IN THE ENVIRONMENT COURT
AUCKLAND

ENV-2009-304-000521
ENV-2010-304-000083

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of appeals under section 120 of the Act and a directly referred resource consent application under section 87G of the Act
BETWEEN	**WINSTONE AGGREGATES, A DIVISION OF FLETCHER CONCRETE & INFRASTRUCTURE LIMITED** Appellant
AND	**ENVIROWASTE SERVICES LIMITED** Appellant
AND	**AUCKLAND COUNCIL (FORMERLY AUCKLAND CITY COUNCIL AND AUCKLAND REGIONAL COUNCIL)** Respondent
AND	**THREE KINGS UNITED GROUP INCORPORATED** Section 274 Party

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FURTHER RESPONSE OF PHILIPPA BLACK ON BEHALF OF THREE KINGS UNITED GROUP INCORPORATED

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ERIONITE

1. Erionite and Zeolites

Zeolites are a family of hydrated aluminium-silicates. They form at low temperatures, generally at less than 150°C. The zeolite minerals are constructed from alumina and silica molecules linked together to form open cages which enclose cavities of various sizes and shapes. A characteristic feature of all zeolite minerals is that their cavities are interconnected to form channels that run through the mineral structure. Because of this property zeolites are commonly known as “molecular sieves”. In scientific terminology zeolites are classified as framework silicates.

The silica and alumina frameworks of zeolites have a negative charge which in nature is neutralised by hydrated sodium, potassium and/or calcium ions loosely held (adsorbed) onto the surfaces of the framework cages and cavities. In all zeolites alkalis are exchangeable, that is they can move freely in and out of the cavities and/or be replaced by other molecules. The cavities also hold water and other natural fluids.

In the fibrous zeolites, such as erionite, the fundamental molecular cage-like units are joined together to form chains. Erionite is one of a small number of fibrous zeolite minerals but the only one that is known to be carcinogenic. Plate 1 (below) shows the typical fibrous (needle-like) shape of the mineral erionite and small fibrils formed by the end-splitting of the large fibres.

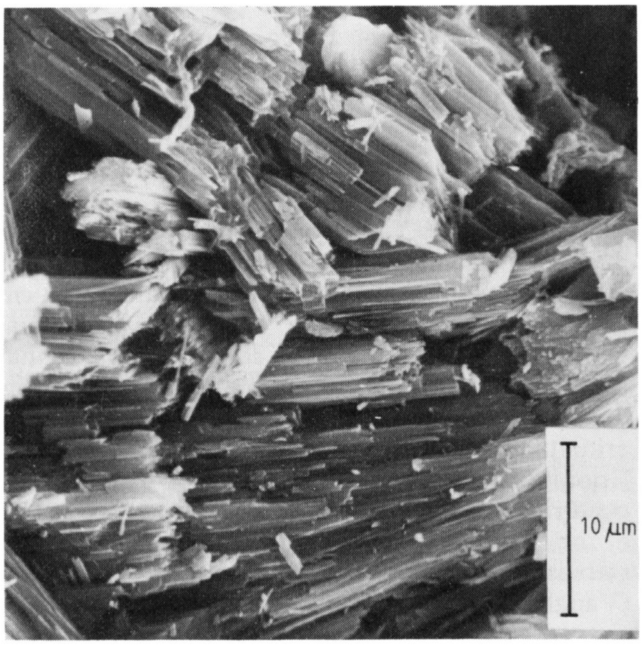

Plate 1 : Scanning Electron Microscope image of erionite crystals from the Kaipara Harbour erionite deposit.
Photo from L.P. Aldridge and C.G. Pope ‘Infrared and absorption studies of a New Zealand erionite.’ *New Zealand Journal of Science*, vol 24, pp 263-271 (1981).

2. **How does erionite differ from asbestos minerals?**

There are chemical and structural differences between erionite and the asbestos minerals.

