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Comparison of gasmercury, mercury-biogeochemical and soil-geochemical investigations on the ore deposits of Siberia

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Abstract. Our investigations of 1966–2001 resulted in working out high effectivity of revealing of ore deposits by Hg anomalies in ash of the nonbarrier bioobjects of plants. In the Ozernoe pyrite-polymetallic deposit gas-Hg haloes above gossan of polymetallic mineralization 500 m wide were revealed with 4 separated local anomalies 30–80 m wide. They have Hg content 12–50 ng/m^3 on the background 6 ng/m^3. The continuos Hg-biogeochemical haloes more than 1–2 km wide have maximal concentrations of Hg above gossan reaching 10–40 ppm. They exceed the local background 50–200 times and the limit of permissible concentrations (LPC) for plants – 5–20 times. Contents of mercury in soils from 0,1 to 1,6 ppm do not exceed LPC Hg for soils – 2 ppm. On the second deposit, the Nazarovskoe pyrite-polymetallic deposit gas-Hg haloes were not established because of the water-logged peat soils. Hg anomalies in plants are up to 800 ppb on the background 20 ppb. On the third deposit, the Malo-Oinogor stockwork molybdenum deposit Hg-biogeochemical haloes exceed LPC 3–6 times. The area and contrast of them exceed significantly the parameters of gas-Hg and soil geochemical haloes. The data on the soils in all three deposits do not give an accurate account of Hg pollution.

Key words. mercury, air, gasmercury, plants, soil, ore deposits, Siberia

1 Introduction

Our investigations of 1966–2001 resulted in working out high effectivity of revealing and contouring of various ore deposits by Hg anomalies in the nonbarrier bioobjects of plants. The peculiarity of these works is their completeness. Hg determination with an atomic-absorption method in ash of plants was carried out in samples being analyzed with 45–60 chemical elements. This original method is published (Kovalevskii, 1983, 1989, 1991, 2000 in Russian; Kovalevskii, 1986, 1987, 1996 in English). Lithogeochemical investigations with sampling of sections of soils and native rocks have been carried out on most of 33 sites Gas-Hg investigations of soil air and geophysical, biogeophysical (biolocation), geoarchaeological, geobotanic, and phytopathogenic investigations have been performed.

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2 Results

The most important result of these studies is that Hg-boigeochemical surveys allow to obtain a considerable body of evidence in comparison to soil geochemical surveys. The data has been obtained on all (31) non-Hg deposits – iron, manganese, barium, pyrite-polymetals, silver, gold, platinoids, tungsten, molybdenum, beryllium, lithium, fluorine and antimony. We have established Hg biogeochemical haloes and anomalies exceeding the local background 10–4000 times. Their contrast and width is much greater than in soil-geochemical and gas-Hg ones. We have found all the ore deposits and some tectonic fault zones are followed by Hg biogeochemical haloes and anomalies. The soil-geochemical haloes and Hg anomalies, found with the same technique as with the ash of plants, follow about half of biogeochemical ones, and their contrast is much less exceeding the background 2–10 times. There are no soil-geochemical anomalies and haloes with biogeochemical ones on half of the sites revealed. Only on two Hg deposits the contrast of lithogeochemical haloes of cinnabar ore bodies 1–2 m deep was higher than biogeochemical ones. In one half of the investigated localities soil geochemical haloes and anomalies of Hg were absent. That is attributable to very intensive accumulation of Hg gaseous forms by plant roots which may be $10^6 - 10^9$ times more than from a solid phase of the root zone. The data obtained indicate that haloes of Hg gaseous forms follow almost all types of ore and non-metallic deposits. The evidence published (Stadnik, 1984 in Russian) suggest that Hg haloes follow some gas and oil deposits. Hg

