

Airborne Asbestos Exposure from Gooch Fiber Use

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KEYWORDS

Anthophyllite, fiber release, gravimetric analysis, polarized light microscopy, phase contrast microscopy, Powhatan Mining Company (Powminco), scanning electron microscopy, transmission electron microscopy, tremolite, X-ray diffraction

ABSTRACT

Microscopical tests, including polarized light microscopy (PLM), phase contrast microscopy (PCM), scanning electron microscopy (SEM) and transmission electron microscopy (TEM) were used along with X-ray diffraction (XRD) in the characterization and testing of a laboratory-grade “Gooch fiber” asbestos sample. The sample was tested for possible fiber release during typical use as a substrate for gravimetric analysis methods. While preparing substrates, the concentrations of airborne asbestos fibers greater than 5 micrometers in length were approximately one fiber per cubic centimeter of air.

INTRODUCTION

In 1878, Francis A. Gooch first proposed the use of asbestos as a “felt” or “mat” for the purposes of gravimetric analysis (1). The process of collecting chemical precipitates from a known volume of liquid, drying the precipitates in an oven and weighing them was nothing new, but the use of asbestos was novel and clearly superior in accuracy to the alternative filter papers, sand filters and porous cones. By the early

1900s, laboratory-grade asbestos (Gooch fiber) used for this and other laboratory methods was imported regularly from Italy. However, in 1916, with the Great War in full swing, the United States was no longer in a position to import laboratory-grade asbestos materials from Italy due to a lack of available ships (2). Companies like the Powhatan Mining Corporation (Powminco) started their own mining operations with aspirations to develop a product worthy of replacing the Italian amphibole. Eventually, Powminco Gooch fiber was sold by several major chemical distributors, including J.T. Baker Chemical Company, Fisher Scientific Company, and Baker and Adamson General Chemical Company. This paper presents the results of a study of asbestos fiber release during the preparation of six Gooch-style asbestos filter mats, which were prepared using an amphibole blend of Powminco Gooch Filter Fiber distributed by J.T. Baker (Figures 1 and 2).

MATERIAL CHARACTERIZATION AND IDENTIFICATION OF ASBESTOS FIBERS

The Powminco Gooch Filter Fiber sample was initially examined under an Olympus SZ-40 stereomicroscope at magnifications ranging from 7x to 40x. Portions of the particulate found were mounted in Cargille refractive index liquids and analyzed with an Olympus BH-2 polarized light microscope with magnification ranging from 100x to 1,000x. The PLM analysis followed the analytical procedures recommended by the U.S. Environmental Protection Agency (EPA) (3). The PLM results for asbestos are given in terms of percent by volume.

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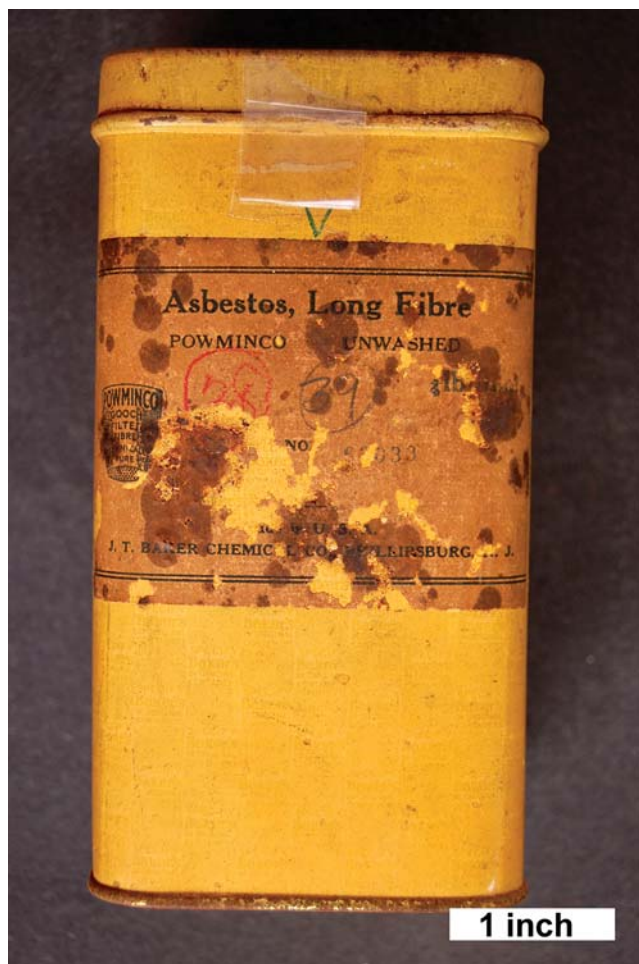


Figure 1. A square can of J.T. Baker Chemical Co. Powminco Gooch Filter Fiber described as “unwashed,” “long fibre” asbestos.

