Photos may improve understanding of volcanic processes

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A team of Penn State researchers studied Telica Volcano, a persistently active volcano in western Nicaragua, to both observe and quantify small-scale intra-crater change associated with background and eruptive activity. Credit: Google Earth

The shape of volcanoes and their craters provide critical information on their formation and eruptive history. Techniques applied to photographs—photogrammetry—show promise and utility in correlating shape change to volcanic background and eruption activity.

Changes in volcano shape—morphology—that occur with major eruptions are quantifiable, but background volcanic activity, manifesting as small volume explosions and crater wall collapse, can also cause changes in morphology and are not well quantified.

A team of Penn State researchers studied Telica Volcano, a persistently active volcano in western Nicaragua, to both observe and quantify small-scale intra-crater change associated with background and eruptive activity. Geologists consider Telica 'persistently' active because of its high levels of seismicity and volcanic degassing, and it erupts on less than 10-year time periods.

The team used direct observations of the crater, photographic observations from 1994 to 2017 and photogrammetric techniques on photos collected between 2011 and 2017 to analyze changes at Telica in the context of summit crater formation and eruptive processes. They used structure-from-motion (SfM), a photogrammetric technique, to construct 3-D models from 2-D images. They also used point cloud differencing, a method used to measure change between photo sampling periods, to compare the 3-D models, providing a quantitative measure of change in crater morphology. They reported their results in *Geochemistry, Geophysics, Geosystems.*

"Photos of the crater were taken as part of a multi-disciplinary study to investigate Telica's persistent activity," said Cassie Hanagan, lead author on the study. "Images were collected from our collaborators to make observations of the crater's features such as the location and number of fumaroles or regions of volcanic degassing in the crater. For time periods that had enough photos, SfM was used to create 3-D models of the crater. We could then compare the 3-D models between time periods to quantify change."

Using the SfM-derived 3-D models and point cloud differencing allowed the team to quantify how the crater changed through time.

"We could see the changes by visually looking at the photos, but by employing SfM, we could quantify how much change had occurred at Telica," said Peter La Femina, associate professor of geosciences in Penn State's Department of Geosciences. "This is one of the first studies to look at changes in crater morphology associated with background and eruptive activity over a relatively long time span, almost a 10-year time period."

Telica's morphological changes were then compared to the timing of eruptive activity to investigate the processes leading to crater formation and eruption.

Volcanoes erupt when pressure builds beyond a breaking point. At Telica, two mechanisms for triggering eruptions have been hypothesized. These are widespread mineralization within the underground hydrothermal system that seals the system and surficial blocking of the vent by landslides and rock fall from the crater walls. Both mechanisms could lead to increases in pressure and then eruption, according to the researchers.

"One question was whether or not covering the vents on the crater floor could cause pressure build up, and if that would cause an explosive release of this pressure if the vent were sufficiently sealed," said Hanagan.

Comparing the point cloud differencing results and the photographic observations indicated that vent infill by mass wasting from the crater walls was not likely a primary mechanism for sealing of the volcanic system prior to eruption.

"We found that material from the crater walls does fall on the crater floor, filling the eruptive vent," said La Femina. "But at the same time, we still see active fumaroles, which are vents in the crater walls where high temperature gasses and steam are emitted. The fumaroles remained active even though the talus from the crater walls covered the vents. This suggests that at least the deeper magma-hydrothermal system is not directly sealed by landslides."

The researchers further note that crater wall material collapse is spatially correlated to where degassing is concentrated, and that small eruptions blow out this fallen material from the crater floor. They suggest these changes sustain a crater shape similar to other summit craters that formed by collapse into an evacuated magma chamber.

"What we found is that during the explosions, Telica is throwing out a lot of the material that came from the crater walls," said La Femina. "In the absence of magmatic eruptions, the crater is forming through this background process of crater wall collapse, and the regions of fumarole activity collapse preferentially."

More information: Catherine Hanagan et al. Changes in Crater Morphology Associated With Volcanic Activity at Telica Volcano, Nicaragua, *Geochemistry, Geophysics, Geosystems* (2020). DOI: 10.1029/2019GC008889

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