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Atmospheric Asbestos Fibre Concentrations in the Baie Verte Area, Newfoundland

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Atlantic Region

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ATMOSPHERIC ASBESTOS FIBRE CONCENTRATIONS IN THE BAIE VERTE AREA, NEWFOUNDLAND

by
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ABSTRACT

Two ambient air surveys were carried out in the Baie Verte area in September 1974 and April 1975, to determine the atmospheric concentrations of asbestos fibres. These studies were made at the request of the Newfoundland Department of Provincial Affairs and Environment.

Asbestos samples were analyzed using the phase-contrast method (USPHS/NIOSH) and the transmission electron microscope technique. The phase-contrast results were considered most indicative of the asbestos concentrations. Transmission electron microscope data are presented, but because of possible sample alteration, no conclusions are based on this data.

During the September-1974 survey, three of seven 24-hour samples equaled or exceeded the Ontario Ministry of the Environment's *tentative* 24-hour ambient air quality objective of 0.04 fibres >5 μm/cc. Data from the second survey in April 1975, suggest that this objective would also be exceeded, but were inconclusive since samples were only of 8-hour duration. The second survey implicates a nearby asbestos mine-mill complex as the major source of asbestos fibres, because other fugitive sources in the area were snow-covered during the survey period.

The limitations of the sampling and analysis techniques used for the measurement of asbestos fibres in the ambient air are discussed. It is recommended that further ambient air sampling for asbestos be done when the present techniques are further evaluated and tested.

RÉSUMÉ

En septembre 1974 et avril 1975, à la demande du ministère des Affaires provinciales et de l'Environnement de Terre-Neuve, on a mené deux études visant à déterminer la teneur de l'air en fibres d'amiante, dans la région de Baie-Verte.

L'analyse des échantillons s'est faite au microscope à contraste de phase (méthode de l'U.S. Public Health Service/National Institute for Occupational Safety & Health, (USPHS/NIOSH) et au microscope électronique à transmission. Dans le premier cas, les résultats obtenus semblaient plus conformes à la réalité. Le présent document traite des données recueillies par microcopie électronique mais, en raison des modifications possiblement subies par les échantillons, on n'en a tiré aucune conclusion.

Au cours de l'étude de septembre 1974, la teneur en fibres de trois des sept échantillons de 24 heures a égalé ou dépassé la limite proposée par le ministère ontarien de l'Environnement, c'est-à-dire 0,04 fibre (supérieure à 5 μm) par cm^3. Les données de l'analyse d'avril 1975 indiquent que la limite pourrait encore être dépassée; toutefois, ces résultats ne sont guère concluants car ils proviennent d'échantillons prélevés pendant une période de 8 heures. D'après la seconde étude, un complexe d'extraction et de traitement de l'amiante constituerait la principale source de fibres, les autres foyers de la région étant couverts de neige, à la date des prélèvements.

Le présent rapport traite des limites des techniques d'échantillonnage et d'analyse des fibres d'amiante, et il y est recommandé le prélèvement d'autres échantillons lorsqu'on aura évalué et éprouvé davantage les techniques actuelles.

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1 INTRODUCTION

An asbestos mine-mill complex located in the vicinity of the Town of Baie Verte (population 2500) and the Village of Coachman's Cove (population 350), Newfoundland, was suspected of being the source of asbestos fibre and particulate contamination in the area. Acting on complaints from Baie Verte area residents, the Newfoundland Department of Provincial Affairs and Environment requested an ambient air survey to determine atmospheric asbestos fibre concentrations in the Baie Verte area.

To comply with this request, the Environmental Protection Service, Atlantic Region, carried out a preliminary survey in the area for one week in September 1974. The results of this preliminary survey suggested high levels of asbestos fibres > 5 μm in length.

The preliminary results prompted further investigation. It was decided to operate a second survey in the spring of 1975. The month of April was selected for the second survey for the following reasons: (1) historical wind data indicated that the Town of Baie Verte would be downwind of the mine-mill complex a greater proportion of this month compared to other months of the year; and (2) the area would be snow-covered, thereby reducing the fugitive and natural emissions of asbestos fibres to the atmosphere.

The data collected during the second survey in April 1975 are presented, together with an overview of the results of both surveys.

2 ASBESTOS MINING AND MILLING OPERATION

2.1 General

Advocate Mines Limited, an asbestos mining and milling complex, is located approximately 5 kilometres north of Baie Verte, Newfoundland. Mill capacity is 6800 metric tons of ore per day and annual production of asbestos fibre is about 68 000 metric tons. Two classifications of fibre are produced. About 90% of the total product is Advocate designated A-25, a high-quality, medium-length fibre particularly suited to the production of asbestos cement pipe and sheets, and the remainder is A-35, a short grade used primarily in the production of asbestos cement sheets.

Mining is done by standard open pit methods in which the material is drilled on square patterns and blasted to form benches. The ore is then loaded into 45-metric-ton trucks and hauled to the primary crusher. Here the ore is reduced in size to approximately 10 centimetres and is sent on to the secondary system where it is screened and further reduced in size to about 1 centimetre. During this step a fraction of rock containing no fibre is sorted out and removed to waste. The remaining ore is then dried in two horizontal and two vertical driers, both fired by bunker "C" oil. The dried ore is then conveyed to the dry rock storage area.

Ore from dry rock storage is run over a scalping screen, the oversize from which is reduced in size by crusher or impact breaker. It is then passed over finer screens along with the undersize from the scalping screen and the released fibre is aspirated. The oversize from this screen is further reduced

in size, screened and the released fibre aspirated. This procedure might be repeated again before discarding the oversize from the last screen in the rock circuit to tailings, along with the undersize or dust sifted out by the screens. The rough fibre thus collected then enters the fibre circuit. It contains dust, rock particles and unopened fibre bundles. The fibre circuit consists of stages of screening to clean fibres and aspirate them with some fibreizing in between stages to release fibres from unopened fibre bundles, sand and rock particles.

