Tremolite in southern African chrysotile

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It is possible that the presence of the amphibole tremolite in chrysotile ore may be the cause of mesotheliomas in miners exposed to this type of asbestos. This article is the first report of the presence of tremolite fibres in the lungs of miners who worked with chrysotile in southern Africa. Although significant exposure to tremolite was not detected, results support the case for a more detailed investigation of the potential health risk.

Malignant mesothelioma, a tumour which arises from mesothelial cells, has been investigated extensively because of its association with asbestos exposure. Nevertheless, important questions about asbestos and mesothelioma remain unanswered. One of these is the capacity for the different asbestos fibre types to cause mesothelioma in exposed individuals. The link between this tumour and the amphiboles, particularly crocidolite (blue asbestos), is well established but the role of chrysotile (white asbestos) in the development of the tumour is less clear. The mining and milling of Canadian chrysotile is associated with a small risk of mesothelioma[1] and animal experiments have shown convincingly that all the major asbestos varieties, including chrysotile, produce the cancer.[2] Nevertheless, the causal association between chrysotile exposure and mesothelioma in humans is not established because certain chrysotile ores contain a small proportion of the amphibole tremolite and this fibre has been found in the lungs of chrysotile miners.[3] It has been shown to cause mesothelioma in rats[4] and has been implicated as the causative agent of mesotheliomas in workers exposed to vermiculite contaminated with tremolite.[5] It has been suggested, therefore, that the fibrous tremolite, rather than the chrysotile itself, may be responsible for the disease in the majority, if not all, of the chrysotile-exposed cases.[1] If this hypothesis is correct, then chrysotile deposits which are not contaminated by fibrous tremolite would carry little if any mesothelioma risk. Despite its potential importance, information on the fibrous tremolite content of southern African chrysotile deposits is not available. To begin to rectify this gap in knowledge, a preliminary investigation to determine whether tremolite fibres are present in southern African chrysotile was conducted at the National Centre for Occupational Health (NCOH). The purpose of this preliminary investigation was to assess the need for a more detailed study of the extent and nature of amphibole in these deposits.

Two methods were used in this investigation; namely, a direct examination of milled chrysotile samples for tremolite, and an indirect approach in which lungs of miners with a recorded history of asbestos exposure exclusively on a chrysotile mine were examined for tremolite fibres.

Samples of milled chrysotile mined at Shabanie mine (Zvishavane), Havelock, Kaapsehoop and African Chrysotile Asbestos (ACA Msauli) mines were obtained from a local mining house. Addison and Davies's recently reported sulphuric acid digestion method for the analysis of amphibole asbestos in chrysotile and other minerals[6] was adopted to concentrate any amphiboles contained in these samples. The authors report that their method improves the sensitivity of amphibole analysis greatly, giving detection limits of 0.01 to 0.05% in chrysotile by X-ray diffractometry (XRD). XRD, using a Phillips PW 1130/00 diffractometer, and phase contrast optical microscopy (OM) and scanning electron microscopy (SEM) were used to analyse the concentrated samples for tremolite.

Following inhalation, chrysotile is cleared from the lungs to a greater extent than amphiboles. Consequently, the amphibole fibres accumulate preferentially and may eventually become the predominant fibre in the lung even if they made up only a small proportion of the total inhaled asbestos burden. This phenomenon has been observed in some Canadian chrysotile miners[1,3,7] and was used in this study as an indirect method of determining the tremolite content of chrysotile ore. Lung tissue from four deceased miners with a history of exclusively chrysotile mining was identified using the PATHAUT database.[8] The four ex-miners had had autopsies at the NCOH and lung tissue had been stored in wax blocks. Asbestos fibre content of the lung tissue was determined by removing the wax with heat and xylene and digesting the lung tissue in 15% sodium hypochlorite. The remaining material was suspended in distilled water and samples were then prepared for OM and SEM. A detailed description of this procedure is contained in a thesis by Rendall.[9]

Results

Milled chrysotile

Tremolite could not be detected by XRD in any of the treated chrysotile samples. This negative finding was confirmed by an independent institution, the Council for Mineral Technology (Mintek). Examination of these samples under

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Table 1. Cases by occupational history, diagnosis and fibre analysis.

Case	Years of service on chrysotile mines	Mine	Occupation	Diagnosis[1]	Fibre content of lung[2]	Tremolite observed OM	Tremolite observed SEM
1	24	ACA	Mill shiftsman Millwright	Asbestosis	697 000	No	No
2	22	Stolzburg	Mill shiftsman Mill foreman	Asbestosis	411 000	No	Yes
3	22	ACA	Mill shiftsman Mill foreman	Asbestosis	312 000	No	Yes
4	22	ACA	Underground skipman Mill shiftsman	Pleural plaques	377 000	No	No

[1]By NCOH specialist pathologist after post-mortem examination.
[2]Per gram of dry lung as determined by fibre counting under optical microscopy.

OM at a magnification of × 450 confirmed the efficacy of the digestion process: only one fibre being observed in several fields of vision. SEM showed that tremolite fibres were present but in very small numbers, being observed only with careful searching (at a magnification of × 1000).

Lung analysis

Selected characteristics of the four cases used for lung tissue examination are presented in Table 1. Years of service in chrysotile mining plus a summary of the jobs performed on the mine, the medical diagnosis and fibre content of the lung tissue are shown in the Table. All four individuals had substantial service (exceeding 20 years) and had worked in the mill — usually the most dusty worksite. Fibres most likely to be tremolite were not observed under OM, but SEM demonstrated fibres with the morphology and spectral characteristics of tremolite in two of the cases. These fibres were scanty, one fibre appearing in approximately 20 fields at × 1000 magnification.

In summary, a few tremolite fibres were found in milled southern African chrysotile and in the lungs of two chrysotile miners. These preliminary findings should be treated with caution and are certainly inadequate both to quantify the risk faced by exposed individuals or even to conclude that a tremolite hazard is definitely present. The XRD results suggest that the tremolite content was under 0.05% in all the samples but more extensive sampling may show that substantial variation in tremolite content exists within a particular mine. Furthermore, an improvement in the methodology of isolating tremolite from chrysotile may facilitate identification and quantification by X-ray diffractometry.

The mesothelioma risk from asbestos fibres is determined partly by the morphology and the inhaled dose of the fibres, with longer, thinner fibres and increasing doses being associated with increased risks.[10] These factors were not examined in this investigation but are particularly pertinent for two reasons. Tremolite fibres in the lungs of the South African miners were scanty and much fewer than in Canadian miners, in whom tremolite fibres frequently exceed chrysotile fibres in lung tissue and can be very numerous: 10–100 million tremolite fibres per gram of dried lung was not unusual in one study.[7] The second reason is that the tumour is not well documented in chrysotile-exposed individuals in southern Africa. The register of mesothelioma cases maintained by the Pathology Department of the NCOH contains over 2 000 cases of mesothelioma, yet none has a history of asbestos exposure exclusively on a chrysotile mine (I. Webster, pers. commun., NCOH, 1992). It should be noted that an exposure history is not recorded in about 50% of these cases,[11] thus reducing the significance of these data.

In conclusion, the results presented here do not confirm significant tremolite exposure in South African chrysotile miners but provide clear support for a more detailed investigation. Such an investigation should focus on two aspects. The fibre content of the lungs of deceased miners will provide data on the cumulative tremolite exposure over time from all sources within the mine and mill, while a systematic analysis of the tremolite content of raw and milled ore will clarify the current situation for specific localities.

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