A puzzling past sea level rise might have its missing piece



Enlarge / Over 14,000 years ago, an ice sheet was perched on Svalbard.

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The rapid rise of global temperature over the last century is almost certainly unprecedented in recent Earth history, but our current rate of sea level rise has stiffer competition. About 14,650 years ago, as the thawing of the last ice began to hit its stride, sea level made a remarkable jump of 12 meters or more—and did so in less than 400 years. It’s an

event known to scientists as Meltwater Pulse 1A.

Figuring out where all that water came from hasn’t been easy. It was certainly the result of melting glacial ice (and not some sort of biblical sky-flood), but models of past ice sheet change haven’t quite added up.

A new study led by Jo Brendryen at the University of Bergen takes an interesting route to discover that the melting of the Eurasian Ice Sheet, which has largely been overlooked, might just explain things.

Looking for a date

It actually comes down to carbon dating—measuring the amount of radioactive carbon-14 in something to calculate its age. Carbon dating works a little differently from other types of radiometric dating, in that carbon-14 is constantly produced by reactions in Earth’s atmosphere. Anything that takes in carbon atoms—which includes living things—will therefore have a similar amount as the atmosphere; once it stops that uptake, carbon-14 will gradually decay and turn into nitrogen-14. The older that thing is, the less carbon-14 will be left in it.

One complication is that the production rate of carbon-14 in the atmosphere varies slightly over time. Because this technique can only be used about 50,000 years or so into the past, however, scientists have been able to measure things with known ages (like tree rings) to cross-check and calibrate carbon-14 concentrations to ages.

But in the ocean, there’s a second complication. Carbon-14 from the atmosphere gets into surface waters quite easily, but deep water is isolated. That means it could be hundreds of years since the carbon in deep water last saw the atmosphere. If a little baby organism takes in that carbon, it’s going to look hundreds of years older than it is, in carbon-dating terms.

So just subtract the right number when working with deep ocean samples and it's fixed, right? Well, the problem is that the "right number" depends on ocean circulation *in that place* and *at that time*. This generally leads to a lot of weeping and gnashing of teeth in paleoceanography.

On ice

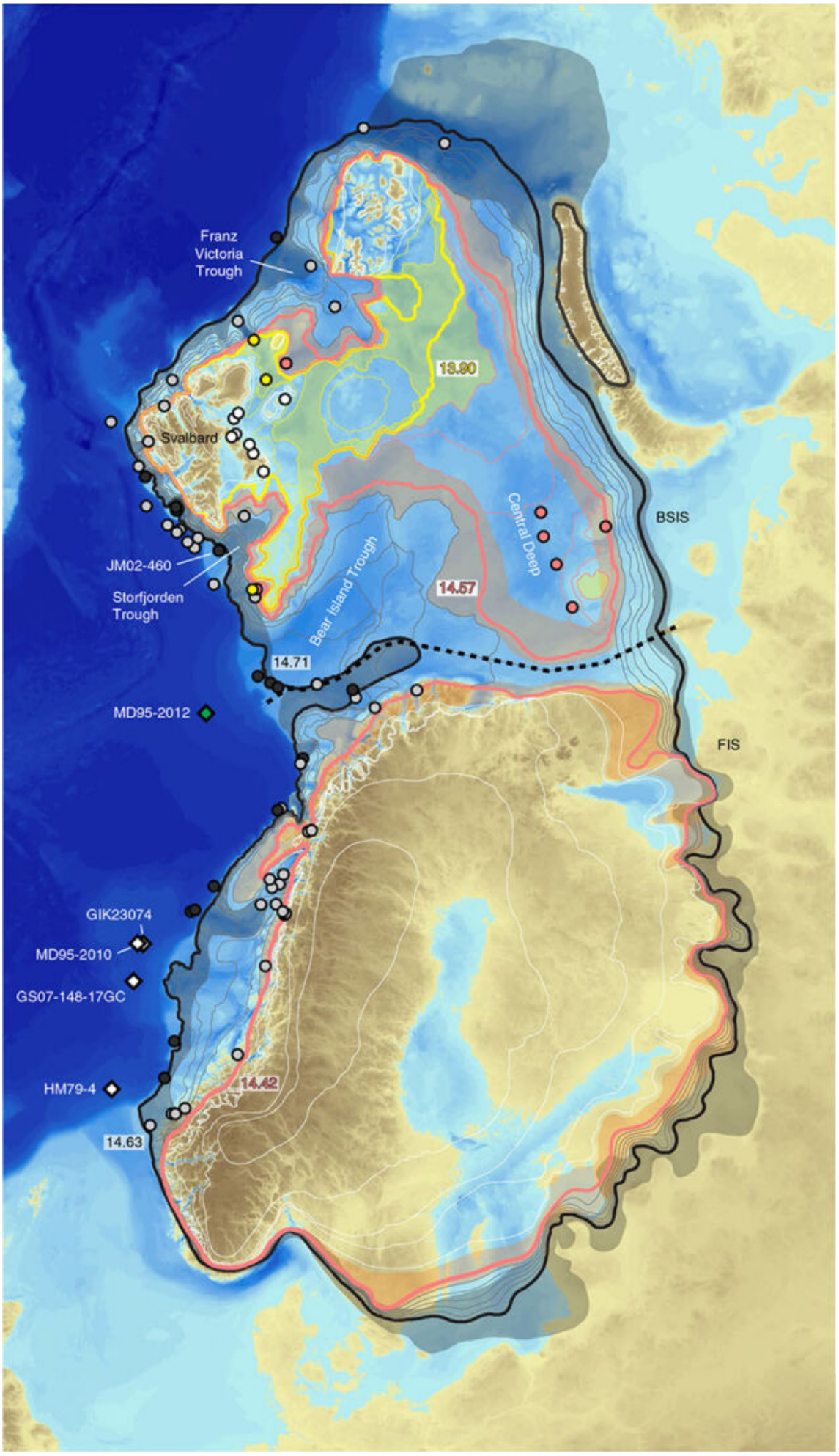
Back to the ice sheets. During the last glacial period, an ice sheet once stretched across Scandinavia and the Barents Sea. The record of its shrinking is based on carbon dating of seafloor sediment cores, pinpointing times that ice retreated and life returned to a location. The reconstructions have indicated that the ice here had basically melted before the start of Meltwater Pulse 1A, giving it a clear alibi. But the carbon-dated ages assumed that the deep ocean carbon-14 delay in that region was constant over time, matching the modern pattern.