Fibres so collected are further cleaned by screening, separated into different grades and aspirated through cyclone separators. Fibre from each cyclone separator drops through a rotary valve to a separate bin for the grade of fibre produced. Air from all the cyclone separators, either in the rock or fibre circuit, is passed through the main mill baghouse before being exhausted to the atmosphere or recirculated in the mill. Air used in dust control is also passed through a baghouse before being exhaused. The catch in the baghouse(s) consisting of very fine particulate containing some fibre, is evacuated by screw conveyors through an airlock, to the tailings conveyor.

2.2 Emission Sources

There are many possible sources of asbestos emissions from the whole operation due to the nature of the materials handled and the process methods used. The two major sources at Advocate Mines are considered to be the tailings disposal site and the drying operations.

Tailings are conveyed to the top of the tailings dump 106 metres above ground level at an annual rate of approximately 1 900 000 metric tons. This material is usually fine and dry and the finer portions may be carried away by wind currents during the 4.5-metre drop encountered during the final disposal step from the stacker.

The drying operation is performed by two horizontal and two vertical driers. The throughput rate varies with the moisture content of the ore, but each drier can treat 90 metric tons per hour when the moisture content is 5%. The total drier flue-gas volume, exhausted through six stacks, is about 6800 standard cubic metres per minute. Because of the nature of the process and material treated, the total particulate loading from the driers to cyclone collectors prior to discharge to the atmosphere is estimated to be around 11 to 13 metric tons per hour. It is not known what the asbestos content of the ore is at this point in the operation.

Other sources of emission may result from the mining activities of drilling, blasting and ore haulage, and from primary and secondary crushing and dry rock storage. Although 18 400 standard cubic metres per minute of process air is used during the milling operation, it is thought that this source is less significant than drying or tailings disposal because of the assumed efficiency of the main mill baghouse which filters this large volume.

The Federal Minister of Environment has announced proposed regulations which limit asbestos fibre emissions to 2 fibres*/cubic centimetre from the crushing, drying, dry rock storage and milling sources. A Code of Good Practice for tailings disposal is currently under development by a

* greater than 5 μm in length

government/industry task force dealing with air emissions from the asbestos mining and milling industry.

3 SAMPLING LOCATIONS

Two ambient air surveys were made in the Baie Verte area during the following periods:

Phase I – September 25 to October 1, 1974
Phase II – April 9 to April 28, 1975

Asbestos fibres were measured at several sites during Phases I and II with either mobile or stationary monitors as described below:

Site Notation	Location	Description
A	RCMP Bldg., Baie Verte, 5 km SSW of Advocate	Stationary, Phases I & II
B	Duck Isle, 1.5 km ENE of Advocate	Mobile, Phase I
C	Coachman's Cove, 7 km NE of Advocate	Mobile, Phase I & II
D	Barker's Store, Coachman's Cove, 7.5 km NE of Advocate	Stationary, Phase II
E	Pond, 0.7 km SSE of Advocate	Mobile, Phase II

Temperature as well as wind speed and direction were monitored at Site A during Phases I and II.

Total suspended particulates were measured at Site A and D during Phase II.

The locations of the sampling sites are illustrated in Figure 1.

4 METHODS OF SAMPLING AND ANALYSIS

4.1 Meteorological Parameters

The wind data and temperature were recorded continuously using a Meteorology Research Incorporated weather station. The wind direction is sensed using a single blade vane, wind speed is

