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SCIENCE DESK

What Makes a Glacier Go? Scientists Look Inside

By DONALD G. McNEIL Jr. (NYT) 1794 words

BENEATH THE SVARTISEN GLACIER, Norway -- To find the Aladdin's Cave of modern glaciology, follow these simple directions:

Fly to Bodo, in the Arctic Circle. Drive three hours south to an empty jetty and wait for the boatman. Cross the fjord, walk a mile on a gravel road toward the glacier, which looks like a huge cracked dragon's tongue of cornflower-blue ice.

Make a brutal climb 1,800 feet up the mountain, sometimes sinking up to your waist in wet snow, sometimes climbing hand over hand on ropes stretched down slopes polished slick by the glacier. (You can use a helicopter in good weather, but that is expensive.)

Enter a hole in the mountain resembling a sewer pipe. Don a hard hat, miner's light and rubber boots, and walk a mile as the tunnel slowly widens until it is big enough for a truck and is lighted by dim electric bulbs. Pass through a vast cement wall that in summer holds back a subterranean torrent. Find and climb the 79 wood steps that lead up through the tunnel roof. You are now at the bottom of the glacier. There are 700 feet of ice above you, and it all seems to be dripping down your neck.

Fumble your way up 15 feet of slippery rock, gripping the ice walls for balance. At the top is a flat spot inside a shimmering wonderland. Long blades of ice -- some glowing white in the work lamp, some filthy with gray glacial sediment -- are coming at you from every direction.

They are literally coming at you. This cave, just big enough for 10 people to stand in, did not exist two days before, and it will not exist in two more. It was carved out with a warm-water jet, and the ice, flowing like toothpaste at these depths, began pressing back in as soon as it was shut off.

There is nothing quite like this back in Iowa, where Dr. Neal R. Iverson usually practices glaciology. There it is mostly theoretical, though he has a model made of two rotating aluminum plates with glacial sediments between them, which he describes as "rotating a bagel and seeing the cream cheese shear." Here he has the real thing -- ice meeting rock under millions of tons of pressure.

Like a vast snail, a glacier rides on a slurry of sediment and water, and Dr. Iverson's team is studying why it can race past at 150 feet a day or slow down to nearly zero.

One preliminary discovery the team made this year is that the friction between the sediment and the rock face is more than 20 times as great as mathematical models had predicted.

No one has ever been sure why a glacier does not race down a mountain valley like an ice cube on a sheet of glass. Recent thinking has been that bumps in the bedrock hold it back. But the team's data suggest that simple friction may apply the brakes, as if the ice cube has a sandpaper bottom.

"This is the only lab in the world like this," Erik Roland, manager of the glaciers and snow section for the Norwegian Water Resources and Energy Directorate, said. The directorate, Norway's state power company, built and maintains it for scientists, with underground bedrooms for eight, telephones, a kitchen, a laboratory with a big freezer, drilling equipment and a huge hot-water spray machine.

Traveling to glaciers is relatively easy. Tunneling beneath them is difficult. Scientists in Greenland take ice cores down to 10,000 feet, but cannot follow their drill bits down. In Antarctica, tunnels have been cut with six-foot chain saws, but that is mere nibbling at the glacial edge.

In past decades, there have been smaller temporary laboratories in natural pockets under the Argentière Glacier in France and in a power tunnel under the Bondhusbrea Glacier in Norway. But they are closed. A short tunnel lies under a glacier in Tianshan, China, but it is a "cold glacier" -- frozen to its bed. So motion studies like those by Dr. Iverson's team are impossible.

The Svartisen is a "temperate glacier," meaning that its ice is right at the melting point, zero degrees Celsius.

One thing the experts have not yet worked out is why, even near the bottom, it is full of water pockets, like Champagne bubbles, except that when these pop, surprised scientists receive ice water showers.

On sunny days, millions of gallons of snowmelt filter down through the glacier, raising the water pressure where it meets the rock.

That melt is the reason the power company built 60 miles of tunnels under the edge of the Svartisen. The tunnels carry the melt to hydroelectric turbines. The hotter the weather, the more water flows -- the reverse of the normal situation for most hydroelectric plants, which cut back in hot summers for fear of drought.

Nearly alone among the world's glaciers, Norway's are increasing in size. For unknown reasons, shifting global weather patterns have brought more precipitation to the fjord-dented coastline.

Glaciers like Svartisen can receive 20 or more feet of new snow a season, thousands of tons bearing down on the center.

"That's good for us," said Dr. Denis Cohen, a Yale glaciologist who collaborates with Dr. Iverson's team. "Gets the glacier moving."

