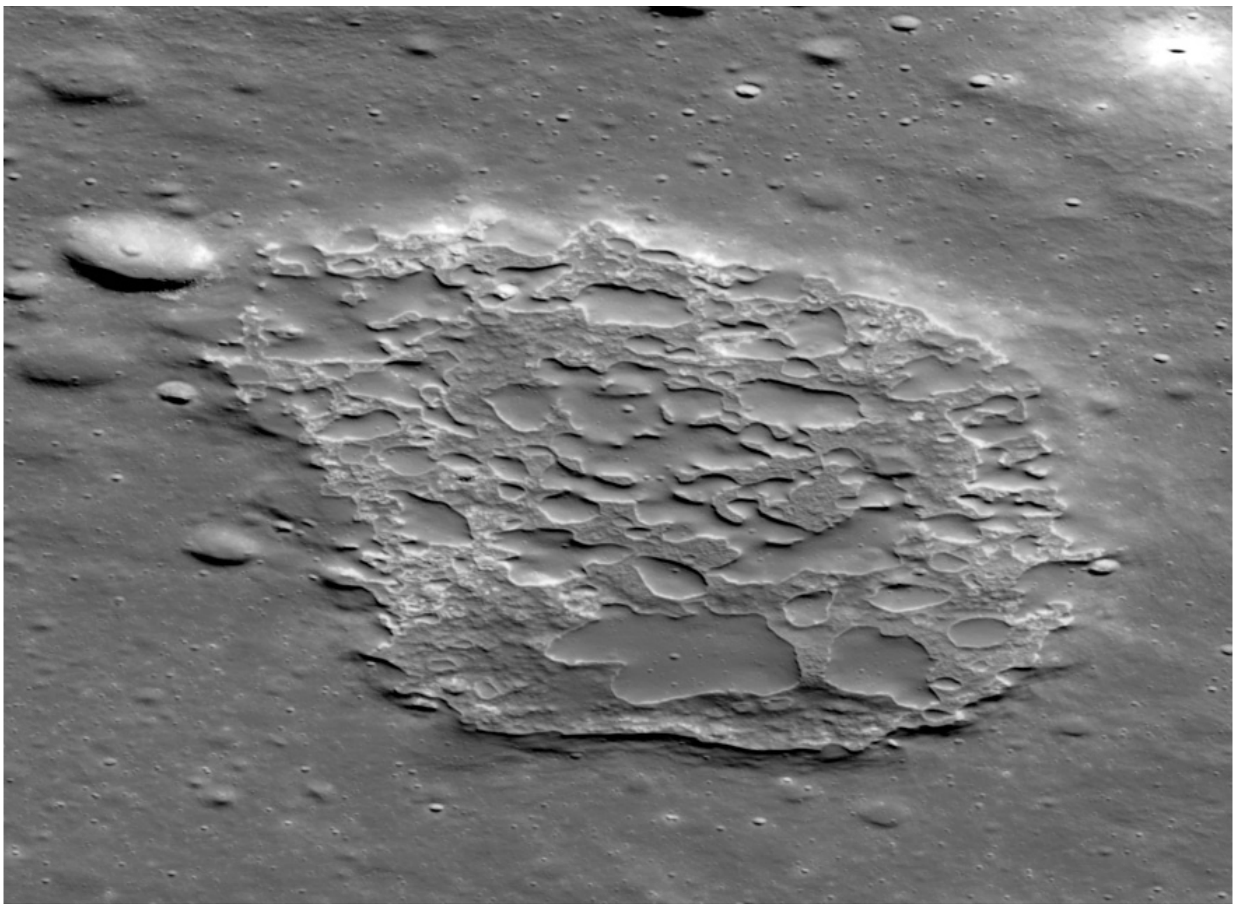
How a young-looking lunar volcano hides its true age

March 28 2017, by Kevin Stacey



The feature known as Ina, as seen by NASA's Lunar Reconnaissance Orbiter, was likely formed by an eruption of fluffy 'magmatic foam,' new research shows. Credit: NASA/GSFC/ASU

While orbiting the Moon in 1971, the crew of Apollo 15 photographed a strange geological feature—a bumpy, D-shaped depression about two miles long and a mile wide—that has fascinated planetary scientists ever since. Some have suggested that the feature, known as Ina, is evidence of a volcanic eruption Moon within the past 100 million years—a billion years or so after most volcanic activity on the Moon is thought to have ceased.

