KOSA RECORDS IN AN ICE CORE FROM MT. LOGAN, YUKON, CANADA

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INTRODUCTION

Subarictic region of the North Pacific is one of the areas called high-nutrient low-chlorophyll (HNLC) ocean water. A hypothesis has been proposed that the biological productivity of the HNLC ocean water is curbed by iron shortage (Martin et al., 1991), and that iron provided from atmosphere to ocean is an essential factor in controlling phytoplankton productivity.

Kosa (Asian dust) aerosol, generated when the surface soil in the arid region of the east Asia continent is lifted by winds, is the major mineral aerosols transported from east Asia to the Pacific region, and plays major role in providing chemical substances to the Pacific Ocean (Mori et al, 2003). Bishop et al. (2002) reported a near doubling of biomass in the mixed layer over a 2-week period after the passage of cloud of Kosa. The frequency and scale of dust events giving rise to Kosa aerosols have increased rapidly in the east Asian region since 2000 (Nishikawa and Mori, 2003). The increase of Kosa impacts on not only the environment in east Asia but also ocean productivity that can influence climate change in the North Pacific.

In this work, we investigate a year-to-year variation of terrestrial dust in an ice core obtained from Mount Logan in Yukon, Canada, that located downwind of transport flow of Kosa from the East Asian continent to the North Pacific, in order to reconstruct the annual variation of dust fluxes provided to the North Pacific.

EXPERIMENTAL

An ice core of 220.52m was drilled at King Col (60°35'20"M. 140°36'15"W; 4135m), a saddle near Mount Logan (5959m), the Canada's highest mountain (Shiraiwa et al., 2003) in 2002 (Figure 1). Upper 30m of the ice core was used for this work. Ice core age was estimated by annual layer counting of detailed density profile of the ice core (Kanamori, 2003). The detailed density was measured by X-ray transmission method (Hori et al., 1999). The ice ages of ice core were also determined comparing with $\delta\,^{18}O$ profiles (Kanamori, 2003). The ice age of 30m-depth was estimated 1982. A total of 161 samples analyzed in this study was obtained from upper 30m of the ice core continuously. Decontamination processes were carried out in a clean bench located in a cold clean room of class 10,000 (temperature -20°C). The decontamination process involved the chiseling of ice cores with a ceramic knife to remove external contamination given during drilling, processing, and transport.

Decontaminated samples were melted into Teflon containers in ambient temperature, and transferred into low-density polyethylene (LDPE) bottles.

A snow pit observation was carried out near the drilling site (Goto-Azuma et al., 2003). There were a few ice layer formed by refreezing of melt water from the upper summer layers from surface to 2.7m depth. Chemical profiles were not disturbed by melt water judging from stratigraphy of snow layers. A total of 33 samples was collected into LDPE bottles from snow pit wall.

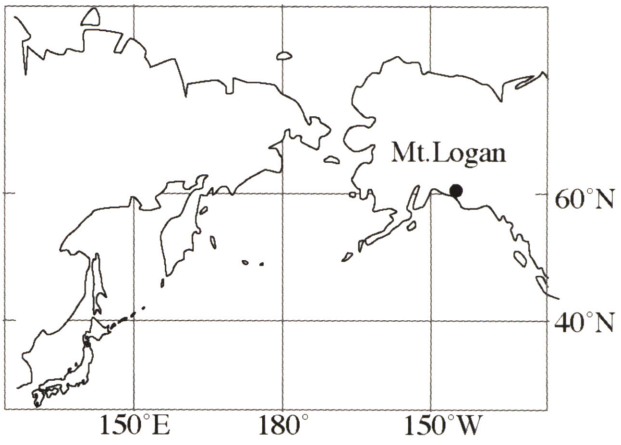

Figure 1. Location map of Mt. Logan

All liquid samples were acidified with nitric acid of ultra pure grade to 1 mol L^{-1} immediately after melting. The samples were stored for two months before analysis because crustal aluminum is dissolved gradually into nitric acid solution and it takes a few months until concentration of aluminum is stabilized. All materials used for the sample preparation process and sample storage were cleaned with 4 mol L^{-1} nitric acid.

