

# Roman mining activities polluted European air more heavily than previously thought

May 8 2019, by Lauren Lipuma

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The remains of Las Médulas, the most important gold mine in the Roman Empire, located in northwestern Spain. The spectacular landscape resulted from the Ruina Montium mining technique. Credit: Rafael Ibáñez Fernández, CC BY-SA 3.0

Roman-era mining activities increased atmospheric lead concentrations by at least a factor of 10, polluting air over Europe more heavily and for longer than previously thought, according to a new analysis of ice cores taken from glaciers on France's Mont Blanc.

Humans have mined metals since the 6th millennium BCE, but the Romans were the first European civilization to mass produce lead for water pipes, household items and silver for coins. Mining and smelting releases many types of pollutants into the air, including several heavy metals, which are toxic.

Scientists have known the Romans mined lead but were not sure how much their mining activities may have polluted European air or for how long, and how large the impact of Roman activities was compared to more recent lead pollution.

Now, concentrations of trace metals in some of Mont Blanc's deepest ice show two spikes in atmospheric lead pollution over Europe during the Roman era, one in the second century BCE and one in the second century CE. Overall, Roman mining and smelting activities polluted the atmosphere for nearly 500 years and also contaminated Europe's air with antimony, a toxic metalloid that can produce effects similar to arsenic poisoning, according to the new study.

The new study in AGU's journal *Geophysical Research Letters* is one of the first to quantify atmospheric lead concentrations over Europe during antiquity, the time period spanning the height of ancient Greek and Roman cultures. Lead is one of the most dangerous environmental pollutants and is toxic to humans at extremely low levels.

The findings add to the evidence that humans have generated lead pollution at large scales for longer than previously thought, according to the study's authors.

"Our very first study of pollution during the antiquity inferred from an alpine ice core allows us to better evaluate the impact of Roman emissions at the scale of Europe and to compare this old pollution to the recent pollution linked with the use of leaded gasoline in Europe between 1950 and 1985," said Michel Legrand, an atmospheric scientist at the Université Grenoble Alpes in Grenoble, France, and co-author of the new study.

"This alpine ice shows that the lead emissions during the antiquity enhanced the natural level of lead by a factor of 10. For comparison, recent human activities related to the use of leaded gasoline in Europe enhanced the natural lead level by a factor of 50 to 100," Legrand said. "Thus, the pollution by the Romans is five to 10 times less than that due to the recent use of gasoline but it took place for a long period of time – several centuries instead of 30 years of leaded gasoline use."



Roman ingots of lead from the mines of Cartagena, Spain, housed in the Archaeological Municipal Museum of Cartagena. Credit: Nanosanchez; public domain

