DEPARTMENT OF HEALTH EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL

NATIONAL INSTITUTE FOR OCCUPATIONAL
SAFETY AND HEALTH — ALOSH
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MORGANTOWN, WEST VIRGINIA 26505

November 8, 1977

Mr. Lauren Choate
General Manager
Interpace Corp.
Mountain View Drive
Willsboro, New York 12996

Dear Mr. Choate:

Enclosed please find a copy of the final report of the Medical Survey of Workers at the Interpace Corporation which was performed in September of 1976. We apologize for the long delay in this report which was caused by both delays in analysis and the departure of Dr. Shasby who performed the study.

We hope this report clears up some of the confusion caused by partial presentation of the data by Dr. Shasby. As noted in the report although several abnormal findings were discovered no definite association of Wollastonite exposure and excess morbidity could be demonstrated. However the number of subjects studied was small and specifically a cross-sectional study of this type is not sensitive in demonstrating an association of an exposure with development of carcinoma. Therefore while useful, the results of this study should be interpreted with caution and not used as a rationale for neglecting further follow up of these workers and future workers who are exposed to Wollastonite.

Sincerely,

Thomas K. Hodous, M.D. for

Brian A. Boehlecke, M.D. (BAB)
Chief, Clinical Investigations Branch

Enclosure

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PLAINTIFF'S EXHIBIT
FOS-708

MEDICAL SURVEY OF WORKERS AT THE INTERFACE CORPORATION, WILLSBORO, NEW YORK

516-73-1269

Survey Date
September 29, 1976

Report Prepared By
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Final Report Date
November 4, 1977

National Institute for Occupational Safety and Health
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WOLLASTONITE

INTRODUCTION

Wollastonite is a fibrous monocalcium silicate ($CaSiO_3$) that requires specific and uncommon mineralogic conditions for its formation. Minable deposits are known to exist only in Finland, Australia and northern New York state. Wollastonite has been mined at Willsboro, New York since 1952 and a mine and mill are presently operated there by the Interpace Corporation.

Wollastonite makes up approximately 50% of the mineral in the Willsboro deposit, with garnet accounting for another 45%. Small amounts of diopside, epidote, calcite and quartz make up the rest. The garnet is captured in the milling process and marketed as an abrasive.

Wollastonite itself has multiple uses, and large numbers of persons are secondarily exposed to the finished product. At present its largest use is in the ceramics industry where it is used as a filler and flux in wall time bodies as well as a compounding agent for binding the bodies and glaze. Wollastonite is similarly used in table china and art ware. It is also used as a filler and flux in grinding wheels, refractories, building block, acoustical tiles and wallboard. In wallboard it has substituted for asbestos as a fire retardant and insulator. Wollastonite's insulting properties also make it a useful extender in fiberglass insulation and brake linings. Its pure white color makes Wollastonite a useful extender in paints and marking compounds as well. It has even been used as a filler in dental pumice.

Because of its fibrous structure Wollastonite might have fibrogenic and carcinogenic potential similar to asbestos and other fibrous minerals but direct evidence is lacking. A study using a red cell hemolysis model to estimate fibrogenicity

suggests Wollastonite may be fibrogenic.[1] The adverse effects associated with asbestos exposure are well recognized and include pulmonary fibrosis, pleural effusions and fibrosis, lung and extra-pulmonary neoplasms, and mesotheliomas. These effects have recently been reviewed.[2]

In September, 1976, the Appalachian Laboratory for Occupational Safety and Health conducted a survey at the Willsboro site to determine the prevalence of pulmonary disease that might be attributable to Wollastonite exposure. Subsequently, information on previous employees was obtained by questionnaire and from a 1964 study of the workers conducted by the Division of Industrial Hygiene, New York State Department of Labor.

