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Mica pneumoconiosis — A literature review

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SKULBERG KR, GYLSETH B, SKAUG V, HANOA R. Mica pneumoconiosis — A literature review. Scand J Work Environ Health 11 (1985) 65—74. Sixty-six cases of mica pneumoconiosis have been reported in the literature. Twenty-six of the cases suggest that pneumoconiosis may be caused by pure mica alone. In only six cases the diagnosis was based on clinical examination, radiography, and lung biopsy or autopsy results. In one of these six, doubt was raised by the authors about the purity of the mica exposure. Seven epidemiologic studies have been performed among mica-processing workers, and these studies are all cross-sectional. In addition 30 experimental investigations have been carried out. However, there are no controlled inhalation studies among them. The results from the intratracheal instillation studies do not give a unanimous conclusion as to whether pure mica is fibrogenic or not. Present knowledge suggests that pure mica is moderately toxic and may induce pneumoconiosis. Exposure to mica is usually associated with exposure to other minerals such as quartz and feldspar.

Key terms: biotite, mixed dust pneumoconiosis, muscovite, sericite.

Introduction

In 1932, Ferguson (18) reported that exposure to mica might represent a health hazard. In 1933, Jones (24) presented the hypothesis that sericite might cause silicosis (29 cases). This suggestion initiated several experimental investigations on mica. Four epidemiologic studies were performed in the 1940s and 1950s. Later several case reports appeared. These were followed in the 1970s by further experimental studies. The latest report on mica pneumoconiosis was published in 1983.

This literature review is based on a broad computer search of the literature. Efforts were also made to include the literature from the mica mining countries India and the Soviet Union. Sixty-one articles were relevant for this study.

The aim of the present investigation was to review and reevaluate the literature on the adverse effects of mica to humans and experimental animals.

Occurrence, production and use of mica

Mica minerals belong to the phyllosilicate group, which comprises nine different entities, whereof muscovite (sericite), biotite, phlogopite, paragonite, and lepidolite are commercially the most important. All mica minerals belong to the monoclinic crystal system. They are flaky structures with a perfect basal cleavage (6).

Mica is one of the most common minerals in the earth crust; it occurs in granitic pegmatite (muscovite), gneisses and schists (sericite, biotite), and metamorphosed limestones (phlogopite).

Unmanufactured mica is classified either as scrap and flake mica or as sheet mica. Scrap and flake mica are produced in India, Korea, the United States, and the Soviet Union. Sheet mica is produced in India, Brazil, and some African countries.

Mica was previously used as a filler in pharmaceuticals and for decoration purposes. Ground mica is now used as a filler in paints, cement, and asphalt and as insulation material in electric cables. It is also applied as a component of drilling muds in the oil industry. Sheet mica is used in the electrical industry in vacuum tubes and condensators. A special product called micansite is used as electrical insulation material. Micansite is composed of small mica sheets and a binder and exists in a variety of shapes.

The industrial use of mica has increased considerably during this century. The annual world production was 2 600 t in 1905, 44 200 t in 1937, 234 000 t in 1974, and 350 000 t in 1981 (8, 9, 11).

Human beings are exposed to mica dust in mines, mills, agricultural and construction work, and in factories which either process mica products or apply mica in their production.

The increased industrial use of mica, partly due to it being more recently used as a substitute for asbestos, has raised the question of possible adverse health effects due to inhalation of its dust. As mica often occurs together with other minerals, for example, with quartz, both in nature and in industrial use, the question of biological interaction has also been raised. Those reports in which the authors conclude that mica exposure alone or above other agents may be responsible for lung diseases are the main objects of the present investigation.

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Hygienic standards

The American Conference of Governmental Industrial Hygienists (ACGIH) (2) has recommended a threshold limit value (TLV) of 20 millions of particles per cubic foot for mica dust containing less than 1 % quartz. In the Federal Republic of Germany mica is classified as a nuisance dust, and the hygienic standard is 8 mg/m³ for the respirable dust fraction defined by the Johannesburg convention. In Norway the corresponding standard is 6 mg/m³ for total dust and 4 mg/m³ for dust less than 5 µm in particle size.

