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September 9, 1977

Mr. David B. Woodbury
Foseco, Inc.
20200 Sheldon Road
Cleveland, Ohio 44142

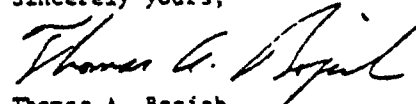
Dear Dave:

Enclosed is a copy of the NIOSH industrial hygiene study of the wollastonite mining and milling operations of the Interpace Corporation. Also enclosed is a copy of their preliminary report, which is referred to in the final report.

As you will note, the reports contain considerably more information than you would need (or probably want) to know about wollastonite. Consequently, I've marked the more significant comments and conclusions in the reports for your information.

The clinical study data is expected to be available in October. I should be able to get a copy at that time.

Sincerely yours,



Thomas A. Bozich
Industrial Hygiene Consultant

TAB:nb

Enclosures

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PRELIMINARY INDUSTRIAL INQUIRY SURVEY

Interprice Corporation

Willsboro, New York

SURVEY DATE:

February 12, 1976

SURVEY CONDUCTED BY:

Robert Wheeler
Mark Boeniger
Ralph Zumalde

REPORT PREPARED BY:

Ralph Zumalde
Mark Boeniger

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INTRODUCTION

As part of the National Institute for Occupational Safety and Health (NIOSH) industrywide studies of industrial processes and air cleaning naturally occurring fibrous minerals, a preliminary environmental hygiene survey was conducted at the wollastonite operation of the Cabot Corporation, Willboro, New York. This survey was performed by Robert Wheeler (NIOSH) and Mark Schneider and Ralph Zemeckis of the Bureau of Surveillance, Hazard Evaluations, and Field Studies on February 12, 1976. In addition to observing the milling process and control measures, preliminary air sampling for characterization of pollution was also conducted.

BACKGROUND INFORMATION

Wollastonite (CaSiO_3) is a naturally occurring fibrous calcium silicate which is rarely found in large amounts because of the rather unique mineralogical conditions required for its formation. It is therefore mined commercially only in a few places around the world.

The Cabot Corporation purchased the mineral rights to the Willboro, New York, wollastonite deposit in 1951. The deposit was conservatively estimated at 15 million tons. In 1953, the Cabot Corporation completed construction of a 60,000 ton per year mill for processing the ore. This operation was later expanded in 1969 when the Interpace Corporation purchased the mine and mill.

Six grades of wollastonite are processed. These grades are designated by commercial use, fiber content, and particle size. Some of the commonly associated minerals found in the wollastonite deposits are garnet (52), diopside, epidote, calcite, and quartz, most of which are salvaged as a by-product and marketed primarily as abrasives. Finished wollastonite has found utility in ceramics, paints, welding fluxes, plastics, cements, wallboards, and glass as filler. It has also been experimentally used as a soil conditioner supplying silica and calcium to deficient soil.

DESCRIPTION OF PROCESS

Mining

The mine is located approximately two miles from the mill. The present mining method employed is open stopes with regular pillars, advancing up dip. Prior to 1959 ore was recovered from an open pit until the depth of overburden became excessive.

The mine is being presently mined on three levels, Ro. 1, Ro. 3, and Ro. 4. A second haulage drift is being opened at an upper level and several vertical interconnecting shafts have been drilled to improve ventilation. Natural draft ventilation is relied upon during the winter with forced

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air being produced by vane axial fans positioned at the mine portals during summer. Booster vane axial fans are also provided to establish a continuous flow of air through the working levels.

Most of the employees at the mine are engaged in drilling. The drilling is done not utilizing two Gardner Denver Jacobs drills, one of which is operated by diesel power, the other by compressed air. When blasting is necessitated, it is always performed at the end of the second shift to allow time for the dust to clear. Ore is collected using a diesel powered pay loader and loaded into dump trucks. Scraping is only done being utilized as a means of removing ore from the face of the mine.

