1988.06

American Journal of Industrial Medicine 14:205–209 (1988)

COMMENTARY

Linking Chrysotile Asbestos With Mesothelioma

Jacques Dunnigan, PhD

Key words: cohort studies, mesothelioma, amphiboles amosite, asbestos

The symposium organized by Dr. J. C. Wagner, "Biological Effects of Chrysotile" (1986), can be considered a benchmark among the many important scientific meetings of the last two decades on the effects of asbestos. The first statement of the monograph, by F. D. Pooley and R. Mitha, is as follows: "The only way at present of estimating the dose and effect of asbestos or other dusts in lung-related diseases with any certainty is by assaying the tissue for residual mineral content."

Since then, this statement, which set the tone of the entire symposium, has led many specialists in the field to take a second look toward the causality of asbestos-related mesothelioma and has led some to state that the time has come to reassess the biological effects of chrysotile asbestos.

This question is not a purely academic one, as it also bears important consequences for the courts. For instance, a recent publication of Mealy's Litigation Report [1987] has reported on the outcome of a litigation involving a shipyard worker, where it was decided that chrysotile asbestos was a cause of his mesothelioma in spite of the fact that the court was aware that the plaintiff had been exposed to substantial amounts of chrysotile *and* amphiboles. The court's decision apparently was based on the observation that mesothelioma has been observed in a few cases of chrysotile mine and mill worker deaths.

In this commentary, I wish to submit that this decision runs counter to an overwhelming consensus as to the vastly different potentials of the different asbestos fiber types in inducing mesothelioma, which can be judged by the monograph mentioned above and by the following review.

Churg's recently published data [1984a] on fiber lung burden in long-term chrysotile miners and millers are as follows: of six workers with mesothelioma, both chrysotile and tremolite/actinolite/anthophyllite types of amphibole asbestos were found in five of the six. In the other patient, both chrysotile ore components and amosite were found. In the five patients with only the chrysotile ore components,

Universite de Sherbrooke, Sherbrooke, Quebec, Canada.
Address reprint requests to Jacques Dunnigan, PhD, Universite de Sherbrooke, Pavillon Marie-Victorin, Suite 336, Sherbrooke, Quebec J1K 2R1 Canada.
Accepted for publication December 29, 1987.

© 1988 Alan R. Liss, Inc.

64 × 10^6 chrysotile fibers/g dry tissue and 540 × 10^6 tremolite group fibers/g were found. In long-term chrysotile miner control subjects with no asbestos-related disease, 23 × 10^6 chrysotile fibers/g and 58 × 10^6 tremolite group fibers/g were found.

These observations led Dr. Churg to make the following statement: "Our observations in chrysotile mine industry workers thus raise the possibility that the amphibole component of the chrysotile ore is important in the genesis of mesothelioma in this group. This situation may be similar to that reported in mesothelioma patients exposed to mixtures of chrysotile and the commercial amphiboles, amosite and crocidolite, where the amphibole appears to play a major role in tumor induction."

Recently, however, Churg [1986] indicated that in chrysotile industry workers of Quebec, the pulmonary ratio of tremolite to chrysotile is fairly constant; but in workers exposed to processed products, the ratio varies widely, and the marked residual predominance of tremolite is not seen in their lungs, "suggesting that processing of the original fibers for different commercial applications results in removal of tremolite from the final product. If tremolite really is important in the genesis of mesothelioma, the relative lack of tremolite may account for the virtual absence of mesotheliomas in those exposed to chrysotile in the textile and friction products industries." When comparing data from chrysotile mining industry workers to other exposure situations, Churg indicates an additional caveat: "*Thus, comments that apply to disease seen in chrysotile mining industry workers may not hold true for individuals with other types of chrysotile exposure.*"

Many other cohorts of workers have been studied over the past decade, and the observations and conclusions of the authors of these studies point to a very clear difference in disease potential between chrysotile and the amphiboles, especially with regard to mesothelioma. The following is an overview of such studies.

Weiss [1977] reported no cases of mesothelioma in 264 workers making millboard and papers using pure chrysotile who were followed 30 to 39 years from onset of exposure.

McDonald and Fry [1982] reported only one death from mesothelioma among 2,341 deaths in two factories, one plant making yarns, cloth, packings, and gaskets, using almost exclusively chrysotile, the other one making friction materials. However, 18 deaths of 1,429 workers occurred in a factory where mixed fiber types were used. These results led the authors to conclude: "This finding supports much other evidence that amphiboles are mainly responsible for mesothelioma, whereas chrysotile has little or no mesothelioma-producing potential."

