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PURCHASE ANALYSIS

REPORT ON ASBESTOS

February 28, 1957

The Dow Chemical Company

Midland Michigan

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I INTRODUCTION

Asbestos is a common name that applies to a group of naturally fibrous minerals. One of these accounts for 95% of world production and will be the subject of this study. It is chrysotile ($3MgO:2SiO_2 \cdot 2H_2O$), a recrystallized form of serpentine which in turn is an alteration product of basic igneous rocks that have been subjected to both regional and contact (localized) metamorphism (heat and pressure). All other forms of asbestos are members of the amphibole group of minerals and have a series of small and specialized end uses. Chrysotile asbestos will be referred to simply as asbestos for the rest of this report.

Asbestos is classified largely according to length. Grades #1 and #2 are long, spinning fibers which are hand-cobbed and very expensive. There is a substantial import market for this type of fiber and it is often in short supply. The milled fibers are Grades #3, #4, #5 and #6 and include the varieties used by Dow. Grade #7 and shorter fibers are called "shorts" and are always in long supply and readily available. Therefore, it is only the supply of milled fibers that reflects changing market conditions, and they will be the subject of this report. All comments discussing asbestos fibers will refer to milled fibers.

Dow uses asbestos as a diaphragm in Dow chlorine cells at a purchased cost of somewhat under $100,000 per year. While this does not constitute an exceptionally large dollar expenditure, asbestos performs a vital function in chlorine production and as yet no adequate substitute has been found. Dow currently has only one supplier, Ruberoid, which sells Dow a #3 length and a #4 length fiber. After much experimentation with blend ratios and fiber lengths, Dow currently uses 20 pounds of #3 fiber and 40 pounds of #4 fiber per diaphragm.

II SUMMARY

Asbestos minerals are relatively abundant on a world-wide basis so only the high-grade ores close to market have been developed. The major deposits of interest to Dow are located in Quebec with other significant ores present in Vermont, British Columbia, and Arizona.

The North American asbestos industry produces slightly over a million tons of fiber annually and has proven reserves of approximately 50 million tons; therefore, current reserves are adequate for half of a century and probable reserves are two or three times proven figures. Johns-Manville is the largest producer of asbestos fibers, accounting for 56% of North American production.

Milled asbestos fibers are in long supply and will continue to be so for several years. This is due to a major capital expansion of new mining and milling facilities over the past few years by the entire industry. Because of the above situation there should be no major price increases for milled asbestos fiber in the next two or three years. Future price increases will more likely be a product of increased labor and material costs than changes in supply and demand.

Dow is interested in the long-range availability of milled fiber because asbestos forms an integral part of chlorine-caustic production. At the same time, our use is relatively small and we cannot command a premium supply position with the asbestos industry. However, it appears that our asbestos needs for the foreseeable future can be satisfied by aligning ourselves with major producers that have abundant reserves. Most of the major producers have built new mills in the past three or four years and are now producing a high-quality fiber at standard prices.

III PRODUCTION

A. Occurrence and Distribution

Asbestos occurs in fissure-filled veins of the host rock in two fibrous forms, cross-fiber and slip fiber. Cross fibers grow perpendicular to the vein while slip fibers roughly parallel the vein. Slip-fiber veins often tend to be shorter, more brittle and, therefore, less valuable. Asbestos minerals are relatively abundant with occurrences known throughout the world. Only the highest grade ores and those closest to major markets have been developed. This report will be confined to North American asbestos deposits as they are the only ones where substantial fiber is economically available to a consumer not interested in crude spinning fibers.

Major domestic deposits are located in Vermont and Arizona. The Vermont deposits are a southern extension of the Canadian serpentine belt and have a similar origin. Over 98% of domestic production comes from Vermont where Ruberoid is the sole producer. They are currently obtaining a 5% recovery on ore mined and have 10-12 years of proven reserves blocked out. Probable reserve estimates would run in the 25-30-year range based on their current production rate. Ruberoid estimates reserves at 800,000 to one million tons of fiber.