Erionite is a hydrous alkali aluminium-silicate with a cation exchange capacity.

The asbestos minerals are either magnesium-rich serpentine (layer silicate) or amphibole (double-chain silicate) minerals; neither has a cation exchange capacity. Serpentine (chrysotile) asbestos is a 2-layer sheet silicate which has bent or curled to form hollow fibres. Amphibole asbestos minerals are magnesium double-chain silicates which form crystals that are elongated parallel to the silicate chain. In some environments the amphibole crystals are so elongated that they become fibrous.

The fundamental chemical and structural differences between the fibrous minerals affect their density. Erionite fibres have a density range of 2.05-2.07 (gm/cc). The serpentine (chrysotile) asbestos fibres are more dense (circa 2.3 gm/cc) while amphibole asbestos minerals have densities of 3.3 – 3.5 gm/cc. Erionite fibres, having the lowest density, will be held longer in the atmosphere than similar-sized fibres of the serpentine and amphibole asbestos minerals.

3. **Formation of zeolites and erionite in the natural environment.**

Deposits of zeolites, including erionite, form by the low-temperature alteration of lavas and volcanic tuff horizons. Essentially when glass contained within a lava or the glass shards in fragmental tuff horizons come in contact with water the glass hydrates and then reacts to form zeolites and clay minerals.

Erionite is a zeolite with a framework that has a high silica: alumina ratio so it is most commonly formed from the alteration of felsic-siliceous tuffs and volcanic rocks (dacites and rhyolites) that have been deposited either in marine or saline lake environments and then subject to low temperature (less than 100° C) alteration. Erionite is also found as crystals growing in gas vesicles and other cavities in basaltic and andesitic rocks. Erionite has, to my knowledge, not been recorded in soils.

4. **Brief history of erionite's emergence as an environmental health hazard.**

Zeolites, including erionite, have a long history of use in industry and agriculture. Commonly they are used to treat waste-water, as absorbents of pollutants, ion exchangers, soil conditioners, and in animal feedstuffs.

In the mid 1970s a number of cases of a rare type of malignant pleural mesothelomia were reported in several small villages in Central Turkey. In the early 1980s, epidemiological, environmental and experimental studies were undertaken. These resulted in the finding of a causal relationship between exposure to erionite fibres and the outbreak of malignant mesothelioma among the village population.[1]

In 1987 mining of erionite deposits and commercial production of erionite ceased.

Since 1987 there have been a number of mineralogical, environmental and pathological studies on erionite and its effect on health. Research has included experiments in which laboratory animals have been exposed to erionite sourced from both Turkey and the USA. These studies have concluded that exposure to erionite provides a higher risk of the development of lung-related cancers than does exposure to asbestos minerals.[2]

Erionite is common in rocks and tuffs in several of the western states of the USA. In 2006 the North Dakota Department of Health became aware of the health issues associated with erionite and recommended that use of aggregate sourced from "erionite contaminated" gravels be discontinued. Epidemiological studies have now been initiated to assess the health risks posed by living near erionite deposits.

At the beginning of 2011 a widely disseminated article discussed the potential health hazards of erionite, describing the mineral as "the new asbestos". [3] The current newsletter of the Mesothelioma Cancer Alliance has also highlighted erionite as a naturally occurring carcinogen.[4]

5. Where does erionite occur in NZ?

Erionite has been recorded as rare crystals in cavities in Tertiary- aged volcanic rocks in the North Island.

Erionite is a relatively common zeolite in altered tuff horizons in the Waitemata Group sediments (see Map p. 7). Deposits of erionite are known in the Kaipara area; these are the deposits that are frequently referred to in current international literature on the toxicity of erionite. Other erionite-bearing tuff horizons occur in the western portion of the Waitemata sedimentary sequence. Rare thin beds of zeolitised tuff also occur in the East Coast Bays Formation; at least one of these tuffs contains erionite.

