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ISOTOPIC GEOCHEMISTRY OF TRACERS FOR MINING AND SMELTING ACTIVITIES IN LANDSCAPE ENVIRONMENT IN THE SOUTHERN URALS

Приведены результаты использования радиометрических трассеров для характеристики горнопромышленного техногенеза Южного Урала. С применением изотопов ^{210}Pb и ^{137}Cs оценены скорости озерной седиментации в условиях природных и природно-техногенных ландшафтов подзоны южной тайги. При пирометаллургии меди важным индикаторным признаком являются низкие отношения стабильных изотопов свинца ^{206}Pb/^{207}Pb для объектов окружающей среды (металлургические пыли, атмосферный аэрозоль, донные отложения озер доиндустриального периода и верхние интервалы гумусово-аккумулятивных горизонтов почв).

The South Ural area has been heavily affected by mining activities, which include mining, transportation, storage, beneficiation and smelting of metaliferous ores. These cause the atmospheric and aqueous transport accumulation, transformation and reactions of trace – toxic elements in this area. These cause a perturbation of the major environmental systems: atmosphere – soil, atmosphere – water surface, water – lake sediments. The most common effects of mining activity and ore processing of massive sulphide deposits are the dispersion and accumulation of chalcophile elements. In this areas, the technogenic industrial elements are added to the already high natural background levels of trace elements in rocks, soils and plants. This enrichment in technogenic constituent elements is largely caused by atmospheric transport of fine particles from the locations of exploitation, wastes, tailings and copper smelters, in particular of copper ores. Native landscapes are modified to natural-industrial landscapes with formation of geotechnogenic systems in and around the locations of mining and ore processing.

A series of geochemical isotopic methods was used to identify the effects of mining and processing. This series of methods includes the use ^{137}Cs and ^{210}Pb as chronological indicators for the dating of lake sediments and the determination of their sedimentation rate. It includes also the ^{206}Pb/^{207}Pb isotopic ratio for the evaluation of chalcophile elements transport and cycling in these natural-industrial landscapes. One of the isotopic geochemical markers for the evaluation of sedimentation conditions and rate in continental lakes and costal areas is ^{210}Pb [Krishnaswami et al., 1971] during 55 years and ^{137}Cs [Pennington et al., 1973] during for 40 years. So far, to our knowledge, no such research was published. These methods have not been used for decoding of ecological processes in lake-ecosystems, that occur as a result of mining and ore processing. This seems to be the reason for the lack of information on geochronological reconstruction of changes in the landscape during the period of most intensive copper mining and smelting activity in the Southern Urals. Previous studies used palinological and radiocarbon methods for dating the effects on lake sediments at the South Urals. These studies showed the changes in the ecosystems in longer geological time scale of the Holocene.

Evaluation of ^{137}Cs in the sediments of 8 lakes makes it possible to identify two types of radionuclide distribution depending on the water surface area. The vertical distribution of radioactive cesium in the euthrophic lakes with the water surface area of approximately 1–2 km^2 has a natural character with a "stretched" peaks in the ranges of 0–22 cm and with the lack of a pronounced contrast of individual peak, which corresponds to the maximum of radiocesium deposition from the atmosphere or troposphere in 1963–1964.

At the same time two peaks of radiocesium can be identified in the oligothrophic lakes with the water surface area of 28–54 km^2: peaks of 1963 and 1986 were identified indicating the event of the Chernobyl disaster. The associated geochemical landscapes confirmed the picture of so-called primary mosaic ^{137}Cs distribution. This mosaic distribution depends on the sources features, fractionation processes during atmospheric radionuclide transport, relief conditions and the atmospheric the conditions.

The comparative analysis of sedimentation rates for ^{137}Cs and ^{210}Pb helped the assessment of sedimentation rates with a minimum of 1.5 mm/year (Lake Svetloe) and a maximum of 2.4 mm/ year (Lake Alabuga). The sedimentation rates of these two oligothrophic lakes are similar. These results are consistent with the data obtained for the lakes of the foothill-Siberian taiga landscapes: 1.5–2.0 mm/year. The sedimentation rate for the lakes near copper smelters increased 2–2.5 times and is 4.8 mm/year. This is due to high level of erosion in the catchment area, increase in terrigenous input and significant contribution of air dust components from copper smelters.