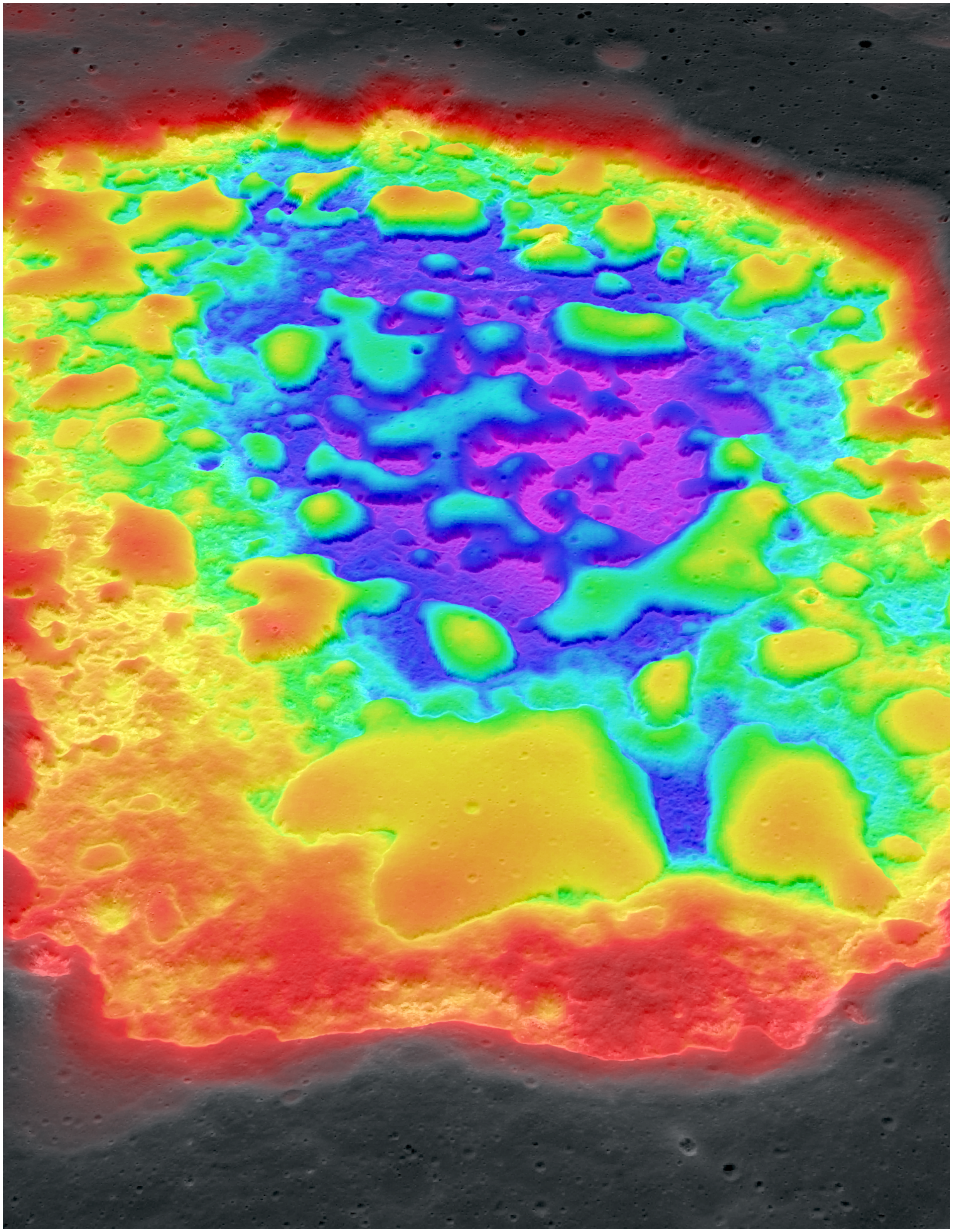
But new research led by Brown University geologists suggests that Ina is not so young after all. The analysis, published in the journal *Geology*, concludes that the feature was actually formed by an eruption around 3.5 billion years ago, around the same age as the dark volcanic deposits we see on the Moon's nearside. It's the peculiar type of lava that erupted from Ina that helps hide its age, the researchers say.

"As interesting as it would be for Ina to have formed in the recent geologic past, we just don't think that's the case," said Jim Head, co-author of the paper and professor in Brown's Department of Earth, Environmental and Planetary Sciences. "The model we've developed for Ina's formation puts it firmly within the period of peak volcanic activity on the Moon several billion years ago."

