Ice shelves fracture under weight of meltwater lakes, study shows

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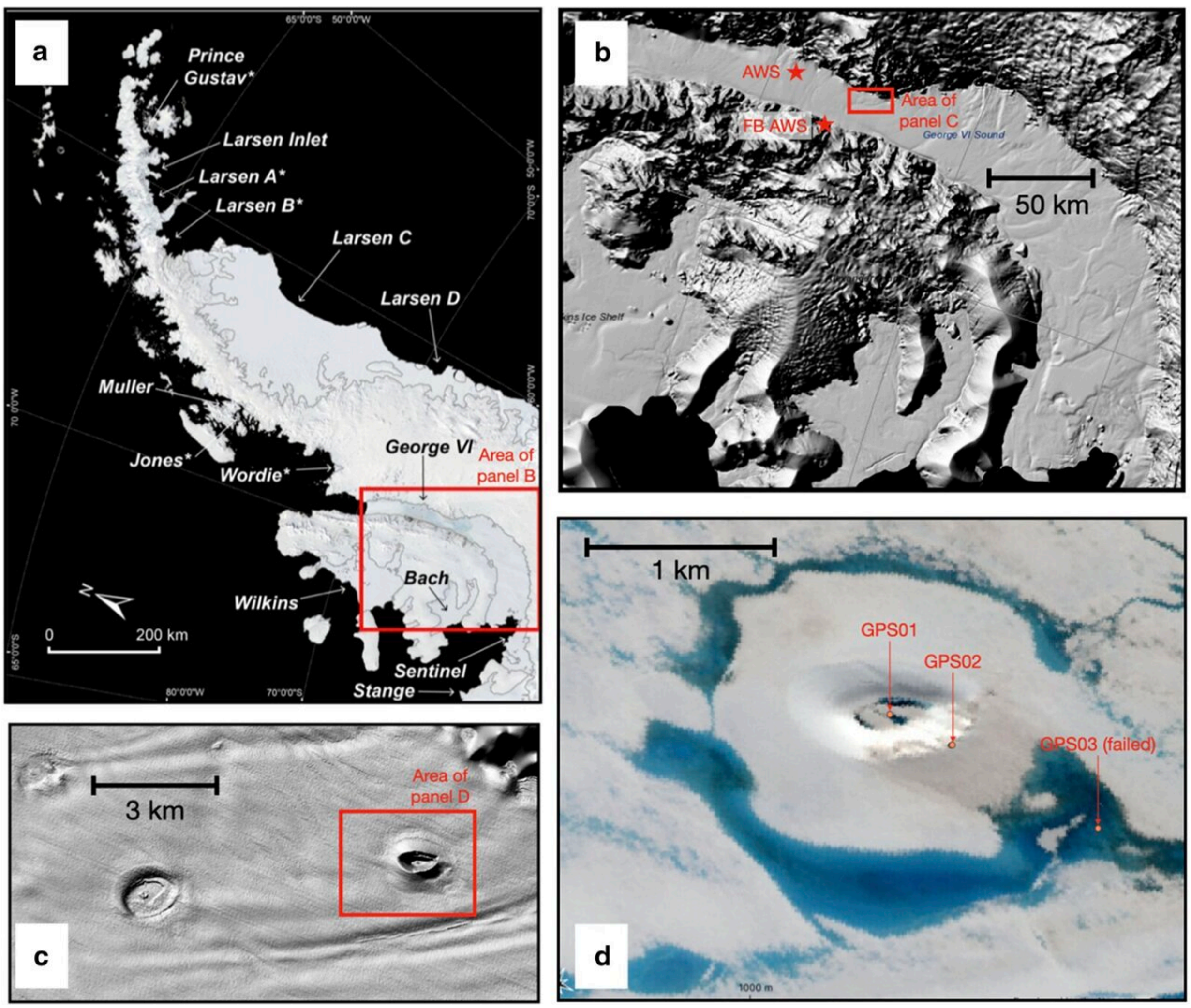

Field area. Credit: *Journal of Glaciology* (2024). DOI: 10.1017/jog.2024.31

When air temperatures in Antarctica rise and glacier ice melts, water can pool on the surface of floating ice shelves, weighing them down and causing the ice to bend. Now, for the first time in the field, researchers have shown that ice shelves don't just buckle under the weight of meltwater lakes—they fracture.