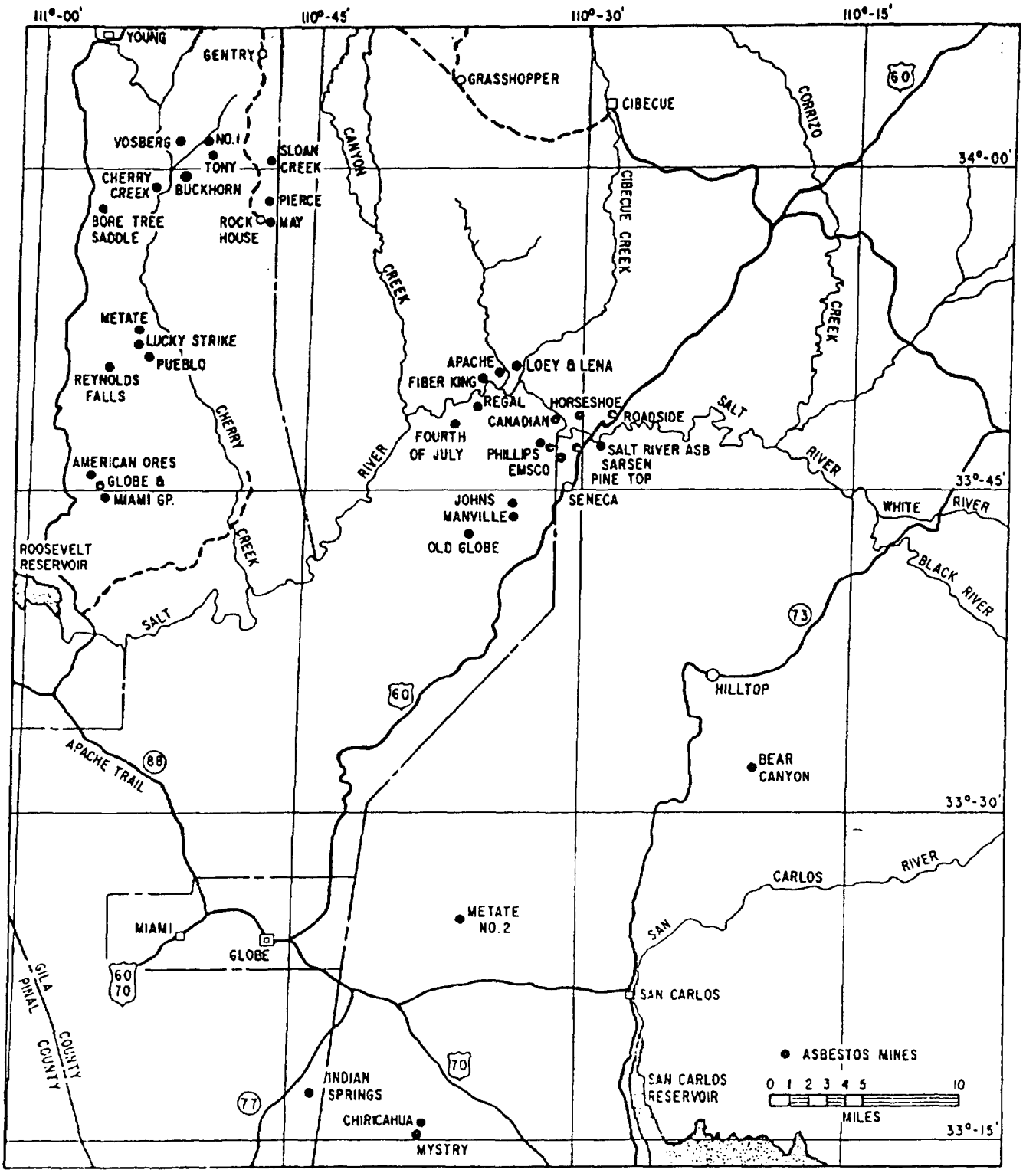
Marginal deposits are located in Gila County, Arizona, and account for the balance of U.S. production. Exhibit I shows the location of these deposits. Currently, the lack of a market for the shorter fibers and the lack of milling facilities are making operating economics difficult. This whole producing area is dependent on Government subsidy for its existence. The occurrence is in limestone and quartzite beds which mineralizing solutions have entered and through contact metamorphism the host rock has altered to serpentine. The veins are narrow and sporadic and reserves appear to be small, although no calculations have been attempted. The chief advantages of these deposits are their low iron content and the length of the fiber, which is spinning grade.

