

How much gas to kill a dinosaur?

Volcanologists **Steve Self**, **Steve Blake** and colleagues have, for the first time, estimated the amount of sulfur dioxide released from a volcanic eruption dating back to the time when dinosaurs went extinct.

Scientists have long puzzled over the cause of mass extinctions. There are two popular theories. One is that huge meteorites collided with the Earth causing large amounts of debris to enter the atmosphere, darkening the skies and causing global cooling. A mass extinction 65 million years ago appears to correlate to a time when the Earth was shocked by a massive meteorite hitting Mexico, but there is scant evidence for impacts at the times of other major extinctions. A second theory is that volcanic eruptions are to blame.

Where the Earth's crust tears apart, staggeringly large eruptions can occur which gradually flood the land with basalt lava. In Siberia, these ancient lava flows cover an area greater than Europe. Thankfully, these types of flood basalt eruptions are rare, none being recorded in the last 15 million years. Intriguingly, all five of the Earth's major mass extinctions coincide with a period of flood basalt eruptions.

Previous arguments for or against a cause-and-effect relationship have centred on the timings of these three natural phenomena. Although we are a long way from resolving this issue, our research paves the way for a better understanding of the interactions between ancient volcanoes and climate, and how volcanic activity could threaten life globally.

India's Deccan Traps province was built from many hundreds of flood basalt eruptions, which entombed the landscape in lava approximately 65 million years ago. Until now, there has been little research into the precise way these eruptions affected the environment. It seems logical that they could severely affect life on Earth by injecting huge amounts of toxic gases

into the atmosphere. Sulfur dioxide gas is potentially one of the biggest culprits, as it results in atmospheric droplets of sulfuric acid, cooling the Earth and causing acid rain.

We decided to estimate the amounts of sulfur dioxide (SO₂) emitted by these ancient eruptions. Since 1979, satellites have been able to measure atmospheric SO₂ from volcanoes, but how could we measure gas released from older eruptions? Crystals growing in cooling magma deep below the surface occasionally engulf small patches of liquid. When the magma erupts, these tiny pockets of trapped liquid retain their dissolved gases but the rest of the liquid violently degasses. By measuring the sulfur content of the liquid pockets and the degassed liquid (both rapidly turn to glass when the lava cools), and roughly knowing the amount of erupted lava, we were able to calculate the amount of SO₂ released into the atmosphere.

We now have the first analytical data on the sulfur content from the Deccan Traps. A maximum of 3.5 to 5.4 million tons of sulfur dioxide could have been released per cubic kilometre of lava. Between one and two million cubic kilometres of lava slowly erupted over hundreds of thousands of years (0.5 to 0.8 million years). We are not clear about the duration of the pulses of activity, but we expect that each eruption could have led to the semi-persistent release of hundreds to thousands of teragrams (one teragram is equal to one million metric tons) of SO₂ each year for a decade or so. This is greater than today's global volcanic SO₂ emissions by more than an order of magnitude, and current human activities result in about 80 teragrams of annual



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SO₂ emissions. We think the Deccan Traps eruptions would have emitted enough sulfur to have a major detrimental effect on life on Earth.

The fate of these massive gas discharges, the heights to which the eruptive plumes rose, and their hazardous effects on the environment are important topics still to be investigated. Our work provides the first attempt to quantify the levels of SO₂ released from ancient basaltic lava flows which will help scientists model the environmental impact of these volcanic outbursts during Earth's history. ❁

Steve Self is professor of volcanology and Steve Blake is a senior lecturer in the Department of Earth and Environmental Sciences at the Open University. Tel: 01908 655167, email stephen.self@open.ac.uk or s.blake@open.ac.uk
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More on this topic:

'Sulfur and chlorine in Late Cretaceous Deccan magmas and eruptive gas release'. *Science*, March 2008. *Planet Earth*, 'Mass Extinctions', Autumn 2006.