Experimental studies

General survey

In table 1 we have listed the experimental studies which have been carried out on the biological effects of mica.

Of the 30 studies 15 were performed prior to 1950, 6 between 1950 and 1970, and the remaining 9 after 1970. In 19 of the studies intratracheal instillation was applied. The inhalation model was used in three and intraperitoneal injection in three. The remaining five applied various methods such as intravenous and subcutaneous injections.

The exposure and observation time has to be sufficient to allow experimental fibrosis to occur. The latency period for pneumoconiosis in man is long, often more than 15 years. The length is dose dependent. Less is known about the latency period in experimental animals. With regard to the highly fibrogenic dust quartz, mature collagen formation may be observed after one month. Less fibrogenic dusts need a longer observation time. Of the 30 previously mentioned studies only three had an observation period exceeding 12 months. In 18 of the studies the observation period was between 6 and 12 months. The remaining nine studies had an observation period of less than six months.

The reports on the experiments performed prior to 1950 present little information on the chemical and physical characteristics of the dust. This lack significantly limits the value of the studies. Proper dust analysis includes chemistry, crystallography, and determination of particle size and shape, all of which may be of biological importance. The reports prior to 1950 do not provide any suggestion of a possible relationship between dust particle characteristics and fibrogenic effect.

Various species have been used in the experimental studies. One species may be more prone to lung fibrosis than others, and thus comparison of experimental results may be difficult. In older studies rabbits, dogs, rats, and guinea pigs were used, whereas more recent studies have used various breeds of rats. It is difficult to induce fibrosis in the lungs of mice by silica and mica (46).

Only one study (14) has looked into the interaction of mica and resin, which are the two components of micanite. Dianova et al (14) concluded that resin reduced the fibrogenic effect of mica.

Intratracheal instillation

Intratracheal instillation has been applied in 19 studies.

Kaw & Zaidi (26), Lemon & Higgins (33), and Sahu et al (46) all reported an acute inflammatory reaction in the lung and the formation of reticulin fibers one week after instillation of a suspension of mica dust. Lemon & Higgins (33) also reported transient atelectasis and consolidation of the lung tissue as an initial event accompanied by alveolar macrophage necrosis.

Between 14 and 90 d after intratracheal instillation Lemon & Higgins (33) and Sahu et al (46) reported an additional proliferation of fibroblasts and reticulin fibers. In this period proliferation of fibroblasts and reticulin fibers was also reported by King et al (27). Le Bouffant et al (32) and Martin et al (36) reported collagen formation in this period, but far less than induced by quartz.

After three to six months' observation further proliferation of reticulin fibers was observed by Kaw & Zaidi (26) and Lemon & Higgins (33). In this period a granulomatous and interstitial lung fibrosis, not further specified, was reported by Krasnopoeeva (29).

After eight to nine months' observation Kaw & Zaidi (26) noted isolated dust cell granulomata containing reticulin fibers and a substantial amount of collagen fibers, but typical nodules as in silicosis were not observed.

Le Bouffant et al (32) reported formation of collagen fibers after three months. They did not find any progression of the collagen formation at 12 months. Sahu et al (46) found no progression of reticulin fiber formation between 150 and 210 d. This result was also observed by King et al (27); however, mica treated with hydrochloric acid induced a nodular reaction within five weeks with increasing reticulin formation up to 15 months later.

Shanker et al (50) used mica particles with a maximum length of less than 5 µm in their experiment and demonstrated that these particles were transported to the tracheobronchial lymph nodes. The lymph nodes showed thick reticulin fibers. These results are supported by those of Sahu et al (46).

