CHARLES S. MOTT PRIZE

Mesothelioma and Mineral Fibers

J. CHRISTOPHER WAGNER

IN 1952, the Chief Mining Engineer of the South African Government wrote a memorandum to the Minister of Mines enquiring if all types of asbestos caused the same diseases. Rather by chance, I was appointed Asbestosis Research Fellow at the South Africa Pneumoconiosis Research Unit in 1954, and asked to answer the question. This investigation is still continuing.

I have had several significant "lucky breaks." The first of these was in 1956, when I undertook a necropsy examination on a black adult male who had been the shower attendant on one of the Witwatersrand Gold Mines. He was thought to have died from tuberculosis, terminating with pleural infection which did not respond to chemotherapy. Much to my surprise I found a huge gelatinous tumor completely filling the right chest cavity, with the collapsed lung in the center. Extensive histologic and histochemical studies confirmed that the tumor was a mesothelioma of the pleura, while in the lung tissue we observed a few asbestos bodies, but no evidence of pulmonary fibrosis.

I presented the case, with the full radiologic and clinical findings, at the next meeting of the local chest group. A week later, our Chief Thoracic Surgeon, Libero Fatti, was called down to the town of Kimberley, the center of the diamond mining industry, to see a patient. While he was there, he was approached by Dr. Kit Sleggs, Chief Medical Officer of the local Tuberculosis Hospital, who stated that when he had first arrived in Kimberley in 1946, tuberculosis was endemic, with a high mortality rate, particularly when the infection had spread to the pleura. In 1952, the antituberculosis drugs became available which led to a rapid increase in survival from the whole region, with the exception of the cases of pleurisy from the west of Kimberley, some of whom seemed to have a secondary tumor. It was recognized by people of this area that anyone who developed fluid in his chest would die within the year. Dr. Sleggs took Dr. Fatti to the hospital where, to his amazement, he saw the radiographs of 14 cases that were identical to those of the patient that I had demonstrated. It was agreed that Paul Marchand, Dr. Fatti's assistant, would biopsy the pleura of these people. Within a month, I had a further 12 specimens of what had previously been considered a very rare tumor. Fortunately, at this stage, Professor Paul Steiner from Chicago was visiting us and he confirmed my diagnosis of mesothelioma.

We were puzzled as to why we were seeing so many of these tumors. I then recalled that we had seen asbestos bodies in the first case and that 90 miles west of Kimberley were the large mines which had been developed along the so-called blue asbestos mountains, a range of hills stretching for more than 400 miles from the Orange River in the south to the Botswana border in the north. We then meticulously examined every scrap of lung tissue that had accompanied the biopsy specimens, and in three more cases we found occasional asbestos bodies. I therefore suggested that we should consider an association between the blue (crocidolite) asbestos mines and development of the mesotheliomas. The next case which was submitted was of a woman aged 55 years who gave a history of having been born in Kimberley where her father was a dentist. When she was 1 year old, the family had moved to Prieska, one of the asbestos mining villages, where she lived for 5 years before returning to Kimberley. All she remembered of it was that there was a mill in the middle of the village which produced clouds of blue dust.

From further cases referred by Dr. Sleggs, we obtained histories showing that few of the patients had been employed by industry working as insulators with blue asbestos on steam locomotives.[1,2] The majority, however, had only lived in the vicinity of the asbestos mills, some for very short periods, and, on average, their tumors developed 44 years after exposure.

The next question was, were the tumors confined to exposure to blue asbestos or were other types of fiber involved? South Africa was the ideal country for this study: First, it is the only region in the world in which the three major types of asbestos—crocidolite, amosite, and chrysotile—are mined, the latter accounting for more than 96% of the world's production. Secondly, these deposits had been exploited for more than 40 years by large labor

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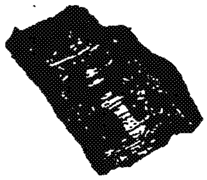
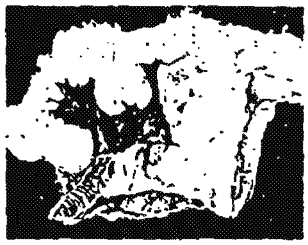
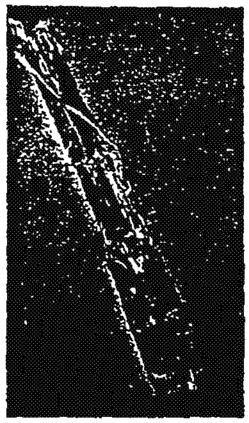


