

PLAINTIFF'S
EXHIBIT
WRG-1441A

LIBBY

TREMOLITE

JCY
4/2/85

15169873

APR 11 1985

Distribution

S. H. Ahern
R. J. Bettacchi
H. C. Duecker
H. A. Eschenbach
O. M. Favorito
M. A. Stecyk
R. M. Vining
R. C. Walsh
J. W. Wolter

15169874

Table of Contents

1. Composition

- a) Table from Boettcher's thesis "The Rainy Creek Igneous Complex Near Libby, Montana, pp. 107
- b) Density Variations of Libby Vermiculites and Tremolites Research Report - J. C. Yang 1/13/76
- c) Tremolite Asbestos Fibers from Libby (Weathered vs. Hard Tremolite) RFTS 49514 - J. C. Yang

2. Associated Minerals

- a) Vermiculite Rock Composition Memo J. C. Yang to R. J. Ostertog 1/12/82
- b) Section of a Research Report - J. C. Yang to E. S. Wood 6/17/77 on composition of Libby rock with sp. gr. between 1.585 -2.60 in ore concentrate composites

3. Morphology

- a) Libby Tremolite
SEM & EDAX Photos (McCrone)
- b) Libby Air Cassette Samples
SEM & EDAX photos (P. Sebastien, McGill Univ. 6/10/83)
- c) Literature W. Campbell, NBS
SEM & EDAX of fibrous and massive tremolite

4. Size Distribution

- a) Air sample from Libby Mill (P. Sebastien, McGill Univ. 6/10/83)
 - i. Table on Sample Characteristics
 - ii. Table on Concentrations and Size Distributions
 - iii. Size Scattergram
- b) MK-5 bulk samples 6/23/83 and 7/1/83 (E. T. Peters, A. D. Little - 7/13/84)
 - i. Graph on fiber size distributions
 - ii. Portion of the report with table on fiber concentration

5. In Vermiculite Deposits

Research Report - J. C. Yang 4/28/75
X-Ray Analysis of the Libby Ore Deposits

15169875

6. In Ore Concentrates

- a) Research Report - J. C. Yang to J. W. Wolter
4/6/85

Summary on Tremolite Analysis of Libby Head
Feeds and concentrates produced in 1984 and
Efficiency of removal.

- b) Research Report - J. C. Yang to J. W. Wolter
3/6/84

Summary on Tremolite Analysis of Libby Head
Feeds and Concentrates produced in 1983 and
Efficiency of Removal

i. Table on comparison of Tremolite Removal
Efficiency from 1979 to 1983 in Libby Mill

ii. Graph on monthly tremolite analysis of
five size ore concentrates

- c) Research Report - J. C. Yang 7/13/83

Tremolite Fiber Content of Libby Ore Concen-
trates other than monthly composites (1976-1984)

- d) Portion of Report to J. C. Yang to E. S. Wood
5/16/77

Tremolite Analysis of Libby Ore Concentrates

7. In Zonolite Products

- a) Research Report - J. C. Yang 7/13/83

Tremolite Analysis of Grace Vermiculite Ore
Concentrate and Zonolite Products.

- b) Research Report - R. C. Howard 5/4/83

Tremolite Content in Expanded Vermiculite

- c) Portion of Research Report J. C. Yang to
E. S. Wood 5/16/77

Table on Tremolite Content in Expanded Vermiculite.

- d) Portion of Research Report - J. C. Yang to
E. S. Wood (4/20/77)

Tremolite Content in Zonolite Products and
Zonolite Job-Site Samples.

- e) Table from memo report S. Venuti to R. C. Walsh
9/10/84

8. General

15169876

The Ruby Creek Igneous Complex Near Libby, Montana

A. L. Boettcher Ph.D. Thesis 6/66 Penn State Univ. Geochim.

AMPHIBOLE ANALYSES

	1.	2.	3.	4.	1a.
SiO ₂	56.74	---	---	---	Si 7.92
TiO ₂	0.28	---	---	---	Al ^{IV} 8.00
Al ₂ O ₃	0.71	---	---	---	Al ^{VI} 0.08
Fe ₂ O ₃	4.71	*5.97	*4.12	*3.76	Ti 0.04
FeO	0.87	---	---	---	Fe ⁺⁺⁺ 0.03
MnO	0.07	---	---	---	Fe ⁺⁺ 5.25
MgO	21.95	---	---	---	Mg 10
CaO	6.15	---	---	---	Mg 4.57
Na ₂ O	5.15	3.22	3.41	3.26	Mn 0.01
K ₂ O	1.80	1.26	1.46	1.58	Na 1.39
H ₂ O	0.87	---	---	---	K 1.32 2.63
F	1.30	---	---	---	Ca 0.92
	100.91				OH 0.81
O = F	-0.54				F 0.57 1.38
TOTAL	100.37				

*Total Fe as Fe₂O₃

1. Richterite -- altered pyroxenite adjacent to aegirine-rich "vein". Includes Cr₂O₃ 0.06, NiO 0.23, SrO 0.02. Larsen, 1942, p. 49. Analyst: F. A. Gonyer.

1a. Analysis 1, calculated on the basis of 24 (O + OH + F).

2, 3, and 4. Soda-rich tremolite -- altered pyroxenite adjacent to quartz veins. Analyses by Zonolite Division, W. R. Grace and Co.

Libby, Montana

CAMBRIDGE

TO: H. C. Duecker

DATE:

January 13, 1976

FROM: J. C. Yang

SUBJECT:

Density Variations of Libby Vermiculites and Tremolites

CC: H. A. Brown

J. W. Wolter

R. J. Kujawa/Libby

G. G. Vaplon/Libby

R. L. Oliverio/Libby

O. P. Stewart/Enoree

File: 71-000

Copy to Malcolm Williams
T.R.

OBJECTIVE

The objective of this study is to determine the range of densities of Libby vermiculites and tremolites, based on the mineral structures.

MINERALOGICAL BACKGROUND

Vermiculites are known to be the weathered products of mica. A hydrothermal process has occurred in the geological formation; the mica structure was altered as interlayer water was introduced. A partially hydrated material is usually classified as hydrobiotite and a more fully hydrated mineral as vermiculite. However, due to the variation of chemical composition at different localities, the degree of isomorphous substitutions and rate of alteration vary in a wide range with the generally accepted formula of vermiculite as $Mg_{0.3} Mg_3 (Al, Si)_4 O_{10} 4.5 H_2O$.

The octahedral Mg may be partly replaced by Fe^{+2} , Fe^{+3} , Al, etc. In tetrahedral position the Al/Si ratio usually lies between 1:2 to 1:3.

The optical properties, densities and x-ray diffraction patterns of the minerals vary with the substitutions and degrees of hydration in the molecular structure. Table 1 attached shows the literature values for the general properties of biotite-vermiculite series.

Tremolite, an amphibole, has the composition $Ca_2 (Mg, Fe)_5 Si_8 O_{22} (OH)_2$. A slight amount of Al may replace the Si, with the attendant additions of Na to the composition.

EXPERIMENTAL

Five samples (three vermiculite and two tremolite) were chosen for analysis.

Sample Description:

- #1, brownish vermiculite flakes, hand-picked from Libby #2 size reserve, thin books or flakes, light brown to red brown with high luster.
- #2, greenish flakes, hand-picked from Libby #2 size, heavy, thick books, dull, green color.
- #3, Libby #3 as received, except some visible bundles of tremolite were removed.
- #4, tremolite fiber bundles, hand-picked from Libby #2 reserve.
- #5, tremolite rock from Libby, slightly crushed.

15169878

Experimental Results

The samples were weighed and immersed in distilled water in the pycnometer, de-aired with temperature measurements for density determination. The determinations were made in duplicate.

Separate samples were crushed to pass 100 mesh for x-ray identification.

<u>Samples</u>	<u>Densities Determined (g/cc)</u>	<u>X-ray Identification</u>
#1	-2.2783	high V, trace B
#2	-2.5850	high H, some V, trace B
#3	2.6069	H & V, some rock
#4	2.9274	T
#5	3.0070	T

key: V = Vermiculite
B = Biotite
H = Hydrobiotite
T = Tremolite

DISCUSSION and CONCLUSIONS

The experimental results indicated that there are differences in density of the Libby vermiculites, depending upon the degree of weathering, i.e., the percentage of hydrobiotite vs. the percentage of vermiculite present.

The x-ray identification of the species agrees with the trend of the density determinations.

Two tremolite picked from different locations, whether in bundles or in rocks, showed no significant difference either in x-ray patterns or density.

The reddish-brown to brown flakes with high luster (#1) are well-hydrated true vermiculite whereas the dull dark green thick books (#2) are mostly hydrobiotite. Hydrobiotites showed higher density and index of refraction, and lesser degree of hydration.

The composite sample Libby size 3 (#3) has slightly higher density than samples 1 and 2, but does not necessarily mean we have more hydrobiotite or biotite since there is a certain amount of rock [pyroxenes ($D = 3.2$) and feldspars ($D \approx 2.7$)] present even some fiber tremolite ($D = 3-3.2$). The presence of any of these minerals, or combinations, would result in a slightly higher density.

Duecker
13, 1976

Density Variations of Libby
Vermiculites and Tremolites

REFERENCES

1. Boettcher, A. L., "The Rainy Creek Igneous Complex near Libby, Montana (1966) pp. 110.
2. Brown, G., "The X-Ray Identification and Crystal Structures of Clay Minerals", London (1972) pp. 297-324.
- Ernst, W. G., "Amphiboles" (1968).
- Larsen, E. S., and Berman, H., "The Microscopic Determination of the Nonopaque Minerals" (1934) pp. 162, 169, 222.
- Varley, E. R., "Vermiculite" (1952) pp. 6-8.

Julie C. Yang
Julie C. Yang

ment

TABLE I

Mineral	$N\alpha$	Optical Properties $n_x = n_y$	Pleochroism	Density (g/cc)	X-ray Main Peak d (Å)
Biotite	1.569	1.609	$x < y = z$ $x =$ light brown $y = z =$ green brown	2.8 - 3.4	10.1 (001), 3.37 (002)
Hydrobiotite	1.545	1.582	$x < y = z$ $x =$ light brown $y = z =$ moderate brown	2.5 - 2.8	12.4 (002), 3.53 (001)
Vermiculite	1.525 - 1.561	1.545 - 1.581	$x < y = z$ $x =$ light brown $y = z =$ moderate brown to red brown	2.2 - 2.5	14.2 (002), 2.62 (200)
Tremolite	1.599	1.613 - 1.625	massive acicular or fibrous	2.9 - 3.2	8.38 (110), 3.12 (010)

$$\frac{n_x}{n_y} \quad \frac{n_x}{n_y}$$

CAMBRIDGE

TO: R. J. Ostertog

DATE

January 12, 1982

FROM: Julie C. Yang

SUBJECT:

Vermiculite
Rock Compositions

CC: H. C. Duecker

R. E. Schneider

J. W. Wolter

D. D. Walczyk

File: 1000

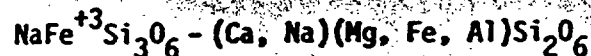
Per your request, the rock compositions generally associated with vermiculite ore in both Libby and South Carolina are tabulated as follows:

Libby

Major:

Pyroxene

Acmite - Augite

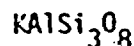


Diopside

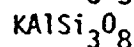


Intermediate: Feldspar

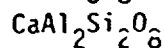
Microcline



Orthoclase



Anorthite

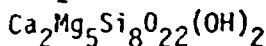


Minor:

Quartz

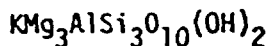


Tremolite

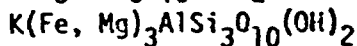


Mica

phlogopite



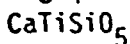
biotite



Magnetite



Sphene



and some unexpanded but expandable
vermiculite and hydrobiotite.

To: E. S. Wood
From: Julie C. Yang
Date: June 27, 1977

Recheck on Vermiculite Content
in L-3, L-4, L-5 Ore Composites
and K-5 Expanded Vermiculite

Size	Fraction (sp. gr. > 1.585) < 2.60	X-Ray Data
L-3	2.59% of the total sample	Major: Biotite Int-Minor: Phlogopite Minor: Feldspar & Quartz
L-4	4.53% of the total sample	
L-5	1.44% of the total sample	

The heaviest portion (sp. gr. > 2.60) was composed of pyroxene, part of the feldspars, large sized quartz and tremolite, determined also by x-rays.

Since the "in-between" floating materials were mostly micaceous material and a small amount of feldspar and quartz, the percentage of vermiculite in ore composite remained the same as described in the Table 1 of 5/16/77 report.

Expanded Vermiculite

A sample of K-5 which we used for the determination in the report was submitted to L. Feldman for vermiculite determination. Len's results were attached. This specific sample showed 38.92% heavy particles using C-31 test of less than one-minute standing versus our results of 51.3% (5-minute standing). This sample therefore is a very poor sample and out of specification.

Julie C. Yang
Julie C. Yang

JCY:mlr

CONSTRUCTION

PRODUCTS

DIVISION

REQUEST FOR TECHNICAL SERVICE

PROBLEM TITLE: TREMOLITE

SIGNIFICANCE:

To choose a tremolite

SPECIFIC OBJECTIVE:

To evaluate three tremolite fiber is clo
product; that sample will be

SUGGESTED APPROACH:

DEADLINE (Last day information

DETAILS OF PROBLEM:

NUMBER: 49511

GROUP: ZONOLITE

DATE: Sept. 30, 1976

CHARGE NO.: 71-070

REQUESTOR: J. W. Holter

MARKETING or MANUFACTURING APPROVAL:

NAME:

APPROVED:

R FROM LIBBY

on studies.

as submitted by Libby mine, and to determine
properties of the fiber found in our Libby
operation study.

ue):

ACCEPTED BY RESEARCH DEPT.:

ASSIGNED TO:

ADDITIONAL COPIES: Original to

DATE: 9/30/76

H.C. Duecker, R.H. Locke,
erio/Libby, S.F. Stewart/Enor
-070 CPD-T2A

CO

IAL

15169884

TEST FOR TECHNICAL SERVICE

HUNTER 49511
GROUP: ZONOLITE
ACTUAL COST: \$650.00
REPORTING DATE: Sept. 30.

SUMMARY:

The tremolite samples were characterized by x-ray diffraction method and the specific gravity of each was determined and compared with the hand-picked tremolite fiber from Libby #2 product.

In addition, screen analysis and the rate of degradation studies were made.

It is concluded that the highly weathered tremolite sample from Level 4 closely resembles the hand-picked fiber found in Libby product. The use of Level 4 Dyke tremolite fiber in the operational test is thus recommended.

