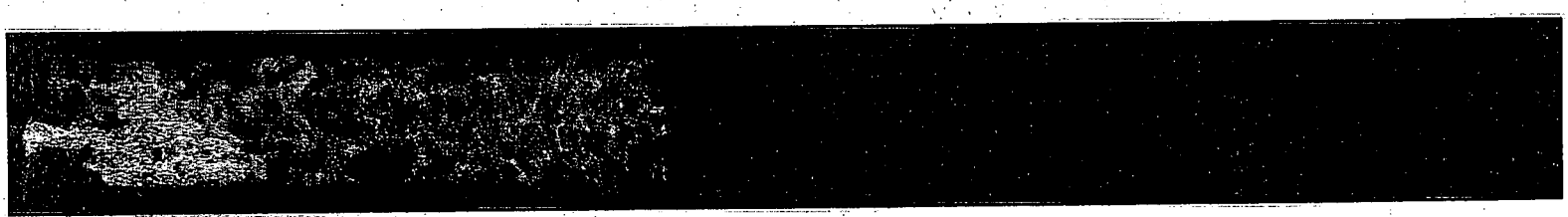

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# ...IC AND SELENIUM IN BOG VEGETATION AS INDICATOR ...SPHERIC POLLUTION FROM ORE SMELTERS IN NORTH-WEST...

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# ARSENIC AND SELENIUM IN BOG VEGETATION AS INDICATORS OF ATMOSPHERIC POLLUTION FROM ORE SMELTERS IN NORTH-WEST QUEBEC

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## INTRODUCTION

The objective of this study is to determine the atmospheric deposition of arsenic and selenium using Sphagnum mosses growing in bogs adjacent to the Rouyn-Noranda copper smelter in northwestern Quebec, Canada. Sphagnum mosses and other bog vegetation have been used in the past to monitor chemical inputs from atmospheric sources(1-4). Such vegetation was chosen over other vegetation as it is ombrotrophic receiving chemical inputs strictly from atmospheric deposition. Rouyn-Noranda, Quebec has a large copper smelter and arsenic and selenium occur in the ores of the rich sulphide deposits. When ores are smelted, large amounts of sulfur, metals and non-metals are released in the flue gas. Sulfur dioxide emission from this source is the second largest in Canada after the Inco smelter at Sudbury, Ontario(5).

**ABSTRACT**

Sphagnum mosses growing in bogs in northwestern Quebec were used to monitor the atmospheric input of arsenic and selenium from a smelter at Rouyn-Noranda, Quebec. The concentrations of arsenic and selenium in Sphagnum varied between 1.4 to 14 mg $kg^{-1}$ and 0.4 to 20 mg $kg^{-1}$ respectively within a 70 km radius from the smelter. Exceptionally high values for As and Se, 243 mg $kg^{-1}$ and 55 mg $kg^{-1}$ respectively, were found in green moss 4 km from the smelter. Intra-site variability study on mosses indicated a coefficient of variations of 54% for arsenic and 15% for selenium.

**METHODS**

Several bogs were sampled in October 1981; sites are shown in Figure 1. All bogs were located within a 70 km radius of the smelter site at Rouyn-Noranda, Quebec (48°15'N,79°00'W). Species of Sphagnum moss, S. fuscum and S. capillaceum were collected by hands covered with plastic gloves to avoid possible contamination. Approximately 1 kg of mosses (wet weight) were obtained randomly from each bog. This composite sampling technique has been previously used(4,6). We also measured intra-site variability of arsenic and selenium at one site (site 3, Figure 1). Ten randomly chosen samples of 1 kg (wet weight) each were obtained in an area of approximately 50x50 meters.

Upon return to the laboratory, samples were frozen until analysis. They were then thawed, oven-dried for 48 hrs. at 100 to 105°C, and ground in a Wiley mill to 60 mesh. The analysis of the samples was done at the Water Quality Branch, Environment Canada (Ontario Region), for arsenic and selenium using the cold vapor technique(7) and atomic absorption spectrometry.

