Siberia's Batagaika Crater Just Keeps Growing, and That's Not Good

By: Patrick J. Kiger | May 15, 2023

The massive Batagaika megaslump is located in Siberia's permafrost. It was discovered in the 1960s on satellite imagery. ALEXANDER KIZYAKOV, LOMONOSOV MOSCOW STATE UNIVERSITY

If you like to peruse the internet for strange, puzzling extreme phenomena — and to be honest, who among us doesn't? — you may already have come across the **Batagaika crater**. It's a massive, growing hole in the landscape of Siberia that's inspired even serious-minded scientific publications to resort to supermarket tabloid-style terminology such as the Doorway to Hell and the Gateway to the Underworld.

First spotted in the mid-1960s by surveillance satellites that were classified, the Batagaika crater has grown over the past 60 years from an insignificant gully to a massive tadpole-shaped depression that covers 200 acres (81 hectares) and stretches 2/3 of a mile (1 kilometer) in length and is 164 feet (50 meters) deep, according to the U.S. Geological Survey.

"From 1991 to 2018, the crater area increased by almost three times," Sarah Cadieux, a lecturer in New York'sRensselaer Polytechnic Institute's department of Earth and environmental sciences, says via email.

But what is it, exactly, and how did it get there? And why does it keep getting bigger?

What Is the Batagaika Crater?

Bataiga megaslump is seen here compared to Meteor Crater in Arizona, which measures 0.75 miles (1.2 kilometers) across and about 600 feet (180 meters) deep. The size of the asteroid that produced Meteor Crater is likely to be about 100 to 170 feet (30 to 50 meters). WIKIMEDIA/(CC BY-SA 4.0)

One key to understanding the Batagaika crater is to understand that it isn't actually a crater. That's a term reserved for bowl-shaped holes in the ground that are caused by

the impact of meteorites (like the Chicxulub crater), volcanic eruptions, or either a natural or man-made explosion of some sort.

Instead, the batagaika "is a retrogressive thaw slump, the largest in the world in fact," explains Roger Michaelides, an assistant professor of Earth and planetary sciences at Washington University in St. Louis. His areas of expertise include permafrost, the term for soil or rock and ice that stays frozen for long periods of time, which is often found in Arctic regions such as Alaska, Greenland and Siberia.

"Retrogressive thaw slumps belong to a class of terrain types called thermokarst that occur in areas underlain by permafrost," Michaelides says in an email.

While a non-scientist might assume that the "perma" in permafrost means that it stays frozen permanently, Michaelides says that isn't necessarily the case.

"With rising air temperatures across the Arctic, permafrost can thaw, and when it thaws it can result in dramatic changes to the landscape," he says. "In areas of ice-rich permafrost, permafrost thaw induces melting of ground ice, which causes the ground to subside and form irregular depressions in the ground surface. Some of these depressions can fill with pooling water and form thermokarst lakes, and sometimes the initiation of thermokarst can result in large gashes and slumps of ground as permafrost continues to thaw and become unstable. That's more or less what happened with the Batagaika crater."

How Did the Batagaika Crater Form?

Cutting down forests around the Batagaika crater during the Soviet era altered the thermal equilibrium of the surrounding permafrost landscape, leading to the depression that showed up in half-century-old satellite images.

"Without a vegetation canopy, more thermal energy from the sun was able to thaw permafrost, leading to the formation of a down-slope gully," Michaelides says. "The formation of this gully can lead to even more thaw of permafrost during subsequent

summer seasons, which causes the gully to expand and grow larger. As larger surface areas of exposed permafrost are liable to thaw, this process accelerates and a megaslump can form."

This type of thermokarst formation is often a positive feedback loop, he says. That's when permafrost thaws and bacteria break down the organic matter trapped inside. As it releases carbon matter into the atmosphere as greenhouse gases, these gases warm the planet, creating a positive feedback loop that then thaws more permafrost.

"The result is a massive, slowly expanding collapse feature," Michaelides continues. "As permafrost thaws, its structural strength goes from something like concrete to wet mud, and on a sloping land surface like here, this causes the ground to slump."

