Rewriting the history of volcanic forcing during the past 2,000 years

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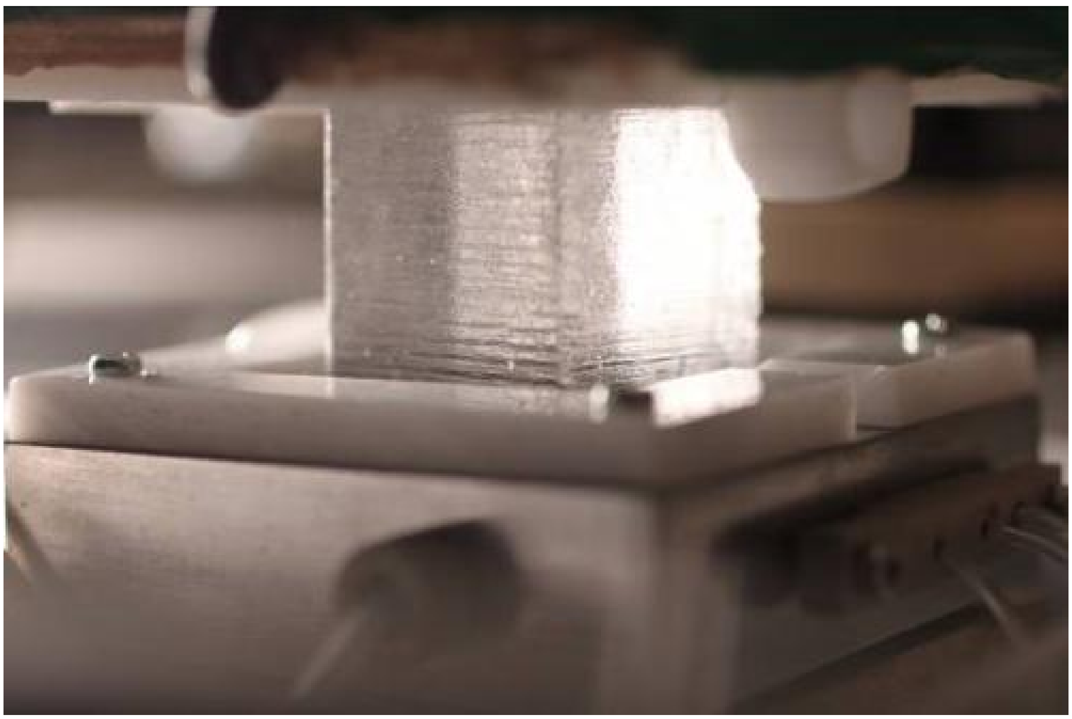


An ice core section is simultaneously analyzed for a variety of elements and chemical species in DRI's ultra-trace ice core laboratory while slowly melting the ice on a heated melter plate Credit: Joseph McConnell