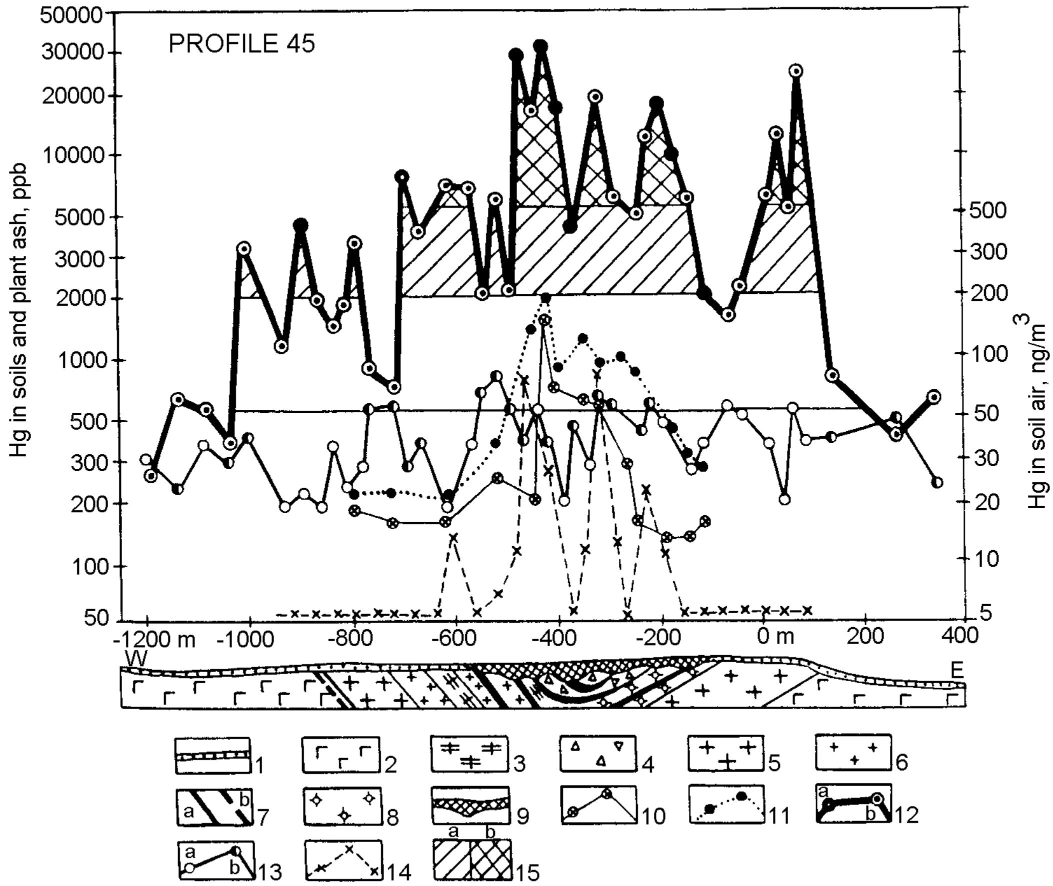

Fig. 1. Mercury distribution in soils, plants ash, and soil air along profile 45 of the Ozernoe pyrite-polymetallic deposit (corrected for the mercury loss during plant sample ashing).

Exploration. 1 – loose cover: 2–4 – Ozernoe series: 2 – welded tuff horizon, lavas and welded tuff of andesite-dacite and porphyrite with lenses and layers of limestone breccia and mineralized tuffites; 3 – tuffite horizon, calcareous tuffites and breccia, tuff gritstone; 4 – first productive horizon, limestones, limestone, breccia and gritstone, tuffites, ignimbrite-type tuff and five orebodies; 5 – automagmatic breccia of rhyolite-dacite porphyry; 6 – dacite porphyry; 7 – pyrite-lead-zinc orebodies (a – prospected, b – suggested); 8 – siderite ores; 9 – gossan of oxidation zone; 10–11 – mercury contents: 10 – in soil horizon A (0–0,1 m); 11 – in soil horizon C (0,5–1,2 m), 12 – comparable nonbarrier bioobjects: a – bark of *Betula platyphylla*; b – outer cork layers of *Larix dahurica*; 13 – in background-barrier bioobjects: a – branches of *Betula platyphylla, Larix dahurica, Populus tremulus, Rhododendron dahurica*; b – sprouts of birch, larch, and aspen; 14 – in soil air (from data by IGO "Buryatgelogiya"); 15 – biogeochemical anomalies of various intensity: a – average; b – high.

