Tracing anthropogenic lead in aerosols using isotopic analysis of spruce needles, Bow Valley, Alberta, Canada

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Lead (Pb) is currently one of the most heavily studied inorganic pollutants due to its known and suspected adverse effects on human health and environment. In order to study anthropogenic Pb contamination via aerosol particulates, it is important to differentiate various sources of Pb. Fortunately, Pb ores generally have distinctly different isotopic signatures. So it is possible to trace anthropogenic lead to its source. Based on analyses of $^{206}Pb/^{207}Pb$ from aerosol particulates, Sturges and Barrie (1989) showed that in eastern North America, one could differentiate U.S. versus Canadian Pb with their distinctly different $^{206}Pb/^{207}Pb$ of *c.* 1.2 and 1.15 respectively. Blais (1996) supported these results by analysing the surface sediments from lakes in eastern Canada, and showed that U.S. and Canadian Pb have $^{206}Pb/^{207}Pb$ of 1.213 ± 0.008 and 1.153 ± 0.005 respectively. Thus using a simple isotope mixing model, one can estimate the contribution of Pb from each source. Carignan and Gariépy (1995) used epiphytic lichen, lake sediments, and spruce needles for $^{206}Pb/^{207}Pb$ aerosol studies. Both organic material and the surface sediment of lake had very similar $^{206}Pb/^{207}Pb$, indicating that all of them represent the contemporary Pb composition of aerosol contaminant. This study focuses on the development of a method in which one may use spruce needles as an indicator of contemporary aerosol Pb contamination.

Study area and samples

Bow Lake is located at the upper end of the Bow Valley in the rugged alpine environment of the Canadian Rockies in Banff National Park, Alberta, Canada. This study site was chosen because of ongoing research in organic pollution in Bow Lake. The lake sediments exhibit annual varve layers (Smith, 1981), thus can be useful in chronological reconstruction of organic pollution and anthropogenic Pb. The vegetation of the area is dominated by white spruce and some sub-alpine fir at higher elevation. Figure 1 shows the study area and sampling sites. Approximately 2.5 m of lake sediment was cored for chronological study of Pb. Young spruce needles (1–2 yr.) from 6 locations were collected with gloved hands and plastic tweezers. BL1SP was collected adjacent to a diesel generator. Since dominant wind direction is from west to east (the Westerlies), samples were taken on a roughly EW traverse.

Methods

Approximately 300 mg of spruce needles were weighed. For isotope dilution analyses of Pb concentration, one sample (BL4SP) was spiked. Needles were completely dissolved in a pre-cleaned Teflon beaker with 5 ml of Teflon-distilled, 16 N HNO_3 over night at *c.* 150C°. Solution is then dried and re-dissolved in 1 ml of 0.5 N HBr. Pb is separated and cleaned from this solution via anion

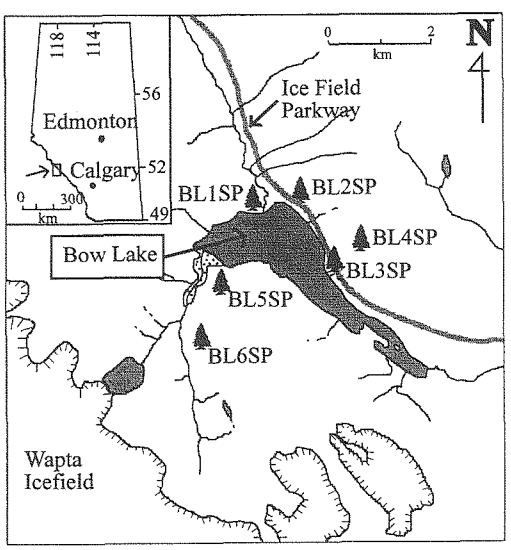

FIG. 1. Map of Bow Lake area and sampling locations. Tree symbols indicate the sample locations. Sample numbers are listed adjacent to the symbol.

TABLE 1. Pb isotopic composition and concentration from spruce needles

Sample name	$^{206}Pb/^{207}Pb$	[Pb] ppb	Note
BL1SP	1.18242(7)		Near diesel generator
BL2SP	1.16866(23)		400 m east of diesel generator
BL4SP	1.15868(22)	24.6	
BL5SP	1.15958(24)		
BL6SP	1.15835(20)		

exchange column. In order to remove organic and further purify Pb, column procedure was repeated twice. Isotopic composition and concentration of Pb was analysed on VG sector 354 multi collector cup mass spectrometer, using 5 faraday cups in static mode.

Results and discussion

Table 1 shows the results from the spruce needles. Those collected adjacent to the diesel generator have $^{206}Pb/^{207}Pb$ similar to the U.S. Pb. Spruce needles located *c.* 400 m east of the generator have $^{206}Pb/^{207}Pb$ of 1.16866 ± 0.00023, still considerably higher than Canadian Pb. In contrast, samples collected in the upwind direction of the diesel generator (BL5SP and BL6SP) have $^{206}Pb/^{207}Pb$ of 1.15958 ± 0.00024 and 1.15835 ± 0.00020, similar in composition to Canadian Pb defined by Blais (1996). Sample BL4SP which is also somewhat out of the path from diesel generator has $^{206}Pb/^{207}Pb$ of 1.15868 ± 0.00022, also similar to the Canadian Pb. Though it is still a preliminary work, it appears that the spruce needles to the west (or upwind direction) of the diesel generator are identical to the average Canadian aerosol Pb composition. Whereas around the diesel generator, spruce needles are strongly affected by the Pb with much different composition (possibly Pb with U.S. source). In downwind direction or to the east of the generator, spruce needles are still being affected by the same Pb as near the generator, but is somewhat diluted.

Conclusion and future studies

From this preliminary work, it is shown that spruce needle can be analysed for its Pb composition precisely, and can delineate the Pb aerosol distribution in a small ecosystem. In order to determine the credibility of its $^{206}Pb/^{207}Pb$ as a tracer of aerosol Pb, however, we will be analysing lake surface sediment collected from Bow Lake and aerosol particulate from the area. Spruce needle represent a much easier sample to work with and can be used in much wider area than, for example, lake sediments, for anthropogenic Pb aerosol studies.

References

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