METHODS AND MATERIALS

Environmental Study

An environmental study was conducted at the mine and mill by the Environmental Investigations Branch of the Appalachian Laboratory for Occupational Safety and Health (ALOSH) and the Division of Surveillance, Hazard Evaluations and Field Studies, National Institute for Occupational Safety and Health (NIOSH). Air samples from sites in the mine and the mill were collected on 37mm Millipore Type AA and 37mm MSA type FWS (polyvinyl chloride) filters using flow rates of 1.7 liters per minute. The air samples as well as the bulk samples of the finished product were analyzed for trace metals by atomic absorption, free silica by x-ray diffraction and fiber size and fiber concentration by optical and transmission election microscopy. (For details of the methods used, see reference 3.) In addition, fiber counts and analyses for free silica were available from the 1964 New York State Division of Industrial Hygiene Study.

Medical Survey

A medical survey of the current and ex-workers was begun in September, 1976. At that time, there were 92 employees at the Willsboro site and 87 (95%) participated in the study. Five ex-employees who had participated in the 1964 survey were also studied. In addition, there were 44 living ex-employees who had worked for more than one year at the mine or mill, and questionnaires were administered to 23 (52%) of them. This group included 13 of 18 (72%) ex-employees who had worked for more than 10 years at the plant. Four ex-employees had died and the cause of death was determined from death certificates or family members in three of these. Analysis of the current workers did not include two females and six other persons who had worked only in the office. In addition, one worker was eliminated because of a history of recurrent spontaneous pneumothorax, and two workers were eliminated for incomplete exams (one without a questionnaire and one without spirometry). Overall the study encompasses 87% of all persons who have worked for at least one year at the mine or mill since 1952 (Table 1).

All participants currently employed at the Willsboro site and the five ex-employees in the original study had a modified British Medical Research Council (MRC) questionnaire directed towards respiratory symptomatology administered to them by an experienced interviewer. Each of these participants also had a posterior-anterior and lateral chest x-ray taken and examination of the chest performed by a single physician. Clubbing of the fingers was judged to be present if the hyponychial angle was less acute than normal. Inspiratory crepitations were noted but were not categorized as to early or late. Each participant also performed routine air as well as helium-oxygen spirometry on an Ohio 800 waterless spirometer. With air each participant performed 5 or more forced vital capacity maneuvers with the flow volume curves recorded on analog tape, later converted to digital data and stored

on tape for analysis. In addition, 23 of the current employees with 15 or more years exposure had a single breath carbon monoxide diffusing capacity performed at the University of Vermont Medical Center using the method described by Lilker, et al.[4]

Total lung capacity was determined from the x-rays using the technique described by Barnhard et al.[5] The x-rays were interpreted by three qualified "B" readers who used the ILO/UC 1971 International Classification System.[6] An x-ray was considered positive for pneumoconiosis if at least 2 of the 3 readers found small opacities of at least category 1 profusion.

Ex-workers were contacted by telephone and the same MRC questionnaire was administered by experienced interviewers.

The study performed by the Division of Industrial Hygiene, New York State used a questionnaire very similar to the one used in the current study. The methods were as described by Kleinfeld, at al in 1964.[7]

Parametric data were analyzed using Fisher's Exact or Chi Square analysis; and correlation of spirometric parameters and total lung capacities with age, smoking history and dust exposure was done using a least squares linear regression. A weighted average fiber exposure for the mine and mill using fiber counts from the 1976 NIOSH study and the 1964 New York State Division of Industrial Hygiene Study was calculated. (See below) These weighted values were used as an index for dust exposure in the linear regression analysis.

RESULTS

Environmental Study

Electron microscopy of the air samples revealed a median fiber diameter of 0.22 um (range 0.1 - 5.2 μm). The median length of 2.5 um (range 0.3 - 41.0) established

an aspect ratio well in excess of 3, the figure currently used by NIOSH to characterize fibrous particles. The x-ray diffraction analysis for free silica showed less than 2 percent free silica in the bulk samples. This was in agreement with the measurements done in 1964 in which all the samples tested were less than 1.3%. Fiber counts by phase contract microscopy revealed counts of 0.3 per cubic centimeter in the mine and 0.8 to 47.7 in the mill. When these measurements were averaged with those from the 1964 study, the mean count in the mine was 1.4 per cubic centimeter and in the mill was 20.2. These values were subsequently rounded off and used to calculate fiber years of exposure by multiplying the average by the number of years worked in the mine or the mill. Thus, one year's work in the mine equalled one fiber year of exposure whereas one year of mill work equalled 20 fiber years. Trace metal analysis of bulk product samples and settled dust revealed average concentration of less than 1% for cadium, chromium, cobalt, maganese, nickel and zinc. Iron was the only trace metal found in any appreciable quantity (0.5 - 5.57%).

