SESSION 9

17 November

OVERALL REVIEW

Chair: G. W. GIBBS

0800–1245 REVIEW OF ALL RAPPORTEURS' SUMMARIES AND DISCUSSION

REPORT OF DISCUSSIONS AND SUMMARIES OF PRESENTATIONS

SESSION 1

CHEMISTRY, PHYSICS, MINERALOGY, USES AND EXPOSURE

SUMMARY OF PRESENTATIONS

CHRYSOTILE: THE MINERAL AND ITS PROPERTIES

A. LANGER

CHRYSOTILE formation arises through serpentinization of ultramafics and silicified dolomitic limestones. Rock types tend to control the trace metal content and both the nature and amounts of admixed minerals in the ore, such as fibrous brucite (nemalite) and tremolite. Some associated minerals and trace metals are thought to play a role in biological potential.

Tremolite, one of the important associated minerals, may occur with different morphological forms, called habits. These habits range from asbestiform (tremolite asbestos) to common blocky or non-fibrous form (tremolite cleavage fragments). The latter is most common in nature. Tremolite in chrysotile ore varies in habit and concentration, both factors determining the degree of risk following inhalation. Tremolite fibre is thought to be important in relation to the occurrence of mesothelioma.

Chrysotile fibrils may vary in diameter. Dust clouds generated following manipulation vary in fibre number and surface area. Chrysotile fibres exhibit a range of physical characteristics. The fibre may be non-flexible ('stiff') and low in tensile strength ('brittle'), and may lack an ability to curl. This fibre, referred to as 'harsh', sheds water more quickly than its curly, flexible 'soft' variety. The behaviour of the harsh fibres is more amphibole-like and their splintery nature suggests an enhanced inhalation potential.

Slip fibre ore from Canada tends to contain more fibrous brucite (nemalite) than cross-fibre ore in the same mine.

Industrial manipulation, which includes chemical treatment, heating and milling, may impart new surface properties to chrysotile dusts. Biological potential may be enhanced (opening of fibre bundles) or reduced (disruption of surface bonds and lessened ability to interact with organic moieties). Leaching of magnesium from chrysotile occurs at a pH less than about 10. Chrysotile has been demonstrated to lose magnesium *in vivo* and undergo clearance from the lung. The biological potential of magnesium-depleted chrysotile is much reduced, or even eliminated. Reduction of mesothelioma-inducing and cytotoxic potential has been observed and quantified experimentally.

Use of chrysotile products in high-temperature environments may heat the mineral to the point where it undergoes alteration of properties, especially by dehydroxylation.

Chrysotile ore may vary in properties and associated minerals: it may form aerosols with different size distributions, especially fibre/fibril diameters and surface areas; it may be associated with varying quantities of tremolite (with differing habits); it may be manipulated both industrially and environmentally to yield surfaces with different properties and, hence, differing biological potentials. Chrysotile's properties may vary from place to place and among different user industries.

distributions at different work places. Commercial fibre grade designations alone are probably of limited value for estimating the airborne fibre characteristics.

It has been suggested that the curled form of chrysotile, as opposed to straight amphiboles, favours deposition in the upper airways. However, the extent to which the curvature contributes to reduced penetration in humans is still not clear. The question of using particle size selective sampling for assessing occupational exposure was discussed. Of the three internationally defined particle size fractions sampled in accordance with the conventions for inhalable, thoracic and respirable particles, the thoracic and respirable fractions are most important for chrysotile.

SESSION 2

ASSESSMENT OF EXPOSURE

SUMMARY OF PRESENTATIONS

LEVELS OF EXPOSURE: WORKPLACE

A. L. RICKARDS

A BRIEF description was presented of the evolution of workplace exposure monitoring. Measurements began in the 1930s and developed through particle counting to the introduction of the membrane filter, light microscope method in the mid-1960s. It is important to be aware that most data from the past were collected in relation to workplace control.

The membrane filter phase contrast microscope method provides an index of exposure. Fibres with diameters less than 0.2 μm are unlikely to be counted. The method is not capable of analysing individual fibre types and consequently all fibres are counted.

There have been several changes to the detail of the membrane filter method. The possible effect of these changes were presented. The Asbestos International Association (AIA) has implemented a fibre counting performance trial and also an annual return of workplace monitoring data. A WHO project is in progress with the objective of harmonizing the membrane filter methods for fibre counting of all fibre types using phase contrast microscopy.