As Siberia warms at an unprecedented rate due to climate change, the Batagaika crater has continued to grow as well, and is likely to keep getting bigger. "In some areas, the crater is expanding at a rate of tens of meters a year," Michaelides says.

The Science of the Batagaika Crater

The foal carcass of the ancient horse that lived on the territory of Yakutia 42,000 years ago was discovered in the Batagaika crater. MAMMOTH MUSEUM OF NORTH-EASTERN FEDERAL UNIVERSITY

In one way, the growth of the Batagaika crater is a gift to science. "As this permafrost thaws, it also reveals a treasure trove of paleontological information in the form of fossils from the last ice age and potentially older," Michaelides explains.

In 2018, for example, scientists found the remains of an extinct baby horse, with well-preserved skin, hair, tail and hooves that died 42,000 years ago. That specimen yielded the oldest sample of liquid blood ever found, according to Live Science.

But the massive slump also is a potentially worrisome environmental omen.

"As permafrost thaws, methane, carbon dioxide and other greenhouse gases previously bound within the frozen permafrost can be released into the atmosphere," Michaelides explains. "This in turn can set off a positive feedback loop of its own. Rates of methane release from degrading permafrost are difficult to quantify, particularly over broad regions, but advances in satellite remote sensing may someday soon enable this type of analysis on regional and Arctic scales."

Thaw and Release of Carbon

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Thawing of permafrost on such large scales not only can yield fossils and preserved remains, like the baby foal, but it also can expose bacteria, carbon and other matter encased in ice for centuries. And that's not a good thing.

"As the crater grows, material that has been frozen and inaccessible for 650,000 years is being exposed. This includes organic matter and carbon," Cadieux says. "It is estimated that permafrost soils hold at least twice as much carbon as the atmosphere does."

Why that's potentially so bad is because microorganisms break down this newly exposed organic matter and release methane and carbon dioxide. If that were to happen slowly and steadily, 220 billion tons (200 billion metric tons) of carbon could be released in about 300 years. But if the permafrost thaws abruptly, it could increase the current permafrost carbon projections by 50 percent, Cadieux explains.

The Arctic has already warmed by almost 5.5 degrees Fahrenheit, (more than 3 degrees Celsius). That's three times faster than the rest of the world. As the air warms, it heats up

the ground and thaws more permafrost. Some studies suggest that the sudden collapse of thawing permafrost in the Arctic might double the warming of the planet from greenhouse gases.

There's also the possibility that the Batagaika crater's growth could cause local ecological problems as well, such as further loss of forest, added stress on wildlife and changes to hydrology, Michaelides says, while cautioning that this is not his area of expertise.

How Big Could the Batagaika Crater Get?

It's difficult to say. "The underlying mechanisms responsible for its growth — this runaway thermokarst formation superimposed on a downward facing slope — are not going to dissipate," Michaelides says. "As long as the surrounding area is subject to above-zero air temperature for an extended period of the year and there is additional downslope permafrost that the Batagaika megaslump can propagate into, we can expect it to continue growing in size."

Luckily, he says, we have the most advanced satellite Earth imagery available to observe changes. "Permafrost scientists like me who use satellite imagery to study permafrost processes will be able to make use of a host of satellite constellations to monitor the growth of the Batagaika crater in the coming years."

Now That's Interesting

As Michaelides cautions, saying that permafrost "melts" is regarded as a big "no-no" by scientists who study the phenomenon. "Permafrost is frozen ground, containing soil, ice, rock and organic matter," he explains. "Only the ice can melt, everything else thaws. So we can say that ground ice in permafrost melts, but permafrost as a whole thaws. The analogy that I always use is if you have a bag of frozen peas

in your freezer. If your freezer stops working, those peas will defrost or thaw. The frozen ice crystals melt, but the peas themselves thaw."

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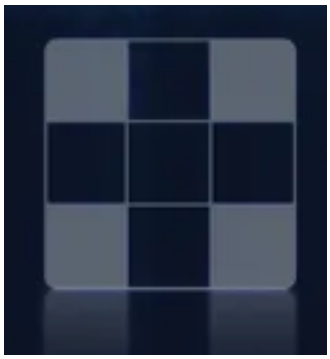

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