Inhalation studies

The inhalation model was used in three studies. Brambilla et al (7) studied lung pathology and the mineral dust content in lung tissue of 100 environmentally exposed mammals and birds in the San Diego Zoo. Fifteen percent of the animals had mild fibrosis, while 5 % had severe fibrosis at autopsy.
| Author                  | Year | Animal species | Number of animals | Methods                  | Dust                  | Dose (mg) | Particle size (μm) |
|-------------------------|------|----------------|-------------------|--------------------------|-----------------------|-----------|-------------------|
| Drinker et al (16)      | 1934 | Dogs           | 2                 | Injection via lymphatics | Sericite              | NI        | NI                |
| Policard (43)           | 1934 | Rats           | NI                | Inhalation               | Muscovite             | NI        | < 6               |
| Fallon & Banting (17)   | 1935 | Rabbits        | 3                 | Subcutaneous injection   | Sericite              | 50        | < 5               |
| Fallon & Banting (17)   | 1935 | Rabbits        | 3                 | Intratracheal instillation | Sericite              | 150       | < 5               |
| Lemon & Higgins (33)    | 1935 | Rabbits        | NI                | Intratracheal instillation | Sericite              | NI        | < 5               |
| Miller & Sayers (38)    | 1936 | Guinea pigs    | NI                | Intraperitoneal injections | Sericite + quartz     | 100 and 200 | < 43             |
| Cummins (12)            | 1937 | Rabbits        | 4                 | Subcutaneous injection   | Sericite              | 20        | Coarse particles, many exceeding 10 |
| Cummins (12)            | 1937 | Rabbits        | 1                 | Intratracheal instillation | Sericite              | 1 000     | < 10              |
| Seltzer & Weiland (49)  | 1937 | Guinea pigs    | 20                | Inhalation               | Sericite + andesin    | NI        | < 2               |
| Gardner (19)            | 1938 | Rabbits        | > 4               | Intravenous injection    | Muscovite + Biotite  | 1 000     | < 3               |
| Gardner (19)            | 1938 | Guinea pigs    | > 5               | Intraperitoneal injection | Muscovite + Sericite | NI        | < 3               |
| Simpson & Strachan (52) | 1940 | Rabbits        | 4                 | Intravenous injection    | Muscovite             | 284       | 67 % < 1 100 % < 5 |
| Belt & King (4)         | 1945 | Rats           | 36                | Intratracheal instillation | 89 % sericite, kaolin, quartz | 200      | < 1               |
| Belt & King (4)         | 1945 | Rats           | 36                | Intratracheal instillation | Muscovite             | 200       | < 5               |
| King et al (27)         | 1947 | Rats           | 53                | Intratracheal instillation | Sericite              | 50        | < 1               |
| Vorwald (60)            | 1960 | Rats           | NI                | Intratracheal instillation | Biotite + Muscovite  | NI        | NI                |
| Krasnopeeva (29)        | 1964 | Rats           | NI                | Intratracheal instillation | Muscovite + Phlogopite | 50       | 80 % < 5 20 % > 5 |
| Tripsa & Rotaru (58)    | 1966 | Rats           | 15                | Intratracheal instillation | Mica                  | 50        | 1—3              |
| Tripsa & Rotaru (58)    | 1966 | Rats           | 15                | Intratracheal instillation | Mica                  | 50        | 1—6              |
| Tripsa & Rotaru (58)    | 1966 | Rats           | 15                | Intratracheal instillation | Mica                  | 50        | 1—25             |
| Goldstein & Rendall (20)| 1970 | Rats           | 20—30             | Intratracheal instillation | Mica + magnetite     | NI        | < 5               |
| Starkov et al (56)      | 1971 | Rats           | NI                | Intratracheal instillation | Mica with 45 % silica | 50       | Ni                |
| Kaw & Zaidi (26)        | 1973 | Rats           | 47                | Intratracheal instillation | Muscovite             | 50        | < 5               |
| Pott et al (44)         | 1974 | Rats           | 40                | Intraperitoneal injection | Biotite               | 100       | < 5               |
| Shanker et al (50)      | 1975 | Guinea pigs    | 36                | Intratracheal instillation | Muscovite             | 75        | < 5               |
| Dianova et al (14)      | 1976 | Rats           | NI                | Intratracheal instillation | Muscovite + phlogopite and resin | 50 | Ni                |
| Martin et al (36)       | 1977 | Rats           | 10                | Intratracheal instillation | Muscovite             | 50        | Ni                |
| Sahu et al (46)         | 1978 | Mice           | 80                | Intratracheal instillation | Mica                  | NI        | < 5               |
| Brambilla et al (7)     | 1979 | Mammals, birds | 100               | Inhalation               | Mica, quartz          | NI        | < 10              |
| Le Bouffant et al (32)  | 1980 | Rats           | 10                | Intratracheal instillation | Muscovite             | NI        | Ni                |
Mineral analysis showed that the dust consisted of 90—95% silicates (whereof 70% was mica) and 5—10% quartz. Selter & Weiland (49) studied the combined effects of tubercle bacilli and mica dust. They found an increased morbidity among animals exposed to both, compared with those exposed to only one. Policard (43) exposed rats (3 to 15 d) to an atmosphere heavily charged with muscovite. He found pulmonary granulomas, some of them containing giant cells.

