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Concentration of Common Lead in Greenland Snow

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Abstract

The recent increase of lead concentration in polar ice sheets is ascribed to smelter fume and lead alkyl decomposition products originating in the northern hemisphere.

The concentration of common lead was measured in seven snow samples taken at ten year intervals from layered snow at Camp Century, Greenland. One hundred gallons of snow were collected at each of the seven points distributed throughout a vertical depth of 150 feet, which depth corresponded to sixty years' accumulation. Isotopic dilution analyses, which have been successfully used for studying lead in sea water, were made on these snow samples. As carried out in this instance, the sensitivity of the method was about 5×10^{-12} gm Pb/gm snow. The background of natural lead in the snow was expected to fall in the range of 10^{-13} gm Pb/gm snow, or below the limit of detection. An additional increment of lead, which came from the washout of lead alkyl decomposition products originating in the United States and Europe, was expected to appear sometime after 1925.

As shown in Figure 1, analyses indicated a level of 0.5 to 1.5×10^{-10} gm Pb/gm snow in the five sampled layers dating from 1904 to 1944. After that time, lead concentrations increased. Snow at 1954 contained about 3×10^{-10} gm Pb/gm snow, and at 1964 the concentration was in one case 7 and in another 25×10^{-10} gm Pb/gm snow. Silica analyses gave Si concentrations in the snows of about 1×10^{-8} gm Si/gm snow, which showed that the observed pre-1904 lead concentrations were a thousand times higher than those which would result from natural dusts.

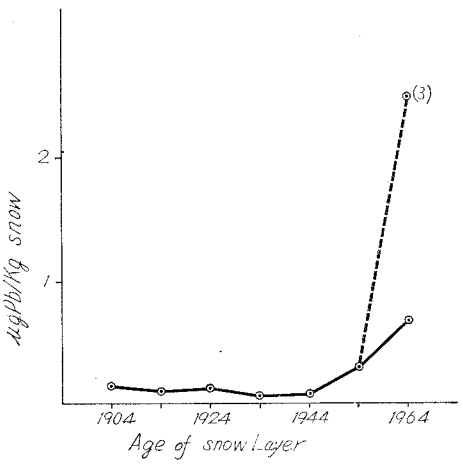

Fig. 1. Pb in Greenland Snow

There are two alternative explanations for these results. On the one hand, the high background of lead in the older snows could have originated from smelter fume, smelter dust, and contributions from lead alkyls may not have exceeded this background until the late nineteen

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forties. This is possible because the fraction of the total yearly lead production in the United States devoted to lead alkyls increased from zero in 1923 to about 15% in 1963, while the total yearly lead production together with the fraction lost to the air as fume remained more nearly constant.

The total annual lead productiod in the United States and the estimated annual lead alkyl production in the world at various times are shown in Figure 2. Atmos-

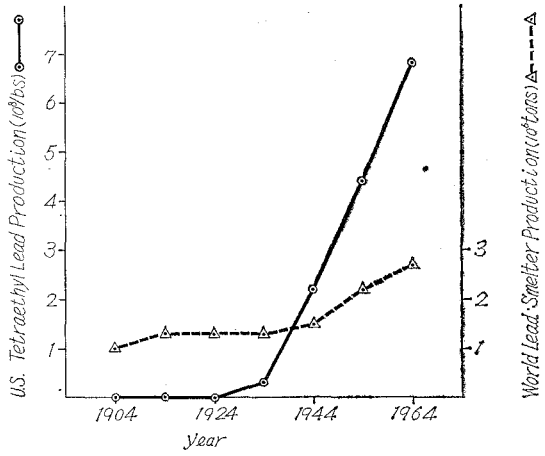

Fig. 2. Lead Smelter and Alkyl Production

pheric contributions from smelter production may amount to about one part in a hundred, while atmospheric contributions from lead alkyls may amount to about two parts in three. This large discrepancy between fractional contributions from these two sources combined with differences in their production histories provides a basis for the interpretation of the lead concentration data which has been offered above.

It is perhaps significant that the concentration of lead in the air at Camp

Table 1. Pb^{206}/Pb^{207} Ratios in Lead from the Air, Snow, Sea Water and Gasoline

Source of Lead	Pb^{206}/Pb^{207}*	Comment
East Coast gasoline	1.186	Compositions of Pb ores differ. Feed to alkyl plants on east and west coasts may differ.
Greenland snow	1.177	Should be mixture of east and west.
West Coast gasoline	1.145	If alkyl lead contributions are significant, lead in air, snow, sea water, and gasoline should be similar locally.
West Coast snow	1.144	
West Coast air	1.154	
West Coast sea water	1.161	
West Coast ocean sediment (deposited 10^{-10} yrs. ago)	1.197	Ancient indigenous lead probably differs from non-indigenous alkyl lead.

Century, uncontaminated by local gasoline exhausts, was found to be about 0.01 γ Pb/m^3 in 1964, which is thousands of times higher than would be expected from natural dusts and salts in the air. Furthermore, as shown in Table 1, the isotopic composition of lead in 1964 snow at Century was intermediate between the slightly non-radiogenic leads in gasoline sold on the west coast of the United States and the slightly radiogenic leads in gasolines sold on the east coast of the United States.

On the other hand, gasoline powered vehicles have operated at Camp Century since 1954, and the rise of lead concentratrations in snow during the last decade may have resulted from local sources of lead contamination. In addition, the size of the samples was scaled up ten times larger than those successfully analyzed before, and the high background of lead in the older snows may have originated from improper cleaning of the large polyethylene snow-melting drums which were used.

The two different lead concentrations in 1964 snow shown in Figure 1 originate from two different sites. The high value came from a site located six miles NE of Century. It was collected by using a gasoline powered vehicle to get to the site and the samples were towed back to camp in the exhaust plume of the vehicle. The amount of lead spewed into the air around the samples by the vehicle on the return trip was about 10^6 times greater than the amount of lead found in the samples. The low value came from a site located three miles E of Century. It was collected by traveling to and from the site on foot. It is not known whether these two values reflect lateral heterogeneity in real lead concentrations or differences in local contaminaiton during collection.

These preliminary results show that it may be possible to evaluate the extent of lead pollution of the atmosphere as a function of time by analyzing fossil snow. It is proposed that additional snow samples older than 1954 be taken at Camp Century and melted in Kel-F coated stainless steel pots to eliminate the possibility of contamination during melting. A grid of surface samples, accessible by helicopter, would be taken in the NE sector at very remote distances from Camp Century to study lead concentration variability in one time zone in an area known to be free of local sources of lead contamination. Two or three deep trenches would be dug and sampled at very remote distances from Camp Century to provide access to snow accumlated during the last fifteen years in areas known to be free of local sources of lead contamination.

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