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Investigation of lead origin and fate in soils using geochemical and archeological methods

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Soil contamination by heavy metals (HM) is a global process because of transboudary air transport, and it has become difficult to distinguish between industrial and natural metals in soils even in the remotest areas. There are evidences that global contamination of the environment with lead took place since Roman Empire (Renberg et al., 2000). Information about the state of the environment in pre-industrial times gives values for natural background metal levels in soils. This information can be obtained from the investigation of different natural or archeological objects.

Our study was focused on the investigation of lead origin and fate in soils using a comparative analysis of Pb isotopic ratios and Pb profile distribution in the modern soils and paleosols buried under burial mounds (kurgans) and historical constructions in Volgograd region, Russia.

We investigated soils buried under kurgans of different ages forming a following chronological sequence: site 1 (Salomatino) - Srubnaya Culture (XVI-XV cent. BC), Late Sarmat (II-III cent. AD), Golden Hord Period (XIII-XIV cent. AD); site 2 - Anna Ioanovna Wall, a fortification between Volga and Don (1718-1720 AD). Location of most of objects (except Anna Ioanovna Wall) in one place, and the fact that all soils belong to the same soil type (chestnut soil) gives a unique opportunity to minimize the influence of spatial and soil heterogeneity factors, and makes it easy to see the influence of historical factor (as a climate change, or development of industry resulting in global environment contamination).

Samples were collected from all genetic horizons of paleosols as well as from the reference modern soils.

Total concentrations of elements and lead isotopes were determined in soils samples by ICP-OES (major elements) and Q-ICP-MS (trace elements and isotopes). The results gave opportunity to describe Pb and its isotopes distribution along soil profiles and to compare modern and buried soil. No statistically significant difference was found with regard to the total lead concentrations and isotopic ratios for the soil profiles buried in XVIII and XIII-XIV centuries AD compared to the modern soil profiles. This could confirm the recent results (Renberg et al., 2000) demonstrating that substantial atmospheric lead pollution took place in Europe already around 1000 AD due to metallurgy. However there is a decreasing difference in Pb concentrations in upper horizons in the row Srubnaya Culture > Late Sarmat > Golden Hord Period > Anna Ioanovna Wall compared to the modern soil, probably reflecting an increasing input of anthropogenic lead. Isotopic compositions of the whole soil profiles in all sampling sites demonstrated very low values of $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$, similar results were demonstrated for some deep horizons of German soils (Haack et al., 2003). This could be treated as an evidence of low input of anthropogenic lead in this region. However in the case of Salomatino range of isotopic ratio along modern and buried soil profiles is much broader than in the case of the fortification wall. In Salomationo soils we observed a clear difference between isotopic ratio in lower horizons D and C ($^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$) and upper horizons A for both modern and buried profiles. Lead compositions of upper horizons fit to ESP line and Russian-GDR gasoline line and probably reflect the influence of airborne Pb deposited from a continent-wide mixing system or local sources of Pb-gasoline.

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