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The long-term mining legacy and remobilization of anthropogenic Pb in a mountainous catchment

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The mining industry associated with ore smelting leads to trace metals (e.g., Pb, Sb, As, Cd, and Cu) dispersal into all compartments of the critical zone. During smelting, a substantial amount of metal-rich particles is emitted toward the atmosphere and transferred airborne at the regional up to the global scale. Such anthropogenic contamination is recorded in environmental archives, from atmospheric fallouts deposited on lake and terrestrial surfaces. This study has evaluated the anthropogenic Pb accumulation rates and inventories related to an ancient mine, in order to decipher the mining heritage and the remobilization of anthropogenic Pb over 200 years.

The Pb-Ag mine of Peisey-Nancroix (NW French Alps, 1550 m a.s.l.) was operated from 1734 to 1866, producing 21 500 t of Pb and 53 t of Ag. Smelting (1745-1834) emitted fumes that were toxic for the local people and crops. Five lake sediment cores were collected in Lake La Plagne (located 7 km uphill and downwind the smelter at 2100 m a.s.l) and 13 topsoils were collected in the lake catchment for major and trace elements as well as for Pb isotopes analyzes. An age depth-model was provided from ^{14}C dating and ^{210}Pb, ^{137}Cs, ^{230}Am short-lived radionuclides for the lake sediment core, allowing calculation of the anthropogenic Pb accumulation rate over time and inventories.

Geochemical and isotopic data show that La Plagne lake surface and its catchment soils have recorded the anthropogenic Pb emitted during smelting. Pb isotope ratios and estimated accumulation rates of anthropogenic Pb in more recent sediments provide evidence of anthropogenic Pb transfer from the catchment to the lake for almost 200 years (i.e., since mine closure). Such hypothesis is being confirmed by soil geochemical and isotopic data. If such transfer decreases over time, the catchment soils still contain significant stocks of anthropogenic Pb (50-85%), suggesting that the most mobile anthropogenic Pb has been leached out, and that the remaining anthropogenic Pb must be more stable. Therefore, 80 years of smelting has contributed to increase the stock of Pb in soils on the long-term, for several centuries at least.