Quantitative XRD analysis of the sample was provided by DCM Science Laboratory, Inc. in Wheat Ridge, Colorado, by scanning over a range of 3° to 45° 2θ using 40kV, 25mA Cu $K\alpha$ radiation. Mineral phases were identified with the aid of computer-assisted programs accessing a CD-ROM powder diffraction database. Mineral concentrations were based on relative peak heights and reference intensity ratios.

The sample was also analyzed by scanning electron microscopy/energy dispersive X-ray spectrometry (SEM/EDS). A representative subsample of fibers was transferred via forceps onto adhesive carbon tabs and then examined with a JEOL JSM-6490LV scanning electron microscope equipped with a Thermo Scientific Noran System SIX energy dispersive X-ray spectrometer.

In addition, the sample was examined by analytical electron microscopy (AEM) using a Philips CM120



Figure 2. Macro image of Powminco fibers from can in Figure 1. Ruler is in inches.

transmission electron microscope capable of selected area electron diffraction (SAED) and equipped with an Oxford INCA energy dispersive spectrometry (EDS) X-ray analysis system. For TEM analysis, fibers from the sample were dispersed in acetone, and an aliquot of the suspension was transferred to a TEM grid using direct preparation procedures. Twenty fibers from random grid openings were characterized.

AIRBORNE FIBER ANALYSIS

During the experiment, the released particles were collected with standard air filter cassettes. These filters and two additional blank filters were analyzed by PCM using NIOSH Method 7400 (4). Two samples (one air sample and one blank) were also analyzed by TEM using NIOSH Method 7402 (5). An air sample collected before the testing events was analyzed by a more sensitive TEM procedure following the EPA AHERA method (6).

STUDY SITE

The study was conducted in a specially built test chamber at MVA's facility in Duluth, Georgia. The test chamber work area was approximately 9 feet high by 10 feet wide by 12 feet long. The study area had a high-efficiency particulate absolute (HEPA) air filtration device that was used to clean the area of particulate, including asbestos, before the testing activities began. The HEPA unit ran at a low flow rate (approximately 45 cubic feet per minute) during the testing. While inside the test chamber, a certified industrial hygienist (CIH) performed the work wearing a respirator and a protective head and body suit.

Table 1. Summary Sample Information and Asbestos Analysis Results

| MVA Sample ID | Description | PLM Analysis Results | SEM Analysis Results | TEM Analysis Results |
|---------------|------------------------------|--|-----------------------------------|-----------------------------|
| U1011 | J.T. Baker Powminco Asbestos | 98% Tremolite/Actinolite, Possible Anthophyllite | Tremolite and Anthophyllite/Talc* | Tremolite and Anthophyllite |

*SEM/EDS alone cannot discriminate between anthophyllite and talc fibers.

Table 2. Results of X-ray Diffraction Analysis, DCM Sciences (% by Weight)

| Phase | J.T. Baker Powminco Asbestos |
|---------------|------------------------------|
| Tremolite | 63% |
| Anthophyllite | 31% |
| Lizardite | 2% |
| Unaccounted | <5% |

STUDY DESIGN

This study for possible fiber release involved the transfer of asbestos fibers from the original container into shallow metal pans using a pair of large forceps. Once enough material was collected to essentially cover the bottom of a pan, the contents of that pan were pressed by hand to form a mat. Prior to the testing, an air sample was collected within the test chamber for 32 minutes at a flow rate of 10 liters per minute.

Personal and area air samples were collected during the activities. The personal air samples on the CIH in the test chamber were collected at approximately 2.0 and 1.5 liters per minute. The area air sample approximately 5 feet from the activity was collected at 10.0 liters per minute. All the samples were collected for 6 minutes.

The test was videotaped. During certain portions of the test, the lighting approximated Tyndall lighting and was used to improve the visibility of suspended particles in the air in the containment chamber. The light was placed outside the room.

RESULTS

Table 1 shows a summary of the bulk analyses. The Powminco sample contains approximately 98% amphibole asbestos (tremolite/actinolite and possible anthophyllite) as determined by PLM analysis. The remaining trace (<1%) to 2% consists of talc and rust particles, most likely from the container. Bulk XRD analy-

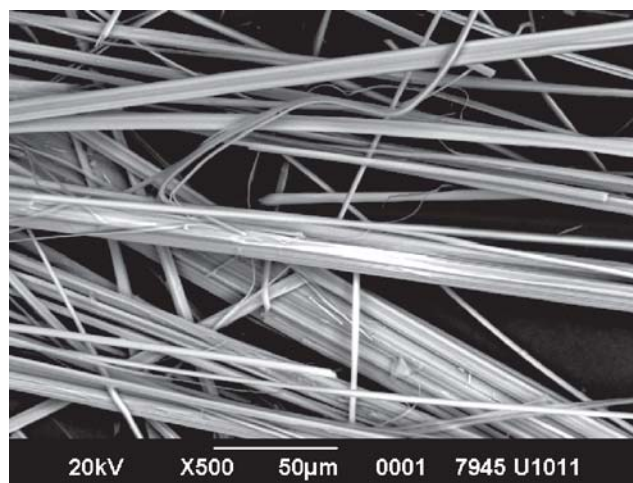


Figure 3. Secondary electron SEM image of asbestiform fibers in Powminco sample.