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[1] I Baris et al. 'Epidemiological and environmental evidence of the health effects of exposure to erionite fibres: A four-year study in the Cappadocian Region of Turkey'. *International Journal of Cancer* 39, 10-17 1987

[2] For example D.L. Coffin et al 'Comparison of mesothelioma induction in rats by asbestos and nonasbestos mineral fibres: Possibile ecorrelation with human exposure data': in *Proceedings of Biological Interaction of Inhaled Mineral Fibres and Cigarette Smoke* AP Wehner (ed) 1989 347-354.

[3] http://www.internalmedicinenews.com/news/oncology-hematology/single-article/mesothelioma-watch-is-erionite-the-new-asbestos/69a869d398.html

[4] http://www.mesothelioma.com/mesothelioma/risk-factors/erionite-exposure.htm. **Document is attached**.

The zeolitised tuffs in the Waitemata Group are comparable in origin and nature to the now much-studied erionite bearing tuffs in Central Turkey where the association of environmental erionite with high levels of malignant mesothelioma has been proven.

6. What is the potential hazard in Auckland region?

The hazard in the Auckland area lies within the Waitemata Group sediments which are increasingly being excavated for major infrastructural projects, including tunnelling. Such projects produce large amounts of spoil that needs to be disposed of.

Waitemata sediments are classified as weak rocks – that is they have unconfined compressive strengths of c. 5 MPa. In practical terms they stand up readily in cliffs and support the multi-storey buildings characteristic of a modern city. However, aggressive mechanical excavation can result in the complete disaggregation of the material and sticky spoil problems.[5] The underlying cause of the rock weakness is the matrix of the sediment (see Plate 2 below) where clay mineral plates assume a honeycomb (house of cards) structure held together by the weak end/face attraction of individual clay plates. Diagenetic zeolite crystals provide a strengthening cement. Disaggregation of the sediment "liberates" the zeolites and clay mineral particles which may then be dispersed as atmospheric dust.

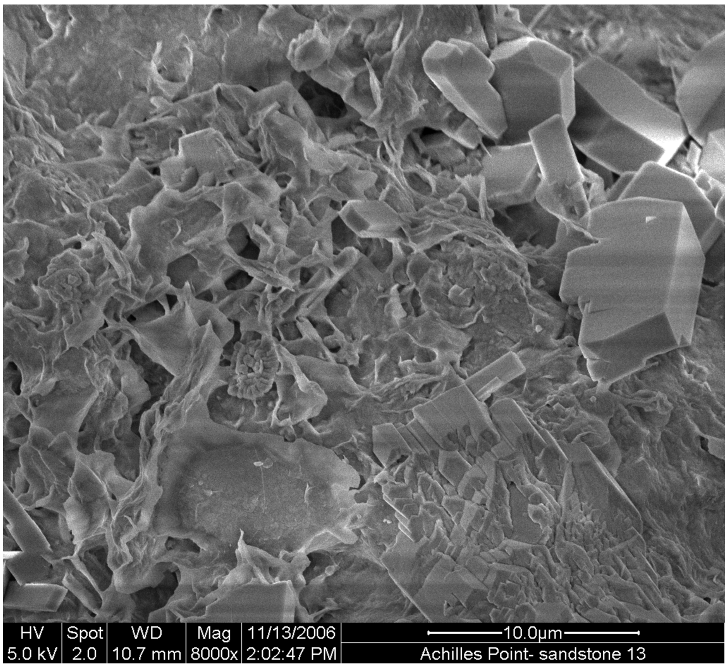

Plate 2 : Scanning Electron Microscope image of Waitemata (East Coast Bays Formation) sandstone. An area showing the honeycomb clay mineral structure of the sediment matrix is slightly left of centre. The individual clay mineral particles are generally less than 3 microns in diameter. Zeolite (clinoptilolite) crystals can be seen (top right).