Dement et al. [1982] reported a study of a textile factory in which almost all the asbestos used was chrysotile, and they found only one case of mesothelioma among 768 workers followed from 1940 to 1975.

Newhouse et al. [1982] reported on the deaths of workers making friction materials in a factory founded in 1898 in U.K. There were two occasions in the factory history (1929/1933 and 1939/1944), when crocidolite was used to produce specially ordered railway blocks. Other than these two brief periods, chrysotile was used exclusively. Of 13,460 workers studied, 10 mesothelioma deaths occurred, for which there is firm documentary evidence that at least 8 of the 10 occurred in workers who had been employed in the manufacure of the particular railway brake blocks in which crocidolite was specified. No death from mesothelioma occurred in the group

of workers employed after the completion of the crocidolite job. In a follow-up, Berry and Newhouse [1983] also mentioned that "the experience at this factory over a 40-year period (1942–1980) showed that chrysotile was processed with no detectable excess mortality."

In that same year, Thomas et al. [1982] reported the results of a follow-up study tracing 1,970 workers employed at an asbestos-cement (A/C) factory between 1936 and 1977. Before this period, some crocidolite had been used in the factory until 1935, when the factory changed ownership and started manufacturing A/C sheeting for the building industry, using chrysotile only. With the exception of two workers who died from mesothelioma, there was no appreciably elevated SMR for causes of death investigated (all causes, all neoplasms, cancers of the lung, and pleura, and cancer of the gastrointestinal tract). It was found that the two workers who had died from mesothelioma had been employed at the factory during the period 1932–1935, when crocidolite was used.

Acheson et al. [1982] reported the mortality experienced during 1950–1980 of two groups of women engaged in the manufacture of gas masks before and during the Second World War. One group (570 women) inserted crocidolite pads into respirators prepared for the Ministry of Defense; the other group (757 women) was involved in packing civilian respirators, which contained chrysotile. Five cases of mesothelioma were found in the group using crocidolite, but so far no cases have been reported from people involved in manufacture of civilian respirators that contained chrysotile. Furthermore, excess mortality, ascribed to lung cancer and various cancers, was found in the factory using crocidolite, but not in the one where chrysotile was used.

LUNG BURDEN BY FIBER TYPE AND DISEASE

The question of asbestos-related disease causality by fiber type has been the subject of much speculation until the pioneering work of Dr. F. D. Pooley, from the Department of Mineral Exploitation, University College in Cardiff, finally brought a solution to this important question. Over the last 20 years, Dr. Pooley has been developing more and more sophisticated methods for identifying, quantifying, and measuring fibers in tissue. The current method depends upon the use of energy dispersive analysis of x-rays (EDAX) on a transmission electron microscope with direct computer read out studying fibers extracted from known amounts of lung tissue. 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 with tissue from age-matched control cases. Here is a sample of such studies recently published.

A study was conducted by J. C. Wagner on lung tissue samples from workers whose deaths were considered to be asbestos-related. Controls had been exposed to different levels of urban pollution. Results showed that amphiboles were present at levels up to 100 times as great in cases as in controls, but the amounts of chrysotile were similar. Furthermore, in asbestotic cases, the amount of amphiboles, but not of chrysotile, related well quantitatively to the pathological severity of the disease. This study by Wagner and coworkers [1982] was performed on cases reported to the U.K. Pneumoconiosis Medical Panels.

The same group [Wagner et al., 1986] later confirmed this increased severity of asbestosis with increased amounts of amphiboles found in the lungs of workers

employed in the period 1966–1982 in the Royal Navy dockyards. Again, in these workers, the amounts of chrysotile remained constant and did not increase with the severity of asbestosis.

In 1980, two reports appeared in a publication by the International Agency for Research on Cancer. One report by Jones et al. [1980], dealing with the pathology and the mineral content of lungs in cases of mesothelioma in U.K. showed that mesothelioma patients had more amphibole fibers in their lungs than did control cases, and chrysotile fibers were not present in greater numbers in the mesothelioma patients than in the control cases.

The other report, by A.D. McDonald [1980], dealing with 274 fatal cases of mesothelioma in North America during 1972, showed that although the quantity of chrysotile was similar in cases and in controls, there was an excess of amosite fibers in cases as compared with controls.

In a study recently conducted on 72 mesothelioma cases in Canada, tissue mineral analysis data again showed that the chrysotile content of mesothelioma cases was identical to that seen in matched controls, but the amosite burden was greatly above control values [McDonald, 1985].

As stated before, Dr. Churg's data are also in agreement with these studies. In 1985, Churg analyzed the mineralogic content in mesothelioma patients in British Columbia. He found that the pulmonary content of chrysotile asbestos was within the range of general population, but the values for the commercial forms of amphibole asbestos, amosite and crocidolite, were an average 300-fold compared with a reference population [Churg, 1985].