Medical Study

Demographic Characteristics

Table 2 depicts the demographic characteristics of the group of workers and ex-workers contacted during 1976-77. It does not include 11 persons excluded from the study done at the mine as described in the methods; eight persons on whom the only source of information was the 1964 study, and the four deceased workers. From the Table it can be seen that 36% of the population had 15 or more years work exposure to Wollastonite and 39% had a latency period from first exposure to Wollastonite until the time of the study of 15 or more years. Only 19 (18%) workers had a latency period of over 20 years, and 13 (13%) had a work exposure of over 20 years. The average work exposure was 9.2 years (range 1-25) and the average latency period was 11.2 years (range 1-25). For the ex-workers, the average work exposure was 10.9 years and the average latency was 16.0 years.

Respiratory Symptomatology

Table 3 demonstrates the prevalence of respiratory symptoms among the workers and ex-workers as detected by the modified MRC questionnaire. Symptoms of bronchitis (chronic cough and phelgm for two years or more) were present in 23% of the smokers and ex-smokers, and in 9% of the non-smokers. They were not more prevalent in those with greater work exposure to Wollastonite, nor were they more prevalent in current workers than ex-workers. One of the two non-smokers with bronchitic symptoms was a 23 year old male with three years exposure and the other was a 26 year old male with less than one year work exposure. There were also no significant differences in the prevalence of bronchitic symptoms when the mine and mill workers were compared with each other, or when the workers within the mine or mill with more than 15 years work exposure were compared to those with less than 15 years exposure ($p > .10$).

Only two workers complained of shortness of breath when walking with others of their own age. One of these was a 27 year old current smoker of 10 pack years with four years exposure to Wollastonite. He also had a history of heart disease and nocturnal wheezing. His spirometry showed moderate obstruction, no restriction and his x-ray was normal. The other was a 54 year old ex-smoker of 38 pack years with symptoms of wheezing and a history of five episodes of pleurisy. His spirometry showed very mild restriction and obstruction and his x-ray was normal. His forced vital capacity (FVC) had decreased by only 10cc since his exam in 1964, but his $\frac{FEV\ 1.0^*}{FVC}$ had fallen from .71 to .66.

Physical Exam

Five workers were judged to demonstrate clubbing although in several cases it was considered an equivocal finding (Table 4). While more of these had 15 or more years exposure, this difference was not significant ($p > .12$ by Fisher's Exact Test). One of the five, a current smoker of 48 pack years had a mild obstructive ventilatory

*$FEV_{1.0}$ = Forced Expiratory Volume in one second.

defect, but no respiratory symptoms and a normal chest x-ray. Clubbing was an isolated finding in the other four.

There were five workers in whom crepitations were detected (Table 4) and again, the increase with increased work exposure was not significant. Despite the similar numbers, none of those with crepitations had clubbing. One of the workers with crepitations was an ex-cigarette smoker of 30 pack years. He had symptoms of bronchitis, a normal FVC, mildly reduced $\frac{FEV\ 1.0}{FVC}$ and unilateral pleural thickening on his chest x-ray. The pleural thickening involved the right costophrenic angle and right chest wall, and was judged to be of grade "a" width and grade 1 extent. This worker also had a history of a gunshot wound to the chest and three bouts of pneumonia. One of the other participants with crepitations was the 54 year old ex-worker with dyspnea described above who had mild restrictive and obstructive ventilatory defects and a normal x-ray. The 3 others had crepitations as an isolated finding.

X-rays

Two of the three physicians interpreting the x-rays agreed that four of the x-rays demonstrated small opacities of category 1 profusion. These were rounded opacities category 1, type q in each case. There was no increase in the prevalence of these findings with increased years of work exposure (Table 5). All of these four workers had normal findings on the questionnaire, physical exam and spirometry. One worker was judged to demonstrate "a" width, grade 1 extent pleural thickening and is the same worker described above under Physical Exam who had a history of a gunshot wound to the chest and three episodes of pneumonia.