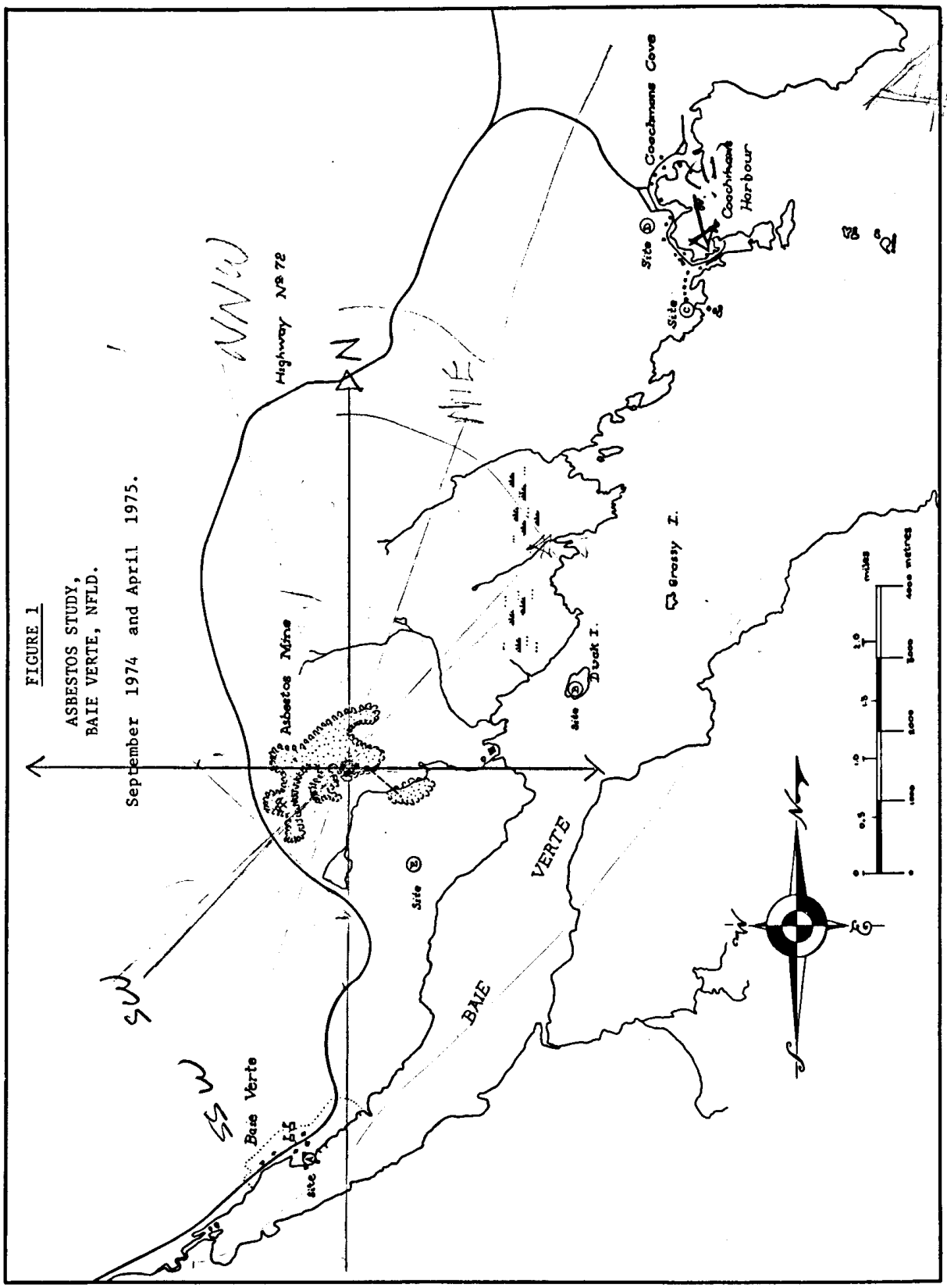


FIGURE 1

ASBESTOS STUDY,
BAIE VERTE, NFLD.

September 1974 and April 1975.

measured by a 3-cup anenometer with a start-up speed of 0.25 metres per second (m/s), and air temperature by a spiral coil bimetal element.

4.2 Asbestos Fibres

Sample Collection. The asbestos fibre samples were collected on 37 millimetre (mm) membrane filters (mixed esters of cellulose) with a 0.8 micrometre (μm) pore size, using an air sampling rate of 2 litres per minute. The sampling time varied from 7 to 12 hours for Phase I and was fixed at 8 hours during Phase II.

At the mobile sampler sites, samples were collected suing a battery operated pump mounted on a tripod at a height of 1.5 metres, and at the stationary sites sequential samplers were used. The flow rates of all the samplers were calibrated with a wet test meter.

Phase-Contrast Analysis. The exposed filters were sent to Ottawa and analyzed for asbestos fibre using the U.S. Public Health Service/National Institute for Occupational Safety & Health (USPHS/NIOSH) method (5) in which the filter is transformed from an opaque solid membrane to a transparent, optically homogenous gel. The fibres were then sized and counted using a phase-contrast microscope at 400-450 x magnification. In this method, all particulates with a length to width ratio of 3:1 or greater and a length greater than 5 μm are considered to be asbestos fibres and counted as such.

Transmission Electron Microscope Analysis. Selected samples from Phases I and II were further analyzed using a transmission electron microscope (TEM). The membrane filters were ashed at 500°C, then taken up in one millilitre of distilled water and agitated in an ultrasonic vibrator to disperse the fibres. Five microlitres of this sample was evaporated on 200 or 400 mesh carbon-coated copper grids. The samples were viewed at magnifications of several thousand times to greater than 20 000 times.

4.3 Particulates

Total suspended particulates were determined using high-volume samplers. In these instruments, a large volume of air (approx. 1.13 cubic metres per minute) is drawn through a preweighed glass fibre filter for 24 hours. The filter is then reweighed to determine the amount of particulates collected. The high-volume samplers were operated on a two-day sampling schedule and results were reported as an average daily concentration in micrograms per cubic meter ($\mu g/m^3$).

5 RESULTS

5.1 Wind Data

Figure 2 is a wind rose illustrating the frequency of occurrence of wind direction and average wind speed with direction during Phase I. The most frequent wind direction was from the southwest (29.8% of the time). This figure indicates that there is a channelling of winds along Baie Verte Inlet.