In 1982, the same author published results of a study indicating that patients in the general population who have pleural plaques have about the same total number of fibers, but their lungs contain about a 50-fold increase in long amphibole fibers of commercial origin [Churg, 1982].

Results of tissue burden analysis have been accepted by a majority of scientists as a key element in pointing to those fiber types that have the longest durability (residence time) in lung tissue and, as a possible consequence, which fiber types are most likely to be related to disease. It should be noted that Churg's data [1984b] on mineral analysis content of lung tissue of insulation and shipyard workers with mesothelioma show a 250-fold increase in amphibole fibers over those found in the general population.

Finally, it should be noted that geologists have observed that chrysotile ores sometimes are contaminated with small amounts of tremolite; but it does not necessarily follow that *all* chrysotile ores from *all* sources contain tremolite.

CONCLUSIONS

When the courts are asked to assume that plaintiffs with mesothelioma have been exposed to mixtures of amphiboles and chrysotile, decisions on individual cases must be based on the best evidence available (and this includes tissue burden mineral analysis), or they must rely on the scientific consensus as it stands today. At present, this consensus is that amphiboles are mainly responsible for mesothelioma, whereas chrysotile alone has little or no mesothelioma-producing potential.

REFERENCES

Acheson ED, Gardner MJ, Pippard EC, Grime LP (1982): Mortality of two groups of women who manufactured gas masks from chrysotile and crocidolite asbestos: a 40-year follow-up. Br J Ind Med 39:344–348.

Berry G, Newhouse ML (1983): Mortality of workers manufacturing friction materials using asbestos. Br J Ind Med 40:1–7.

Churg A (1982): Asbestos fibers and pleural plaques in a general autopsy population. Am J Pathol 109:88–96.

Churg A, Wiggs B, Depaoli L, Kampe B, Stevens B (1984): Lung asbestos content in chrysotile workers with mesothelioma. Am Rev Resp Dis 130:1042–1045.

Churg A, Wiggs B (1984): Fiber size and number in amphibole asbestos-induced mesothelioma. Am J Pathol 115:437–442.

Churg A (1985): Malignant mesothelioma in British Columbia in 1982. Cancer 55:672–674.

Churg A (1986): Pathologic reactions to chrysotile and their mineralogic correlates. In Wagner JC (ed): "Accomplishments in Oncology." New York: Lippincott, pp 54–58.

Dement JM, Harris RL, Symons MJ, Shy C (1982): Estimates of dose-response for respiratory cancer among chrysotile asbestos textile workers. Ann Occup Hyg 26:869–887.

Jones JSP, Roberts GH, Pooley FD, Clark NJ, Smith PG, Owen WG, Wagner JC, Berry G, Pollock DJ (1980): The pathology and mineral content of lungs in cases of mesothelioma in the United Kingdom in 1976. WHO/IARC, Pub. No. 30, Vol 1, pp 187–199.

McDonald AD (1980): Mineral fibre content of lung in mesothelial tumours: Preliminary report. WHO/IARC, Pub No. 30, Vol 2, pp 681–685.

McDonald AD, Fry J (1982): Mesothelioma and fiber type in three american asbestos factories.—Preliminary Report. Scand J Work Environ Health 8:53–58.

McDonald JC, Case B, Doell D, McCaughey WTE, McDonald AD, Sebastien P (1985): Lung dust analyses in mesothelioma cases and controls. Report to Health and Welfare Canada, Ottawa, No. 6605-1943-03.

Mealey's Litigation Reports (1987): Asbestos 343.

Newhouse ML, Berry G, Skidmore JW (1982): A mortality study of workers manufacturing friction materials with chrysotile asbestos. Ann Occup Hyg 26:899–909.

Thomas HF, Benjamin IT, Elwood PC, Sweetnam PM (1982): Further follow-up study of workers from an asbestos cement factory. Br J Ind Med 39:273–276.

Wagner JC, Pooley FD, Berry G, Seal RME, Munday DE, Morgan J, Clark NJ (1982): A pathological and mineralogical study of asbestos-related deaths in the United Kingdom in 1977. Ann Occup Hyg 26:423–431.

Wagner JC, Moncrieff CB, Coles R, Griffiths DM, Munday DE (1986): Correlation between fibre content of the lungs and disease in naval dockyard workers. Br J Ind Med 43:391–395.

Wagner JC (1986) The biological effects of Chrysotile. In Wagner, JC (ed): "Accomplishments in Oncology." New York, Lippincott, Vol. 1, No.2.