As the climate warms and melt rates in Antarctica increase, this fracturing could cause vulnerable ice shelves to collapse, allowing inland glacier ice to spill into the ocean and contribute to sea level rise.

Ice shelves are important for the Antarctic Ice Sheet's overall health as they act to buttress or hold back the glacier ice on land. Scientists have predicted and modeled that surface meltwater loading could cause ice shelves to fracture, but no one had observed the process in the field, until now.

The new study, published in the *Journal of Glaciology*, may help explain how the Larsen B Ice Shelf abruptly collapsed in 2002. In the months before its catastrophic breakup, thousands of meltwater lakes littered the ice shelf's surface, which then drained over just a few weeks.

To investigate the impacts of surface meltwater on ice shelf stability, a research team led by the University of Colorado Boulder, and including researchers from the University of Cambridge, traveled to the George VI Ice Shelf on the Antarctic Peninsula in November 2019.

First, the team identified a depression or "doline" in the ice surface that had formed by a previous lake drainage event where they thought meltwater was likely to pool again on the ice. Then, they ventured out on snowmobiles, pulling all their science equipment and safety gear behind on sleds.

Around the doline, the team installed high-precision GPS stations to measure small changes in elevation at the ice's surface, water-pressure sensors to measure lake depth, and a timelapse camera system to capture images of the ice surface and meltwater lakes every 30 minutes.

In 2020, the COVID-19 pandemic brought their fieldwork to a screeching halt. When the team finally made it back to their field site in November 2021, only two GPS sensors and one timelapse camera remained; two other GPS and all water pressure sensors had been flooded and buried in solid ice.

Fortunately, the surviving instruments captured the vertical and horizontal movement of the ice's surface and images of the meltwater lake that formed and drained during the record-high 2019/2020 melt season.

GPS data indicated that the ice in the center of the lake basin flexed downward about a foot in response to the increased weight from meltwater. That finding builds upon previous work that produced the first direct field measurements of ice shelf buckling caused by meltwater ponding and drainage.

The team also found that the horizontal distance between the edge and center of the meltwater lake basin increased by over a foot. This was most likely due to the formation and/or widening of circular fractures around the meltwater lake, which the time lapse imagery captured. Their results provide the first field-based evidence of ice shelf fracturing in response to a surface meltwater lake weighing down the ice.

"This is an exciting discovery," said lead author Alison Banwell, from the Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado Boulder. "We believe these types of circular fractures were key in the chain reaction style lake drainage process that helped to break up the Larsen B Ice Shelf."

"While these measurements were made over a small area, they demonstrate that bending and breaking of floating ice due to surface water may be more widespread than previously thought," said co-author Dr. Rebecca Dell from Cambridge's Scott Polar Research Institute.

"As melting increases in response to predicted warming, ice shelves may become more prone to break up and collapse than they are currently."

"This has implications for sea level as the buttressing of inland ice is reduced or removed, allowing the glaciers and ice streams to flow more rapidly into the ocean," said co-author Professor Ian Willis, also from SPRI.

The work supports modeling results that show the immense weight of thousands of meltwater lakes and subsequent draining caused the Larsen B Ice Shelf to bend and break, contributing to its collapse.

"These observations are important because they can be used to improve models to better predict which Antarctic ice shelves are more vulnerable and most susceptible to collapse in the future," Banwell said.

More information: Alison F. Banwell et al, Observed meltwater-induced flexure and fracture at a doline on George VI Ice Shelf, Antarctica, *Journal of Glaciology* (2024). DOI: 10.1017/jog.2024.31

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