PLAINTIFF'S EXHIBIT
KM-230

Asbestos
A Family of Minerals

SUMMARY:
This paper sets forth some of the reasons why the term "asbestos" should not be used loosely in discussing medical questions.

There is no single mineral known as asbestos. "Asbestos" is a name given to a family of minerals. It includes two major groups, containing a total of six varieties of asbestos. Each of these six differs from the others, physically, chemically and in biological effect. Any study of the effects of asbestos is complicated by this diversity.

Studies of both people and animals show differing types of reaction to the various types of asbestos. Animal studies of excessive exposure made with three of the major commercial types of asbestos indicate that commonly-used chrysotile is least likely to produce a reaction.

Because different varieties of asbestos produce different reactions, scientists are working on better methods for identifying the types of asbestos involved in their studies on human health. Other complications arise because trace amounts of mineral impurities are often found in samples of raw asbestos ore and refined fiber.

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TYPES OF ASBESTOS

Any attempt to assess the effect of asbestos on health is complicated by the fact that asbestos is not a single chemical or physical entity. "Asbestos" is a generic name given to a group of hydrated silicate minerals that have one common attribute – namely, the ability to be separated into relatively soft, silky fibers.

The known varieties of these minerals can be divided into two main classes on the basis of their crystalline structures: **serpentine** asbestos and **amphibole** asbestos. The lone member of the serpentine class is **chrysotile** asbestos, which is by far the most common of the asbestos minerals. About 95 per cent of the asbestos used in this country is chrysotile, principally from mines in Canada.

There are five recognized varieties of amphibole asbestos: **crocidolite, amosite, anthophyllite, tremolite and actinolite.** Of these, crocidolite and amosite have the greatest commercial significance, although the use of anthophyllite is increasing.

Each of the six types of asbestos differs from the others, chemically and physically. To add to the complexity, chrysotile asbestos from one Canadian mine, for example, will differ in chemical impurities and physical properties from the chrysotile taken from another Canadian mine.

CHARACTERISTICS OF THE FOUR MAJOR TYPES

Each of the four types of asbestos that are most important commercially – chrysotile, crocidolite, amosite and anthophyllite – exhibits distinguishing characteristics.

Chrysotile

By far the leading producers are Canada and the Soviet Union. Smaller deposits are found in South Africa, Rhodesia, China, the United States and Italy. Chrysotile is a *white* serpentine asbestos and occurs in areas where serpentine rock was cracked by earth movement thousands of years ago and subjected to intense pressure and the flow of volcanic waters. This action transformed some of the granular serpentine

into fibrous chrysotile. Chemically, chrysotile is hydrous magnesium silicate with a magnesium hydroxide surface. It has a positive electrical charge. It can be attacked by acids. It is a flexible fiber and does not pulverize readily. Commercial chrysotile contains small and varying amounts of iron and calcium compounds, depending upon its origin.

Crocidolite

The bulk of the world's supply comes from South Africa; there are also small deposits in Australia, but they are no longer mined commercially. Crocidolite is an amphibole asbestos occurring in iron-rich sedimentary rock. Chemically, it is a ferrous sodium silicate with a silica surface. It has a negative electrical charge. It is acid-resistant. It is characterized by a deep *blue* color. Crocidolite is less flexible than chrysotile.

Amosite

The Transvaal district of South Africa is the only place in the world where amosite is mined commercially. It is a member of the amphibole asbestos family, occurs in the same type of rock as does crocidolite, has the same negative electrical charge, but is brown in color. Chemically, amosite is a ferrous magnesium silicate with a silica surface. It is acid-resistant, but less so than crocidolite. It is brittle and pulverizes easily.

Anthophyllite

The least used of the commercial fibers, it comes primarily from Finland but small amounts are mined in the United States. It is an amphibole asbestos, has a negative electrical charge, and is white in color. Chemically, anthophyllite is a magnesium silicate with a silica surface. It is acid resistant like the other amphiboles. It is brittle and pulverizes easily.

