



SNOW CHEMISTRY  
IN THE FLIN FLON AREA OF MANITOBA 1981 - 1983

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## SNOW CHEMISTRY IN THE FLIN FLON AREA OF MANITOBA, 1981-1983

### ABSTRACT

Snow was sampled from seven sites along two 40 km transects, southeast and south of the Hudson Bay Mining and Smelting Co. smelter in Flin Flon. The purpose of the program was to monitor pH and the deposition of heavy metals (Zn, Cu, Fe, Pb, Cd) and sulfur. An acrylic tube was used to sample the accumulated snow profiles in January, February and March in each of three years, 1981-1983 inclusive.

Zinc was the major heavy metal found, the highest deposition ( $5393 \text{ mg/m}^2$ ) occurring at site 5, 5.8 km southeast of the smelter in March, 1981. Copper, iron and lead deposition was lower but nevertheless still elevated at 163, 81, and  $82 \text{ mg/m}^2$ , respectively. At a similar distance in the southeast direction, heavy metal deposition was lower.

Amounts of zinc, copper, iron and lead in the snow decreased, according to an inverse curvilinear relationship ( $y = ax^b$ ), with distance from the smelter which implicated the smelter as the source of metal bearing particulates. Relatively small amounts of cadmium were found in the snow and the relationship with distance was not as clearly defined as for the other heavy metals. Sulphate deposition to the snow was highly variable but there was a general trend of decreasing amounts with distance from the smelter.

The pH of the snow was variable and in most cases was above the currently accepted acid precipitation level of pH 5.6. The snow from sites 7 (35.7 km S) and 4 (38.1 km SE) was usually more acidic than at closer sites. However, the variability in the data precludes the determination of cause and effect relationships.

Deposition of zinc, copper, iron, lead and cadmium decreased markedly from 1982 to 1983. That was attributed to the installation of a new electrostatic precipitator on the zinc process in November, 1982.

Snow monitoring proved to be an effective and highly sensitive tool with which to determine the winter-time deposition of smelter emissions in the Flin Flon area.

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## **I. INTRODUCTION**

Precipitation monitoring has been used extensively in both North America and Europe to monitor the "acid rain" phenomenon (Shewchuk 1982, Barrie and Walmsley 1978, Thornton and Eisenreich 1982, Seip 1978). Precipitation monitoring was previously conducted in the area of Flin Flon, Manitoba, Canada in 1976 and 1977 to determine air pollutant fallout from the zinc/copper smelting complex (Franzin *et al* 1979). They found that the naturally deposited snow profile was an efficient receptor of smelter emissions and was an effective monitoring tool in determining the dispersion of air pollutants. Air pollutants can be deposited to the snow profile via three processes, (i) gravitational fallout of particulates (ii) scavenging of pollutants from the air during precipitation events and (iii) adsorption/absorption of gaseous pollutants to the surface of fallen snow (Barrie and Welpdale 1977).

Since 1976, the Environmental Management Division of Manitoba has been undertaking studies in the vicinity of primary smelters in Northern Manitoba to assess the environmental impacts of heavy metals and sulfur contained in the stack emissions. Monitoring programs which were undertaken had two basic objectives; to determine the deposition pattern of emissions and to determine the effects of emissions on environmental components, including soils, vegetation and wildlife. Annual snow sampling surveys have been carried out in the Flin Flon area since 1979 to monitor pH and the deposition patterns of heavy metal and sulfur emissions from the Hudson Bay Mining and Smelting stack. Results of the 1979 and 1980 snow sampling surveys have been reported previously (Hogan and Wotton 1980). The present report deals with the results of the 1981, 1982 and 1983 snow sampling programs.

## **II. PROCEDURE**

### **A. Sampling Methods**

Snow samples were collected in the Flin Flon area at seven sites located in the southeast quadrant and within a 40 km radius of the Hudson Bay Mining and Smelting stack (Figure 1). The sample stations were close to the terrestrial monitoring plots but were located on nearby ice-covered ponds or small lakes. The rationale was that ponds/small lakes provided natural open areas which would minimize contamination by extraneous organic particles such as bark and

needles. In addition the ice provided a "clean" substrate which facilitated sampling to insure that no litter or soil particles would be picked up with the sample.

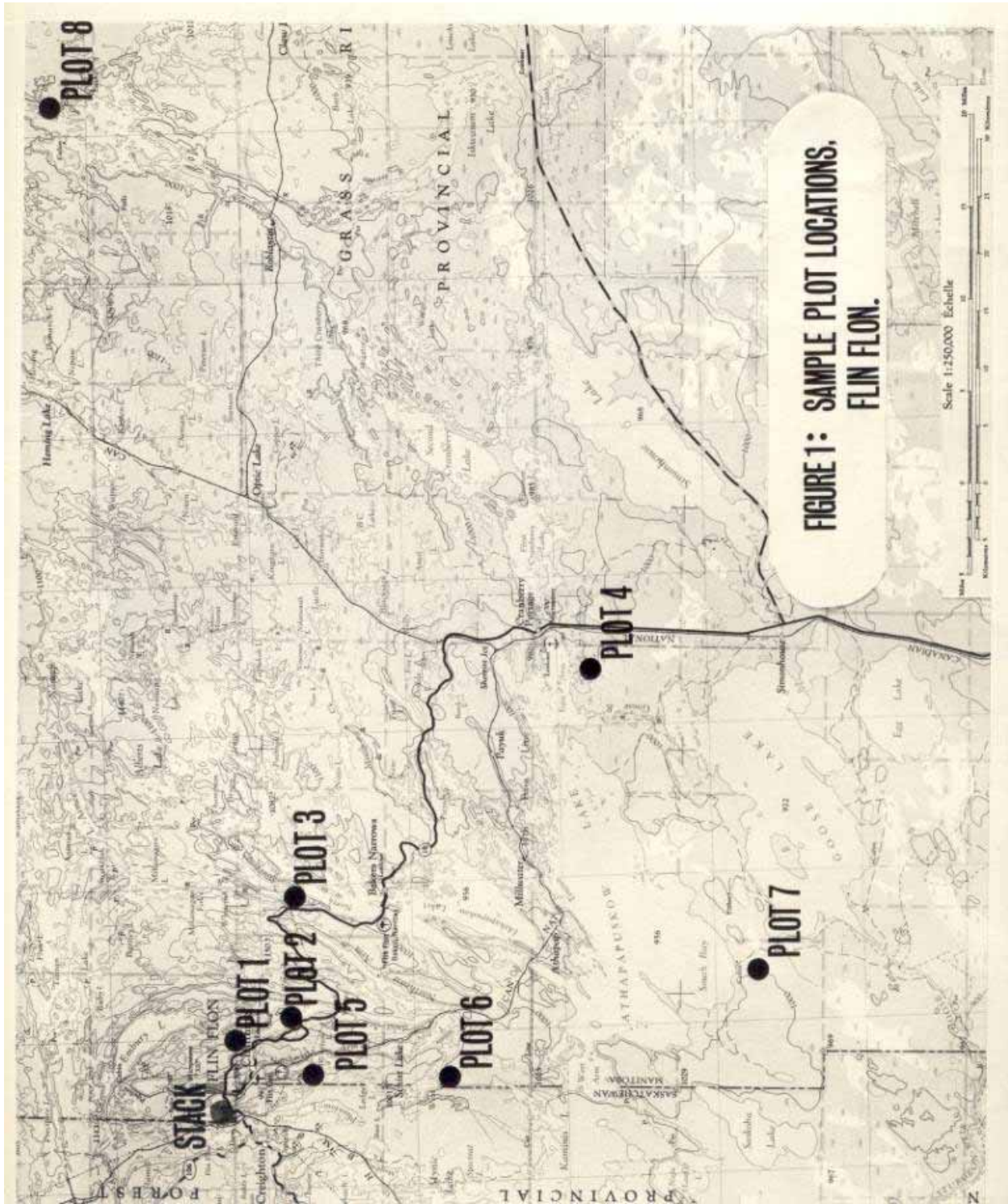


Figure 1. Sample plot locations, Flin Flon.