DETAILS:

Sample Received from Libby

	<u>I.D. No.</u>	<u>Description</u>
	22279-1	Level 4 Dyke, high grade asbestos,
2	22279-2	Level 15 Dyke, high grade asbestos,
3	22279-3	Asbestos Concentrate Dump, relatively low grade asbestos.

Observation

Sample: 1 very lumpy but soft, highly weathered.
2 rocky and hard, more impurities than 1 and 3,
3 moderately hard, more asbestos pencils.

X-Ray Diffraction Characterization

All three samples showed very good tremolite patterns, identical to the pattern of the hand-picked tremolite from Libby #2 product. All have small amounts of vermiculite-hydrobiotite and pyroxenes. Sample no. 3, "asbestos concentrates", has the least impurities - vermiculite only.

Specific Gravity Determination

The -100 mesh samples were weighed, immersed in distilled water in the pycnometer, de-aired with temperature measurement for density determination in grams per cc.

<u>Sample No.</u>	<u>Description</u>	<u>Density Determined (g/cc)</u>
1	Level 4	2.867
2	Level 15	2.776
3	Asbestos Conc.	2.919
	Hand-picked tremolite from Libby #2 product	3.008

15169885

REQUEST FOR TECHNICAL SERVICE

NUMBER: 49514
GROUP: ZORON
ACTUAL COST: \$650.00
REPORTING DATE: Sept 30, 1976

V. Screen Analysis

A 300 g sample was taken and Ro-tapped through a series of screens. Trial tests were made to determine the optimum time interval from 20 to 80 minutes. It was found that Ro-tapping at 60 minutes would give us good and consistent results.

The Screen Analysis data are presented in Tables 1, 2, and 3.

The screened fractions were examined visually. The following observations were made:

- 1) The Level 4 Dyke material is the softest of the three specimens, about 25% to 35% of which tends to degrade and ball; the remaining breaks down to hard pencils.
- 2) The sample from Level 15 Dyke is hard, shows high aggregates and rock content. When screened, the fine fractions are all in hard pencils; no white fiber balls are observed.
- 3) The "Low Grade Asbestos Concentrates" seems to have the highest grade of tremolite with very little impurities; when screened, the fine fractions again show hard pencils.

VI. Degradation Studies

The objective of this study is to find the degradation behavior of each asbestos sample, thus to achieve better understanding if the material is present in the vermiculite concentration operation.

The fraction (-6 + 20 mesh size) of samples obtained from the screen analysis was taken for this analysis. Samples of about 5 g by weight were subjected to SPEX-milling for a predetermined time, then sized and weight percent determined.

The results are presented in Tables 4a, b and c, and Figures 1a, b, and c.

From the figures it showed that the Level 4 Dyke material and the "low grade" asbestos concentrate are somewhat similar in degradation behavior except the Level 4 material broke down a little faster in the 5 minute test due to high degree of weathering. These two samples were comparatively softer and did not break down as fast in the degradation process as the less-weathered Level 15 material when SPEX-milled. The soft fiber would have a cushioning effect to reduce the impact force.

HUNTERS 1951

HUNTERS 1951

GROUP: 1700 LITS

ACTUAL C.O.F.: \$650.00

REPORTING DATE: Sep 30, 1976

CONCLUSION and RECOMMENDATION:

Based on all the findings and observations made above, and the experience in handling and studying Libby ores with tremolite, the highly weathered loosely aggregated Level 4 Dyke material, which closely resembles the tremolite fiber in the Libby product, is recommended to be used in R. H. Locke's proposal for determining residual tremolite in up-graded vermiculite.

Julie C. Yang
Julie C. Yang

JCY:nlr

Appendix I

Tables 1 - 4 a, b, c

Appendix II

Figures 1 a, b, c

REQUEST FOR TECHNICAL SERVICE

HUNBERT 1971

GROUP 3000 LITE

ACTUALS TO 4650.00

REPORT DATE Sept. 30, 1976

Mesh Size	% Retained			
	20 Mins.	40 Mins.	60 Mins.	60 Mins.
TABLE 1 - Screen Analysis of Level 14 Dyke Material				
+ 3.5	29.5	23.6	28.1	27.6
- 3.5 + 6	17.2	17.5	17.5	17.5
- 6 + 20	32.2	32.2	32.4	32.5
- 20 + 70	14.1	14.2	14.3	14.3
- 70 + 100	2.6	2.5	2.5	2.5
- 100	4.3	4.9	5.4	5.5
% Recovery:	99.9%	99.9%	100.2%	99.9%

TABLE 2 - Screen Analysis of Level 15 Dyke Material

+ 3.5	0.6	0.6	0.6	0.6
- 3.5 + 6	12.0	10.7	9.5	8.4
- 6 + 20	44.3	44.2	44.3	44.4
- 20 + 70	23.7	28.8	29.0	29.1
- 70 + 100	5.1	4.6	4.5	4.4
- 100	8.5	9.9	10.6	11.0
% Recovery:	99.3%	93.9%	98.4%	97.9%

TABLE 3 - Screen Analysis of Low Grade Asbestos Concentrates

+ 3.5	1.2	0.8	0.6	0.6
- 3.5 + 6	15.3	16.4	14.7	14.7
- 6 + 20	46.9	46.9	46.7	46.4
- 20 + 70	24.5	24.4	24.2	24.1
- 70 + 100	4.8	4.3	4.1	4.0
- 100	6.1	7.3	7.9	8.2
% Recovery:	93.3%	100.1%	93.2%	97.9%

15 169886

REQUEST FOR TECHNICAL SERVICE

1051 1951

CHSR 75 DATE

ACTUAL COST \$20.00

REPORTING DATE Sept. 30, 1976

TABLE 1 - Degradation Studies of Tremolite Fiber

(a) Level 4 Dyke Material

Mesh Size	SPEX Milling Time:	% Retained		
		5 Min.	10 Min.	25 Min.
+ 20 M		0.2	1.1	1.3
- 20 + 50 M		5.6	7.4	8.1
- 50 + 100 M		31.7	17.8	13.1
- 100 M		61.1	69.0	72.6
% Recovery		98.6%	95.3%	95.1%

(b) Level 15 Dyke Material

Mesh Size	% Retained		
	5 Min.	10 Min.	25 Min.
+ 20 M	0.2	0.5	1.3
- 20 + 50 M	4.1	5.4	7.6
- 50 + 100 M	12.7	12.7	13.3
- 100 M	80.5	76.7	74.0
% Recovery:	97.5%	95.7%	96.2%

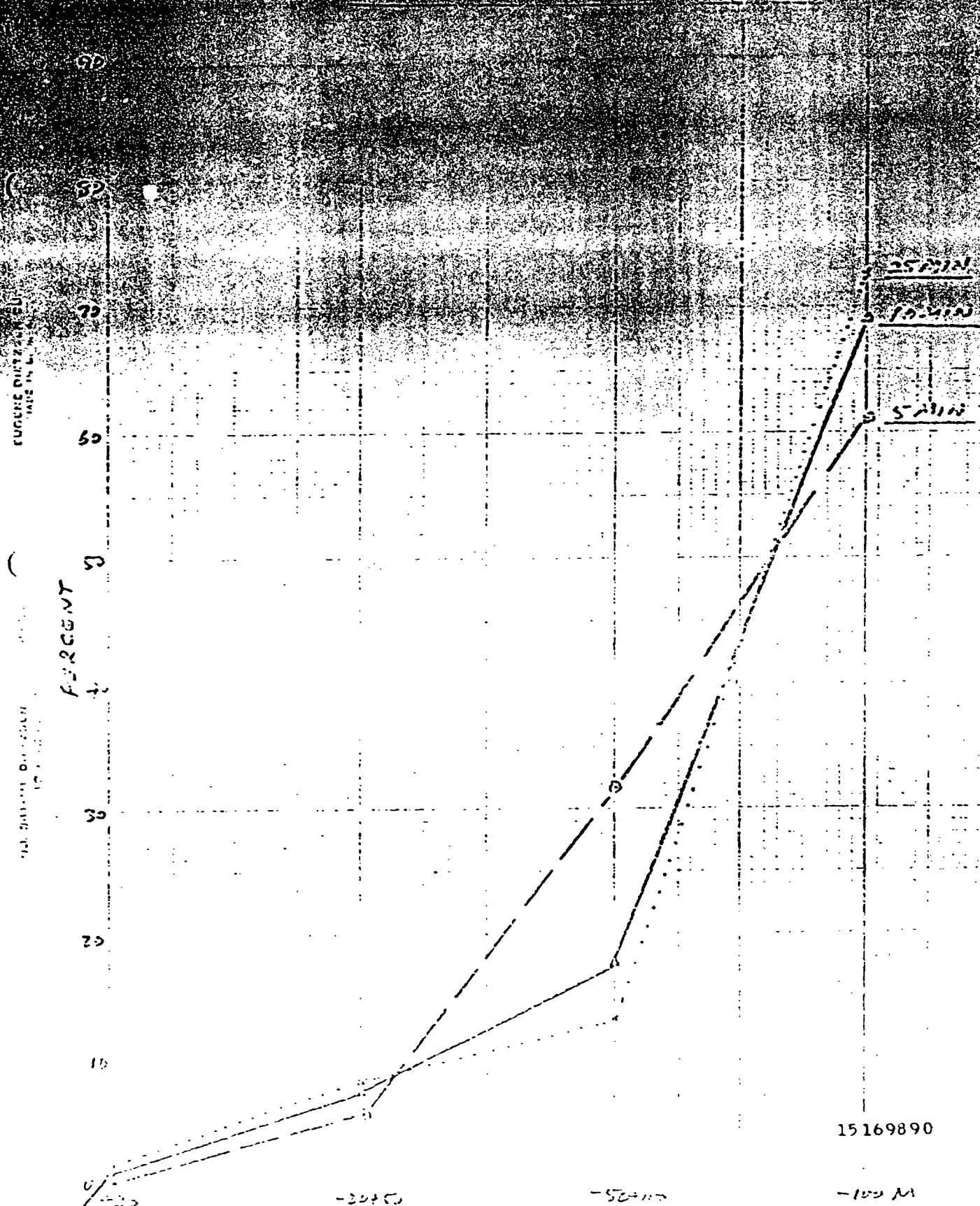
(c) Low Grade Asbestos Concentrates

Mesh Size	% Retained		
	5 Min.	10 Min.	25 Min.
+ 20 M	0.2	1.0	1.1
- 20 + 50 M	4.8	7.6	9.2
- 50 + 100 M	45.8	19.9	13.3
- 100 M	47.3	65.7	74.9
% Recovery:	98.1%	95.5%	98.5%

15169889

FIG. 1 DEGRADATION STUDIES

a) 5% - 10% - 15% - 20%



15169890

9/1

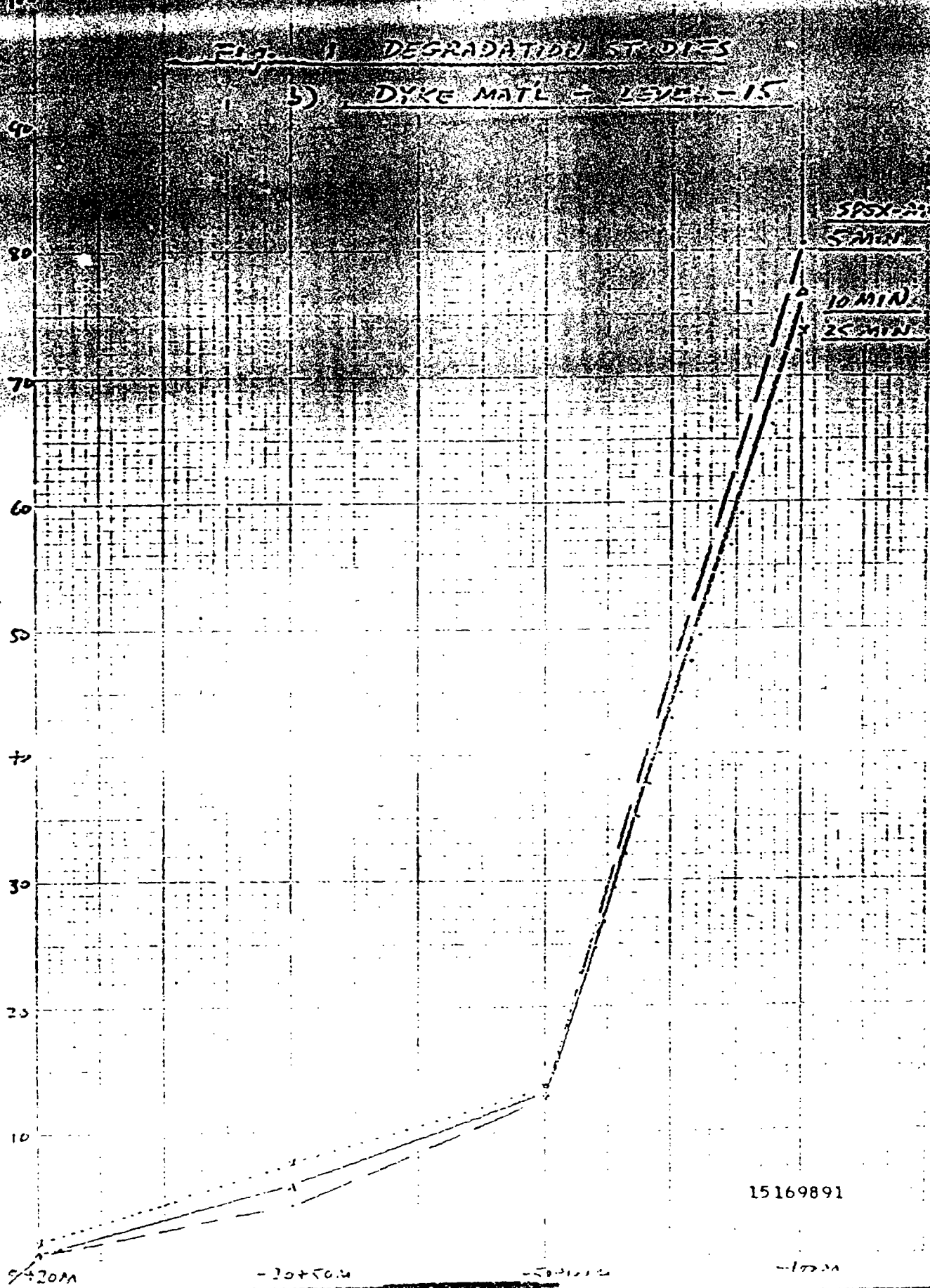
Fig. 1 DEGRADATION STUDIES

3) DYKE MATL - LEVEL - 15

EUGENE BENTZON CO.
MADE IN U. S. A.

NO. 341 - G DISTZON 1 - 1000
10 X 10 1/2 IN.

