Volcanic super eruptions are millions of years in the making—followed by swift surge, scientists find

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Researchers at the University of Bristol and Scottish Universities Environmental Research Centre have discovered that super-eruptions occur when huge accumulations of magma deep in the Earth's crust, formed over millions of years, move rapidly to the surface disrupting pre-existing rock.

Using a model for crustal flow, an international team of scientists were able to show that pre-existing plutons—a body of intrusive rock made from solidified magna or lava—were formed over a few million years prior to four known gigantic super eruptions and that the disruption of these plutons by newly emplaced magmas took place extraordinarily rapidly. While the magma supplying super eruptions takes place over a prolonged period of time, the magma disrupts the crust and then erupts in just a few decades.

The findings, published today in *Nature*, explain these extreme differences in time ranges for magma generation and eruption by flow of hot but solid crust in response to ascent of the magma, accounting for the infrequency of these eruptions and their huge volumes.

Professor Steve Sparks of Bristol's School of Earth Sciences explained: "The longevity of plutonic and related volcanic systems contrasts with short timescales to assemble shallow magma chambers prior to large-magnitude eruptions of molten rock. Crystals formed from earlier magma pulses, entrained within erupting magmas are stored at temperatures near or below the solidus for long periods prior to eruption and commonly have very short residence in host magmas for just decades or less."

This study casts doubt on the interpretation of prolonged storage of old crystals at temperatures high enough for some molten rocks to be present and indicates the crystals derived from previously emplaced and completely solidified plutons (granites).

Scientists have known that volcanic super-eruptions eject crystals derived from older rocks. However, before this, they were widely thought to have originated in hot environments above the melting points of rock. Previous studies that show the magma chambers for super-eruptions form very rapidly but there was no convincing explanation for this rapid process. While modeling suggested that super-volcanic eruptions would need to be preceded by very long periods of granite pluton emplacement in the upper crust, evidence for this inference was largely lacking.

Prof Sparks added: "By studying of the age and character of the tiny crystals erupted with molten rock, we can help understand how such eruptions happen.

"The research provides an advance in understanding the geological circumstances that enable super eruptions to take place. This will help identify volcanoes that have potential for future super-eruptions."

Such eruptions are very rare and Bristol scientists estimate only one of these types of eruptions occur on earth every 20,000 years. However such eruptions are highly destructive locally and can create global scale severe climate change that would have catastrophic consequences.

"Time scales for pluton growth, magma chamber formation and super-eruptions" is published in *Nature*.

More information: Steve Sparks, Timescales for pluton growth, magma-chamber formation and super-eruptions, *Nature* (2022). DOI: 10.1038/s41586-022-04921-9.
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