Three surveys (January, February and March) were conducted in each winter. six replicate snow samples were collected at each sampling site per survey. In 1981, all six samples were collected in one liter linear polyethylene bottles; three bottles, designated for heavy metal analyses (Zn, Cu, Fe, Pb and Cd), were pre-washed with hydrochloric acid and nitric acid. The other three which were washed with de-ionized water, were used for sulphate and pH determinations. In 1982 and 1983, the three replicates for heavy metal analyses were collected in the polyethylene bottles, while the sulphate/pH samples were collected in new heavy-weight plastic bags. A subsample of the plastic bags had been tested previously to insure that they were durable and that they were free of chemical contaminants.

Samples of snow were collected with an acrylic plastic tube of 3.7 cm inside diameter. The tube was plunged through the snow pack to the ice below, which forced the snow up into the tube. A plastic plunger was used to tamp the snow in the tube to a compact cylinder to ensure that it would stay in the tube. The acrylic tube containing the snow cylinder was then lifted out of the snow, placed in the opening of a plastic sample bottle or plastic bag and the snow cylinder was ejected by applying pressure with the plastic plunger.

Cores were sampled until each bottle was filled or alternately until a sufficient sample was accumulated in each bag. The number of cores taken for each replicate was recorded. Screw tops were used to close the bottles while the plastic bags were folded over and stapled. The samples were kept frozen by placing them in insulated coolers with freeze packs. The samples were stored in a freezer until analyzed. Before the replicates for heavy metal analyses were melted, the sample was weighed and acidified with 5 mL of concentrated nitric acid. After melting, the samples were submitted to the W. M. Ward Technical Services Laboratory for analyses.

In 1982, the first year the plastic bags were in general use for the sulphate and pH replicates, the samples were submitted to the laboratory immediately upon return to Winnipeg. That resulted in large batches of samples which were difficult for the laboratory schedule. There was also a problem with the bags in that they were difficult to handle once the contents had melted. Two changes were implemented in 1983 to alleviate these problems:

- (i) The samples were stored in a freezer and delivered to the laboratory daily in batches of 20,

- (ii) Plastic containers with a handle were purchased and each bag was placed in a container, heat sealed, and then a small hole cut on one corner to facilitate decanting the melt water as required for analyses.

## B. Data Analysis

Results of the metal and sulphate analyses were reported from the laboratory as mg/L. These data were standardized to mg/m<sup>2</sup> using the formula:

$$D = C \times \frac{V}{A} \times 10.0$$

where **D** = the deposition in mg/m<sup>2</sup>.

**C** = the concentration of metal or sulphate in the melt water mg/L.

**V** = the volume of water (mL) obtained from the snow sample based on the weight of the sample and the relationship 1 gm = 1 mL.

**A** = the area sampled (cm<sup>2</sup>); area was determined by multiplying the cross sectional area of the acrylic sampling tube by the number of snow cores included in each sample.

**10.0** = a constant to account for conversion of mL to L and cm<sup>2</sup> to m<sup>2</sup>.

The mean deposition at each site was calculated for each metal and sulphate by averaging the results of the three replicates from each site for each survey. To calculate the mean pH, individual pH readings were first converted to hydrogen ion concentration (equivalents per liter), the mean hydrogen ion concentration was determined for each set of three replicates, and the mean value converted back to pH. The relationship between pH and hydrogen ion concentration is expressed by:

$$\text{pH} = -\log [\text{H}^+]$$

where [H<sup>+</sup>] is the hydrogen ion concentration in equivalents per litre.

The data were found to be very consistent, with good agreement for the most part between each of the three replicate samples collected from each site on each sampling date. In summarizing the data to mean deposition quantities, a few analyses were found to be excessively high or excessively low relative to the other two replicates. In certain cases, these were determined to be outliers and were excluded from the calculations. In other instances analytical

data for all three replicates were high or low relative to the general distribution of metals for other survey periods. We have retained those values as real data but do not try to explain the reason for the apparent anomalies. Finally, analysis of snow collected in February 1983 yielded very low metal levels which were often below the detection limits. We suspect that those snow samples may not have been acidified with nitric acid in the sample preparation stage. It is theorized that the particulates could then have settled to the bottom of the containers instead of being solubilized. Therefore, they would not have been present in the aliquots decanted for the metal analyses. Consequently, the heavy metal results from the February 1983 snow samples are not included in the graphs or in the discussion.

### **III. RESULTS AND DISCUSSION**

#### **A. Heavy Metals**

The metals which are emitted as particulates from the Hudson Bay Mining and Smelting stack include, but are not restricted to, zinc, copper, iron, lead and cadmium (Hudson Bay Mining and Smelting 1982). Of these zinc comprised the largest fraction in the emissions and was also the dominant metal in the snow samples. Since the distribution pattern was similar for all metals, this discussion deals primarily with the zinc data.

Mean accumulations of zinc in the snow for the January, February, and March sampling dates in 1981, 1982, and 1983 are presented in Table 1. The data are presented graphically in Figures 2, 3, 4, and 6. The highest zinc deposition occurred in 1981 with March 9, 1981 samples having accumulated the largest amounts (Table 1). Over the 122 day period from November 7, 1980 to March 9, 1981 (November 7 was the first persistent snowfall in 1980, as recorded at the Flin Flon municipal airport), 5393 mg/m<sup>2</sup> of zinc was deposited at site 5, 5.8 km southeast of the smelter. In comparison, copper, iron and lead also had the highest deposition at site 5 for the same snow accumulation period (see Appendix A-1, 2, 3). Copper ranked second at 163 mg/m<sup>2</sup> while iron and lead were 81 and 82 mg/m<sup>2</sup> respectively. Cadmium levels on the other hand, were relatively low at close-in sites in March 1981, e.g. 0.34 mg/m<sup>2</sup> at site 5 (Appendix A-4). Cadmium deposition was highest on March 11, 1982 with a value of 8.3 mg/m<sup>2</sup> at site 1, 5.1 km east southeast. Because cadmium ranks relatively high in toxicity compared with other heavy metals, the figure of 8.3 mg/m<sup>2</sup> might prompt some concern. However, the potential for that

amount of cadmium to produce health effects or impacts on soils and vegetation cannot be determined because there are no data with respect to concentrations of cadmium in the air nor on the past accumulation of cadmium per square metre of soil. Even if the missing data were available, an assessment of the potential for toxic effects would be deficient without information on conditions at the time of exposure, particle size, and the chemistry of the particles (National Research Council 1979, Nomiya 1980).

Table 1: Accumulation of zinc in snow (mg/m<sup>2</sup>) in the Flin Flon area for the winters of 1980/81, 1981/82 and 1982/83.

