Ten years of icy data show the flow of heat from the arctic seafloor

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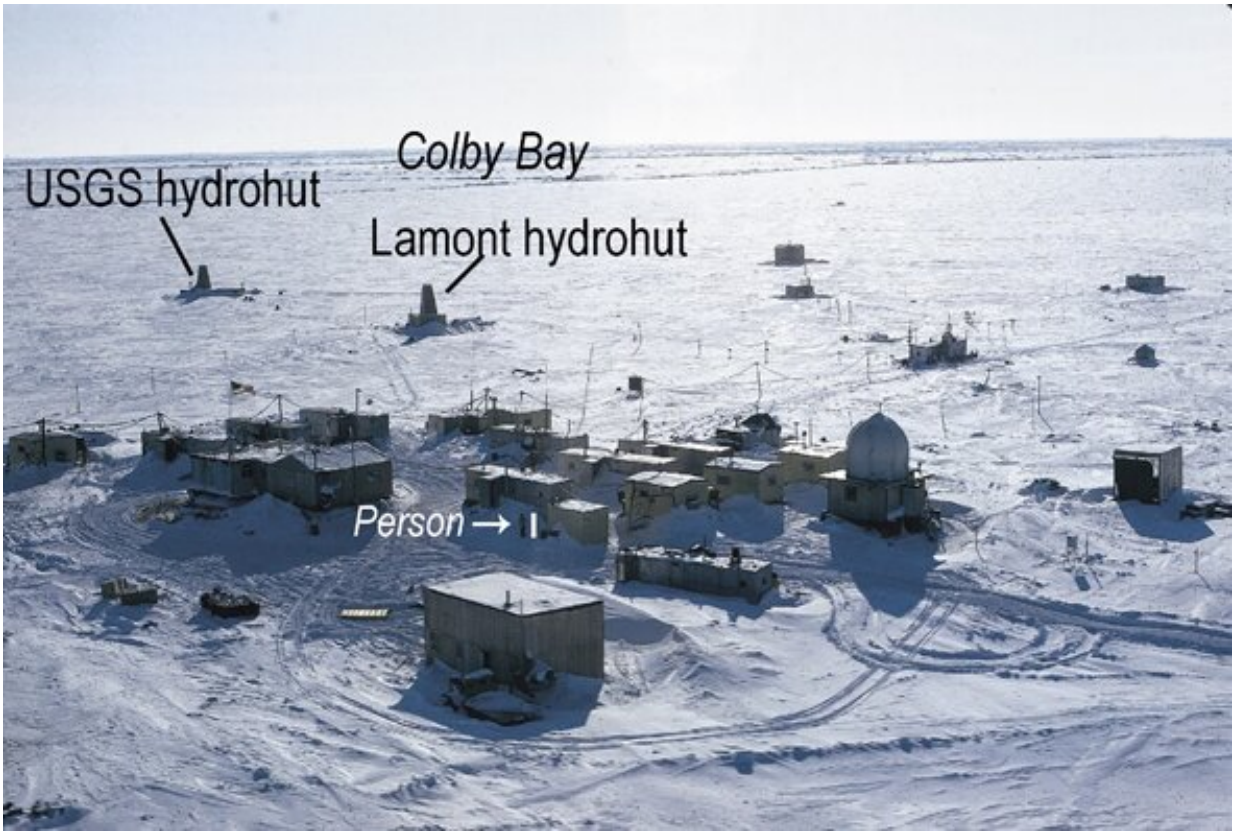


Aerial view of T-3 Ice Island science encampment in spring 1967 at ~79°N, with person in center for scale. The USGS heat flow data and sediment cores were acquired in the USGS hydrohut on the left. Credit: John K. Hall

Scientists have taken the temperature of a huge expanse of seafloor in

the Arctic Ocean in new research by the U.S. Geological Survey and the Geological Survey of Canada. The study, published in the *Journal of Geophysical Research*, is accompanied by the release of a large marine heat flow dataset collected by the USGS from an ice island drifting in the Arctic Ocean between 1963 and 1973. These never-before-published data greatly expand the number of marine heat flow measurements in the high Arctic Ocean.

