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AUTHORS: L. R. Ruhberg

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TITLE: EXAMINATION OF ASBESTOS MATERIALS FOR DOW CHLORINE CELL DIAPHRAGMS BY X-RAY POWDER DIFFRACTION TECHNIQUES

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INFORMATIVE SUMMARY WITH CONCLUSIONS

Eighteen samples of asbestos materials were studied by X-ray diffraction techniques to identify crystalline impurities that could cause problems in chlorine cell use. The most prominent impurities are: Fe_3O_4 and $Mg(OH)_2$, in the chrysotile samples, and talc in the anthophyllite samples. Sample "JM 4A12" (AL 80619-1) appears to be the most free of impurities of the chrysotile samples.

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ST0284358

EXAMINATION OF ASBESTOS MATERIALS FOR DOW CHLORINE CELL DIAPHRAGMS BY X-RAY POWDER DIFFRACTION TECHNIQUES

INTRODUCTION

Dow presently buys asbestos from the General Aniline and Film Company (GAF) for use in the chlorine cells diaphragms. GAF is going out of this business. Therefore, Dow must find another suitable source of asbestos - preferably one without problem impurities such as iron, which is known to cause problems in the cells. Since the diaphragms must withstand strong alkali on one side and acid on the opposite side, the presence of any alkaline or acid reactive impurity constitutes a potential problem to the system and should be avoided. This study was undertaken to aid in determining an acceptable source of asbestos. Eighteen samples were studied by X-ray powder diffraction techniques. Nine samples contained mainly chrysotile, eight contained mainly anthophyllite, and one contained mainly crocidolite.

SAFETY

The samples were ground in a closed container. The container was kept wet with water when cleaning so that air-borne dust was prevented.

ST0284359

SUMMARY

Eighteen samples of asbestos materials were studied by X-ray diffraction techniques to identify crystalline impurities that could cause problems in chlorine cell use. The most prominent impurities identified are: Fe_3O_4 and $Mg(OH)_2$, in the chrysotile samples, and talc in the anthophyllite samples. Sample "JM 4A12" (AL 80619-1) appears to be the most free of impurities of the chrysotile samples.

MINERAL TERMINOLOGY

Anthophyllite:	$(Mg,Fe)_7Si_8O_{22}(OH)_2$. A natural magnesium-iron silicate, usually occurring in metamorphic rocks; a member of the amphibole group. See also asbestos.
Antigorite:	See serpentine.

Asbestos:	A group of impure magnesium silicate minerals which occur in fibrous form. 1. Serpentine asbestos is the mineral chrysotile, a magnesium silicate. The fibers are strong and flexible so that spinning is possible with the longer fibers. 2. Amphibole asbestos includes the minerals tremolite, actinolite, amosite, crocidolite, and anthophyllite, which are various silicates of magnesium, iron, calcium, and sodium. The fibers are generally brittle and cannot be spun but are more resistant to chemicals and to heat than serpentine asbestos.
Brucite:	$Mg(OH)_2$. Natural magnesium hydroxide, usually found as a decomposition product of magnesium silicates, or as an alteration of dolomite [$CaMg(CO_3)_2$]. Soluble in acid.
Chlorite:	$(Mg,Fe,Al)_6(OH)_8(Si,Al)_4O_{10}$. A hydrous silicate of magnesium and iron with or without aluminum. Also, aluminum may be replaced by ferric iron or chromium, and magnesium by nickel or manganese. Serpentine is a chlorite mineral with no trivalent element. In this report chlorite refers to a mineral giving rise to an X-ray diffraction pattern including a d-spacing of 14Å. Serpentine does not fit this criteria.
Chrysotile:	See serpentine.
Crocidolite:	$Na_2Fe_3^{+2}Fe_2^{+3}Si_8O_{22}(OH)_2$. A natural sodium-iron silicate. A fibrous variety of riebeckite forming blue asbestos; it contains some Mg.
Feldspar:	General name for a group of sodium, potassium, calcium, and barium aluminum-silicates. It is the common mineral in igneous and metamorphic rocks.
Kaolin Clay:	$Al_4(OH)_8Si_4O_{10}$. A clay mineral, also called kaolinite. Insoluble in acids.
Magnetite:	Fe_3O_4. Black mineral. Soluble in hydrochloric acid.

