CASITILE, THE NEW ASBESTOS: Time to clear the air and save £20 billion

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INTRODUCTION:

One of the biggest costs to those responsible for Britain’s built-environment is now that involved in the management of asbestos. Under the current regulatory regime, these costs have been estimated at many billions of pounds. The purpose of this review is to show how recent research has demonstrated that much of the concern over what is generically known as ‘asbestos’ is based on a fundamental scientific confusion. If the lessons of these studies can be properly learned, it will be seen that a very high proportion of the costs involved in the management of asbestos could be avoided, with immense savings to the national economy.

THE SOURCES OF MISUNDERSTANDING

‘Asbestos’ is not a mineral in itself. It is a collective term given to a group of minerals whose crystals occur in fibrous forms. The term ‘asbestos’ was adopted for the purposes of commercial identification alone; any use of the word to define the properties of the minerals within the group as if they were all the same is a serious scientific error.

The major minerals covered under the umbrella term ‘asbestos’ are listed in Table 1.

Table 1. Minerals covered by the term ‘asbestos’

Name	Formula
Chrysotile	Mg3 Si4 O10 (OH)2
Crocidolite	Na2 Fe5 Si8 O22 (OH)2
Amosite	(Fe,Mg)7 Si8) 22 (OH)2
Tremolite	Ca2 Mg5 Si6 O22 (OH)2
Actinolite	Ca2(Mg,Fe)5 Si8)22 (OH)2
Anthophyllite	(Fe,Mg)7 Si8) 22 (OH)2

These 6 minerals, are members of two quite distinct mineralogical groups. Chrysotile is a serpentine mineral, the other 5 are all amphibole minerals. The name ‘chrysotile’, derives from the Greek for ‘fine golden hair’ (chrysos - "gold" and tilos - "fiber) (Browne, 2003). This mineral has long, flexible silky fibres unlike the straight rigid fibres of the amphiboles. The magnesium oxide/hydroxide surface of chrysotile (brucite) means it is chemically unstable in an acid milieu. It can be degraded by even a weakly acid environment such as that found in the lungs. Animal experiments have shown that chrysotile has low biopersistence with half-lives from a few hours to 15 days depending on the minerals origins. (Bernstein DM, Rogers R, Smith P, 2004). The amphibole mineral are chemically more stable and are biopersistent with half-lives ranging from a few years to a lifetime.

Only 3 of the asbestos minerals have had significant commercial use: chrysotile (white asbestos), crocidolite (blue asbestos) and amosite (brown asbestos). By far the most commonly used type was and is chrysotile, comprising 90% of all asbestos used in the built environment. Amphiboles, because of their danger to health, are little used today and have been banned in most countries for many years. Chrysotile is still in common us in many countries, largely because, of the six types of minerals, it poses by far the least risk to human health.

Manufacturing products from the three commercial types of asbestos was a thriving industry for nearly a century following the discovery of large mineral deposits in the nineteenth century; by 1900 asbestos was being used in over 3000 products. The use of amphiboles decreased rapidly, mostly through legislation and because of the health effects, from the 1970s. All these products can be classified into two types. The first consists of those, such as asbestos cement, which encapsulate the mineral fibres within a matrix to give a product with a density greater than 1 g/ml (these are known as High Density Products). The second group includes low density insulation boards, textiles and uses such as asbestos pipe lagging applied using raw mineral fibres. These lower density products typically have a density less than 1g/ml.

Studies over many years on both amphibole and serpentine asbestos fibres have examined their physico-chemical properties and their effects on health. It is now established and well known that amosite and crocidolite in their raw form are potentially very hazardous to human health. It is also generally accepted that chrysotile is very significantly less hazardous, posing no measurable risk to human health at present day mandated permissible exposure levels in the workplace (Hodgson and Darnton, 2000). So great is this disparity that amosite has been estimated to pose a health risk 300 times that of chrysotile, and that of crocidolite 500 times greater (Hodgson and Darnton, 2000). Figures, which incidentally, are considered by many scientists to over-estimate the dangers from chrysotile by a factor of 2 or more.

By 1985 the use and supply of amosite and crocidolite were banned. In November 1999 the use of chrysotile in all building materials and virtually all manufacturing processes was also banned, by the Health and Safety Commission (HSC).

Although no new asbestos products are now manufactured in the UK, many asbestos containing materials (ACMs) remain in millions of the nation’s buildings and products. Current legislation demands that any existing ACMs, except in privately-owned domestic premises, must be identified and managed.

