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SECTION

J

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M A G A Z I N E



Photos by Ken Golden

# VOYAGE TO ANTARCTICA

# Chain Saws and Beet Juice Become Research Tools for Utah Mathematician studying Polynia 'Ice Factory'

BY LEE SIEGEL

THE SALT LAKE TRIBUNE

Utah's January weather is mild compared with Ken Golden's last winter, when blizzards brought 86 mph winds and driving snow while temperatures plunged to 15 degrees below zero Fahrenheit -- not counting the wind chill.

While most Wasatch region residents basked in hot weather last summer, the University of Utah mathematician spent almost eight weeks at the bottom of the world aboard an Australian research ship on a voyage into the Antarctic winter. The sun rose above the horizon as little as five hours a day, and daytime highs never exceeded freezing and usually were subzero.

When foul weather abated, the scenery was splendid: giant icebergs bathed pink by the sunrise, hordes of penguins skimming across the sea, towering cliffs of glacial ice and the moon shining over a vast frozen terrain.

Golden and four dozen others on the Australian icebreaker *Aurora Australis* worked long, cold hours. He and some other researchers often descended onto polar ice via a cage suspended from the ship's crane. But there was time for play, including football games on ice floes and a party featuring burly Austra-

lian men dressed in drag.

The expedition's goal was to study the "polynya" at the toe of Mertz Glacier, on the Antarctic coast south of the Australian island state of Tasmania.

A polynya is a zone of mostly open ocean water that remains relatively ice-free even in winter and is surrounded by solid sea ice. It may seem contradictory, but Golden said a polynya is both "an oasis of open water" and a factory where new sea ice is produced in a process that influences the world's climate and ocean circulation.

The trip was Golden's fourth to Antarctica. He went on successful expeditions in 1980 and 1994. A third trip in 1998 was aborted when an engine-room fire crippled the *Aurora Australis*, forcing the vessel to return to Hobart, Tasmania, for repairs.

Golden's 1999 journey began when he left

Salt Lake City for Los Angeles, then flew across the international date line, arriving in Sydney, Australia, July 12. By that afternoon,

he was in Hobart, where he obtained heavy winter gear and the ship was loaded before proceeding to nearby Port Arthur for fueling.

On July 16, bagpipers played as the *Aurora Australis* left Port Arthur with 50 scientists, support personnel and crew members. Seas were calm, disappointing Golden, who on previous voyages had thrilled at 30-foot seas while other researchers became violently sea sick.

As the ship crossed the Antarctic Circle, crew members dressed as King Neptune and his helpers for a humorous ceremony in which scientists were doused with water and