Montmorillonite Clay: Basically an aluminum silicate with varying substitution and water content. Gelatinizes with HCl.

Riebeckite: $Na_2Fe_3^{+2}Fe_2^{+3}Si_8O_{22}(OH)_2$. Prismatic crystals; insoluble in acids.

Serpentine: $Mg_6(OH)_8Si_4O_{10}$. A natural hydrous magnesium silicate sometimes containing small amounts of nickel and partial replacement of magnesium by ferrous iron. An alteration product of olivine.
Varieties: Antigorite - platy or massive variety
Chrysotile - fibrous variety
See also asbestos.

Talc: $Mg_3(OH)_2Si_4O_{10}$. A natural hydrous magnesium silicate, usually occurring as a natural alteration of magnesium silicate rocks or in metamorphose d dolomites.

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SAMPLE INVESTIGATION

SAMPLE: JM 4A12 AL 80619-1

Microscopic Observations

Color - Very light gray or off white.

The asbestos is very fibrous with fine wavy fibers and some larger masses of fibers still in rock formation; i.e., a bundle of fibers unseparated, clear, and transparent. ^{A}A few dark, opaque crystals are present and appear to be striated or fibrous in nature and are somewhat magnetic. ^{B}Tiny black magnetic particles can be found scattered through the sample. ^{C}A few colorless, frosty particles are present which blend in with the asbestos and are difficult to see. ^{D}A few clear, orange particles were also found.

Particle Designation

A - Dark, opaque particle with striated surface - possibly fibrous in nature and somewhat magnetic.

B - Tiny, black, magnetic particles - opaque.

C - Frosty, colorless particles.

D - Clear, orange particles

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite: A portion of the sample was ground in a ball mill for 10 min., 20 min., and 30 min. To determine the length of grinding time needed to reduce the fibers to a powder without sacrificing crystallinity. A diffractometer trace was obtained after the various grinding times. A 30 min. grind reduced the fibers to a useable powder without destroying the crystallinity appreciably so all samples will be given this treatment. This sample was diffracted using a diffractometer (chart method) and film method. The isolated particles were diffracted using either a Gandolfi camera or a Debye-Scherrer camera.

Analysis

Composite - Serpentine (fibrous-chrysotile), chief constituent
Quartz, trace present
Fe_3O_4, trace present

Particles -

A - Fe_3O_4, chief constituent
Unidentified lines at 2.35, 2.02, 1.27, minor constituent

B - Fe_3O_4

C - Probably antigorite since it is not fibrous

D - Unidentified. Elemental data is needed to help identify this material.

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SAMPLE: JM AX3667 AL 80619-2

Microscopic Observations

Color - Very light gray or off white.

This sample appears to be very much like JM 4A12 (p. 3) with fine wavey fibers and bundles of fibers. [A]A few dark, opaque crystals are present that have a striated surface and are magnetic. [B]Some tiny black particles are scattered through the sample. [C]Some larger particles (∿.5 mm cross-section), irregular in shape, gray, translucent with black particle imbedded in it. [D]A larger particle, similar to the previous, but beige with black material imbedded in it. [E]Also, some tiny clear, colorless particles were found and [F]some white frosty particles. [G]A few flat, yellow, smooth, translucent to transparent particles were also isolated and [H]a flat, dark, micaceous particle was found.

Particle Designation

A - Dark, opaque particle with striated surface, somewhat magnetic.

B - Tiny, black, magnetic particle.

C - Larger, gray, translucent particle with black imbedded.

D - Larger, beige, translucent particle with black imbedded.

E - Tiny clear, colorless particle.

F - White, frosty particle.

G - Flattened, yellow, translucent to transparent particle.

H - Dark, micaceous appearing flake.