Pulmonary Function

One worker demonstrated a mild restrictive ventilatory defect, defined as a FVC more than 2 standard errors below the estimated regression line.[8]

This was the 54 year old male, ex-smoker of 38 pack years described above with the symptom of dyspnea on exertion. As noted previously, his FVC had fallen by only 10 cc in the twelve years since 1964. Two other persons had very mildly reduced FVC's. They were age 33 and 31, both with less than 10 years exposure or latency, and felt by the examining physician to have had a respiratory infection that precluded adequate spirometry. The reduced FVC was an isolated finding in the 33 year old and was associated with bronchitis symptoms alone in the 31 year old.

The spirometric values for FVC and the total lung capacity (TLC) as determined by x-ray were analyzed for a correlation with fiber years of Wollastonite exposure and age. Fiber years were calculated as described in Methods and the regression was done for nonsmokers separately from smokers and ex-smokers. For the TLC, there was no significant correlation with fiber years for smokers and ex-smokers ($F=3.17$, $p > .08$) or for nonsmokers ($F=.02$, $p > .88$). Because of the suspicion of a more significant effect of Wollastonite exposure in smokers, interaction between smoking and fiber years on TLC was also tested, but no significant interaction was noted ($F=1.14$, $p > .29$). For the FVC there also was no significant effect for fiber years among the nonsmokers ($F=.61$, $p > .44$) or the smokers ($F=1.22$, $p > .27$) after allowing for age.

The prevalence of obstructive ventilatory defects also failed to increase with increased work exposure (Table 6). As expected, obstructive defects were more prevalent in smokers and the slight increase in prevalence with increased exposure was paralleled by increasing age (35% of participants > 50 years old had an $FEV_{1.0}/FVC \leq .69$). As with TLC and FVC, a linear regression was performed searching for a correlation between fiber years and reduced $FEV_{1.0}/FVC$. No significant correlation of falling $FEV_{1.0}/FVC$ with increasing fiber years of exposure was

noted for smokers and ex-smokers ($F=.15$, $p > .69$) or for nonsmokers ($F=.71$, $p > .42$). Among smokers and ex-smokers a significant correlation between increasing age and a decreasing $FEV_{1.0}/FVC$ was found ($F=7.3$, $p < .01$). This was not noted among the nonsmokers.

Because of suggestions in the literature that early changes associated with asbestos exposure may manifest as small airways obstruction,[9] a linear regression of fiber years and age against the forced expiratory flow at 50% vital capacity (FEF_{50}) using values obtained from both conventional air spirometry and a helium-oxygen mixture was performed.[10] Smokers and ex-smokers were considered separately from nonsmokers. With the air spirometry there was no association between the FEF_{50} and fiber years for smokers and ex-smokers ($F=0.74$, $p > .40$) or for nonsmokers ($F=.48$, $p > .50$). There was an association between age and a decreasing FEF_{50} in the smokers and ex-smokers ($F=9.50$, $p < .005$), but not for the nonsmokers ($F=.01$, $p>.91$). With the helium-oxygen spirometry the results were very similar; the only significant relationship being between a decreasing FEF_{50} with age for the smokers and ex-smokers ($F=4.3$, $p < .05$).

Only two of the 23 workers with 15 or more years exposure who performed a single breath carbon monoxide diffusing capacity (DLCO) test had low values. One of these was a 51 year old current smoker of 53 pack years whose observed DLCO was 83% of predicted. This value is within 2 standard errors of the estimate, however. The other was in a 52 year old ex-smoker of 63 pack years whose value was 67% of predicted. However, this worker was felt to have polycythemia vera based on an evaluation at a nearby medical center. The DLCO can be altered in this condition without other associated pulmonary diseases.[16]

Workers Not Contacted but Studied in 1964 or Deceased

There were eight workers studied in 1964 who were not contacted during 1976-77. In 1964 they had an average exposure of 8.9 years (range 3.5 - 12). One of the workers had symptoms of chronic cough and phelgm and shortness of breath and demonstrated mild obstruction on spirometry. His physical exam, ECG and chest x-ray were normal. The other seven workers had no abnormalities in 1964. Four of the previous employees are deceased, and information was obtained on three of them. Two died of myocardial infarcts and one of trauma. No autopsy information was available, but phone conversation with family members failed to reveal any evidence of pulmonary disease or carcinoma in these persons.

