5500 YEARS OF LEAD DEPOSITION RECORDED IN STAROSELSKII MOCH, AN OMBROTROPHIC PEAT BOG IN NW RUSSIA

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Introduction

Ombrotrophic peat is widely used as an archive for reconstructing atmospheric deposition of Pb and other elements. Profiles dated with ^{210}Pb and ^{137}Cs and covering the past 100-150 years allow tracing of changes in Pb sources and deposition fluxes, reflecting industrial activity and also consequences of the introduction and ban of leaded gasoline over the past decades. Recent changes can be related to pre-industrial changes recorded in deep peat layers dated with ^{14}C. Application of Pb isotope geochemistry facilitates the identification of Pb sources and their changes over time. However, no such documentation is available for the vast territory of Russia. The aim of this study was the reconstruction of the natural and anthropogenic Pb deposition history over several millennia, based on a combination of elemental concentrations and isotopic ratios in dated ombrotrophic peat.

Methods

Peat cores were collected in the ombrotrophic peat bog Staroselskii Moch located in the Central Forest State Natural Biosphere Reserve, Tver region, NW Russia (56.47588°N, 33.04627°E) in August 2013: three 5.5 m cores covering almost 9000 years and a 64 cm surface monolith were taken using a Russian and a Wardenaar corer, respectively. The lower margin of ombrotrophic peat was determined at 4.0 m (5500 years). Peat cores and monolith were sliced into 2-cm sections, and bulk density and loss on ignition (550, 900°C) were determined. The upper part of the peat was dated from profile of unsupported ^{210}Pb ($t_{1/2}$ 22.3 yr) determined by alpha spectrometry (Flett Research Ltd., Canada). Two dating models (linear regression model LRM and constant rate of supply model CRS, Appleby, 2001) provided very similar results, and also showed good agreement with ^{137}Cs profiles determined by gamma spectrometry (Stockholm University) revealing a distinct peak from the Chernobyl fallout in 1986. The lower part of the core was dated using ^{14}C (Institute of Geography RAS, Moscow). After ashing (550 °C), samples were totally digested in concentrated HF, HNO_3 and HCl at 120 °C, dried, and diluted in 3% HNO_3 for

determination of element concentrations and Pb isotopes by ICP-MS (NexION 300D, Institute of Geochemistry RAS, Irkutsk).

Results

Deep layers in the ombrotrophic (atmospherically fed) peat represent background conditions 2200-5000 yr ago with respect to Pb atmospheric deposition flux and isotopic composition: 0.014 ± 0.011 Pb mg m^{-2} yr^{-1}, $^{206}Pb/^{207}Pb$ = 1.197 ± 0.006, $^{208}Pb/^{206}Pb$ = 2.080 ± 0.006. Already 1500-2000 years ago, Pb concentrations started to grow, and isotopic composition started to shift towards less radiogenic ore-Pb. Deposition of Pb reached a maximum of about 17 mg m^{-2} yr^{-1} in the 1930s, exceeding the background level about 1200 times. Despite a pronounced decrease in Pb deposition since the 1970s, the modern deposition (0.7 mg m^{-2} yr^{-1}) still exceeds the background value about 50 times. Likely sources of anthropogenic Pb in the study area are 1) brown coal excavated from local mines in 1948-1996 yr from which the slagheaps still remain at a distance of about 40 km ($^{206}Pb/^{207}Pb$ = 1.285 ± 0.063, $^{208}Pb/^{206}Pb$ = 1.954 ± 0.095) and 2) leaded gasoline used in Russia from the 1930s until 2003 ($^{206}Pb/^{207}Pb$ = 1.151 ± 0.009, $^{208}Pb/^{206}Pb$ = 2.115 ± 0.007, Mukai et al., 2001). The isotopic composition of gasoline Pb agrees well with the average isotopic composition of the main Pb-ore deposits in Russia and the former USSR (Mukai et al., 2001). Shift of isotopic ratios with time towards the less radiogenic values confirms the dominating role of ore-derived Pb in anthropogenic deposition. Fractions of natural (background) and anthropogenic (ore=gasoline) Pb in deposition were calculated using a mixing model based on $^{206}Pb/^{207}Pb$ ratios. Results show that the fraction of ore-Pb reached a maximum of 80% in the last decade of the XX century, while in the modern deposition the fraction is about 70%. However, the uncertainty of such calculations is considerable (standard error about 20%).

Conclusion

Our study demonstrated a predominance of anthropogenic Pb in modern deposits of lead in NW Russia, even after the significant reduction of Pb (deposition) emissions during the past decades.

References

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