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite (30 min. grind) - chrysotile, chief constituent
$Mg(OH)_2$, 5-10%
SiO_2 (quartz) } possibly a trace o
Fe_3O_4 (magnetite) } each present (<5.%

Particle Identification

A - Fe_3O_4

B - Fe_3O_4

C - Antigorite

D - Antigorite (white, beige portion of particle), chief const.
Fe_3O_4 (black portion of particle), minor const.

E - Unidentified (same as particle "1D")

F - Antigorite, chief const.
$Mg(OH)_2$, possibly a minor amount present

G - Antigorite

H - Not analyzed

ST0284363

SAMPLE: SPECIAL ASBESTOS MX3KDW AL 80619-3

Microscopic Observations

Color: Light tan (beige)

The sample is fibrous in appearance and contains fiber bundles to a large degree. It is quite free from obvious impurities of contrasting colors, however a few can be found. [A]There are black particles laying in the fibers and [B]black particles that appear to be formed as part of the fiber or formed along the fiber. No other particle impurities are obvious except for discoloration in the fibers themselves.

Particle Designation

A - Black particles (flakes) laying in the fibers (non magnetic)

B - Black particles formed with the fibers

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite (30 min. grind) - Anthophyllite

Particle Identification

A - No pattern obtained - non crystalline

B - Non crystalline

ST0284364

SAMPLE: SPECIAL ASBESTOS MX4TB AL 80619-4

Microscopic Observations

Color: Light tan (beige) - darker than AL 80619-3

The sample is fibrous in appearance, however they do not cling together as much as the previous 3 samples - possibly due to shorter fiber length. There are some black particles similar to -3A and -3B but the most predominant non-fibrous particles appear to be flakes that are scattered throughout the sample and range in color from reddish-orange to yellow to white with a silky luster.

Particle Designation

A - Black flake (non magnetic)
B - Dark brown-black fibrous (striated)
C - Reddish-orange flake
D - Clear, colorless flake
E - White, silky luster flake
F - Black particle attached to fibers (magnetic)
G - Large black chunk (∿1 mm x .5 mm)
H - Agglomerate of reddish brown material

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite (30 min. grind) - Anthophyllite, chief constituent
Unidentified line at 14Å, possibly montmorillonite clay or chlorite (see Particle -H)
Talc, minor const.

Particle Identification

A - Antigorite and/or kaolin clay - The pattern is diffuse making it difficult to distinguish which phase/phases are present.
B - Anthophyllite
C - Poor pattern - possibly anthophyllite
D - Not analyzed
E - Talc
F - Not analyzed
G - Highly oriented pattern - appears to be anthophyllite
H - Kaolin clay, major const.
Feldspar, major c. (c.c.).
Montmorillonite clay, possibly a minor amount present.

ST0284365

SAMPLE: STADE 1084-6010 AL 80619-5

Microscopic Observations

Color: Light tan (beige ∿ same as AL 80619-3)

The sample is fibrous with many fiber bundles. Dark impurity particles are very low in number, however, a[A] tiny black particle and some[B] reddish-brown particles were isolated. Small clear to translucent[C] flakes are present that fall out of the sample when the fibers are shaken or moved about. The fiber characteristics are very similar to AL 80619-3 (i.e., color, fiber length, appearance, handling).

Particle Designation

A - Tiny black particle

B - Reddish-brown particle

C - Flake particles

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite (30 min. grind) - Anthophyllite, chief const.
Chlorite (penninite, clinochlore, prochlorite type), minor c.
Talc, minor c. (5-15%)

Particle Identification

A - Non crystalline

B - Non crystalline

C - chlorite

ST0284366

SAMPLE: STADE 4653 AL 80619-6

Microscopic Observations

Color: Light tan (beige - slightly darker than -3 but lighter than -4)

The sample is similar in texture to -3 and -5 and is quite free of the small black impurities, however, there are discolored fibers ranging from the beige to orange to[A] brown-black. The orange type seem to be the most predominant of the discolored fibers. Flakes of varying colors are also present and appear to be the most prevalent non-fibrous material. These flakes tend to fall out of the fiber mat when it[B] is moved or handled - much like -5. The flakes range in color from clear, colorless to reddish-orange (like -4c) to[C] gray-black.