Marine heat flow data use temperatures in near-seafloor sediments as an indication of how hot Earth's outer layer is. These data can be used to test plate tectonic theories, provide information on oil and gas reservoirs, determine the structure of rock layers and infer fluid circulation patterns through fractures in those rock layers.

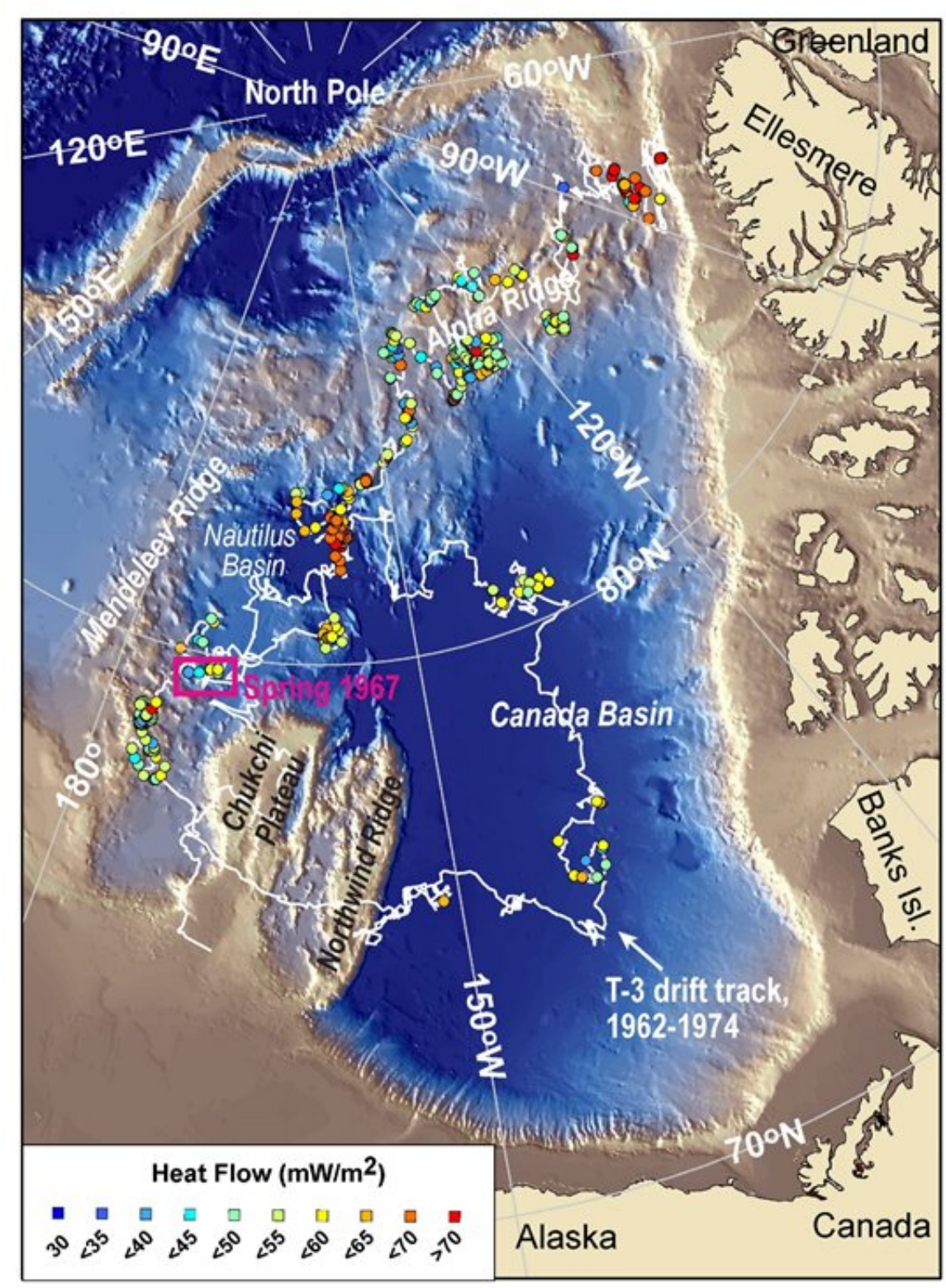
"This body of work and the fact that it remains relevant so many years later underscores the enduring contribution that USGS researchers have made to understanding even the most remote corners of the planet," said USGS associate director for natural hazards, David Applegate. "As focus on the Arctic region continues to increase, I look forward to seeing how scientists at the USGS and other institutions build on this valuable research."