Crocidolite



The First Mesothelioma



Tremolite

forces. Through the South African Pneumoconiosis Bureau, we were able to examine the lungs of the majority of asbestos miners who died, revealing that mesotheliomas of pleura, and occasionally of peritoneum, were only observed in the workers from the Cape asbestos mines and those living in the vicinity. In recent years, a few cases have been reported from the amosite mining areas, but detailed analysis is required to see if these men had worked on the associated crocidolite deposit. No cases have been recorded among chrysotile miners or from the mines of the neighboring countries of Swaziland and Zimbabwe. On this evidence, we considered that we were justified in implicating crocidolite asbestos in the development of these tumors.[3] If we were correct, there were three obvious worrying aspects: first, the exposure could be for as short as 3 months in some cases; secondly, there was a long time between first exposure and development of the tumors; and thirdly, the majority of the cases had paraoccupational exposures.

A further question arose as to whether a similar situation existed with the manufacturers of asbestos products. In 1962, we began to investigate the problem in the United Kingdom where, in that year, the Inspectorate of Factories had records of over 100 carcinomas occurring in asbestos workers, but only 4 mesotheliomas. This was because there had been surveillance of the employed asbestos workers, but not of the people who had only worked for a short period, particularly those employed in the factories during the two World Wars; in addition, there had not been an intensive surveillance of the laggers (insulators). By going through hospital records and material in the pathology departments, we discovered more than 100 cases during the next 2 years, and in association with various colleagues (Dr. Muriel Newhouse deserves special mention),[4] we were able to establish the association with exposure to asbestos dust.[5] In Britain, however, as we found later in other industrial countries, the actual fiber implicated was much more difficult to assess, as the majority of workers had been exposed to most varieties of asbestos dust. An unaccountable feature was the high incidence of peritoneal tumors, which has also been found in New York.[6] A significant proportion of the mesothelioma cases was from people who had lived in the vicinity of the asbestos factories, or had been exposed to the clothing of relatives who had brought dust home on their clothes.

By 1964, cases were being reported from several other countries, and an international meeting was organized in New York by Dr. Harold Stewart to correlate the studies, under the aegis of the International Union Against Cancer (UICC).[7] From this meeting, plans were formulated to establish whether crocidolite was the main cause of the tumors and whether the general population was at risk. A major problem was the need for a method for establishing the type of fiber to which a case of mesothelioma had been exposed when the only remaining evidence was a small block of lung tissue or histologic sections. This was eventually solved by Dr. F.D. Pooley, from Department of Mineral Exploitation, University College, Cardiff, who over the last 20 years has been developing more and more sophisticated methods for identifying, quantifying, and measuring fibers in tissue.[8] The current method depends upon the use of EDAX (energy dispersive analysis of x-rays) on a transmission electron microscope with direct computer read-out studying fibers extracted from known amounts of lung tissue.[9] These methods have shown a predominance of amphibole fibers, mainly amosite and crocidolite, but occasionally tremolite, in the lungs of cases of mesothelioma when compared to tissue from age-matched control cases.[10] Cases of pure crocidolite exposure have occurred among women who inserted the crocidolite pads into the cannisters of the respirators prepared for the Ministry of Defense during the last World War; in contrast, so far no cases have been recorded from the people involved in packing the civilian respirators, which contained chrysotile.

The epidemiologic studies started under the UICC and later continued under the International Agency for Research on Cancer, have now been in progress for 20 years. It has been established that mesotheliomas are rare in the Quebec mining area and have never occurred in people living in the vicinity of these mines, nor have any been recorded among the Russian chrysotile miners, working in the Urals, nor from the south African chrysotile mines or the Italian mines in the Alps. The one exception was the chrysotile mine in Cyprus, and the fact that mesotheliomas were occurring at this most ancient of asbestos mines started a new concept in our studies. Before coming to this, however, it is necessary to discuss the fibrous minerals, which will be considered under the following headings: (1) asbestos minerals of commercial value; (2) asbestos minerals as potential environmental contaminants; (3) synthetic mineral fibers; (4) naturally occurring fibrous minerals of commercial value; and (5) naturally occurring fibrous minerals as potential environmental contaminants.[11]