Particle Designation

A - Brown-black particle in fiber bundle

B - Clear, colorless flake

C - Gray-black flake

D - Elongated, reddish brown particle with striated surface - possibly fiber-bundle type

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite (30 min. grind) - Anthophyllite, chief const.
Chlorite, possibly present (minor c.)
Talc, minor c. (~ same as -4 or slightly less)
} ≅ -5

Particle Identification

A - Non crystalline

B - Not analyzed

C - Not analyzed

D - Non crystalline

ST0284367

SAMPLE: CROCIDOLITE ASBESTOS AL 80619-7

Microscopic Observations

Color: Dark blue-gray

The sample is fibrous with some very fine fibers and fiber bundles. The only obvious non-fibrous impurity is small black particles. The texture of the fibers appear to be similar to the chrysotile samples in that they "mat" well.

Particle Designation

A - Black particle

X-ray Powder Diffraction Analysis of Composite and Separated Particle

Composite (30 min. grind) - crocidolite

Particle Identification

A - Riebeckite

ST0284368

SAMPLE: ASBESTOS GAF #1 AL 80619-8

Microscopic Observations

Color: Light gray (∿ same as -1, -2)

The sample is fibrous with some fiber bundles present. Only two types of non-fibrous particles are obvious. One type is [A]black with some magnetic response and the second is [B]greenish colored. [C]A clear, colorless particle was also found. The black particles are scattered throughout the sample.

Particle Designation

A - Black, magnetic

B - Greenish colored particle

C - Clear, colorless particle

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite (30 min. grind) - Chrysotile, chief constituent
Fe_3O_4 (magnetite), (5-15%)
$Mg(OH)_2$ (Brucite), ∿5%

Particle Identification

A - Not analyzed (assumed to be Fe_3O_4)

B - Antigorite, Brucite } both major constituents

C - $CaMg(CO_3)_2$ (dolomite)

ST0284369

SAMPLE: ASBESTOS GAF #2 AL 80619-9

Microscopic Observations

Color: Light gray (darker than any other of the chrysotile samples studied)

The sample texture is very similar to the other chrysotile samples. This sample has an abundance of [A]black, magnetic particles scattered through it. The second most obvious non-fibrous materials are [B]clear, colorless crystals. Some [C]flakes (colorless with silky luster) are also present.

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Particle Designation

A - Black, magnetic particles

B - Clear, colorless particles

C - Colorless flakes with silky luster

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite (30 min. grind) - Chrysotile, chief const.
Fe_3O_4, 5-15%
$Mg(OH)_2$ (Brucite), ~5.%
Calcite, dolomite, unidentified phase, trace of each present

Particle Identification

A - Not analyzed (assumed to be Fe_3O_4)

B - Antigorite, Calcite, Dolomite } All are major components
Unidentified phase, trace present

C - Not analyzed

SAMPLE: MX-4-TB AL 80619-10

Microscopic Observations

Color: Light tan (beige - slightly darker than -4)

The sample is fibrous with fiber bundles. The texture is comparable to the other anthophyllite samples with shorter fibers that do not cling together in large matted clusters. The non-fibrous particles are: [A]a few black, tiny, non magnetic particles; [B]an abundance of flakes are present ranging in color from colorless, clear to reddish-brown opaque; [C]some reddish-brown to black material is present in the fibers.

Particle Designation

A - Tiny, black non magnetic particles

B - Flakes - colorless, clear to reddish brown opaque

C - Reddish brown to black material found in the fiber bundles.

