Environment research

Is lead pollution of the atmosphere a global problem?

from David A. Peel

LEAD pollution has been studied for decades, yet still there is controversy over whether large-scale contamination has occurred. Purely natural processes, such as volcanism and the weathering of rocks, release lead into the atmosphere. Some still believe that these sources dominate concentrations in the global atmosphere

IMAGE UNAVAILABLE FOR COPYRIGHT REASONS

Fig. 1 Sampling the Antarctic ice sheet for global pollutants (photograph by M. Vallance).

but there is a growing consensus[1] that lead derived from human emissions is dominant even in the remotest parts of the planet. The report by Boutron and Patterson on page 222 of this issue[2] contains the best data yet obtained for natural levels of lead in Antarctic ice through the peak of the last ice age (Wisconsin) and into the Holocene (see Fig. 1).

Fortunately, records of the changing composition of the Earth's atmosphere over thousands of years have been perfectly preserved within the ice layers of the polar ice sheets. Analysis of ancient ice can provide a vital reference for the natural state of the Earth's atmosphere and allow modern trends to be judged in proper perspective. Unfortunately, analyses are generally carried out in laboratories close to sources of lead pollution and, as a result, most reported measurements have been affected by contamination.

The data of Boutron and Patterson are from a period of dramatic change in the Earth's atmosphere, when massive increases in mineral dusts and sea salts in the atmosphere accompanied the coldest part of the ice age. At the same time concentrations of lead in the Antarctic atmosphere were greater than at any time during the Holocene, including the present. It is therefore an ideal period to test our understanding of processes that contribute to natural levels of lead in the environment.

The results of this new, extremely careful piece of work show clearly that, within reasonable limits, the observed levels of lead in the prehistorical period can be accounted for simply on the basis of their average abundance in the Earth's crust. Although contributions from volcanic activity may have been similar to crustal contributions during the Holocene, they were evidently insignificant during the height of the Wisconsin. All this must undermine seriously the arguments of those who suggest[3] that levels of lead from natural sources are enhanced by a range of exotic natural enrichment processes. Such processes have been invoked to account for orders of magnitude discrepancies between high measured levels of lead in the environment and predicted levels based on estimated emission rates from the various sources. The observation that several workers have been unable to detect increasing levels of lead during recent decades was also attributed to the existence of these large enrichments of natural sources. It is now apparent that these findings are much more likely to represent flaws in contamination control.

The new data are in accord with values previously published[4] by the same laboratory for a few samples of both Greenland and Antarctic ice cores between 1,500 and 5,500 years old. The new mean concentrations (0.7×10^{-12} g Pb g^{-1} ice) for Holocene ice from Antarctica can be compared with the most reliable data available for modern snow[5,6]. This comparison suggests that there was a modest increase of up to sixfold in lead concentrations in Antarctic snow between prehistoric times and the present (Fig. 2), but there are insufficient data free from contamination to show a clear increasing trend through the industrial period.

The evidence from Greenland is little better and the most reliable time series, published in 1969[7], is still cited widely. These data were a composite from three locations and systematic differences between the sites may have influenced the time series. Methods of sample collection and contamination control have improved greatly since then. However, several authors independently have measured concentrations of around 200 pg g^{-1} in present-day snow in Greenland, Alaska and the eastern Arctic Ocean. The best-documented values[4] for ancient ice, obtained from three samples of a Greenland ice core (1,500–5,500 years old) are around 1.4 pg g^{-1}, a value essentially supported by the new data from Antarctica. There seems little doubt that lead concentrations have increased around 200-fold in Greenland snow since prehistoric times. The observed contrast in the response of the Greenland and Antarctic atmospheres to rising environmental levels of lead accords with the fact that lead emissions

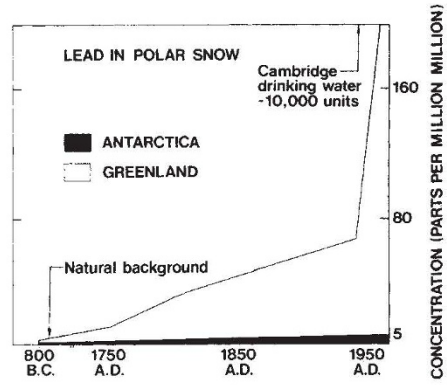

Fig. 2 Contrasting trends of Pb concentrations in Antarctic (first-order interpolation of available data) and Greenland[7] snow.

occur predominantly in the Northern Hemisphere. There is effectively little transfer between the hemispheres, because the atmospheric residence time of lead aerosol in the troposphere is short in comparison with the time required for inter-hemispheric mixing.

Overall a generally blurred picture is emerging of increasing lead pollution in both the north and south polar regions, with a much more pronounced change in the Northern Hemisphere. There is now an urgent need for new and detailed time series to cover the past few hundred years in both Greenland and Antarctica at single sites remote from any form of human activity. The new data show that if meaningful time series are to be achieved, then the scientists involved must be able to demonstrate at the outset that they can make reliable measurements at the level of one picogram per gram. □

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