WINDROSE FOR PHASE-I BAIE VERTE ASBESTOS STUDY

September 25—October 1, 1974

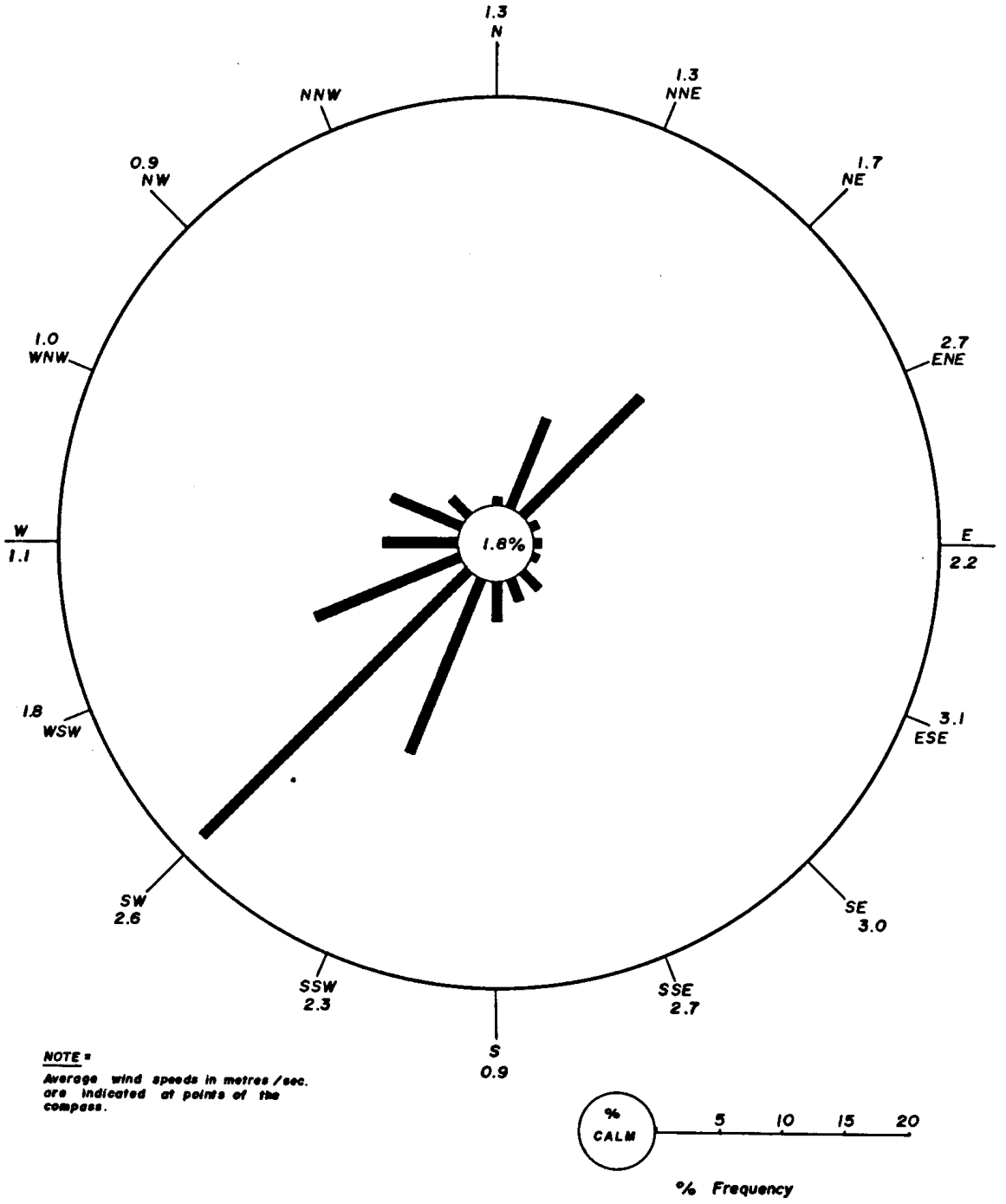


FIG.— 2

Figure 3 shows similar data for Phase II. The channelling effect is also evident from this figure, with the major wind direction from the northeast (25% of the time). A second wind instrument was operated at Site D during Phase II, but data are not presented because instrument operation was sporadic.

5.2 Asbestos

Phase-Contrast Microscope Data. The results of the phase-contract (P-C) analysis for Phase I and the prevailing wind direction(s) are presented in Table 1. The maximum concentration of 0.15 fibres*/cc was measured at Site A on September 28, 1974. There is no correlation between wind direction, the relative locations of sampling site and the mine-mill complex, and the asbestos concentrations. This may be due to the meteorological conditions, the small number of samples and the possibility of sources of fugitive dust other than the mine-mill complex.

Table 2, however, presents the 24-hour average asbestos concentrations measured during Phase I in the Town of Baie Verte, which indicate that three of the seven 24-hour samples equal or exceed the Ontario Ministry of Environment's tentative 24-hour air quality objective of 0.04 fibres*/cc (6). This objective is based on a safety factor of 50:1, compared to Ontario's Occupational Health Standard of 2 fibres*/cc, based on an 8-hour day, 5 days per week.

P-C results for Phase II are listed in Table 3. It should be noted that these samples were of 8-hour duration; this was done to allow a greater number of samples to be collected at each site and for comparison of the stationary and mobile sites. It is obvious that several of the 8-hour samples, specifically: S1-19, M-3, M-5 and M-9 indicate that the Ontario 24-hour ambient air objective would be equalled or exceeded even if no fibres were collected during the remaining 16 hours.

Table 3 also shows a correlation between high asbestos concentrations (arbitrarily selected to be $\geq$0.04 fibres*/cc) and the location of the sample relative to the mine-mill complex. For example, when asbestos levels of greater than 0.04 fibres*/cc were measured at Sites A, C and E, these sites were downwind of the mine-mill operation (e.g. Site A - NE winds; Site C - WSW-W winds; and Site E - NE winds).