X-ray Powder Diffraction Analysis of Composite and Particles

Composite (30 min. grind) - Anthophyllite, chief const.
Chlorite, possibly present, minor c.
Talc, possibly present, minor c.
(∿ same as -6)

Particle Identification

A - }
B - } Not analyzed
C - }

ST0284371

SAMPLE: MX-3-2B AL 80619-11

Microscopic Observations

Color: Light tan (∿ same as -10)

The sample is fibrous containing fiber bundles as well as the loose fibers. It is quite free from [A]black particles, although a few were noticed. The most predominant non-fibrous material appears to be [B]colored flakes and [C]clear flakes ranging from colorless to orange. Some tiny clear flakes fall from the fibers when shaken. The colored flakes seem to be much larger than the clear flakes. There does not appear to be any black material in the fiber bundles, however, there is some [D]reddish-orange material in the bundles.

Particle Designation

A - Black particle
B - Flakes - orange
C - Flakes - clear, colorless
D - Reddish-orange material in fiber bundles

ST0284372

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite (30 min. grind) - Anthophyllite (∿ same as -3)

Particle Identification

A -
B -
C -
D - } Not analyzed

SAMPLE: MX-5D-DW AL 80619-12

Microscopic Observations

Color: Light tan (∿ same as -10)

The sample is basically fibrous with fiber bundles also plentiful. There is also an abundance of flake particles present ranging in color from [B]colorless-clear, to [A]orange to brown-opaque. The flakes are large and obvious to the naked eye. [C]Black particles are very low in number. Some fiber bundles contain [D]reddish-orange material and some contain [E]black material. The fibers do not cling or mat together as well as the chrysotile samples possibly due to the shorter fibers and abundance of flakes.

Particle Designation

A - Flakes, colored
B - Flakes, clear, colorless
C - Black particles
D - Reddish orange material in fiber bundles
E - Black material in fiber bundles

ST0284373

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite (30 min. grind) - Anthophyllite, major constituent
Talc, minor constituent (5-10%)
Chlorite, possible present - minor const

Particle Identification

A -
B -
C - } Not analyzed
D -
E -

SAMPLE: MX-6-DB AL 80619-13

Microscopic Observations

Color: Light tan (slightly darker than -10)

This sample is fibrous with fiber bundles and contains an abundance of flakes. The sample texture is similar to -12, in that, the fibers do not cling together like the chrysotile samples. [A]Black particles are very low in population but are present. The flakes vary in color from [B]colorless-clear to reddish-orange to [C]brown-opaque. There are particles also noticeable that are [D]colorless, clear and have a striated surface. Other particles are [E]colorless, clear with very flat surface (possibly a stack of flakes). A few fiber bundles with black material present and a few fiber bundles with reddish-orange material were noticed.

Particle Designation

A - Black particles (non-magnetic)

B - Flakes, colorless, clear

C - Flake, brown

D - Colorless, clear with striated surface

E - Colorless, clear with flat surface

ST0284374

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite (30 min. grind) - Anthophyllite, chief constituent
Talc, 10-20%
Chlorite, ~5%

Particle Identification

A - Non-crystalline

B - Talc

C - Mainly non-crystalline with some talc present

D - Chlorite mainly with a minor amount of talc present

E - Anthophyllite and talc - both major constituents

SAMPLE: CAREY ASBESTOS GRADE 4K-1 AL 80619-14
SAMPLE OS-4764

Microscopic Observations

Color: Light gray

This sample is very fibrous with some fiber bundles present. Small black particles are scattered throughout the sample and are magnetic. Som clear, colorless, particles are also present but low in population. No flake material was noticed. Many of the black particles are elongated and thin (blade type).

Particle Designation

A - Black, magnetic particles
B - Large clear, colorless particle
C - Small clear, colorless particle

ST0284375

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite (30 min. grind) - Chrysotile, chief constituent
$Mg(OH)_2$, 10-20%
Fe_3O_4, 5-15%

Particle Identification

A - Not analyzed (assumed to be Fe_3O_4)
B - $Mg(OH)_2$
C - Antigorite plus a weak (trace) unidentified line at 2.70Å.

