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Scientific Paper

CONCENTRATIONS OF ^{210}Pb AND ^{210}Po IN THE ATMOSPHERE OF NY-ÅLESUND, SVALBARD

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Abstract: Daily aerosol samples were collected from 24 February to 14 March 1995 in Ny-Ålesund, Svalbard. The samples were analyzed for ^{210}Pb and ^{210}Po radioactivities, and the following results and conclusions were obtained. Atmospheric ^{210}Pb concentrations varied from 82.5±7.1 μBq/m^3 to 1204±130 μBq/m^3. According to the correlation analysis, the ^{210}Pb concentrations positively correlated to the gradient of atmospheric pressure. The result indicates that the ^{210}Pb concentrations increase as a function of air mass exchange over the Svalbard region. Residence times of the aerosols in Ny-Ålesund, which were calculated by using the ^{210}Po/^{210}Pb activity ratios, were approximately twice values obtained in the mid-latitude region. This may be the outcome of less efficient removal processes of aerosols from the atmosphere, *e.g.* coagulation and precipitation, owing to the low temperature conditions.

1. Introduction

Atmospheric ^{210}Pb (half-life 22.3 yrs) and ^{210}Po (half-life 138 days) are useful tracers of terrigenous secondary aerosols because they are radioactive decay products of atmospheric ^{222}Rn which are emanated from the land surface (Turekian *et al.*, 1989). Furthermore, the activity ratio of these nuclides provides an atmospheric residence time of aerosols, because these nuclides grow on the aerosol surfaces and the aerosol ^{210}Po/^{210}Pb ratio increases with elapsed time (Warneck, 1988). It is well known that the Arctic is strongly influenced by long range transport of polluted air masses from industrialized areas in Europe and North America (Barrie, 1986). Some scientists suggest that this anomalous enrichment of pollutants in the Arctic atmosphere may be due to a long residence time of aerosols over the Arctic (Turekian *et al.*, 1989; Shaw, 1994). However, studies on the atmospheric residence time of aerosols in the Arctic are very scarce.

In winter, 1994, the Japanese Arctic Glaciological Expedition (JAGE-94) performed successive aerosol and snow sampling in Ny-Ålesund, Svalbard. Here, we report on the preliminary results of daily variation of atmospheric ^{210}Pb and ^{210}Po concentrations in Ny-Ålesund and discuss the atmospheric residence time of terrigenous aerosols over the Svalbard region.

2. Method

Aerosol samples were daily collected on the roof of the Arctic Environmental Research Center, National Institute of Polar Research at Ny-Ålesund, Svalbard (78°56′N, 11°52′E, 35 m asl) by using a high-volume air sampler (Shibata HV-500) and Whatman 41 filter. Sample collection was carried out from 24 February to 14 March 1995. Radioactivities of ^{210}Pb and ^{210}Po in the samples were measured by α-spectrometry after suitable chemical separation (SUZUKI and SHIONO, 1995).

3. Results and Discussion

All the concentration data of ^{210}Pb and ^{210}Po obtained are listed in the Appendix together with the atmospheric pressure data. Daily variations of atmospheric concentration of ^{210}Pb and ^{210}Po are shown in Fig. 1. Averaged atmospheric concentration of ^{210}Pb in Ny-Ålesund was 325 μBq/m^3. This value is on the same order of magnitude as that in the maritime atmosphere of the mid-latitude region (TUREKIAN *et al.*, 1989). The maximum concentration of ^{210}Pb (1204±130 μBq/m^3) was observed during 3–4 March. On the other hand, the concentration of ^{210}Po showed a maximum value (135±16 μBq/m^3) during 2–3 March. The ^{210}Po/^{210}Pb activity ratio in the 3–4 March sample was 0.091 while those of other samples were 0.152–0.258 (Table 1). This indicates that the 3–4 March aerosols are clearly younger than other aerosol samples. The atmospheric concentrations of ^{210}Pb are plotted against a gradient of atmospheric pressure, the pressure on a certain day minus that on the previous day, at the same site (Fig. 2). According to correlation analysis, they have been positively correlated at 1% of significant level (r=0.657, ϕ=16, P=0.01). This indicates that the ^{210}Pb atmospheric concentrations increase as a function of air mass exchange over the Svalbard region. The ^{210}Po/^{210}Pb