[5] P.Black, B.Riddolls and P.Horrey. 'Petrographic determination of clay content within East Coast Bays Formation for mechanized tunnelling projects.' Proceedings of the 11th Congress of the International Association of Engineering Geologists, Auckland, 5-10 September 2010, Extended Abstracts p.196.

In the East Coast Bays Formation, which contains little volcanic debris, the cementing mineral is usually clinoptilolite, a zeolite that does not need a volcanic glass precursor. This mineral is the common diagenetic zeolite found in the older deepwater marine sediments of the world's oceans.

Tuff horizons and sandstones enriched in volcanic debris in the Waitemata Group sedimentary sequence contain other zeolites, including erionite.

Greywacke sediments, the major aggregate resource for the Auckland region, are strong rocks that have been metamorphosed to temperatures around 200ºC, which is well above the stability limit for zeolites. There are no records of erionite, and very few records of any other zeolites, in the young Auckland and South Auckland basalts and tuffs that are another aggregate resource for the region.

Miocene andesitic volcanics, such as those in the Waitakere Ranges are locally zeolitised, and the possibility does exist that erionite may occur in cavities in them.

The erionite-contaminated gravels used as aggregate in North Dakota and elsewhere in western USA, which are currently the subject of much medical and media interest, are not relevant as comparators with rocks used as aggregate in the Auckland region.

7. Recognising zeolitised tuffs beds and testing for erionite

Zeolitised tuff horizons in the Waitemata sediments are easy to recognise. They are cream coloured, fine-grained and massive. These properties are in striking contrast to the enclosing "normal" Waitemata sediments which are grey or brownish-grey coloured, have alternating beds with variable grainsizes, and are often friable.

Erionite can be identified from its X-ray powder diffraction pattern. Protocols exist, using X-ray Powder diffraction methods, for the detection of trace amounts of erionite in rocks and soils.[6]

8. Final Comment

Since erionite deposits are known to occur in New Zealand, and are frequently mentioned in the accumulating mesothelioma literature, it seems prudent to take note of the debate, consider what hazard the erionite deposits might pose for the people of Auckland, and introduce precautionary measures into resource consents to minimise any possible health hazard.