sis reports a composition of 63% tremolite, 31% anthophyllite, 2% lizardite, and <5% unknown (Table 2). SEM results are useful in representing the asbestiform nature of the sample, which is characterized by long, thin, flexible fibers (Figure 3). Fibers consistent in elemental composition with tremolite (Figures 4 and 5) and anthophyllite/talc¹ (Figures 6 and 7) were identified by SEM/EDS. TEM/SAED/EDS

¹Analytical results from SEM data cannot be used to discriminate between anthophyllite and talc due to similarities in chemical composition. TEM analysis with SAED capabilities are recommended for confirmation.

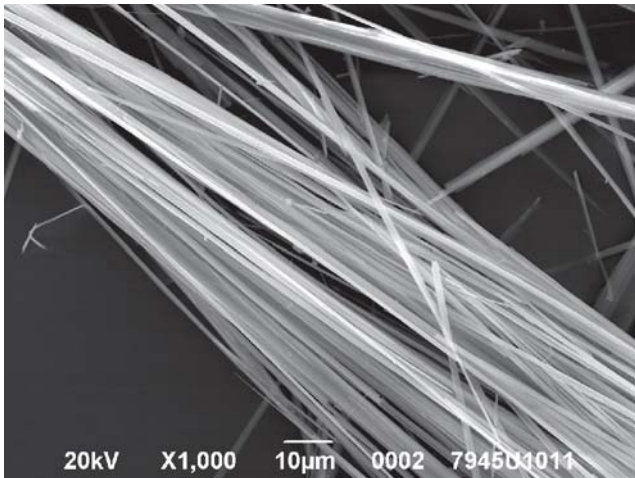


Figure 4. Secondary electron SEM image of a fiber bundle consistent with tremolite asbestos.

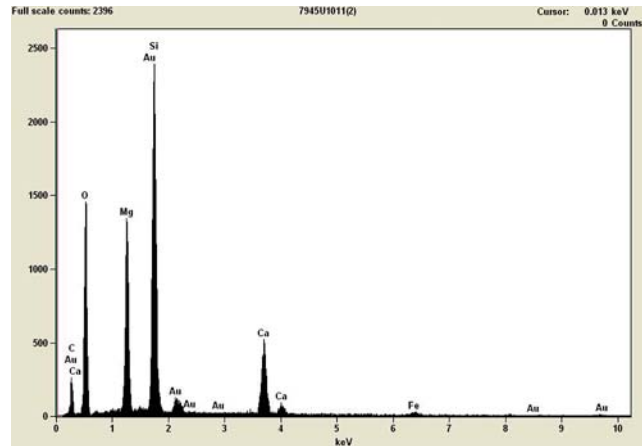


Figure 5. SEM/EDS X-ray spectrum of the tremolite fiber shown in Figure 4.

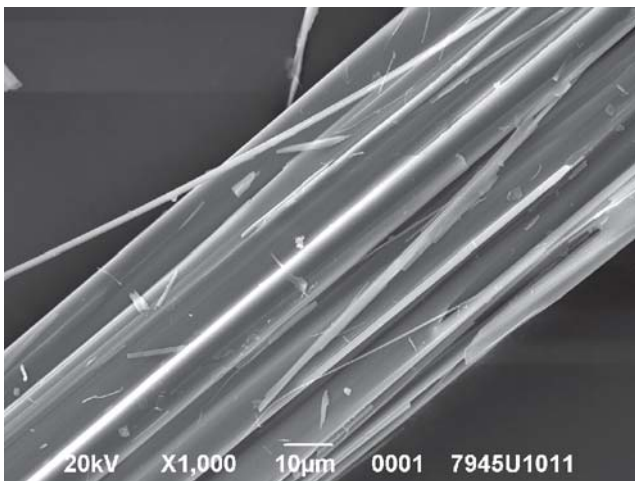


Figure 6. Secondary electron SEM image of a fiber bundle consistent with anthophyllite/talc.