PERCENT



SP5X-ANL

5 MIN

10 MIN

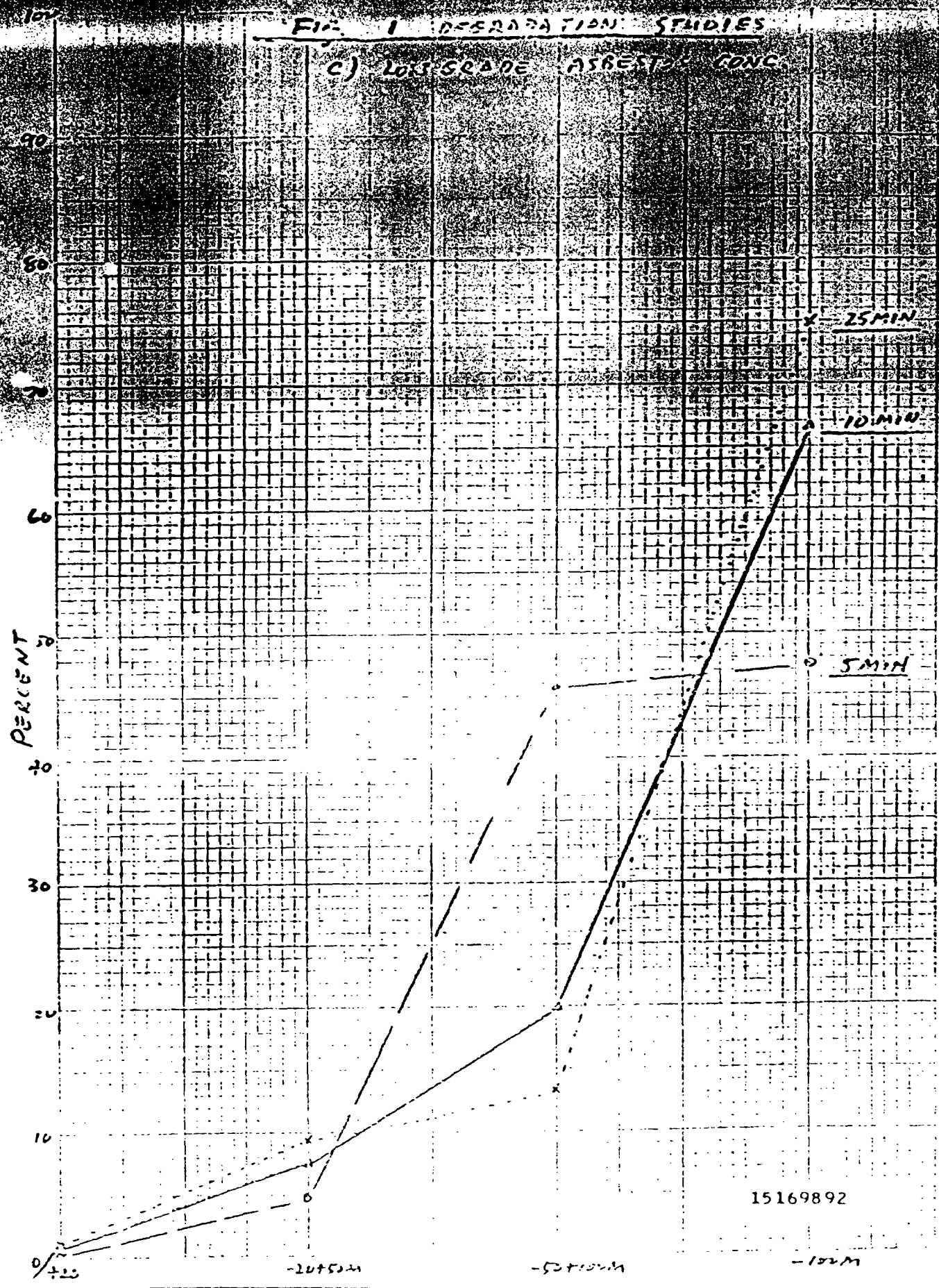
25 MIN

15169891

9/25/72

FIG. 1 DEGRADATION STUDIES

C) LOW GRADE ASBESTOS CONC.



15169892

CUDENE DIETZGEN CO.
MADE IN U.S.A.

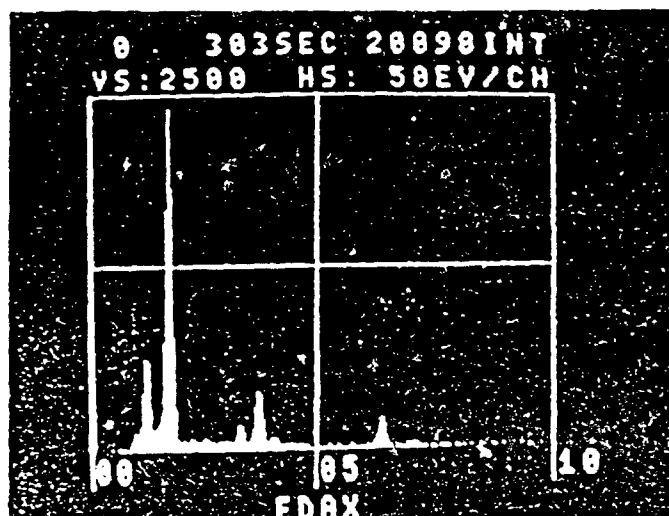
NO. 341-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

LIBBY TREMOLITE



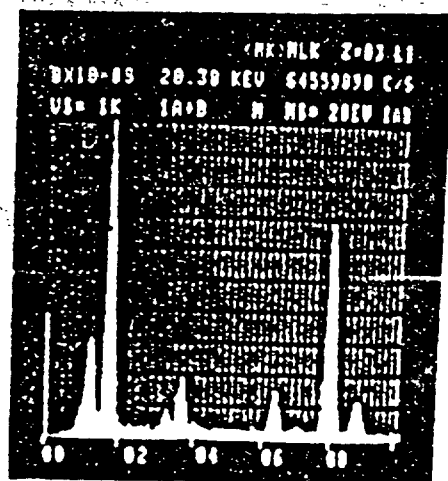
22360-5

10000X

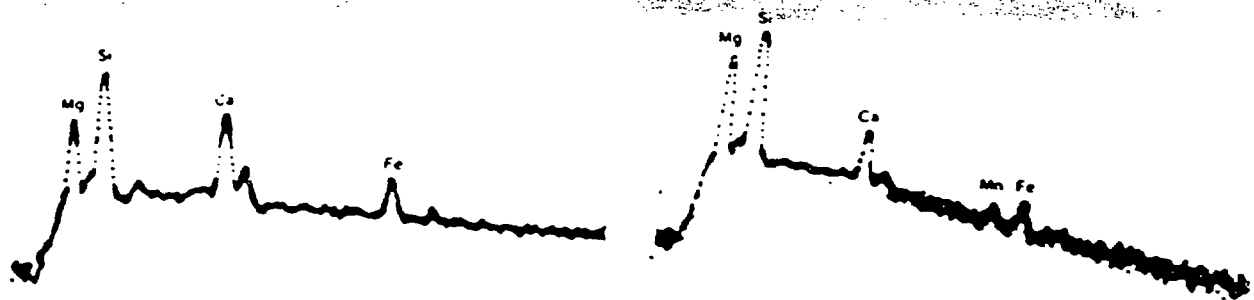
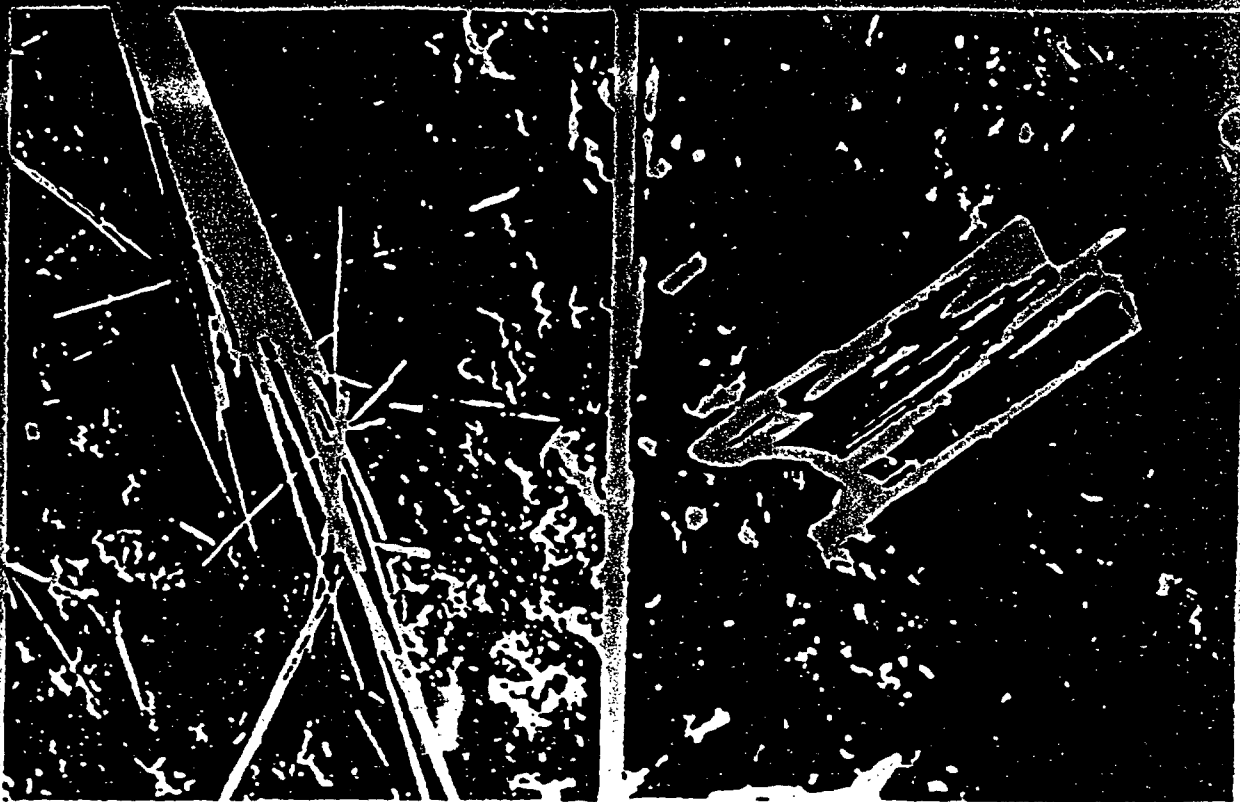


TREMOLITE (Libby)

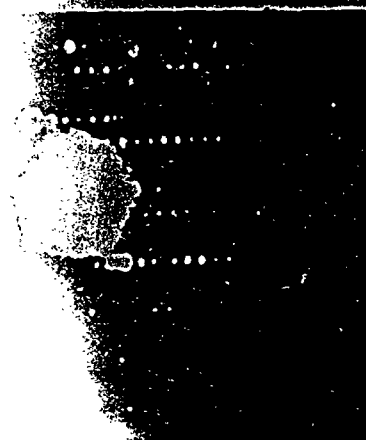
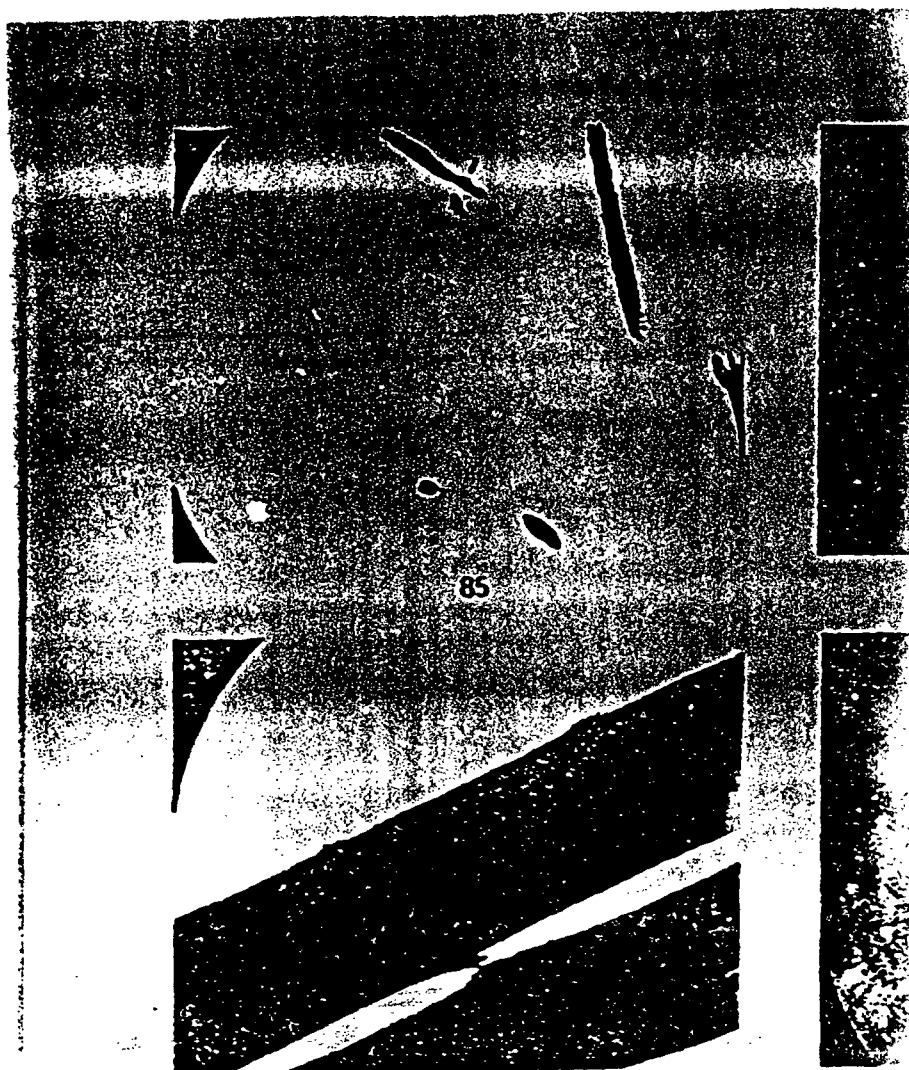
15169892



Chemical analysis of individual fibers by Energy
Dispersive Spectrometry of x-rays. Typical spectrum.



Scanning electron microscope (SEM) and energy dispersive X-ray spectra (EDX) photographs of asbestos and nonasbestos tremolite. Upper panels - SEM, left - tremolite asbestos and right - nonasbestos tremolite, lower panels - EDX, left - tremolite asbestos and right - nonasbestos tremolite.