By far the most commonly used ACM is chrysotile asbestos cement (AC), which current regulation now places on a par with all other ACMs. But around 200 studies have shown that the health risks from exposure to any chrysotile fibres released during the use and handling of this High Density Product (HDP) are extremely low (Hoskins and Lange, 2004). The common factor from all major recent studies is that chrysotile HDPs present no measurable risk to health.

In the manufacture of chrysotile AC, it is common practice to use a machine to render down the cement sheets from faulty production into a dust for re-use in later batches. Air monitoring tests carried out in the Lusalite factory in Portugal have shown that no actionable levels of chrysotile fibres were being emitted through this process, despite the aggressive and violent reduction of the sheets in an unenclosed machine (Health and Safety Department, Lusalite). Similar official tests conducted in the UK, to examine the effect of crushing cement sheeting using a JCB digger driven over piles of chrysotile asbestos cement roofing sheets, confirmed that no actionable level of airborne chrysotile fibres were detected.

Herein lies the problem. The authorities make a most fundamental mistake by transposing the risks posed by exposure to raw fibres onto the products made from them. This is scientific nonsense and shows a complete disregard for the many risk assessments that have been made. It is an application of the precautionary principle to attribute the health risk posed by a raw material to products made from it. That is, it is hazard rather than risk based. If this approach were taken for every potentially hazardous material, no product would be left unregulated (nickel, for instance, is officially classified, like asbestos, as a Class One carcinogen, yet it is used to make euro coins).

Among issues studied by research on fibre release from HD products has been the question of whether the chrysotile fibres undergo chemical change when they are used in ACMs and if so how does this affect their properties. Where chrysotile is used in asbestos brake linings, for instance, it has been shown that heating the material (as occurs where the brakes are used) causes the chrysotile fibres to alter their chemistry and structure, transforming them into a different mineral: an olivine known as Forsterite ($Mg2\ Si2\ O4$).

Until recently, though less well documented, has been the question of whether a similar process occurs when raw chrysotile is added to cement. In light of the abundance of asbestos cement, by far the commonest use of asbestos in the built environment, this question becomes one of the greatest importance. This review aims to summarise the answers given by recent research, and to discuss their implications.

EXPERIMENTAL EVIDENCE AND EXAMPLES:

In 1980, a paper on the ‘Characterization and properties of cement dust’ (Deruyterre A, Baetten J, Helsen J, 1980) looked at how chrysotile fibres are changed during manufacture, discovering that when chrysotile is added into a cement mix in the manufacture of AC products, the composition of supposedly ‘pure’ chrysotile actually changes through incorporation of calcium, a metal which is absent from raw chrysotile.

This study echoed the findings of a paper written even earlier by N. Smirnov in 1962, ‘The petrography of asbestos-cement’. Smirnov’s study immersed asbestos fibres in the hydration products of Portland cement. After extensive analysis, he also noticed that a chemical reaction occurred between the two, creating chrysotile fibres that had altered their appearance.

The current implications of these papers are considerably more profound than they might have appeared to be in the 1960s and 1970s. Now that it has been shown that pure chrysotile fibres are cleared very rapidly from the lung (they have low biopersistence) (Bernstein DM, Rogers R, Smith P (2004). It also emerges that the fibres undergo chemical alteration and in most cases have cement particles adhering to them so changing their aerodynamic diameter that they are no longer respirable.

The altered chrysotile fibres have very little chance of making it past the upper airways, let alone into the lung, as will be documented below.

Another study which found these alterations to chrysotile was a paper written by L Elovskaya in 1992 entitled, “Modification of chrysotile asbestos under the influence of environment and cement hydration products in asbestos cement”.

In a series of original experiments, using electron microscopy and energy dispersion tests, Elovskaya also explored the existence of a chemical reaction between hydration products in Portland cement and the surface of chrysotile fibres.

The conclusions drawn in Elovskaya’s paper were that:

a) fibres emitted from asbestos cement products in the course of their exploitation are significantly different from those emitted by raw chrysotile. Their surface characteristics, composition and crystal structure all change
b) such chemical changes lead to a marked decrease in the biological penetrability of chrysotile fibres. Therefore any risk posed by asbestos cement becomes significantly less

In echo of these findings, Professor Pooley in 2004 wrote a paper, entitled “Report on the examination of asbestos cement products to investigate changes in character of its asbestos content”. This investigated Elovskaya’s and all previous findings, and found definitively that chrysotile fibres included in a Portland cement based matrix are chemically and structurally altered.

Samples prepared from the AC products and a control sample of pure chrysotile were subjected to, before and after dispersal in distilled water, X-ray diffraction in an electron microscope (EM). Samples of respirable AC dust were also generated and examined in a similar manner.

