This Week in Science

Editorial

The Arctic: A Key to World Climate

Letters

Navy Marine Mammals: S. H. RIDGWAY; D. C. MORRISON ■ Snowbird II: A Dissenting View: A. RICE

News & Comment

Bush Adopts Reagan’s R&D Budget
New U.K. Science Initiatives Backed
R&D Suffers After Corporate Raids
Environment, Culture, and Change in the Arctic
Shuttle Faces Tough Schedule in 1989
Bahcall to Head New Astronomy Survey
Court Ruling Rekindles Controversy Over SATs
AIDS Panel Urges New Focus
CIA Details Chemical Weapons Spread
High Energy Physics Crunch Foreseen
Wanted: Normal Brains
Frazier Reinstated at McLean
Cancer Board Attacks Tobacco

Research News

Our Future in the Stars?
1988 Ties for Warmest Year
The Supernova 1987A Pulsar: Found?
New Trial Evaluates Parkinsonian Therapy
Quantum Chaos: Enigma Wrapped in a Mystery ■ Chaos in a Hydrogen Atom
Random Samples: Unclogging L.A.’s Streets ■ One Mailing List to Avoid ■ Banishing the “Mad Scientist”

Articles

Finite Social Space, Evolutionary Pathways, and Reconstructing Hominid Behavior: R. A. FOLEY AND P. C. LEE
Polymer Synthesis and Organotransition Metal Chemistry: R. H. GRUBBS AND W. TUMAS
Coordinate Regulation and Sensory Transduction in the Control of Bacterial Virulence: J. F. MILLER, J. J. MEKALANOS, S. FALKOW
A fragment of lunar cordierite-spinel troctolite from the Apollo 15 mission. Two spinel crystals (reddish brown) and an adjacent grain of cordierite (lavender pink, upper left) are included in twinned plagioclase feldspar (blue and yellow). The cracked textures, offset twin lamellae, and weblike pattern (lavender pink and yellow) of finely crushed feldspar are shock features. (False-color photomicrograph taken in partially cross-polarized light with gypsum accessory plate; long edge of field is 0.53 millimeter.) See page 925. [Photomicrograph by Ursula B. Marvin]
The Arctic: A Key to World Climate

The Arctic is part of a great global heat engine. Changes in the arctic atmosphere, ocean, sea ice, and permafrost are early precursors to climate change elsewhere. In the past, those changes have been drastic. Only 18,000 years ago, virtually all of Canada and some of the United States were covered by a thick layer of ice.

At the recent AAAS Annual Meeting, a symposium brought together some of the leading research scientists active in studies of resources and climate.* In one of the sessions, speakers reviewed information about the evolution of the arctic climate.

A principal impression that could be drawn from the symposium was that the current hypothesis concerning effects of greenhouse gases on arctic behavior is probably simplistic and may be quite wrong. The public has been told repeatedly that a result of increased greenhouse gases would be a substantial rise in sea level due to melting of polar ice. A related statement frequently made is that the increase in polar temperatures would be substantially greater than those of global averages. For example, one estimate is that an average rise of 2°C could be accompanied by a 10°C increase in the Arctic. That estimate may or may not adequately take into account climatic feedback mechanisms. At the symposium this point was raised implicitly by John T. Andrews, who stated that the Greenland Ice Sheet and the Laurentide Ice Sheet advanced during the last glacial interstadial.

The vapor pressure of water is quite sensitive to temperature. Condensing moisture in the form of snow provides a surface cover that highly reflects solar energy leading to a regional cooling. The albedo (reflectivity) of ordinary soil is about 0.1. The albedo of snow is about 0.8. At present, some of the arctic land areas that have averaged annual temperatures of about −14°C receive only 10 centimeters of total H2O per year. Most of the time the ice cap is bare and is a good absorber of solar heat. Were precipitation to occur, the total heat absorbed by the surface would decrease. With greater moisture in the air, there would be more clouds. The net effects of these are controversial. Some say that more clouds would reflect more energy away from the earth. Others point out that added moisture would enhance a greenhouse effect in the Arctic. In any event, the factors controlling arctic climate are complex.

One of the obstacles to confidence in predicting the future of the arctic climate is an imperfect knowledge of the past. We know that 70 million years ago, the climate was mild and the Arctic Ocean was ice-free. Sediments formed about 5 million years ago contained glacially related materials. We know little about what happened in the long interval, and knowledge concerning more recent events is sketchy. No long cores have been obtained from the Arctic Ocean. The impediment is the perennial ice sheet that covers most of that ocean. The thickness is usually about 3 to 4 meters, and the sheet tends to keep moving. At the geographic North Pole, the depth of the ocean is about 3500 meters.

Our best source of evidence concerning the last million years is found in near-shore sediments, and particularly on fossil-bearing terraces. Molluscan fossils are particularly useful. Different molluscan species have different temperature affinities. In addition, they contain partially hydrolyzed proteins. The degree of racemization of isoleucine is a function of times and temperatures. The shells also contain strontium as a trace element which provides a dating potential. The ratio of 87Sr to 86Sr in seawater has changed monotonically over the last several million years. For events during the past 40,000 years 14C dating can be applied. Other types of fossils are being studied and additional dating methods employed. Measurements of ratios of 18O to 16O in ice are useful in determining temperatures at which atmospheric moisture was converted into ice. Oxygen isotope ratios of snows reveal temperatures present during their formation.

The importance of understanding the past, present, and future of the arctic climate requires that support for such activities have a top priority. Desirable efforts include more studies of fossils, an international program of deep drilling in the Arctic, more weather monitoring, and additional satellite surveillance of the polar region.—PHILIP H. ABELSON


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