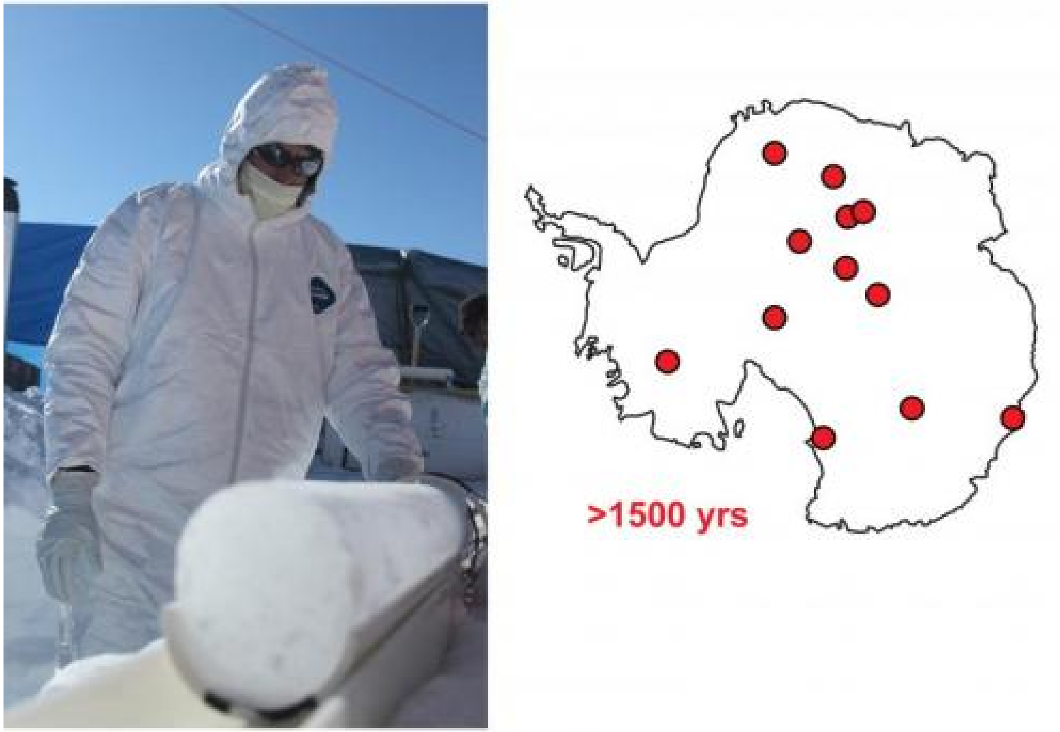
A team of scientists led by Michael Sigl and Joe McConnell of Nevada's Desert Research Institute (DRI) has completed the most accurate and precise reconstruction to date of historic volcanic sulfate emissions in the Southern Hemisphere.

The new record, described in a manuscript published today in the online edition of *Nature Climate Change*, is derived from a large number of individual ice cores collected at various locations across Antarctica and is the first annually resolved record extending through the Common Era (the last 2,000 years of human history).

"This record provides the basis for a dramatic improvement in existing reconstructions of volcanic emissions during recent centuries and millennia," said the report's lead author Michael Sigl, a postdoctoral fellow and specialist in DRI's unique ultra-trace ice core analytical laboratory, located on the Institute's campus in Reno, Nevada.

These reconstructions are critical to accurate model simulations used to assess past natural and anthropogenic climate forcing. Such model simulations underpin environmental policy decisions including those aimed at regulating greenhouse gas and aerosol emissions to mitigate projected global warming.

Powerful volcanic eruptions are one of the most significant causes of climate variability in the past because of the large amounts of sulfur dioxide they emit, leading to formation of microscopic particles known as volcanic sulfate aerosols. These aerosols reflect more of the sun's radiation back to space, cooling the Earth. Past volcanic events are measured through sulfate deposition records found in ice cores and have been linked to short-term global and regional cooling.



Locations of Antarctic ice core sites used for volcanic sulfate aerosol deposition reconstruction (right); a DRI scientist examines a freshly drilled ice core in the field before ice cores are analyzed in DRI's ultra-trace ice core analytical laboratory. Credit: M. Sigl

