EXPERIMENTAL STUDY OF MINERAL AND GEOCHEMICAL COMPOSITION OF AEROSOLS IN NOVOSIBIRSK SITY

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In large cities of Siberia, there are many industrial enterprises being emission sources. To determine of mineral and geochemical composition of Novosibirsk city technogenous aerosols produced 1) on tin concentrate smelting; 2) combustion of coal at heat power plants (HPP-2, HPP-3, HPP-5); 3) aerosols formed along highways was the goal of study. In Siberia, snow is an ideal model object to study industrial emissions, because from early November to late March-early April, a steady snow cover contains solid aerosol particles as well as gaseous products adsorbed on solid phases.

In winter, south and southwest winds prevail in the rose of the winds [1]. Therefore, aerosol emissions of the above industrial enterprises are spread mainly in the northeastern and northern directions, so snow sampling profiles are located in those directions.

Finely dispersed solid aerosol phase was concentrated by filtration of melted snow. The elemental composition of solid aerosol particles was quantitatively determined by X-ray fluorescent analysis on synchrotron radiation (SR-XRFA) at the VEPP-3 Elemental-Analysis Station of the Budker Institute of Nuclear Physics, Novosibirsk. This method permitted determination of 35 elements (Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ga, Ge, As, Br, Mo, Ag, Cd, Sn, Sb, Te, Hg, Tl, Bi, Th, Pb, etc.) with detection limits of up to 0.1 ppm depending on the excitation energy of emission lines [2]. The relative standard deviation was 10-15%.

X-ray diffraction analysis of aerosol particles was carried out on a DRON-3M powder diffractometer (CuK_{α}, U = 40 kV, I = 24 mA). This method permits a semiquantitative estimation of mass fractions of mineral phases.

The morphology and chemical composition of aerosol particles were studied on an LEO 1430 VP scanning electron microscope equipped with an (EDS) OXFORD energy dispersion spectrometer. Scanning beam was ~3-5 μm in diameter, which permitted determination of the compositions of aerosol particles larger than 5 μm. Some spectra revealed intimate intergrowths of fine grains. The particles were examined in secondary and back-scattered electron images. Sizes and forms of 1286 grains, including 665 aluminosilicates, 509 spherical vitreous particles, and 112 ore minerals (cassiterite, hematite, and magnetite) are studied.

By correlation analyses, we distinguished a group of elements being indicators of the NTC aerosol pollution: Se, Mo, Ag, Cd, Sn, As, Bi, Hg, Tl, and Cr. The contents of these elements in aerosol particles in the near-field zone of the plant are two to three orders of magnitude higher than their contents near HPP-2, HPP-3, HPP-5, and the highway (fig. 1). The concentrations of Zn and Sb in the NTC, HPP-2, and HPP-3 aerosols are commensurate. Possibly, it is on coal and coke breeze firing that Zn- and Sb-containing aerosols are produced in large amounts. The lower concentrations of these elements in aerosols from HPP-5 might be due to its high exhaust pipe and more effective treatment facilities. Along the highway, K, Ca, and Mo are typomorphic elements of aerosols: Their abnormally high concentrations have been revealed within a 100 m wide strip. The concentrations of Cu, Pb, Ga, Ge, Ni, Sr, and Br in industrial and highway aerosols are equally higher than their background values.

The studied aerosol particles are few submicrons to 150 μm in size. Occasional particles reach 300 μm. Finely dispersed particles smaller than 10 μm are predominant. Aerosol particles produced on combustion of coal (HPP) and coke breeze (NTC) are mainly an amorphous phase. They also contain mullite and admixtures of magnetite and hematite (Table 3). The amorphous phase consists of finely dispersed particles of glass and carbon (product of incomplete combustion of coal). Mullite [$9Al_2O_3 \cdot 6SiO_2 \cdot (H_2O, F_2)$], resulting from sintering of finely dispersed aluminosilicate particles, is a typomorphic crystalline phase of the plant emissions produced in high-temperature processes. Usually mullite hollow aluminosilicate spheroids are contained in NTC and HPP aerosols (fig.2).