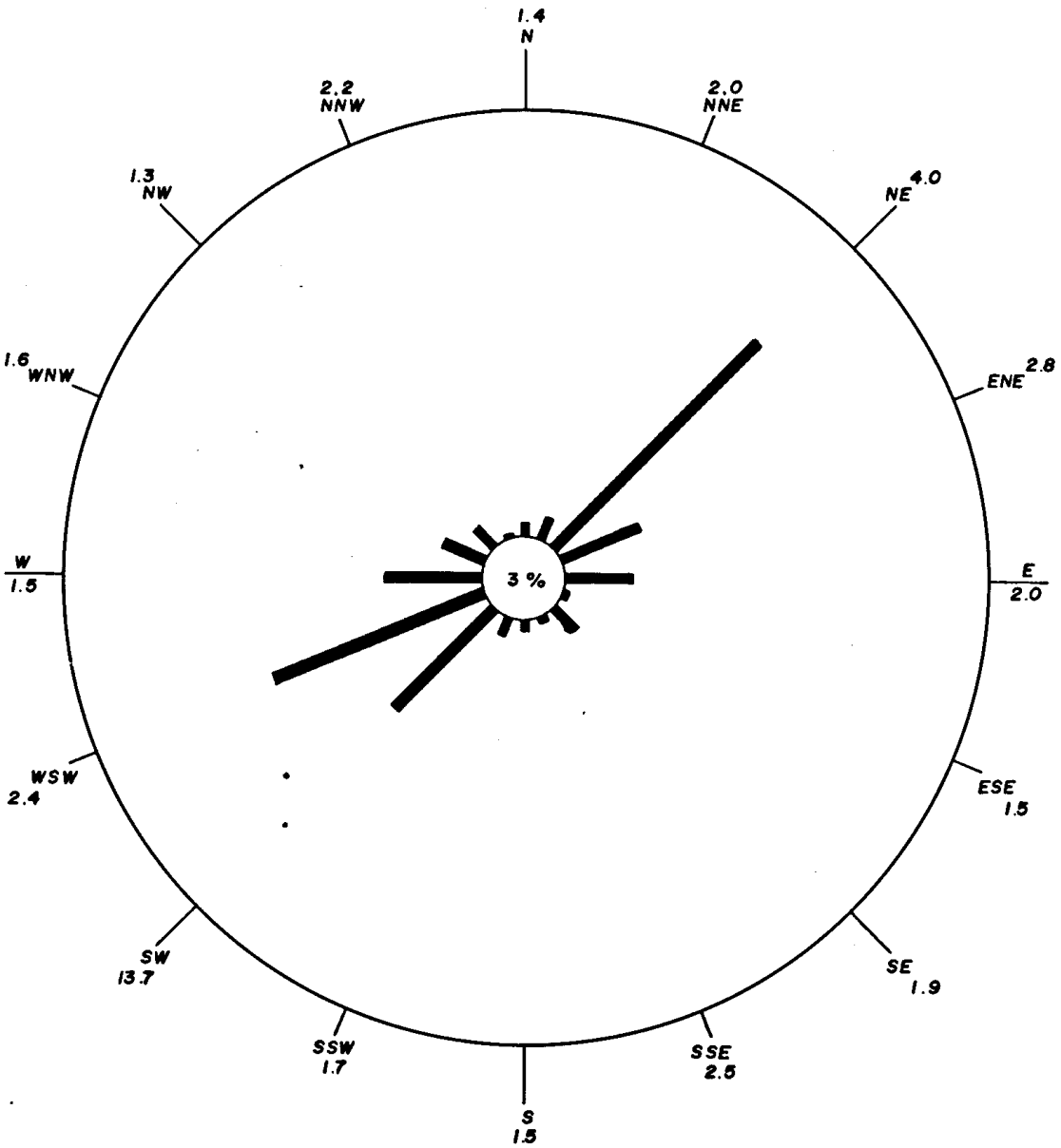
The maximum asbestos concentration of 0.19 fibres*/cc was measured at Site E on April 18, 1975 and a level of 0.13 fibres*/cc was measured at Site A on April 28, 1975. On both these occasions, the sampler was downwind of the mine-mill complex.

Transmission Electron Microscope Data. Tables (a) and (b) in Appendix A present the transmission electron microscope data (TEM) for Phase I for different analysis dates in November-December 1974 and December 1975 respectively. In Table (a) four of the five samples analyzed show a very high percentage of the fibres greater than 5 μm in length (50% - 70% of the total fibres). This data prompted further investigation in the area. As a check on this data, the remaining samples collected during Phase I were analyzed by TEM and only one sample of fourteen contained a significant percentage of fibres greater than 5 μm (approximately 6%). To date, it has not been

* greater than 5 μm in length

WINDROSE FOR PHASE-2 BAIE VERTE ASBESTOS STUDY

April 4 — April 29, 1975



NOTE:
Average wind speeds in metres/sec. are indicated at points of the compass.

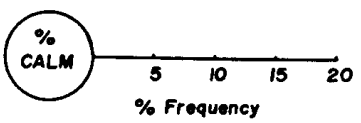


FIG:- 3

TABLE 1 ASBESTOS CONCENTRATIONS BY PHASE-CONTRAST ANALYSIS, BAIE VERTE - PHASE I, SEPTEMBER 1974

Date	Sample no.	Location*	Sample time (h)	Asbestos conc. fibres >5 μm/cc	Prevailing wind direction
25.09.74	S1	A	12.00	0.06 ✓	SSW
	S2	A	12.00	0.04	
26.09.74	S3	A	12.00	0.02	WNW - NE
	S4	A	12.00	0.01	
	M1	B	10.92	0.14 ✓	
27.09.74	S5	A	12.00	0.01	NE
	S6	A	12.00	0.01	
	M3	B	11.08	0.03	
28.09.74	S7	A	12.00	0.15 ✓	SW
	S8	A	12.00	0.09 ✓	
	M4	C	8.08	0.01	
29.09.74	S9	A	12.00	0.06 ✓	WSW
	S10	A	12.00	0.02	
	M5	C	7.16	0.08 ✓	
30.09.74	S11	A	12.00	0.02	SSW
	S12	A	12.00	0.01	
	M6	C	9.58	0.07 ✓	
01.10.74	S13	A	12.00	0.01	SW
	S14	A	12.00	0.02	
	M7	B	10.25	0.10 ✓	

*Site A - Baie Verte, 5 km SSW of Advocate
Site B - Duck Isle, 1.5 km ENE of Advocate
Site C - Coachman's Cove, 7 km NE of Advocate

TABLE 2 24-HOUR AVERAGE ASBESTOS CONCENTRATIONS, BAIE VERTE (SITE A)- PHASE I, SEPTEMBER 1974

Date	Sample no.	*Concentration fibres > 5 μm/cc
25.09.74	S1[2] + S2	1 0.050[1]
26.09.74	S3 + S4	2 0.025
27.09.74	S5 + S6	3 0.010
28.09.74	S7 + S8	4 0.120[1]
29.09.74	S9 + S10	5 0.040[1]
30.09.74	S11 + S12	6 0.015
01.10.74	S13 + S14	7 0.01

Total number of 24-hour samples = 7

* Analysed by phase contrast

[1] 24-hour samples equal to or greater than Environment Ontario's tentative asbestos objective of 0.04 fibres/cc

[2] Each discrete sample 12 hours in duration

determined why the samples analyzed in November - December 1974 showed such a high concentration of fibres greater than 5 μm.