CONCLUSIONS

This study has information on 87% of the persons who worked for one year or more at the Willsboro mine or mill; the data on 81% of the group is current, and in 6% was obtained from the 1964 study alone. Although there are several abnormal findings, this study does not document a serious disease prevalence associated with Wollastonite exposure at the levels encountered at the two sites.

The prevalence of bronchitis in this population was higher than that for non-dusty working populations. This may represent an example of industrial bronchitis due to a nonspecific dust effect as has been suggested in other dusty occupations.[11,12] However the numbers are small, particularly in the non-smoking group. Moreover, there was no significant increase in the bronchitis prevalence with increasing exposure, although the possible preferential migration out of the industry of symptomatic employees makes this data difficult to interpret.

While clubbing was noted in 5 of the workers, this was equivocal in some and was an isolated finding. Likewise, the crepitations were not characterized as to

whether they occurred in early or late inspiration, the latter more characteristic of restrictive pulmonary disease.[13] They also tended to be isolated findings.

Evaluation of the chest x-rays revealed a prevalence of 4% for small rounded opacities. This is close to the value noted among Quebec asbestos workers; however the Wollastonite group had none of the irregular opacities commonly associated with asbestos exposure.[14] The one worker with pleural changes had multiple other reasons for pleural thickening. In a similar rural population without known significant asbestos exposure, previous non-occupational pleural disease has been found by others to be the most likely etiology of pleural changes on x-ray.[15] However, the latent period for x-ray changes in asbestos workers can be longer than twenty years and the mine has been operating only 25 years.

/The pulmonary function testing failed to reveal any changes suggestive of asbestosis, that is, restrictive ventilatory defects or decreased diffusing capacity. Similarly no correlation could be found for decreasing lung volumes and fiber years of Wollastonite exposure./ While there was not a statistically significant increase in obstructive ventilatory defects with exposure, the prevalence rate in the smokers and ex-smokers was high; 15 and 29% respectively. Muldoon and Warwick[9] and Jodoin et al[17] have suggested that early changes of asbestosis may be in the small airways and the latter group suggested that the maximal expiratory flow rates may be reduced before other spirometric abnormalities appear. We failed to find a significant correlation between decrease in the FEF_{50} breathing air or helium-oxygen with fiber years of exposure. Decrease in flow rates did correlate with increase in age as expected.

The DLCO was minimally abnormal in one of the workers and may be related to an obstructive ventilatory defect and long smoking history. The value in the worker with polycythemia vera is difficult to interpret.[16]

To date no evidence of lung carcinoma or mesothelioma has been detected in any of the workers or ex-workers, although all of the subjects did not receive chest x-rays and only 18% of the work force has had over 20 years exposure. In addition, a possible bias exists in that those who did not participate in this study may have refused because of pulmonary symptoms or known disease.

SUMMARY

While the number of people presently engaged in mining and milling Wollastonite is small, those persons secondarily involved are numerous. Moreover, as Wollastonite continues to find new applications, this latter category will increase rapidly. This may be especially important in areas where Wollastonite is a substitute for asbestos. This report fails to document any increase in serious disease prevalence related to mining or milling Wollastonite, although the latency period is short. Continued follow-up of this group of workers is therefore indicated to protect future workers engaged both in mining and milling Wollastonite and the many more who will be secondarily exposed.