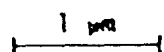


85

87

89

TREMOLITE



97

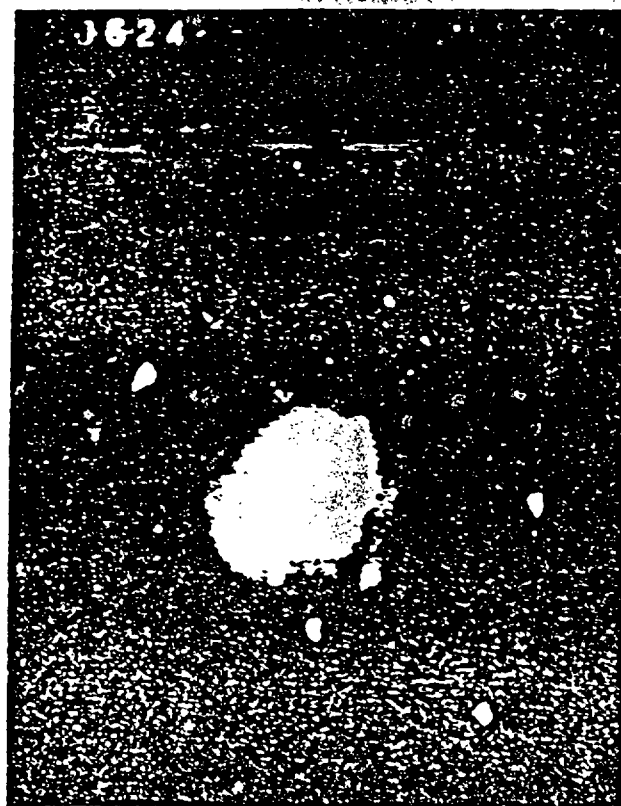
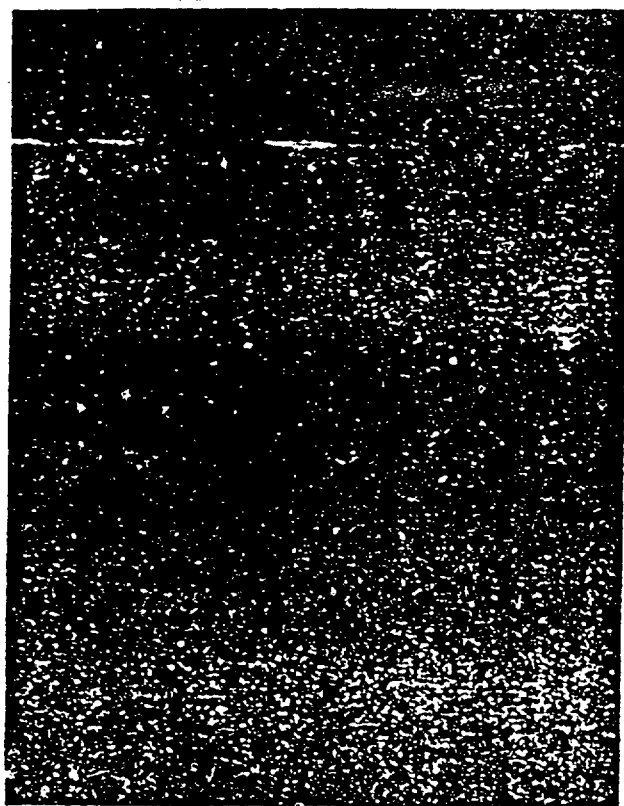


Figure 19. - Transmission electron microscope (TEM) photographs and selected area electron diffraction (SAED) patterns of asbestos and nonasbestos tremolite: Upper panels - TEM, left - tremolite asbestos and right - nonasbestos tremolite; lower panels - SAED, left - tremolite asbestos and right - nonasbestos tremolite.



Megascopic and microscopic photographs of asbestos and nonasbestos tremolite: Upper panels - megascopic, left - tremolite asbestos and right - nonasbestos tremolite, lower panels - microscopic, left - tremolite asbestos and right - nonasbestos tremolite

TABLE I SAMPLE CHARACTERISTICS
(As given by the Company's Industrial Hygienist)

			CONCENTRATION (Fibers/cc)
L3	252	1.8	453.6
L1	248	2.0	496
L2	480	2.0	960

SAMPLING LOCATIONS

- L3 Mill, 7th Floor - Over 8-M Feed Prep Derrick Screens
- L1 Mill, 4th Floor - Rock Circuit Conditioner Discharge End
- L2 Luis Vasquez Office

13169900

TABLE II CONCENTRATIONS AND SIZE DISTRIBUTIONS

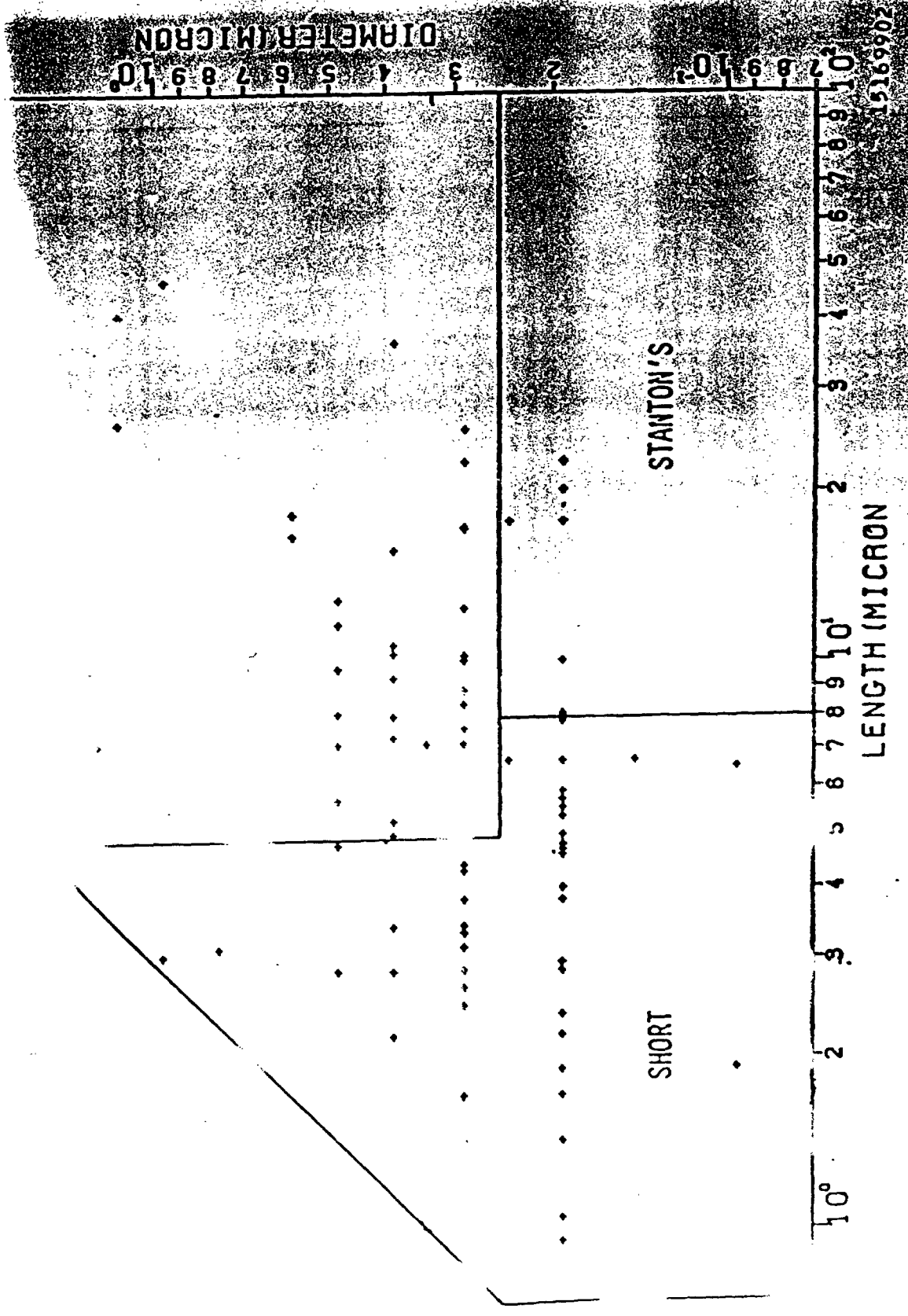
SAMPLE	SAMPLE CONCENTRATION (FIBERS /CC)		DISTRIBUTION IN SIZE CATEGORIES (%)		
	OPTICAL COUNT	ATEM COUNT	SHORT	OPTICAL	STANTON'S
L3	0.93	2.90	50	43	7
L1	0.25	0.83	47	52	1
L2	0.05	0.16	33	67	2

15169901

Dr. P. S. Sabin
McGill Univ.

6/10/71

AIR SAMPLE - C



15169902

MK-5 Bulk Samples

7/19/83 10:40 J.C.Y.

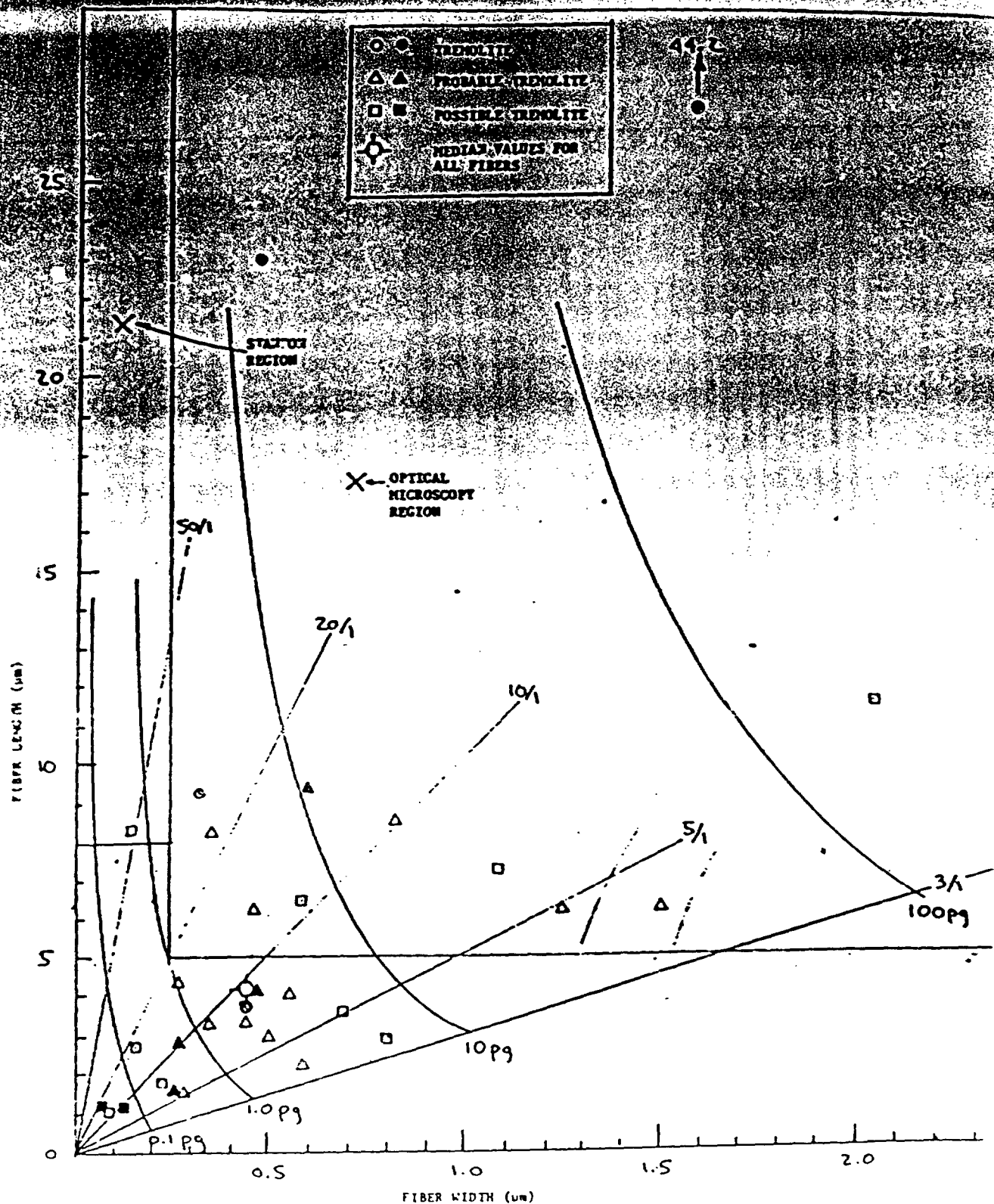


Figure 1. Distribution of fiber dimensions by classification category (open symbols: June 23, 1983 sample; filled symbols: July 1, 1983 sample)

15169903

July 13, 1983

-8-

Dr. Julie Yang
Manager - Research Technologies
W.R. Grace & Co.

It is clear that median value is preferred.

Relating to the representativeness of a particular analysis, statistical approaches are available for estimating the range of results that could be expected for a series of replicate analyses. The Poisson distribution function is generally used for comparing the results of replicate analysis or for computing a confidence interval. The usual confidence interval is the range in which 95 of 100 replicate analyses would fall assuming the fibers analyzed satisfy the Poisson distribution. This can be examined for the two recently completed analyses.

<u>Category</u>	<u>Fibers</u>	<u>June 27</u>	<u>July 12</u>
		<u>Confidence Interval</u>	<u>Confidence Interval</u>
Tremolite	2	0.24 - 7.22	2 0.24 - 7.22
Tremolite + Probable tremolite	14	7.65 - 23.49	6 2.2 -13.06
Tremolite + Probable tremolite + possible tremolite	23	14.58 - 34.51	8 3.45 -15.76

For the conversion formula and the median fiber masses given earlier, the results rounded off to the nearest ppm are

<u>Category</u>	<u>Fiber Concentration (ppm)</u>	
	<u>June 27</u>	<u>July 12</u>
Tremolite	0 - 5	30 - 913
Tremolite + probable tremolite	4-14	14 - 81
Tremolite + probable tremolite + possible tremolite	9-22	4 - 19

15169904

CAMBRIDGE

TO: H. C. Daecker

DATE:

April 28, 1975

FROM: Julie C. Yang

SUBJECT:

X-ray Analysis of
the Libby Ore Deposits

CC: H. A. Brown
D. Riggleman
File: 71-000

OBJECTIVE

To identify and estimate semi-quantitatively the mineral components present in the Libby ore deposits at the locations of which were identified from the blast reports provided by D. Riggleman.

SUMMARY

The results are shown in the attached tables, 1 and 2. Most of the findings agree with the key (vermiculite content determined from the assay reports), but some showed deviations from the key, generally with vermiculite contents higher than the amounts shown in the key.

Minerals associated with vermiculite ores are mainly feldspars (orthoclase, microcline, anorthite, plagioclase, etc.) pyroxenes (aegirite, augite, hypersthene, Johannsenite, etc.) and, surprisingly, very minor amounts of tremolite, talc and hornblends.

