Huge volcanic eruption didn't cause climate change and mass extinction 140 million years ago

March 31 2021, by Joshua Davies, Brenda Chung Rocha and Nicolas Greber

Credit: AI-generated image (disclaimer)

Mass extinctions are times in Earth's past when large proportions of life suddenly and catastrophically died. These have occurred periodically over the past 550 million years. The exact causes of these extinctions are

not fully understood, but there appears to be a remarkable coincidence between mass extinctions and huge volcanic eruptions that form large igneous provinces (LIPs).

LIPs are massive volcanoes that produce millions of cubic kilometers of basaltic magma in a very short time. They are much bigger in scale than the famous super eruptions—like the Yellowstone caldera supervolcano—which typically release less than 5,000 cubic kilometers of magma.

The magma from LIPs can release enough gases during eruption, such as carbon dioxide (a greenhouse gas) or sulfur-based compounds, to change the climate. This climate change in turn affects the composition of the oceans and quickly leads to the death of life on Earth.

While huge volcanic eruptions have been linked to mass extinctions on Earth, our research shows that one of the world's largest known LIPs may have had no effect on climate or caused any extinctions. Before our study, the precise age of the LIP was not really known; with our improved dataset and higher precision analysis, we were able to show that these things did not occur at the same time.

Not just eruptions

Research has also suggested that basalt from LIPs, which intrude into the crust, can heat up and change—metamorphose—sedimentary rocks that are rich in volatiles, compounds that vaporize readily. This metamorphism can release huge amounts of gases such as methane and sulfur dioxide from the sediments, which also change the climate—leading to mass extinctions.

Both of these mechanisms have been blamed for causing the climate change which resulted in mass extinctions. However, there are also cases of LIPs that don't seem to cause mass extinctions and also extinctions

that have no apparent LIP. The relationship between these huge LIP volcanic eruptions and mass extinctions may not be as clear as previously thought. Disentangling the exact mechanisms involved has been the focus of numerous scientific studies.

One extremely important factor to consider is the exact age of the LIP relative to the mass extinction. If the ages of the climate change, associated mass extinction and the LIP do not overlap, then the volcanism is not the cause.

Credit: AI-generated image (disclaimer)

Brazilian eruption

To investigate whether one of the world's largest LIPs caused massive

climate change and a mass extinction, our research team generated highly precise ages for the Paraná-Etendeka LIP in Brazil. We dated the mineral zircon that crystallized within the erupted lava flows using the U-Pb system allowing us to precisely determine the eruption age of the lavas. This technique produces precise and accurate ages for LIPs.

Numerous studies had linked this LIP to a mass extinction event found in the oceans. The first thing we wanted to know was when did this LIP erupt, and for how long. Once we had this information, we could determine if it occurred at exactly the same time as the mass extinction event.

Our study focused on the Paraná Magmatic Province—the South American portion of the LIP in Brazil—which is by far the largest, and produced approximately one million cubic kilometers of magma.

When this LIP erupted, 140 million years ago, South America and Africa were connected and were part of the Gondwana supercontinent. This LIP erupted in Brazil and Namibia, when both of these areas were neighbors before the opening of the Southern Atlantic Ocean.

Many studies have suggested that this LIP caused global climate change which led to a small mass extinction and also a reduction in the oxygen concentration in the oceans. This period is called the Valanginian event.

Volcanic rocks (dacites overlying basalts) from the Paraná LIP related to the opening of the South Atlantic Ocean at Caracol State Park, in Rio Grande do Sul, Brazil. Credit: Ana Carolina Lucchetti, Author provided

No environmental effects

Our research shows that that the Paraná LIP erupted extremely quickly, around one million years after the mass extinction and so it is unlikely to have been the cause. There is one older part of the Paraná LIP that we did not work on which could have caused the Valanginian event. But most LIPs erupt over a very short period of time, so it is unlikely that the older portion is more than one million years older than the rest of the

province.

We also did not work on the Etendeka part of the province in Namibia. However this part of the province is extremely small in comparison to the South American part, and we expect that it erupted coincidentally with the Paraná, although it may have continued to erupt for longer (and therefore may be younger).

Our study of the Paraná LIP proves that the eruption of huge volumes of LIP magma alone may not be enough to cause mass extinctions. The question that remains is why this huge eruption of magma had almost no effect on the climate; our theory is that the lack of volatile-rich sediments around the Paraná LIP meant that no extra volatiles were released due to metamorphism during the positioning, or emplacement, of the LIP. Perhaps the metamorphism of sediments by LIP magmas, and the gas released associated with this, is the main driver of climate change leading to mass extinctions?

Earth's largest mass extinction event occurred at the end of the Permian period, coinciding with the eruption of the Siberian Traps LIP. This LIP intruded large volatile rich sedimentary basins which likely caused the release of massive amounts of volatile compounds.

Our findings for the Paraná LIP also depend on the age of the Valanginian event. Currently, the age estimation for this event is based on cyclic analysis of ocean sediments, but it is possible that with greater precision, we may find it overlaps with the Paraná LIP. While huge volcanic eruptions have been linked to mass extinctions on Earth, our research shows that one of the world's largest known LIPs may have had no effect on climate or caused any extinctions. But for now, it seems that the Paraná LIP had almost no environmental effect on our planet.

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