TABLE 1

SOURCES OF INFORMATION ON CURRENT AND EX-WOLLASTONITE WORKERS

Source	Number
Workers and Ex-workers Studied at the Willsboro Site in Sept., 1976.	92
Workers Excluded from Analysis (See Methods) (11)	
Ex-workers Contacted by Telephone During 1976-1977.	23
Workers on Whom the Only Information was the 1964 Study.	8
Deceased Workers with Known Cause of Death.	3
	126
Total Number of Persons Employed for $\geq$ 1 Year at the Wollastonite Mine or Mill.	145
Percent of Workers Reported On.	87%

TABLE 2

DEMOGRAPHIC CHARACTERISTICS OF WORKERS
AND EX-WORKERS FROM THE WOLLASTONITE MINE AND MILL*

	Number of Non-Smokers	Number of Ex-Smokers	Number of Current Smokers	Totals	(%)
e (Years)					
<29	9	5	20	34	(33)
30-29	7	11	10	28	(27)
40-49	3	6	8	17	(16)
>50	3	13	9	25	(24)
	22	35	47	104	(100)
posure to Wollastonite (Years)					
<5	12	6	27	45	(43)
5-9	1	7	6	14	(13)
10-14	3	3	2	8	(8)
15-19	4	11	9	24	(23)
20-25	2	8	3	13	(13)
	22	35	47	104	(100)
Average Exposure	7.5 years	12.7 years	7.4 years	9.2 years Range 1-25	
tency Period++ (Years)					
<5	11	4	22	37	(36)
5-9	1	6	7	14	(13)
10-14	3	5	4	12	(12)
15-19	4	8	10	22	(21)
20-25	3	12	4	19	(18)
	22	35	47	104	(100)
Average Latency	8.6 years	15.8 years	9.0 years	11.2 years Range 1-25	

*Includes only persons contacted during 1976-1977 and not excluded from the analysis as noted under Methods.

++Time from first exposure to Wollastonite until the time of the study.

TABLE 3

RESPIRATORY SYMPTOMS AMONG CURRENT
AND
EX-WOLLASTONITE WORKERS CONTACTED DURING 1976-77

Smokers and Ex-Smokers

Years Work Exposure	<5	5-9	10-14	15-19	20-25	Totals
Number in Group	33	13	5	20	11	82
Number with Symptoms of Chronic Bronchitis	8(24%)	3(23%)	0	5(25%)	3(27%)	19(23%)
Number with Symptom of Dyspnea on Exertion	1(3%)	0	0	1(5%)	0	2(2%)

Non-Smokers

Years Work Exposure	<5	5-9	10-14	15-19	20-25	Totals
Number in Group	12	1	3	4	2	22
Number with Symptoms of Chronic Bronchitis	2(17%)	0	0	0	0	2(9%)
Number with Symptom of Dyspnea on Exertion	0	0	0	0	0	0

TABLE 4

PREVALENCE OF CLUBBING AND CREPITATIONS
DETECTED ON PHYSICAL EXAM AMONG WOLLASTONITE WORKERS

	Smokers + Ex-Smokers		Non-Smokers	
Years Work Exposure	<15	≥15	<15	≥15
Clubbing	1/40	4/24*	0/13	0/4
Crepitations	1/40	4/24*	0/13	0/4

*p >.12 by Fisher's Exact Test for workers with <15 vs. ≥15 years exposure.

Note: None of those with crepitations had clubbing.

TABLE 5

PREVALENCE OF SMALL ROUNDED OPACITIES
ON CHEST X-RAYS AMONG WOLLASTONITE WORKERS

Years Exposure	Smokers + Ex-Smokers	Non-Smokers	Total	(%)
<15	1/40	1/13	2/53	(4)
≥15	1/24*	1/4*	2/28	(7)

* p>0.6 by Fisher's Exact Test for workers with <15 vs. ≥15 years exposure for smokers and ex-smokers and for non-smokers.

TABLE 6

VENTILATORY DEFECTS
AMONG WOLLASTONITE WORKERS

Years Exposure	Smokers + Ex-Smokers <15 (%)	Smokers + Ex-Smokers ≥15 (%)	Non-Smokers <15 (%)	Non-Smokers ≥15 (%)	Total (%)
Reduced FVC*	0/40	1/24 (4)	0/13	0/4	1/81 (1)
FEV 1.0 / FVC ≤0.69	6/40 (15)	7/24 (29)+++	1/13 (8)	1/4++ (25)	15/81 (19)

*See text for explanation.
++ $p > .7$ for <15 vs ≥15 years for non smokers.
+++ $X^2 = 1.86$, $p > .10$ for <15 vs ≥15 years for smokers and ex-smokers.

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