The conclusions which emerged from Professor Pooley’s report were unequivocal. They confirmed that mixing with cement induces chemical and structural changes in the chrysotile fibres. These show increased levels of calcium and silicon and an increased tendency to aggregate.

This report provided clear images of the altered fibres, confirming the results from the papers previously published.

Figure 1 shows an EM image of the control chrysotile sample, whereas Figure 2 shows an image of the fibres from the cement dust sample. Figure 3 clearly shows the calcium and silicon bodies on the dust sample fibre, demonstrating the chemical change taken place.

Figure 1. EM image of chrysotile fibres

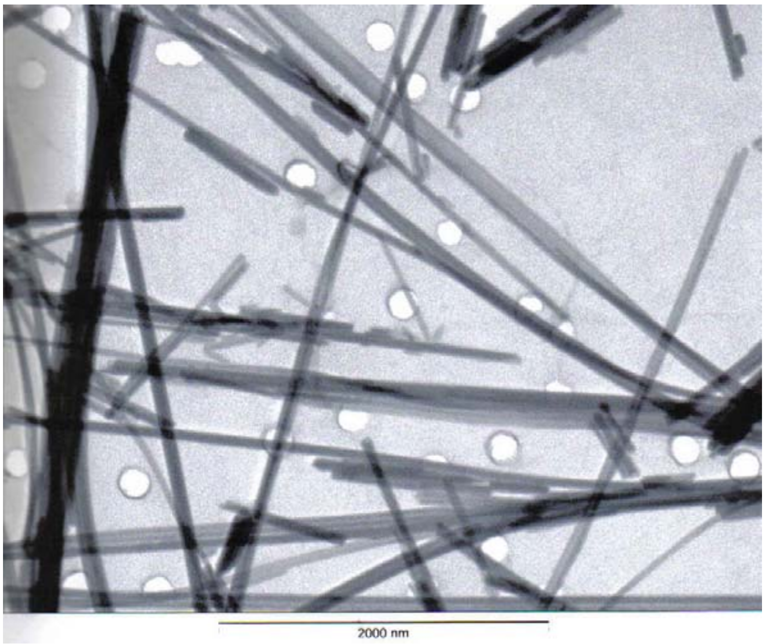


Figure 2. EM image of the fibres from the AC dust comparison

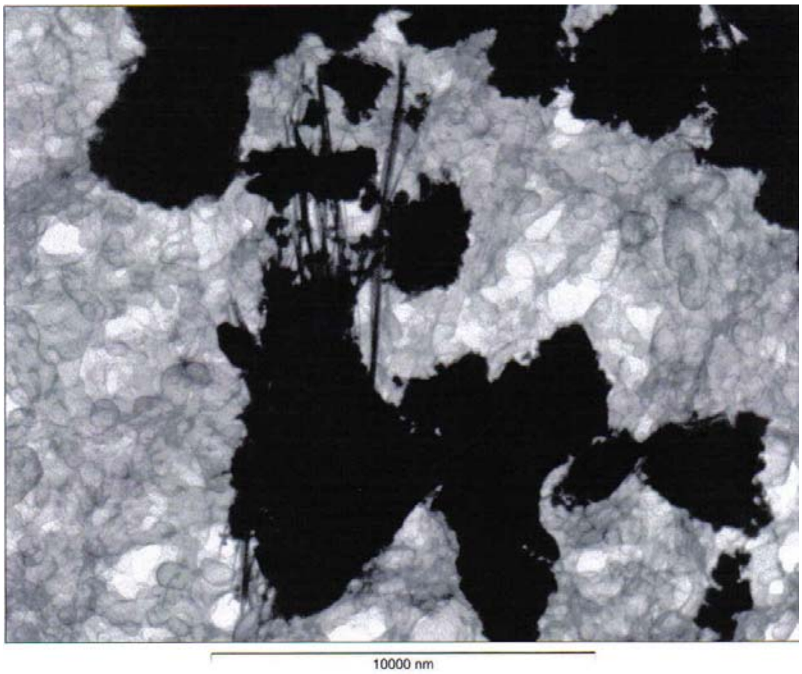


Figure 3. EM images of the altered chrysotile fibre with ‘calcium and silicon’ adhering bodies