That gives the team a chance to record sliding speeds, friction, viscosity under various water pressures, porosity of the sediments and such.

Unusual ice crystals form under such pressures. In the right light, hexagons bigger than baseballs can be spotted in the cave's walls.

A few years ago, Dr. Cohen carried home a sizable block of the subglacier, arranging for dry ice along the way and assuring airline personnel that his big smoking suitcase was harmless.

The work can be backbreaking. In the rock floor, the scientists chiseled out a sort of bathtub and filled it with $4,000 worth of instruments that measure water pressure, load, tilt and strain. The gear has to be buried by hand under 5,000 pounds of glacial till, the fine grit created by ice grinding over rock.

Dr. Iverson's nine-member team carried the till up the 79 steps and the ice slope in bucket relays. One debate -- over the brown goat cheese and salmon caviar in tubes that Norwegians consider lunch meat -- was over who would shovel, who would stoop through the narrow doorway and whose boots were too worn to get up the slope.

A stake through the till marks each buried instrument, and the last act by a scientist before leaving the shrinking cave is to pull those stakes. One departs the ice lab with the unmistakable sense that Dracula has been awakened -- but is going to be pretty shocked to discover just how cold his tomb is. The ice will close in, start pressing down on the "bathtub" and then flow across it.

Just finding a good spot for a red plastic ball the scientists wanted the glacier to "pick up" took an hour of chiseling out a hole with an electric hammer. The ball was attached by wire to a data recorder and was to act as a speedometer as the glacier moved away.

But they were uncomplaining. Glaciologists consider themselves hardier than, say, microbiologists.

"Most of us like being outdoors," said Dr. Miriam Jackson, a glaciologist for the Norwegian power company who works with Dr. Iverson's team. "You have more than your number of keen skiers and keen mountaineers."

But, she added, the discipline does have its desk jockeys who model glaciers on computers and others who collect satellite photos.

"They don't get out very much," she said with a trace of pity.

Glaciologists have another reason to be pleased with themselves. In the last few years, fear of global warming has made theirs a much hotter field.

"Before, if you studied ice mechanics," Dr. Jackson said, "it was regarded as pretty useless. Now, if you can relate it to climate change, people regard it as relevant and you get the funding."

Some financing comes from the Army, the United States Geological Survey and NASA. But the National Science Foundation underwrites the bulk of the pure science work.

Much of that effort is going into digging ice cores, which give remarkably accurate data about weather changes eons ago. "You get amazing time resolution," Dr. Iverson said. "You can tell things like the climate changed by 8 degrees for three years 11,000 years ago."

Testing the slipperiness of ice is a bit more esoteric. But, as Dr. Iverson pointed out, there are many scientists and satellites keeping an eye on the vast Antarctic ice shelves and their potential to raise ocean levels.

"If Ice Sheet B started moving at 10 times its rate," he said, "there would be a big cry for finding out what goes on at the bottom of ice sheets."

Dr. Iverson is a romantic about glaciers, perhaps not surprising because his studies in Iowa work with all that is left -- their scuffed footprints. He sees them not as passive snowmen whose smiles droop wanly as global warming beats down on them, but as major actors on the world weather stage, scenery chewers full of pent-up energy. As an example, he cites the Laurentide Ice Sheet, a fast mover that once barnstormed the American Midwest and then retreated.

"About 14,000 years ago, it changed the drainage of the center of America," he said. "Instead of draining to the North Atlantic, it started flowing to the Gulf of Mexico. I'm sure that had a huge effect on global heat in the atmosphere.

"So glaciers don't just respond to climate change, they trigger it. That idea wouldn't have been accepted 20 years ago."

CAPTIONS: Photos: Dr. Tom Hooyer, left, and Dr. Neal R. Iverson examine stress-measuring instruments in a chamber under the Svartisen Glacier. Stakes mark the depth of each instrument. (Donald G. McNeil Jr./The New York Times)(pg. F4); Seven hundred feet of ice from the Svartisen Glacier lie above a laboratory chamber containing instruments that measure glacial movement. Chambers and tunnels leading to them are hollowed out by hot-water jets and usually last for just a few days. (Photographs by Donald G. McNeil Jr./The New York Times)(pg. F1)

Chart/Diagram: "Tunneling for Icy Secrets"
The Svartisen Glacier in Norway is at the melting point, allowing it to slip over its bed. An extensive system of passageways below, shown in cross section, gives scientists a look at how the 70-story-thick ice cap behaves.

GETTING AROUND
The main tunnel is about 25 feet square. The walk between living quarters and laboratory is about one mile.

(Source: Dr. Neal R. Iverson, Iowa State University)

Map of Norway shows the Svartisen Glacier.
