Inside Old Faithful

Scientists look down the throat of a geyser

By SID PERKINS

When the world's most famous geyser opened up and said "Aaaah" for geologists, there were surprises in store.

Under the supervision of National Park Service personnel, researchers lowered several instruments, including a video camera, into Yellowstone's Old Faithful to observe conditions there. Their findings, published in the October GEOLOGY, provide the first detailed look inside a geyser that is unmatched in its combination of size, frequency, and regularity of eruptions.

James A. Westphal, a geologist at the California Institute of Technology in Pasadena, says many of the team's discoveries confirmed previous suspicions, but there were also a few unexpected findings—for example, the eruption cycle behaves more simply than the scientists had surmised.

In April and October 1984, during several eruption cycles, the researchers measured temperature and pressure every 5 seconds at eight different depths along the uppermost 21.7 meters of the geyser, its only accessible portion. Susan W. Kieffer, a coauthor of the report, says these first data were so complicated that they did not match any established theory of geyser behavior.

Says Westphal, "That's when she [Kieffer] said to me, 'You know, I'd sure like to see what it looks like in there.'"

In 1992, when miniature video cameras became widely available, the scientists returned to Yellowstone. They insulated a 2-inch video camera and lowered it into Old Faithful to map the vent and see what happens there between eruptions. "The vent had a much more complicated shape than we expected," Westphal says.

Kieffer had assumed that the vent would be a smooth vertical tube, but the camera showed that it is actually a crack running in an east-west direction that extends downward at least 14.3 m. In some portions of this fissure, the walls lie beyond the 1.8-m field of view of the camera, but other regions are extremely narrow. In one spot, at a depth of about 6.8 m, the walls close to within 15 centimeters of each other—a feature critical to explaining the geyser's behavior.

The camera also revealed that the wall of the vent is riddled with cracks and that water enters continuously at several different depths. Cool water from the local water table flows into the fissure 5.5 m and 7.5 m underground, and superheated water and steam shoot into the vent 14.3 m down.

Spikes in temperature readings at the beginning of an eruption—some of them reaching nearly 130°C—suggest that water and steam also surge into the fissure from geothermal sources at depths below 21.7 m, says Westphal.

Old Faithful blows its top every 79 minutes, on average, with intervals between eruptions ranging from 45 to 105 minutes, depending on the amount of boiling water left in the fissure when the geyser runs out of steam. "There's no real pattern, except that a short eruption is always followed by a long one," Westphal says. "The geyser pretty much keeps its own schedule."

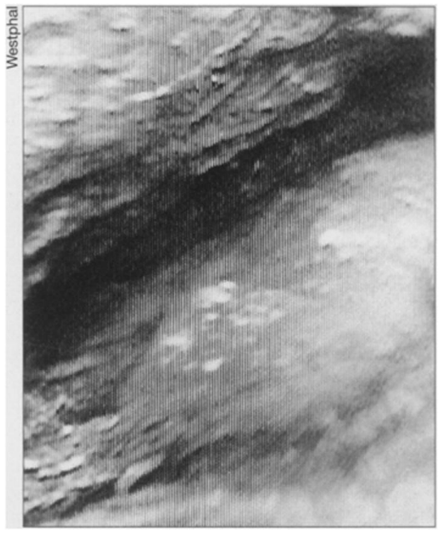
Temperature and pressure measurements show that for the first 20 or 30 seconds of each 3- to 5-minute eruption, steam and boiling water rocket through the narrowest part of the fissure at the speed of sound. During that time, the 15-cm-wide slot behaves just like the throat of a wind tunnel, limiting the geyser's discharge rate. When the pressure driving the eruption falls below a critical value, the outflow slows and the geyser's plume, which can reach a height of 55 m, begins to shrink.

"I was assuming a simple geometry for the fissure and expected a complicated physical explanation for the geyser's behavior," Kieffer says. "The video camera showed us it was just the reverse."

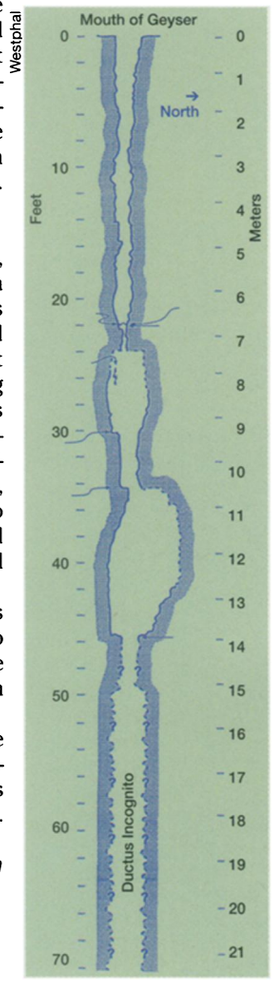
The researchers observed the water as it boiled, churned, and surged through the fissure. The behavior of the bubbles in the water confirmed their suspicion that carbon dioxide is present in the geyser's water, although the power behind the eruption comes from steam.

Moreover, Westphal was surprised to find that even though groundwater constantly replenishes the pool of liquid in the fissure, the water will sometimes recede to the unobservable lower levels of the fissure for minutes at a time. What's happening in the deeper recesses of Old Faithful remains a mystery, he says.

The forces of nature that give life to the geyser also contain the agents of its ultimate demise. The superheated water that constantly recharges the fissure is saturated with minerals, which precipitate onto the walls of the vent as silica. In a geological equivalent of hardening of the arteries, Old Faithful will eventually become clogged and die, a fate Westphal says has already befallen several nearby geysers. □



A look downward at the narrowest portion of the vent, where the walls come within 15 cm of each other. The north wall of the fissure is at the top of photo.



Scientists used images from a video camera to generate the first detailed map of the upper 14.3 m of Old Faithful's vent.