TEM results for Phase II, Appendix B are similar to those in Table b, Appendix A; that is, the asbestos fibres were less than 5 μm in most samples. In fact, only two of twenty-eight samples showed a significant percentage of the sample to be greater than 5 μm in length (S1-15 - 4%; S2-15 - 5.2%).

It should be noted that several of the samples collected downwind of the mine-mill complex show extremely high total fibre counts, for example:

Sample (Phase II)	Total Fibre Concentration (fibres/cc)
M8	118.9
M9	187.0
M11	44.57
S1-8	57.10

In all of the above, the fibre lengths were 1 μm or less. The significance of these results is not known at the present time (2,3,6).

TABLE 3 ASBESTOS CONCENTRATIONS BY PHASE-CONTRAST ANALYSIS, BAIE VERTE - PHASE II, APRIL 1975

Asbestos Concentration Fibres >5 μm/cc.

Date (April 1975)	No.	Site A	No.	Site D	No.	Mobile sites (C or E)	Prevailing wind direction(s)
10	S1-1	0.02	S2-1	0.03	M1	0.02 (C)	WSW
11	S1-2	S.D.	S2-2	0.02	M2	0.01 (C)	WSW
12	S1-3	0.02	S2-3	S.D.	M3	0.13 (C)	SW-W
13	S1-4	0.03	S2-4	0.03	M4	0.10 (C)	SW-W
14	S1-5	S.D.	S2-5	0.01	M5	0.12 (C)	WSW-WNW
15	S1-6	0.05	S2-6	0.02	M6	0.05 (C)	WSW-NE
16	S1-7	0.02	S2-7	0.02	M7	0.03 (C)	WNW-SW
17	S1-8	0.05	S2-8	S.D.	M8	0.03 (E)	NNE-E
18	S1-9	0.08	S2-9	0.03	M9	0.19 (E)	NE
19	S1-10	S.D.	S2-10	0.03		-	E-S
20	S1-11	0.06	S2-11	0.01		-	SW
21	S1-12	S.D.	S2-12	0.02		-	WSW-SW
22	S1-13	S.D.	S2-13	0.02	M10	0.05 (E)	NE
23	S1-14	S.D.	S2-14	0.03	M11	0.03 (E)	SSW-WNW
24	S1-15	0.06	S2-15	0.03		-	SW-NW
25	S1-16	0.03	S2-16	S.D.		-	SE-NNE
26	S1-17	0.04	S2-17	0.03		-	NE
27	S1-18	0.10	S2-18	0.02		-	NE
28	S1-19	0.13	S2-19	0.01		-	NE-E
No. Samples		13		16		11	
Average		0.05		0.02		-	
Maximum		0.13		0.03		0.19 (E)	
Minimum		0.02		0.01		0.01 (C)	

Total no. samples collected = 47 Total no. samples analyzed = 35

S.D. - sample damage

Notes

Site A - Baie Verte, 5 km SSW of Advocate
Site D - Coachman's Cove, 7.5 km NE of Advocate
Site C - Coachman's Cove, 7 km NE of Advocate
Site E - Pond, 0.7 km SSE of Advocate

Discrepancies between the P-C and TEM results are discussed in Section 6.

5.3 Particulates

Total suspended particulate levels for Phase II are listed in Table 4. The average particulate concentrations measured in Baie Verte and Coachman's Cove were 49 $\mu g/m^3$ and 14 $\mu g/m^3$ respectively. Only one sample collected on April 24, 1975 in Baie Verte, of 115 $\mu g/m^3$ approached the federal 24-hour maximum acceptable objective for particulates of 120 $\mu g/m^3$.

Normal background levels for particulates vary from 40 to 70 $\mu g/m^3$. The levels measured during Phase II are in or below this range.

6 DISCUSSION

It is obvious from Section 5 that discrepancies exist between the phase-contrast and transmission electron microscope results. It is, therefore, necessary to discuss both of these techniques and the method of collection in order to better understand the significance of the results.

(i) It must be noted that the collection method used for this study was adopted directly from the USPHS/NIOSH method (5) which was developed for sampling asbestos in industrial hygiene situations (i.e. in plant). Therefore, the method used is not a tested or an approved method for the ambient air sampling of asbestos, but it was the best available at the initiation of the study. One drawback of this method is that background particulates may mask the smaller amounts of asbestos fibres in the sample.

(ii) The phase-contrast and electron microscope results cannot be directly compared due to the different resolving powers of the two techniques. The P-C method is only capable of resolving fibres down to about 1 μm in diameter. Also, only those fibres greater than 5 μm in length with an aspect ratio of 3:1, or a diameter 1.67 μm are counted. In the TEM method, increased resolution will allow fibres less than 5 μm in length with diameters much less than 1.67 μm to be seen and counted.

(iii) In a recent paper by Spurny (4), it was suggested that the preparation technique using ashing and ultrasonic treatment for TEM (see Section 4) may significantly alter the original lengths and shapes of deposited asbestos fibres. This may possibly account for the P-C/TEM differences. The phase-contrast method does not require ashing or ultrasonic treatment prior to counting.

(iv) The P-C method is an accepted method, used in the United States for industrial hygiene standards, and a modified version will be the standard reference method for Environment Canada's Asbestos Mining and Milling Emission Standard Regulation, to be applied to actual stack emission measurements.

After considering the above facts, it was decided to base the conclusions of the study on the phase-contrast data to prevent confusion.