The data present are indicative but not conclusive. We will have good petrographic analysis of these to confirm our findings in the near future.

Julie C. Yang
Julie C. Yang

JCY:mlr

attachments

LIBBY DEPOSIT - LC

Location	Key	Major (>50%)
	40-60% V	Hy, V
	20-40% V	F, Py
	40-60% V	Hy, V
	20-40% V	F
	20-40% V	
	40-60% V	Hy, V
	40-60% V	Py, V
	-5% V	Py
	-5% V	Py
	40-60% V	Hy, V*
	-5% V	
	-5% V	
	20-40% V	
	40-60% V	F
	20-40% V	Hy, V

* quantity 1

Hy - hydrobiotite
V - vermiculite
F - feldspar

42 (GOOD)

Immediate (>4%)	Minor (<10%)
Py	Tr (?)
	Tr
	Tr
	V, Hy, Tr, Talc
Py,	Tr
	Tr, Py
	Tr
	V, Hy, Tr
	V, Hy, Tr
	Tr
Py	Talc, Tr
V	Talc, Tr
	F, Tr
	Tr
	Tr, Talc

TABLE 2

LIBBY DEPOSIT - LOCATION 15-38 (BAD)

Position	Key	Major (> 50%)	Intermediate (10-49%)	Minor (≤ 10%)
10	-5% V	F	Py, Talc, Tr	Q, V, Hy
17	-5% V	F, Tr	Talc, Py	Q, Hy, V
19	-5% V	F	Q, Py	Hy, V, Talc, Tr
27	-5% V	F	Tr, Talc, Hy, V	Py, Q
33	40-60% V	V, Hy	F, Py	Q, Tr
48	+60% V	V, Hy	F	Py, Tr (?)
80	20-40% V	V, Hy	F, Py, Tr, Talc	----
82	10-15% V	----	Hy, V, Talc, Tr, Py	F
84	20-40% V	V, H	F, Py*	Tr, Talc
86	-5% V	F	Py*	Tr, Talc

* Intermediate minor - 5-20%

F - feldspar

V - vermiculite

Py - pyroxene

Hy - hydrobiotite

Tr - tremolite

Q - quartz

BY _____ DATE _____ # _____

627N

221N



550E

551E

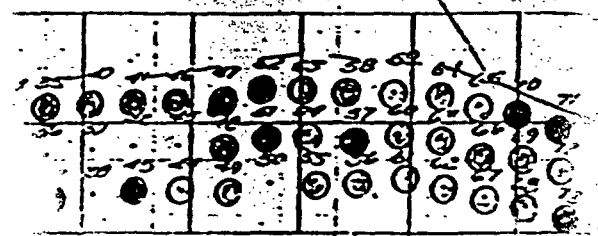
552E

553E

N 3600

E 16600

8 (BAD) JOB NO. _____



557E

558E

559E

0E

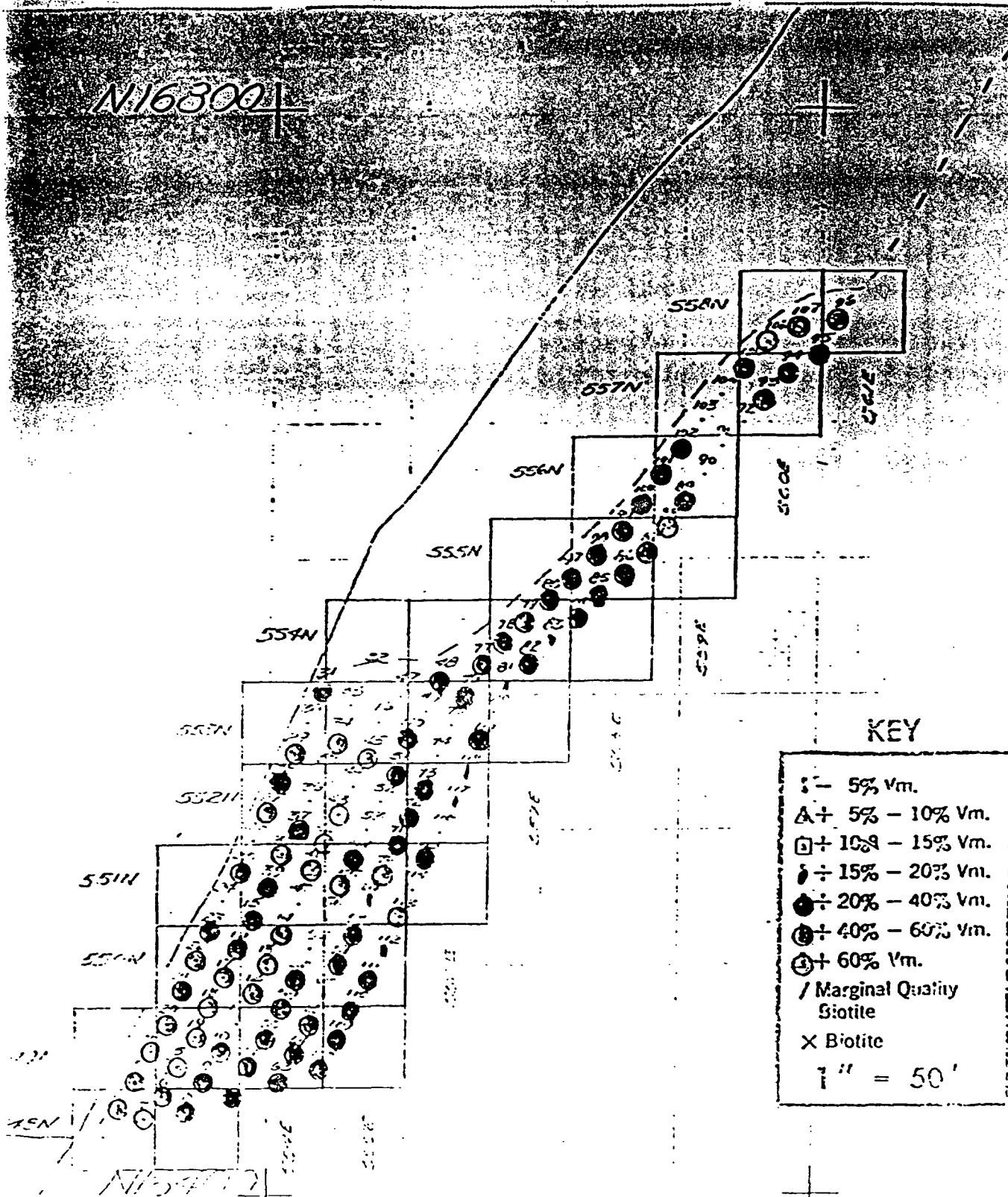
- m.
- 10% Vm.
- 15% Vm.
- 20% Vm.
- 40% Vm.
- 60% Vm.

Quality

50'

E 16100

N163004



KEY

- :- 5% Vm.
- A+ 5% - 10% Vm.
- + 10% - 15% Vm.
- + 15% - 20% Vm.
- + 20% - 40% Vm.
- + 40% - 60% Vm.
- + 60% Vm.
- / Marginal Quality Biotite
- X Biotite

1" = 50'

Yearly Average of Tremolite Content of Libby Ore Concentrate

<u>Size/Year</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>1984</u>
L-1	1.47	1.08	1.26	1.35	1.19	1.14	0.40
L-2	1.71	1.71	1.96	1.84	1.63	1.32	0.77
L-3	0.46	0.57	0.82	0.52	0.38	0.38	0.31
L-4	0.28	0.48	0.66	0.30	0.26	0.33	0.26
L-5	1.10	1.55	2.03	0.54	0.36	0.42	0.55

JCY
4/9/85

15169910

Comparison of Tremolite Removal Efficiency of Year 1979 to 1984

<u>Year</u>	<u>Total Tremolite in Head Feed (%)</u>	<u>Total Tremolite in Ore Concentrate (%)</u>	<u>Total Tremolite Efficiency (Rel. %)</u>
74/1979	4.68	0.72	84.6
1980	6.40	1.02	83.7
1981	3.81	0.58	84.4
1982	3.93	0.47	87.4
1983	4.00	0.51	85.8
1984	3.45	0.35	88.8

JCY
4/9/85

15167911

Tremolite Fiber Content of Libby Ore Concentrates Other Than Monthly Composites (1976-Present)

Date	2/23/76	1/7/77	3/9/77	6/20/77	10/77	11/77	12/77	3/2/78	7/31/80	6/25/81	2/9/83	2/1/83
Reference (RTS NO)	Memo to HCD	49974	-----	67569	67631	67631-5	67634-67645	69525	69608	65538	67936	Memo J. Yang
Size												
L-1	1.92		1.2	2.12	2.6	2.0	2.18	-----	88, + 144	0.77	1.50	1.02
L-2	4.97	+6M 1.8 - 2.5 -6M 0.36-0.75	2.5	2.96	3.5	2.91	2.34	-----	88, + 144	0.78	1.49	1.21
L-3	0.65		0.7	0.28	0.7	0.94	0.60	0.34			0.45	0.33
L-4	0.76		1.7	0.38	0.9	0.74	0.96	-----			0.61	0.60
L-5	1.71		3.0	1.52	-----	-----	-----	-----			0.51	0.51

15169912

To: E.S.Hood
 From: J.C. Yang
 Date: May 16, 1977

Tremolite & Vermiculite Content
 Libby & Kearney Ore Deposits
 and Expanded Vermiculite

TABLE 1

Tremolite Content of Ore

<u>ID No.</u>	<u>Description</u>	<u>Date</u>	<u>% Vm.</u>
-31	L-1	3/10/77	<u>91.7</u>
-32	L-2	3/10/77	<u>91.2</u>
-33	L-3	3/10/77	<u>78.1</u>
-34	L-4	3/1/77	<u>70.1</u>
-35	L-5	3/1/77	<u>63.9</u>
-36	K-3	3/1/77	<u>72.0</u>
-37	K-4	3/1/77	<u>75.1</u>
-38	K-5	3/1/77	<u>76.6</u>
-46	Head Feed, Libby	3/9/77	<u>7.0</u> **

<u>olite</u>	<u>Total Tremolite*</u>
1.2 .005	<u>1.2</u>
.5 .018	<u>2.5</u>
3	<u>0.7</u>
.495 .232 .009	<u>1.7</u>
.9 .16 3	<u>3.0</u>
.60 .158	<u>1.8</u>
2.903 .554 .492	<u>10.0</u>
.874 .070 3.034	<u>15.9</u>
3.02 .34 .235 .609	<u>3.8</u>

* Includes all amphibole mineral

** The material floated after exp

GRACE

TO: H. C. Dueck

FROM: J. C. Yang

CC: R. J. Bett
J. A. Dann
R. C. Eric
H. A. Esch
O. M. Fave
R. M. Vini
R. C. Wals
J. W. Wolt

In 1977, we analyzed South Carolina ore products containing tremolite. A memo was issued on April 19 at the time of the analytical procedure and the analyses are attached.

Since then, various samples have been analyzed. The results are tabulated in Tables 1, 2 and 3.

The tremolite content of Libby ore has been monitored monthly since 1977. The results are shown in Figures 1 through 6. Only a sample was analyzed on October 1977. The results are shown in Table 4. The results for the size of Libby ore concentrates are shown in Table 5.

These data cover all Libby ore concentrates and Zonolite feeds and ore concentrates. The results are designated numbers in the reports and are kept in the library.

JCY/ph

Attachments

JUL 14 1983

Construction Products Division

DATE: July 13, 1983

SUBJECT: Tremolite Analysis in Grace Vermiculite Ore Concentrates and Zonolite Products

The content of all sizes of Libby and expanded vermiculites, and all Zonolite E. S. Wood's request. Two memos were respectively describing the analytical procedures and the analyses. Summarized tremolite

analyses were analyzed from time to time. The results are shown in Tables 1, 2 and 3.

The results for the size of Libby ore concentrates and ore concentrates were analyzed from 1977. The yearly plots of this data are shown in Figures 1 through 6. Only a sample was analyzed on October 1977. The results are shown in Table 4. The results for the size of Libby ore concentrates are shown in Table 5.

The results for the size of Libby ore concentrates and ore concentrates were analyzed from 1977. The yearly plots of this data are shown in Figures 1 through 6. Only a sample was analyzed on October 1977. The results are shown in Table 4. The results for the size of Libby ore concentrates are shown in Table 5.

Julie C. Yang

Julie C. Yang

15169914

Table 1

Tremolite Fiber Content of Zonolite Products Using Expanded L-1 & L-2

<u>Date</u>	<u>Reference</u>	<u>Material</u>	<u>Location</u>	(Z) <u>Tremolite Content</u>
(a)				
3/14/78	RFTS 69515 S	Attic Fill	W. Chicago	0.02
6/7/78	RFTS 69530	L-1	Hanna Furnace, Buffalo	0.013
8/19/80	RFTS 69622	CMC Coated L-1	Aldrich	.005
4/24/81	RFTS 69755	+14M, L-1	Weedsport	.56 ± 0.13*
6/25/81	RFTS 65538	SS L-1, + 14M Attic Ins. CMC Coated Uncoated		0.44 0.79
5/4/83	Memo to J. Wolter	L-1	Easthampton	.003
(b)				
2/27/79	RFTS 69545	Ind. L-2	Pyro Engineering, Ca.	.008
5/5/80	RFTS 67583	+14M Ind. L-2	W. Chicago	.002
	RFTS 67589	+14M Ind. L-2	Ventron, Alpha	.021
2/3/82	RFTS 69755	+14M, L-2	Weedsport	.10 ± 0.02*
5/4/83	Memo to J. Wolter	L-2	Easthampton	.002

* average value of 6 determinations

Table 2

Tremolite Fiber Content of Zonolite Products Using Expanded L-3 & L-4

<u>Date</u>	<u>Reference</u>	<u>Material</u>	<u>Location</u>	(X) <u>Tremolite Content</u>
(a)				
7/22/77	RFTS 50110	L-3	W. Chicago (0-18)	.076
3/1/78	RFTS 69512	L-3	W. Chicago	.0036
5/16/83	RFTS 67016	L-3	A. H. Hoffman	.002
8/7/78	RFTS 69534	Screened, + 14M L-3	J. D. Brush Co.	.010
5/4/83	Memo to J. Wolter	L-3	Easthampton	.001
(b)				
7/22/77	RFTS 50110	L-4	W. Chicago	.062
1/31/78	RFTS 67012	L-4	Agway, NJ	.032
1/31/78	RFTS 67013	L-4	Voluntary Purchasing Group, Texas	.006
4/28/78	RFTS 67015	L-4 Unscreened Unscreened	QC	.16 .003
5/16/78	RFTS 67016	L-4	Rockland Chemicals	.007
5/16/78	RFTS 67016	L-4	Sea Coat Lab Screened Unders	1.5
5/78	RFTS 67020	L-4	Dallas D-18 (dry) D-18 (wet)	.0099 .0025
1/19/79	RFTS 67026	L-4 Agricultural Grade	Wilder (D-18)	.039
2/27/79	RFTS 69544	L-4, Roof Deck	Gem Tel Bldg., CA	.61
3/6/79	RFTS 69543	L-4	Sinclair Paint Bldg., CA	0.15
5/8/83	Memo to J. Wolter	L-4	Easthampton	.002