Site	Distance (Km)	1981			1982			1983		
		Jan. 04	Feb. 09	Mar. 09	Jan. 11	Feb. 08	Mar. 11	Jan. 12	Feb. 09	Mar. 09
1	5.1	1450.71	2188.31	2552.13	2658.26	2124.05	2819.18	49.93	0.46	55.66
5	5.8	3083.60	4472.86	5393.67	1322.07	2726.36	2256.66	129.41	0.36	83.50
2	8.9	1343.10	1976.42	2096.88	704.04	1438.71	1863.89	95.07	0.54	54.80
6	14.6	276.51	567.65	559.67	152.63	392.15	209.46	15.03	0.66	11.53
3	15.5	409.22	441.62	686.53	254.62	330.37	215.73	34.24	0.93	13.21
7	35.7	42.40	127.37	97.04	9.71	51.42	71.62	5.25	0.53	10.05
4	38.1	55.39	81.06	84.99	14.36	39.39	38.11	3.31	0.68	4.24

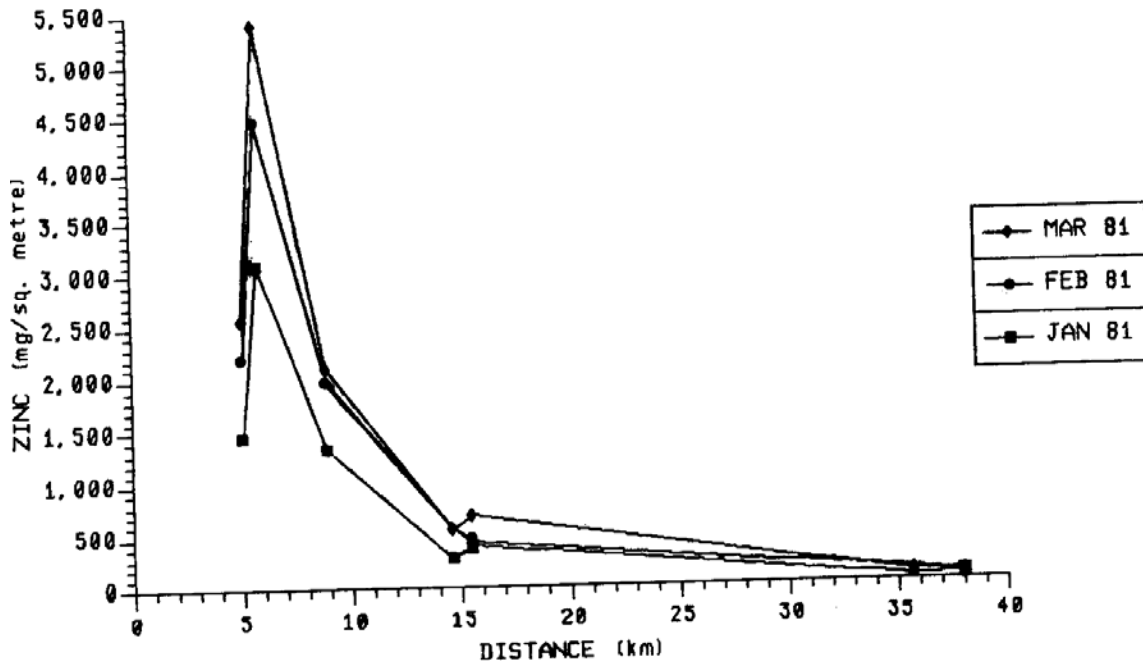


FIGURE 2: ZINC IN SNOW, FLIN FLON, MANITOBA, 1981

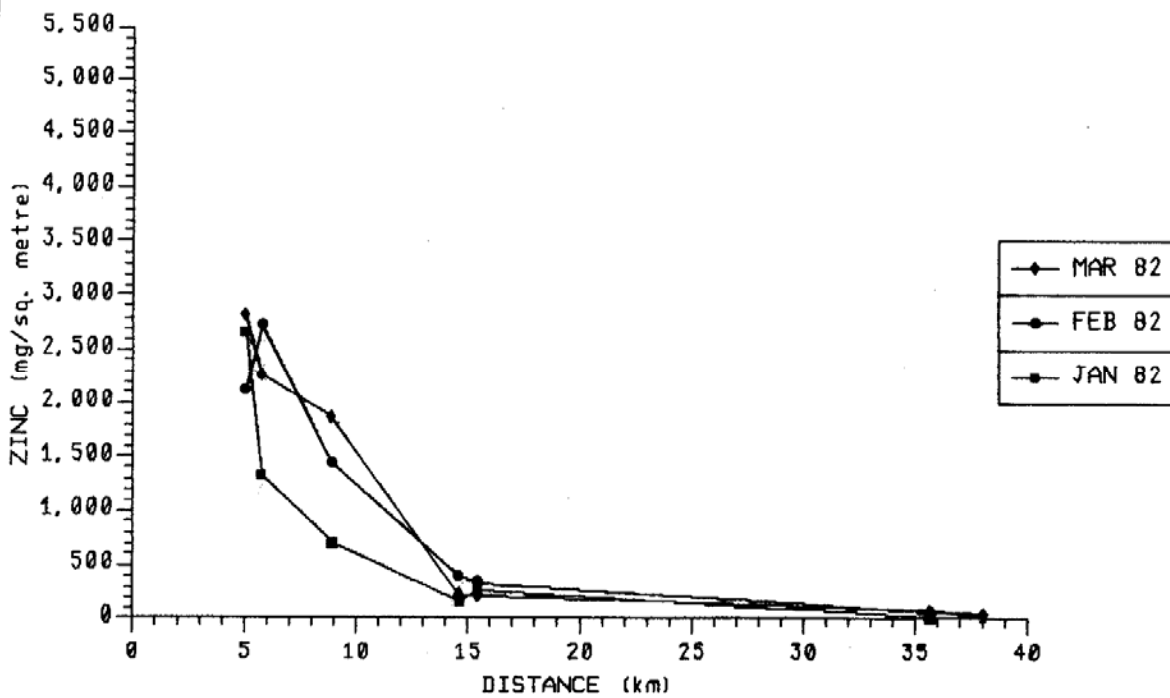


FIGURE 3: ZINC IN SNOW, FLIN FLON, MANITOBA, 1982

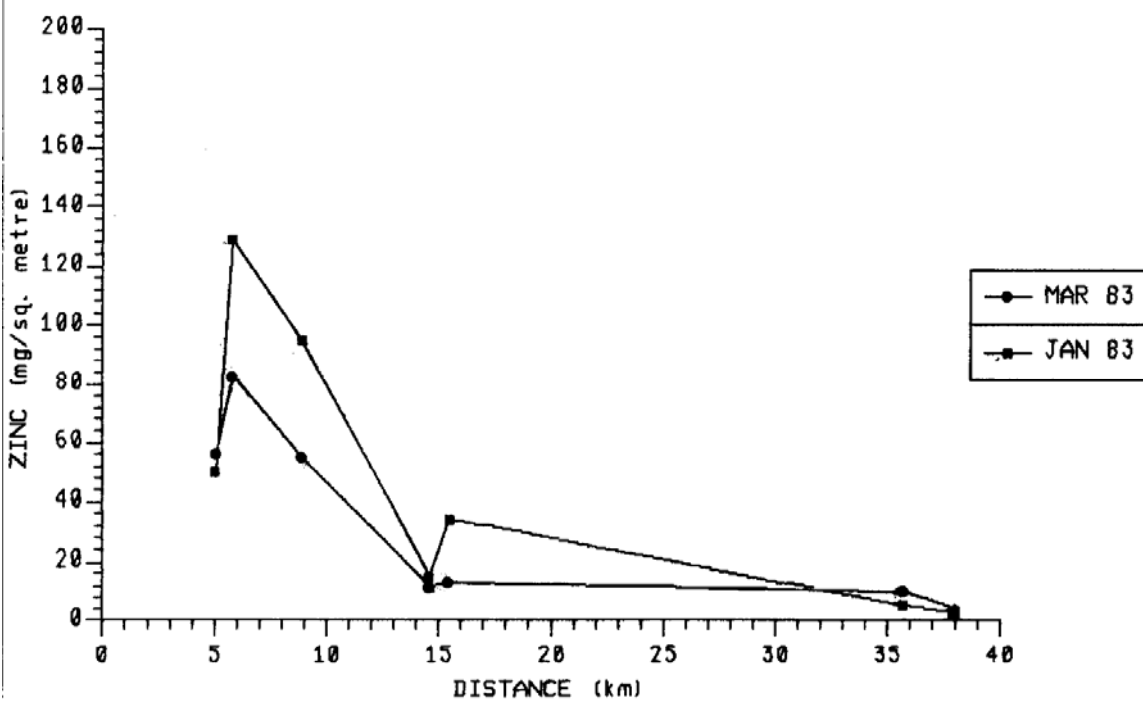


FIGURE 4: ZINC IN SNOW, FLIN FLON, MANITOBA, 1983

Deposition of zinc to the snow was highest close to the smelter, decreasing with distance, that is, an inverse relationship. The correlation of zinc with distance can best be described by the curve:

$$Zn = aD^b,$$

where Zn is the Zinc deposition in  $mg/m^2$  and D is the distance from the smelter in kilometres. This is a curvilinear relationship wherein the greatest decline in zinc occurs over the first 10 to 15 km from the smelter. Beyond 15 km, concentrations are considerably lower but continue to decline, albeit gradually, toward background amounts. The correlation between metal deposition and distance is consistent with that found by Franzin *et al* (1979). This provides evidence that the HBM&S smelter was the source of the heavy metals in the snow.

Furthermore, these data show that heavy metal deposition was generally highest at site 5, 5.8 km southeast of the smelter. That was most clearly demonstrated in the 1981 data (Figure 2) but also occurred in February 1982 (Figure 3) and in the 1983 results (Figure 4). Of the many factors affecting dispersion of the plume, wind direction exerts the greatest influence, followed by the inversion characteristics of the air mass, wind speed and topography, to name a few. Wind direction in Flin Flon during the winter months of November to March is predominantly from the northwest with relatively strong west and north components. Thus it follows that the plume would be carried in the southeast direction, a greater percentage of the time (Figure 5). That explains why more metals were deposited at site 5, 5.8 km southeast than at site 1, 5.1 km east southeast.

