

STUDY OF AEROSOL USING THE TECHNIQUE OF SECONDARY ION MASS SPECTROMETRY

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Results presented in this paper demonstrate high efficiency of the technique of secondary ion mass spectrometry in studies of the atmospheric aerosol composition. Using this method we have carried out a phase and quantitative analysis of the element composition of aerosol samples collected in Novosibirsk region. We have revealed that the composition of surface layers of aerosols differs from volume one. The results obtained allowed us to draw a conclusion that the source of aerosol is the soil erosion.

This paper presents some results of study of the atmospheric aerosol composition of a Siberian region. The permanent station of Biological Institute of Siberian Branch of the Russian Academy of Sciences was chosen for collecting aerosol samples. It is 12 km far from the town of Karasuk (Novosibirsk region). Samples were collected on the WHATMAN 41 filters. The filter area, through which the atmospheric aerosol was pumped, was 500 cm². A part of filter with the area of 2 cm² was cut out for the analysis, and the aerosol deposit was transported to a plate of highly pure In by means of scalpel in the form of scrapings.

The study was carried out using an MS-7201M device, the bombardment was done by Ar ions with 4 keV energy and 30 μA·cm⁻² current density. The diameter of a primary ion beam incident at the angle of 45° to the normal direction onto the surface of holder was 2 mm, and the treated area of the sample was 5 mm². All samples contain Na(23), Mg(24–26), Al(27), Si(28–30), K(39,41), Ca(40,42,44), Ti(46–50), Fe(56,54), and Cu(63,65). The presence of the signals of ions AlO⁺(43), SiO⁺(44), and SiOH⁺(45) in the spectra as well as the fact that the values of the ratio of masses 43/27, 44/28, and 45/28 are close to that for hydrated aluminosilicates allow us to suppose that aerosols are aluminosilicates or the mixture of SiO₂ and Al₂O₃. Really, the flux ratios for the masses 43/27 and 44/28 are (4±2)·10⁻³ and (8±3)·10⁻² and for α-Al₂O₃ and SiO₂ they are 3·10⁻³ and 2·10⁻², respectively. This is for the aerosol samples under investigation and standard soil samples SSK-2 and ST-IA that were used as a standard, with the known element concentrations. Let us note that the value of the flux of the masses 43/27 and 44/28 essentially depends on the presence of adsorbed water, since production of both ions AlO⁺ and SiO⁺ is possible from the ions AlOH⁺ and SiOH⁺ as an additional way.

The relative atomic concentrations (concentration of Fe is taken as unit) calculated from the relationship $C_i = I_i/\gamma_i$, where I_i is the intensity of the peak of i th element, and γ_i is the relative sensitivity coefficient, are given in three first lines of Table I. The values γ_i were determined from the data of the study of standard samples with known element concentrations. As it was already noted, they were the standard samples of natural mineral substances SSK-2 and ST-IA that are widely used for calibration in the atomic absorption spectroscopy.¹ On the

basis of the aforementioned we suppose that such standards are close to the aerosol under investigation in their nature. The measured relative sensitivity coefficients γ are given in the last line of Table I.

TABLE I.

Parameters	Sample (Fe)	Na	Mg	Al	K	Ca	Cu	Si	Ti
Atomic concentration	4	1.2	0.2	1.4	1.0	3.8	0.08	5.6	1.2
	11	1.2	0.3	1.5	0.6	5.8	0.07	9.1	4.0
	28	1.8	0.4	3.0	0.4	5.5	0.2	12.5	3.4
X_{Fe}	—	0.6	0.51	1.75	0.56	0.77	0.001	6.4	0.11
Enrichment coefficient	4	1.9	0.4	0.8	1.8	4.8	84	0.9	11
	11	2.0	0.6	0.9	1.1	7.6	68	1.4	36
	28	2.9	0.9	1.7	0.7	7.1	188	2.0	31
γ	—	5.2	4	7.3	21	3.1	3.1	0.7	1.5

Note: the values of concentration obtained on February 7, February 14, and March 2, 1994 are given in the first, second, and third line, respectively.

Measurements of the temporal variations of ion current of the elements during the bombardment show that aerosol particles are covered by hydrocarbons. Really, the ion current of the peaks C⁺(12), CH⁺(13), CH⁺(14), and CH⁺(15) rapidly decreases with time, while the ion current of the other masses (23, 24, 27, 28, 39, and 40) increases. The stationary values of the ion currents are settled approximately through 1500 s of treatment that corresponds to the etching depth of 300 Ошибка!. Relative atomic concentrations of the elements are given in Table I for these conditions.

It is necessary to note that many studies of the temporal behavior of ion currents showed that the data given in Table I for all elements, except for Ti, have relative error of 50%, while for the Ti the deviation is 6–7 times. Obviously, the reason for this is nonuniform distribution of the particles of different composition over the filter area.

To identify the source of atmospheric aerosol one usually analyzes the particle element composition from their

quark content² and then introduces the enrichment coefficient determined by the relationship

$$EF_i = \frac{(X_i / X_{Fe})_{\text{aer}}}{(X_i / X_{Fe})_{\text{soil}}}, \quad (1)$$

where X_i is the content of i th element in the sample analyzed and X_{Fe} is the content of Fe in the sample. The ratio measured in the sample under investigation is in the numerator, and the analogous ratio for the soil or the bedrocks is in the denominator. The enrichment coefficients are given in 5–7th lines of Table I for different elements, and the values of the denominator from Eq. (1) are given in the fourth line. These values are taken from Ref. 2. The enrichment coefficients calculated by Eq. (1) show that during the experiment the main amount of aerosol was the particles produced due to the soil erosion. In comparison with the global average element content, the soils of the southern part of Novosibirsk region are evidently enriched

with Ca (enrichment coefficient is 5–8). As special experiments showed, the high enrichment coefficients of Cu can be connected with the local source, namely, the sparks of the air pump motor brushes.

One can note, as a preliminary result, that the atmospheric aerosol composition varied insignificantly during the period of the experiment. It does not contradict to the conclusion that the main amount of atmospheric aerosol in this part of Siberia is connected with the soil erosion.

REFERENCES

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