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Tracing Asian lead emissions over the last 1,000 using Denali ice core Pb concentration and isotope data

Content

Lead (Pb) deposition is typically associated with anthropogenic emissions, and time-series trends can show the influence of human policy, culture, and technology across hundreds to thousands of years. Previous ice core studies have used changes in lead levels through time to examine the effects of industrialization, legislation and worldwide health pandemics. The North Pacific region (Alaska, USA; Kamchatka Peninsula, Russia) is of particular interest when examining historical trends in pollutants (e.g., lead from gasoline, copper from metal smelting) because its position uniquely links the Asian and North American continents. The majority of the ice cores which have been collected in the North Pacific to date have been shallow, encompassing just the last few centuries. At the Mt. Hunter site (62.95 °N, 151.09 °W, 3900 m asl) in 2013, two twin cores (Denali core 1 and 2) were drilled to bedrock (208 m), with a shallow core drilled in 2019 extending the record. We present a new Pb concentration and isotope record obtained from the Denali Ice Core 2 and 2019 shallow core spanning from 1,000 BP to 2019 CE. The cores were melted at Dartmouth College using a continuous ice core melting system with discrete sampling for Pb analyses. All analyses were conducted at the University of Maine Climate Change Institute (CCI) Inductively Coupled Plasma Mass Spectrometer (ICP-MS) facility equipped with a Thermo Scientific Element 2.

The Pb record from Denali allows evaluation of pre-industrial and modern Chinese emissions from smelting, manufacturing, transportation and incineration. Work on the Mt. Logan PR Col ice core indicates a potential Pb signal recorded at ~4500 BP (~2800 BCE). If this signal is found in the Mt. Hunter ice core and confirmed to be Asian in origin, it may record the beginning of mining and metallurgy in the Lianghzhi Lake region, China. In the industrial era, Pb records in the North Pacific are available for Mt. Logan (PR Col) and Eclipse Icefield ice cores, but only extend until 2001. Since the 1970s, global efforts to reduce Pb emissions have been made through legislation that prohibits leaded gasoline and improved coal combustion and the use of non-ferrous metal smelting technology. The new data we evaluate here fills a critical gap in knowledge about changes in lead levels in China over the last two decades, tracking increasing industrial production and resource demand as a response to the worldwide Great Acceleration (the major acceleration in the human population in the mid-20th century, driving fast development of industrialization and high resource demand). While Pb emissions from gasoline in the region have been phased out, the industrial revolution of China has resulted in an overall net increase in Pb emissions since the 1970s. Using Pb isotopes, this work will trace the new dominant sources of emissions, which we expect to be non-ferrous metal smelting, coal combustion, trash incineration and manufacturing.

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Track Classification: Pollution records