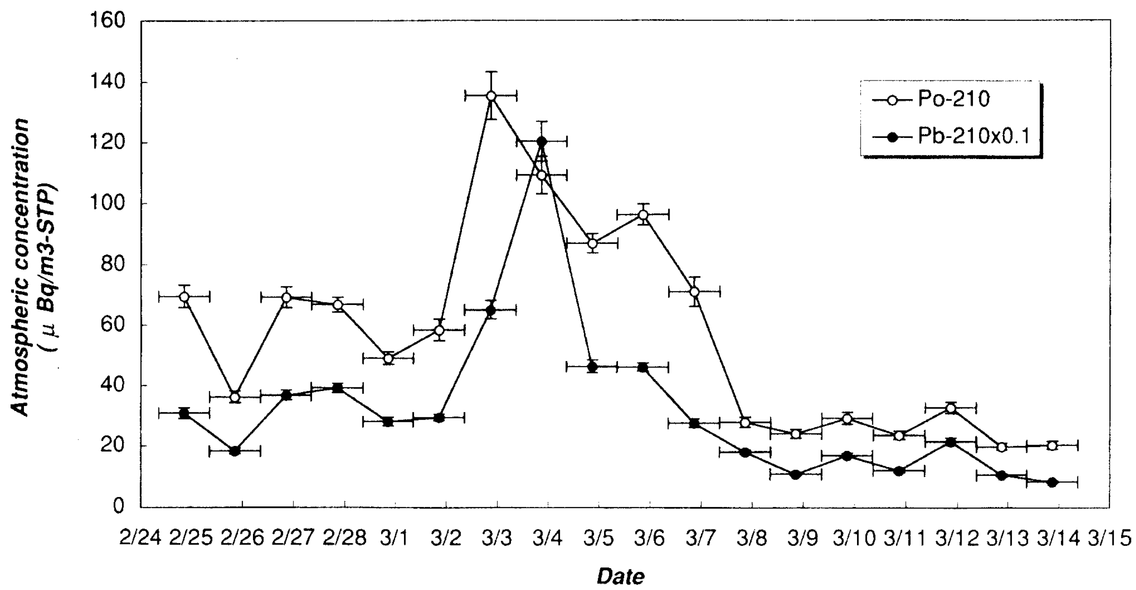

Fig. 1. Daily variation of atmospheric concentrations of ^{210}Pb and ^{210}Po at Ny-Ålesund, Svalbard. Bars in each plot indicate sampling duration (horizontal) and counting error (vertical).

Table 1. Summary of $^{210}Po/^{210}Pb$ activity ratios and calculated residence time of aerosols in Ny-Ålesund, Svalbard.

Date	^{210}Po/^{210}Pb	Residence time (days)
2/24–25/95	0.226	66
2/25–26	0.198	57
2/26–27	0.188	54
2/27–28	0.171	48
2/28–3/1	0.174	50
3/1–2	0.199	57
3/2–3	0.208	60
3/3–4	0.091	26
3/4–5	0.188	54
3/5–6	0.209	61
3/6–7	0.258	78
3/7–8	0.155	44
3/8–9	0.224	66
3/9–10	0.173	49
3/10–11	0.198	57
3/11–12	0.152	43
3/12–13	0.189	54
3/13–14	0.244	73