Asbestos Minerals

Asbestos of Commercial Value

Practically all the present knowledge about the hazards associated with inhalation of fibrous mineral dusts has been obtained in studies of asbestos. Asbestos is now considered to consist of six naturally occurring minerals: chrysotile, crocidolite, amosite, anthophyllite, tremolite, and actinolite. Chrysotile is a member of a group of minerals referred to as the serpentines and it is composed almost exclusively of magnesium in combination with silica, while its sheet structure is curled to produce hollow tube-like fibers. The other five minerals, members of the mineralogic group referred to as the amphiboles, are very similar in crystal structure, being chain silicates, but they vary in chemical composition. Crocidolite and amosite are iron-rich varieties, anthophyllite is a magnesium-rich mineral, and tremolite and actinolite contain a large amount of calcium together with magnesium. The world production of asbestos in 1976 was 5×10^9 kg, 97% of this being chrysotile, while the remainder was crocidolite and amosite. The commercial production of the other three amphiboles had been minimal in the past, but they are important as contaminants of other minerals and agricultural soil, as will be discussed later. Chrysotile is widely distributed, with the largest commercial production from the Ural mountains in Russia, Quebec Province in Canada, Zimbabwe and Swaziland in Southern Africa, the Italian Alps, and Cyprus. Until recently, crocidolite was mined in Western Australia, but is now mined almost exclusively in the Cape Province in South Africa. Amosite is exploited only in the Transvaal, but deposits have been discovered in Southern India.

Asbestos has over a thousand uses, so that the number of occupations in which exposure may have occurred is large. Crocidolite, because of its resistance to acids and sea water, was extensively used in naval insulation and fireproofing, as insulation for steam locomotive boilers, and later for soundproofing in passenger coaches. A significant amount was used in the insulation of buildings, but in Britain the use of crocidolite and its importation has been severely limited since 1969. Amosite has been used for thermal insulation, in floor tiles, and in the superstructure of ships. Chrysotile has been used for all other purposes, but particularly in asbestos cement products, insulation, fireproofing, and in the manufacture of friction materials such as brake linings and clutch plates. Chrysotile is still the main fiber used in textiles, but this is no longer a major section of the industry. The destruction by demolition of buildings, ships, and railway rolling stock is a source of environmental pollution.

Asbestos Minerals as Potential Environmental Contaminants

Asbestiform minerals contaminating banded ironstone: Although banded ironstone deposits frequently contain small seams of fibrous silicates, occasionally large deposits occur, which are the source of the amphibole asbestos fibers that are exploited in the southern hemisphere. Other deposits are of no commercial value, such as the taconite fibers in the Mesabi Range on the shores of Lake Superior. Although iron-ore mining in this region is causing contamination of the atmosphere and the water of the lake, no evidence of a hazard to humans has been established.

Tremolite as a contaminant of other mineral deposits: Tremolite is friable and of little economic importance, but has been used as an industrial talc. It is a contaminant in chrysotile and talc deposits and is released when the materials are milled. It has been used as material for stuccoing of domestic dwellings in certain villages in Turkey, Cyprus, and elsewhere in the Eastern Mediterranean. In Turkey, the villagers collect it from quarries that have been used for generations, and it is sometimes removed from the tailing dumps in the vicinity of the chrysotile asbestos mine in Cyprus. In Korea, there are mines producing tremolite for which a market is being sought.

Possible contamination in agriculture: Fibrous mineral contamination in agriculture has only been appreciated during the last few years, and may yet be shown to be of consequence, as evidence to date is still fragmentary. The first confirmed situation as far as asbestos is concerned is in Bulgaria, where the finding of pleural plaques in workers in the tobacco fields containing tremolite and anthophyllite in the soil has been reported.

Synthetic Mineral Fibers

Synthetic mineral fibers can be divided into four groups: Slag wools, rockwools, glass and ceramic wools, and filaments. The materials of each group consist of glassy mineral fibers. All man-made mineral fibers are formed from a liquid melt at temperatures of 1000 to 1500°C, but the methods of producing the fibers vary.

All the man-made mineral fibers produced have glassy structures, and thus are not crystalline. Their length and diameter distribution differ considerably and are dependent on the method of production and the chemical composition. Usually, commercially produced fibers of man-made minerals are considerably coarser than asbestos fibers, although specialized samples have been produced with dimensions very similar to those of asbestos. These synthetic fibers fall into three broad categories of fiber size. The first is the continuous filament glass fibers that are used in textiles and as a reinforcement for plastics and other materials, with fiber diameters greater than 8 μm. In the second category are insulation wools with fibers nominally 1–6 μm in diameter; however, there are ends that are as small as 0.2 μm. The third category contains fibers smaller than 1.0 μm in diameter, which are used for specialized purposes such as scientific filter papers.