Photo by Andrew Roberts

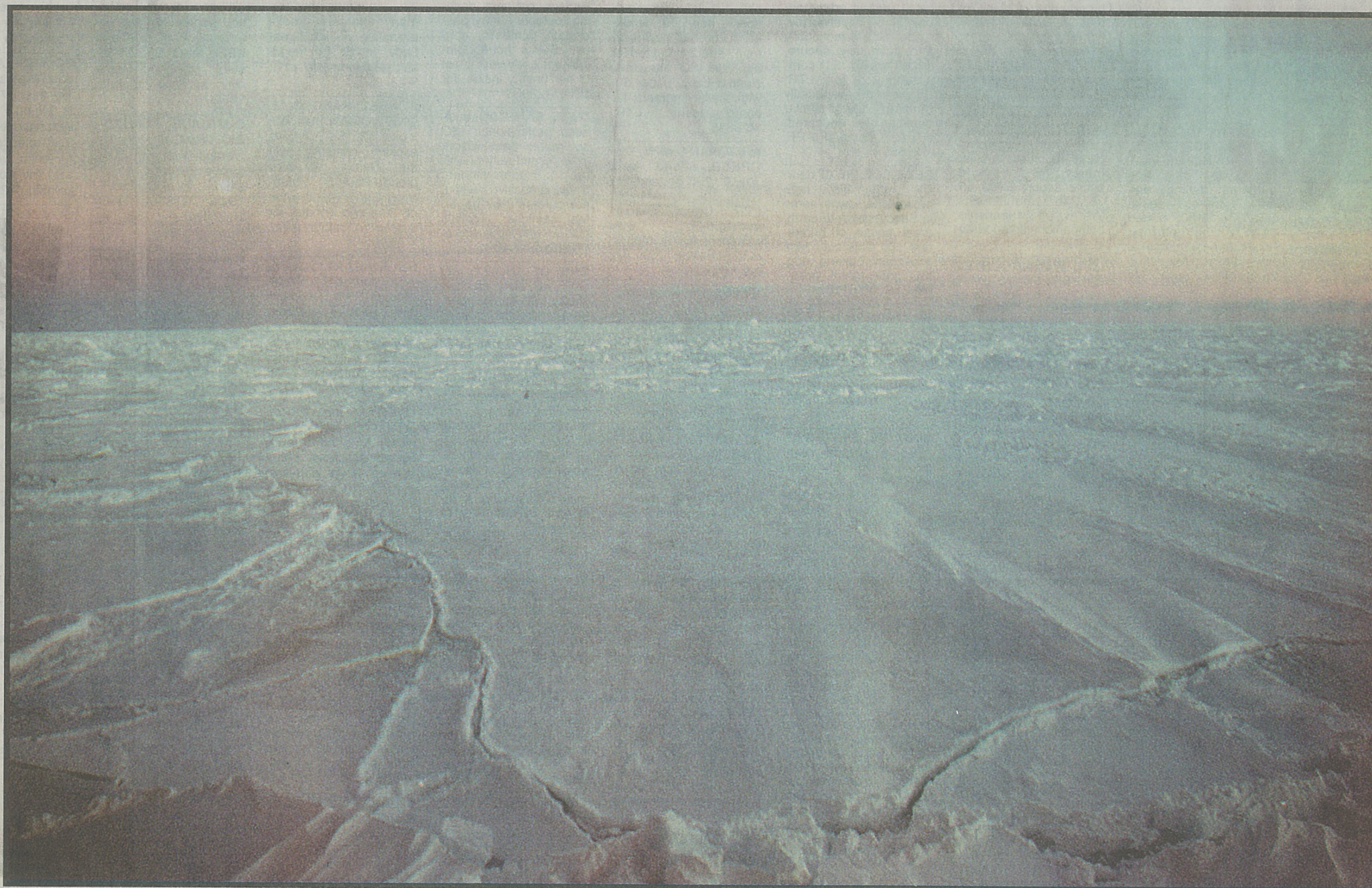
Top, penguins and the *Aurora Australis*.  
Above, Ken Golden with "percolation pit."

**As Golden and Massom remained on the ice, the crack closed, but one slab of the ice floe rode up and over the slab on which they stood, and sea water started flooding it.**

## VOYAGE TO **A**NTARCTICA



Above, working in the Antarctic winter night, Anton Rada and Matt Paget of the Australian Antarctic Division cut a slice of sea ice. Below, the moon shines over Antarctic sea ice.



# ANTARCTIC

## The bitter and the beautiful in an ocean of ice

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required "to kiss a raw fish," Golden said.

On July 22, the *Aurora Australis* reached Antarctic ice. It was an eerie sight. Golden's video recordings show large pancake-shaped pieces of broken ice rising and falling on ocean swells.

The ship — capable of breaking through ice only about three feet thick — soon entered solid ice, encountering floes more than 16 feet thick. For two days, the ship could move only 6 miles a day. A helicopter repeatedly flew off the *Aurora Australis* to scout for "leads" — narrow passageways in the ice through which the ship proceeded south toward Mertz polynya.

On the way, the ship stopped twice to drop off instruments to measure the ocean and the ice. Golden and Australian researcher Vicky Lytle, with whom he collaborated during past expeditions, were the first to leave the ship and work on the ice.