Table 3

Tremolite Fiber Content in Monokote

<u>Date</u>	<u>Reference</u>	<u>Source</u>	<u>Analyst</u>
6/25/76	RFTS 49189 & A. D. Little	Santa Ana, CA Newark, CA	J. C. Yang* E. T. Peters
3/4/80	A. D. Little	Prudential Bldg. Morristown, N.J.	E. T. Peters
6/27/83	A. D. Little	Easthampton	E. T. Peters Confirmed Possible
7/11/83	A. D. Little	Trenton, Lot 2F1 Mt. Sinai "wipe- out" technique	E. T. Peters Found Estimated detection limit

* J. C. Yang has concentrated the tremolite containing fine portion by plaster of Paris binder burning off the cellulosic fiber and organic floatings off the vermiculite and submitted to ADL for electron micro

PRODUCT	CONCENTRATE GRADE	DATE OF LAST MSDS	TREMOLITE CONTENT (Z)		DATE OF TEST (Most Recent)
			PER MSDS	ACTUAL	
Attic Insulation	L-1	NA	NA	0.003	5/4/83
Agriculture	L-3	NA	NA	0.001	5/4/83
Agricultural	L-4	5/19/77	<0.5	0.002	5/4/83
Agricultural	SC-4	5/20/77	<5.0*	7.9	5/17/77
Concrete Aggregate	L-4	5/19/77	<0.5	0.002	5/4/83
Concrete Aggregate	SC-4	5/19/77	<5.0*	7.9	5/17/77
Dealer Concrete Aggregate	L-4	SEE CONCRETE AGGREGATES ABOVE			
Dealer Concrete Aggregate	SC-4	"	"	"	"
Industrial	L-1	6/10/77	<0.1	0.003	5/4/83
Industrial	L-2	6/10/77	<0.1	0.002	5/4/83
Industrial	L-3	6/10/77	<0.1	0.001	5/4/83
Industrial	L-4	7/19/77	<0.5	0.002	5/4/83
Industrial	SC-3	7/19/77	<5.0*	1.6	5/17/77
Industrial	SC-4	7/19/77	<5.0*	7.9	5/17/77
Masonry Insulation	L-3	5/19/77	<0.5	0.001	5/4/83
Masonry Insulation	L-4	5/19/77	<0.5	0.001	5/4/83
Masonry Insulation	SC-3	5/19/77	<5.0*	1.6	5/17/77
Monokote	MK-4 & 5 (L-3)	1/29/82	No Mention	0-20ppm 0-10ppm	7/11/83
Monokote	MK-5 (SC-3)	1/29/82	No Mention	NA	NA
Plaster Aggregate	L-3	NA	NA	0.001	5/4/83
Plaster Aggregate	SC-3	NA	NA	1.6	5/17/77
Terra-Lite	L-2	NA	NA	NA	NA
Terra-Lite	L-3	NA	NA	NA	NA
Terra-Lite	L-4	NA	NA	NA	NA

AIR SAMPLING DATA (f/cc)				WARNING LABEL			
TWA	MAX EXP	AVG MAX	DATE OF TEST (Most Recent)				
0.29	1.56	1.17	5/5/83	Caution: Dust/Ventilation/Respirator			
0.26	1.85	1.11	5/3/83				
NA	NA	NA	NA	"	"	"	"
0.10	0.72	0.20	6/8/83	"	"	"	"
NA	NA	NA	NA	"	"	"	"
0.06	0.13	0.07	3/17/83	"	"	"	"
0.02	0.14	NA	5/12/77	"	"	"	"
NA	NA	NA	NA	"	"	"	"
NA	NA	NA	NA	"	"	"	"
NA	NA	NA	NA	"	"	"	"
0.04	0.06	0.04	6/1/83	"	"	"	"
0.06	0.22	0.12	6/1/83	"	"	"	"
NA	NA	NA	NA	"	"	"	"
NA	NA	NA	NA	"	"	"	"
NA	NA	NA	NA	"	"	"	"
0.08	0.83	0.63	4/27/83	"	"	"	"
0.02	0.33	0.13	6/27/83	"	"	"	"
0.03	0.21	NA	5/12/77	"	"	"	"
0.01	0.09	0.04	4/26/83	"	"	"	"
≤0.10	≤0.25	NA	5/12/77	"	"	"	"
NA	NA	NA	NA	"	"	"	"
NA	NA	NA	NA	"	"	"	"
NA	NA	NA	NA	"	"	"	"
0.10	0.82	0.19	6/20/83	"	"	"	"
0.10	0.72	0.20	6/20/83	"	"	"	"

GRACE

Construction Products Division

re all
of

TO: J. W. Volter

DATE: May 4, 1983

c of:

FROM: R. C. Howard

SUBJECT: Tremolite Content in
Expanded Vermiculite

ghouse

CC: H. C. Duecker
R. C. Ericson
R. C. Walsh
J. C. Yang
File: 1000

pped
for
oner
is

Introduction:

This memorandum is being issued in response to your verbal request for quantitative tremolite determination in our expanded Libby products. Samples L-1, L-2, L-3, and L-4 were received in four cubic foot bags from Easthampton and the L-5 sample in a five gallon bucket from Libby. Each sample was quartered using a large plastic sheet until portions weighing 1500.00 g or more were obtained. Samples so obtained were separated on the basis of density using:

- a. Water floatation to separate the bulk of the expanded vermiculite from any heavy particles or "sink",
- b. Heavy liquid (density = 2.7 g/mL) to further separate any vermiculite fines from the sink.

After separation both fractions were dried and reweighed. The sink portions were then pulverized for quantitative analysis of their tremolite contents via X-ray Diffraction.

Results:

The mean tremolite content, based upon duplicate analyses for each sample, have been summarized in Table 1.

Table 1 - Mean Tremolite Content of Expanded Vermiculite

<u>Sample</u>	<u>Wt. % Tremolite Content</u>
L-1	0.003
L-2	0.002
L-3	0.001
L-4	0.002
L-5*	0.04

*based on only one determination.

15169920

Comments:

As seen
in the
L-5.

I suspect

a.

b.

Material
with a
two rem
rem
conc

Ref

Table 1 the total tremolite contents of these samples are all
of 0.001 - 0.003% or ten to 30 ppm with the exception of

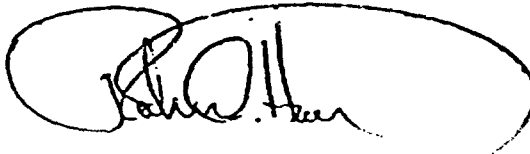
difference between L-5 and the others to be a result of:

tion of L-5 at Libby in an assay furnace without baghouse
of airborne tremolite,

ating the expanded product to stoner treatment.

Easthampton is done in a Model A furnace equipped
stoner. As such tremolite levels are reduced for
house isolates airborne tremolite while the stoner
portion of heavy particle in which tremolite is

14-23
52-18
1000-242.



R. C. Howard

RCH:j

15169921

To: E.S.Wood
From: J.C.Yang
Date: May 16, 1977

Tremolite & Vermiculite Content
in Libby & Kearney Ore Deposits
and Expanded Vermiculite

TABLE 2

Tremolite Content of Expanded Vermiculite

<u>ID No.</u>	<u>Description</u>	<u>Date Collected</u>	<u>% Vermiculite</u>	<u>% Tremolite</u>
99952-39	L-1	3/18/77	97.7	0.074
99952-40	L-2	3/18/77	97.1	0.028
99952-48	L-3	3/9/77	97.7	0.049
99952-41	K-3	3/3/77	91.0	1.6*
99952-42	K-4	3/3/77	79.4	7.9*
99952-43	K-5	3/3/77	48.7	interference

*Includes all amphibole minerals.

15169922

CONFIDENTIAL

To: L. S. W.
From: J. C. Yang
April 20, 1977

Tremolite Content
in ZONOLITE® Products
Page 3

Libby

ID No.	Description	% Tremolite
10		< 0.10
6	Chicago	0.01
19	Chicago	0.035
25	W. Chicago	.013
28	anta Ar (s rec'd)	.031 (dried) .051
14		< 0.02
15		(s rec'd) 0.034 (dried) <.043
12	go	< 0.007
3	Chicago	0.344
16	(L)	W 0.009
22	(L) L	< 0.009

B. Tremolite Libby Job- Site Samples

ID No.	Description	Location	% Tremolite
8	(5 B)	Montgomery, Ala.	2.828
9		Columbus, Ohio	0.050
28		Forest Service, Santa Ar	0.031 (.05)
51		San Diego	< 0.106
54		W. Palm Beach, Fla.	2.86
55		Edison, Miami, Fla.	0.476
58		Masfurn & Coe Bldg., Oklahoma	0.250
57		Hyatt Regency, Dallas	0.240

dried base

GRACE

Construction Products Division

03653583

TO: H. C. Duecker

DATE: July 13, 1983

FROM: J. C. Yang

SUBJECT: Tremolite Analysis in
Grace Vermiculite Ore
Concentrates and
Zonolite Products

CC: R. J. Bettacchi

J. A. Danneker

R. C. Ericson

H. A. Eschenbach

O. M. Favorito

R. M. Vining

R. C. Walsh

J. W. Wolter

In 1977, we analyzed the tremolite content of all sizes of Libby and South Carolina ore, concentrates, expanded vermiculites, and all Zonolite products containing vermiculite at E. S. Wood's request. Two memos were issued on April 19 and May 16, 1977 respectively describing the analytical procedure and the results of these analyses. Summarized tremolite analyses are attached with this memo.

Since then, various Zonolite products were analyzed from time to time. The results are tabulated by product in Tables 1, 2 and 3.

The tremolite content of Libby head feeds and ore concentrates were monitored monthly since October 1977. The yearly plots of this data are shown in Figures 1 through 5, and a running plot of each size is given in Figure 6. Only a few sets of ore concentrates were analyzed prior to October 1977. The results and analysis, other than monthly composites, are shown in Table 4. Yearly averages of the tremolite content of each size of Libby ore concentrates are tabulated in Table 5.

These data cover all the analyses of tremolite fibers in Libby ore concentrate and Zonolite products to date. The analyses of Libby head feeds and ore concentrates were reported under individual RFTS' with designated numbers in the block of 675XX to 68499. These reports are kept in the library.

Julie C. Yang
Julie C. Yang

JCY/ph

Attachments

15054727

08653584

Table 1

Tremolite Fiber Content of Zonolite Products Using Expanded L-1 & L-2

<u>Date</u>	<u>Reference</u>	<u>Material</u>	<u>Location</u>	(2) <u>Tremolite Content</u>
(a)				
3/14/78	RFTS 69515 S	Attic Fill	W. Chicago	0.02
6/7/78	RFTS 69530	L-1	Hanna Furnace, Buffalo	0.013
8/19/80	RFTS 69622	CMC Coated L-1	Aldrich	.005
4/24/81	RFTS 69755	+14M, L-1	Weedsport	.56 ± 0.13*
6/25/81	RFTS 65538	SS L-1, + 14M Attic Ins. CMC Coated Uncoated		0.44 0.79
5/4/83	Memo to J. Wolter	L-1	Easthampton	.003
(b)				
2/27/79	RFTS 69545	Ind. L-2	Pyro Engineering, Ca.	.008
5/5/80	RFTS 67583	+14M Ind. L-2	W. Chicago	.002
	RFTS 67589	+14M Ind. L-2	Ventron, Alpha	.021
2/3/82	RFTS 69755	+14M, L-2	Weedsport	.10 ± 0.02*
5/4/83	Memo to J. Wolter	L-2	Easthampton	.002

* average value of 6 determinations

15054728

03053585

Table 2

Tremolite Fiber Content of Zonolite Products Using Expanded L-3 & L-4

<u>Date</u>	<u>Reference</u>	<u>Material</u>	<u>Location</u>	(Z) <u>Tremolite Content</u>
(a)				
7/22/77	RFTS 50110	L-3	W. Chicago (0-18)	.076
3/1/78	RFTS 69512	L-3	W. Chicago	.0036
5/16/83	RFTS 67016	L-3	A. H. Hoffman	.002
8/7/78	RFTS 69534	Screened, + 14M L-3	J. D. Brush Co.	.010
5/4/83	Memo to J. Wolter	L-3	Easthampton	.001

(b)				
7/22/77	RFTS 50110	L-4	W. Chicago	.062
1/31/78	RFTS 67012	L-4	Agway, NY	.032
1/31/78	RFTS 67013	L-4	Voluntary Purchasing Group, Texas	.008
4/28/78	RFTS 67015	L-4 Unscreened Unscreened	QC	.16 .003
5/16/78	RFTS 67016	L-4	Rockland Chemicals	.007
5/16/78	RFTS 67016	L-4	Sea Coat Lab Screened Unders	1.5
5/78	RFTS 67020	L-4	Dallas D-18 (dry) D-18 (wet)	.0099 .0025
1/19/79	RFTS 67026	L-4 Agricultural Grade	Wilder (D-18)	.039
2/27/79	RFTS 69544	L-4, Roof Deck	Gem Tel Bldg., CA	.61
3/6/79	RFTS 69543	L-4	Sinclair Paint Bldg., CA	0.15
5/8/83	Memo to J. Wolter	L-4	Easthampton	.002

15054729

03653586

Table 3Tremolite Fiber Content in Monokote

<u>Date</u>	<u>Reference</u>	<u>Source</u>	<u>Analyst</u>	<u>Tremolite Content</u>
6/25/76	RFTS 49189 & A. D. Little	Santa Ana, CA Newark, CA	J. C. Yang* E. T. Peters	<1.7 ppm <4.1 ppm
3/4/80	A. D. Little	Prudential Bldg. Morristown, N.J.	E. T. Peters	<1 ppm
6/27/83	A. D. Little	Easthampton	E. T. Peters Confirmed Possible	1-3 ppm 7-30 ppm
7/11/83	A. D. Little	Trenton, Lot 2F1 Mt. Sinai "wipe- out" technique	E. T. Peters Found Estimated detection limit	none 10 ppm

* J. C. Yang has concentrated the tremolite containing fine portion by dissolving the plaster of Paris binder burning off the cellulosic fiber and organic matters and floatings off the vermiculite and submitted to ADL for electron microscopic analysis.