Man-made mineral fibers are usually coated with binding compounds to produce fabricated shapes and forms. In the past, insulation wool binders have included bitumen, urea, and phenol-formaldehyde resin compounds. Today, innovations in binding agents based on resin systems are continuously being made.

Naturally Occurring Fibrous Minerals

The naturally occurring fibrous minerals are a miscellaneous collection. The majority are silicates, but one metal—rutile (the fibrous form of titanium)—is proving of interest because it has been recovered from the lungs of various industrial workers, including slate miners and processors. The two groups of fibrous silicates of particular current interest are the clays and the zeolites. Zeolites are a complex group of silicates formed by metamorphosis in deposits of volcanic ash. They are characterized by an open lattice structure useful for infiltration catalysis and absorption in the chemical industry and agriculture. Most of the commercially used zeolites are now synthesized and nonfibrous. Few of the natural materials are fibrous, but there are at least three that are: mordenite, clinoptilite, and erionite. These fibrous zeolites form hexagonal glassy rods that may occur singly or in strands and vary in diameter from deposit to deposit. Extremely fine erionite fibers have been found in a few deposits in Oregon in the United States, and in central Turkey. The implications of erionite fiber exposure will be explained later.

The absorbent clays have been used for various industrial purposes for many years, and recently there has been an increasing demand for these materials as cat litter. A chance discovery was that some of the material used for cat litter was fibrous in nature. Although these minerals appeared visually to consist of solid minerals, when finely ground samples were examined under the transmission electron microscope, they were found to contain numerous short fine fibers. The fibers were particularly noticeable in minerals of the meerschaum group, including attapulgite, palygorskite, and sepiolite.

Sequelae of Exposure to Asbestos Dust

There have been numerous descriptions of the lesions resulting from exposure to asbestos dusts. The sequelae are as follows: (1) the presence of asbestos bodies in the sputum; (2) pleural plaques and diffuse pleural fibrosis; (3) interstitial pulmonary fibrosis (asbestosis); (4) carcinoma of the lungs; (5) diffuse mesothelioma of pleura and peritoneum; and (6) an increased incidence of gastrointestinal tumors and possible increase in incidence of carcinoma of the larynx. On detailed investigation, each of these findings has provided problems that not only apply to asbestos exposure, but also have to be considered in the wider assessment of other mineral fibers.

The comparison between the fibers in the lungs of the mesothelioma cases collected in Britain with those in the United States and Canada has shown that, in both countries, chrysotile fibers are found equally in cases and controls. In Britain, it is crocidolite that is associated with mesotheliomas; whereas in the United States, it is usually amosite and, less frequently, crocidolite.[12] The Advisory Committee to the British Secretary of State for Employment concluded that in the causation of mesotheliomas, crocidolite was more dangerous than chrysotile, and amosite may be intermediate between the two.[13]

Significance of Fiber Size

The importance of fiber size in the inhalation and retention of fibrous mineral dusts was first emphasized in a study that showed that the fiber diameter is the most important factor in the deposition, and the length is only of minor significance. Later, in a study of the ultimate diameters of crocidolite and amosite fibers, the diameter was identified as a vital factor in assessing the probability of a fiber being associated with the development of a mesothelioma. Similar results were recorded from animal experiments in which asbestos and other mineral fibers were implanted into the pleural and peritoneal cavities of rats. At this stage of the investigations, Dr. Harold Stewart introduced me to Mearl Stanton. Dr. Stanton and I planned a series of collaborative investigations in which we compared the results of our initial implantation studies.[14] Then Dr. Stanton undertook a detailed program on intrapleural implantations of a large variety of fibrous dusts in different size ranges. It was from these outstanding experiments that the concept of the importance of specific fiber size was recognized.[15] From these and other investigations, it now appears that the size of the fiber responsible for mesotheliomas has a diameter of less than 0.25 μm and probably a length greater than 5.0 μm. Fibers up to 3.0 μm in diameter inhaled and retained in the peripheral airways are associated with pulmonary fibrosis, and the effective length of at least 10 μm suggested by Timbrell and Skidmore in 1968 has not been challenged.[16] There is no agreement on the maximum length of fibers that would be hazardous. The most important finding in all these experiments was that mineral fibers other than asbestos having these diameters and lengths are capable of causing mesotheliomas. Whether this finding also applies to the development of pulmonary fibrosis is still under investigation.