In this new study, the researchers looked carefully at that assumption. They turned to a seemingly unlikely source—a cave in China. There is actually a pretty good correlation between ocean circulation, the temperatures in the North Atlantic, and the Asian Monsoon rains, linked by a series of climatic dominoes. Cave records have excellent timelines, with annual layers and uranium radiometric dating.

By lining up the wiggles in the cave record and Norwegian Sea sediment records, the researchers avoid having to guess the unknown deep ocean carbon-14 delay. Instead, they can *calculate* that delay and its changes, providing a new calibration for seafloor paleoclimate records in this region.

With that done, the reconstructed timing of Eurasian Ice Sheet melt shifts. Rather than showing that the local ice melted before Meltwater Pulse 1A even started, they see a major loss of ice during this event. Previous reconstructions gave the Eurasian Ice Sheet credit for perhaps one meter of the 12 or

more meters of sea level rise that occurred then. This study pushes that contribution up to about five meters—plus another meter or so in the century following.


Franz
Victoria
Trough
13.90
Svalbard
BSIS
Central Deep
JM02-460
Storfjorden
Trough
Bear Island Trough
14.57
14.71
MD95-2012
FIS
GIK23074
MD95-2010
GS07-148-17GC
HM79-4
14.42
14.63

Enlarge / Previous extent of ice sheet with ages labeled in thousands of years.

There are obvious challenges to working out which giant block of ice melted thousands of years ago. But there are valuable clues. When an ice sheet melts, sea level rise doesn't rise equally all around the world. The gravitational attraction of a massive ice sheet actually pulls seawater to it, raising sea levels near the sheet a bit. As the ice sheet shrinks, its gravitational pull relaxes, so sea level can actually *fall* right next to the ice sheet, even as it rises elsewhere. And the records of sea level change in various places are actually consistent with the Eurasian Ice Sheet being a big source: sites around Norway and Finland show a drop in sea level during this period of high-speed global sea level rise.

Re-aligning the Eurasian Ice Sheet history would make it significantly easier to understand where 12 meters of sea level came from, but it also raises some interesting questions. For example, such a massive flow of fresh water into the Norwegian Sea could be expected to gum up the critically important south-to-north conveyor-belt current in the Atlantic Ocean, but records indicate it was actually quite strong during this time. And how, exactly, did this portion of the Eurasian Ice Sheet collapse so quickly?

That question about the past is of interest to our future. The portion of the Eurasian Ice Sheet in question straddled topographic lows in contact with the ocean, making it vulnerable to rapid collapse. The same is true of the West Antarctic Ice Sheet today—the biggest wildcard for future sea level rise. Every ice sheet is different and the local details matter, but an equally rapid collapse of ice in Antarctica would be a worst-case scenario.

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