is a universal indicator of mineralization, including oil and gas (Kovalevskii, 1989 in Russian).

The comparison of Hg-biogeochemical data with gas-Hg ones which were gained by the Industrial Geological Organization "Buryatgeologiya" on three deposits is of great interest.

On the first deposit – the Ozernoe pyrite-polymetallic deposit we revealed gasmercury and Hg-biogeochemical haloes, gas-Hg haloes above a gossan of the polymetallic mineralization 500 m wide represented by 4 separated local anomalies 30–80 m wide (Fig. 1). The interval between points of soil air sampling was 20 m. The contents of Hg 13–50 ng/m^3, on the background – 6 ng/m^3 exceeding the background 2–8 times. The inner structure of the gas-Hg halo does not correspond to the areal distribution of the gossan of the deposit. The Hg-biogeochemical halo with the level exceeding the local background close to 0,2 ppm 10 times, i.e. 2 ppm is 600 m wide. It is accompanied by some similar maximums in both sides of the gossan of the deposit. Maximum concentrations of Hg in the nonbarrier bioobjects of plants above the gossan are up to 10–40 ppm exceeding the local background 50–200 times, and the limit of permissible concentrations (LPC) for plants – 5–20 times. The continous Hg biogeochemical halo is 1,2 km wide with Hg with 0,6 mg/kg exceeding the local background 3 times. The inner structure of this mercury biogeochemcal halo corresponds to the gossan of the deposit and the surrounding mineralized zones. The content of mercury in soils varies here from 0,1 to 1,6 ppm and does not exceed LPC for soils – 2 ppm. It is this – the Ozernoe deposit where the first mercury biogeochemical locality with high concentrations of Hg in plants was revealed when its content in soils and rocks was low. This locality is a part of non-contoured mercurybiogeochemical province of a complicated inner structure more 400 km^2 in area. The province corresponds to the Ozerniy ore knot but is outside it in the east where high Hg concentrations were found in the liver of the sheep, exceeding LPC 3–10 times.

On the second deposit – the Nazarovskoe pyrite-polymetallic deposit – gas-Hg haloes were not revealed because of the water-logged peat soils. Mercury-biogeochemical haloes and anomalies in the ash of nonbarrier bioobjects of plants exceed the local background 10–30 times and is up to 800 ppb with the background 20 ppb. Maximum concentrations of Hg in plants exceed LPC for vegetable food 4 times.

On the third deposit – the Malo-Oinogor stockwork molybdenum deposit – in the bark of *Larix dahurica* and *Pinus sibirica* there revealed Hg-biogeochemical haloes with maximum concentrations of Hg exceeding LPC 3–6 times. Their area and contrast exceed significantly the parameters of gas-Hg and soil geochemical haloes.

3 Conclusions

The comparison of mercury-biogeochemical and gas-Hg haloes and anomalies in all three ore deposits suggest they provide quite different informativity on biogeochemistry. Hg concentrations in some non-barrier bioobjects exceed LPC for food 10–40 times what is very dangerous for man and animals. Data on soils and soil air gained support low Hg concentrations in that area. These data are invalid and suggest one should study gaseous Hg forms in root zones of soil and rocks and aerial air taking into account Hg content in plants and non-barrier organs and tissues of animals. They are liver, kidneys, hair, feathering. The examples discussed indicate that biogeochemical data give an accurate account of the environmental pollution by Hg gaseous forms.

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