**Intraperitoneal injection**

In three experimental studies intraperitoneal injection has been applied. Miller & Sayers (38) and Gardner (19) reported biological effects similar to those of nuisance dusts. In the study of Pott et al (44) the primary objective was to look for tumorigenic effects. The mica applied (biotite) did not produce malignant tumors in the animals.

**Other administration routes**

Mica has also been injected to lymphatics, subcutaneously or intravenously (12, 16, 17, 19, 52). All five of these studies are rather old; they do not give relevant knowledge of the biological effects of mica particles on lung tissue. In the studies the lesions caused by mica were compared with lesions caused by quartz. Four studies (12, 17, 19, 52) showed that mica induced considerably less fibrosis than quartz.

**Mica exposure and pneumoconiosis in man**

This literature review comprises 368 cases of pneumoconiosis associated with mica exposure. Table 2

| Author           | Year | Number of cases | Type of dust | Type of workplace or workprocess | Diagnostic methods | Author's view of the causation of the disease |
|------------------|------|-----------------|--------------|----------------------------------|-------------------|-----------------------------------------------|
| Ferguson (18)    | 1932 | 3               | Mica, no details | NI                               | Clinical examination, radiography | Mica pneumoconiosis |
| Jones (24)       | 1933 | 29              | Sericite, quartz, others | 21 underground workers in collieries, 8 others | Mineral analysis of silicotic lungs | Pneumoconiosis, probably caused by sericite |
| Dreessen et al (15) | 1940 | 9               | Pure mica     | Mica grinding                     | Clinical examination, radiography | Mica pneumoconiosis |
| Dreessen et al (15) | 1940 | 1               | Pure mica     | Mica factory/mica grinding       | Clinical examination, radiography | Mica pneumoconiosis |
| Dreessen et al (15) | 1940 | 23              | Mica, quartz, feldspar | Mica miners/pegmatite millers | Clinical examination, radiography | Silicosis |
| Vestal et al (59) | 1943 | 7               | Pure mica     | Mica grinding                     | Clinical examination, radiography | Mica pneumoconiosis |
| Vestal et al (59) | 1943 | 2               | Pure mica     | Mica grinding                     | Clinical examination, radiography | Borderline mica pneumoconiosis |
| Vestal et al (59) | 1943 | 12              | Mica, quartz, feldspar | Mica mine                        | Clinical examination, radiography | Pneumoconiosis, no expressed opinion |
| Vestal et al (59) | 1943 | 22              | Mica, quartz, feldspar | Mica mine                        | Clinical examination, radiography | Borderline pneumoconiosis, no expressed opinion |
| Heimann et al (22) | 1953 | 112             | Mica with 11—67% quartz | Mica mine                        | Clinical examination, radiography | Silicosis |
| Vorwald (60)     | 1960 | 1               | Biotite, probably along with talc | Rubber factory                  | Clinical examination, radiography, autopsy, X-ray diffraction | Diffuse pulmonary fibrosis caused by mica or other inhaled agents |
| Vorwald et al (61) | 1962 | 1               | Biotite        | Rubber factory                   | Clinical examination, radiography, autopsy, X-ray diffraction | Mica pneumoconiosis |
| Krasnopoeva (29) | 1964 | NI              | Mica, no details | Mica factory                     | Clinical examination, radiography | Mica pneumoconiosis |
| Podnebesnaya (42) | 1965 | 66              | Mica with 25—30% quartz | Mica mine                       | Clinical examination, radiography | Pneumoconiosis, no expressed opinion |
| Kleinfeld (28)   | 1966 | 1               | Pure muscovite | Sawing and sanding mica          | Clinical examination, radiography | Mica pneumoconiosis, calcified pleural plaques |
| Michailov & Berova (37) | 1968 | 1               | Mica, asbestos | Asbestos and mica curing factory | Clinical examination, radiography | Asbestosis |
| Kajita et al (25) | 1972 | 1               | Sericite, quartz | Latex factory                   | Clinical examination, radiography, autopsy | Mixed dust pneumoconiosis |