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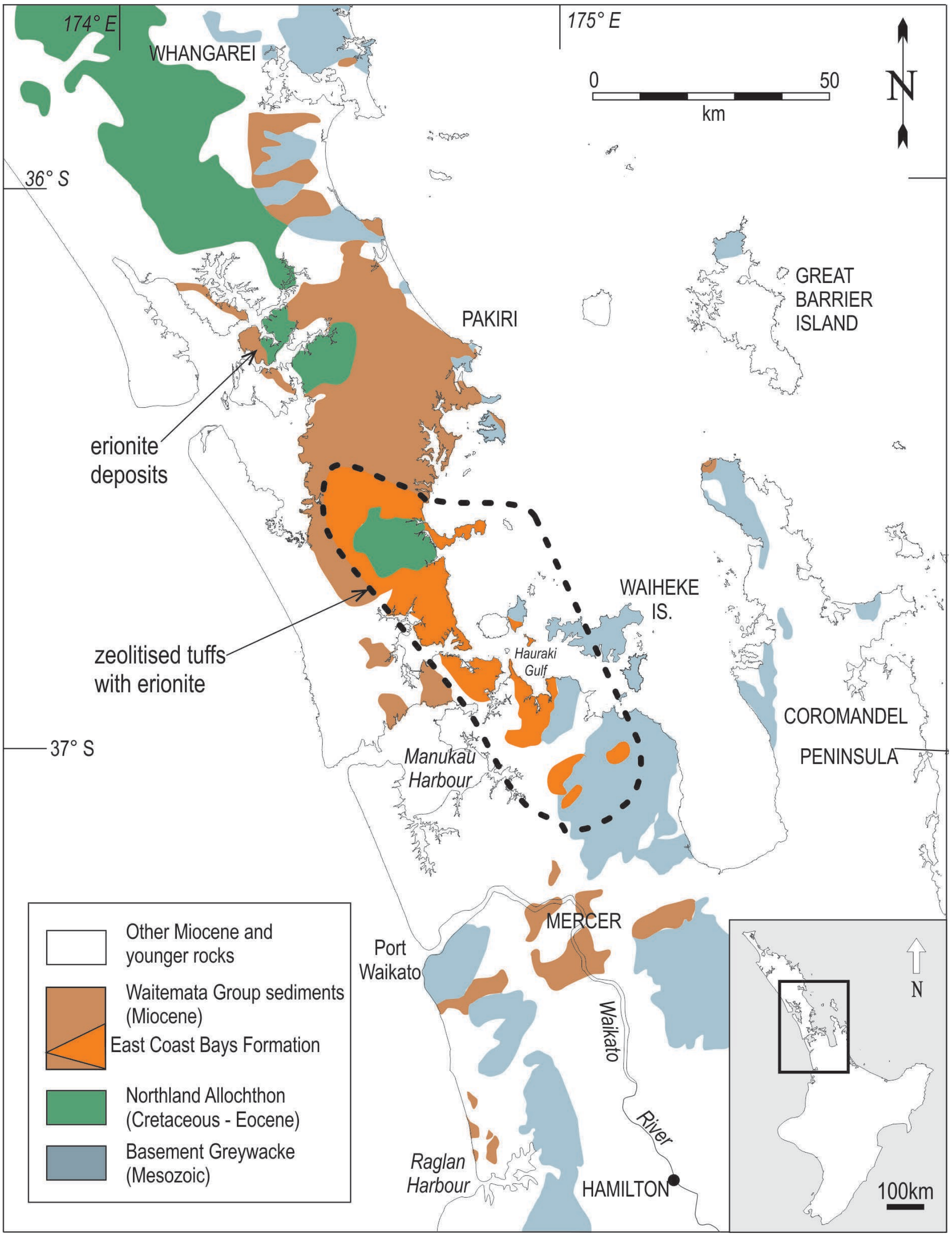
[6] David L. Bish and S.J Chipera 'Detection of trace amounts of erionite using X-ray powder diffraction: Erionite in tuffs of Yucca Mountain, Nevada, and Central Turkey.' *Clays and Clay Minerals* 39 No 4, 437-445, 1991.



Simplified geological map of the Greater Auckland Region showing outcrops of major rock types and the locality of the known erionite deposit and other known significant outcrops of zeolitised tuffs containing erionite. The East Coast Bays Formation (delineated by dashed line) contains rare zeolitised tuff horizons.

Map after S.W. Edbrook (2001). Geology of the Auckland area Scale 1:250,000. Institute of Geological and Nuclear Sciences geological map 3. 1 sheet + 74p. Lower Hutt, New Zealand. Institute of Geological and Nuclear Sciences Ltd.

Footnote 4 --- ATTACHMENT
http://www.mesothelioma.com/mesothelioma/risk-factors/erionite-exposure.htm
(accessed 12 March 2011)

Mesothelioma.com

The Mesothelioma Cancer Alliance
- Resources for Patients and their Families

›Mesothelioma›Mesothelioma Risk Factors›Erionite Exposure

Erionite Exposure

Though less familiar and common than asbestos minerals, erionite is another naturally occurring carcinogen that, through prolonged and repeated exposure, can lead to mesothelioma, lung cancer and other deadly diseases. Erionite exposure is mainly environmental, a drastic difference from asbestos exposure which is typically occupationally related. Individuals who contracted mesothelioma from erionite exposure usually lived near significant deposits of the mineral.

Through laboratory tests in animals, erionite exposure has shown to have a higher risk of development lung-related cancers like mesothelioma than any other mineral tested, including asbestos. Further, mesothelioma develops with less exposure to erionite than asbestos.

