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COMMENTARY

Asbestos contamination in feldspar extraction sites: a failure of prevention?

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Abstract
Fibrous tremolite is a mineral species belonging to the amphibole group. It is present almost everywhere in the world as a natural contaminant of other minerals, like talc and vermiculite. It can be also found as a natural contaminant of the chrysotile form of asbestos. Tremolite asbestos exposures result in respiratory health consequences similar to the other forms of asbestos exposure, including lung cancer and mesothelioma. Although abundantly distributed on the earth's surface, tremolite is only rarely present in significant deposits and it has had little commercial use. Significant presence of amphibole asbestos fibers, characterized as tremolite, was identified in mineral powders coming from the milling of feldspar rocks extracted from a Sardinian mining site (Italy). This evidence raises several problems, in particular the prevention of carcinogenic risks for the workers. Feldspar is widespread all over the world and every year it is produced in large quantities and it is used for several productive processes in many manufacturing industries (over 21 million tons of feldspar mined and marketed every year). Until now the presence of tremolite asbestos in feldspar has not been described, nor has the possibility of such a health hazard for workers involved in mining, milling and handling of rocks from feldspar ores been appreciated. Therefore the need for a wider dissemination of knowledge of these problems among professionals, in particular mineralogists and industrial hygienists, must be emphasized. In fact both disciplines are necessary to plan appropriate environmental controls and adequate protections in order to achieve safe working conditions.

Key words
- tremolite
- feldspar
- asbestos contamination
- extraction sites

The health effects caused by exposure to asbestos fibres of the most common commercial series (amosite, crocidolite, chrysotile) during the extraction, processing and use of products containing them, are now well known [1], but although asbestiform tremolite has been well characterized since the early 1900s, its health effects were established only later [2, 3].

Tremolite is a mineral species belonging to the amphibole group, a hydrated silicate of magnesium and calcium ($Ca_2Mg_5Si_8O_{22}(OH)_2$). The molecular structure of amphiboles consists of two chains of SiO_4 molecules that are bound to the oxygen atoms: the basic crystalline structure of all amphiboles is identical, but the chemical composition is different.

Tremolite can be present in the two morphologies, asbestiform and non-asbestiform. Non-asbestiform tremolite (CAS No. 14567-73-8) is the predominant form found in earth's crust, while asbestiform tremolite (CAS No. 77536-68-6) is present almost everywhere in the world. It also shows a wide range of chemical composition, correlated to variations in the content of magnesium, iron, calcium and sodium, and it is frequently found as a contaminant in the natural extraction sites of talc and vermiculite [4-6].

Often it is present as a contaminant of another asbestos, chrysotile, which makes a specific assessment of health effects of the tremolite more complicated [7- 9].

Although abundantly distributed on the earth's surface, tremolite is only rarely present in significant deposits and it has had little commercial use. However until 1996, some tremolite mines were found to be active in Rajasthan, India, supplying the production of cement-factories.

Epidemiological data on the effects of tremolite come mainly from studies of workers occupationally exposed, as a result of tremolite contamination on extraction sites of other minerals (vermiculite, talc) [10, 11].

Other available data derive from studies carried out on the population resident in some areas of Turkey, where exposure comes from natural outcrops of rocks containing it in fibrous form [12].

The conclusions reached in the most recent IARC

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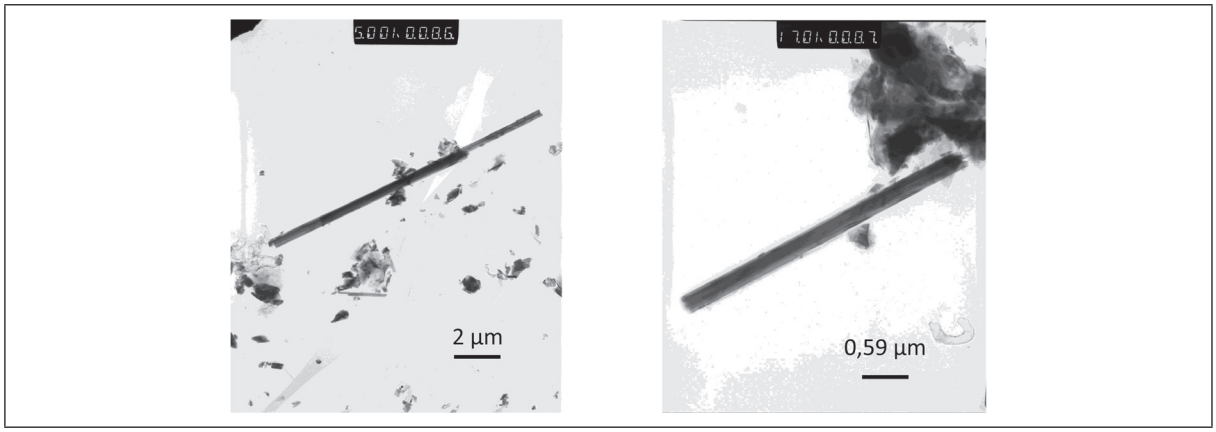

Figure 1
Images of tremolite in feldspar by TEM.