(continued)
| Author                        | Year | Number of cases | Type of dust       | Type of workplace or workprocess | Diagnostic methods                                                                 | Author’s view of the causation of the disease                          |
|-------------------------------|------|----------------|--------------------|----------------------------------|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Rüttner et al (45)            | 1972 | 1              | Mica, kaolin,     | Electric insulation factory       | Clinical examination, radiography, autopsy                                          | Diffuse "asbestosis-like" interstitial fibrosis due to the dust exposure  |
| Misra & Jain (39)             | 1973 | 1              | Mica, no details  | Manufacture of tazias             | Clinical examination, radiography, autopsy                                          | Progressive massive fibrosis, caused by the mica exposure               |
| Dianova et al (14)            | 1976 | 7              | Muscovite,        | Mica goods factory                | Radiography                                                                        | Mica pneumoconiosis                                                    |
| Berry et al (5)               | 1976 | NI             | Quartz, mica,     | NI                               | Electron diffraction and electron probe microanalysis of dust from lungs           | Silicosis                                                              |
| Berry et al (5)               | 1976 | NI             | Talc, cristobalite, chlorites, mica, spinelles | NI                               | Electron diffraction and electron probe microanalysis of dust from lungs           | Pneumoconiosis, no expressed opinion                                    |
| Sedov et al (48)              | 1977 | 31             | Phlogopite with 2-71% | Mica mine                       | Clinical examination, radiography, biopsy                                          | Pneumoconiosis, no expressed opinion                                    |
| Pimentel & Menezes (41)       | 1978 | 1              | Pure muscovite    | Mica grinding                    | Clinical examination, radiography, autopsy, X-ray diffraction                      | Mica pneumoconiosis                                                    |
| Sherwin et al (51)            | 1979 | 7              | Silicates (mostly micas), quartz | Farm workers                   | Clinical examination radiography, autopsy                                           | Interstitial inflammation and fibrosis related to the dust exposure or toxic soil additives |
| Hayashi (21)                  | 1980 | 1              | Quartz, sericite  | Miner                            | Analytical electron microscopy of pulmonary dust                                     | Pneumoconiosis, no expressed opinion                                    |
| Li Weizu (34)                 | 1980 | 16             | Mica with 36-55% quartz | Mica mine                      | Clinical examination, radiography                                                  | Mica mine silicon lung                                                  |
| Seaton et al (47)             | 1981 | 4              | Mica, quartz, kaolin | Shale mine                      | Clinical examination, radiography, autopsy (3 cases)                                 | Shale miners pneumoconiosis                                             |
| Lapenas et al (31)            | 1982 | 1              | Pure mica         | Exposed via husband (grinder)    | Clinical examination, radiography, biopsy, mineral analysis by scanning electron microscopy | Interstitial fibrosis, probably caused by the mica exposure            |
| Lapenas et al (31)            | 1982 | 1              | Mica, probably along with quartz | Slate quarrying                | Clinical examination, radiography, biopsy, mineral analysis by scanning electron microscopy | Interstitial fibrosis and fibrotic nodules, probably caused by the mica exposure |
| Lapenas et al (31)            | 1982 | 1              | Kaolinite, mica, pigments | Wire insulation                  | Clinical examination, radiography, biopsy, mineral analysis by scanning electron microscopy | Interstitial fibrosis, probably caused by the mixed dust exposure     |
| Lapenas et al (31)            | 1982 | 1              | Talc, mica        | Exposed via use of body talc     | Clinical examination, radiography, biopsy, mineral analysis by scanning electron microscopy | Interstitial fibrosis, probably caused by the talc                      |
| Davies & Cotton (13)          | 1983 | 1              | Pure muscovite    | Mica grinding                    | Clinical examination, radiography                                                  | Mica pneumoconiosis                                                    |
| Davies & Cotton (13)          | 1983 | 1              | Pure muscovite    | Mica grinding                    | Clinical examination, radiography, autopsy, X-ray diffraction                      | Mica pneumoconiosis                                                    |
| Lankester (30)                | 1983 | 2              | Mica and/or talc  | Rubber tire factory              | Clinical examination, radiography                                                  | Diffuse interstitial shadowing due to the dust exposure                 |
| Sinha (53)                    | 1983 | NI             | Mica, no details  | Mica factories                   | Radiography                                                                        | Lung dust disease                                                       |

