

Lead pollution likely caused widespread IQ declines in ancient Rome

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Grass covered mounds mark the site of the Roman-era lead mine at Charterhouse on Mendip in the United Kingdom. Credit: Andrew Wilson

Lead exposure is responsible for a range of human health impacts, with even relatively low levels impacting the cognitive development of

children. DRI scientists have previously used atmospheric pollution records preserved in Arctic ice cores to identify periods of lead pollution throughout the Roman Empire, and now new research expands on this finding to identify how this pollution may have affected the European population.

The study, published Jan. 6 in *Proceedings of the National Academy of Sciences*, examined three ice core records to identify lead [pollution](#) levels in the Arctic between 500 BCE through 600 CE. This era spans the rise of the Roman Republic through the fall of the Roman Empire, with the study focusing on the approximately 200-year height of the Empire called the Pax Romana.

Lead isotopes allowed the research team to identify mining and smelting operations throughout Europe as the likely source of pollution during this period. Advanced computer modeling of atmospheric movement then produced maps of atmospheric lead pollution levels across Europe. Combined with research linking lead exposure to cognitive decline, the research team also identified likely reductions in IQ levels of at least 2 to 3 points among the European population.

"This is the first study to take a pollution record from an ice core and invert it to get atmospheric concentrations of pollution and then assess human impacts," says Joe McConnell, research professor of hydrology at DRI and lead author of the study. "The idea that we can do this for 2,000 years ago is pretty novel and exciting."

Records of the past preserved in ice

McConnell's Ice Core Laboratory at DRI has spent decades examining ice cores from places like Greenland and Antarctica, where sheets of ice have built up over millennia.



Ice in the core barrel while drilling on the Greenland ice sheet. Credit: Joseph McConnell

Using enormous drills, they painstakingly extract columns of ice as much as 11,000 feet (3,400 meters) long, reaching more distant depths of Earth's history with each inch. McConnell's team creates precise timelines using records of well-dated volcanic eruptions, which stamp the ice record like postcards from the past.

Gas bubbles trapped in the ice offer insight into the atmosphere of past eras, while pollutants like lead can be used to interpret mining and industrial activity.

McConnell began developing methods to create very detailed lead records in ice more than twenty years ago, when he applied them to more recent history.

When archaeologists and historians learned of this work, they approached him hoping to apply these new techniques to the Roman period, seeking answers to lingering historical questions.

"The resulting research changed our understanding of the era by finding precise linkages between the lead pollution records and historical events such as population declines associated with periodic plagues and pandemics," adds co-author and ancient historian Andrew Wilson of Oxford University.

A growing understanding of the harms of lead pollution

Ancient lead pollution stemmed largely from silver mining, whereby the lead-rich mineral galena was melted down to extract silver. For every ounce of silver obtained, this process produced thousands of ounces of lead—much of which was released to the atmosphere.



Ice sample on the melter during continuous ice core chemical analyses at the Desert Research Institute. Credit: Sylvain Masclin

In the 20th century, lead pollution predominantly came from the emissions of vehicles burning leaded gasoline. Following the passing of the Clean Air Act in the U.S. in 1970, which restricted the use of [leaded gasoline](#), researchers have tracked the sharp decline of lead in human blood. However, the nationwide exposure, [particularly for children born between 1950 and 1985](#), allowed scientists to track lead's impact on health and cognitive development.

"As lead pollution has declined during the last 30 years, it has become more and more apparent to epidemiologists and medical experts just how bad lead is for human development," McConnell says.

In adults, high levels of lead exposure are linked to infertility, anemia, memory loss, cardiovascular disease, cancer, and reduced immune response, among other impacts. In children, even low levels of exposure have been connected to reduced IQ, concentration challenges, and reduced academic success.

While the U.S. Centers for Disease Control and Prevention (CDC) considers a blood lead level of $3.5 \mu\text{g}/\text{dl}$ the point for medical intervention for children, they have stated that there is no level of [lead exposure](#) without risk.



Carefully preparing the longitudinal ice core samples for high-resolution lead measurements. Credit: Jessi LeMay/DRI



Longitudinal ice core samples awaiting analysis for lead and other chemicals using the continuous ice core analytical system at the Desert Research Institute. Credit: Jessi LeMay/DRI

"Lead is known to have a wide range of human health impacts, but we chose to focus on [cognitive decline](#) because it's something we can put a number on," says study co-author Nathan Chellman, assistant research professor of snow and ice hydrology at DRI.

"An IQ reduction of 2 to 3 points doesn't sound like much, but when you apply that to essentially the entire European population, it's kind of a big deal."

The study found that atmospheric lead pollution began during the Iron Age and reached a peak during the late 2nd century BCE at the height of the Roman Republic. It then declined sharply during the 1st century BCE, during the crisis of the Roman Republic, before increasing around 15 BCE following the rise of the Roman Empire.

Lead pollution remained high until the Antonine Plague from 165 to the 180s CE, which severely affected the Roman Empire. It wasn't until the High Middle Ages in the early 2nd millennium CE that lead pollution in the Arctic exceeded the sustained high levels of the Roman Empire. According to the research, more than 500 kilotons of lead were released into the atmosphere during the nearly 200-year height of the Roman Empire.

Although ice core records show that Arctic lead pollution was up to 40-fold higher during the highest historical peak in the early 1970s, the insight gained from this study demonstrates how "humans have been impacting their health for thousands of years through industrial activity," McConnell says.

More information: McConnell, Joseph R., Pan-European atmospheric lead pollution, enhanced blood lead levels, and cognitive decline from Roman-era mining and smelting, *Proceedings of the National Academy of Sciences* (2025). [DOI: 10.1073/pnas.2419630121](https://doi.org/10.1073/pnas.2419630121)

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