WORK ENVIRONMENT OF PLANTS MANUFACTURING ASBESTOS-CONTAINING PRODUCTS IN JAPAN

T. HIGASHI

IN 1985, a comprehensive study of asbestos-containing product plants (A/C, friction, textile) was performed. The data presented were based not on personal but on area sampling. A conversion equation from area sampling data to personal exposure values was developed. Exposure concentrations were 0.07–0.66 f ml^{-1}. In workplaces which belonged to member companies of the Japan Asbestos Association, the percentage of workplaces whose exposure concentrations was less than 0.3 f ml^{-1} was 70% in 1985 (N=510), but 98% in 1992 (N=430). Concentrations in a new, well-controlled A/C plant were less than 0.1 f ml^{-1}.

THE ASSESSMENT OF EXPOSURE IN TERMS OF FIBRES

G. W. GIBBS

THE membrane filter (MF) method for evaluating asbestos fibre concentrations was introduced in the 1960s. Before that time the midget impinger (MI) was used in North America, while the long running (LRTP) and regular thermal precipitator (TP) were used in the U.K. All studies from which estimates of long-term health risks can be derived (i.e. those with individual cumulative lifetime exposure estimates) were based on the now

obsolete methods. The reliability of converting these indices of exposure to MF equivalent concentrations was reviewed.

It was concluded that no overall single factor could be derived for the Quebec mining and milling industry. However, it has been possible to derive conversion factors at the individual mill and work area level. Applying these in one Quebec mortality study analysis based on all jobs held by persons in the cohort gave an overall MF/MI ratio of 3.6. An examination of the confidence intervals surrounding the Quebec data, ratios derived for other chrysotile mines by other investigators, and measurements of fibre concentrations in the 1970s suggest that this was probably not unreasonable.

Side-by-side and other measurements were used to convert MI concentrations in the U.S. textile industry to MF fibre concentrations. While conversions involve considerable uncertainty, independent measurements of fibres in the lung tissues of workers from the U.S. textile plant and Quebec mills show that in lungs the ratios of the concentrations of chrysotile to those of tremolite are quite consistent with the ratio of assessed exposures to these fibres in the two industries.

There is an apparently higher risk of mesothelioma in one Quebec mining area (Thetford Mines) than in another (Asbestos). A high concentration of fibrous tremolite has been found in the lungs of workers in Thetford. A method of evaluating the extent to which mesothelioma risk in the chrysotile mining industry might be explained by tremolite exposures was proposed.

The slope of the lung cancer dose–response relationship for the textile industry is approximately 50 times that for the mining and milling industry. Available data on the length distributions of fibres from Quebec mines and mills (up to 5% > 5 μm) and the Charleston textile plant (up to 21% > 5 μm) and some marginal indication of longer fibres in tissues from Charleston workers suggest that further work specifically addressing differences in the size distributions of long fibres in these industries is needed.

AIRBORNE CONCENTRATIONS OF ASBESTOS IN NON-OCCUPATIONAL SETTINGS

M. CORN

CONCENTRATIONS of asbestos in air were determined from analysis of samples collected in over 300 buildings involved in litigation. Samples were collected by certified industrial hygienists and analysed in certified laboratories by transmission electron microscopy. Building group mean concentrations of asbestos in building air inhaled by occupants were generally less than 0.0005 f ml^{-1} > 5 μm (90th percentile). At these concentrations the risk from asbestos exposure would be very low for building occupants.

Another data set was obtained from the maintenance logs kept by owners of buildings containing asbestos fireproofing and subject to Operations and Maintenance Programmes to evaluate asbestos inhalation risk to maintenance workers. The logs were kept to document protective measures and maintenance personnel exposures during 1991–1992. Data are presented for one commercial building, which is typical of data for three additional commercial buildings and a medical centre. All samples were evaluated by the NIOSH 1400 protocol for sampling and analysis by phase contrast microscopy. Operations and maintenance precautions to reduce dust emission were modest; they included spraying of ceiling tiles with amended water, HEPA vacuuming tile edges before entry and after tile replacement, respirator usage and careful work. Negative pressure containment was not used. In this building personal exposures in electrical/plumbing work ranged from 0.000 to 0.035 f ml^{-1} > 5 μm in length (average work time of one job was 118 min); the 8-h TWA was 0.0149 f ml^{-1} > 5 μm. During cable running above the ceiling exposure was 0.001–0.228 f ml^{-1} > 5 μm in length (average work time of one job was 169 min); the 8-h TWA was 0.0167 f ml^{-1} > 5 μm. The maximum time any worker spent above the ceiling was 3.31% of his working time for the period of the log. Results for maintenance personnel exposures in four other buildings were similar to those presented; the 0.2 f ml^{-1} Permissible Exposure Limit (U.S.A.) was not exceeded.

