

Glaciers Are Star Witnesses to the History of Earth's Climate

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JUST a short eagle's flight from the highest peak of Europe, amid rolling rocks and a sudden blizzard, Louis Reynaud was drilling deep under the skin of an aged glacier.

"This ice is hundreds of years old," he said. Overhead, in shreds of mist, drifted the summit of the Mont Blanc.

The wilderness of boulders and treacherous crevasses at an altitude of more than 8,000 feet looked menacing and bleak to ordinary mortals, but it loomed before the scientists like a rich laboratory. Mr. Reynaud was leading a team of glaciologists from the University of Grenoble in France, who were studying the behavior of glaciers, how they swell or melt, advance or retreat.

To glaciologists, the high ice fields are the star witnesses in the complicated debate about global climate change. They see them as key indicators of warming and cooling, more reliable than climate models, which scientists plot on computers to predict changes in the atmosphere.

"Glaciers have one great advantage," said Mr. Reynaud, stopping for a bar of chocolate and turning his back on the rasping wind. "There's no mystery. This is pure physics. If the air warms up, the ice will melt. It's that simple."

In the Alps, at the heart of Europe, where glaciers are monitored more closely than anywhere else in the world, researchers say the ice cover has been shrinking rapidly. Estimates are that one-third to one-half of the ice volume has vanished over the last century.

The main questions asked by glaciologists here are, precisely how fast is the ice melting and is the rate of melting accelerating? They believe that the answers will help them determine if these high ice caps are simply reacting to natural shifts of the climate or if the rate of melting is now quickening, suggesting that temperatures are indeed rising due to human activities.

At the World Glacier Monitoring Service in Zurich, which keeps the earth's glacial archives, scientists say that very little is known about the ice that covers 10 percent of the planet's surface. Ice studies in the North Pole region began seriously only during the cold war, because of the American and Soviet governments' strategic interests.

Fluctuations of ice in Antarctica, which holds most of the glacial mass, are the least understood, said Wilfried Haeberli, the center's director. There are only limited studies of the greatest mountain glaciers such as those of Alaska, Patagonia or the Himalayas. The better-known glaciers of the Alps, he noted, are just pocket-sized.

But the research going on in the Alps is crucial, Mr. Haeberli said, because this is where glacier studies first began more than a century ago. Austria, France and Switzerland began studying glaciers to monitor the water running off these enormous frozen watertowers because of their powerful impact on the region's farming, shipping and hydroelectric dams.

Increasingly, though, glaciologists here and on other continents are expanding their observation network as interest in the environment has surged and more scientists try to understand the planet's complex weather systems. American spy satellites, released from cold war duty, are joining in the monitoring of ice.

"The glaciers of the Alps are among the best indicators we have of a warming or cooling world," said Mr. Haeberli. "They are small and react quickly, they are accessible and they may be representative of what is happening in cold mountain regions in general. Here we have the oldest first-hand records available."

Looking for the messages hidden in ice, researchers have been poring through the records of churches, villages and the military. They found accounts from the warmer Middle Ages, showing that people and animals passed easily across some mountain passes of the Alps that must have had less ice than today.

In the colder 17th and 18th centuries, Swiss village records noted farmers complaining that glaciers were destroying their fields and vineyards.

At one point, the people of Chamonix, below the Mont Blanc in France, worried so much about the expanding Mer de Glace glacier that they feared it might knock over the church. A painting of the Mont Blanc, dated 1740, shows the Mer de Glace reaching the edge of the village.

But since the mid-19th century, the Mer de Glace has retreated by almost a mile. And the biggest glacier of mainland Europe, the 13-mile-long Aletsch in Switzerland, has retreated more than one mile and lost more than 300 feet in thickness over the last century.

"Since the 1980's ice in the Alps is melting faster," said Dr. Haeberli. "Our figures clearly show that. But we need to know more."

Glaciers are also shedding ice in other mountain regions, as far apart as the Russian Caucasus and Urals and the Andes of South America.

But Dr. Haeberli cautioned that it is too early to draw conclusions because record keeping is recent and spotty in most parts of the world. Glaciologists, he explained, need long-term measurements to identify trends.

Complicating this picture are recent studies showing that ice covers are growing in Scandinavia, Greenland, Iceland and New Zealand.

Norway, which monitors its mountain ice closely because it uses the thawing water for its power stations, found its glaciers on average growing by more than 30 feet over the last five years. Some have expanded by hundreds of feet, said Jon Ove Hagen, professor of glaciology at the University of Oslo.

"That's an enormous new volume of ice," he said. "The same is happening in Sweden. Between 1900 and 1950, all of Scandinavia's ice was shrinking. Then it stabilized. Now it's growing."

Anker Weidick, a Danish geologist who is in charge of ice studies for Greenland, part of which lies within the Arctic Circle, refuted recent reports that Arctic ice was melting. He said Greenland's "great ice towers and the main ice sheet are relatively stable or growing."

John Houghton, a leading British scientist, said he sees no contradiction in the growth of ice in one part of the world and melting in another. Dr. Houghton is a co-chairman of the Intergovernmental Panel on Climate Change and in its most recent report, the panel cited the melting of mountain glaciers as evidence of global warming in which human activities may play a role. "A warmer world is a wetter world," Dr. Houghton said. "This means we get more snow and ice near the polar regions."

Scientists have long known about the planet's great cycles of cooling and warming by their analysis of ice cores and moraines, the piles of stones carried by moving glaciers. But current studies in the Alps are focused on the changes of this century and even the last few decades.

The researchers here who slog through the cold Alpine wilderness say they are aware that the recent use of aerial photography and satellite observation of glaciers may seem more efficient. But they argue that such sweeping surveys do not provide crucial information they can get up close, such as the thinning of ice, its movement and its rate of melting.

Twice a year, these geologists or physicists, among them Mr. Reynaud and his colleagues, go up by helicopter or climb to great heights to monitor several dozen Alpine glaciers.

They dig snowpits in the spring to measure the winter snowfall. Recently, they were lugging their gear across the frozen folds of the Argentiere, a six-mile-long glacier on the Mont Blanc range. In this still, austere world, a few dark birds and a distant airplane were the only signs of life.

"It's difficult to see, but here everything moves," said Mr. Reynaud, swinging a pick ax into the hard surface. "The glacier is always in motion, shifting and sliding. Its own weight pushes it down." Undercurrents of the ice move differently from the upper layers, he went on. The whole glacier may glide down half an inch per hour, perhaps more.

A sharp burst of sounds cracked across the silence. "That's ice tearing open," Mr. Reynaud said. A long rumble followed, which Mr. Reynaud explained as a rockfall.

Nearby, Francoise Guirardot was making the ice sizzle as she drove a hot metal rod some 30 feet deep. She lowered wooden stakes into the hole. "They will show us next fall how much the ice has melted," she said.

As they took a break, the team members were asked about global warming. What is certain, they said, is that judging by the glaciers they know well, the 20th century is not very cold and ice here continues to melt. One member of the group made the point that reportedly there has never been more carbon dioxide in the air than now and that the burning of fossil fuels is causing concentrations to rise and warm the air.

"Perhaps," said Mr. Reynaud. "But we know that in the Middle Ages, these glaciers were even smaller than today. Was that because of a great burst of carbon dioxide? How do we answer that?"

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