The major asbestos deposits of the world are located in Quebec, Canada. Exhibit II outlines the producing areas and locates the major producers. Quebec asbestos deposits occur in fissures in serpentine that is an alteration product of various igneous rock complexes. The fibers range up to 4 or 5 mils in length with the bulk of production being obtained from fibers less than 1/4" long. The Canadian deposits are high in iron impurity;

EXHIBIT I

MAP OF ASBESTOS DEPOSITS

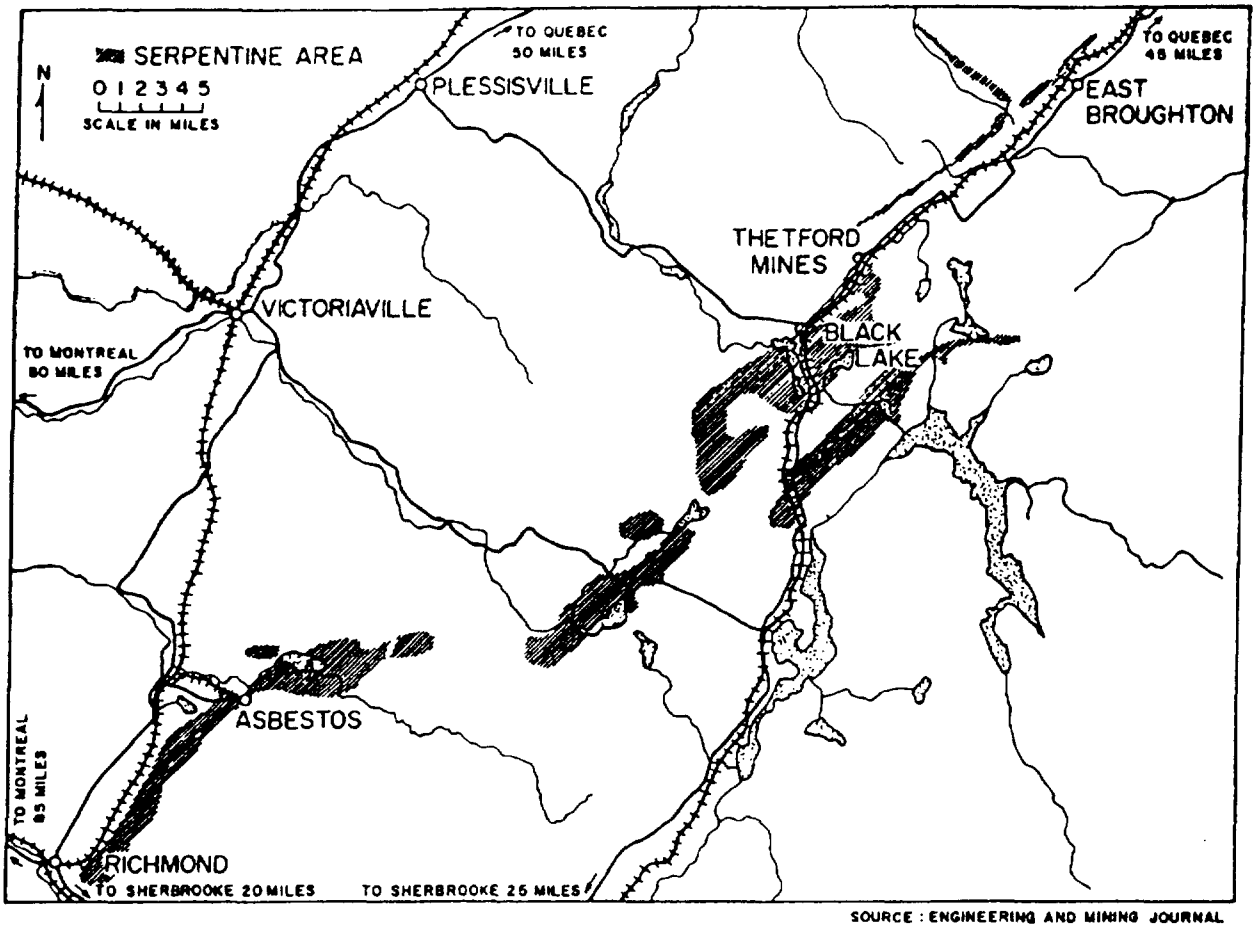
GILA COUNTY, ARIZ.



SOURCE: BULLETIN 552 BUREAU OF MINES
"THE ASBESTOS INDUSTRY"
BY OLIVER BOWLES

EXHIBIT II

QUEBEC ASBESTOS REGION



SOURCE : ENGINEERING AND MINING JOURNAL VOL. 157; NO. 1; PG. 100

LOCATION OF ASBESTOS MINES AND MILLS

ASBESTOS

JOHN'S MANVILLE LTD.
NICOLET ASBESTOS MINES LTD.

BLACK LAKE

AMERICAN SMELTING & REFINING
ASBESTOS CORP. LTD.
JOHNSON'S CO. LTD.
NICOLET ASBESTOS MINES LTD.

EAST BROUGHTON

QUEBEC ASBESTOS CORP.