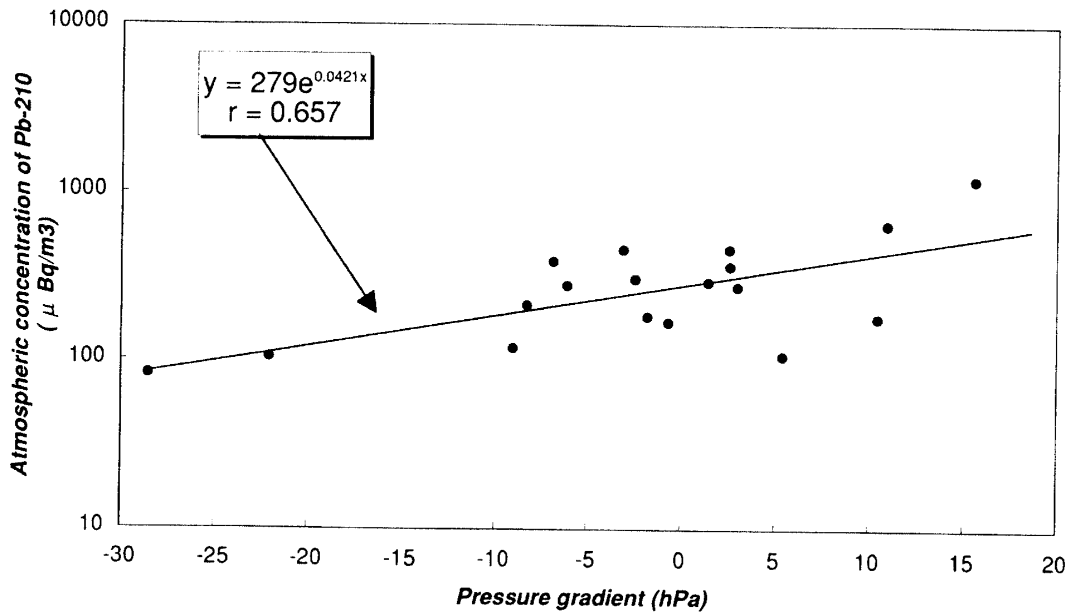

Fig. 2. Relationship between atmospheric concentrations of ^{210}Pb and pressure gradient (see the text) at Ny-Ålesund, Svalbard. The straight line is obtained by a least square method.

activity ratio and pressure gradient also show a mirror image for the daily variation (Fig. 3). This implies that a larger pressure gradient brings the younger aerosols into the atmosphere of Svalbard. These results may be caused by rapid atmospheric transport of a large amount of terrigenous aerosols over the Svalbard region, which is induced by an

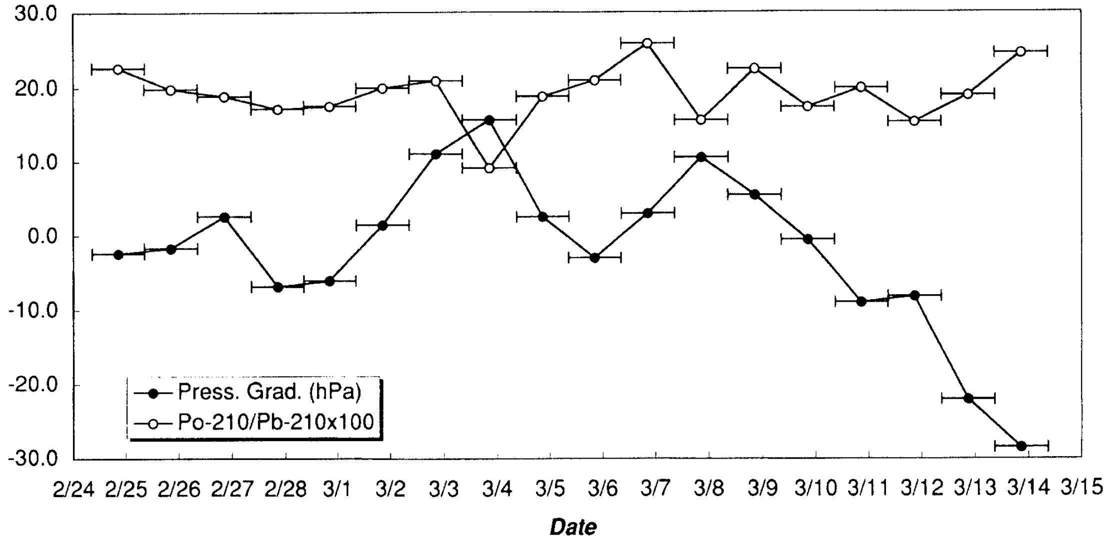

Fig. 3. Daily variation of $^{210}Po/^{210}Pb$ activity ratios and pressure gradient (see the text) at Ny-Ålesund, Svalbard. Horizontal bars indicate sampling duration.

atmospheric high pressure system.