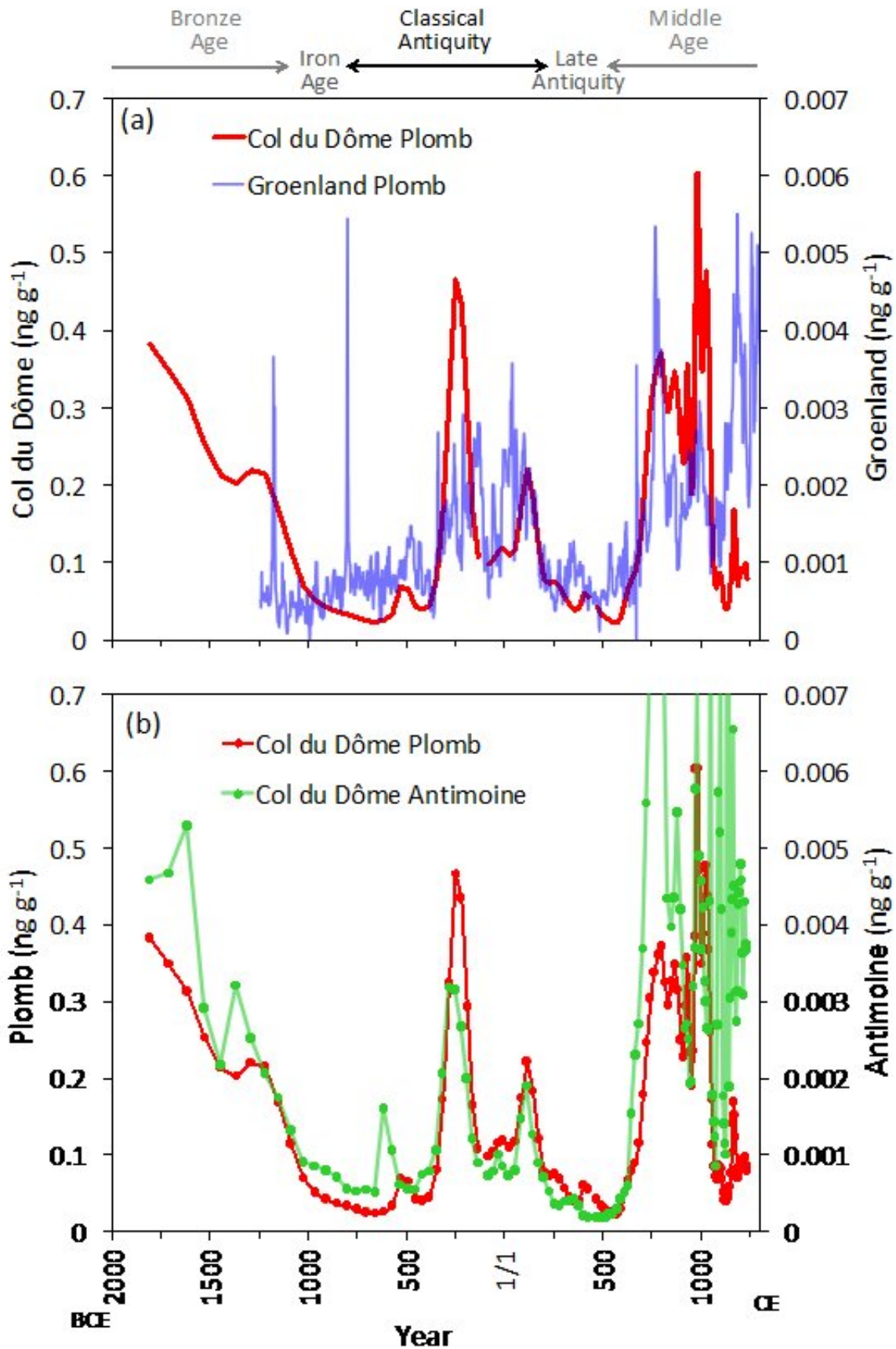


Figure 1. (a) Lead concentrations in ice in Greenland (blue) and in the Col du Dôme (CDD, red). (b) Lead (red) and antimony (green) concentrations in ice from the CDD. On the bottom scale, age is indicated in years, from 1 A.D. onwards). Phases of increasing lead emissions were accompanied by a simultaneous rise in the presence of antimony – another toxic metal – in the alpine ice. Credit: CNRS

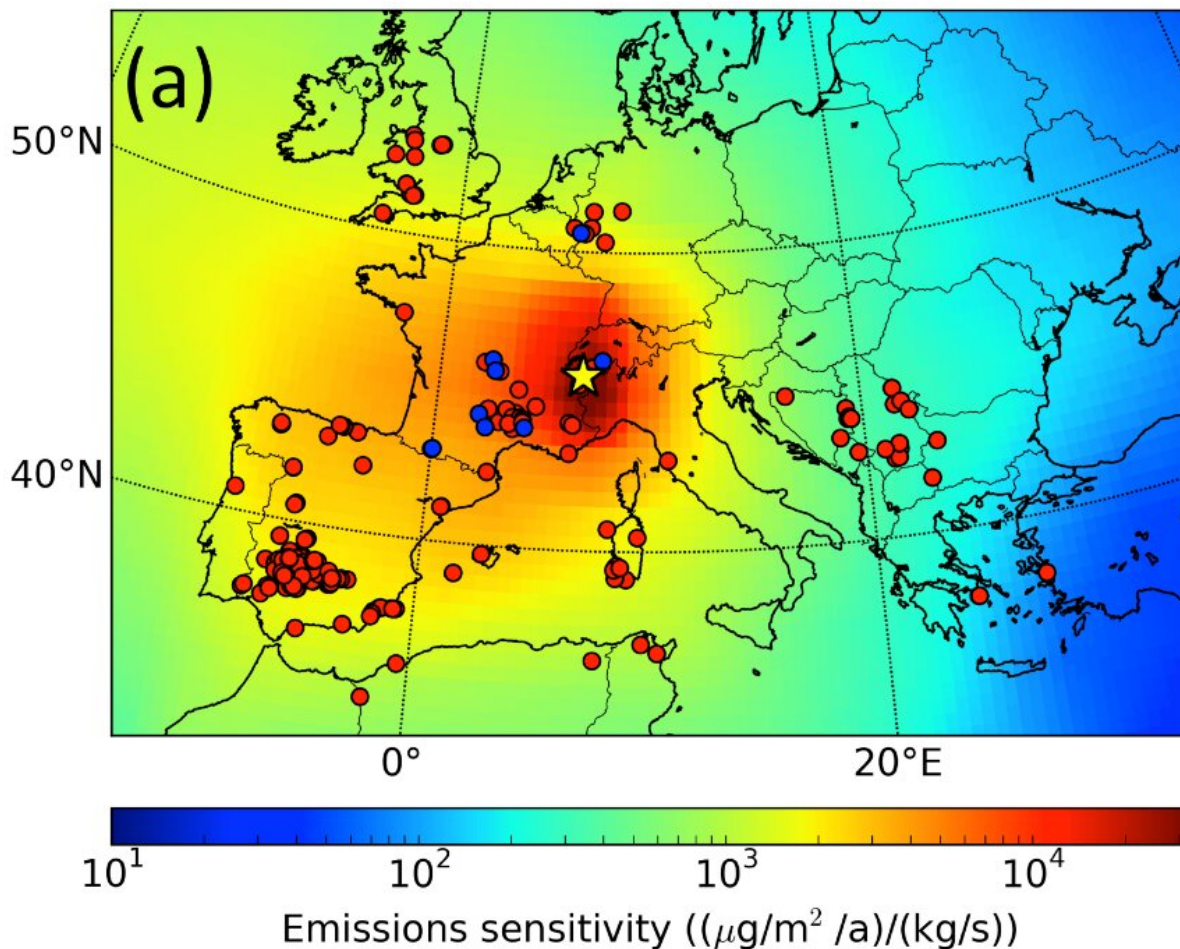


Figure 2. Simulations to assess the sensitivity of lead deposits in the Col du Dôme (yellow) to the geographical location of the emission. This map also indicates the location of major mines known to have existed in Roman antiquity.