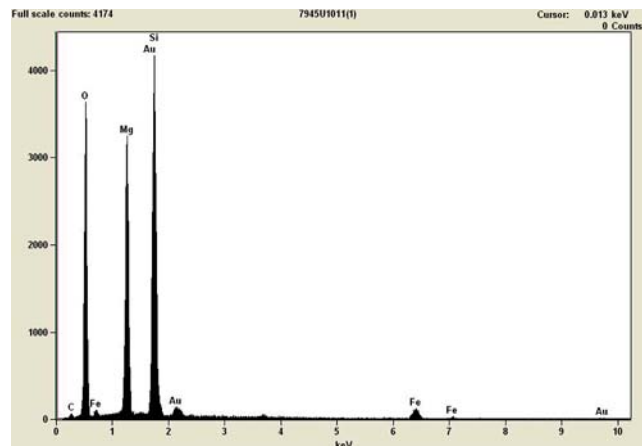


Figure 7. SEM/EDS X-ray spectrum of the anthophyllite/talc fiber shown in Figure 6.

analysis confirmed the presence of both anthophyllite and tremolite asbestos. Asbestos fiber size information observed by TEM is provided in Table 3. Within the first 20 fibers observed, aspect ratios (length:width) ranged from 11:1 to 127:1 with an average width of 0.9 micrometers.

Figures 8 and 9 (see page 170) are captured images from a video of the fiber release study. The fiber levels (PCM) in the personal air samples ranged from 1.0 to 1.2 fibers per cubic centimeter (F/cc) and were below the PCM limit of detection (0.04 F/cc) in the area air sample. The data are shown in Table 4 (see page 170). The TEM NIOSH 7402 analysis of personal air sample W0631 showed that 93% of the PCM size fibers collected in the personal air samples

were asbestos. No asbestos was detected in the blank sample or in the sample collected in the chamber before the study.

CONCLUSIONS

The Powminco Gooch Filter Fiber asbestos sample contains both anthophyllite and tremolite asbestos fibers as determined by the combination of PLM, SEM/EDS, TEM/SAED/EDS and XRD techniques. Asbestos fibers are released into the breathing zone of the worker during the preparation of Gooch filter mats at levels of approximately 0.9 to 1.1 asbestos fibers per cubic centimeter, based on personal air sample analyses.

Table 3. TEM Amphibole Asbestos Fiber Data

| Structure No. | Length μm | Width μm | Aspect Ratio | Asbestos Type |
|---------------|----------------------|---------------------|--------------|---------------|
| 1 | 66.7 | 1.73 | 39 | Tremolite |
| 2 | 4.7 | 0.08 | 59 | Anthophyllite |
| 3 | 4.2 | 0.16 | 26 | Tremolite |
| 4 | 43.6 | 1.03 | 42 | Tremolite |
| 5 | 29.2 | 0.41 | 71 | Anthophyllite |
| 6 | 10.7 | 0.25 | 43 | Anthophyllite |
| 7 | 16.0 | 0.74 | 22 | Anthophyllite |
| 8 | 35.0 | 0.95 | 37 | Tremolite |
| 9 | 2.7 | 0.12 | 23 | Anthophyllite |
| 10 | 87.7 | 3.79 | 23 | Tremolite |
| 11 | 15.2 | 0.12 | 127 | Anthophyllite |
| 12 | 11.7 | 0.49 | 24 | Anthophyllite |
| 13 | 20.6 | 0.25 | 82 | Tremolite |
| 14 | 32.1 | 0.62 | 52 | Anthophyllite |
| 15 | 8.2 | 0.21 | 39 | Tremolite |
| 16 | 76.1 | 1.23 | 62 | Tremolite |
| 17 | 88.5 | 0.95 | 93 | Tremolite |
| 18 | 12.3 | 1.15 | 11 | Tremolite |
| 19 | 55.6 | 2.88 | 19 | Tremolite |
| 20 | 96.7 | 1.65 | 59 | Tremolite |

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Figure 8. Transfer of fibers during experiment from original container to metal pan.



Figure 9. Pressing the fibers by hand to form a filter mat, with Tyndall lighting to show particles present in the air.

Table 4. Results of Air Sample Analysis: Preparation of Six Gooch Asbestos Filter Mats

| MVA ID | Description | Duration Minutes | Volume Liters | 7400 Fibers/cc | 7402 % Asbestos | AHERA Structures/cc |
|--------|------------------------|------------------|---------------|----------------|-----------------|---------------------|
| W0629 | Chamber Before Testing | 32 | 320 | NA | NA | NSD <0.01* |
| W0630 | Personal Sample: P-1 | 6 | 11.9 | 1.01 | NA | NA |
| W0631 | Personal Sample: P-2 | 6 | 9.0 | 1.18 | 93% | NA |
| W0632 | Area Sample | 6 | 60.0 | <0.04** | NA | NA |
| W0633 | Blank B-1 | 0 | 0 | — | NFD | NA |
| W0634 | Blank B-2 | 0 | 0 | — | NA | NA |

NA – Not analyzed. NSD – No [asbestos] structures detected. NFD – No fibers detected.

*Analytical sensitivity. **PCM limit of detection.