In the dark of night with winds blowing 40 mph, they used a hollow, auger-like tube or barrel to remove cylinder-shaped ice cores. With temperatures 4 degrees below zero Fahrenheit, the drilling barrel froze in the ice, "and we had to use a chisel and our hands to dig it out," Golden said.

"The next day we had beautiful weather and saw a lot of big icebergs — many times bigger than the ship."

By July 26, the ship was within 8 miles of the Mertz polynya. Then a blizzard struck. Winds reached 75 mph, temperatures dropped to 13 degrees below zero and driving snow reduced visibility to 230 feet, according to a dispatch posted on an Internet web site by expedition leader Ian Allison of the Australian Antarctic Division at the University of Tasmania's Antarctic Cooperative Research Center.

"Nobody was allowed out of the interior of the ship because with the icy decks you can easily get blown off or knocked out, and that would be it," said Golden, who e-mailed messages to *The Salt Lake Tribune* as the voyage progressed. E-mail messages could be sent twice daily by bouncing signals off satellites.

The *Aurora Australis* finally entered Mertz polynya Aug. 1. It was the first expedition to work in the region in mid-winter, Allison said.

After scientists erected a weather station on a coastal island, the ship navigated around the perimeter of the polynya, stopping every five miles so an instrument could be lowered into the sea to measure temperature, salinity and currents. Water samples were collected to measure nutrients, plankton and bacteria.

The Mertz polynya exists because Mertz Glacier's tongue and adjacent sea ice extend about 100 miles north from Antarctica, blocking other ice from entering the polynya, which also is kept relatively free of ice by winds blowing off the glacier and out to sea, Golden said.

"Winds pour off the continent and blow the ice out," Golden said. "But it's so cold that new ice



The roughly 150-foot-tall edge of Mertz Glacier's tongue.

forms rapidly, making this small region into an ice factory."

When researchers first arrived at Mertz polynya, it was 20 miles wide, smaller than expected. The normal northward movement of fresh ice out of the polynya probably was stalled by inadequate winds and blocked by thick ice to the north, Golden said.

But the polynya's size grew dramatically as winds picked up. It eventually became about 100 miles long and 70 miles wide, Golden said.

Expedition glaciologists wanted to calculate how much ice is produced in the polynya, both from fresh water flowing from Mertz Glacier and from sea water. They also wanted to learn where winds blowing off the glacier carry the ice as they push it northward out of the polynya. So they deployed buoys that froze into the ice and drifted with it. The buoys were tracked by satellites.

By tracking ice movements and thicknesses, the researchers sought to learn how much salty brine flowed out of the ice as it froze. The brine sinks to the sea floor to produce "bottom water" that spreads out and influences ocean circulation patterns and global climate far from Antarctica, Golden said.

Researchers also made hourly measurements of ice concentrations in the polynya, the type and topography of the ice, temperatures of air and water, wind speeds and so forth.

After the ship circumnavigated the polynya, Golden joined other researchers in descending onto the ice daily for five straight days, drilling to remove ice cores, analyzing snow, and measuring ice growth.

With only five to seven hours of daily sunlight during the expedition, Golden and the others did most of their work on the ice floes at night, illuminated by the ship's glaring flood lights.

Golden's research, funded by a four-year, \$290,000 grant from the National Science Foundation, focuses on studying how sea water percolates up through

solid sea ice, flooding the top of the ice to turn fallen snow into slush, which then freezes into new ice.

The process maintains the polar ice pack, preventing heat from polar oceans from pouring into the atmosphere and overheating the entire planet's climate. Water percolating up through ice also is essential for supplying nutrients to algae growing in the ice. The algae are at the base of the food chain that nourishes all Antarctic creatures.