THETFORD MINES

ASBESTOS CORP.
BELL ASBESTOS MINES
FLINKOTE MINES LTD.
JOHNSON'S CO. LTD.

but the fiber breaks away from the wallrock with facility, thus preserving more of the longer fibers. Johns-Manville, the largest Canadian producer, gets 12% fiber recovery from their ore and have proven reserves estimated at 100 years at the current rate of production. Asbestos Corporation, Limited, has estimated their ore reserves at 105 million short tons, which would be in excess of six million tons of fiber. Recent heavy expenditures for expansion in the asbestos industry indicate that most of the large companies have proven reserves in the 25-30-year range with potential reserves amounting to two or three times that figure. A minimum of 20 years of reserves is needed to justify building a mill.

Smaller asbestos properties are being mined in several other Canadian provinces and show future promise. Johns-Manville has a mine and mill at Matheson, Ontario, which produces Group #4 and shorter milled fibers. Cassiar Asbesto , which is affiliated with the Turner-Newell interests, has a deposit at McDame Mt., British Columbia, with reserves estimated at 6 million tons of rock at 7% recovery, or 420,000 tons of fiber running very high in spinning grade fibers. The fiber is low-iron chrysotile with 1955 production running about 15,000 short tons of fiber. This would indicate 25-30 years proven reserves at current production levels. A new asbestos area has been discovered in Newfoundland where 13,500 tons of ore have been blocked out and 50 million tons are indicated by present exploration. Production is expected to start in 1958 at the rate of 5,000 tons of ore per day. Estimated costs of production at this rate include:

	Dollars Per Ton of Ore
Open-pit mining	1.00
Crushing, drying & ore storage	.30
Milling	.90
Hand cobbing	.02
Warehousing & Boat Loading	.10
General overhead	.50
Sales	.20
Miscellaneous	.23
Total	3.25

Canadian asbestos now sells at an average price of $5.74 per ton of ore. This will be a major discovery if fully substantiated and developed.

In 1956 Canadian sales of milled fiber were 1,060,000 short tons and proven Canadian reserves are estimated at slightly over 50 million tons of fiber, so reserves are statistically adequate for half a century and undoubtedly adequate for a much longer period.

B. Mining and Milling

Asbestos is mined by both open-pit and underground methods. The open-pit method is generally more economic at shallow depths; however, many companies are tending to reach the economic limit of open-pit mining. Most of the Canadian producers in Quebec have switched to underground mining and Ruberoid at Lowell, Vermont, is seriously considering a similar move. The two most common methods of open-pit mining are the bench method, where the open pit is mined in spiral benches starting at the top, and a simple caving operation, where large chunks of ore are blasted loose and hauled to the top of the pit.

Underground mining usually follows one of two patterns. The first is to tunnel into a hillside at the vein outcrop and mine by following the vein as you would a coal seam. The second method is of more utility in a large operation and is called "block caving". This is similar to the room-and-pillar method of coal mining except that the "room" is caved into ore cars on a lower level by blasting rather than being machine mined. In both cases, the pillars are left to support the overburden. The second method yields ore that averages roughly 10% fiber. The first would have higher yields but be more expensive.

The milling operation concerns only Group #3 and shorter fibers. Longer fibers are hand-cobbed. Asbestos milling consists of a series of crushing, grinding, screening, aspirating and grading steps. It is a completely physical process and the ore is thoroughly dried before entering the mill with no water necessary for processing. The purpose of the milling process is to separate the fibers according to length (grade) and to clean and open the individual fibers. There is a standard Canadian specification which applies to various asbestos fiber grades and it is presented on the following page. This classification is based on length and a standard 16-ounce sample. The numbers indicate the minimum weight distribution by length that is acceptable for each grade of fiber. Vermont specifications adhere to Canadian standards.

CANADIAN SPECIFICATIONS FOR MILLED FIBERS

Box	1	2	3	4
Opening	1-1/2"	4 mesh	10 mesh	Fines
Wire Diameter	0.105	0.063	0.047	
Group 3				
3F	7	7	1.5	0.5
3K	4	7	4	1
3R	2	8	4	2
3T	1	9	4	2
3Z	0	8	6	2
Group 4				
4H	0	5	8	3
4K	0	4	9	3
4M	0	4	8	4
4R	0	3	9	4
4T	0	2	10	4
4Z	0	1.5	9.5	5
Group 5				
5D	0	0.5	10.5	5
5K	0	0	12	4
5M	0	0	11	5
5R	0	0	10	6
Group 6				
6Z	0	0	7	9

C. Production Statistics

Exhibit III shows a list of the North American producers and their approximate capacities. All mills are located in Quebec unless otherwise noted. The exhibit lists the total daily rock capacity for the industry as 73,400 short tons. Allowing for a 6% fiber recovery and a 300-day year, both of which are conservative, this figure translates into 1,325,000 short tons of fiber per year. Since 1956 production figures for North America are very close to 1,100,000 short tons of fiber, there is already substantial excess mill capacity.