In the approximately 500-km region around the Alps, in blue, mines believed to have been active in the Republican period, and in red, those active later. Outside this radius, all other mines are indicated in red (all eras combined). Alpine ice is therefore representative of the high altitude atmosphere which receives emissions from France, Spain, Italy, islands in the Mediterranean Basin, and, to a lesser degree, Germany and England. Credit: CNRS

The new results support previous research challenging the idea that environmental pollution began before the Industrial Revolution in the 1800s, according to Alex More, a climate historian at Harvard University who was not connected to the new study.

Current policies that set standards for acceptable levels of lead pollution use pre-industrial levels as their baseline. But the new findings suggest pre-industrial levels are not an accurate baseline and only levels from before the start of metallurgy can be considered natural, More said.

"Man-made air pollution has existed for a long time, and the baseline that we thought was natural is in fact not so," More said. "All standards of pollution that rely on this assumption of a pre-modern, pre-industrial baseline, are wrong."

## **The original plumbers**

Historians credit ancient Rome with being the first civilization to mass produce lead and the Romans were the first to build large-scale plumbing systems with lead pipes. At the height of the Roman Empire, the Romans mined lead from many areas of Europe, including the Iberian Peninsula and Great Britain. Lead production declined after the fall of Rome in the 5th century and did not reach comparable levels until the Industrial Revolution.

Researchers had previously found lead in an ice core from Greenland that they connected to the detailed story of Roman mining activities, but because Greenland is so far from the pollution's source, scientists have been unsure exactly what the lead concentrations were in European air at the time.

Several previous studies have looked at past lead contamination in ice cores from the Alps, but none had yet focused on the Roman Era. A 2017 study in AGU's journal *GeoHealth* found lead mining activities in Europe during the Middle Ages plummeted to nearly zero during the Black Death pandemic of 1349 to 1353.





The arches of an elevated section of the Roman provincial Aqueduct of Segovia, in modern Spain. Roman aqueducts supplied water to public baths, latrines, fountains, and private households. They also supported mining operations, milling, farms, and gardens. Credit: Bernard Gagnon, CC BY-SA 3.0

## **Metals in ice**

In the new study, researchers measured concentrations of trace metals in an ice core taken from Mont Blanc, the highest peak in the Alps, to understand how Roman activities may have affected Europe's environment. Studies of lake sediments and peat bogs have shown local lead pollution in some parts of Europe during this time, but ice cores provide better evidence for the European continent as a whole.

The new study provides a record of lead pollution over Europe for roughly the past 5,000 years, spanning the Bronze Age (3000 to 800 BCE), antiquity (800 BCE through the 5th century CE), and into the early Middle Ages.

The researchers found the Romans polluted European air for roughly 500 years, from around 350 BCE to 175 CE. Within that period, they found two times where lead pollution spiked to more than 10 times higher than background levels. The study can't pinpoint the exact years, but the spikes occur around 250 BCE and 120 CE and may correspond to times of expansion and prosperity of Roman culture. The Roman Republic expanded to the entire Italian peninsula in the 3rd century BCE, and the Roman Empire expanded to most of mainland Europe in the 2nd century CE. By comparison, the Greenland ice core showed lead levels peaking at roughly four times the background level.

Between the two spikes, the study found lead pollution dropped,

although not to pre-Roman levels. This could correspond to the Crisis of the Roman Republic, a period of political instability that marked the transition from the Roman Republic to the Roman Empire from around 134 to 44 BCE, although the exact dates are uncertain.

The researchers also quantified antimony pollution during antiquity for the first time and found antimony concentrations at least six times higher than background levels during the Roman era. Lead ores commonly contain elements like arsenic, antimony, copper, silver and gold.

The findings show the Romans impacted air quality beyond simple lead pollution and their effect on the European atmosphere was longer-lived than previously thought, according to the study's authors.

The ice core data gives scientists a better context for understanding how toxic modern air [pollution](#) is, according to More.

"Our ultimate goal is to show the man-made impact on the atmosphere for millennia now," he said. "The baseline that we can now show is much more detailed, compared to modern times."

**More information:** Susanne Preunkert et al. Lead and Antimony in Basal Ice From Col du Dome (French Alps) Dated With Radiocarbon: A Record of Pollution During Antiquity, *Geophysical Research Letters* (2019). [DOI: 10.1029/2019GL082641](https://doi.org/10.1029/2019GL082641)

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