TABLE 4 TOTAL SUSPENDED PARTICULATES ($\mu g/m^3$), BAIE VERTE-PHASE II, APRIL 1975

Date (1975)	Station A (Baie Verte)	Station D (Coachman's Cove)	Average wind dir. speed (m/sec)	Weather conditions
April 10	38	8	WSW 2.5	Sunny with some cloud
April 12	30	14	SW^{to}W 2.4	Overcast, snow flurries
April 14	34	13	W 1.4	Sunny with overcast evening.
April 16	61	12	W 1.5	Sunny and clear
April 18	26	14	NE 4.5	Snow and freezing rain
April 20	66	29	SW 3.8	No observation
April 22	22	6	NE 2.4	Cloudy, snow flurries
April 24	115	-	SW^{to}NW 1.5	Sunny and clear
Total no. samples	8	7		
Maximum	115	29		
Mean	49	14		

Total No. 24-h TSP samples = 15
No. of TSP samples ≥ 24-h Max. Accept. Obj. = 0

The Ontario Ministry of the Environment has recently formed an expert committee to study asbestos analysis and sampling techniques for asbestos in the ambient air. It is hoped that the recommendations of this committee will be available in 12 to 18 months.

In this report, 24-hour asbestos measurements were compared to Ontario's *tentative* 24-hour asbestos air quality objective of 0.04 fibres*/cc. It must be noted that this criteria was selected using a 50:1 safety factor compared with Ontario's health standard for the occupational environment and not based on health effects data for low-level exposures.

* greater than 5 μm in length

The threshold limit value (TLV) for occupational exposures was not used in this report since this standard was not intended for the evaluation of community air pollution (7). The asbestos TLV was used in the preliminary survey only as a "very rough" estimate of the potential asbestos problems in the area, to determine if further investigation was necessary.

The health effects of asbestos fibres in the industrial situation are well documented (3). The effect of smaller doses on the general population over an extended period of time is not known at this time (3,4,6). Despite this uncertainty as to the effects of environmental levels on the health of man, asbestos concentrations and changes in levels in the ambient air should still be carefully monitored. Data from ambient air surveys may provide useful information if and when cause-effect relationships are better understood.

7 CONCLUSIONS

The original intention of the study was to determine the asbestos fibre concentrations in the ambient air. This has been accomplished, but the results obtained must be used with the knowledge that the sampling and analysis methods for determining the levels of asbestos fibres in the ambient air are in the early stages of development.

The following conclusions are based on the phase-contrast data gathered during both phases of the study:

1. Three of the seven 24-hour atmospheric asbestos fibre concentrations in the Baie Verte area measured during Phase I (September 1974) exceeded the Ontario Ministry of the Environment *tentative* air quality objective for asbestos.

2. Asbestos fibre levels measured on four of thirty-five samples collecting during Phase II (April 1975) indicate that the Ontario 24-hour objective for asbestos would be equalled or exceeded during these days even if no fibres were collected during the remaining 16 hours.

3. Phase II asbestos results correlate well with the wind direction and the relative location of the sampler to the mine-mill, implicating the asbestos mine-mill complex as the major source of fibres during the survey period. This correlation was not observed during Phase I, probably because of the lack of snow cover during this survey, which allowed a greater influence from fugitive or natural sources of asbestos on the sampling sites.

4. Further ambient air studies should be conducted in the area when: (i) sampling and analysis techniques for asbestos fibres in the ambient air have been further researched and evaluated, and (ii) after air pollution controls are operational at the asbestos mine-mill complex.

5. Total suspended particulate levels measured during Phase II are considered to be background levels.

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APPENDIX A - TRANSMISSION ELECTRON MICROSCOPE DATA - PHASE I

TABLE (a) BAIE VERTE, NFLD. - PHASE I
SEPTEMBER - OCTOBER, 1974

TRANSMISSION ELECTRON MICROSCOPE ASBESTOS DATA
(SAMPLES ANALYZED NOVEMBER - DECEMBER, 1974)

Sample no.	Location	Date	Total asbestos fibres/cc	% Fibres >5 μm	Conc. fibres >5 μm/cc
M-5	C	29.09.74	6.732	50	3.37
M-7	B	01.10.74	31.805	50	15.90
S-7	A	28.09.74	Trace	-	-
S-9	A	29.09.74	0.085	70	0.06
S12	A	30.09.74	0.598	70	0.42

Site A - Baie Verte, 5 km SSW of Advocate
Site B - Duck Isle, 1.5 km ENE of Advocate
Site C - Coachman's Cove, 7 km NE of Advocate

TABLE (b) BAIE VERTE, NFLD. - PHASE I
SEPTEMBER, 1974

TRANSMISSION ELECTRON MICROSCOPE DATA
(SAMPLES ANALYZED DECEMBER, 1975)

Date	Sample no.	Site	Fibre length (μm)	Cumulative frequency ($\leq$ stated fibre length)	Concentration fibres/cc
26.09.74	M-1	B	1.0	100	5.59
			0.5	75	4.19
			0.25	50	2.8
28.09.74	M-4	C	1.0	100	7.59
			0.75	90	6.83
			0.50	80	6.07
			0.25	50	3.80
30.09.74	M-6	C	0.5	100	2.39
25.09.74	S-1*	A	6.5	100	0.73
			4.5	92	0.67
			4.0	84	0.61
			1.5	74	0.54
			1.0	68	0.50
			0.5	63	0.46
			0.25	13	0.09
25.09.74	S-2	A	3.5	100	1.97
			2.0	96	1.89
			1.5	92	1.81
			0.75	77	1.52
			0.50	67	1.32
			0.25	32	0.63
26.09.74	S-3	A	4.5	100	14.63
			2.0	87	12.73
			1.0	74	10.83
			0.75	70	10.24
			0.5	26	3.80

TABLE (b)