The application of Pb isotopic ratios was first proposed in the 1970-s to assess the antropogenic impact on the environment. Since then, nearly two hundred publications about Pb isotopic reported the data one human influence on atmosphere, hydrosphere, soil, and lakes sediments. The

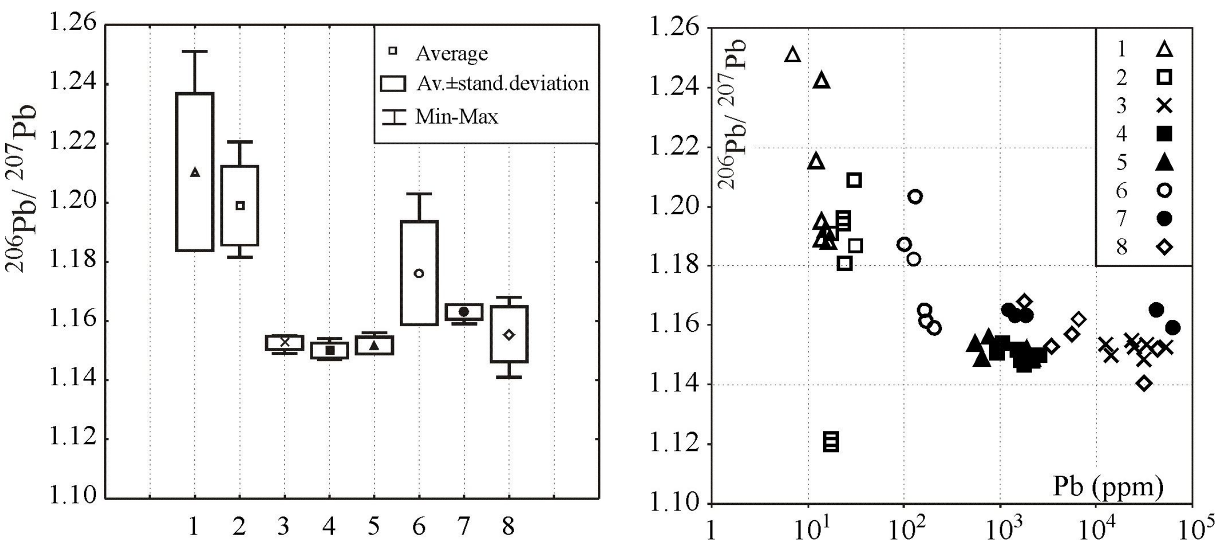

Fig. Isotopic ratio $^{206}Pb/^{207}Pb$ (left) and correlation rations from Pb concentration (right) in "background" environment and smelting area (1 – background lake sediments (depth 1 m), 2 – mineral horizons of soils (depth 30 cm), 3 – metallurgical dust, sulfide ores, slags, 4 – top soil horizons (0–8 cm), 5 – lake sediments smelting industry period (interval 0–20 cm), 6 – snow dust "background" environment, 7 – snow dust in smelting and mining area, 8 – atmospheric dust wet summer precipitation.

general observation is that the most contrast $^{206}Pb/^{207}Pb$ ratios for the background samples are at the level of 1.18–1.35, and reflects the original Pb isotope ratio. In contrast, alkyllead gasoline, atmospheric aerosoils, smelting dust have low $^{206}Pb/^{207}Pb$ in the range of 1.04–1.15. As the difference in isotopic ratios of $^{206}Pb/^{207}Pb$ is approximately 2%, it seems to be sufficient to distinguish between the natural and the anthropogenic components, and even to assess their relative contribution to the overall balance of the substances in the environment [Ettler et al., 2004]. Therefore the Pb isotope method is widely used in geochemical studies.

Figure 1 illustrates the Pb isotopic ratios of the major components in the natural environment of the Southern Urals. We can clearly see the contrast in $^{206}Pb/^{207}Pb$ isotope ratios for the two main components of the natural environment – lake sediments and soils of the pre-industrial period with average ratios of 1.210 and 1.198, respectively. In contrast industrial pollution has an $^{206}Pb/^{207}Pb$ average value of 1.152. The upper intervals, the humic part of soils and lake sediments under the influence of mining and smelting impact have similar relationships (Fig.). The Pb isotope ratio is a good indicator of anthropogenic impact on the snow dust composition, its "background" landscapes have an average ratio of 1.174 and atmospheric dust, which comes with rains in the summer has an average value of 1.154. These low values of isotopic ratios demonstrate regional scale of mining and smelting impact on the South Ural environment [Weiss et al., 2004; Spiro et al., 2013].

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CHARACTERISTICS OF PRIMARY ORE AND FORMATION CONDITIONS OF KONTROL'NOE GOLD DEPOSIT (UCHALY REGION, RUSSIA)

Контрольное месторождение приурочено к серицит-кварцевым метасоматитам, образованным по вулканогенным породам карамалыташской свиты (D_2ef-zv*kr*). Для определения физико-химических параметров нами были изучены первичные флюидные включения из кварца и барита из сульфидсодержащих жил в рудной зоне. Измерения первичных флюидных включений показали следующие интервалы температур гомогенизации: для кварца 160–320 °C, для барита 160–250 °C. Температура эвтектики включений в барите варьирует в пределах от –20.5