Milling

The mill site consists of the mill, mill change house, and office building. The ore is processed to separate the wollastonite from the garnet and diopside and to reduce the wollastonite to six grades of commercial. The ore from the mine is dumped into a crusher pit, scraped to a pay feeder, and discharged through an 18" x 30" jaw crusher. An operator is stationed at the jaw crusher to direct the rock into the crusher and ascertain its own feed. The primary discharge is passed over a screen (Tyler Ty-Rock) with the minus fraction passed through a parallel flow, cylindrical dryer. The oversize is directed to a gyratory crusher (Telsmith) for additional size reduction. The dryer discharge and secondary crusher discharge are in closed circuit with a screen (Tyler Ty-Rock). The reduced crude ore is metered to one of two roll crushers for further reduction. The roll crusher discharge is passed over high frequency, low amplitude screen (Derrick) for separation in various product size ranges. These six classifications are fed at a predetermined rate through magnetic separators. The garnet and diopside, being feebly magnetic, are held close to the lines of magnetic flux of the induction rotor. The wollastonite being non-magnetic passes through the magnetic field and drops onto a conveyor belt and transferred to storage bins.

The purified wollastonite can be ground into four product sizes within a pebble mill. The pebble mills utilize an air separation system to separate the wollastonite into different size fractions enabling the diversification of end products. Two additional "fifteen" products are manufactured on an attrition mill. All finished products are bagged and/or shipped in bulk by truck. The wollastonite mill processing flow diagram is illustrated in Figure 1.

PERSONNEL

The Millabero operation currently employs 60 hourly employees, and 12 salaried employees. The number of workers has remained fairly constant since the start of operation in 1953.

The mine operates on two shifts with an average of eight workers per shift. The mill operates on three shifts, employing about twenty workers on each of the first two shifts and three during the third shift. All hourly

employees in the mine and mill are represented by the United Steel Workers of America.

MEDICAL, SAFETY AND INDUSTRIAL HYGIENE PROGRAMS

Medical

All new employees are required to undergo a pre-employment physical. A local physician, Dr. Hacemul, performs the physical examinations and is on call if an emergency arises. Up until 1965 every employee was given an annual physical. The mandatory annual exam was then limited to the ten oldest seniority employees. However, any employee will be granted a medical examination if it is requested. A sample medical exam card, which is used on both pre-employment and annual physicals, can be seen in Figure 2.

Safety

A formal safety program is active at the Interspace mine and mill. Each employee is issued a list of safety rules with which he is expected to acquaint himself so that his actions do not provide a hazardous situation to himself or others. The program is under the direction of the mine and plant superintendent. A staff appointed safety man (on a rotational basis) conducts an unannounced inspection of the mine and mill and reports his findings at a monthly staff safety meeting. Two incentive awards are offered to the employees who have demonstrated safe work practices. At least one worker on each shift is trained in performing first aid.

The workers in the mine and mill are all provided with safety glasses, safety shoes, and hard hats. Work clothing is not provided. Self-rescuers are provided for all mine personnel. Change rooms and showers are provided at both the mine and mill.

Industrial Hygiene

No industrial hygienist is employed at the site. However, from recommendations resulting from several surveys performed by government (Mine Enforcement and Safety Administration and New York State Health Department) and private underwriters, changes have been made to improve the general working environment. Eight fabric baghouse filters have been installed to remove dust from local exhaust vents in the mill. These have greatly reduced the dust released at the magnetic separators and the bagging operations. However, installation of additional local exhaust ventilation appears warranted. Accumulations of settled dust were noted on ledges and machinery. The company has provided a central vacuum system with take-off connections on the upper floors. Effort is being directed at recycling baghouse wastes and other settled dust back into the product line without sacrificing the quality of the product.

Dust respirators are not required to be worn by any of the workers, although some workers were observed wearing them. Respirators are available upon request.

DESCRIPTION OF RECORDS SYSTEM

Personnel records are available from 1942 to the present. These include social security numbers, work histories, age, work title, and last time characterized according to accident or illness. Most present and past workers are easily traceable because of the rural location and stability of the population. Medical records are retained on all past and present workers.