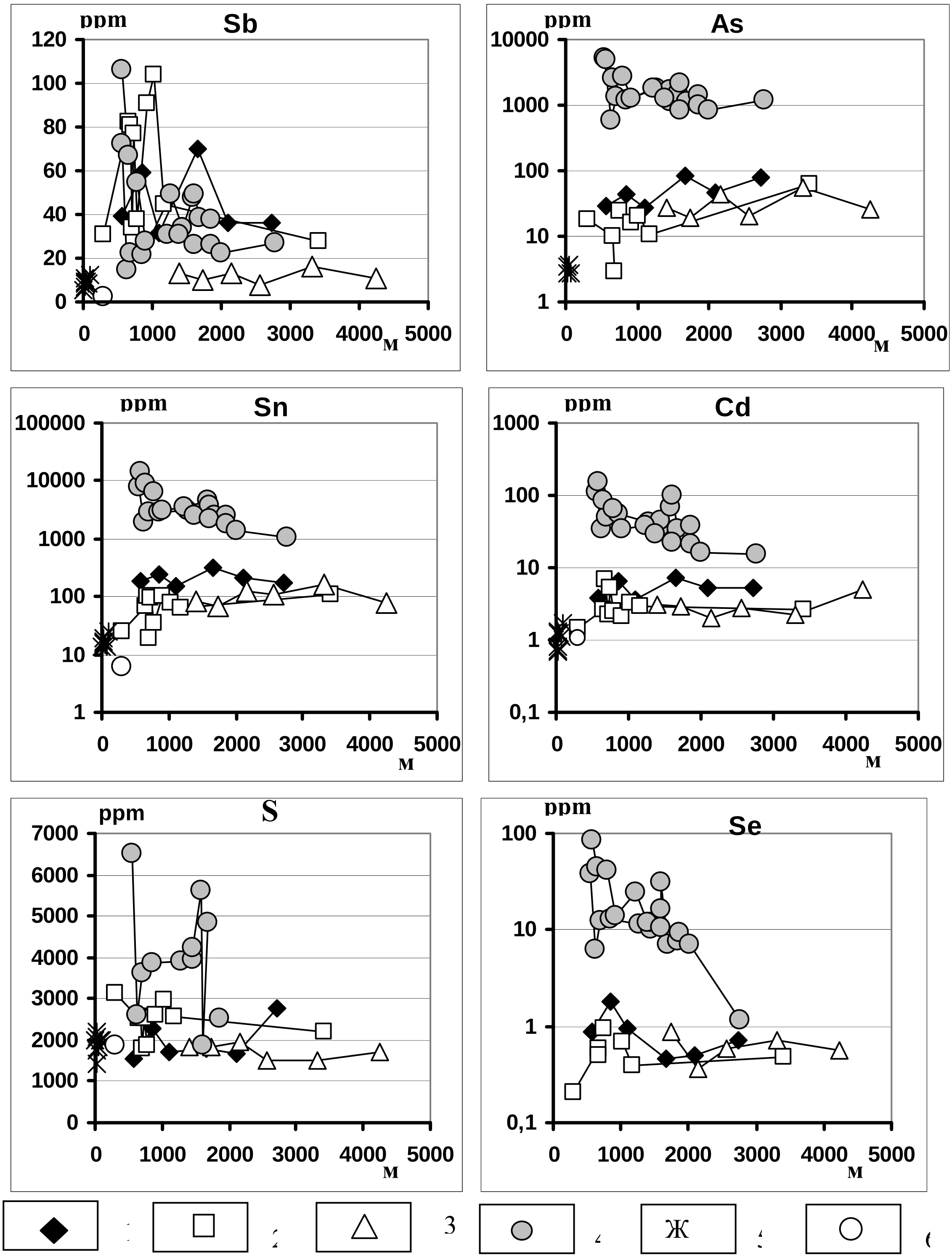

Fig.1. Contents of elements in aerosol particles in the Novosibirsk area (vertical axis - ppm, horizontal axis - distance in northen direction from the pipes of plants, m).
Analyses were made in the vicinities of: 1 - HPP-2, 2 - HPP-3, 3 - HPP-5, 4 - NTC (large circles - data of 2005, small circles - data of 2006), 5 - Highway; 6 - background concentrations

Fragments of cassiterite grains and euchroite $[Cu_2{\cdot}(AsO_4){\cdot}(OH){\cdot}3H_2O]$ (As-containing secondary copper mineral produced on copper-ore smelting) are indicators of the NTC emissions. Aerosol particles of the highway and background sites lack mullite and are poor in amorphous phase but are rich in terrigenous minerals. The background-site aerosols are dominated by natural minerals: quartz, plagioclase, mica, and clay minerals. Within the 50 m wide wayside, abnormally high contents of calcite are observed, which might be related to the erosion of the highway asphalt covering with a rubble limestone filling material.