15054730

Re Pipe: Control of Low Use Concentration for Chlorinated Composites (1976-1981)

Date	2/23/76	1/7/77	3/9/77	6/20/77	10/77	11/77	3/1/78	7/31/80	6/25/81	2/9/82	2/1/83
Reference (RFTS NO)	Memo to HCD	49974	-----	67969	67631	67631-5	67631-5 67643	69408	69338	67916	67916
Size	1.92	1.2	2.12	2.6	2.0	2.18	-----	SS, + 14M SS, + 14M CNC Coated	1.24	1.02	1.02
L-1	4.97	2.5	2.96	3.5	2.91	2.34	-----	SS, + 14M SS, + 14M CNC Coated	0.79	0.44	0.44
L-2	0.65	0.7	0.28	0.7	0.94	0.60	0.34	SS, + 14M SS, + 14M CNC Coated	1.45	1.21	1.21
L-3	0.76	1.7	0.38	0.9	0.74	0.56	-----	-----	0.45	0.37	0.37
L-4	3.71	3.0	3.52	-----	-----	-----	-----	-----	0.51	0.06	0.06
L-5									0.34	0.11	0.11

03653587

15054731

03654588

Table 5Yearly Average of Tremolite Analysis of Libby Ore Concentrate

<u>Size/Year</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>
L-1	1.47	1.08	1.26	1.35	1.19
L-2	1.71	1.71	1.96	1.84	1.63
L-3	.46	.57	.82	.52	.38
L-4	.28	.48	.66	.30	.26
L-5	1.10	1.55	2.03	.54	.36

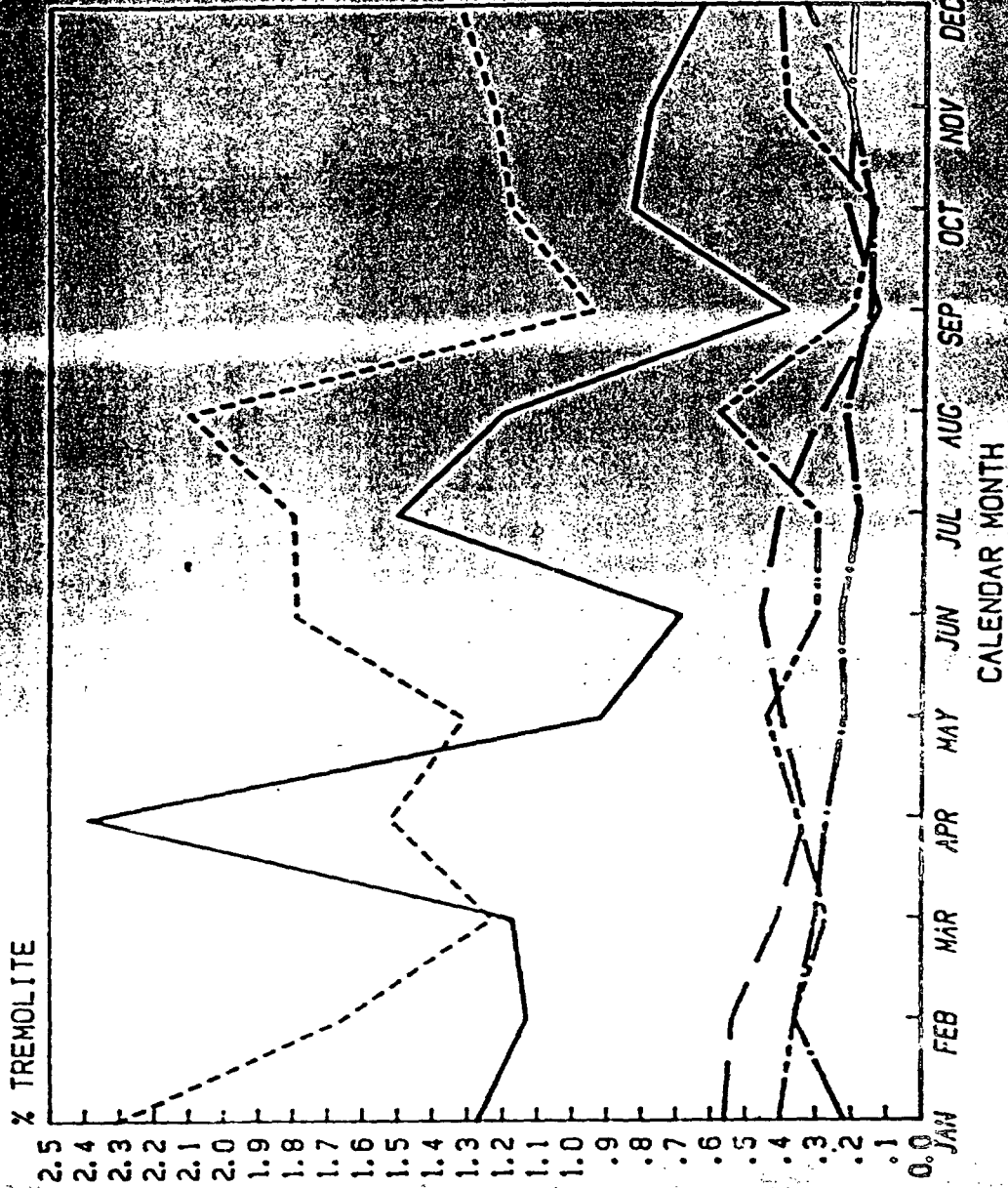
15054732

03653589

Figure 1

TREMOLITE ANALYSIS OF ORE CONC.

1982



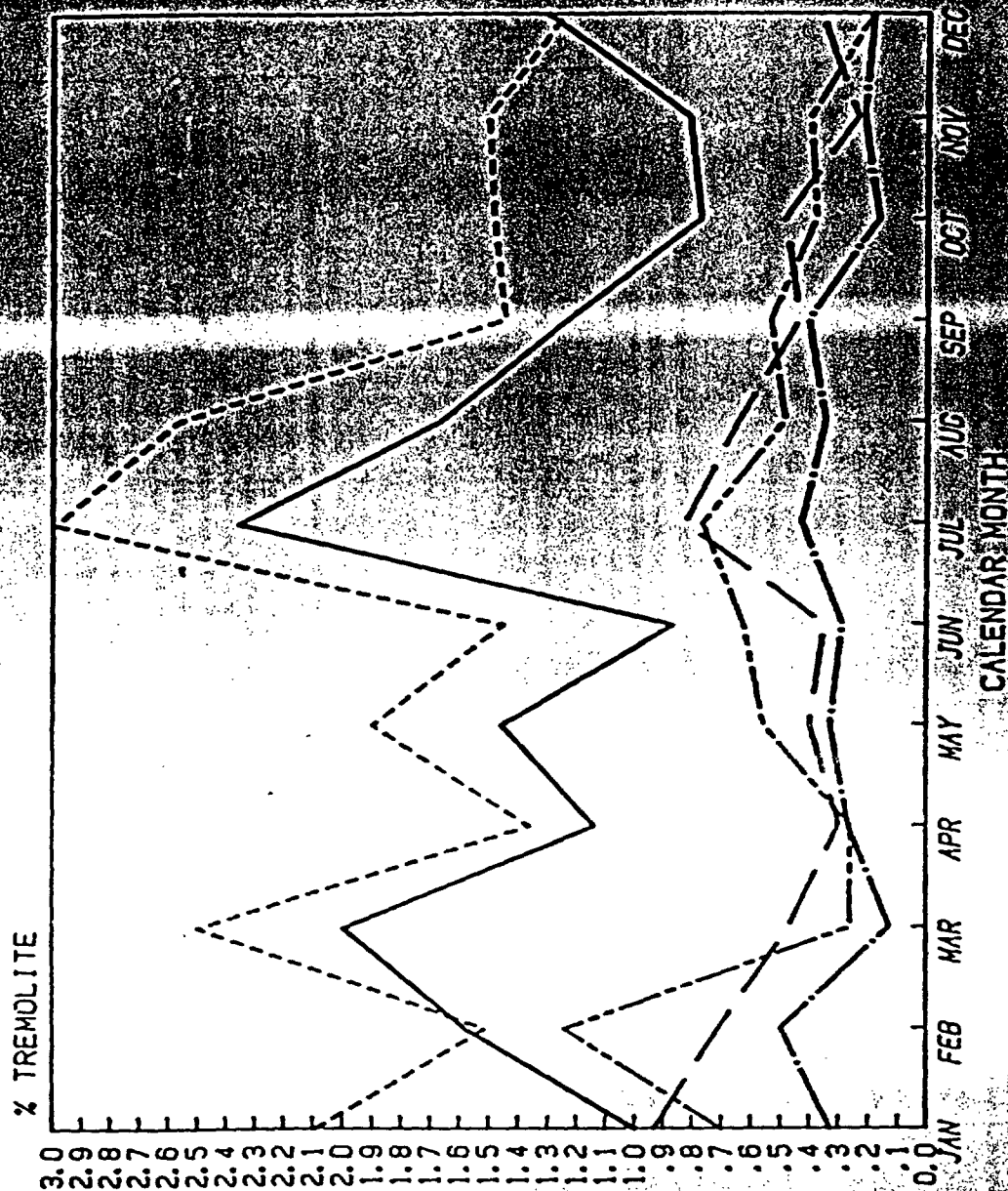
L-1
L-2
L-3
L-4
L-5

15054733

Figure 2

TREMOLITE ANALYSIS OF ORE CONC.

1981

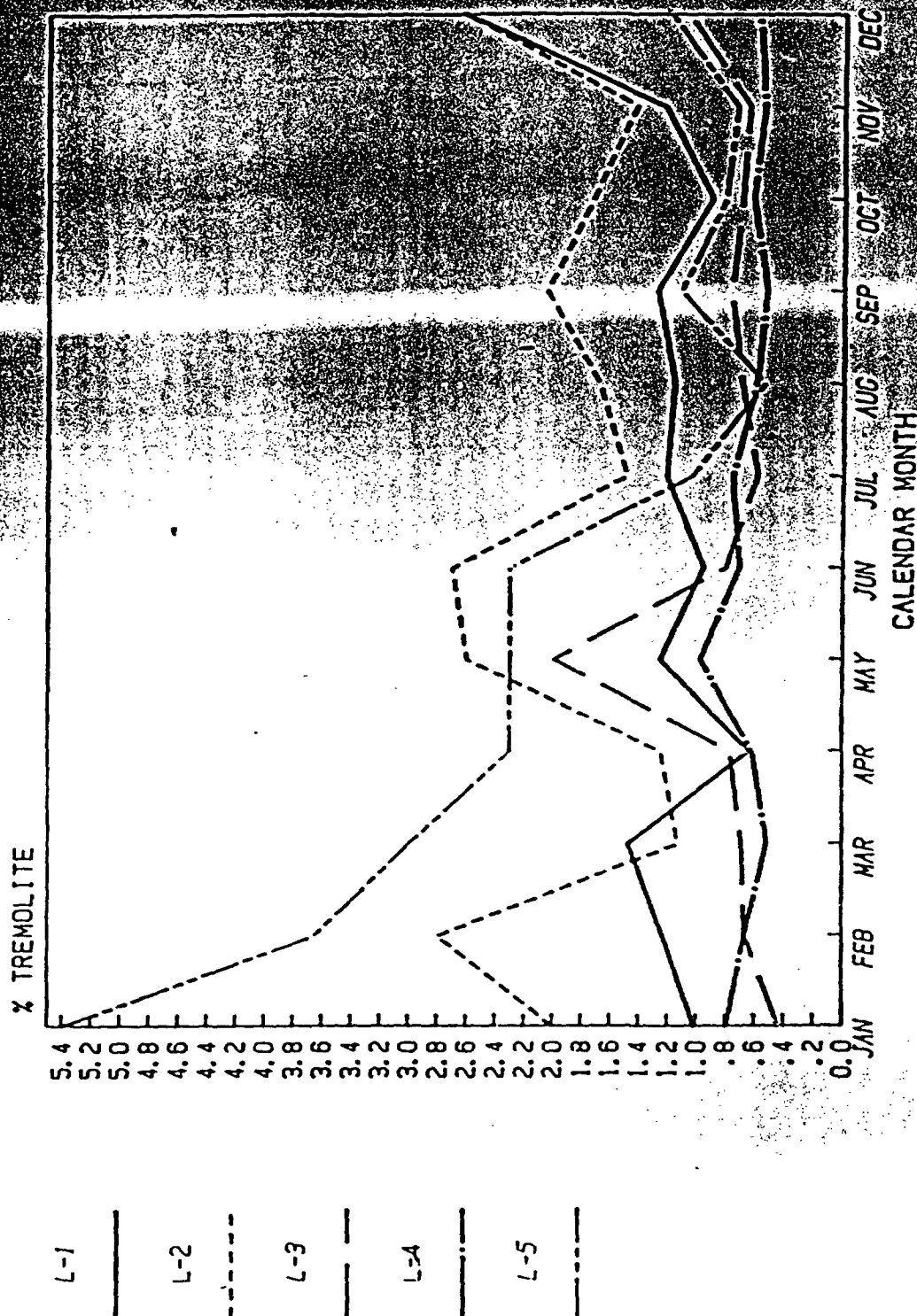


15054734

Figure 3

TREMOLITE ANALYSIS OF ORE CONC.