INSPECTION OF THE PLANT

Potential Hazards

From the observations made during this survey and the results of the measurements made, the following conclusions are drawn and recommendations for improvements made:

1. There appears to be significant exposure to respirable wollastonite in various processing areas. No human data presently exists to indicate respiratory problems due to such exposure, however, it must be emphasized that human experience with this mineral is limited. It would appear prudent that exposures to respirable wollastonite fibers be kept at an absolute minimum by the use of good work practices and engineering controls. The use of brooms and hand brushes for cleaning should be eliminated in favor of much cleaner vacuum methods. In addition, those persons working in areas of excessively high dust exposure should be requested to wear respiratory protection unless they have an existing health problem which prohibits it, in which case, they probably should be removed from this work environment.
2. The workers in the mine may be exposed to excessive levels of carbon monoxide and nitrous gases (CO , NO_2) released during blasting and by the operation of the diesel engine equipment. It is recommended that the mine environment be monitored to determine levels of exposure.
3. High noise levels are prevalent in both the mine and mill. Within the mill, high noise levels existed around the crushing and grinding operations. Sound level measurements should be made to determine if excessive noise levels exist. If excessive, an appropriate hearing conservation program should be set up. Drillers along with others in the immediate mine area should continue to wear hearing protection.

SURVEY PROCEDURES AND DATA ANALYSIS

The major portion of the survey was devoted to observation of milling and mixing procedures, exposure control practices, and plant personnel record assessment. Bulk samples of the finished products along with a limited number of air samples were collected for the purpose of characterizing wollastonite. The air samples were collected in the mine and at various process operations within the mill. The collection media used for air sampling were 37 mm Millipore Type AA cellulose ester membrane filters (0.8 µm pore size) and 37 mm Nuclepore membrane filters (0.8 µm pore size). The sampling instruments were calibrated at a flow rate of 2.0 lpm.

Laboratory analyses were performed on all airborne samples and/or bulk samples for trace metals (Cd, Cr, Co, Fe, Mn, Ni, Zn) by atomic absorption, free silica by x-ray diffraction and fiber size distribution and fiber concentrations by optical and transmission electron microscopy.

All Millipore AA air samples were evaluated using phase contrast microscopy at a magnification of 400X. (NIOSH/OSHA method for counting asbestos.)¹ This analytical method was used to establish an index of exposure (fibers/cc) and for determining the relative size of the fibers (diameter and length).

The electron microscopy analysis of the collected samples was performed using a JEOL 100-B side entry transmission electron microscope along with an attached EDAX energy dispersive x-ray analyzer. The collected air samples were prepared using a transfer membrane filter technique utilizing a 200 mesh, formvar/carbon coated grid and observed by transmission electron microscopy.² Utilizing this method, the air samples were analyzed at 5,000X, 10,000X, and 20,000X magnification to determine fiber and particulate morphology. To document and verify the observed fibrous material, both energy dispersive x-ray analysis and selected area electron diffraction were performed.

RESULTS

Industrial Hygiene

Due to the fibrous nature of wollastonite both optical and electron microscopy were utilized for determining an index of exposure (fibers/cc). Fibers were defined as having an aspect ratio of 3:1 or greater. All airborne samples were analyzed for total fibers and fibers greater than 5 microns in length. The microscopy analysis was performed at 400X magnification phase contrast and 10,000X magnification transmission electron microscopy. Table 1 illustrates fiber concentrations found at various locations within the mine and mill. By characterizing each sample for fiber size distribution by both optical and electron microscopy, a good comparison between optical and electron microscopy concentrations for fibers greater than 5 microns was achieved. It is apparent that a 2-4 fold increase in total fiber concentrations exists with the electron microscopy analysis. This difference can probably be contributed to the increase in magnification and resolution of the electron microscope.

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Along with the tabulation of airborne fiber concentrations, fibers were also sized by diameter and length to determine airborne fiber diameter and length data. This was accomplished by sizing approximately 600 fibers by transmission electron microscopy at 10,000X magnification. All airborne samples were evaluated using randomly selected field for fiber sizing. The fiber size data is shown in Table 2.

