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A mysterious reawaking of the world's tallest geyser from decades of sleep

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The world's tallest geyser began frequently erupting in 2018. Despite many decades of study, basic questions about geyser formation, structure, and eruptive behavior remain unanswered. We investigated potential causes for the geyser's reactivation and created a model to explain why some geysers sputter while others reach magnificent heights.

Steamboat Geyser near the end of a major eruption
Image credits: Mara H. Reed

The geysers in Yellowstone National Park enthrall millions of visitors each year. Geysers are hot springs that erupt tumultuous mixtures of liquid water and steam. Although the park contains about half of the roughly 1000 geysers that exist worldwide, major geyser fields also occur in Iceland, New Zealand, Chile, Kenya, and Russia. These features are so rare because they require a specific set of geologic ingredients: a heat source, usually from volcanism; abundant water, usually in regions with lots of snow or rainfall; and silica-rich rocks overlain by unconsolidated sediments, which enable a plumbing system to form through fracture networks.

Some geysers, like Yellowstone's Old Faithful or Iceland's Strokkur, are famous for their combination of beauty and longstanding predictability. Other geysers lie dormant for years before springing back to life in a frenzy of activity. This is what Steamboat Geyser did in March 2018. Of course, Steamboat is not just any geyser—its eruptions can exceed 115 meters, making it the tallest active geyser on Earth, and it can go 50 years without a major eruption. When such a large and unpredictable geyser comes back to life, an obvious question is: why?

Steamboat Geyser has a history of cycling through active phases and relatively dormant periods. The geyser was very active in the 1960s and between

1982 and 1984. In the 34 years following the end of the last active phase, Steamboat erupted just 15 times. Since March 2018, Steamboat has erupted an impressive 141 times. This current active phase fortunately occurs at a time when Steamboat and the surrounding Norris Geyser Basin are scientifically well monitored by satellites, seismometers, GPS stations, streamgages, temperature loggers, and a weather station. We took advantage of these data sources in addition to water samples and a crowdsourced catalog of eruptions to dig into the questions raised by Steamboat's activity.

During the current active phase, the intervals between eruptions are longer in the winter than in the summer, possibly due to seasonal changes in the water table. An average eruption discharges 350 cubic meters of liquid water, which could fill nearly 500 hot tubs. Interestingly, the time between eruptions was not influenced by how much water was ejected.

But why did Steamboat reactivate in the first place? Neither anomalous precipitation nor earthquake activity seemed to be the culprit. Other scientists had already suggested that Steamboat eruptions could be tied to underground magmatic processes. The area around Norris Geyser Basin "breathes" up and down by a few centimeters due to the movement of gasses released from magma several kilometers below the surface. Indeed, steamboat's 2018 reactivation came after a period of steady uplift.

To investigate this hypothesis further, we searched for other evidence that the hydrothermal system was being affected. We estimated the amount of heat released into the atmosphere from Norris Geyser Basin using infrared satellite data and found a slight but steady increase during the years of uplift. However, the temperature of the deep reservoir supplying water to a hot spring near Steamboat did not change over the same time period. No other geysers in Norris Geyser Basin reactivated at the same time as Steamboat. Therefore, we could not conclude that Steamboat's eruptions were tied to magmatic processes and the reasons for its reactivation are still unknown. Internal changes caused by precipitation and dissolution of silica might cause dormant-active transitions in geysers, but this idea requires future study.

Finally, the reason behind Steamboat's status as the world's tallest geyser likely has to do with its plumbing system. The shallow structure of geysers is hard to map. Hot water and tight constrictions make direct imaging impractical in most cases. However, limited video observations and seismic imaging have revealed the existence of "bubble traps," which are cavities or highly fractured areas where fluids accumulate prior to eruptions. Geysers that have deeper bubble traps tend to erupt to greater heights. Water that is stored deeper has more energy to power eruptions.

To understand geysers is to understand how hot fluids circulate through our planet. Geyser study also has applications for volcanology: while volcanoes erupt lava and ash and geysers erupt water, some of the underlying physics is similar. Scientists can use geysers as volcano analogs and improve our ability to predict hydrothermal and volcanic eruptions. In the meantime, it is clear that geysers will continue capturing the curiosity of researchers and visitors alike.