Starting in 1963, now-retired USGS scientist Arthur Lachenbruch and his team of researchers conducted 356 marine heat flow measurements and acquired more than 500 seafloor sediment samples while working from a hut installed on Fletcher's Ice Island, a 30-square-mile ice floe also known as T-3. These Arctic Ocean heat flow measurements taken by the USGS over the course of 10 years represent far more than the number available for the U.S. Atlantic margin.

When asked about the release of the T-3 legacy heat flow dataset, Lachenbruch commented, "I am pleased to see the T-3 heat flow results made widely available to researchers and re-analyzed using Arctic

seismic data acquired in the past few decades."

T-3 ice island was managed by the U.S. Naval Arctic Research Laboratory and the Office of Naval Research. Researchers from the USGS, the Lamont-Doherty Earth Observatory (LDEO) and other institutions worked on T-3 for months at a time between 1962 and 1974. During this period, the LDEO recorded navigational and geophysical data at one-hour intervals, and the USGS has also released this T-3 dataset in collaboration with former LDEO researcher John K. Hall, Geological Survey of Israel (retired).



Track of drifting T-3 Ice Island around the Western Arctic Ocean from 1962 to 1974 with the 356 USGS heat flow points superposed as color-coded circles. The

location of the aerial photograph taken in Spring 1967 is indicated by the pink box. Credit: C. Ruppel, USGS

During the decade of USGS research, ocean currents and the movement of the polar ice pack carried T-3 Ice Island nearly 21,000 km (13,050 miles) through the western part of the Arctic Ocean, which is known as the Amerasian Basin. This remains one of the most remote and least-studied places on Earth even today, making the large number of heat flow measurements released by the USGS even more remarkable.

The USGS acquired the marine heat flow measurements by lowering a probe equipped with thermal sensors through a permanent hole in the ice until the probe entered the seafloor. The probe recorded temperatures in the sediments and also retrieved a sediment core that was used for other measurements by USGS researchers and colleagues at the University of Wisconsin.

In the *Journal of Geophysical Research* paper describing these measurements, USGS geophysicist Carolyn Ruppel and co-authors combine the legacy T-3 heat flow data with modern seismic images. These Arctic Ocean seismic data are acquired by icebreakers taking images hundreds to thousands of meters (up to many miles) below the seafloor to reveal sediment and rock structures, faults, and other features.

Some of the modern seismic data used in the paper were collected or compiled by the U.S. and Canadian Extended Continental Shelf projects, whose lead scientists, USGS geophysicist Deborah Hutchinson and Geological Survey of Canada researcher David Mosher, coauthored the new study. Other co-authors include Lachenbruch and retired USGS scientist Robert Munroe, who conducted laboratory thermal

measurements on recovered sediment samples while on T-3.

The new paper analyzes the variability in the T-3 heat flow dataset and shows that the temperatures of the seafloor and upper levels of the crust are not dependent on bathymetry or sediment thickness. The analysis also shows that high heat flow variability on Alpha Ridge, which was formed when a mantle hotspot triggered the creation of the High Arctic Large Igneous Province, is consistent with thin sediment cover over fractured basement rock permeated by circulating fluids.

The new study also confirms results obtained in the 1960s by Lachenbruch and USGS colleague B. Vaughn Marshall. They had postulated that differences between the make-up of the rock layers between Canada Basin and Alpha Ridge could account for a heat flow anomaly at the boundary between these provinces.

More information: C. D. Ruppel et al, Heat Flow in the Western Arctic Ocean (Amerasian Basin), *Journal of Geophysical Research: Solid Earth* (2019). DOI: 10.1029/2019JB017587

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