Erionite in Auckland bedrock and malignant mesothelioma: an emerging public and occupational health hazard?

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ABSTRACT

Overseas, emerging research has shown that where erionite is present in bedrock as a zeolite, and then subsequently disturbed and blown into the atmosphere, resulting exposure is associated with health effects similar to those caused by asbestos, including malignant mesothelioma (MM). Erionite-induced MM is thought to be particularly prevalent in the construction and quarrying industries, in regions where rock containing erionite is disturbed. In 2015, the then Government Chief Scientist, Sir Peter Gluckman, reported that erionite was a more potent carcinogen than asbestos, and more recent studies have established its presence in the Auckland Region. However, globally at present, there are no established occupational exposure limits for erionite, standard sampling and analytical methods or exposure mitigation guidelines. Given the many major construction projects being carried out in Auckland at the present time, which involve the removal of large quantities of bedrock containing erionite, an assessment of the health risks such activities pose to the public is needed.

Asbestos-induced malignant mesothelioma (MM) is of worldwide concern but particularly in New Zealand.[1,2] The highest mesothelioma incidence is in the construction and building trades.[2] In addition, non-occupational asbestos induced MM for both men and women is of increasing concern.[1] Studies[1] report that New Zealand is one of a number of high-income countries with elevated incidence of MM (2.6 per 100,000), and that this is a direct result of exposure to airborne asbestos fibres in occupational settings. Indeed, recent reports have highlighted some tragic outcomes of the asbestos disease epidemic here.[3] These include cases of how MM was apparently a consequence of exposure to asbestos in the home, following transfer of the asbestos fibres from the workplace. This was thought to have occurred on the hair and clothes of occupationally-exposed family members.[3]

Erionite and malignant mesothelioma (MM)

Erionite is a naturally occurring fibrous zeolite mineral, first described by Eakle.[4] Erionite is produced in silica-rich volcanic eruptions, and is then later dissolved by water and recrystallized as zeolites, often in sedimentary rocks.[5] When aerosolised and inhaled, erionite fibres have been associated with health effects similar to those typically seen with exposure to asbestos, such as malignant mesothelioma (MM).[6] Several studies have reported how erionite was found to be the causative agent for the mesothelioma epidemic in the Cappadocia region of Turkey, where there is an extremely high level of mortality (800 cases/100,000 population) from exposure to erionite in rock used to build houses.[2] Most of the affected population had been exposed to erionite by inhalation since childhood, resulting in up to 50% of all deaths in three villages.[7,8] Many of the affected people later migrated to Germany and Sweden, and cases of MM caused by erionite were also identified in those Turkish immigrants.[8] Genetic susceptibility was also thought to be a possible factor in determining the susceptibility of the population to MM, specifically the pathogenic role of BAP1 mutations resulting in mesothelioma, and in other cancers globally, as well as in Cappadocia specifically.[9] The prevalence of the BAP1 gene in the global population and its more recent link to other cancers globally, along with studies linking MM to erionite exposure in countries other than Turkey (including the US and Mexico), suggest that the results from Cappadocia may not be accounted for entirely by local conditions or be atypical at global scales. [9]

In the US, the carcinogenic properties of erionite have recently sparked interest in erionite as an occupational and public health hazard, particularly in areas where erionite is found in regional bedrock or sediments. However, data concerning health outcomes there are equivocal. A study of North Dakota quarry and road workers reported only a few cases of pleural changes.[10] Notwithstanding that study, although the long-term health impacts remain uncertain, there is concern about inhalation of airborne dust and particulates containing erionite fibres from gravel pits, quarries, roads, building and construction sites.[10] Thus, erionite is now classified by the International Agency for Research on Cancer (IARC) as a Group 1 carcinogen (ie, carcinogenic to humans).[11] The potency of erionite as a human carcinogen appears to be higher than that of asbestos, particularly for the development of MM.[2] However, in contrast to asbestos, erionite mineral fibres do not have established occupational exposure limits (OELs).[6]