Total 368
Six epidemiologic studies have been carried out among mica miners (15, 22, 34, 42, 48, 59). All were cross-sectional. Four of them presented information on the quartz content of the dust in the work atmosphere; the quartz content varied from 2 to 71%. Pneumoconiosis among mica miners has thus been named silicosis (15, 22), mica mine silicon lung (34), or pneumoconiosis (42, 48, 59). A total of 282 cases of pneumoconiosis are reported in the six studies. In five of them tuberculosis was also observed among the patients; the prevalence ranged from 6% (34) to 50% (42).

Seven epidemiologic studies (14, 15, 18, 23, 34, 55, 59) have been carried out among mica processing workers. Three of the studies (23, 34, 55) did not report any case of pneumoconiosis among these workers. Some of the earliest epidemiologic studies do not fulfill standard methodological demands for epidemiologic surveys of today (18, 55). Adequate information on Sinha's study (53) is not available, and for this reason it is not classified as an epidemiologic study in our review.

Table 3 presents the 368 reported cases according to the author's view on the causation of the pneumoconiosis. Tables 4, 5, and 6 comprise only the 66 cases which the authors presented in their reports as definitely or probably caused by mica (i.e., mica pneumoconiosis).

Table 4 shows the distribution of the cases of mica pneumoconiosis by type of dust and workplace. One of the older investigations (18) presented little information on the type of dust and workplace. In nearly half the cases [all of them reported by Jones (24)] quartz was found in the dust. Twenty-one of the 26 cases who were exposed to pure mica had been working in grinding and packing operations (13, 15, 41, 59).

In Table 5 the reported cases of mica pneumoconiosis are presented according to the diagnostic methods. In the six cases in which clinical examination, radiography, and autopsy or biopsy were performed, interstitial fibrosis was observed (13, 31, 39, 41, 61). Fibrotic nodules were observed in three cases (13, 31, 39). Vorwald et al (61) noted that the diffuse fibrosis had also fused into irregular massive lesions. Jones (24) performed mineral analysis of 29 lungs obtained at autopsy.

In Table 6 the reported cases of mica pneumoconiosis are distributed by the number of years of exposure. Information on the length of the exposure period and the level of exposure is often scarce. In 38 of the 66 cases no such information was given. Of the remaining cases 16 had an exposure time exceeding 20 years.

The recent study of Davies & Cotton (13) is of great value although it only reports two cases. In this report a detailed occupational history is given. The patients have been investigated by clinical examination and chest radiographs. In one of the cases
Whether it is the true physical diameters of the particles were in size. They found granulomas were more pathogenic than particles of size. Dyspnea and dry cough were recorded in 1972 and 1975. The patient was a smoker. In 1973 the patient contracted myocardial infarction and died from heart failure in 1977. At autopsy, ill-defined fibrotic nodules, more pronounced in the lower lobes, and diffuse interstitial fibrosis in all lobes were found along with deposits of birefringent crystals. Some histiocytes and foreign body giant cells were found, but there were no granulomas. The authors came to the conclusion that there was a direct correlation between the concentration of crystalline material and the extent of the fibrosis. Electron microscopy and X-ray microanalysis of dust extracted from the tissue revealed thin mineral sheet particles varying from less than 1 µm to more than 50 µm. X-ray diffractometry of the particles identified them as muscovite mica.