By 1958 American Smelting and Refining at Black Lake, Quebec, and Dominion Asbestos Co. at St. Adrian, Quebec, will be in production with 5,000 short tons/day and 2,200-short-ton-per-day mills. Continental Asbestos, National Gypsum Co. and Eastern Asbestos are all considering entering the business; thus, there will be ample asbestos mill capacity for the foreseeable future. Johns-Manville should continue to dominate the asbestos production picture as they currently account for 56% of North American fiber.

Part nine of Exhibit III mentions Arizona producers. The following is a list of the more substantial Arizona producers.

ARIZONA PRODUCERS

Producer	Address	City
Bear Canyon Mining Co.	P.O. Box 1730	Globe
Arthur Enders	P.O. Box 362	Globe
Jaquay's Mining Corp.	1219 S. 19th Ave.	Phoenix
Metate Asbestos Corp.	P.O. Box 1506	Globe
Phillips Asbestos Mines	Drawer 71	Globe

Jaquay's and Phillips have facilities to mechanically sort their ore.

Exhibit IV depicts production history for all grades of U.S. and Canadian asbestos. Currently, domestic asbestos production is running about 5% of Canadian production. In future years this percentage should diminish unless major new domestic ore bodies are uncovered.

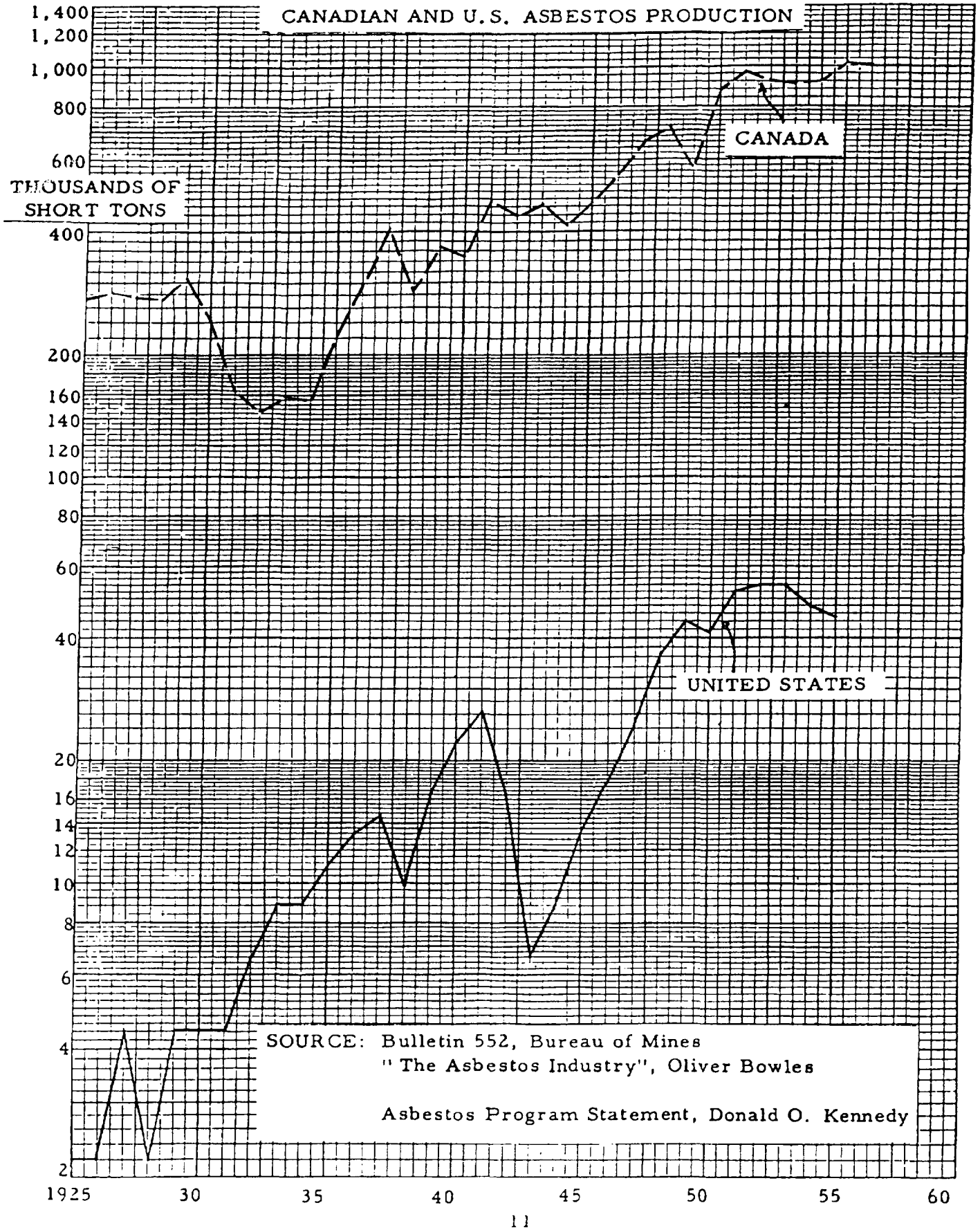
EXHIBIT III

NORTH AMERICAN PRODUCERS AND CAPACITIES - 1956

Producer	Mill	Daily Rock Capacity (Short Tons)
(1) Johns-Manville	Jeffrey Mill	20,000
	Danville Mill (shut down)	12,500
	Munro (Ontario) Mill	2,000
(2) Asbestos Corporation Ltd.	Beaver & King Mills	7,200
	British Canadian Mill	5,000
	Normandie Mill	5,000
	Vimy Ridge Mill (shut down)	2,800
(3) Johnson's Company	Megantic Mill	4,000
	Thetford Mines Mill	2,000
	Coleraine Mill (shut down)	1,200
(4) Ruberoid Corporation	Lowell (Vermont) Mill	3,200
(5) Nicolet Industries Inc.	Danville Mill (Nicolet Asbestos Mines Ltd.)	3,000
(6) Turner and Newell Interests	Bell Mill (Bell Asbestos Mines, Ltd.)	2,000
	McDame (British Columbia) (Cassiar Asbestos Corp. Ltd.)	600
(7) Flintkote Company	Thetford Mines Mill	2,400
(8) Philip Corey Mfg. Co.	East Broughton Mill	1,500
(9) Arizona producers	no mill	0
Total Mill Capacity (short tons)		73,400

SOURCES: Oliver Bowles - Personal Communication
Engineering and Mining Journal, Vol. 157 #1, p.98