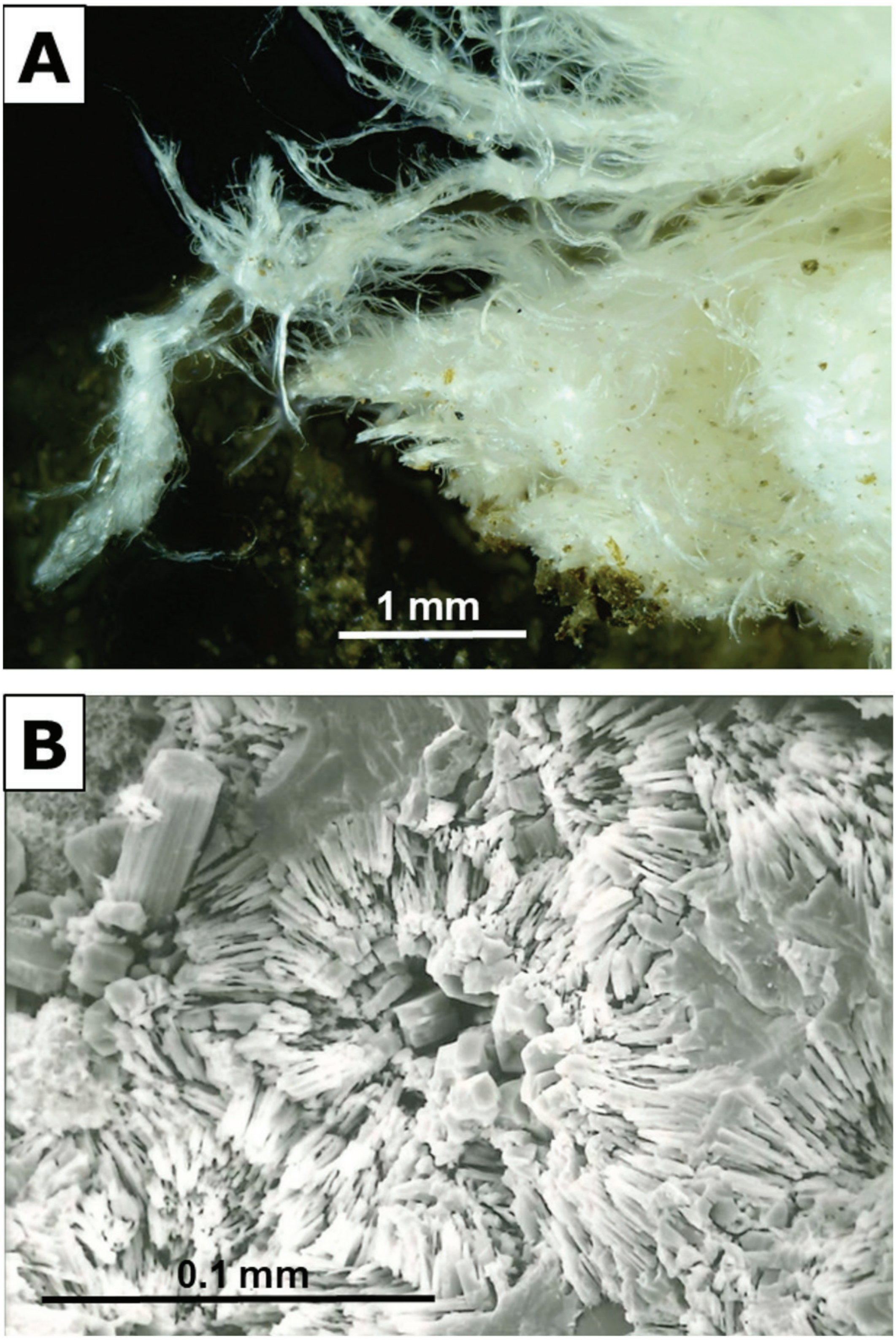
Despite the establishment of OELs for asbestos, controversy remains as to whether short intense exposure to asbestos is particularly harmful since it is complicated by non-linear dose concentration-duration-risk relationships.[12] There is also uncertainty as to how asbestos dose-response may relate to erionite dose-response for a number of reasons.[13] Epidemiological data alone typically lack accurate fibre counts (for erionite or asbestos exposure) and are inconclusive about risks at specific concentrations.[12] Fibres also vary in toxicity due to morphology and chemical characteristics (composition, surface reactivity, biopersistance etc).[14] There even exists considerable heterogeneity in the responses of cells within the same local volume of tissue,[12] and in vitro techniques do not provide accurate estimates of biologically-effective doses (eg, the numbers of fibres accumulated in mesothelial tissue over time).[12] Nevertheless, exposure concentration does appear to part-control the latency interval between first exposure to asbestos or erionite and the development of MM. Indeed, workers in trades with higher levels of exposure (eg, naval personnel removing asbestos from warships; builders; extractive industry workers), may experience shorter latencies compared to those exposed to lower amounts of asbestos.[13] Age at first exposure also appears to be important.[9] Indeed, once a sufficient amount of asbestos or erionite has been inhaled, such as by a six-year-old child growing up in a village or suburb contaminated with erionite, they will develop MM, which suggests that additional exposure(s) may not significantly increase the risk.[13] However, the threshold above which asbestos and erionite will cause MM, varies among individuals due to genetics, exposure to co-factors, the exact characteristics of the mineral fibre inhaled, etc.[13,14]