The second patient worked from 1957 to 1974 grinding and packing powdered mica. Radiographic evidence of pneumoconiosis was observed after six years' exposure to mica dust. The radiographic abnormalities progressed up until 1978. The changes have been classified as category 2, simple pneumoconiosis. On examination a moderate number of crackles at the lung bases and a restricted lung function were recorded.

Other reports on biological effects of mica dust

Seven cases of pleural plaques among mica workers have been reported (28, 55). All had been engaged in sawing and sanding mica sheets. In two of the seven cases other occupational dust exposure was excluded.

In a study of 69 cases of malignant mesothelioma Chahinian et al (10) reported one person with peritoneal mesothelioma who had been exposed to mica. The authors stressed that there was no evidence so far that mica is carcinogenic. Mica has also been observed along with other minerals in the lung tissue in cases of lung cancer (3, 47).

Michaillov & Berova (37) observed that many employees in the asbestos and mica curing factory suffered from skin lesions caused by the dust.

Discussion

Experimental studies

Intratracheal instillation is the most frequently employed administration technique. This method is easily carried out but is considered “nonphysiological.” When one large dose is instilled, a nonspecific inflammatory reaction may occur and may give a foreign body reaction with cholesterol clefts in the alveoli (26).

Transportation of mica particles to the tracheobronchial lymph nodes (26, 46, 55) is one of the mechanisms which slowly reduces the concentration of mica in the lungs. Le Bouffant et al (32), Sahu et al (46), and Shanker et al (50) found no progression of collagen and/or reticulin formation between 6 and 12 months after exposure. This result might have been due to the efficient clearance of the single dose given by intratracheal instillation. Inhalation studies are therefore important for the evaluation of long-term effects of mica.

The lung tissue response to a certain dose of dust may vary with the particle size distribution. In most studies it is indicated that the particle size has been less than 5 µm. Whether it is the true physical diameter or the aerodynamic diameter (considering shape and density) is only indicated in one report (20). Tripsa & Rotaru (58) claimed that mica particles of 10—25 µm were more pathogenic than particles between 1—6 µm in size. They found granulomas similar to foreign-body granulomas. In the study by Krasnopeeva (29), who also reported granuloma formation and diffuse fibrosis, 20% of the particles were larger than 5 µm. Three studies (26, 32, 36) reported collagen fibrosis. Two of them (32, 36) did not indicate particle size.

The purity of the mica used in the experimental studies is also important. In most studies detailed chemical and mineralogical analyses are lacking. In earlier investigations light microscopy and chemical analysis have been used for characterizing the dust. However, compared with methods used today, the techniques provide limited information.

In a review of experimental studies of mica (20, 26, 27, 38, 58, 60), Parkes (40) concluded that there is no evidence that mica induces pneumoconiosis.

The results from the experimental studies do not give a unanimous conclusion as to whether pure mica is fibrogenic or not. It is necessary to perform new experimental studies with pure and well-characterized mica samples to determine whether mica induces collagen formation.

Only one experimental report illuminates whether mica is carcinogenic (44).

Case studies

Of the 29 cases described by Jones (24), 21 had worked in collieries. He demonstrated that the “silicotic” lungs contained mainly sericite. He also demonstrated that the incidence of “silicosis” was related to the sericite rather than the quartz content in the rock in gold-bearing quartz areas of South Africa and India and in the anthracite coal fields of Wales and Scotland. Jones (24) concluded that quartz was not the main cause of the pneumoconiosis among the colliers but rather sericite. The question of sericite as
a causative agent in coal worker’s pneumoconiosis was again raised in 1982 (54).

Pimentel & Menezes (41) reported one case of mica pneumoconiosis. The autopsy showed extensive areas of diffuse pulmonary fibrosis, emphysematous foci, and honeycombing. Microscopy demonstrated increased numbers of histiocytes, fibroblasts, reticulin, and collagen fibers in the interalveolar septa. In addition, sarcoid-type granulomas were observed in the liver. Mica was found in the sarcoid-type granulomas, and the authors suggested that this observation excludes the differential diagnosis sarcoidosis. The patient had been working for only seven years grinding and packing mica before dying of respiratory failure. The diagnosis of primary generalized sarcoidosis cannot definitely be excluded since granulomas in general may accumulate dust as a secondary phenomenon.

