentrations with a period of about 120 years. The prime cause of the oscillations, they surmise, is probably related to fluctuations in solar radiation, since solar variations are also considered to cause changes in carbon 14 concentrations in the atmosphere, and five C-14 minima noted during the last thousand years correspond to maxima in the oxygen isotopic profile.

In a report in the Aug. 1 NATURE, Langway, Dansgaard, Johnsen and Clausen examine (in greater detail) the isotopic changes over the period from A.D. 1200 to 2000. Again they note the agreement with other studies of ancient climatic variations. For instance there



CRREL

Antarctic core taken from a depth of 2,000 meters.



Nature

Greenland core's O-18 values give temperature trends.

appear 10 maxima between A.D. 1240 and 1930 at intervals of about 63 years, which correspond to a 66-year climatic oscillation previously found from studies of Greenland fauna.

However, their graph is complicated by a number of accidental deviations that do not occur regularly. In order to eliminate these and simplify the curve into dominant trends, the scientists applied a Fourier analysis, a technique for reducing a complex curve into its basic components. Their analysis neglects long-range and short-term trends, such as the 11-year sunspot period, revealing only the trends of medium recurrence, but the resulting curve displays two dominant peaks at periods of 78 and 181 years. The 78-year period had been noticed before as oscillations in the length of the sunspot cycle. Relatively long intervals with short sunspot cycles occur at A.D. 1560 to 1590, 1750 to 1790 and 1900 to 1930. These intervals coincide with the three last maxima in the 181-year cycle on the curve. These two cycles, the scientists conclude, seem to originate from changing conditions on the sun.

By extrapolating the smoothed curve, the scientists were able to predict the probable climatic trend for the next 50 years. The gradual decline in temperatures that has been in progress for the last three decades (SN: 11/15/69, p. 458) should continue for the next 10 or 20 years, followed by an increase toward a maximum between A.D. 2010 and 2020. This future curve, they caution, will be influenced by accidental events and possibly by pollution of the atmosphere.

The studies on the Greenland core were so profitable that in 1968 the technique was tried at the other end of the earth. A new ice core was taken near Byrd Station in Antarctica, using the same drilling technique as was used in Greenland. This core, a much longer one, 2,164 meters, was sufficiently revealing, says Dr. Langway, to justify a full-scale Antarctic coring project. Accordingly, a National Academy of Sciences ad hoc group was convened to make recommendations for a project to drill through the Ross Ice Shelf. The plan was presented in August of this year at the 11th Scientific Committee on Antarctic Research (SCAR) meetings in Oslo, and SCAR president Gordon Robin of the Scott Polar Institute in Cambridge, England, has appointed a permanent committee, headed by Dr. James H. Zumberge of the University of Arizona. The committee, says Dr. Zumberge, will serve as an advisory body not only for the Ross Shelf project but also for any future drilling by the 12 member nations of SCAR.

The Ross Shelf project is still in the planning stage, but it is expected to break ice with a pilot hole in the Austral summer of 1971-72. Three research holes are planned: one to study the water under the shelf, which is inaccessible to modern submersibles and remote sensing devices; one to pass through both shelf and water into the ocean bottom to provide samples of sediments that have fallen off the base of the shelf, and one for glaciologists, which would penetrate only partially into the shelf. Dr. Langway, a member of the permanent committee, will be deeply involved in this third phase.

Dr. Langway believes that the ice core method of studying past climates has a spectacular future. Ice cores, he says, provide information unobtainable elsewhere. They give more detail than any other method, even to the point of showing seasonal variations. Further, since the stable isotope method is independent of radioactive decay, the climatic record contained in glaciers endures as long as the glacier itself, and cores from some dry-snow zones can provide continuous records spanning several hundred thousand years. □