SAMPLE: CAREY ASBESTOS GRADE 4T-1 AL 80619-15
Sample OS-4763

Microscopic Observations

Color: Light gray

This sample is very fibrous with fiber bundles, also. Several different looking particles, non-fibrous in appearance, were observed. There are many [A]black, magnetic particles both loose in the fiber material and black, magnetic particles that appear to be part of fiber bundles. [B]A small translucent particle with a greenish-yellow color was isolated. [C]A tiny transparent, colorless particle was isolated. [D]Some flake particles were found that have a striated surface and [E]lath-like particles that are striated were found. The lath-like particles might be an earlier stage of fiber formation. A small [F]particle that is translucent and colorless was also found. This particle might be the same as particle "B".

Particle Designation

A - Black, magnetic, particles
B - Translucent, greenish-yellow particle (faint color)
C - Clear, colorless particle
D - Flake, striated particles
E - Lath-like particles
F - Small colorless, translucent particle

ST0284376

X-Ray Powder Diffraction Analysis of Composite and Particles

Composite (30 min. grind) - Chrysotile, chief const.
$Mg(OH)_2$, 10-20%
Fe_3O_4, 5-15%
} ~ same as -14

Particle Identification

A - Not analyzed (assumed to be Fe_3O_4)
B - Antigorite
C - $Mg(OH)_2$
D - Antigorite
$Mg(OH)_2$
} Both are major constituents
E - Antigorite or tightly packed fibers (chrysotile)
F - $Mg(OH)_2$

SAMPLE: BL-4C-40 AL 80619-16
ASBESTOS CORP. LTD.

Microscopic Observations

Color: Light gray

This sample is very fibrous with fiber bundles present. [A]Black, magnetic particles are scattered throughout the sample and some black material is present in the fiber bundles. [B]A long, lath-like, translucent, colorless particle was isolated that has a striated surface. [C]A small particle, translucent and colorless, was also isolated. These particles ("C") seem to be scattered throughout the sample. Particle "B" above reduces to needle crystals when broken.

ST0284377

Particle Designation

A - Black, magnetic particles

B - Long, lath-like, translucent, colorless particle (∿3/8" x 1 mm cross section)

C - Small translucent, colorless particle

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite (30 min. grind) - Chrysotile, chief const.
$Mg(OH)_2$, ∿5%
Fe_3O_4, ∿5%

Particle Identification

A - Not analyzed (assumed to be Fe_3O_4)

B - Antigorite, $Mg(OH)_2$ } Both present

C - Antigorite, $Mg(OH)_2$ } Both present

SAMPLE: KB-424-4D AL 80619-17
ASBESTOS CORP. LTD.

Microscopic Observations

Color: Light gray

This sample is very fibrous with fiber bundles present. [A]Black, magnetic particles are scattered throughout the sample and black, magnetic material is present in fiber bundles. [C]Small, colorless, translucent particles seem to be scattered throughout the fibers but low in population. [B]Long lath-like, striated particles similar to -16B and -15E are present. The small, translucent particles are similar in appearance to -16C. No flakes are noticeable in this sample.

Particle Designation

A - Black, magnetic particles

B - Long, lath-like particles

C - Small translucent particles

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite (30 min. grind) - Chrysotile, chief const.
$Mg(OH)_2$, ~5%
Fe_3O_4, ~5%
} same as -16

Particle Identification

A -
B -
C - } Not analyzed (assumed to be the same as -16A, B, C)

ST0284378

SAMPLE: N-4D AL 80619-18
ASBESTOS CORP. LTD.

Microscopic Observations

Color: Light gray

This sample is very fibrous with fiber bundles, also present. There are [A]black, magnetic particles scattered throughout the sample and black, magnetic material in some of the fiber bundles. There are two types of translucent particles - one has a [B]gray color and the second has a [C]faint yellow color. [D]Larger, lath-like, striated chunks with a greenish-yellow faint color are present which might be earlier stages of fiber forming mineral. When broken, these lath-like particles cleave along the long direction and form fibers. No flakes are noticeable in this sample.

