Scientists use volcanic emissions to study Earth's atmospheric past

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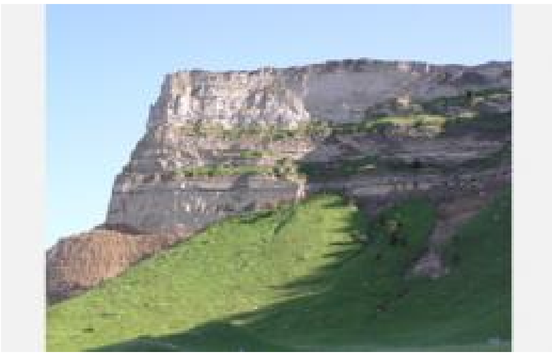

Multiple ancient volcanic ash beds exposed at Scotts Bluff in Nebraska. Credit: Huiming Bao

This wide angle view of the Earth is centered on the Atlantic Ocean between South America and Africa.

On March 20, Iceland's Eyjafjallajokull volcano woke from its nearly 200-year slumber to change the way the world viewed volcanoes forever. Bringing almost all transatlantic air travel to a halt for the first time in modern history, this volcano reminded humanity of the powers these forces of nature contain - and of our relative inability to understand them. Associate Professor Huiming Bao of LSU's Department of Geology & Geophysics has published research in the journal *Nature* about massive volcanic eruptions and their atmospheric consequences in the past in North America.

"Past volcanic eruptions have had significant impacts on the environment," said Bao. "We humans have witnessed the various impacts of volcanic eruptions like the 1991 Mount Pinatubo and the more recent Icelandic one. The physical aspect of the impacts such as explosion or ash plumes is often short-lived, but the chemical consequence of its emitted massive gases can have a long-lasting effect on global climate."

The paper, titled "Massive Volcanic SO2 Oxidation and Sulfate Aerosol Deposition in Cenozoic North America," represents research into the Earth's climactic past. Using computer models and geological data, Bao and his colleagues, Shocai Yu of the EPA and Daniel Tong of the National Oceanic and Atmospheric Administration, or NOAA, were able to simulate the sulfur gas oxidation chemistry and atmospheric condition of the northern high plains region of North America long before human activities began significantly impact the air quality. Yu and Tong contributed to the modeling aspect of the study. They used a state-of-the-art atmospheric sulfur chemistry and transport model to simulate the atmospheric conditions necessary for the observed sulfate isotope data preserved in rock records.

Bao and his colleagues discovered that many of the volcanic ash beds are rich in sulfate, the product of atmospheric oxidation of sulfur gases. Most importantly, these sulfates have distinct stale isotope signatures that can tell how they were formed in the atmosphere, particularly which oxidation pathways they went through. In order to explain their geological data, they did an extensive modeling test and found that it is imperative to have an initial alkaline cloudwater pH condition, which rarely exists in modern days.

According to Bao, the most important volcanic gas - as far as atmospheric implications go - is sulfur dioxide, or SO2. This gas is oxidized in the atmosphere, where it is turned into sulfate aerosol, which plays a very sensitive role in the rate and impact of climate change. When the sulfate aerosol is dense or long-lasting and the depositional condition is right, the sulfate aerosol can be preserved in rock records.

"These sulfate aerosol deposition events were so intense that the sulfate on the ground or small ponds reached saturation and gypsum mineral formed," Bao said. He pointed out that the closest analog event is perhaps the 1783 Laki eruptions of Iceland and the subsequent "dry fogs" in continental Europe. "That event devastated Iceland's cattle population. People with lung problems suffered the worst. In North America, the next year's winter was the longest and one of the coldest on record. The Mississippi River froze at New Orleans. The French Revolution in 1789 may have been triggered by the poverty and famine caused by the eruption."

These explosive eruptions are much more intense and sulfur rich than any human has ever experienced or recorded. But that doesn't mean that eruptions of such magnitude can't happen today.

"It is important to note that the volcanic eruptions we experienced in the past thousands of years are nothing compared to some of the eruptions occurred in the past 40 million years in western North America, either in the level of power or the amount of SO2 spewed," said Bao. "What we reported in our Nature paper is that there were many massive volcanic

SO2 emissions and dense sulfate aerosol events in the northern High Plains of North America in the past. We show that in the past the sulfate aerosol formed in a very different way than today, indicating a difference in the past atmospheric condition or something peculiar with these explosive eruptions in the west."

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