Date	Sample no.	Site	Fibre length (μm)	Cumulative frequency (≤stated fibre length)	Concentration fibres/cc
			0.25	4	0.59
26.09.74	S-4	A	2.0	100	0.32
			1.0	80	0.26
			0.5	60	0.19
27.09.74	S-5	A	2.0	100	0.38
			1.0	84	0.32
			0.5	39	0.15
27.09.74	S-6	A	1.5	100	0.7
			1.0	95	0.67
			0.75	88	0.62
			0.5	48	0.34
28.09.74	S-8	A	TRACE		
29.09.74	S-10	A	TRACE		
30.09.74	S-11	A	1.5	100	2.22
			0.5	87	1.93
01.10.74	S-13	A	0.5	100	0.07
01.10.74	S-14	A	2.0	100	2.3
			1.0	85	1.96
			0.5	55	1.27

NOTE * S-1 Fibres ≥ 5 μm = 6.2% *or* a concentration of 0.045 fibres/cc

APPENDIX B - TRANSMISSION ELECTRON MICROSCOPE DATA PHASE II

BAIE VERTE, NFLD. - PHASE II
TRANSMISSION ELECTRON MICROSCOPE ASBESTOS DATA, APRIL 1975

Date (April '75)	Sample no.	Site	Fibre length (μm)	Cumulative frequency ($\leq$ stated fibre length)	Concentration total fibres/cc
10	M1	C	0.75	100	0.25
			0.50	50	0.13
11	M2	C	2.0	100	1.43
			1.5	70	1.00
			1.0	56	0.80
			0.75	42	0.60
			0.5	30	0.43
12	M3	C	1.5	100	7.09
			1.25	98	6.95
			0.75	96	6.81
			0.5	94	6.66
13	M4	C	1.75	100	0.26
14	M5	C	1.5	100	0.45
			1.25	85	1.23
			1.0	78	1.13
			0.75	70	1.02
			0.5	55	0.80
			0.25	25	0.36
15	M6	C	0.37	100	0.18
			0.25	50	0.09
16	M7	C	1.0	100	1.12
			0.5	75	0.84
			0.37	50	0.56
			0.25	25	0.28
17	M8	E	0.75	100	118.9
			0.50	92	109.4
			0.37	57	67.8

Date (April '75)	Sample no.	Site	Fibre length (μm)	Cumulative frequency (≤ stated fibre length)	Concentration total fibres/cc
			0.25	32	38.5
18	M9	E	1.0	100	187.0
			0.75	93	173.9
			0.5	72	134.6
			0.38	65	121.6
			0.30	37	69.2
22	M10	E	1.0	100	1.83
			0.75	82	1.50
			0.50	73	1.34
			0.25	38	0.70
			0.15	12	0.22
23	M11	E	0.38	100	44.57
			0.25	50	22.29
			0.15	25	11.14
15	S1-6	A	1.0	100	9.52
17	S1-8	A	0.5	100	57.10
			0.25	63	35.97
			0.15	50	28.55
18	S1-9	A	0.75	100	19.03
			0.5	50	9.52
20	S1-11	A	1.0	100	1.81
			0.75	58	1.05
			0.5	21	0.38
			0.37	10	0.18
24	S1-15*	A	10.0	100	5.43
			5.0	96	5.21
			2.0	94	5.10
			1.5	83	4.51
			1.25	80	4.34
			1.0	78	4.24
			0.75	50	2.72
			0.5	47	2.55
			0.37	7	0.38
			0.25	5	0.27

Date (April '75)	Sample no.	Site	Fibre length (μm)	Cumulative frequency ($\leq$ stated fibre length)	Concentration total fibres/cc
25	S1-16	A	1.75	100	0.16
			0.37	50	0.08
26	S1-17	A	1.5	100	2.47
			1.0	95	2.35
			0.75	80	1.98
			0.5	45	1.11
			0.25	15	0.37
28	S1-19	A	1.25	100	0.48
			0.75	80	0.38
			0.5	60	0.29
			0.25	40	0.19
			0.37	20	0.10
10	S2-1	D	1.0	100	0.29
			0.50	67	0.19
			0.37	34	0.10
11	S2-2	D	1.0	100	0.29
			0.5	67	0.19
13	S2-4	D	0.5	100	0.10
15	S2-6	D	2.0	100	3.72
			1.5	97	3.61
			1.4	87	3.24
			0.5	76	2.83
			0.37	71	2.64
			0.25	68	2.53
19	S2-10	D	0.75	100	3.91
			0.50	66	2.58
			0.25	29	1.13
20	S2-11	D	0.75	100	0.48
			0.33	60	0.29
			0.25	40	0.19

Date (April '75)	Sample no.	Site		Cumulative frequency (≤ stated fibre length)	Concentration total fibres/cc
21	S2-12	D	1.75	100	2.47
			1.0	96	2.37
			0.75	92	2.27
			0.50	72	1.78
			0.25	12	0.30
24	S2-15**	D	6.5	100	0.48 ≥
			0.5	80	0.38
			0.25	60	0.29
			0.125	20	0.10
26	S2-17	D	1.0	100	0.48
			0.5	60	0.29
			0.25	20	0.10

Site A – Baie Verte, 5 km SSW of Advocate
Site C – Coachman's Cove, 7 km NE of Advocate
Site D – Coachman's Cove, 7.5 km NE of Advocate
Site E – Pond, 0.7 km SSE of Advocate

NOTE * S1-15 Fibres ≥5μm = 4% *or* a concentration of 0.22 fibres/cc
** S2-15 Fibres ≥ 5μm = 5.2% *or* concentration of 0.025 fibres/cc

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ATMOSPHERIC ASBESTOS FIBRE CONCENTRATIONS IN THE BAIE VERTE AREA, NEWFOUNDLAND
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