1980



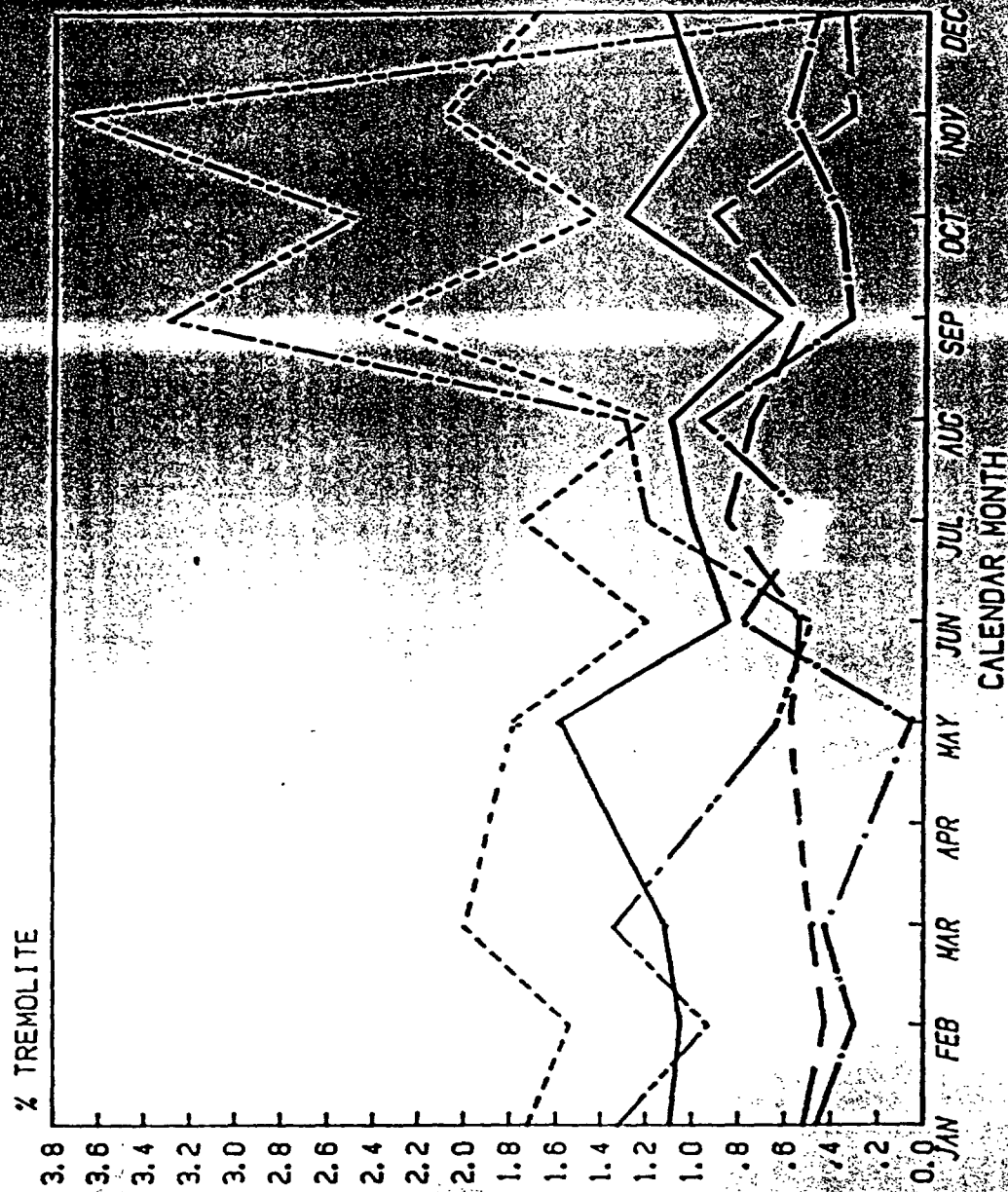
15054735

03653591

Figure 4

TREMOLITE ANALYSIS OF ORE CONC.

1979

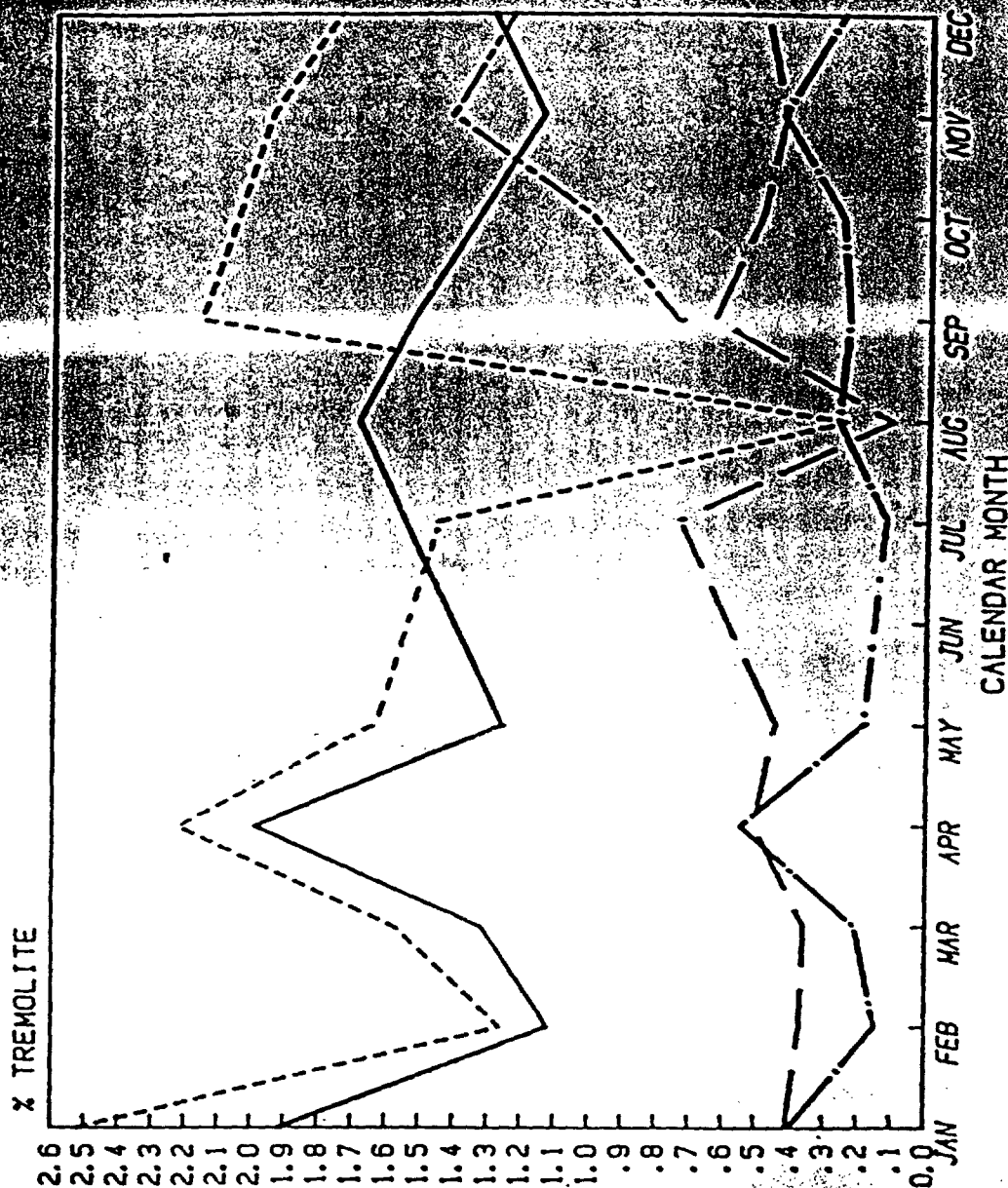


15054736

02653592

Figure 5

TREMOLITE ANALYSIS OF ORE CONC. 1978



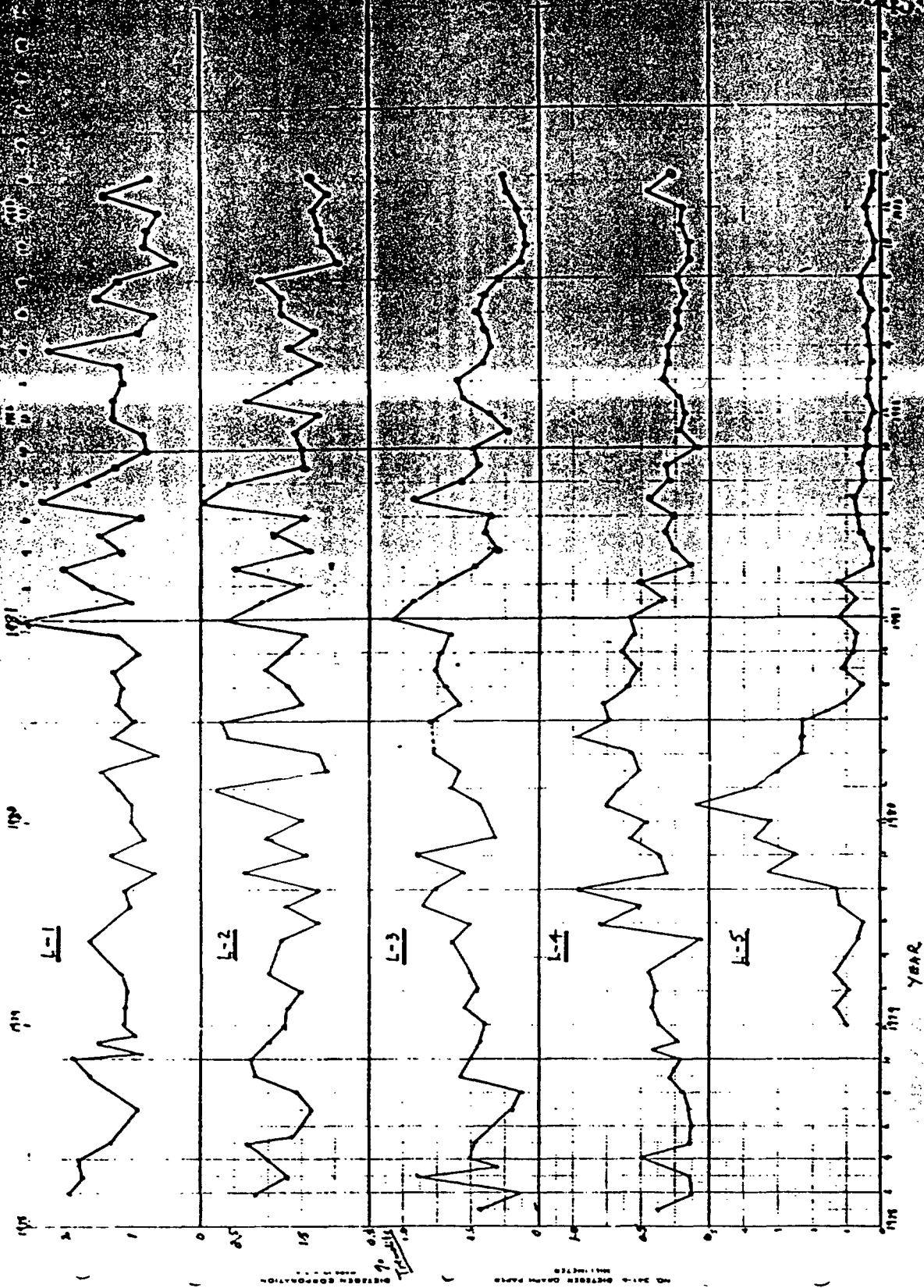
L-1 —
L-2 - - -
L-3 - · -
L-4 · · ·
L-5 - - -

15054737

03653393

PERMITS TO CONCENTRATE URINE CONCENTRATION

03653590



JCYANG
7/7/83

To: E.S. Hoon
 From: J.C. Yang
 Date: May 16, 1977

Tremolite & Vermiculite Content
 in Libby & Kearney Ore Concentrate
 and Expanded Vermiculite

TABLE 1

Tremolite Content of Ore Concentrate

03653595

<u>ID No.</u>	<u>Description</u>	<u>Date</u>	<u>% Vm.</u>	<u>% Tremolite</u>	<u>% Total Tremolite*</u>
-31	L-1	3/10/77	<u>91.7</u>	(+50M) 1.2 (-50M) .005	<u>1.2</u>
-32	L-2	3/10/77	<u>91.2</u>	(+50M) 2.5 (-50M) .018	<u>2.5</u>
-33	L-3	3/10/77	<u>78.1</u>	(+50M) .653 (-50M) .013	<u>0.7</u>
-34	L-4	3/1/77	<u>70.1</u>	(+70M) 1.495 (-70 +100M) .232 (-100M) .009	<u>1.7</u>
-35	L-5	3/1/77	<u>63.9</u>	(+70M) .119 (-70 +100M) 1.016 1.913	<u>3.0</u>
-36	K-3	3/1/77	<u>72.0</u>	(+50M) 1.60 (-50M) .158	<u>1.8</u>
-37	K-4	3/1/77	<u>75.1</u>	(+70M) 8.903 (-70 +100M) .554 (-100M) .492	<u>10.0</u>
-38	K-5	3/1/77	<u>76.6</u>	(+70M) 0.874 (-70 +100M) 2.070 (-100M) 13.034	<u>15.9</u>
-46	Head Feed, Libby	3/9/77	<u>7.0</u> **	(+6M) 1.302 (-6 +20M) .684 (-20 +70M) 1.235 (-70M) .609	<u>3.8</u>

* Includes all amphibole minerals.

** The material floated after expanded with 30% H₂O₂.

15054739

CONFIDENTIAL

To: E.S. Wood
From: J.C. Yang
Date: May 16, 1977

Tremolite & Vermiculite Content
in Libby & Kearney Ore Deposits
and Expanded Vermiculite

TABLE 2

Tremolite Content of Expanded Vermiculite

03653596

<u>ID No.</u>	<u>Description</u>	<u>Date Collected</u>	<u>% Vermiculite</u>	<u>% Tremolite</u>
99952-39	L-1	3/18/77	97.7	0.074
99952-40	L-2	3/18/77	97.1	0.028
99952-48	L-3'	3/9/77	97.7	0.049
99952-41	K-3	3/3/77	91.0	1.6*
99952-42	K-4	3/3/77	79.4	7.9*
99952-43	K-5	3/3/77	48.7	interference

* Includes all amphibole minerals.

CONFIDENTIAL

15054740

03653597

To: E. S. Wood
 From: J. C. Yang
 April 20, 1977

Tremolite Content
 in ZONOLITE® Products
 Page 3

Libby

<u>ID No.</u>	<u>Product Description</u>	<u>% Tremolite</u>
10	MK-4 (L-3) West Chicago	< 0.10
6	Masonry Fill (L&D-18) West Chicago	0.01
19	Terra-Lite, W. Chicago	0.035
25	Attic Fill (L-2) W. Chicago	.013
28	Redi-Earth (L) Santa Ana (as rec'd)	.031 (dried) .051
14	Redi-Earth (L) W. Chicago	< 0.02
15	Metro-Mix 200 (L) W. Chicago (as rec'd)	0.034 (dried) < .043
12	Zonolite 3300 (L-3) W. Chicago	< 0.007
3	Concrete Aggregate (L&D-18) W. Chicago	0.344
16	Scott Turf Builder (L) Dark	0.009
22	Scott Turf Builder (L) Light	< 0.009

B. Tremolite Content in Zonolite Job-site Samples

<u>ID No.</u>	<u>Product Description</u>	<u>Location</u>	<u>% Tremolite</u>
8	ZK Roof Deck (K 4/5 B)	Montgomery, Ala.	2.828
9	Masonry Fill (K-3)	Columbus, Ohio	0.050
28	Redi-Earth (L-4)	Forest Service, Santa Ana	0.031 (.051)*
51	Monokote-5 (L-3)	San Diego	< 0.106
54	Masonry Fill (K-4)	W. Palm Beach, Fla.	2.86
55	ZIC (K-4)	Edison H.S., Miami, Fla.	0.476
58	Masonry Fill (L-3)	Mashburn & Coe Bldg., Oklahoma	0.250
57	Monokote-4 (L-3)	Hyatt Regency, Dallas	0.240

*oven-dried basis

15054741

1441