## RESULTS AND DISCUSSION

For the purpose of this study the two stacks at the smelter in Rouyn-Noranda were considered the ejection point of arsenic and selenium. Since there is no dominant wind direction (13) the dispersion of these elements was examined in bog mosses within the 70 km radius surrounding the ejection point.

An exponential decrease of As was found in Sphagnum mosses in relation to decreasing distance from the smelter (Fig. 2). The results for arsenic within 70 km varied between 1.3 to 14 mg $kg^{-1}$ of dry weight, with an exception of the unidentified green moss species located in a bog at 4 km from the smelter which had a value of 243 mg $kg^{-1}$. The results of arsenic and selenium analysis obtained from this study suggest that substantial amounts of arsenic and selenium are released via the stacks. (i.e. The unrecoverable form of arsenic $As_4O_6$ which is stable up to a temperature of 1073°C, will escape in the flue gas (10))

Selenium (Figure 3) similarly exhibited an exponential decrease from the smelter, and the concentration varied between 0.4 to

2.0 mg $kg^{-1}$ dry weight. The green moss sample from site 7 had a high selenium concentration of 55 mg $kg^{-1}$. The differences in concentration levels between arsenic and selenium is probably explained by the difference in As and Se content in the ore.

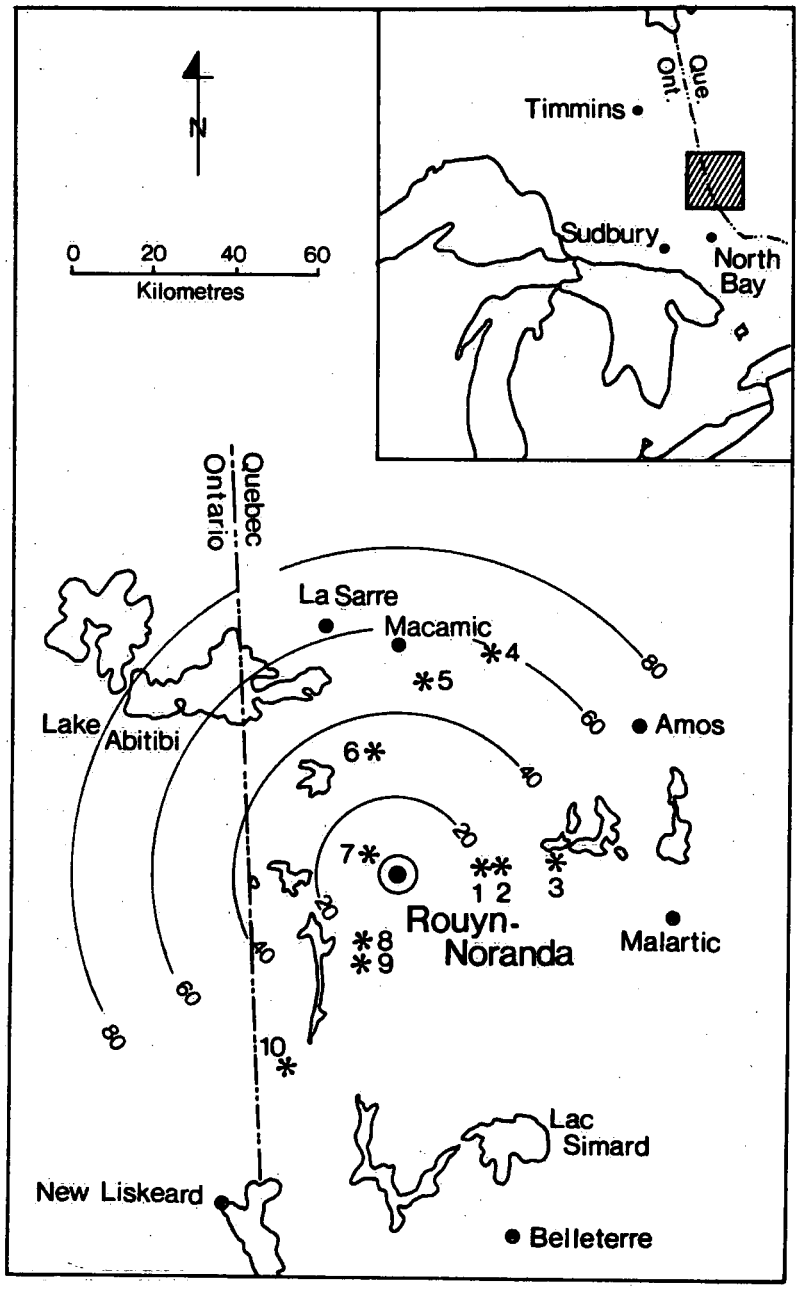
Site 3 (Figure 1) was chosen for intra-site variability and ten replicate samples were chosen randomly from the bog and were analysed for their arsenic and selenium contents. Results of these analyses are shown in Table 1.

