Chemistry trick kills climate controversy

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Matthew Johnson, University of Copenhagen, is an associate professor at the Department of Chemistry where he studies chemical mechanisms in the atmosphere. Credit: Mikal Schlosser

Volcanoes are well known for cooling the climate. But just how much and when has been a bone of contention among historians, glaciologists and archeologists. Now a team of atmosphere chemists, from the Tokyo Institute of Technology and the University of Copenhagen, has come up with a way to say for sure which historic episodes of global cooling were caused by volcanic eruptions.

The answer lies in patterns of isotopes found in ancient volcanic sulfur trapped in ice core, patterns due to stratospheric photochemistry. Their mechanism is published in the highly recognized journal *PNAS*.

Matthew Johnson is an associate professor at the Department of Chemistry, University of Copenhagen where he studies chemical mechanisms in the atmosphere. He is thrilled at the prospect of giving a more precise tool to historians studying cold spells.

"Historical records are not always so accurate. Some may have been written down long after the fact, or when a different calendar was in use by a different culture. But the chemistry does not lie", says Johnson.

Powerful volcanoes can shoot gases through the atmosphere and high into the stratosphere where it can affect climate globally for a year or more. Less powerful eruptions can also have powerful impacts, but only locally, and for shorter times. And here's the trick. High plumes spend longer in the harsh sunlight of the stratosphere, and that changes the chemical signature of the sulfur in the plume. The balance of various isotopes is changed according to very precise rules, explains Mathew Johnson.

"Using our method we can determine whether a given eruption was powerful enough for the plume to enter the stratosphere affecting global climate. If we can find material from ancient eruptions it can now be used to give an accurate record of global volcanic events extending many hundreds of thousands of years back in time.", says Johnson.

Strangely, the best place to look for traces of the fiery events is in ice. Tracking climate history is performed on cores drilled from the ice shields of Greenland and Antarctica. Much like tree rings, the snows of each year is compacted into a layer representing that year. As you go further down in the borehole, you descend into deeper history.

If volcanic material shows up in a layer, you know there was an eruption in that year. Using the method developed by Johnson and his colleagues it is now possible to analyze exactly how powerful a given eruption was.

"With the sulfur isotope method, we now have a way to prove whether a given eruption was so explosive that it entered the stratosphere, affecting global climate and civilizations, or, whether a given eruption was confined to the troposphere and local in its effects" says Johnson and goes on: "There are many controversial eruptions. The Mediterranean island of Santorini blew apart and caused the end of the Minoan culture. But there is a huge debate about when exactly this occurred. 1601 was the 'year without a summer' - but nobody knows where the volcano was that erupted. There's debate over whether there was an eruption on Iceland in 527, or 535, or 541. The sulfur isotope trick is a definite method to solve debates like this and get the most information out of the ice core records" Says Matthew Johnson.

Denmark has absolutely no volcanoes. So revealing the mechanism required the very different talents of two groups practically on opposite sides of the globe, explains Johnson.

"The Tokyo Institute of Technology specializes in analysis of the patterns of sulfur isotopes found in samples in nature, and was able to synthesize the isotopically labelled samples. The University of Copenhagen has a strong group in atmospheric chemistry and spectroscopy; the laboratory measurements were carried out in Copenhagen. Together we were able to do the experiments and build the atmospheric chemical model that demonstrated the stratospheric photoexcitation mechanism", concludes Johnson.

Provided by University of Copenhagen