EXHIBIT IV



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The following table breaks down Canadian production into those fiber lengths of interest to Dow and portrays a six-year history. The production ratio between these fiber lengths has remained fairly stable over the past several years and it is reasonable to expect this trend to continue.

CANADIAN PRODUCTION BY GRADE
(Short Tons)

Grade	Group #3	Group #4	Group #5	Totals
Year				
1950	33,955	164,861	106,378	305,194
1951	33,136	188,130	111,175	332,441
1952	35,932	198,506	117,206	351,644
1953	35,970	187,466	102,904	326,340
1954	35,208	192,285	99,160	326,653
1955	43,081	234,998	117,017	395,096

SOURCE: Oliver Bowles - Personal Communication

Similar data is not available for U.S. production as there is only one producer, Ruberoid; however, Ruberoid produces almost no fiber of Group #3 length. About 75% of all Canadian fiber production goes into U.S. markets with the heaviest export market being in the "shorts". The U.S. does not import significant quantities of milled fiber from any source other than Canada as is shown by the ensuing table.

IMPORTS INTO U.S.A. - 1955
(Short Tons)

Grade	Canada	Other Sources
Group #3	19,053	709
Group #4	74,090	144
Group #5	55,316	5
Total	148,459	

SOURCE: Asbestos

About 30% of Canada's Groups #3, #4 and #5 production is imported by the United States.

IV END USES

Asbestos has a myriad of end uses. Since this report is chiefly concerned with the milled fibers Groups #3, #4 and #5, only the major end uses for these three groups are listed below.

END USES BY FIBER LENGTH

Group #3 (Spinning & Filtering)	Textiles, clothing, theater curtain, different types of packings, brake linings, gaskets, clutch facings, magnesia pipe covering and insulating blocks.
Group #4 (Shingle)	Asbestos shingles, asbestos-cement pipe, insulating jackets, packings, gaskets, magnesia pipe coverings, asbestos paper, millboard, plastic fireproof cements, asbestos-asphalt roof coatings, and putties.
Group #5 (Paper)	Asbestos-cement sheets, flat or corrugated. Asbestos-cement pipe, electrical panels, paper and millboard, pipe coverings, gaskets and packings, brake linings, asbestos cements for insulation, asbestos-asphalt roof coatings, putties and plastic fillers.