Erionite Exposure

Erionite is an asbestiform, a naturally occurring highly fibrous volcanic mineral with similar properties of asbestos minerals. Erionite is a zeolite mineral, where as asbestos is either serpentine or amphibole. Unlike asbestos minerals, erionite is not regulated in the United States, and does not have the same expansive and various commercial applications as asbestos.

Typically, trace amounts of erionite have been found in other zeolite products like water softener or water purification systems. However, exposure to erionite comes from mining other zeolites or through natural, environmental exposure. Trace amounts in zeolite products may lead to low-levels of exposure, though it is unknown whether these products can lead to mesothelioma.

Generally, asbestos exposure is occupationally related, where individuals are intimately involved in the manufacturing, handling or installation of asbestos products. Through repeated inhalation of asbestos particles, mesothelioma cancer and other asbestos cancers develop. However, with erionite, the majority of exposure is environmentally related, where individuals live near or around erionite deposits.

Worldwide, there are known erionite deposits in Germany, New Zealand, Russia, Japan, Kenya, Turkey and Italy. In the United States, most of the erionite deposits are located in the West, mainly in Oregon, Arizona, Nevada, California, Wyoming, North Dakota and Utah.

Higher Rates of Mesothelioma

Tuzkoy, a small village in Turkey, has an unusually high rate of environmentally related malignant mesothelioma, lung cancer and other lung diseases. With an excessive concentration of erionite deposits in the areas surrounding Tuzkoy, exposure results from inhalation of the fibrous minerals. The erionite particles are airborne, and occur naturally in the surrounding air and dust.

Further, a small number of villagers have used erionite blocks as cool storage for food. Again, like the deposits, exposure to erionite particles may attribute to the storage blocks. However, the majority of mesothelioma cases in Tuzkoy resulted from the deposits rather than the storage blocks.

This “Cancer City” has an alarmingly high rate of pleural and peritoneal mesothelioma related deaths, nearly seventy-times of the average yearly mortalities. Studies have shown that the adjacent erionite deposits are to blame.

Currently, studies are underway in North Dakota among residents living near erionite deposits on the possible adverse health effects of the exposure. In comparison to asbestos, little is known about erionite exposure, and many worldwide health organizations are aggressively studying the health effects of the mineral. As in Tuzkoy, there could be other pockets near erionite deposits that may also have extremely high rates of mesothelioma cancer.

As a naturally occurring carcinogen, erionite affects individuals similarly as asbestos. Through prolonged exposure and inhalation, erionite particles settle specifically into the lungs or generally in the mesothelium, the lining of internal organs. Eventually, the embedded erionite particles spur carcinogenesis or the transformation of normal cells into cancer cells.

In addition, the incubation period of erionite in the lungs and mesothelium is similar to that of asbestos – ranging from ten to twenty years. Symptoms of mesothelioma caused by erionite are similar to asbestos, including shortness of breath, pain in the chest wall and weight loss.

Further, studies have shown that a smaller level of erionite exposure has a higher risk of developing cancer than asbestos minerals. Essentially, it takes a much smaller amount of inhaled erionite particles to cause cancer than asbestos.

Whether it is caused by erionite or asbestos, mesothelioma disease is devastating. What is certain, however, is that in comparison to asbestos, erionite research is scant but growing. Since establishing the link between erionite exposure and high mesothelioma incidences, the scientific and medical fields are exhaustively conducting further research. The mineral with negligible commercial applications is a naturally occurring carcinogen, and in some affected areas, the environmental exposure is deadlier than occupational. As in Tuzkoy, breathing the ambient air around erionite deposits can cause mesothelioma.

Sources

Y. Izzettin Baris and Philippe Grandjean. Journal of the National Cancer Institute. *Prospective Study of Mesothelioma Mortality in Turkish Villages with Exposure to Fibrous Zeolite*. January 26, 2006. Accessed on November 5, 2010. http://jnci.oxfordjournals.org/content/98/6/414.full?sid=e759edd6-b7d1-467d-9dfe-373a31cf4f4a

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