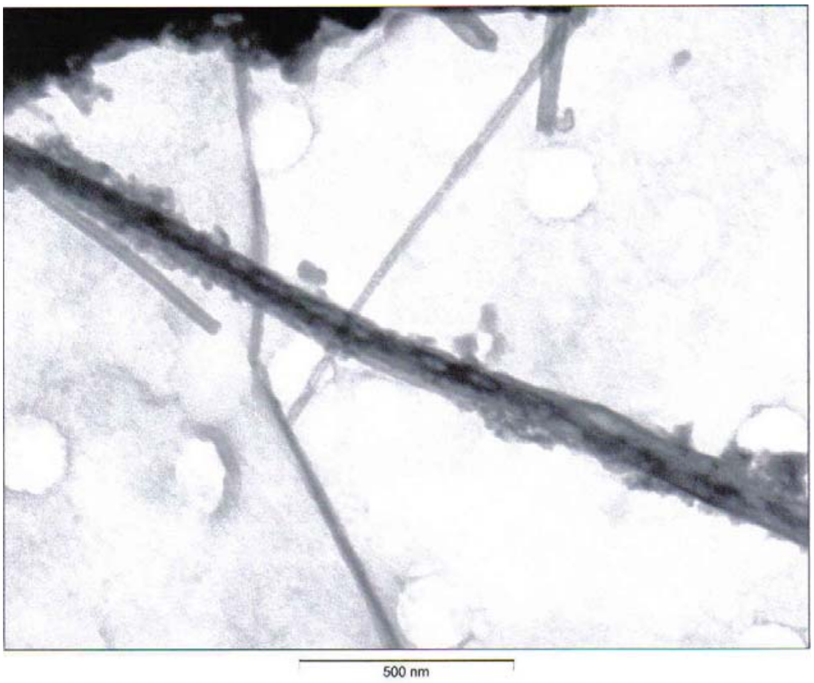
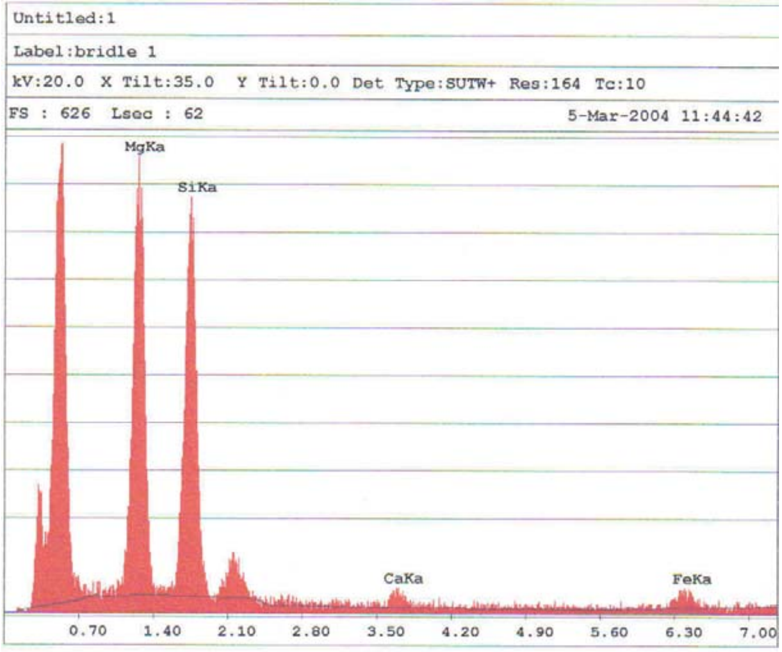


Figure 3 clearly shows the visibly altered nature of the AC sample fibre when compared with the pure chrysotile fibres in Figure 1. Figure 4 (below) shows the actual chemical analysis of the AC samples alongside a control chrysotile sample. The calcium and silicon spikes are consistently present in the dust sample fibre, significantly altering the chemical composition of what was once a chrysotile fibre.

Figure 4. Chemical analysis of fibres from a control chrysotile sample and AC samples



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Untitled:1
Label:bridle 1
kV:20.0  X Tilt:35.0   Y Tilt:0.0  Det Type:SUTW+  Res:164  Tc:10
FS : 626  Lsec : 62                              5-Mar-2004 11:44:42
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Thin Apx
Theoretical KAB, Elements, Model : Zaluzec