Studies on the Other Fibers

Our experiences with the other fibers will be described in chronological order from the time when we first became involved with a particular material.

Tremolite and Actinolite as Contaminants of Other Mineral Deposits

As mentioned previously, we received our first mesothelioma case from Cyprus in 1968 of a woman who had lived all her life in the vicinity of the 3000-year-old Amiandos Chrysotile Asbestos Mine. On microscopic examination of the biopsy specimen, a small fragment of lung tissue was attached to the tumor in which a few asbestos bodies were seen. Pooley[8] had demonstrated that asbestos bodies are rarely seen in the lungs of workers exposed to chrysotile dust, but on examination of the tissue he confirmed that amphibole fiber was present which was either tremolite or actinolite (as these two minerals are very similar, no differentiation has been made in this and in further studies). To date, we have confirmed the diagnosis of seven cases of mesothelioma from Cyprus and have been notified of an additional five cases. We have only obtained lung tissue from one further case of mesothelioma and a miner with early asbestosis, both of which also contained tremolite/actinolite fibers. We were fortunate to obtain the lungs of six mature sheep which were being prepared for a wedding feast, which also contained tremolite/actinolite fibers. Previously, in 1969, Dr. Pooley had visited the mine and had found fine tremolite in the ore body and in the surrounding area with a diameter of less than 0.5 μm. A similar situation occurs in Eastern Turkey, although the finest tremolite that we have obtained is mined in South Korea, which, when inoculated intrapleurally into rats, resulted in a high incidence of mesotheliomas.

In contrast, a coarser flake-like tremolite occurs in the talc mine in California, but no evidence of disease has been observed among the miners and millers from this site, nor were lesions produced when this material was used in our experimental studies.[17] A coarse fibrous tremolite is found as a contaminant of the Quebec chrysotile deposits, which is found in the lungs of the miners and millers who develop pleural plaques and asbestosis.[18] This contaminant is incorporated with the commercial chrysotile, particularly with the fiber produced from the tailings, and has been found in the lungs of United States factory workers, especially where the plants had used the Canadian crude fiber in the past. A similar tremolite is quarried in Central Turkey, where it is used for stuccoing houses, causing huge calcified pleural plaques in both workers and house-dwellers, some of the houses even being "white-washed" inside as well as out. Tremolite contamination of the soil is widespread, and evidence of pleural plaqueing in agricultural workers has been found in Turkey,[19] Greece,[20] Bulgaria,[21] Yugoslavia and Czechoslavakia, and more recently in Austria.

Erionite

In 1974, Professor Izzet Baris came to visit us to demonstrate the radiographs of the case with large calcified pleural plaques which he had found in Central Turkey.[19] I had previously written a paper for the Abbot Pharmaceutical firm on blue asbestos and mesotheliomas; produced in *Abbottempo,* with excellent illustrations, which had been translated into numerous languages including Turkish. I discussed the asbestos story with Baris and gave him the Turkish copy of the *Abbottempo* journal,[22] after which he wrote a short article for a Turkish Medical Journal, which was taken up by several Turkish newspapers. Much to his surprise, Baris received a letter from the head man of the village of Karain in the Urgup region of Cappadocia, stating that he thought a similar tumor was occurring in his villagers as had been described in South Africa.

As is now well known,[23] Baris went to investigate and discovered a horrifying situation with several villages in the area, including the town of Tuskoy, having the highest incidence of mesothelioma in the world. In Karain, with a population of 327 people older than age 20 years, during the last 5 years, 50 deaths have been recorded, 21 of which were due to mesotheliomas, with a slightly lower rate in Tuskoy. There has been a great deal of controversy concerning the origin of the tumors. One of my colleagues, J.W. Skidmore, joined the epidemiologic team in the valley and collected dust samples which were analyzed by Fred Pooley, who found the presence of very fine fibers of a zeolite fiber known as erionite, while Patrick Sebastien found this material in the sputum of people from the afflicted population of one of the villages. Baris has obtained numerous biopsy specimens from these villages, but very few of these have associated lung tissue, although in two specimens, Pooley has found these fine erionite fibers which do not present in lung biopsy specimens from elsewhere in Turkey. We were able to collect the lungs of 40 sheep from various regions of Turkey, and these fine fibers were only found in the animals which had come from the suspect villages, while coarse zeolite fibers were found in the lungs of sheep from other sites in the Urgup Valley. In experimental studies of 40 animals that we inoculated with the dust that Skidmore had obtained from the village of Karain,[24] 38 animals developed mesotheliomas. In many of the volcanic areas of the world, tuff containing zeolite fibers including erionite occur, but only in a few situations does the very fine erionite fiber occur, such as western states of Oregon, Nevada, and Utah. We obtained some of the Oregon erionite from Professor F. H. Mumpton of New York, which produced a 100% rate of mesotheliomas in the animals after inoculation. A similar rate of tumors was produced following inhalation, which is unique in our experience, for the highest rate we had previously produced by this technique was 10% with crocidolite. Dr. Allen Poole undertook *in vitro* studies with the Oregon erionite and showed it to be "the only fibrous dust we have so far examined which gives reproducible and unequivocal results in *in vitro* assays designed to detect genotoxicity."[25] Fortunately, the region where this fiber is found in Oregon is sparsely populated ranching country.