To help characterize the mineral, energy dispersive x-ray analysis was performed on individual fibers to determine the elemental make-up. A typical wollastonite fiber x-ray spectra is illustrated in Figure 3. In addition to the x-ray spectra characterization, electron micrographs of typical sample fields were also taken at 2,000X and 10,000X magnification. Two such sample fields are illustrated in Figures 4 and 5.

The analytical results for trace metals (Cd, Cr, Co, Fe, Mn, Ni, Zn) and free silica obtained from six finished products and two settled dust samples are shown in Table 3. These samples were analysed by atomic absorption and x-ray diffraction, respectively.

DISCUSSION AND RECOMMENDATIONS

The fiber size data obtained from the electron microscopy analysis indicates count median measurements of 0.26 microns for diameter and 2.0 microns for length for airborne wollastonite. Because of these physical dimensions airborne exposures may be respirable and harmful to health. Although the respirability of airborne fibers is not clearly understood it is thought to be mainly dependent on the fiber diameter. Timbrell's³ work suggests that the two major mechanisms of fiber deposition in the upper airways (sedimentation induced by gravity and inertial deposition) are chiefly dependent upon particle free falling speed (i.e. equivalent Stokes' diameter). Fibers with densities less than 3.5 g/cm^3 and less than $3.5 \text{ }\mu\text{m}$ in diameter may escape deposition by these two mechanisms and penetrate deeply into the lungs. Airborne wollastonite fibers satisfy both the density and fiber diameter requirements as stated above and may be considered potentially respirable.

Recent studies utilizing fibrous particulates have indicated potential adverse physiological effects. One such animal study performed by Pott⁴ has shown that the fibrous structure of chrysotile, with lengths of 2-3 μm , are carcinogenic. Pott concluded that fiber shape and size was a more important factor in carcinogenesis than trace metal contamination. In another study conducted by Pott, et al.,⁵ it was demonstrated that other fibrous dusts, after intraperitoneal injection into rats, induced tumors equivalent to that produced by the same dose of fibrous chrysotile.

A study performed by Hefner, et al.,⁶ showed a comparison of the relative rates of hemolysis induced by various fibrogenic and non-fibrogenic particulates with rat erythrocytes in vitro. Attempts were made to measure the amount of hemolysis of the cell with a variety of particulates (i.e., chrysotile, talc, kaolin, brucite, actinolite, wollastonite, Hiv-O-Sil silica, etc.). The percent of hemoglobin not released from the cells by hemolysis was measured with a function of time. Results indicated that only Hiv-O-Sil silica, chrysotile and wollastonite were all potentially hemolytic. Both chrysotile and Hiv-O-Sil silica have been shown to be fibrogenic in vivo as well as hemolytic in vitro by numerous investiga-

ters, hence, for these two particulates a direct correlation between *in vivo* fibrinogenemia and *in vitro* hemolysis exists. The fibrinogenic activity of wollastonite has not been evaluated *in vivo*, however, the hemolytic potential of wollastonite is in the same range as that obtained for other fibrinogenic particulates.

The conclusions indicate a need for an epidemiological evaluation of the relationship of worker exposure to wollastonite. Because of the small work force and employment stability it could be advantageous to perform a follow-up morbidity study. As a guideline for the detection of possible chronic effects, the medical study which was performed at the Interspace facility by Dr. Kleinfeld and staff, New York State Department of Labor, in October, 1964 could be utilized. This study included a complete medical work-up (i.e. physical examinations, chest roentgenograms, electrocardiograms, pulmonary function tests, etc.) conducted on fifty-five plant workers (miners and millers) with an additional thirty-two males serving as a control group.⁷

TABLE 1
Interpace Corporation
SUMMARY OF FIBER CONCENTRATIONS* (fibers/cc)
FOUND IN A MOLLASTONITE MINE AND MILL

SAMPLE LOCATIONS	OPTICAL MICROSCOPY 400X		ELECTRON MICROSCOPY 10,000X	
	Total Fibers fibers/cc	Fibers > 5 microns	Total Fibers fibers/cc	Fibers > 5 microns
Mine 1st Level	0.35	0.26	1.14	0.33
Mine 2nd Level	1.4	0.9	7.2	0.9
Mine 3rd Level	0.43	0.3	1.68	0.24
Mill Primary Crusher	40.4	25.5	161.2	24.5
Mill Secondary Crusher	70.0	41.0	132.0	30.3
Mill Dryer	85.0	43.3	236.0	67.9
Mill Bagging Operations	20.5	10.3	39.9	5.1