Our previously published findings of arsenic atmospheric deposition of arsenic from the Sudbury, Ontario(3) varied from 0.03 to 2.3 mg $kg^{-1}$ while in Rouyn-Noranda the concentration varied between 3.0 to 143 mg $kg^{-1}$. Perhaps the taller Sudbury stack increased the dispersion of these elements to farther distances from the surrounding area. Comparing our results with those of others(11) for arsenic from the Yellowknife, NWT, area, levels of As as high as 11,438 mg $kg^{-1}$ were determined in lichens at a distance of 0.28 km from smelters, while at 45.23 km, levels were 38 mg $kg^{-1}$. Those levels are considerably higher than those measured in our study, 243 mg $kg^{-1}$ at 4 km and 3 mg $kg^{-1}$ at 69 km. However, our values were higher than found in a study(12) of As levels in Sphagnum mosses which varied between

0.0 to 0.2 mg $kg^{-1}$ in the Adirondack mountains of New York. Arsenic levels in lichens collected in the Northwest Territories, Canada(1) had mean values of 0.26, 0.28 and 0.24 mg $kg^{-1}$ which are quite similar to background levels found in Adirondack mountains.

There is insufficient information available about the distribution of selenium from atmospheric inputs in the literature. The selenium background level in the Adirondack mountains (11) varied between 0.3 to 0.5 mg $kg^{-1}$ compared with ours, 55 mg $kg^{-1}$ at 4 km from smelter decreasing to, 0.4 - 20 mg $kg^{-1}$ at further distances.

The data obtained from this study indicate a potential toxic problem occurring and requires further investigation with a major source of arsenic and selenium from Rouyn-Noranda smelter. This study provides an easy and inexpensive method to monitor air pollutants with respect to possible sources. Also, it serves as an indicator of transboundary transport of potentially hazardous material and establishes the baseline concentration levels for arsenic and selenium for future studies in this region of northwest Quebec.


N
0 20 40 60
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Rouyn-Noranda
Malartic
New Liskeard
Lac Simard
Belleterre
1 2
3
4
5
6
7
8
9
10
20
40
60
80

Figure 1

Table 1. Results for Intra-site Variability of *Sphagnum* Mosses

| | Concentration, mg $kg^{-1}$ | |
|---|---|---|
| Sample Number | Arsenic | Selenium |
| 1 | 0.90 | 0.70 |
| 2 | 0.91 | 0.54 |
| 3 | 0.92 | 0.80 |
| 4 | 2.6 | 0.53 |
| 5 | 1.2 | 0.78 |
| 6 | 0.58 | 0.56 |
| 7 | 0.77 | 0.62 |
| 8 | 1.3 | 0.73 |
| 9 | 1.1 | 0.61 |
| 10 | 0.50 | 0.61 |
| Mean | 1.078 | 0.648 |
| Standard deviation | 0.59 | 0.098 |
| Coefficient of variation | 54% | 15% |