Figure 6 compares the November to March deposition of zinc in the snow for 1981, 1982 and 1983. The data show clearly that zinc emissions were decreasing over the period, with the largest reduction occurring in 1983. Zinc deposition experienced a 20 fold reduction from 1982 to 1983 which can be attributed to improvements in control technology within the smelter, namely the installation of a new electrostatic precipitator on the zinc process (Hudson Bay Mining and Smelting 1982). Data presented in Figures 7, 8 and 9 show that the improved emission controls also effected reductions in copper, iron and lead emissions.

The cadmium data are also similar to the zinc data except that deposition in 1981 was lower at close-in sites than at mid-distance (15 km) sites (Figure 10). However, in 1982, cadmium deposition decreased with distance, a relationship which was consistent with the zinc, copper, iron and lead results. The data also demonstrate that cadmium emissions were reduced in 1983 along with the zinc, copper, iron and lead.

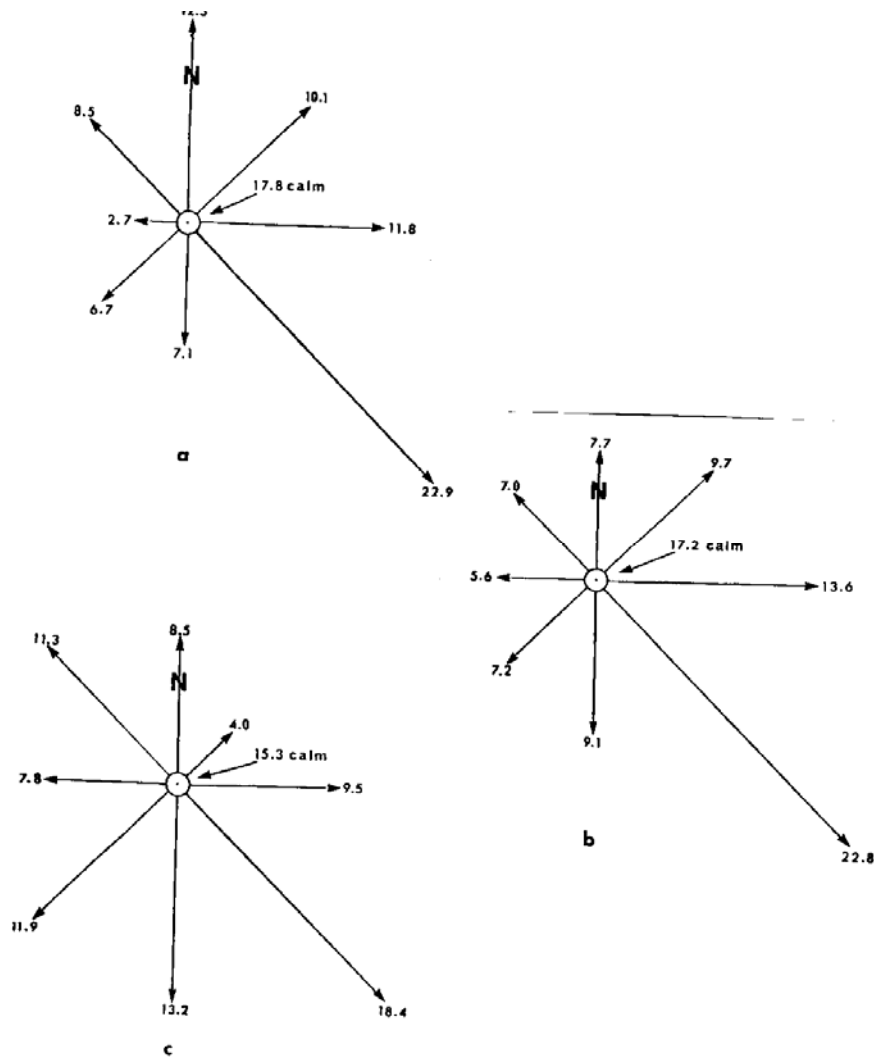


Figure 5. Plume direction based on percentage frequencies of wind direction in the Flin Flon area for the snow accumulation periods (a) 7 Nov. 1980 – 9 Mar. 1981 (b) 16 Nov. 1981 - 10 Mar. 1982 (c) 18 Nov. 1982 – 8 Mar. 1983.

It is anticipated that the reduction of heavy metal deposition will be beneficial to the environment in the Flin Flon area. Past deposition of smelter emissions have resulted in elevated levels of heavy metals in soils close to Flin Flon (Hogan and Wotton 1980). If smelter emissions are not controlled, the levels of contamination and the size of the heavily impacted area would continue to increase. Elevated levels of heavy metals in the soil can impede nutrient recycling in the litter zone (Ruhling and Tyler 1973, Strojan 1978). Elevated levels of zinc, copper and cadmium can also have an adverse effect on root development of seedlings, which would be detrimental to regeneration of forest stands (Mitchell and Fretz 1977, Whitby and

Hutchinson 1974). The recent improvements in emission control technology by Hudson Bay Mining and Smelting will help to slow the rate of environmental degradation in the Flin Flon area.