* ONLY FIBERS WITH DIAMETERS LESS THAN 375 MICRONS
AND LENGTHS LESS THAN 50 MICRONS WERE COUNTED

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Interpace Corporation

SUMMARY OF AIRBORNE NOLLASTONITE
FIBER SIZE DATA

DETERMINED BY ELECTRON MICROSCOPY

Fiber Measured	Count Median (μ m)	Range (μ m)	Geometric Standard Deviation Vg
Diameter	0.26	0.1- 3.2	2.7
Length	2.0	0.4-26.0	2.5

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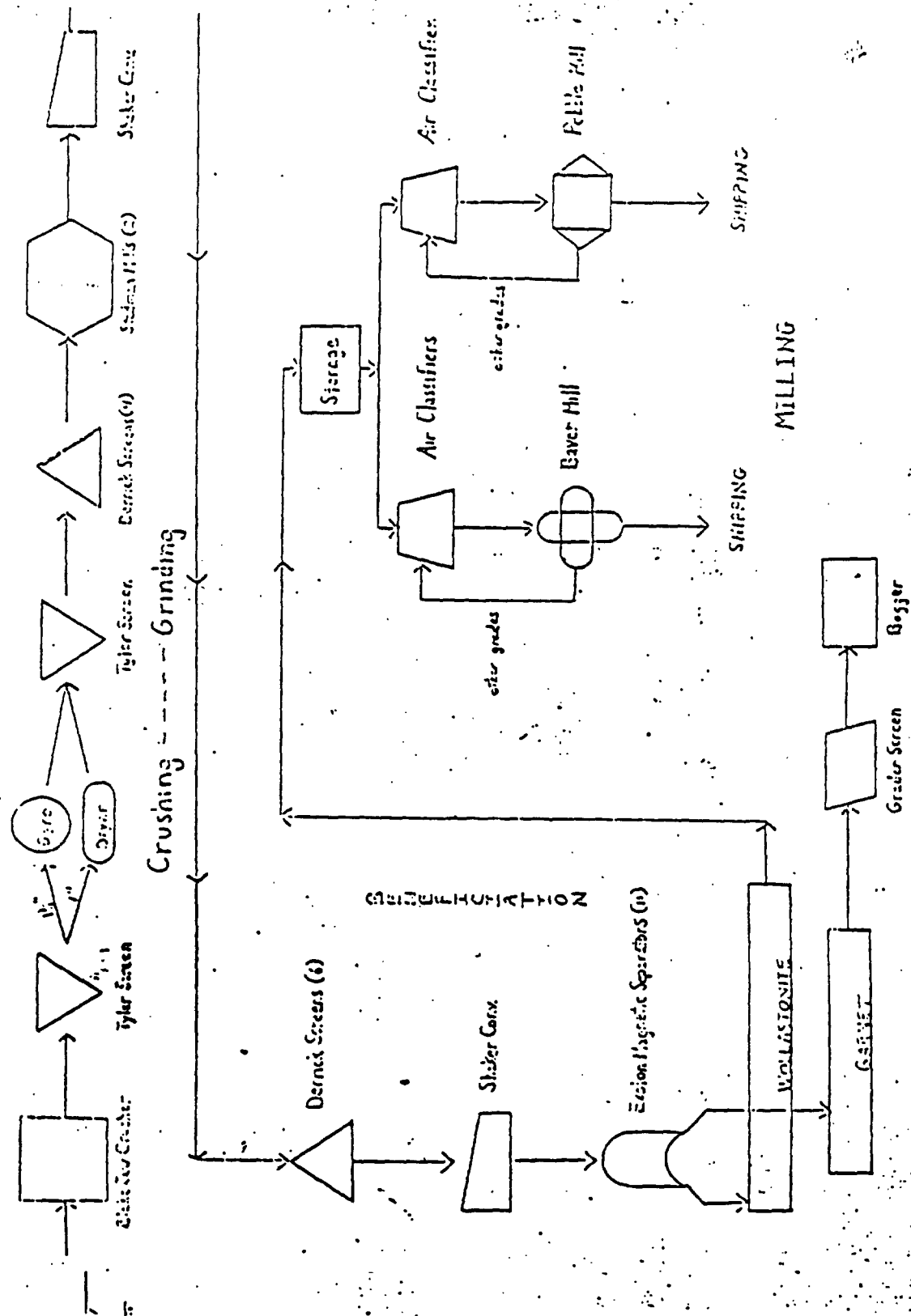
TABLE 3
Interpace Corporation
RESULTS OF TRACE METAL AND
FREE SILICA ANALYSIS