Lapenas et al (31) reported microanalytical findings in lung biopsies from four cases with interstitial lung fibrosis associated with mica exposure. One of them had worked 12 years in a slate quarry. The authors were not able to draw any conclusion as to whether the fibrosis resulted from pure mica or mica in interaction with small amounts of quartz (not detected by the mineral analysis). Another of the cases was exposed to mica dust while laundering her husband’s clothing. The diagnosis of pneumoconiosis in this case of pulmonary fibrosis was not considered likely prior to the biopsy and particle analysis. This case demonstrates the importance of a proper dust analysis along with the occupational history. An analysis of minerals from the lungs may be performed by electron microscopy and X-ray microanalytical techniques. These methods, as applied in pneumoconiosis studies, have been described by Abraham (1), Berry et al (5), and Hayashi (21).

Davies & Cotton (13) found mica particles of up to 50 \( \mu \text{m} \) in the lung tissue of one of their reported cases. Usually only particles less than 5 \( \mu \text{m} \) are expected to reach the lung. Tomb & Corn (57) found that mica particles tested in a horizontal elutriator did not assume a preferred orientation during settling and that the orientation influenced the settling velocity. A reduction in the settling velocity would permit larger particles to be deposited at places where only smaller particles would be expected. These findings can explain the rather large mica particles found in the lung tissue of the exposed patient (13).

Epidemiologic studies of mica-processing workers

Seven epidemiologic studies of mica-processing workers have been published (14, 15, 18, 23, 34, 55, 59). They are all cross-sectional. The prevalence rates vary from 0 % (23, 34, 55) to up to 25 % (18). The variation in prevalence may be explained both by methodological differences and by real differences in the prevalence of mica pneumoconiosis.

In the studies of Ferguson (18) and Smith (55) sufficient information on occupational history and exposure time was not given. Thus the etiology of the disease in these cases might only be a matter of assumption. Smith (55) and Diano va et al (14) used radiography alone as the standard examination method. Ferguson (18) examined only 12 individuals. Thus these studies are of limited value.

Heimann et al (23) examined 61 workers of whom 44 % had abnormal lung radiographs. They classified these findings as early events in the development of dust-induced lesions but not really as pneumoconiosis. The ACGIH Documentation of the Threshold Limit Values (2) presents the findings of Heimann et al (23) as mild pneumoconiosis.

In the report by Heimann et al (23) only a few workers had exposure periods exceeding five years. On the other hand Li Weizu (34) examined 302 workers, of whom 90.7 % had worked more than 15 years in mica processing. No cases of mica pneumoconiosis were found, and he concluded that the toxic potential of mica is low. Only three studies give information on the level of dust exposure (15, 23, 34). All of them report mica exposure that is far above the present Norwegian hygienic standard.

Twenty-one of the 66 reported cases of mica pneumoconiosis had worked grinding and packing mica. Parkes (40) maintains that, when crude mica is milled, quartz is not separated until the later stages in the refining process. Dreessen et al (15) have shown that the highest levels of dust exposure occur during the drying and packing process, and the authors claimed that the exposure consists of nearly pure mica. Heimann et al (23) found that during mica processing the mica dust in the work atmosphere contains less than 1 % free silica.

In a review of human studies (15, 23, 28, 41, 55, 59) Parkes (40) concludes that there is no evidence that pure mica can cause pneumoconiosis in man. Luis (35) points out in his review that respirable mica particles act as inert foreign bodies in the lung, and as such they induce scar tissue formation. After these conclusions were drawn, another three papers (13, 31, 32) have been published demonstrating collagen fibrosis related to exposure to mica.

Present knowledge does not exclude the possibility that pure mica may cause pneumoconiosis in man. Probably there is a causal relationship, but a definite such relationship is difficult to establish. This is due to (i) the long latency period (the disease occurs late in life), (ii) often scarce symptoms, and (iii) coexposure to other types of dust such as quartz, feldspar, and/or asbestos. Mica may also occur in mixed-dust pneumoconiosis. The interaction of mica and other minerals should be further studied with regard to both pneumoconiosis and malignant disease.
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