The first assessment of toxic heavy metal pollution in the Southern Hemisphere over the last 2,000 years

January 11 2024

U.S. and Norwegian researchers traversing the East Antarctic ice sheet to collect the ice cores used in the study. Credit: Stein Tronstad/NPI

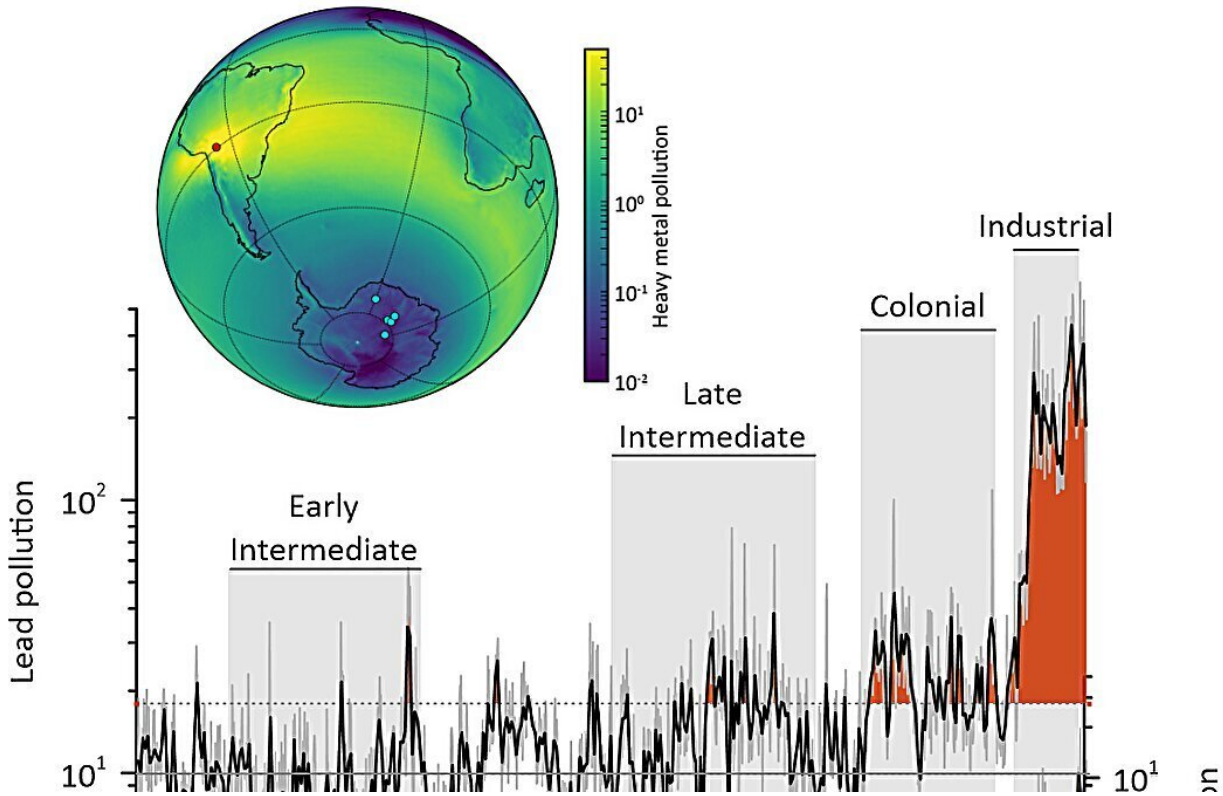
Human activity, from burning fossil fuels and fireplaces to the contaminated dust produced by mining, alters Earth's atmosphere in countless ways. Records of these impacts over time are preserved in everlasting polar ice that serves as a sort of time capsule, allowing scientists and historians to link Earth's history with that of human societies. In a new study, ice cores from Antarctica show that lead and other toxic heavy metals linked to mining activities polluted the Southern Hemisphere as early as the 13th century.

The work is published in the journal *Science of the Total Environment*.

"Seeing evidence that early Andean cultures 800 years ago, and later Spanish Colonial mining and metallurgy, appear to have caused detectable lead pollution 9,000 km away in Antarctica is quite surprising," said Joe McConnell, Ph.D., research professor of hydrology at Desert Research Institute (DRI) and lead author of the study.