Youthful appearance

Ina sits near the summit of a gently sloped mound of basaltic rock, leading many scientists to conclude that it was likely the caldera of an ancient lunar volcano. But just how ancient wasn't clear. While the flanks of the volcano look billions of years old, the Ina caldera itself looks much younger. One sign of youth is its bright appearance relative to its surroundings. The brightness suggests Ina hasn't had time to accumulate as much regolith, the layer of loose rock and dust that builds up on the surface over time.

Then there are Ina's distinctive mounds—80 or so smooth hills of rock, some standing as tall as 100 feet, which dominate the landscape within the caldera. The mounds appear to have far fewer impact craters on them compared to the surrounding area, another sign of relative youth. Over time, it's expected that a surface should accumulate craters of various sizes at fairly constant rates. So scientists use the number and size of craters to estimate the relative age of a surface. In 2014, a team of researchers did a careful crater-count on Ina's mounds and concluded that they must have been formed by lava that erupted to the surface within the last 50 to 100 million years.



A relief image (red and yellow indicate higher elevation) shows Ina's volcanic mounds rising from the caldera floor. Credit: NASA/GSFC/ASU

"That was a really puzzling finding," Head said. "I think most people agree that the volcano Ina sits on was formed billions of years ago, which means there would have been a pause in volcanic activity for a billion years or more before the activity that formed Ina. We wanted to see if there might be something about geologic structure within Ina that throws off our estimation of its age."

Not so young?

The researchers looked at well-studied volcanoes on Earth that might be similar to Ina. Ina appears to be a pit crater on a shield volcano, a gently sloping mountain similar to the Kilauea volcano in Hawaii. Kilauea has a pit crater similar to Ina known as the Kilauea Iki crater, which erupted in 1959.

As lava from that eruption solidified, it created a highly porous rock layer inside the pit, with underground vesicles as large as three feet in diameter and surface void space as deep as two feet. That porous surface, Head and his colleagues say, is created by the nature of the lava erupted in the late stages of events like this one. As the subsurface lava supply starts to diminish, it erupts as "magmatic foam"—a bubbly mixture of lava and gas. When that foam cools and solidifies, it forms the highly porous surface.

The researchers suggest that an Ina eruption would have also produced magmatic foam. And because of the Moon's decreased gravity and nearly absent atmosphere, the lunar foam would have been even fluffier than on Earth, so it's expected that the structures within Ina are even more porous than on Earth.

It's the high porosity of those surfaces that throws off date estimates for Ina, both by hiding the buildup of regolith and by throwing off crater counts.

An eruption at Kilauea Iki in 1959 was probably similar to the eruption that formed Ina on the Moon. Credit: USGS

A highly porous surface, the researchers say, would allow loose rock and dust to filter into surface void space, making it appear as though less regolith has built up. That process would be perpetuated by seismic shaking in the region, much of which is caused by ongoing meteor impacts. "It's like banging on the side of a sieve to make the flour go through," Head said. "Regolith is jostled into holes rather than sitting on the surface, which makes Ina look a lot younger."

Porosity could also skew crater counts. Laboratory experiments using a high-speed projectile cannon have shown that impacts into porous targets make much smaller craters. Because of Ina's extreme porosity, the researchers say, its craters are much smaller than they would normally be, and many craters might not be visible at all. That could drastically alter the age estimate derived from crater counts.

The researchers estimate that the porous surface would reduce by a factor of three the size of craters on Ina's mounds. In other words, an impactor that would make a 100-foot-diameter crater in lunar basalt bedrock would make a crater of a little over 30 feet in a foam deposit. Taking that scaling relationship into account, the team gets a revised age for the Ina mounds of about 3.5 billion year old. That's similar to the surface age of the volcanic shield that surrounds Ina, and places the Ina activity within the timeframe of common volcanism on the Moon.

The researchers believe this work offers a plausible explanation for Ina's formation without having to invoke the puzzling billion-year pause in volcanic activity.

"We think the young-looking features in Ina are the natural consequence of magmatic foam eruptions on the Moon," Head said. "These landforms created by these foams simply look a lot younger than they are."

More information: Le Qiao et al, Ina pit crater on the Moon: Extrusion of waning-stage lava lake magmatic foam results in extremely young crater retention ages, *Geology* (2017). DOI: 10.1130/G38594.1

Provided by Brown University