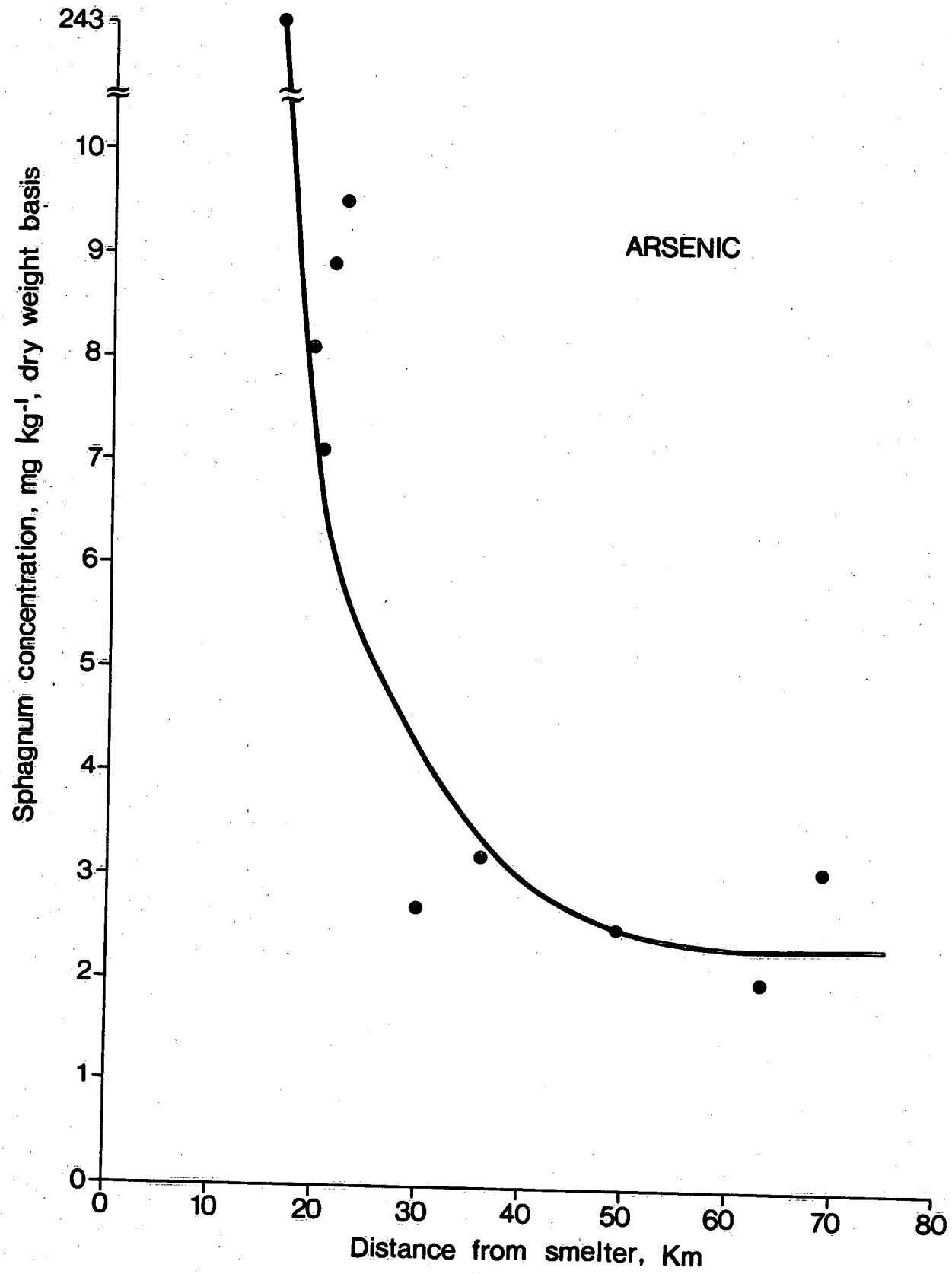
ARSENIC
Sphagnum concentration, mg kg⁻¹, dry weight basis
243
10
9
8
7
6
5
4
3
2
1
0
0
10
20
30
40
50
60
70
80
Distance from smelter, Km