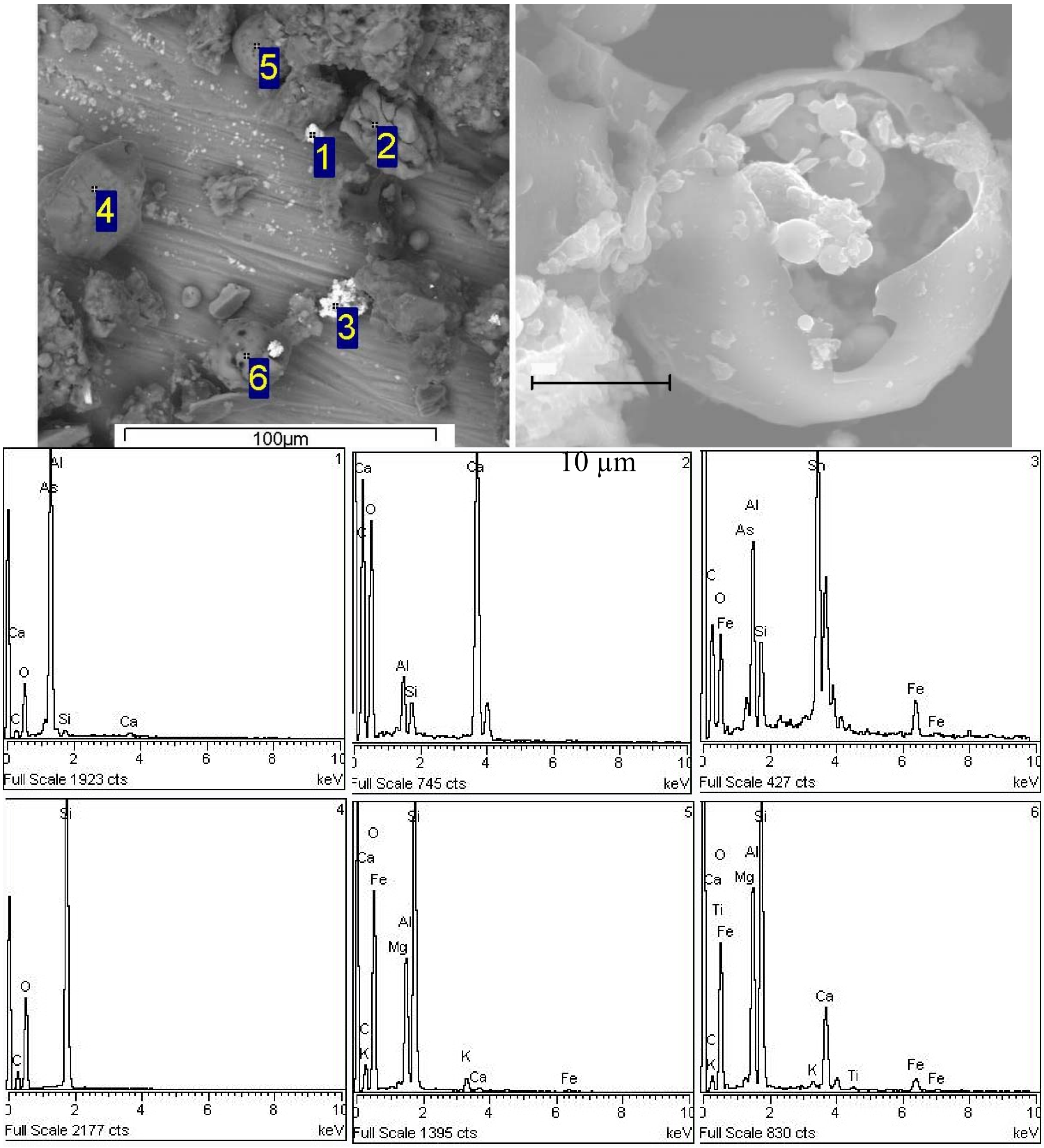

Fig.2. Electron photomicrograph of aerosol particles from the NTC near-field zone (650 m north of the pipe), on the left -common view, on the right - hollow aluminosilicate spheroids, and composition diagrams of particles, viewed on the left photo.

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References

1. Climate of Novosibirsk // Leningrad. Gidrometeoizdat. 1979. 221p.

2. *Baryshev V., Kulipanov G., Skrinsky A***.** X-ray fluorescent elemental analysis // Handbook on Synchrotron Radiation. - Eds.: Brown G., Moncton D.E. // Elsevier Science Publishers B.V. 1991. V. 3. P. 641-688.

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