Because of the basic chemical and physical differences among chrysotile, crocidolite, amosite and anthophyllite, it would be expected that over-exposure to the four varieties would show varying biological effects. And scientific observation confirms this expectation. There seems to be broad agreement that chrysotile, the type of asbestos most widely used in the United States, is least likely of the three most commercially significant fibers (chrysotile, crocidolite, amosite) to produce asbestosis, a non-malignant lung disease brought on after inhalation of excessive concentrations of asbestos dust over a period of many years.

ANIMAL EXPERIMENTS SHOW DIFFERENT EFFECTS

Dr. J. C. Wagner experimented with three types of asbestos (chrysotile, crocidolite and amosite) on various laboratory animals, and found that –

crocidolite produced the most severe asbestosis, and

amosite was more than five times as likely to produce a reaction as chrysotile. He reported[1] in 1963:

"With chrysotile dust it was possible to produce severe lesions in the lungs of guinea pigs, slight fibrosis in monkeys, while no significant effect was observed in two rabbits. Amosite dust causes marked asbestosis in all three kinds of animals. Lesions occur more rapidly in guinea pigs exposed to this dust than in those exposed to chrysotile. There is an indication that the disease is progressive in monkeys and rabbits. Similar pathology to that which occurred in a monkey exposed to chrysotile for 22 months was observed in a monkey exposed to amosite for four months. The impure crocidolite dust caused severe disease in guinea pigs, and the rate of respiratory infection among animals exposed to this dust was more marked than with the other types. It is possible that this may be due to the high quartz content of the dust.

"Finally, asbestos bodies could be demonstrated in the lungs of animals exposed to all three types of asbestos dust. These were scanty in the animals exposed to chrysotile and usually segmented. Only occasional fibers were observed. In contrast to this, the asbestos bodies in the animals that were dusted with amosite were plentiful, and segmentation was rare: fibers were extremely numerous and far outnumbered the bodies."

Following further investigation, Dr. Wagner offered an explanation[2] for this observation at a medical symposium in 1965:

"A method of producing asbestos dust clouds has been devised and an animal inhalation experiment carried out to test it... The elimination rate of Rhodesian chrysotile has been found to be three times greater than that of the amosite and crocidolite, which suggests an explanation for the previously observed reduced fibrogenicity of this dust. The reason for the difference in the elimination rate remains to be determined."

COMMERCIAL ASBESTOS CONTAINS OTHER MATERIALS

Asbestos ore and refined asbestos fiber contain mineral impurities, trace elements, and trace quantities of organics, which vary from type to type and from mine to mine. In addition, the ore may pick up additional trace organic impurities when in transit.

These trace materials are also the subject of medical study to see if they may have a role in any of the health effects observed in animals. Trace impurities of nickel, chromium and manganese, for example, were found by Cralley, et al.[3] in samples of chrysotile used in the asbestos textile industry. Other impurities in commercial asbestos fiber include iron, aluminum, calcium, sodium and potassium.

WORLD ASBESTOS BANK

Much scientific research has focused on studying the varying biological effects of different types of asbestos and on developing techniques for identifying asbestos fibers of unknown origin. In 1967, a "World Asbestos Bank" was established in Johannesburg, South Africa, under the direction of the British Medical Research Council. The purpose of the "bank" is to provide standardized samples of asbestos from regions all over the world to be supplied to medical researchers for chemical, physical and biological investigation and for comparison purposes in clinical studies.

CHARACTERISTICS OF MAJOR COMMERCIAL TYPES OF ASBESTOS

NAME	**Chrysotile**	**Crocidolite**	**Amosite**	**Anthophyllite**
CLASS	Serpentine	Amphibole	Amphibole	Amphibole
COLOR	White	Blue	Brown	White
CHEMICAL COMPOSITION	Hydrous Magnesium Silicate	Ferrous Sodium Silicate	Ferrous Magnesium Silicate	Magnesium Silicate
SURFACE COMPOSITION	Magnesium Hydroxide	Silica	Silica	Silica
ELECTRICAL CHARGE	Positive	Negative	Negative	Negative
REACTION TO ACID	Susceptible	Resistant	Resistant	Resistant
TEXTURE	Flexible	Medium Flexibility	Brittle	Brittle

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