Monograph about asbestos and its carcinogenic risks apply to fibrous tremolite, wherever it is found. It is clear that tremolite asbestos exposure results in respiratory health consequences similar to the other forms of asbestos exposure, including lung cancer and mesothelioma [1].

To date the hazard of inhaling tremolite fibres during the mining and extraction of feldspar has never been described or reported.

The term feldspar identifies a widespread group of minerals (aluminosilicates) which represent the constituents of more than 50% of the earth's crust. It is a mineral that crystallizes from magma in both intrusive and extrusive rocks and can also be found in many types of metamorphic and sedimentary rocks.

The extraction of feldspar usually occurs in quarries, followed by crushing and further processes of grinding and mineralogical purification, to obtain a powder of several grain sizes that may be very fine (up to a few microns) and which usually constitutes the marketed product. This material is widely used in manufacturing various products such as glass and abrasives, adhesives and mortars for bricks, paints and other adhesives, as well as in the production of chimneys and ceramics (tableware, sanitary, floor tiles and pottery), where feldspar is added to the mixture, which also contains quartz, clays and kaolin, in order to decrease the firing temperature.

Until a few years ago, Italy was the world's largest producer of feldspar [13], while it currently occupies second place on the global market (with 4.7 million tons/year, part of which is imported from other producing countries) after Turkey (with 5.0 million tons/year), followed by Slovakia (2.1 million tons/year), India (1.2 million tons/year) and Thailand (1.1 million tons/year). The extraction and trade of these minerals are to date significant in many countries and the total annual production is estimated at over 21 million tons [14].

The identification of the presence (estimated at between 1% and 2% by weight) of tremolite[1] fibres *(Figure 1)* was done in the powder of a heap of feldspar rocks coming from a Sardinian quarry in a deposit of raw materials for ceramic production. In this plant, feldspar rocks are ground and mixed with other materials (quartz, mainly) to obtain a powder preparation, packed in bags or delivered in silos, to provide mixtures used for the composition of both bodies and vitrifying glazes in ceramic production[2].

The slip used for shaping and coating the pieces, contains feldspar in proportions varying between 20% and 50% by weight.

A static monitoring to measure airborne asbestos fibres, carried out in the proximity of the grinding, mixing and bagging plants, also highlighted contamination with tremolite fibres (at concentrations of airborne fibres around 100 fibres/litre).

These findings have therefore brought to notice a health hazard not previously recognised or described, affecting employees in the extraction of the mineral, those who work in the preparation of these materials for industry and those who, in industries such as the early stages of ceramic manufacture, handle the material[3].

The presence of asbestos in feldspars, also in Sardinia, has been known for a long time and some mineralogists have even praised this presence as sign of the quality of the material: *"... the addition of a fibrous component should have the function of increasing the mechanical strength, both in cooked and unfinished products"* [15].

[1] Identification and analysis of the fibres was carried out on the powder by optical microscopy with phase contrast and by scanning electron microscopy equipped with energy dispersive X-ray scanning analysis. These analysis was performed in the Laboratory of the Regional Centre for Asbestos of Latium Region. The mineralogical nature of the fibres was further confirmed by X-ray diffractometry in the Laboratory of Mineralogy and Mineral Physics of the University of Rome "La Sapienza" and with a TEM, trasmission electron microscope, in the Laboratory of Mineralogy and Crystallography of the University of Turin. These last two technics allowed the mineralogical and morphological characterization of tremolite asbestos in the sample of feldspar.

[2] According to a survey of 2013, organized by Confindustria Ceramica, in Italy there are 236 ceramic factories (production of floor tiles, sanitaryware, pottery, tableware and refractories) with more than 27 000 employees, located mainly in two industrial areas, in Sassuolo (MO) and Civita Castellana (VT).

[3] In the ceramic production, the firing temperatures of the materials in oven, usually above 1000 °C, cause the vitrification of asbestos in the dough and in the enamel coating, thus eliminating the problem of possible inhalation of the fibres by the employees.

This underlines a disturbing separation and an absolute lack of communication between the scientific world and health protection and environmental risks agencies[4].

This overview raises several issues, beginning with the question of how common and widespread is the presence of asbestiform tremolite contamination in feldspar rocks, which could represent, in the quantities extracted in the world and its widespread use, a significant problem that should be regulated accordingly.

[4] It should be emphasized that since 1995 Law 257/1992, prohibiting both the business and the direct use of asbestos in any production process, has been in full force.

In order to assess and characterize possible exposure to asbestos fibres, experts in occupational health are needed, alongside people with specialized knowledge in the fields of mineralogy and petrography. Only a complete collaboration on extraction sites and a consciousness of the hazard, would allow the activation of effective preventive controls so that unjustifiable exposure and damage to the health of the employees may be avoided.

Conflict of interest statement

None to declare.

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