4 samples of snow pit and 6 samples of ice core, which contained more than 100ppb aluminum, were decomposed by acid according to the following procedures. 2mL of samples were evaporated to dryness into Teflon containers of 7mL volume. The residue was decomposed by heating with 0.5mL of nitric acid and 0.2mL of hydrofluoric acid for 1 hour, and evaporated to dryness. The residue was re-dissolved with 0.1mL of nitric acid, and diluted to 1mL with ultra pure water. The Teflon containers used for the decomposing were cleaned in heated nitric acid for a few hours and all reagents for that were ultra pure grade.

Concentrations of elements were determined by an ICP-MS using Agilent 7500ce with a micro concentric nebulizer whose consumption rate of sample was less than 100μL·min^{-1}. For determination of iron, the ICP-MS was operated on the Hydrogen Reaction Mode using a collision cell.

The sample preparation was carried out in the Institute of Low Temperature Science, Hokkaido University in Sapporo, and the decomposition and determination were carried out in National Institute for Environmental Studies in Tsukuba, Japan.

RESULT AND DISCUSSION

We use aluminum as an indicator of crustal source contribution in the discussion described below because aluminum is one of the major elements of crustal materials and cannot be provided from other sources such as sea salt, bioactivities, and biomass burning. A concentration profile of aluminum from the snow pit showed two high concentration layers at

0.20-0.35m and 1.30-1.40m (Figure 2). The layer at 1.30-1.40m corresponded to a distinct brownish snow layer containing dust. The dust was likely to be originated from arid area in the East Asia. A modeling study showed that Asian dust was transported from the Asia continent to the North Pacific and Alaska (Takemura et al., 2002). Although no distinct colored layers were observed at 0.20-0.35m, the high concentration aluminum was also caused by Asian dust. Stratigraphical observation showed the snow layers containing high concentration aluminum at 0.20-0.35m and 1.30-1.40m were deposited in early spring 2002 and 2001, respectively (Goto-Azuma, 2003).

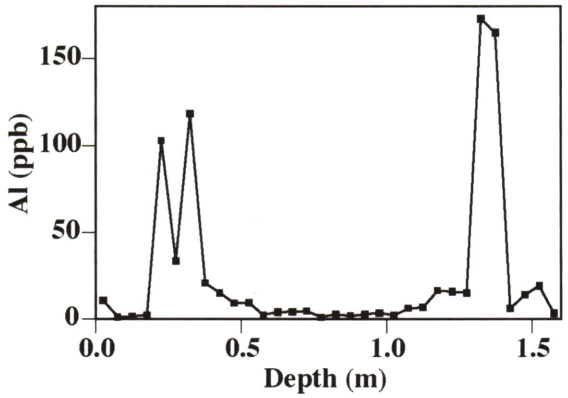

Figure 2. Aluminum concentration profile of the snow pit from surface to 1.65m.

A concentration profile of aluminum in the ice core is shown in Figure 3. The concentration of aluminum varied widely from a few ppb to more than 600ppb. The feature of the profile shows that terrestrial dust causing the high concentration of aluminum was provided by sporadic event occurring in terrestrial area such as Asian dust storm or volcanic eruption (Alaska Volcano Observatory, 1993). The highest peak and second highest peak were shown in the snow layers corresponding to 1992 and 1986. In 1992, Mount Spurr, which is located on the east flank of the Aleutian range, 130km west of Anchorage erupted three times. At the second eruption a very light dusting was reported at Burwash Landing, Yukon Territory, 700 km east (Miller et al., 1998). In 1986, Mount St. Augustine, which is located on Augustine Island in lower Cook Inlet, 290km southwest of Anchorage, erupted. A nearly continuous ash-rich plume rose 3000 to 4600 m; periodic explosive bursts reached altitudes of 12,200 m (Yount et al., 1987). Therefore, the high concentration aluminum in 1992 and 1986 resulted from Mount Spurr and Mount St. Augustine, respectively.

