Volcanoes may have killed Venus with a runaway greenhouse: Implications for Earth-bound volcanism

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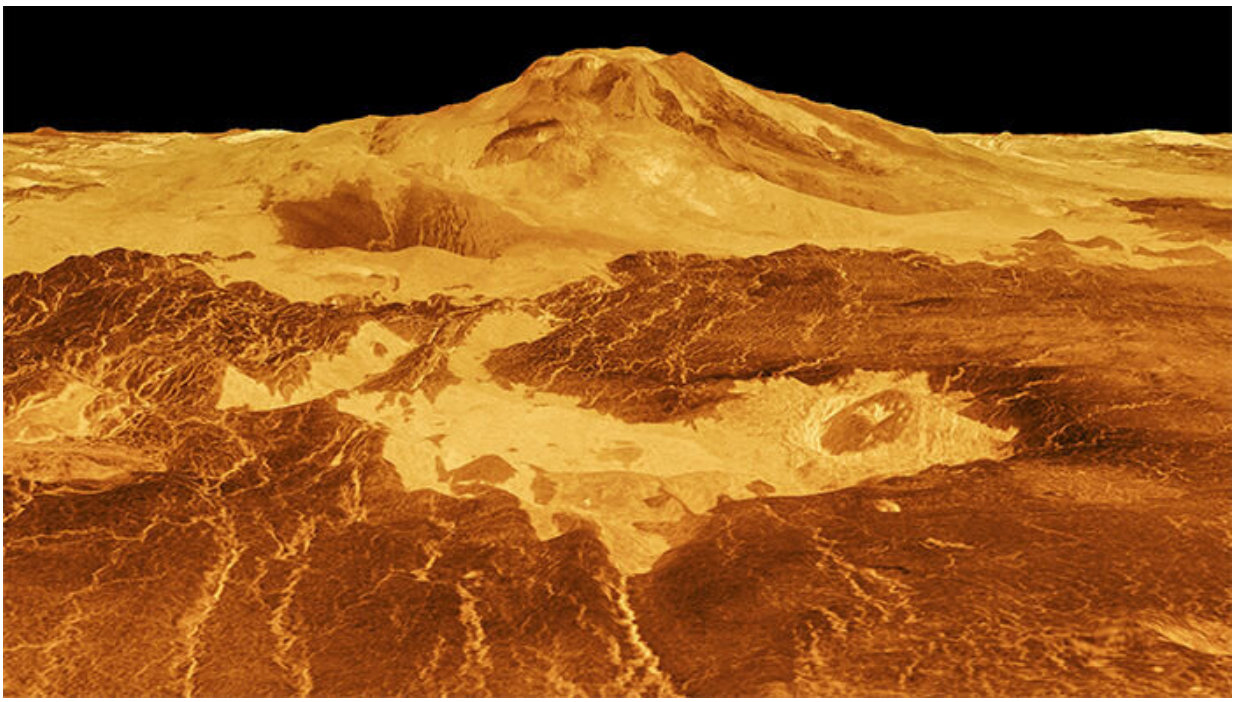

Maat Mons, a massive shield volcano, is displayed in this computer generated three-dimensional perspective of the surface of Venus. This NASA Magellan image was released on April 22, 1992. Credit: NASA

What turned Venus into hell? It could have simply been a steadily warming sun, but new research suggests that volcanoes may have played

a role in creating a runaway greenhouse effect. And the same history of active Volcanism almost killed the Earth, too.

Earth and the volcano

Exactly how often has the Earth suffered massive episodes of volcanism, and how bad did those episodes affect our planet? To get a handle on these questions, a team of researchers investigated the occurrence of large igneous provinces (LIPs), which are huge deposits of magma-born rock scattered across the globe.

The only way to make an LIP is to rip open the crust of the Earth. This can happen when tectonic plates diverge or when mantle plumes rise to the surface. During the formation of an LIP, tons of greenhouse gases release into the atmosphere, dramatically altering the climate. The formation of a single LIP lasts for around five million years, and they have devastating impacts on the climate. They've even been linked to more mass extinction events than comets or asteroids impacting the Earth's surface.

Brewing disaster

We only have an incomplete record of LIPs on the Earth. This is because our planet constantly resurfaces itself through plate tectonics. But even though the present surface of the Earth is only roughly 500 million years old, clever geologists have been able to discover the remains of LIPs buried deep in the crust.

According to the research, recently published in *The Planetary Science Journal*, individual LIPs appear to be random. There is no known cause that could trigger the formation of multiple LIPs together. Also, presumably a single LIP formation event does not permanently alter a

climate system, because the Earth has experienced multiple LIP formations and we still have a stable climate.

However, a single LIP formation can damage a climate, drastically increasing the atmosphere's temperature through the greenhouse effect. And some LIP formation events do coincide with each other out of pure chance. Based on the geological record, the researchers found that simultaneous LIP formation events are likely. Many occur within a million years of each other, which is shorter than the duration of the impact of a single one.

The runaway Venus

Multiple simultaneous LIP formation events can totally wreck a planet. If too many go off at once, then too many greenhouse gases escape into the atmosphere. This can trigger a runaway effect. If the atmosphere traps too much heat, then the oceans begin to evaporate. With more water in the atmosphere, it traps even more heat, warming the oceans further. The cycle goes on and on, eventually leading to the "heat death" of a temperate world.

Obviously the Earth avoided this fate, but only by the skin of our teeth, according to the research. If too many LIPs formed at once, our climate could have shifted into overdrive. Perhaps then this is what happened to our sister planet, Venus. We see evidence of many extinct volcanoes on Venus, although we don't know how many have been erased by weathering or plate tectonics.

If Venus experienced too many LIPs at once, it could have triggered the runaway greenhouse effect that killed the world. The next step in this research is to try to understand how many LIPs is too much and figure out where the tipping point is. With increased interest in Venus and space probes on the slate to explore that planet, we may have a window

into the history of that planet's volcanism. Putting that all together may reveal the nasty history of that twisted, blasted world.

More information: M. J. Way et al, Large-scale Volcanism and the Heat Death of Terrestrial Worlds, *The Planetary Science Journal* (2022). DOI: 10.3847/PSJ/ac6033