Volcanoes under ice: Recipe for a flood

When a volcano erupted beneath Iceland's largest ice cap on Sept. 30, geoscientists there waited anxiously for the jökulhlaup, a deluge of water pouring out from beneath the ice. With records of these glacial floods going back to the 12th century, Icelanders have grown adept at anticipating jökulhlaups and avoiding any loss of life. Yet when this flood finally burst forth from the Vatnajökull ice cap, it carried some new lessons for the expectant researchers.

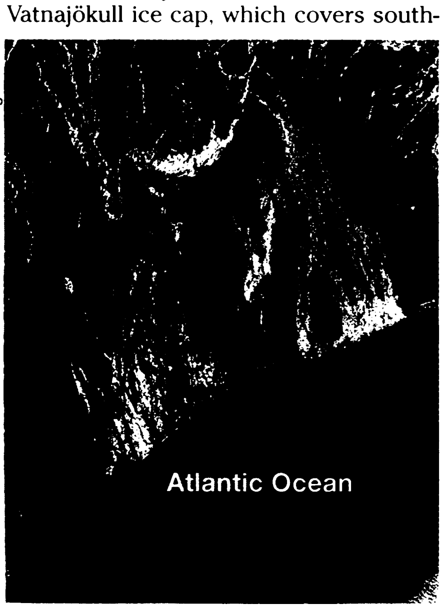

ESA/TSS/J. Garvin/NASA

Chasm formed by water flowing under ice.

Instead of striking immediately after the eruption, as predicted, the jökulhlaup didn't come until the morning of Nov. 5. It then confounded forecasts by ending too quickly. While the fastest previous flood this century took 3 days to peak, this one crested in 14 hours and died within 2 days. For a few brief hours, the surge of water and icebergs flowing toward the sea formed the second largest river in the world.

"We have learned that the descriptions from older times, which we found close to unbelievable, are probably quite correct," says Oddur Sigurdsson of the National Energy Authority in Reykjavík.

Geothermally warmed rock under the Vatnajökull ice cap, which covers southeast Iceland, generates smaller jökulhlaups every few years. Giant floods take place when eruptions under the ice cap melt vast volumes of water.

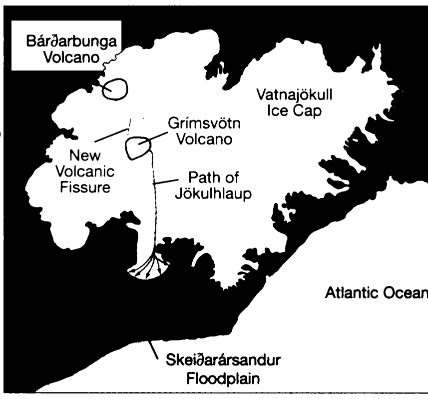

Sigurdsson

Radar image taken by Europe's ERS-2 satellite at the end of the flood. Water from beneath the glacier spreads across the floodplain and into the ocean.

The recent events started when a fissure developed between the two major volcanoes under western Vatnajökull. Within 2 days, the eruption melted through the 500-meter-thick ice cap. Water flowed beneath the ice into a large crater belonging to a hidden volcano called Grímsvötn, says Karl Grönvold of the Nordic Volcanological Institute in Reykjavík.

As the eruption subsided over the next 2 weeks, the growing lake in Grímsvötn's crater pushed up the overlying ice cap. The lake height soon exceeded the triggering point of past jökulhlaups, but the flood did not start for another 3 weeks. This delay shows that jökulhlaups are more complex than scientists have appreciated, says Sigurdsson.

The flood volume reached an estimated 3 to 4 cubic kilometers of water, with a peak discharge rate of 45,000 cubic meters per second. It damaged or destroyed three bridges, key telephone lines, and the only road running along Iceland's southern coast. Damage totaled U.S. $15 million, a considerable burden for Iceland's 250,000 people, says Sigurdsson. On the other hand, nutrients washed into the Atlantic by the flood should improve future cod stocks.


Sigurdsson

Map of the Vatnajökull ice cap shows the eruption site and the path of the glacial flood.

— *R. Monastersky*

Drawing a bead on quantum dot lasers

Tiny clusters of atoms that trap electrons like shipwrecked passengers on an island may hold the key to a new generation of lasers. Scientists want to use these atomic clusters, known as quantum dots, to make more powerful and efficient lasers that would replace the standard variety widely used in compact disc players and other devices.

To date, quantum dot lasers have been made only in infrared wavelengths. Now, scientists at the National Research Council of Canada in Ottawa have demonstrated the first quantum dot laser that emits visible light, thus increasing the potential versatility of these lasers.

In standard lasers, electrons are restricted to a flat semiconducting layer and generate light when an electric current causes them to jump between different energy levels. In a quantum dot laser, electrons are confined to a tiny volume, one only a few nanometers across (SN: 4/4/92, p. 222). Because their movement is so limited, these electrons can't waste energy on random motion, as electrons in standard lasers do.

As they report in the Nov. 22 SCIENCE, the researchers sandwiched a dense carpet of indium aluminum arsenide clusters between two layers of aluminum gallium arsenide. Each cluster had a diameter of about 20 nanometers, says study coauthor Simon Fafard. Although infrared quantum dot lasers have been made before, the Canadian team tackled the "much more difficult" task of pushing the laser energy into the red part of the visible spectrum. Going from infrared to visible light entails spreading the energy levels of the semiconductor further apart by fine-tuning its chemical composition.

Part of the technical challenge lies in making a large number of quantum dots all of the same size, says Evelyn Hu, director of the Center for Quantized Electronic Structures at the University of California, Santa Barbara. There must be enough dots initially emitting photons to trigger further emissions, leading to the coherent cascade of photons that constitutes laser light. Quantum dots of different sizes emit light of many different wavelengths—also undesirable in a laser.

It's difficult to "make a million or billion of them and guarantee that the size fluctuation is going to be less than 10 percent," Hu says. In a typical quantum dot, that constraint allows 20 atoms or fewer of leeway.

By choosing the right combination of semiconductors, however, researchers can induce the material they deposit to bead into islands of the correct size, much like water droplets on the hood of a freshly waxed car. Scientists try to avoid this beading when making flat semiconductor layers, but for quantum dots, the effect works to their advantage.

The current that a set of quantum dots needs to produce light compares well with the requirements of a flat system, Fafard says, but he hopes to make the new device more efficient by stacking layers of quantum dots. "Funny things happen when you grow one layer of quantum dots over another," Hu says. "We don't yet understand completely the best way to control the growth." — *C. Wu*