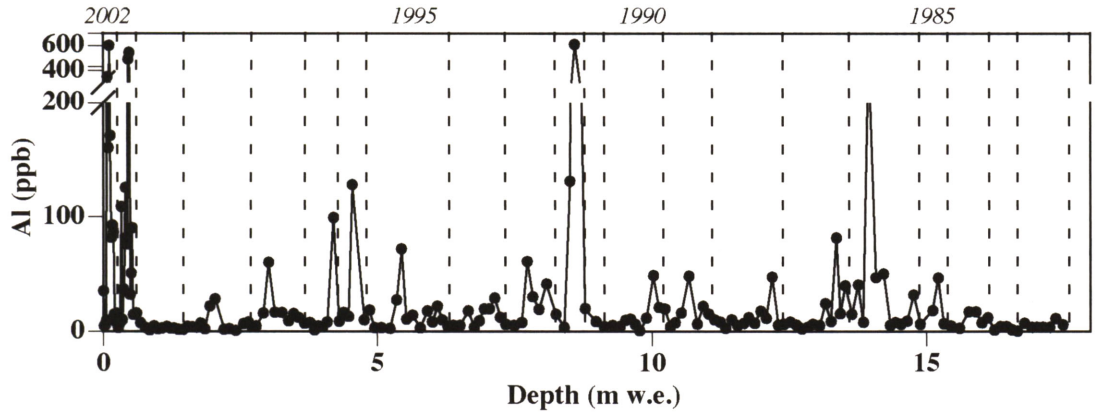

Figure 3. Aluminum concentration profile of ice core. Dashed lines indicate the boundary of annual layer corresponding to the winter estimated by detailed density profiles (Kanamori et al., 2003).

A profile of annual variations of aluminum flux, that is the amount of aluminum depositing on the glacier surface is shown in Figure 4 with an annual variations of total number of day when Kosa phenomena was observed in Japan by Japan Meteorological Agency (Nishikawa et al., 2003). The aluminum flux was calculated with the concentration of aluminum, density of the core sample, and annual accumulation rate. The profile also showed the highest and second highest fluxes in 1992 and 1986, respectively, that are affected by volcanic activities. Aside from 1992 and 1986, the significant high values of number of Kosa day in 2001 and 2002, and slight high values in 1998, 1993, and 1988-1990 well correspond to the profiles of aluminum flux and aluminum concentration in the ice core. It is required to evaluate the local source contribution and to distinguish between crustal dust and volcanic ash in order to extract records of the Kosa contribution accurately from ice cores.

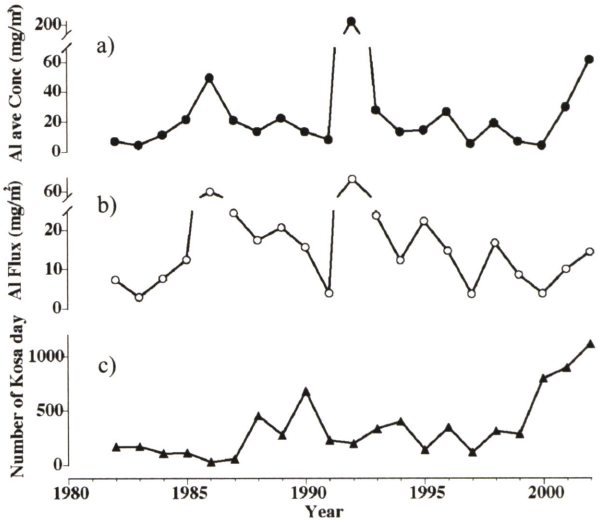

Figure 4 Annual variation of aluminum concentration (a), flux (b), and of the total number of Kosa phenomena in all meteorological station reported by Japan weather association (c) (Nishikawa and Mori, 2003).

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