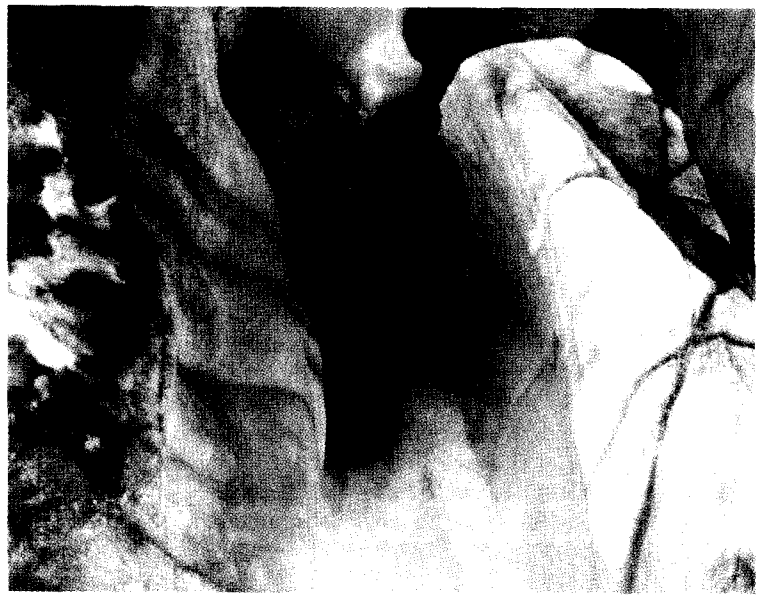
GLACIOLOGY

Greenland Ice Slipping Away but Not All That Quickly



CREDIT: I. JOUGHIN, PSC/APL UNIVERSITY OF WASHINGTON

Down the hatch. Meltwater pouring into moulins like this one can lubricate the ice sheet's base, but the ice's resulting acceleration into the sea is modest.

Almost 6 years ago, a paper in *Science* warned of an unheralded environmental peril. Melted snow and ice seemed to be reaching the base of the great Greenland ice sheet, lubricating it and accelerating the sheet's slide toward oblivion in the sea, where it was raising sea level worldwide (12 July 2002, p. 218).

Now a two-pronged study—both broader and more focused than the one that sounded the alarm—has confirmed that meltwater reaches the ice sheet's base and does indeed speed the ice's seaward flow. The good news is that the process is more leisurely than many climate scientists had feared. "Is it, 'Run for the hills, the ice sheet is falling in the ocean'?" asks glaciologist Richard Alley of Pennsylvania State University in State College. "No. It matters, but it's not huge." The finding should ease concerns that Greenland ice could raise sea level a disastrous meter or more by the end of the century. Experts remain concerned, however, because meltwater doesn't explain why Greenland's rivers of ice have recently surged forward (*Science*, 24 March 2006, p. 1698).

The original paper described work by glaciologist Jay Zwally of NASA's Goddard Space Flight Center (GSFC) in Greenbelt, Maryland, and colleagues. They noted that whenever summer warmth swelled, producing more meltwater on the ice sheet, the ice beneath Swiss Camp—70 kilometers inland of the west coast—sped up as much as 28% on its 115-meter-per-year creep toward the Davis Strait. Presumably, the meltwater disappearing down tubular chasms called moulins somehow reached the ice sheet's base a kilometer down and slicked it up, letting the ice take off, if only for a couple of months.

But no one was sure how meltwater managed the feat or whether the ice acceleration at Swiss Camp continued all the way to the sea. So glaciologists Ian Joughin of the University of Washington's Applied Physics Laboratory in Seattle, Sarah Das of Woods Hole Oceanographic Institution in Massachusetts, and their colleagues took a dual approach to meltwater lubrication, as they report in two papers published online this week in *Science* (www.sciencemag.org/cgi/rapidpdf/1153288.pdf). They took a close look at how lubrication works by instrumenting a growing puddle of meltwater south of Swiss Camp. For the broad view, they went to images made from satellite-borne radar that tracked ice sheet movement every 24 days across a 425-kilometer-by-100-kilometer swath of the west coast, including Swiss Camp.

The meltwater monitoring caught a 4-kilometer-long, 8-meter-deep lake disappearing into the ice in an hour and a half. As theorists had supposed, once the lake water was deep enough, its weight began to wedge open existing cracks, which only increased the weight of overlying water on the crack tip and accelerated cracking downward. Once the main crack reached the bottom of the ice, heat from churning water flow melted out parts of the fracture, and drainage took off. The lake disappeared in about 1.4 hours at an average rate of 8700 cubic meters per second, exceeding the average flow over Niagara Falls. That's almost four Olympic pools a second.

For all the lake's water dumped under the ice that day and all the water drained into new moulins in the following weeks, the ice sheet moved only an extra half-meter near the drained lake. Das and her colleagues conclude that an unknown number of lake drainages and new moulins account for the acceleration reported by Zwally and now confirmed more broadly by the radar observations. Joughin and his colleagues report that in August 2006 the ice sheet sped up over a broad area by a hefty 48% above its 76-meters-per-year mean speed as melt lakes grew—and disappeared—under summer warmth.

The good news came toward the coast, where the ice speeds up as the flow narrows into a few outlet glaciers that deliver the ice to the sea. Those glaciers moved only 9% faster than normal in August of 2006. "Meltwater does indeed cause substantial speedup" inland on the ice sheet, says Joughin, "but it has a small effect on outlet glaciers." That may be because the beds on which outlet glaciers slide are already smooth and well lubricated year-round, the group speculates. All in all, meltwater lubrication "likely will have a substantive but not catastrophic effect on the Greenland Ice Sheet's future evolution," the group writes.

Alley agrees. "Could things go two times faster [due to meltwater] than we thought 10 years ago?" he asks. "Yes. They can go faster but not ridiculously faster." The danger now, warns glaciologist Robert Bindschadler of GSFC, is "falling into the same 'We now know how ice sheets work' trap that my generation was guilty of 5 years ago." After all, some of Greenland's outlet glaciers began galloping to the sea in recent years. If not meltwater, what set them off?

–RICHARD A. KERR