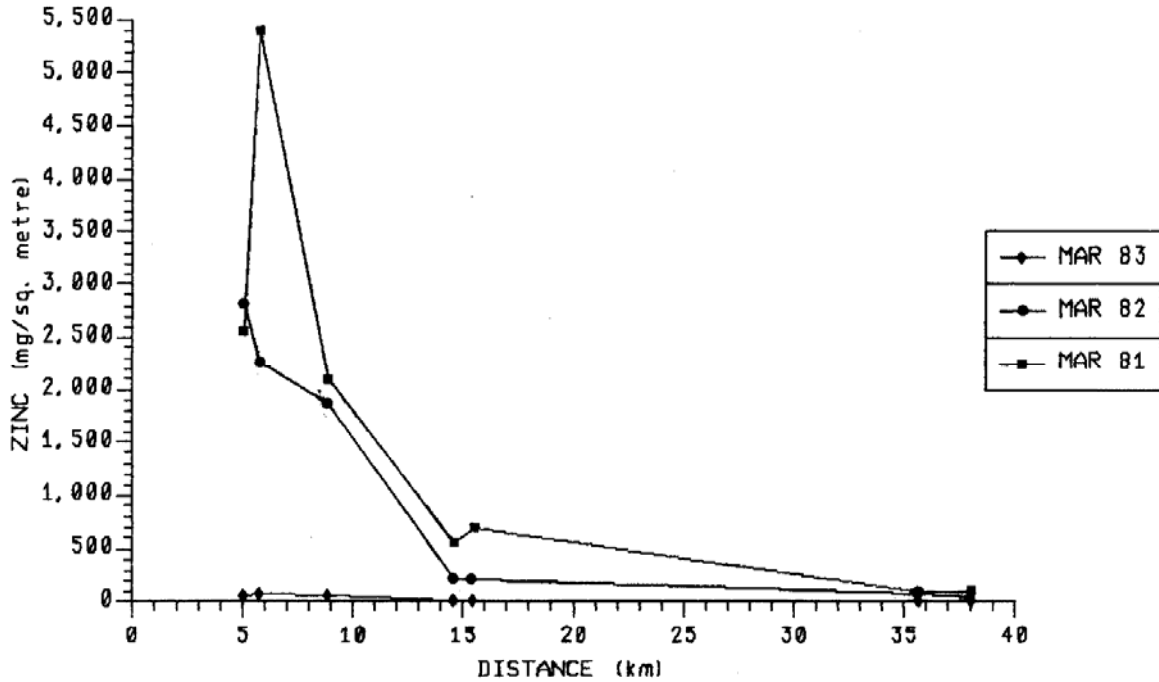


FIGURE 6: ZINC IN SNOW, FLIN FLON, MANITOBA, 1981-1983

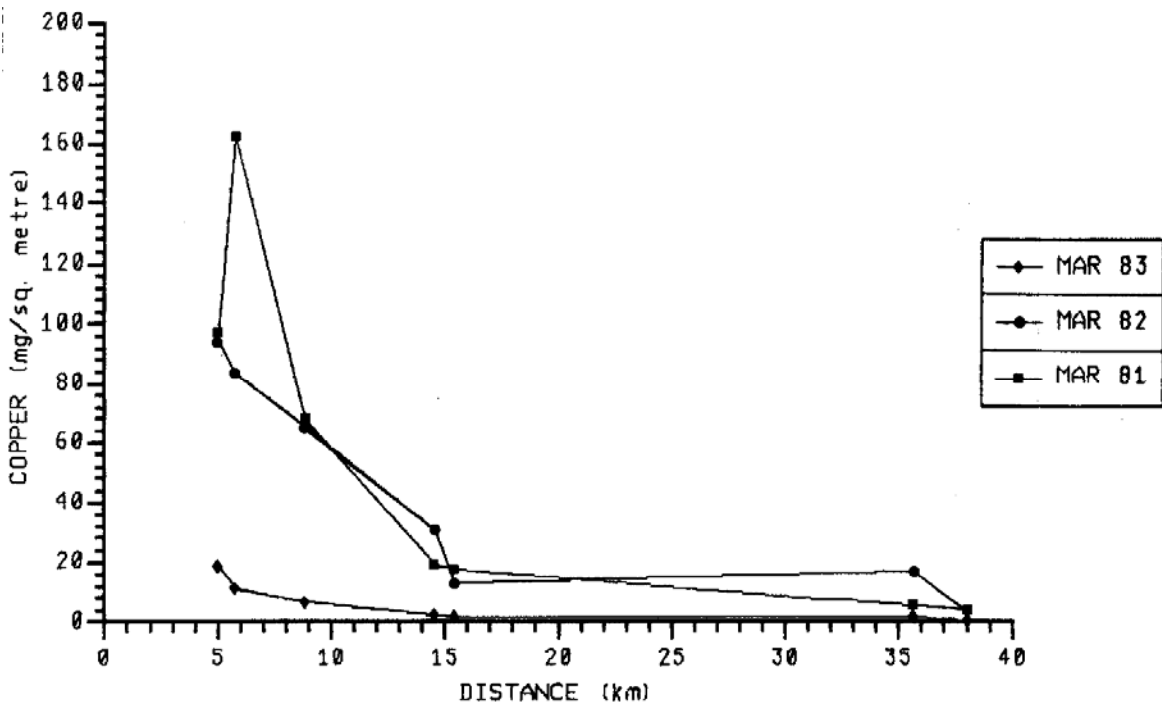


FIGURE 7: COPPER IN SNOW, FLIN FLON, MANITOBA, 1981-1983

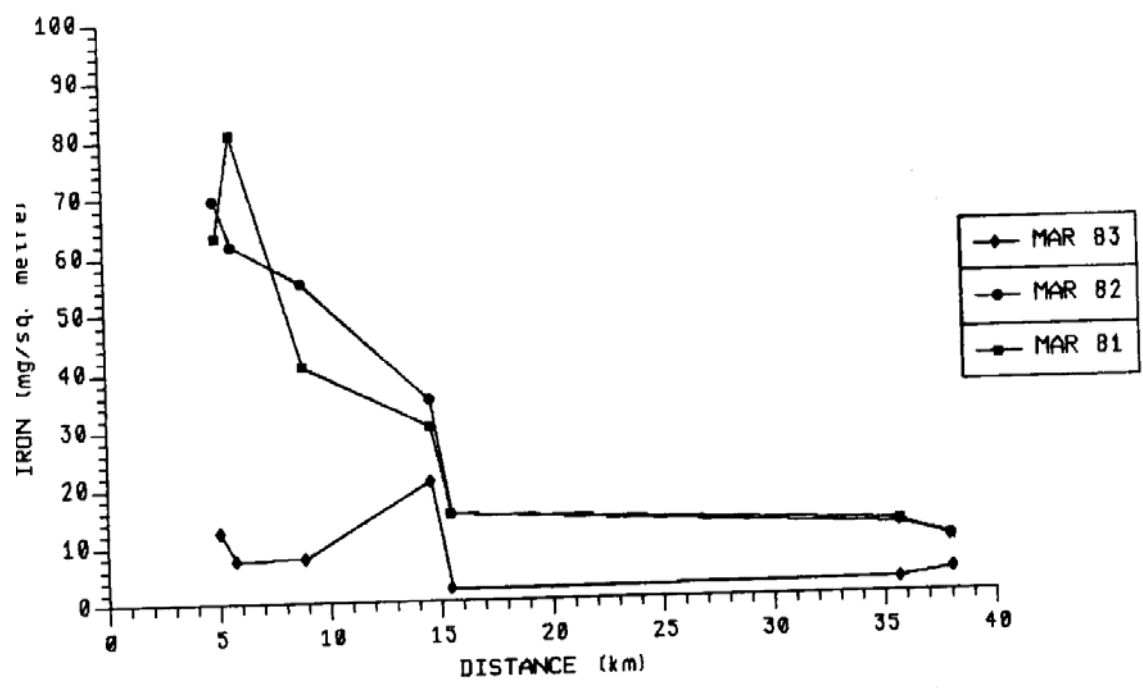


FIGURE 8: IRON IN SNOW, FLIN FLON, MANITOBA, 1981-1983

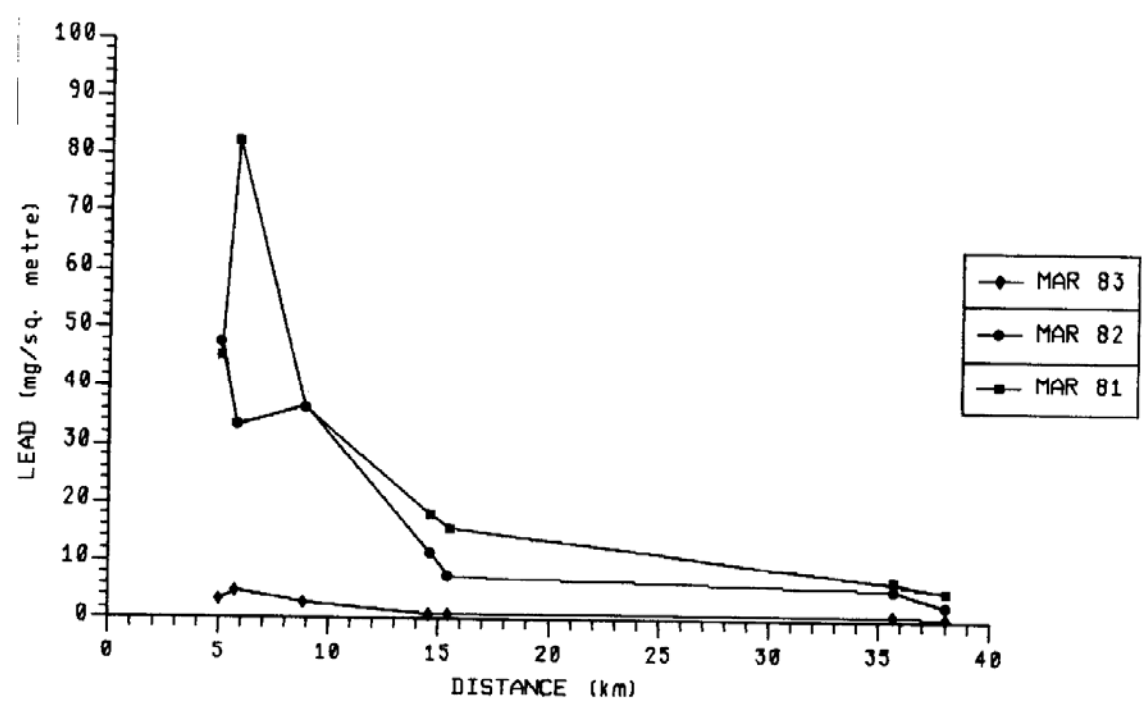


FIGURE 9: LEAD IN SNOW, FLIN FLON, MANITOBA, 1981-83

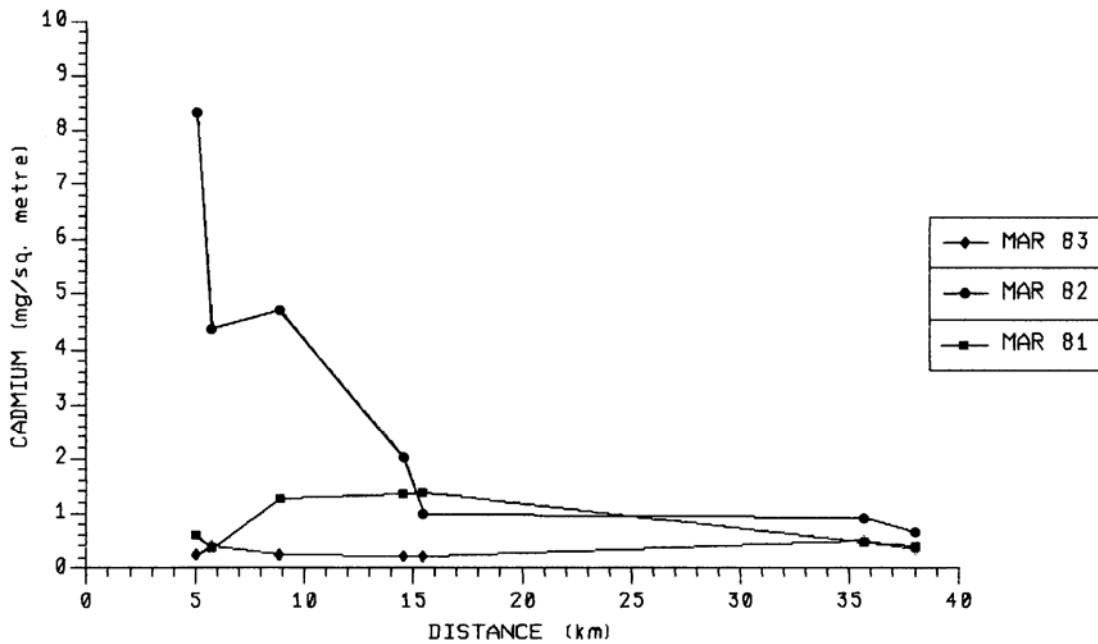


FIGURE 10: CADMIUM IN SNOW, FLIN FLON, MANITOBA, 1981-1983

### B. Sulphate-Sulphur

The sulphate data also show a decrease with distance from the smelter (Figure 11; Appendix A-5). The relationship between deposition and distance is characteristically more linear than in the case of the metals but nevertheless confirms that the smelter was the source. Franzin *et al* (1979) speculated that the sulphate ion was probably deposited in the form of zinc sulphate, copper sulphate, etc. On the surface, our data seem to lend support to his theory, since the distribution pattern of sulphate was similar to that for the metals and there was a coincident although slight reduction in the sulphate in 1983. However, the fact that the sulphate reduction in 1983 was not as great as for the metals, indicates that sulphur may have been deposited simultaneously by other processes such as the scavenging of sulphur oxides during precipitation events and direct adsorption/absorption of sulphur oxides to the snow surface. The proportional contribution of these processes to the net accumulation of sulphate is not known.

The impact of the sulphur depositions on the environment can not be readily determined. If there were high concentrations of sulphur dioxide in the air, foliage could be injured. Alternately, sulphur oxides dissolved in precipitation are theorized to produce acid precipitation

but there is no correlation with snow pH in the present study (see section C following).

Sulphates on the other hand may be relatively innocuous unless high levels already exist in the soil. Thus it would be difficult to speculate on the environmental impacts of the observed sulphur deposition without knowing the chemical species involved.