WOLLASTONITE

Bulk and Settled Dust Samples	Trace Metals $\mu\text{g/g}$							Free Silica %
	Cd	Cr	Co	Pb	Mn	Ni	Zn	
F - 1	0.8	3.5	3.3	6060	1070	7.0	9.7	< 3
C - 6	0.5	3.7	6.7	6570	1020	2.0	7.4	< 3
C - 101	1.0	4.1	-	3510	930	-	1.0	< 3
P - 4	0.5	1.8	4.0	4340	1020	3.0	9.6	< 3
P - 1	0.5	2.0	3.6	5830	1100	2.0	14.0	< 3
C - 1	0.5	2.0	3.6	5900	1050	3.0	7.3	< 3
10	0.5	3.6	4.6	5340	990	4.0	4.5	< 3
11	1.0	10.0	6.0	5980	1030	10.0	14.0	< 3

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FIGURE 1
Hollastonite Mill



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FIGURE 2
Medical Examination Card
Interpace Corporation

01-12-60 11/7/70

MEDICAL EXAMINATION

DATE <u>11/7/70</u>	ORIGINAL	YEARLY EXAM.	SPECIAL EXAM.
FULL NAME <u>JOHN J. VERACINI</u>	DATE OF BIRTH <u>11/7/11</u>		
MARRIED ☒	SINGLE	WIDOWED	DIVORCED
OPERATIONS <u>BP</u>			
SYMPTOMS: IF ANY <u>inflammation of (G) ST. Digest</u>			
COLOR OF EYES <u>BROWN</u>	HEIGHT <u>6-1</u>	WEIGHT <u>225</u>	COLOR SKIN <u>NO</u>
GENERAL APPEARANCE <u>Healthy</u>	APPARENT INTELLIGENCE <u>72</u>	CHEST MEAS. INSP.	EXP.
VISION R-20/ <u>20</u>	L-20/ <u>170</u>	WITH GLASSES R-20/	L-20/
HEARING R-20/ <u>20</u>	L-20/ <u>20</u>	EARS <u>20</u>	TEETH <u>20</u>
NOSE <u>20</u>	MOUTH <u>20</u>	TONSILS <u>20</u>	GLANDS <u>20</u>
CHEST <u>20</u>	LUNGS <u>clear</u>	ARTERIES <u>20</u>	SKIN <u>20</u>
HEART SIZE <u>100</u>	RATE <u>80</u>	RHYTHM <u>20</u>	MURMURS <u>20</u>
BLOOD PRESSURE-SYSTOLIC <u>110/70</u>	DIASTOLIC <u>60/110</u>	ABDOMEN <u>20</u>	JOINTS <u>20</u>
HERNIA <u>20</u>	SPINE <u>20</u>	DEFORMITIES <u>20</u>	HYDROCELE <u>20</u>
PENIS <u>20</u>	TESTICLES <u>20</u>	VARICOCELE	TESTES <u>20</u>
REFLEXES <u>20</u>	TENDONS <u>20</u>	FEET	VAGINAL EXAM.
RECTAL EXAM. <u>20</u>	URINE	ALBUMIN	SUGAR
X-RAY CHEST EXAM. <u>1</u>	HINTON	WPMGLODIN	BLOOD SWEAT
IMPRESSION <u>Healthy</u>	SIGNATURE <u>John J. Veracini</u>		
	MEDICAL EXAMINER		