Particle Designation

A - Black, magnetic particles
B - Gray, translucent, particles
C - Yellow, translucent particles
D - Large; lath-like particles

ST0284379

X-ray Powder Diffraction Analysis of Composite and Separated Particles

Composite (30 min. grind) - Chrysotile, chief const.
Fe_3O_4, ∿5% of less

Particle Identification

A - Not analyzed (assumed Fe_3O_4)
B - Antigorite
C - Antigorite

GENERAL OBSERVATIONS: Chrysotile Samples (-1, -2, -8, -9, -14, -15, -16, -17, -18)

Physical Characteristics

All of the samples seem to cling together about equally. Sample -8 appears to have the longest fibers. The grayness of the samples seem to correlate with Fe_3O_4 concentration (directly) and $Mg(OH)_2$ (inversely). However, the correlation is quite subjective since it was done visually and there is not a great deal of difference in grayness among the samples.

The gross impurities detected in the composite samples were Fe_3O_4 and $Mg(OH)_2$. The following lists show the sample designation listed in increasing impurity:

Fe_3O_4	$Mg(OH)_2$
-1, -2	-1
-16, -17, -18	-18
-14, -15	-2
-8	-9, -16
-9	-17
	-14
	-15

Sample -1 contains the least amount of impurities (crystalline), with just a trace of Fe_3O_4 and no $Mg(OH)_2$ detected.

Tabulated Analysis of Chrysotile Samples (-1, -2, -8, -9, -14, -15, -16, -17, -18)

Quantities (%) listed are visual estimates from X-ray diffraction data - not quantitatively determined.

Sample (composite)	Chrysotile	Fe_3O_4	$Mg(OH)_2$	Miscellaneous
1	chief const. (c.c.)	trace <5.%	not detected	Quartz <5.%
2	c.c.	<5.%	5-10%	Quartz
8	c.c.	5-15%	∿5%	-
9	c.c.	5-15%	∿5%	Calcite, Dolomite Unident. - trace each
14	c.c.	5-15%	10-20%	-
15	c.c.	5-15%	10-20%	-
16	c.c.	∿5%	∿5%	-
17	c.c.	∿5%	∿5%	-
18	c.c.	∿5%	not detected	-

NOTE: See text for particle identification.

ST0284380

GENERAL OBSERVATIONS: Anthophyllite Samples (-3, -4, -5, -6, -10, -11, -12, -13)

Physical Characteristics

Samples -3, -4, -5, -6, -10 and -11 cling together similar to the chrysotile samples, however, samples -12 and -13 do not cling together as readily. Generally, these samples appear to have straight or straighter fibers than those found in the chrysotile samples.

The gross impurities detected in the composite samples were talc and a chlorite mineral. The following list shows the sample designation listed in increasing amounts of talc impurity:

Talc
3, 11
6, 10
4, 5, 12
13

These samples all are free from detectable Fe_3O_4, however, small black, non-magnetic particles can be found which are non crystalline. The black particles are low in population. The flakes with a silky luster appear to be talc.

NOTE: Anthophyllite alters to talc upon weathering in nature.

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Tabulated Analysis of Anthophyllite Samples (-3, -4, -5, -6, -10, -11, -12, -13)

Quantities listed (%'s) are visual estimates from X-ray diffraction data - not quantitatively determined.

Sample (composite)	Anthophyllite	Talc	Chlorite	Miscellaneous
3	chief const. only crystalline phase detected	-	-	-
4	c.c.	5-10%	possible trace	Montmorillonite Clay - possible trace
5	c.c.	5-15%	minor c.	-
6	c.c.	∿5%	possible trace (∿ = .5)	-
10	c.c.	∿5%	possible trace	-
11	c.c. only crystalline phase detected	-	-	-
12	c.c.	5-15%	possible trace	-
13	c.c.	10-20%	possible trace (> other samples)	-

NOTE: See text for particle identification.

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REFERENCES

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3. X-ray Identification and Crystal Structures of Clay Minerals, The Mineralogical Society of Great Britain and Ireland, 1951.

Author L. R. Ruhberg
L. R. Ruhberg

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