Because the diaphragm-cell end use is insignificant in terms of total Groups #3-#5 end use, this market is not attractive to the average asbestos producer. Therefore, Dow could expect to be cut off in time of short supply as they will never be a major consumer of asbestos. As for the diaphragm-cell market, Dow uses approximately 250 tons of asbestos per year. Sixty pounds of asbestos are used in the diaphragm of one chlorine cell which produces about 250,000 pounds of chlorine before the cell has to be torn down. This indicates a Dow chlorine-from-diaphragm-cells production figure of 1.04 million tons for the year 1955 compared with a total national production of 3.06 million tons. Of this figure, 2.48 million tons are attributed to various types of diaphragm cells which would suggest that Dow produces about 42% of the diaphragm-cell chlorine in the country. This would make the total end use for asbestos in diaphragm cells about 600 tons a year. Roughly 200 tons of this amount would be Group #3 fiber and 400 tons, Groups #4 and #5 fiber. These figures should be compared with the following Canadian production figures for 1955:

Group #3	43,000 tons
Group #4	234,000 tons
Group #5	117,000 tons

Furthermore, a very high-quality fiber gives the best results in

efficiencies for chlorine production. Thus, one of Dow's major problems is to interest enough producers in making high-quality fiber for such a small end use. A guesstimate, based on diaphragm-cell capacities, of the breakdown for asbestos in this end use would be as follows:

ASBESTOS CONSUMPTION IN DIAPHRAGM CELLS

Company	Use (Tons/Year)
Dow	250
Columbia-Southern	100
Diamond Alkali	60
Wyandotte	45
Hooker	45
Other	50
Total	600

This would be a very slowly expanding end use as it would be tied to chlorine production and there are no substitutes of any economic significance in this end use.

V PRICE AND AVAILABILITY

The graph in Exhibit V shows the price history of milled fibers of Groups #3, #4 and #5 length in Canada and Vermont. These prices are standard except in Arizona and British Columbia (Cassiar) where nomenclature varies. Current Cassiar prices for milled fibers in the range of interest to Dow are shown below.

Group #3K	$460/ton,	f.o.b. Vancouver
Group AC (intermediate)	$300/ton	" "
Group #4K	$205/ton	" "