Figure 2

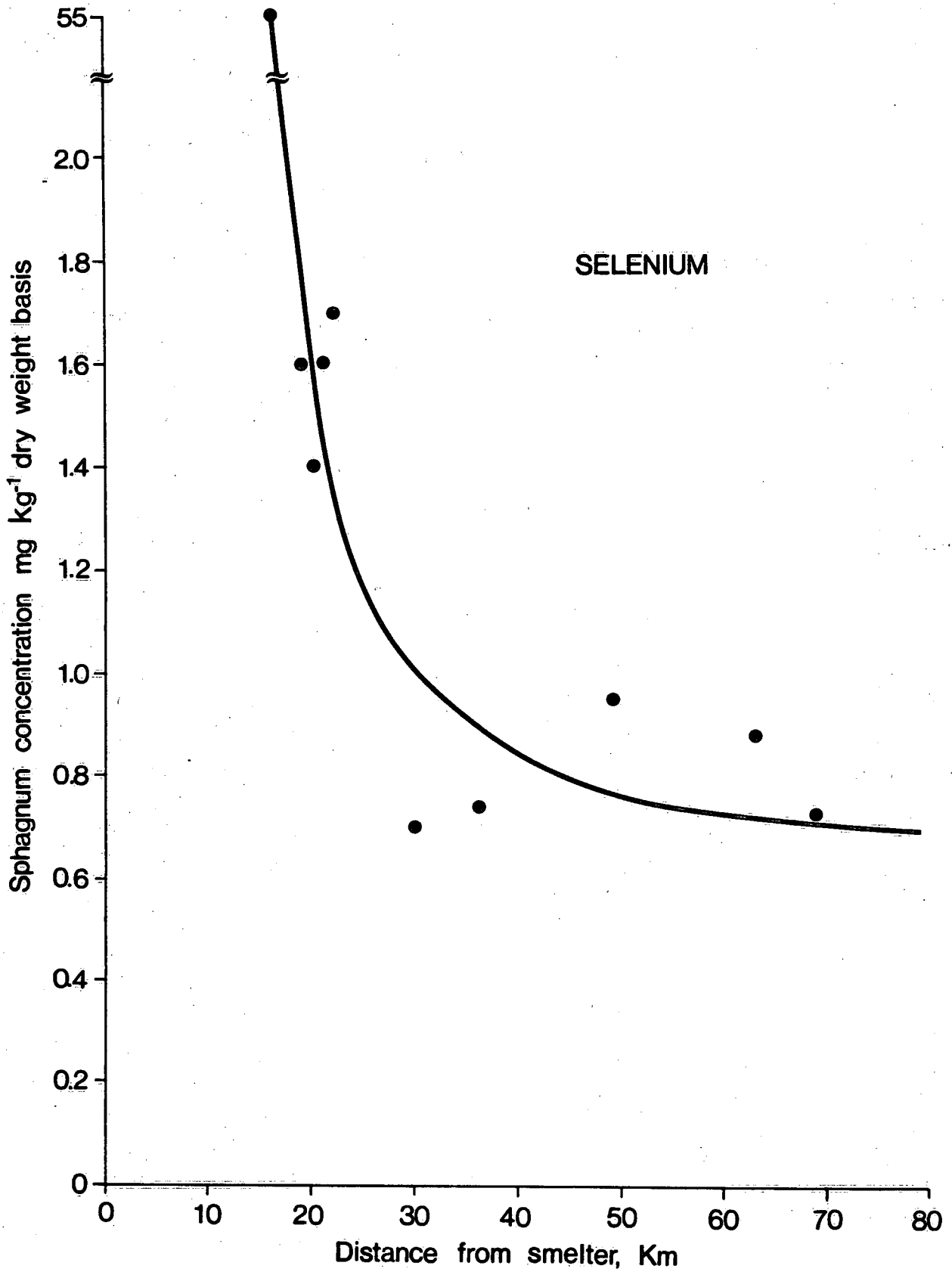
SELENIUM
Sphagnum concentration mg kg-1 dry weight basis
55
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0
10
20
30
40
50
60
70
80
Distance from smelter, Km

Figure 3

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## FIGURES

FIGURE 1. Map of study area showing sampling sites.

FIGURE 2. Concentration of arsenic in sphagnum moss tissues as a function of distance from smelter.

FIGURE 3. Concentration of selenium in sphagnum moss tissues as a function of distance from smelter.

## Date Due

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