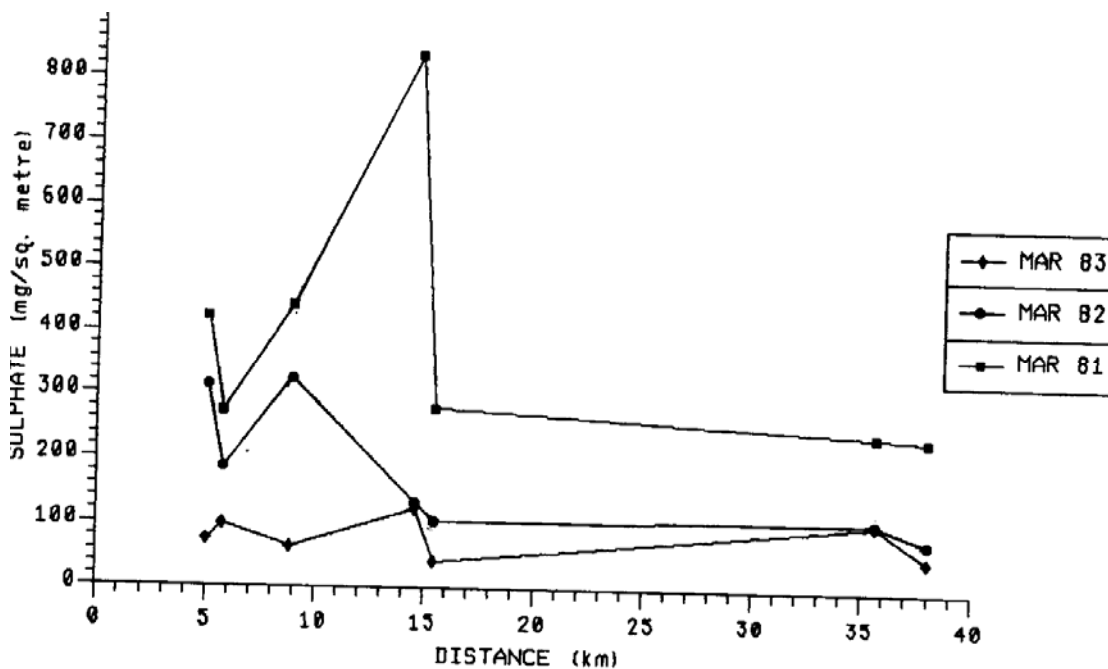


FIGURE 11: SULPHATE IN SNOW, FLIN FLON, MANITOBA. 1981-1983

### C. Snow pH

The pH of the snow was generally above the accepted figure of pH 5.6 which has been used as the upper limit in the definition of acid precipitation (Figure 12a, b, and c; Appendix A-6). The pH of the snow tended to decrease with distance from the smelter but contrary to the findings of Franzin *et al* (1979), did not appear to be positively correlated with metal levels. Although data from each snow survey showed pH to be decreasing with distance from the smelter (while metal levels were also decreasing), the lower metal deposition in 1983 did not result in lower pH levels. In theory, long-range transport plus time dependent chemical reactions on acid precursors could be used to explain the decreasing pH. However, in the absence of information identifying the chemical origin of hydrogen ions in the snow and without solid data which could relate those to stack emission chemistry, no cause and effect relationship can be proven.

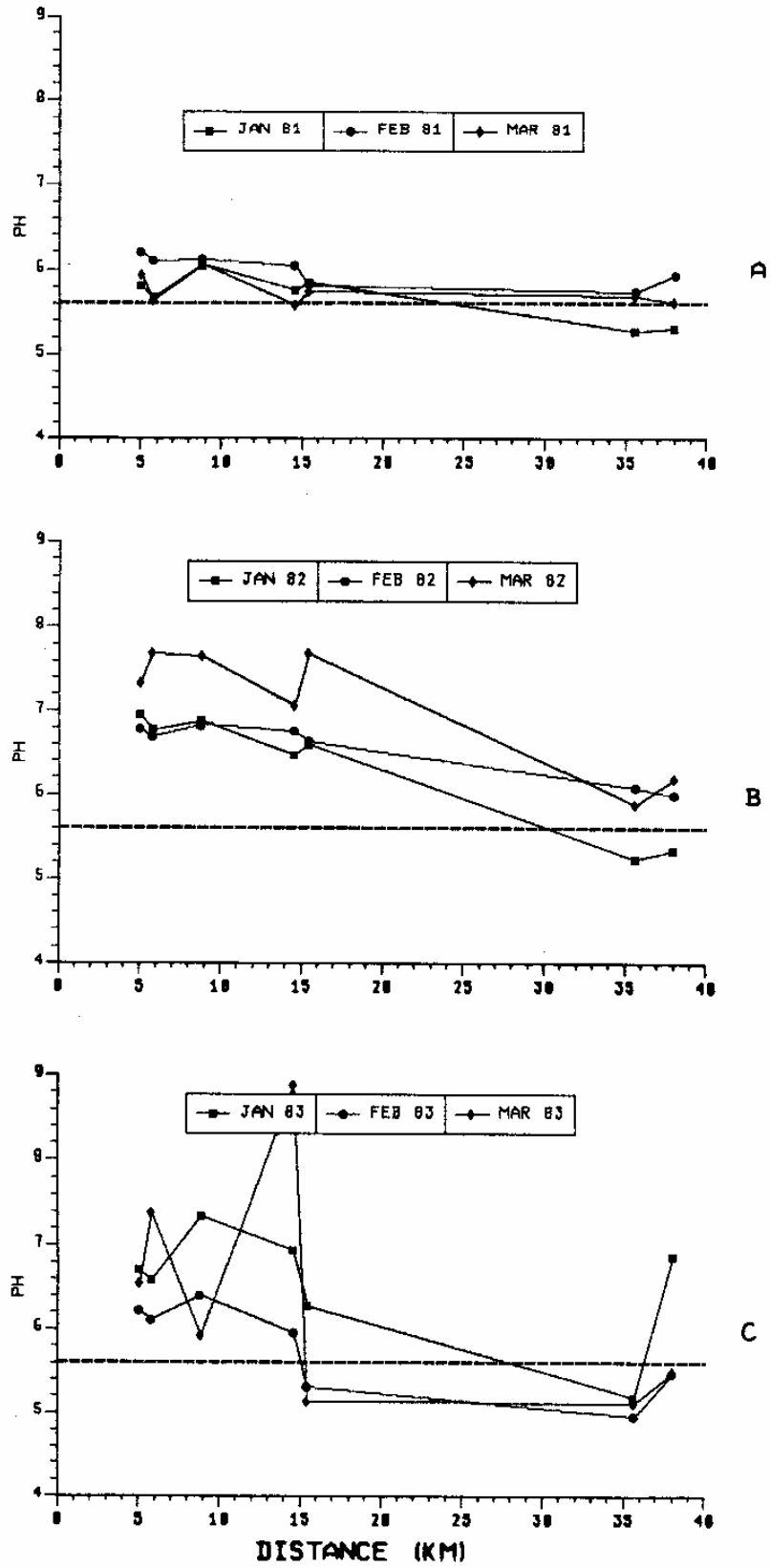


FIGURE 12: PH OF SNOW, FLIN FLON, MANITOBA 1981-1983

#### **IV. CONCLUSIONS**

Zinc, copper, iron, lead and cadmium accumulations in snow profiles were inversely correlated with distance from the Hudson Bay Mining and Smelting stack. The relationship was best described by a power curve of the form:

$$Y = aX^b$$

where Y was the amount of metal deposited ( $\text{mg}/\text{m}^2$ ) and X was the distance (km). The smelter emissions were implicated as the source of the metal bearing particulates.