Residence time of aerosols was calculated by the method of BURTON and STEWART (1960). If we assume that the production rates of each nuclide of the ^{222}Rn-^{210}Po series in the atmosphere are equal to their removal rates, then the ^{210}Po to ^{210}Pb activity ratio can be expressed by the following equation:

$$^{210}\mathrm{Po}/^{210}\mathrm{Pb} = T^2/(T+\tau_{\mathrm{Bi}})(T+\tau_{\mathrm{Po}}), \qquad (1)$$

where T=atmospheric mean residence time of an individual atom in the atmosphere; τ_{Bi}=radioactive mean life time of ^{210}Bi=7.2 days; τ_{Po}=radioactive mean life time of ^{210}Po=199 days. The ^{210}Po/^{210}Pb activity ratios obtained in this study were substituted into eq. (1), and the results of calculation are summarized in Table 1. Calculated residence times of the Ny-Ålesund aerosols were 26–78 days (Ave. 55 days). These values are approximately twice larger than the values obtained in the mid-latitude region (12–49 days) by the same method (WARNECK, 1988). The result indicates that the atmospheric residence time of aerosols in the Svalbard region is longer than that in the mid-latitude region. This may be the outcome of less efficient removal processes of aerosols from the atmosphere, *e.g.* coagulation and precipitation, owing to the low temperature conditions.

4. Conclusions

The following conclusions were obtained by the measurements of the atmospheric ^{210}Pb and ^{210}Po in Ny-Ålesund, Svalbard.

(1) Temporal variation of the atmospheric concentrations of ^{210}Pb and the ^{210}Po/^{210}Pb activity ratios in Ny-Ålesund seem to be controlled by change in the atmospheric pressure.

(2) Atmospheric residence times of the aerosols in Ny-Ålesund were approximately twice those in mid-latitude regions.

Further investigations including size distribution, deposition rate and chemical composition of aerosols are necessary for more precise explanation of behavior of aerosols in the Arctic region.

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Appendix. Atmospheric pressure and concentration of ^{210}Pb and ^{210}Po in Ny-Ålesund, Svalbard.

Sample No.	Duration	Atmos. press. (hPa)	Pb-210 (μBq/m^3)	Po-210 (μBq/m^3)
022495	2/24/95 8:45-2/25/95 8:27	997.2	307±35	69.5±7.3
022595	2/25/95 8:35-2/26/95 8:24	995.4	183±19	36.1±3.8
022695	2/26/95 8:26-2/27/95 8:30	998.0	367±33	69.2±6.8
022795	2/27/95 8:39-2/28/95 8:20	991.1	391±30	66.8±4.8
022895	2/28/95 8:25-3/1/95 8:27	985.0	281±29	49.0±4.2
030195	3/1/95 8:35-3/2/95 8:27	986.4	294±20	58.3±7.1
030295	3/2/95 8:38-3/3/95 8:35	997.4	650±62	135±16
030395	3/3/95 8:45-3/4/95 8:30	1013.0	1204±130	109±12
030495	3/4/95 8:37-3/5/95 8:42	1015.5	463±43	86.9±6.3
030595	3/5/95 8:45-3/6/95 8:03	1012.4	460±28	96.2±6.9
030695	3/6/95 8:27-3/7/95 8:32	1015.3	275±27	71.0±9.6
030795	3/7/95 8:41-3/8/95 8:27	1025.8	179±14	27.8±3.4
030895	3/8/95 8:37-3/9/95 8:22	1031.2	107±6	24.0±3.0
030995	3/9/95 8:30-3/10/95 8:32	1030.5	168±14	29.1±4.0
031095	3/10/95 8:40-3/11/95 8:55	1021.5	119±11	23.5±2.8
031195	3/11/95 9:05-3/12/95 8:45	1013.2	214±23	32.6±3.9
031295	3/12/95 8:58-3/13/95 9:00	991.1	105±10	19.7±2.1
031395	3/13/95 9:03-3/14/95 8:48	962.6	82.5±7.1	20.2±2.6