The research was led by McConnell's team at DRI along with collaborators in Norway, Austria, and Germany, as well as in Florida. It is the first time that scientists have assessed human impacts on lead pollution in Antarctica as far back as 2,000 years ago. It is also the first detailed assessment of thallium, bismuth, and cadmium pollution. In addition to lead, these heavy metals (save for bismuth at low levels) are considered highly toxic and harmful to human and ecosystem health.

The team found that the first increase in heavy metal pollutants—specifically lead—started around the year 1200, coincident with the establishment of urban communities by the Chimú people on the north coast of South America.



Graphical summary of the study data showing the increase in heavy metal pollution found in five East Antarctic ice cores over time. The heatmap in the upper left corner depicts the simulated flow of heavy metal pollution from Potosi in South America throughout the Southern Hemisphere and to Antarctica. Ice core collection sites are shown as cyan circles. Credit: DRI

"These settlements required vast amounts of silver and other metals obtained through mining," said University of South Florida archaeologist and study co-author, Charles Stanish, Ph.D. Lead is often found in silver ores, and samples of lake sediments in the Potosí region of Bolivia also suggest lead emissions throughout the 12th and 13th centuries, consistent with the Antarctic ice records.

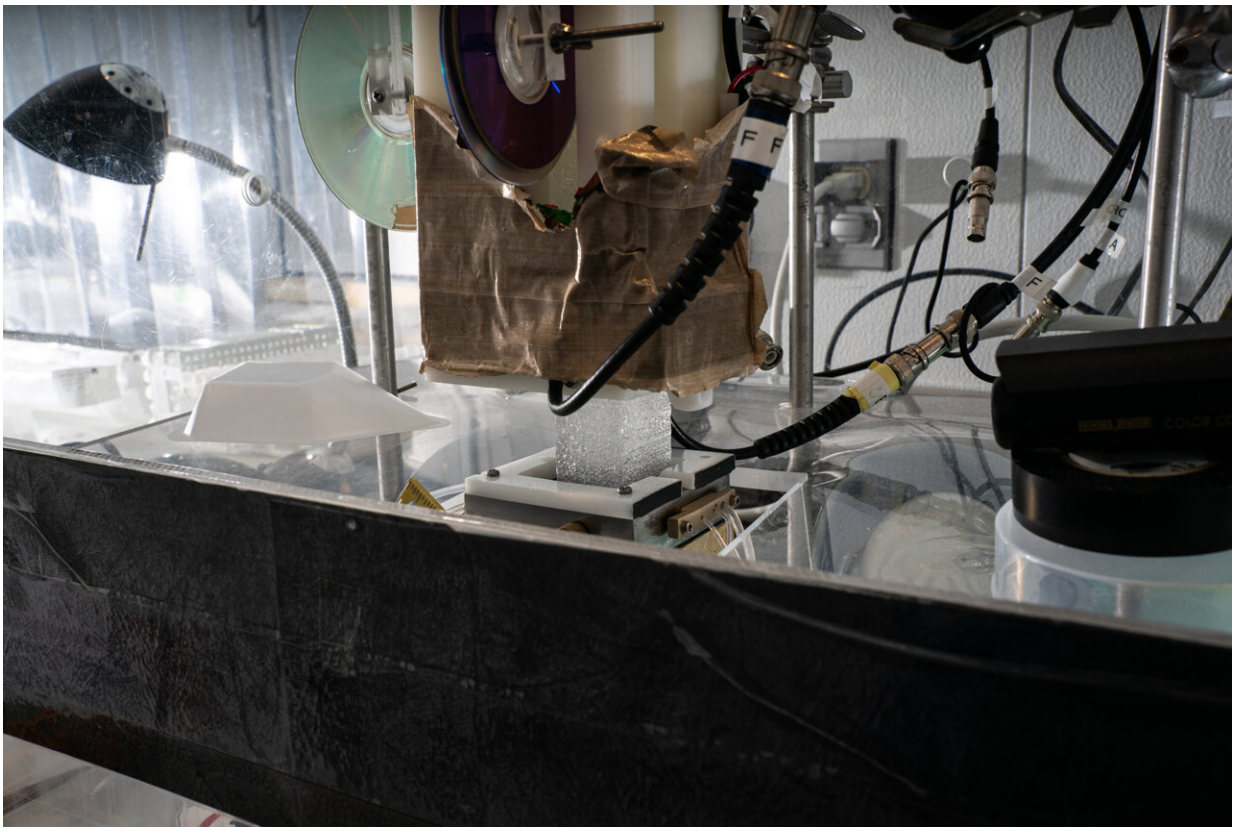
More lasting and consistent pollution began soon after the 1532 arrival