The highest deposition of heavy metals occurred at site 5, 5.8 km southeast, while site 1 at 5.1 km in the east southeast direction was much lower. Prevailing winds from the northwest account for the differences between site 5 and site 1.

Sulphate analyses on the snow samples yielded variable results although there was a general trend of decreasing amounts with distance from the smelter. That fact identifies the smelter as the source of sulphur although the chemical speciation could not be identified.

The pH of the snow was usually higher than the currently accepted pH of 5.6 for acid rain. Although there was a trend of decreasing pH with distance from the smelter, the data are insufficient to implicate the smelter emissions as the cause.

Deposition of heavy metals, zinc, copper, iron, lead and cadmium decreased significantly in 1983. Smelter emissions were obviously reduced by the new electrostatic precipitator which was installed prior to the 1982-83 snow accumulation season. That should slow the rate at which heavy metals accumulate in the impact zone around the smelter.

Overall, the data demonstrate that snow monitoring is an effective and sensitive tool with which to determine winter-time depositions of emissions around a point source such as the HBM&S smelter at F1in F1on.

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APPENDIX

Appendix A-1: Mean Deposition of copper to snow (mg/m<sup>2</sup>), Flin Flon, Manitoba, 1981-1983

Site	Distance (Km)	1981			1982			1983		
		Jan. 04	Feb. 09	Mar. 09	Jan. 11	Feb. 08	Mar. 11	Jan. 12	Feb. 08	Mar. 09
1	5.1	47.11	84.14	98.10	71.14	63.29	94.57	11.93	0.23	19.07
5	5.8	99.65	149.18	162.69	38.56	76.14	83.77	13.47	0.18	11.87
2	8.9	2.29	66.41	67.94	21.49	47.21	65.82	6.48	0.28	7.13
6	14.6	9.48	23.60	19.61	10.33	14.05	30.99	2.89	0.33	2.53
3	15.5	12.35	15.30	18.01	10.19	12.58	13.34	4.20	0.45	2.36
7	35.7	2.14	8.14	5.49	0.55	3.44	17.34	0.76	0.25	1.98
4	38.1	2.74	4.74	4.60	1.01	2.03	3.26	0.49	0.34	0.70

Appendix A-2: Mean Deposition of iron to snow (mg/m<sup>2</sup>), Flin Flon, Manitoba, 1981-1983

Site	Distance (Km)	1981			1982			1983		
		Jan. 04	Feb. 09	Mar. 09	Jan. 11	Feb. 08	Mar. 11	Jan. 12	Feb. 08	Mar. 09
1	5.1	23.58	68.14	63.22	60.59	54.96	69.95	4.69	2.14	12.14
5	5.8	28.14	81.03	80.84	36.72	57.24	61.78	4.87	0.69	7.30
2	8.9	16.39	44.53	40.77	19.36	37.69	54.91	5.09	1.08	7.65
6	14.6	10.95	42.84	30.02	13.56	18.10	34.80	12.14	1.32	20.84
3	15.5	5.17	14.20	15.08	13.15	13.06	15.04	3.40	4.02	2.21
7	35.7	4.21	11.72	12.61	6.05	6.90	12.05	1.31	1.06	2.67
4	38.1	3.28	12.06	9.19	5.58	5.41	9.77	0.93	1.36	4.24

Appendix A-3: Mean Deposition of lead to snow (mg/m<sup>2</sup>), Flin Flon, Manitoba, 1981-1983

Site	Distance (Km)	1981			1982			1983		
		Jan. 04	Feb. 09	Mar. 09	Jan. 11	Feb. 08	Mar. 11	Jan. 12	Feb. 08	Mar. 09
1	5.1	25.91	42.48	45.17	40.66	40.60	47.80	1.95	0.44	3.59
5	5.8	55.10	72.99	82.20	19.90	38.47	33.12	4.43	0.18	4.89
2	8.9	25.07	36.32	36.21	12.43	30.72	36.66	3.54	0.27	2.75
6	14.6	5.94	16.32	18.02	5.39	9.23	11.30	1.15	0.33	1.12
3	15.5	10.12	12.50	15.57	7.61	8.22	7.52	1.82	0.50	1.12
7	35.7	2.06	7.56	6.37	1.10	2.86	5.56	0.64	0.26	1.00
4	38.1	1.88	5.29	5.43	1.01	2.03	2.61	0.43	0.34	0.64

Appendix A-4: Mean Deposition of cadmium to snow (mg/m<sup>2</sup>), Flin Flon, Manitoba, 1981-1983

Site	Distance (Km)	1981			1982			1983		
		Jan. 04	Feb. 09	Mar. 09	Jan. 11	Feb. 08	Mar. 11	Jan. 12	Feb. 09	Mar. 09
1	5.1	1.65	1.36	0.58	4.39	5.35	8.33	0.33	<0.23	0.26
5	5.8	1.18	1.15	0.34	4.16	4.69	4.39	0.85	<0.18	0.40
2	8.9	2.24	1.86	1.25	2.72	3.90	4.71	0.76	<0.27	0.26
6	14.6	1.05	2.49	1.34	0.81	1.80	2.01	<0.29	<0.33	0.22
3	15.5	1.47	1.94	1.37	1.52	0.97	0.97	0.40	<0.42	0.22
7	35.7	<0.25	1.14	0.48	0.27	0.46	0.93	<0.33	<0.26	0.50
4	38.1	0.24	0.74	0.42	0.25	0.47	0.65	<0.20	<0.34	0.35

Appendix A-5: Mean Deposition of sulphate to snow (mg/m<sup>2</sup>), Flin Flon, Manitoba, 1981-1983

Site	Distance (km)	1981			1982			1983		
		Jan. 04	Feb. 09	Mar. 09	Jan. 11	Feb. 08	Mar. 11	Jan. 12	Feb. 09	Mar. 09
1	5.1	268.22	326.55	425.07	291.70	305.70	316.25	34.33	67.22	74.54
5	5.8	518.22	574.89	272.78	289.73	386.85	187.31	81.54	110.34	1830.43
2	8.9	259.01	381.47	442.32	129.00	259.92	326.73	79.92	82.72	64.36
6	14.6	135.55	208.02	837.11	86.41	122.89	132.91	59.65	68.43	124.02
3	15.5	116.16	126.27	279.03	139.47	122.63	105.49	66.08	83.83	41.20
7	35.7	56.82	151.34	240.70	54.99	76.67	108.08	48.12	37.09	104.03
4	38.1	40.50	82.20	237.3	49.04	78.85	78.24	33.04	54.54	49.51

Appendix A-6: Mean pH of snow samples, Flin Flon, Manitoba, 1981-1983

Site	Distance (Km)	1981			1982			1983		
		Jan. 04	Feb. 09	Mar. 09	Jan. 11	Feb. 08	Mar. 11	Jan. 12	Feb. 09	Mar. 09
1	5.1	5.82	6.21	5.93	6.96	6.78	7.33	6.71	6.22	6.54
5	5.8	5.67	6.10	5.64	6.75	6.69	7.68	6.58	6.11	7.39
2	8.9	6.07	6.12	6.07	6.87	6.83	7.65	7.35	6.41	5.92
6	14.6	5.76	6.04	5.59	6.47	6.75	7.06	6.93	5.95	8.88
3	15.5	5.85	5.82	5.74	6.60	6.63	7.69	6.28	5.32	5.14
7	35.7	5.28	5.75	5.69	5.24	6.09	5.89	5.19	4.96	5.12
4	38.1	5.32	5.94	5.62	5.35	6.00	6.19	6.87	5.47	5.50