Absorbent Clays

Absorbent clays which are fibrous are used as oil absorbents in factories and garages, cat litter, and a "gelling" agent in drilling muds for the oil industry. During this last year, major industrial groups are considering further use for these materials. Our studies of the absorbent clays have led to detailed mineralogic–environmental–radiologic studies in Spain, together with experimental investigation at this Unit. Our human and animal investigations have been confined to the production of Sepiolite and Attapulgite in Spain. We have, however, carried out fiber sizing of attapulgite fibers from the United States, West Africa, and France. The main study with the Spanish fibers did not produce mesotheliomas following implantation, with the exception of one particular attapulgite fiber from a small mine in a village called Torrejon near Placentsia in the far western region of Spain. According to the producers, this fiber has been used as a substitute for chrysotile, since it has an excellent gelling effect and has been used for "drilling muds" by several major oil companies, who have confirmed that they are mixed dry in enclosed chambers on the rigs, producing a very dusty atmosphere. Experimentally, when this material is implanted intrapleurally, it has produced nearly as many mesotheliomas as the contaminated chrysotile it is replacing.

The Significance of the Selective Retention of Fibers

At present, we are endeavoring to assess the significance of the selective retention of fibers. We are convinced that the diseases associated with exposure to mineral fibers are due to the fibers that are retained in the lungs. If this hypothesis is correct, then the lungs are the most important dust samplers that are available for the recording of lifetime exposure of an individual. In the investigations that have been described, there are a number of situations in which the significant mineral or minerals retained in the lungs have either not been recorded or are a minimal fraction of the total dust sampling of the appropriate environmental or occupational atmosphere. This is particularly important in the chrysotile millers, who were found to have significant amounts of tremolite in their lungs, and again in the discovery of erionite fiber in lungs of the population in the Turkish villages. In view of the findings, it would appear that the analysis of the lung mineral content is essential when searching for a potential occupational hazard. By relying on environmental dust studies, it is possible to obtain results that may be misleading.

The Chrysotile Factor

Our view that chrysotile, if uncontaminated, is probably a material causing little disease, is not accepted by many workers, although the number of converts is increasing. We have provided the major evidence for the innocence of chrysotile to humans, but our experiments suggested that chrysotile is both fibrogenetic[26] and carcinogenitic.[27,28] Dr. Pooley is now undertaking a major study into both original samples that we used in our studies and those fibers retained in the lungs, and preliminary results suggest that we were using contaminated fiber.

It is obvious that the whole fate of chrysotile after inhalation requires further study. We know of certain commercial treatments which will straighten out the fiber, and that if chrysotile has been subjected to heat for long periods, it loses the coiled-woven configuration, while a search is being made to see if there is a source of chrysotile that is free of contamination by other mineral fibers. The other possibility is for the industry to develop economic methods for the removal of these contaminants.

Conclusions

It is now established that the inhalation of all mineral fibers of a specific diameter and length size range may be associated with the development of diffuse pleural and peritoneal mesotheliomas. Pulmonary fibrosis is associated with the inhalation of mineral fibers which can be coarser than those involved in the development of mesotheliomas. In these situations, the importance of the selective retention of fibers must be stressed. It is the fiber that is retained in the lung tissue that is responsible for the disease.

Finally, I have not answered the question of the relative toxicity of the various asbestos fibers, but evidence points to exposure to the amphiboles, or material containing amphibole, as being more hazardous than exposure to uncontaminated chrysotile fibers.

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