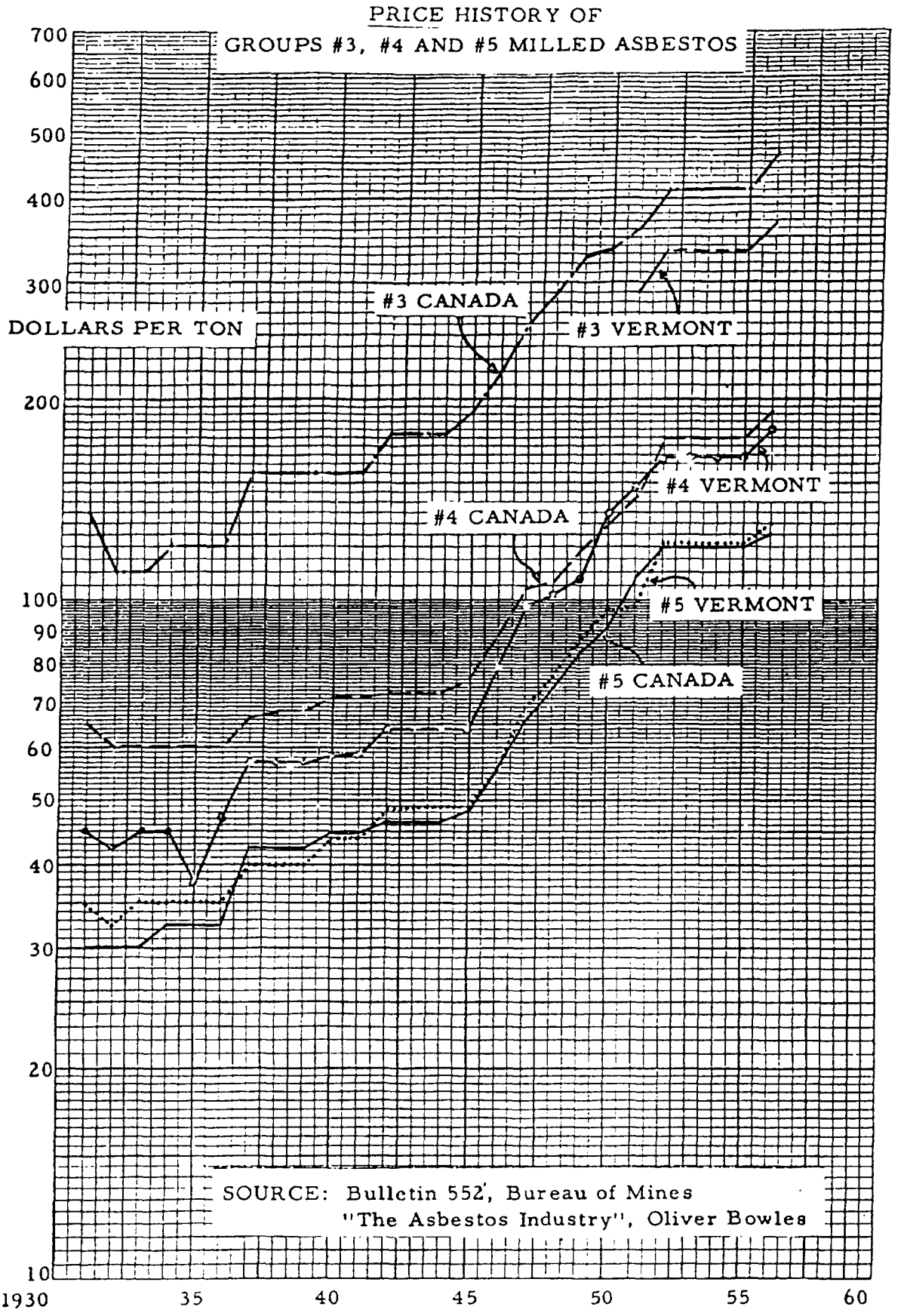
SOURCE: Engineering and Mining Journal

Basic price lists are for car-load lots. Since requirements of some divisions are for less-than-car-load quantities on an annual basis, purchases should be coordinated in order to take advantage of the lower price. The price history of asbestos coincides fairly well with movements in its major markets (construction and automobiles) and shows the effects of inflation and removal of price controls after World War II. Asbestos prices reached a plateau in 1952 with the next and last major increase coming early in 1956.

The Canadian asbestos industry has recently completed a major expansion including a substantial increase in mill capacity. Since these expansions are costly and a twenty-year program is needed to justify the capital expense, mill capacity is now a good deal in excess of current production. Bill Reakes of Johns-Manville, Ltd., has gone so far as to say that he thinks milled fibers will never be in short supply again. J. C. Kelleher, vice president in charge of sales and merchandising for Johns-Manville Asbestos Fiber Division, thinks that asbestos is currently in good supply and will be for at least five years. He sees no need for the U. S. Government's strategic mineral classification on asbestos. Comments in the trade journal Asbestos also indicate that asbestos is currently in good supply; thus the current price level should be fairly stable with no major price increases apparent in the near future. The above comments, of course, refer to milled fibers and not to crudes or shorts.

The availability of asbestos fiber in the milled grades is considered excellent. Proven reserves for chrysotile asbestos are roughly estimated at 50 million tons of fiber, which is half of a century's supply at current production rates. Probable reserves are considerably in excess of this amount, especially with the recent discovery in Newfoundland which appears to be of major significance. Since the supply is ample on the North American Continent, no consideration has been given to foreign reserves. Several foreign countries, notably South Africa and Russia, are exporters

EXHIBIT V



of the more valuable spinning grades of asbestos; however, any potential dollar savings would be small and the advantage of dealing with a major domestic supplier would appear to outweigh consideration of a foreign source.

Dow's problem in asbestos is not one of supply and demand for asbestos as a whole but for the particular high-quality grades that Dow uses. Asbestos used in diaphragm cells forms an insignificant percentage of the total market for asbestos products; therefore, the incentive is not always there for producers with older mills to go through the extra steps necessary to provide the well opened and clean fiber that Dow desires. For these reasons Dow has been tied to a single supplier, The Ruberoid Company, which is not a primary supplier of the length of fiber that Dow needs. In addition Ruberoid is charging premium prices for a fiber that has received no apparent special treatment. Therefore, Dow's problem appears to be the need for primary suppliers of diaphragm-cell asbestos at standard market prices. Several new mills have been recently built by the industry, many of which should be able to produce a fiber as desirable as Ruberoid's. Interest has recently been generated in this area, particularly through Johns-Manville, Ltd.; and, if tests soon to be undertaken prove successful, Dow would be able to align themselves with major suppliers that have good reserves of #3 and #4 length fiber and help insure long-range availability. Other large suppliers, aside from Johns-Manville, are listed under Exhibit III.