Erionite in Auckland

Despite this emerging body of work overseas on causative links between erionite exposure and MM, any effects of erionite on MM in New Zealand have hitherto not been established.[2] This is despite erionite being present, for example, in the Waitemata Group sedimentary rocks and the Waitakere Group volcanic rocks that are present throughout much of the Auckland region (Figure 1).[15] In a report on asbestos exposure in New Zealand by the Chief Science Advisor[2] in 2015, it was mentioned (on page 11) that while most cases of MM are associated with asbestos exposure, erionite is also a risk factor. They then accurately stated that erionite is present in some volcanic ash deposits in New Zealand, but, since the report focused on asbestos, did not further note that erionite is also present in sedimentary rocks such as those underlying

New Zealand's most populous, and fastest-growing region, Auckland. Indeed in the Auckland region, the presence of erionite has been reported by geologists in several studies over the last five decades.[15,16] It is present within the Early Miocene Waitemata Group sediments in association with highly altered andesitic clastic material.[15] These are the sedimentary rock formations, for example, that outcrop as sea cliffs along Auckland's North Shore, the eastern bays, and along Tamaki Drive. Thus, erionite is present and exposed in many locations across the Auckland region.

Figure 1: (A) Example of "woolly" erionite in Waitakere Group rock from Te Henga Road Quarry, Waitakere Ranges (Rod Martin); (B) Scanning Electron Microscopy (SEM) image of crystalline erionite (hexagonal crystal and acicular habit) from the Waitemata Group, Hobsonville (sample AU42046).



Over the last decade, Auckland's population growth has led to large transport infrastructure projects such as the Waterview Tunnel and the City Rail Link (CRL), as well as excavations in the city for high-rise building foundations. Most of these excavations are into Waitemata Group rock, and the material is usually loaded onto trucks, transported by road and dumped as fill or in former quarries.[17,18] For example, the Waterview Tunnel project saw two twin tunnels driven mainly through weathered and unweathered Waitemata Group sedimentary rock. The approx. 800,000m^3 of spoil (enough to fill 320 Olympic-sized swimming pools) that was excavated from the tunnels was transferred via a conveyor belt to the on-site storage facility. From there, the spoil was trucked to, and filled, the disused Wiri Quarry in Manukau, south Auckland.[20] The current CRL project in Auckland CBD involves tunnelling mainly through Waitemata Group sandstones and siltstone, and the removal of two million tonnes of spoil. Given the scale of these,[21] and other earthworks in the Auckland region and the current uncertainty regarding the precise location and quantity of erionite in the rocks and soils, there is the potential for significant exposure of some of Auckland's population to erionite-bearing rock dust if appropriate dust management strategies are not carefully implemented. The extent of this risk needs urgently quantifying as there are likely to be significant differences in exposure risks between ground engineering workers in Auckland, and areas of Turkey where houses were constructed with erionite-bearing sandstone blocks, as demonstrated by studies in the US.[10]

Concluding remarks

A recent report[1] claimed that the elevated incidence of malignant mesothelioma in New Zealand is a direct result of exposure to airborne asbestos fibres in occupational settings. There is usually a long latency period (20–40 years) for MM between exposure and diagnosis.[22] Importation and use of crude (raw) asbestos in New Zealand peaked in 1974,[1] yet cases of MM have increased almost exponentially since 1974 and remain high.[2] Some MM cases have been attributed not to direct occupational exposure to asbestos, but from the transfer of asbestos from the workplace to the home. Notwithstanding this, the potential effects of exposure through handling, use and disposal of erionite-bearing rock in both occupational and non-occupational settings in New Zealand remain unknown. The Auckland region is growing rapidly, including excavations for residential, infrastructure and transport works. The corollary is that the effects of airborne erionite need to be established. Indeed, further research on the source occurrence, and airborne transport of erionite would be advantageous, as well as epidemiological research to improve understanding of the extent of exposure to erionite in the population and who is most at risk. This could include developing testing regimes and occupational exposure limits, and then appropriate management of erionite exposure within a hierarchy of controls. Finally, if prediction of future peak MM incidence is based primarily on asbestos exposure and ignores exposure to erionite, then this could be painting an inaccurate picture of the likely future MM trends in the community.

Competing interests:
Nil.
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