BIOLOGICAL INDICATORS OF CHRYSOTILE EXPOSURE

B. CASE

CHRYSOTILE asbestos is retained in lung tissue, where it may be used as a marker of exposure. Studies include analysis of sputum and bronchoalveolar lavage fluid, but principally lung parenchyma from autopsy or surgically resected specimens. Asbestos bodies form on chrysotile fibres but are generally not a good indicator of human exposure to chrysotile because of their greater probability of formation on amphiboles.

Chrysotile fibre analyses in lung have advantages and limitations. Chrysotile concentration is related to the level of environmental and occupational exposure, but in the latter situation owing to deposition, fibre alteration and clearance cumulative exposure and interval between end-exposure and death clearly affect results.

Autopsy case series are biased toward increased proportions of asbestos-related diseases as compared to epidemiological cohort data. Analytical problems include potential contamination by chrysotile at autopsy, from fixatives, from post-fixative processing and in the analytical laboratory itself. These may have greatest effect in studies of individuals with low exposure, for tissue other than lung, and for short chrysotile fibres. Selection of control subjects should be contemporaneous with that of cases, and control subjects should fully reflect the hospital population at the time of case death.

Limited data are available on fibre analysis in pleural tissue. More are needed. Issues requiring attention include avoidance of contamination, selection of controls, and sample site selection (parietal pleura, or tumour or plaque). For mesothelioma, two case-control studies of lung fibre burden show the principal relationship to be with long amphiboles, but some methodological problems exist. Lung cancer shows no such fibre-type differences. Asbestosis seems to be associated with long-fibre chrysotile and tremolite in one study and short fibres in others. Overall, lung retained dose is a useful indicator of chrysotile exposure if used cautiously in inference, and is very useful in the evaluation of historical exposures and industrial hygiene data in epidemiological studies.

DISCUSSION

Rapporteurs: W. Nicholson and F. Pooley

There was an extended discussion concerning the relationship between particle and fibre number concentrations. It was agreed that approximate conversions between the two can be made, provided that the conversions are industry specific and, as far as possible, process specific. Conversions from particle to fibre counts have been made for mines and mills in Quebec, for a textile plant in South Carolina, for an asbestos-cement plant in Louisiana, and elsewhere. It was suggested that the changes in membrane filter methods in the U.K. over time may have resulted in a several-fold increase in the fibres counted. Some felt there was much less change in fibre-counting efficiency in the United States over the past years than suggested. Development of methods for sampling airborne and tissue samples should be designed to enable them to be archived for future epidemiological studies and portions of the original filters should be retained.

The issue of the higher tremolite content of the ores of the Thetford mines compared with that of the ores of the Asbestos mines, and the implications for mesothelioma risk, were discussed. Interest was expressed in obtaining information relating to the size distributions of airborne tremolite in different work environments in order to assess its contribution to any health risk in different circumstances.

Past fibre concentrations in the chrysotile mining industry have been estimated to be as high as 400 f ml^{-1} (Gibbs, G., this Workshop). By comparison, exposures in the South Carolina textile plant were lower, but some concentrations as high as 80 f ml^{-1} were estimated (Dement, J., 1982, in Dement, this Workshop). Conversion factors for converting from mppcf to f ml^{-1} have been strongly influenced by the presence of non-fibrous particles. The effect of non-fibrous particles has rarely been taken into account when relating exposure to dust containing chrysotile asbestos fibre and the incidence of related lung disease. In some cases, such as when high concentrations of quartz are present, non-fibrous particles could be of importance. It was reported in the discussion that the effects both of fibres and of non-fibrous particles were examined in some studies of asbestos cement plants on the basis of round and irregular small opacities on X-ray.

Very little information is available relating to asbestos levels in household atmospheres. Some data collected in the United States have shown levels to be similar to those measured in public buildings (generally below 0.0005 f ml^{-1}. See Corn's presentation summary). It was noted that earlier data on asbestos concentrations in schools with severely damaged material yielded mass concentrations which on a fibre basis would be equivalent to levels between about 0.001 and 0.01 f ml^{-1} or above. The results for asbestos in air presented at the Workshop were for buildings with operations and maintenance programmes. Highly friable surfacing material in easy reach of pupils in many U.S. schools has been removed or enclosed; present conditions are much better than in the past.

Some radiographic changes had been identified in three radiological surveys of maintenance workers. (Oliver *et al.*, 1991; Levin and Selikoff, 1991; Balmes *et al.*, 1991). Investigation of other, similar work forces should be undertaken.

An extensive discussion took place regarding the meaning of the reported strong association between tremolite lung fibre concentration and mesothelioma (Case, B., this Workshop). It was pointed out that in the Quebec mine and mill cohorts tremolite lung fibre concentration is directly related to estimated chrysotile