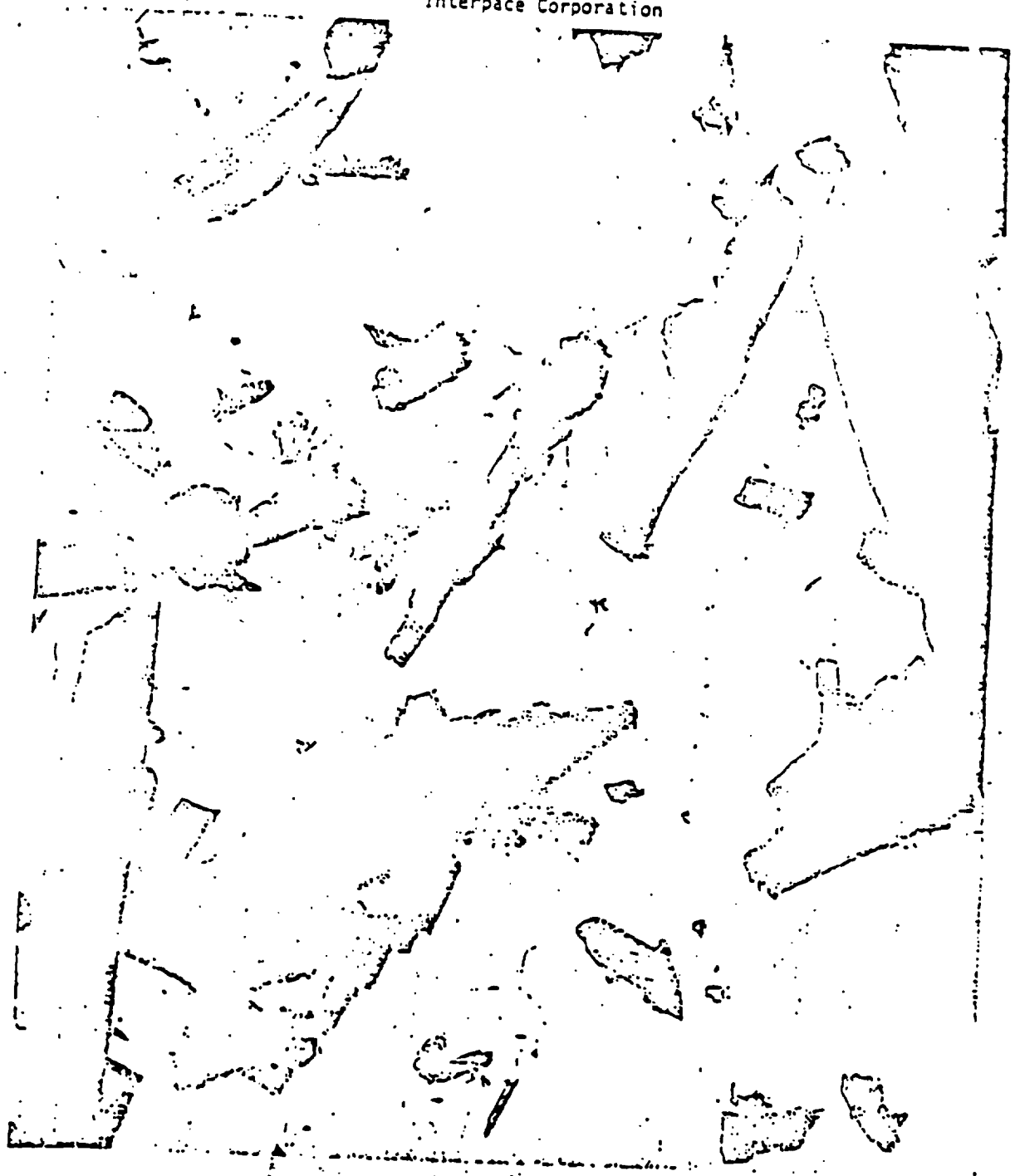
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Interpace Corporation