To conduct his research, Golden scraped snow off the surface of the ice and counted tube-like "brine channels" through which sea water percolates upward. Golden and colleagues used a chain saw to cut 15- to 26-inch-thick slabs out of the ice and examine the brine channels in detail. He referred to the method as "the sea ice chain saw massacre."

To get a better look at the channels' structure, Golden went to the ship's kitchen and drained juice from containers of beets, then poured the salty juice over the ice slabs, watching it percolate through the brine channels.

"Seeing the red juice seeping through the crystalline ice bathed in the ship's floodlights made for quite a spectacular effect," Golden said. "It gave me a much better feel for how brine moves through the ice."

While Golden and other researchers measured the ocean and the ice, expedition biologists studied sea birds, penguins, seals, whales and krill, which are small shrimp-like crustaceans eaten by larger creatures. At times, the researchers saw hundreds of penguins swimming or waddling in lines extending miles across the ice.

"They are beautiful to watch," Golden said. "We saw lots of them diving for fish and krill. Sometimes they skim in and out of the water surface very fast like dolphins."

On the ice, biologists chased and tackled penguins, then "made them throw up to see what they're eating," Golden said. "They pump warm water into

their stomachs through a surgical hose to make them vomit. It was pretty cool. I got it all on video."

At times, Golden flew on the ship's helicopter, participating in aerial photography missions to study the formation of ridges in sea ice and to bounce laser beams off the ice to measure its roughness.

During off hours, scientists delivered lectures to each other about their research. They also relaxed by rappelling off the side of the ship's ice-coated helicopter hangar and by staging some wild parties.

"Booze, dancing 'til 5 a.m. the usual," Golden said.

One party was a "Ladies Night," where all the men were required to dress in drag.

"It seems the Aussies take this very seriously, and some had even brought dresses along for the occasion as it appears to be a part of the Australian Antarctic culture," Golden said. "Seeing big, burly Antarctic expedition members in makeup and evening gowns made from garbage bags was quite a scene."

On August 24, Golden wrote: "Today we saw a family of killer whales playing near the ship. It was beautiful. ... An emperor penguin flew out of the water and onto the ice a few feet from my cabin window. ... Later there were a whole bunch of penguins porpoising along side the ship."

The same day, Golden almost met with disaster after he, Lytle, researcher Rob Massom and three other scientists descended onto the ice to collect samples.

"As soon as we got out there a small crack appeared," Golden recalled. "Vicky said we should finish up quickly. Then the crack got bigger."

Lytle and three others boarded the cage at the end of the ship's crane and returned to the *Aurora Australis*. The cage can hold only four people at once.

As Golden and Massom remained on the ice, the crack closed, but one slab of the ice floe rode up and over the slab on which they stood, and sea water started flooding it. The crane soon brought the cage to them. They hopped to safety.

"Two minutes later, the floe where we had been standing was completely broken apart," said Golden.

That night at dinner, colleagues ribbed Golden. "Hey Ken! Looks like you almost died out there," said one.

The same night, the *Aurora Australis* left Mertz polynya. A reconnaissance flight by the ship's helicopter revealed 30 miles of heavy ice to the north.

"Our progress has been very slow, less than one mile in six hours, with lots of backing and ramming," Golden said in an e-mail message the next day. "Visibility is also really bad. We're just sitting here now, in the midst of big ridges and ice probably over two meters [6.5 feet] thick. ... Things are definitely winding down and people are now in the frame of mind of getting home as quickly as possible."

At times, the ship simply drifted with the ice pack at less than 2 mph.

The research vessel left the ice in late August — early spring in Antarctica. On the way back to Tasmania, the ship stopped at Antarctica's Macquarie Island to drop off supplies and personnel at a research station there. As the weather warmed somewhat, the entire crew barbecued steaks and sausages during a picnic on the ship's deck.

The *Aurora Australis* pulled into Hobart on Sept. 8. Golden spent a weekend warming up in Hawaii before returning to Utah to resume his teaching duties and spend numerous hours sorting his 800 slides and 10 hours of video.