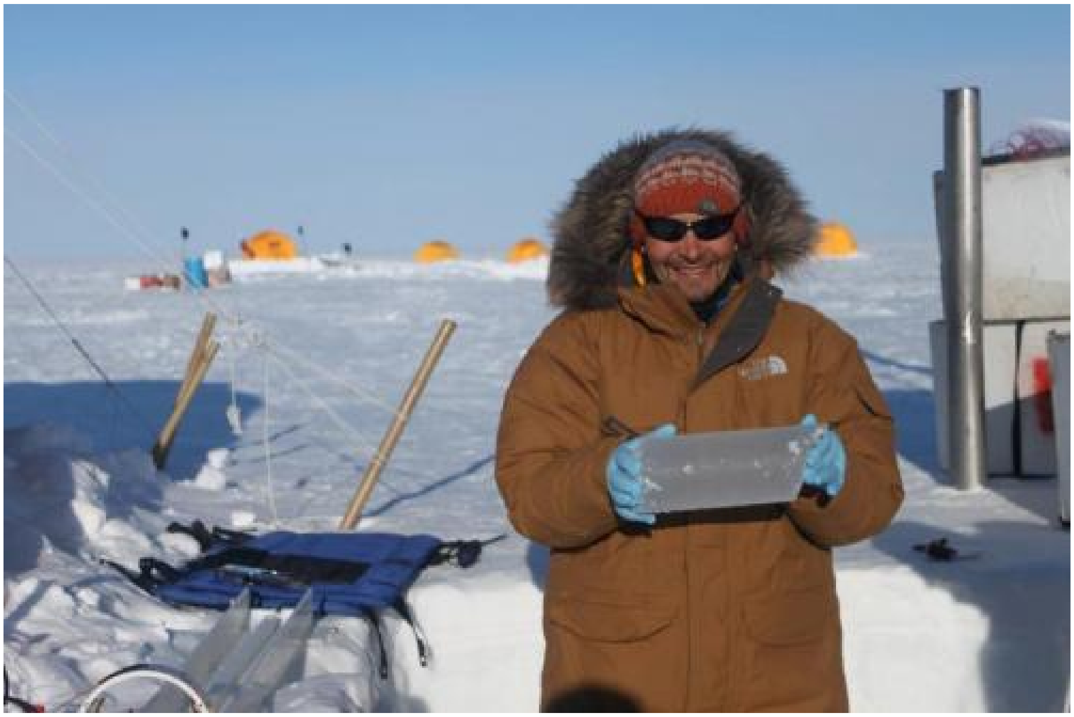
This effort brought together the most extensive array of ice core sulfate data in the world, including the West Antarctic Ice Sheet (WAIS) Divide ice core – arguably the most detailed record of volcanic sulfate in the Southern Hemisphere. In total, the study incorporated 26 precisely synchronized ice core records collected in an array of 19 sites from across Antarctica.

"This work is the culmination of more than a decade of collaborative ice core collection and analysis in our lab here at DRI," said Joe McConnell, a DRI research professor who developed the continuous-flow analysis system used to analyze the ice cores.

McConnell, a member of several research teams that collected the cores (including the 2007-2009 Norwegian-American Scientific Traverse of East Antarctica and the WAIS Divide project that reached a depth of 3,405 meters in 2011), added, "The new record identifies 116 individual volcanic events during the last 2000 years."

"Our new record completes the period from years 1 to 500 AD, for which there were no reconstructions previously, and significantly improves the record for years 500 to 1500 AD," Sigl added. This new record also builds on DRI's previous work as part of the international Past Global Changes (PAGES) effort to help reconstruct an accurate 2,000-year-long global temperature for individual continents.

This study involved collaborating researchers from the United States, Japan, Germany, Norway, Australia, and Italy. International collaborators contributed ice core samples for analysis at DRI as well as ice core measurements and climate modeling.



DRI scientist Michael Sigl holds an ice core section that contains detailed information about the volcanic aerosol composition of Earth's atmosphere 1,700 years ago. Credit: Olivia Maselli

According to Yuko Motizuki from RIKEN (Japan's largest comprehensive research institution), "The collaboration between DRI, National Institute of Polar Research (NIPR), and RIKEN just started in the last year, and we were very happy to be able to use the two newly obtained ice core records taken from Dome Fuji, where the volcanic signals are clearly visible. This is because precipitation on the site mainly contains stratospheric components." Dr. Motizuki analyzed the samples collected by the Japanese Antarctic Research Expedition.

Simulations of volcanic sulfate transport performed with a coupled aerosol-climate model were compared to the ice core observations and used to investigate spatial patterns of sulfate deposition to Antarctica.

"Both observations and model results show that not all eruptions lead to the same spatial pattern of sulfate deposition," said Matthew Toohey from the German institute GEOMAR Helmholtz Centre for Ocean Research Kiel. He added, "Spatial variability in sulfate deposition means that the accuracy of volcanic sulfate reconstructions depends strongly on having a sufficient number of ice core records from as many different regions of Antarctica as possible."

With such an accurately synchronized and robust array, Sigl and his colleagues were able to revise reconstructions of past volcanic aerosol loading that are widely used today in climate model simulations. Most notably, the research found that the two largest volcanic eruptions in recent Earth history (Samalas in 1257 and Kuwae in 1458) deposited 30 to 35 percent less sulfate in Antarctica, suggesting that these events had a weaker cooling effect on global climate than previously thought.

More information: Insights from Antarctica on volcanic forcing during the Common Era, *Nature Climate Change*, DOI: 10.1038/nclimate2293

Provided by Desert Research Institute

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