of Spanish settlers in South America, when Potosí became the primary supply of silver for the Spanish Empire and the largest single source of silver in the world. The ice records show a marked decline in lead pollution between approximately 1585 to 1591, when severe epidemics ravaged Andean communities. The team was able to compare silver registrations at the Colonial Mint in Potosí to the ice core data, finding that they lined up with the pollution drop in the Antarctic.

"It's pretty amazing to think that a 16th century epidemic in Bolivia altered pollution in Antarctica and throughout the Southern Hemisphere," said DRI post doctoral researcher and co-author on the study Sophia Wensman, Ph.D.

"Although Antarctica's remote location thousands of kilometers from South America and Australia means that only trace amounts of pollutants are deposited and preserved in the ice, the precisely dated, year-by-year records can give insight into how and when human pollutants impacted the entire hemisphere," added co-author and atmospheric modeler, Andreas Stohl, Ph.D., of the University of Vienna.

A U.S. ice core driller collecting a core used in this study as part of the Norwegian-U.S. scientific traverse of East Antarctica. Credit: Stein Tronstad



The ice core sample being processed on the unique ice core analytical system at DRI's Ice Core Lab. Credit: Jessi LeMay/DRI

As expected, pollutants increased significantly following industrialization, with large spikes at the start of Australian lead mining during the late 19th century. There are also marked declines in the records corresponding with both World Wars and the Great Depression, demonstrating the worldwide impacts of industrial activities and political events in the Northern Hemisphere.

The study results from the analysis of five different ice cores extracted from the East Antarctic ice sheet at DRI's Ice Core Lab, a unique facility with instruments capable of detecting trace amounts of metals in ice and

snow. McConnell and his team have honed their techniques over decades in order to advance scientific understanding of how humans have impacted Earth's atmosphere throughout time and have tracked historic plagues and wars using changes in Greenland pollution levels.

"We're arguably the only research group in the world that routinely makes these kinds of very detailed measurements, especially in Antarctic ice where concentrations of these trace metals are extremely low," added DRI assistant research professor and study co-author Nathan Chellman, Ph.D.

The ski plane used to transport German researchers and ice cores used in this study across East Antarctica. Credit: Sepp Kipfstuhl/AWI

Study co-author Nathan Chellman preparing the ice core sample for analysis at DRI's Ice Core Lab. Credit: Jessi LeMay/DRI

Thanks to these advancements, this study offers a deeper look into history than previously possible. Prior studies were unable to identify heavy metal pollution that preceded the industrial age because it was impossible to differentiate between the metals produced by volcanic eruptions and those produced by human activity. For this study, the team used thallium levels recorded in the ice to estimate and subtract the volcanic background levels of lead, bismuth, and cadmium, which allowed them to identify when human-sourced pollution started, as well as the magnitude.

"We found that lead, bismuth, and cadmium levels all went up after industrialization by an order of magnitude or more," McConnell says. "But thallium didn't change really at all, indicating little or no human emissions of thallium, so that was what allowed us to use it as an indicator of volcanism during the past 2,000 years."

McConnell says that he and his team hope to use the techniques developed in this study to refine understanding of pre-industrial pollution levels in the Arctic, where mining and metallurgy were more pronounced far earlier in human history than in South America.

More information: Joseph R. McConnell et al, Hemispheric-scale heavy metal pollution from South American and Australian mining and metallurgy during the Common Era, *Science of The Total Environment* (2023). DOI: 10.1016/j.scitotenv.2023.169431

Provided by Desert Research Institute