Wollastonite X-ray Spectra

FIGURE 4
Interpace Corporation

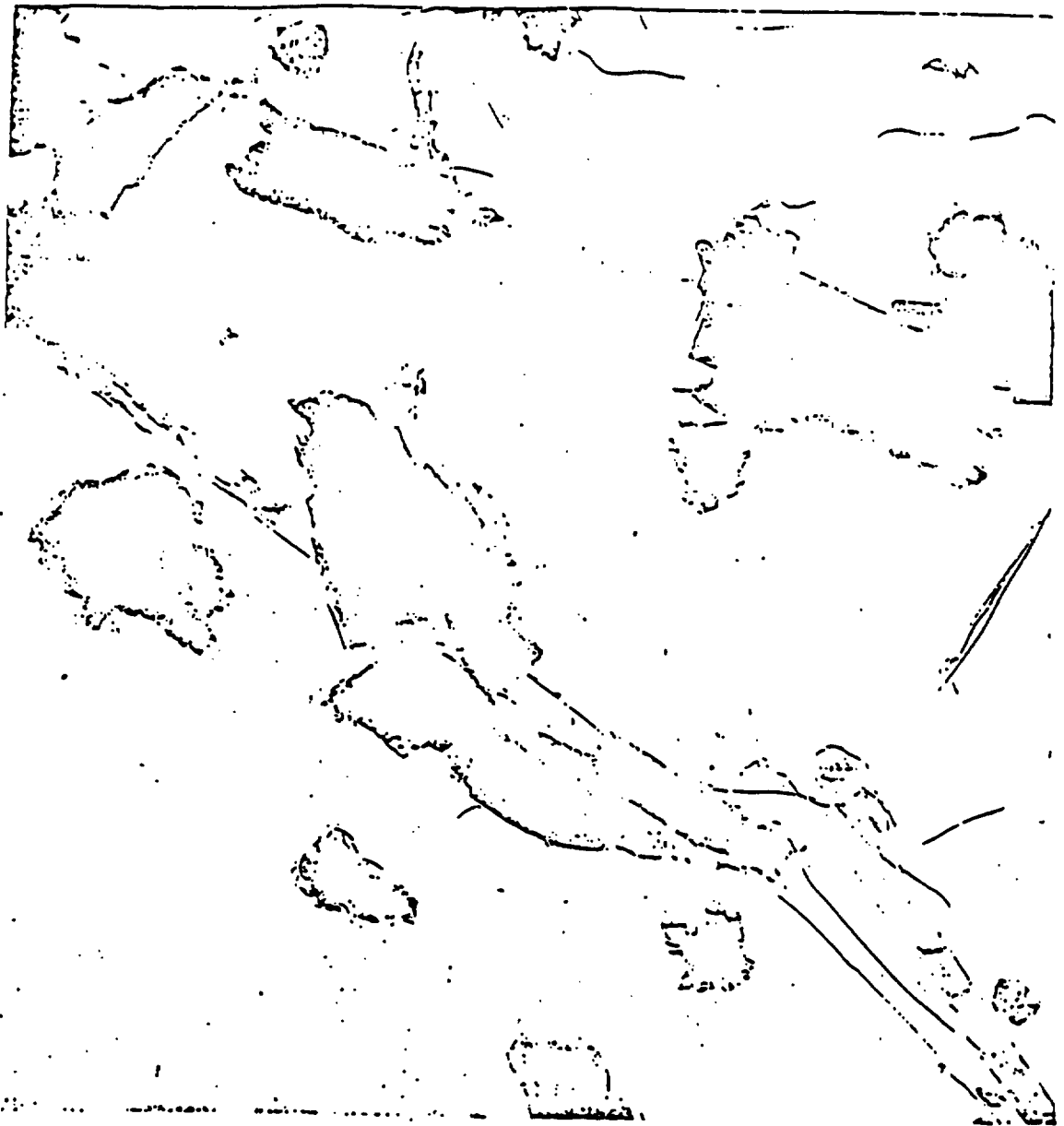


Hollastonite

2,000X Magnification

1 micron

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Wollastonite
10,000 Magnification

1 micron

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