Element   Weight %  Atomic %

   MgK      45.5      51.3
   SiK      44.1      43.0
   CaK       3.4       2.3
   FeK       7.0       3.4
 Total     100.0     100.0
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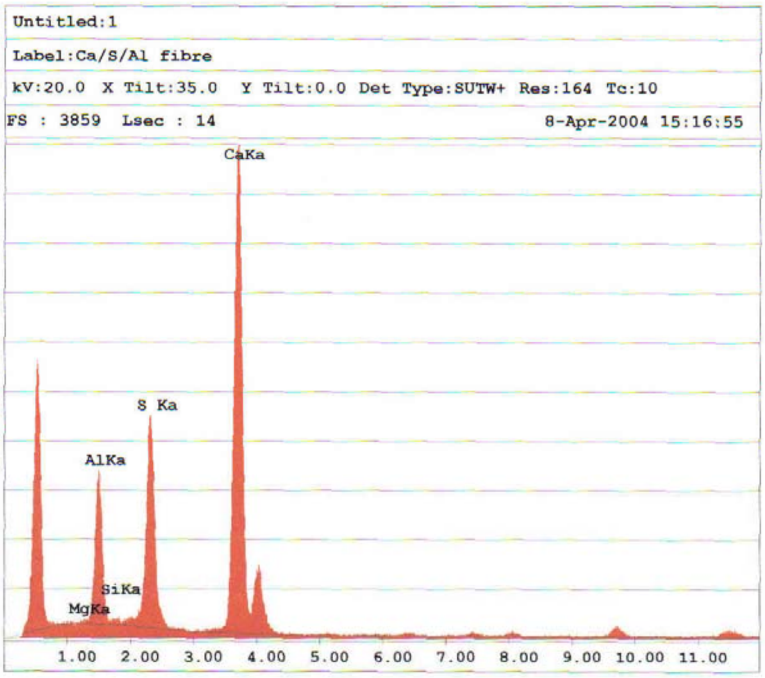

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Untitled:1
Label:Ca/S/Al fibre
kV:20.0  X Tilt:35.0  Y Tilt:0.0  Det Type:SUTW+  Res:164  Tc:10
FS : 3859  Lsec : 14                                8-Apr-2004 15:16:55
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Thin Apx
Theoretical KAB, Elements, Model : Zaluzec

Element  Weight %  Atomic %

   MgK      0.2       0.4
   AlK     11.3      15.1
   SiK      0.5       0.6
   S K     19.5      22.1
   CaK     68.5      61.8
 Total    100.0     100.0
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So important are the implications of these findings that the Health and Safety Executive (HSE) instructed the Health and Safety Laboratory (HSL) to duplicate Professor Pooley's investigation. The results became available in 2007 but unfortunately government spin had altered the hypotheses to be tested out of all recognition and the analyses produced were arguably flawed.

DISCUSSION AND CONCLUSIONS:

Of all asbestos containing materials in the world, 85% consist of asbestos cement (HDPs). The media interest surrounding this topic serves to highlight the vast numbers of people affected by concern over the dangers of asbestos, and by the costs which arise from that concern. If the significance of these research findings is properly appreciated and recognised, their practical implications could be immense.

One implication would be a breakthrough in preventing that hysteria which has been aroused by the general confusion and ignorance over 'asbestos' from spreading further than it has done already. If the general public can be reassured that 85% of the products they have been encouraged to fear as hazardous have in fact been rendered by the manufacturing process into a stable non-reactive material posing no measurable risk to health, this will be an enormous gain for common sense and for the national economy.

A key role here must be played by changes to the HSE's interpretation of the UK's asbestos legislation. Although the HSL felt itself unable, for reasons which are presumably political, to duplicate the findings of the several scientific reports to the satisfaction of the HSE and the HSC their work may have to be defended in the courts where obfuscation is less liable to be allowed. Chrysotile AC products should be seen as containing a mineral mix which overall is less hazardous than the mineral which has been banned and which pose negligible risk. These products should be exempt from many of the asbestos regulations. One of the most contentious of these regulations to be affected should be the application of the Hazardous Waste Regulations. Currently under these, chrysotile cement products are treated in exactly the same manner as loose crocidolite (blue asbestos), imposing potential costs on property owners and businesses which can scarcely be estimated.

A simple recognition that asbestos fibres, locked into HDPs, pose much less risk than the raw fibre as a consequence of the chemical changes that occur during the manufacturing process could potentially save billions of pounds; not only by drastically reducing the involvement of the asbestos abatement industry and in savings on waste disposal, but in legal fees, compensation and insurance claims. In total, it is not difficult to estimate the saving to UK businesses and property owners as amounting to £20 billion pounds.

Lastly but, ironically perhaps most importantly, there is the matter of a small name change. The findings of the papers in this review support the view that chrysotile fibres have been so altered, chemically and structurally, that it is no reasonable to continue to be describe them as chrysotile. Since a new term is required to classify their altered state, one suggestion, in light of their chemical absorption of Calcium (Ca) and Silicon (Si), is that they should be called 'Casitile'.

Until now, confusion over the word 'asbestos' has acted as the major catalyst to a health scare that is in no way justified by 85% of the products included under this loose heading. Perhaps it is fitting that the recognition of a new material 'Casitile', a mineral mixture not under the curse of any existing legislation or prejudice, should be what is needed to restore sense to a debate which has become not only nonsensical but highly damaging to our society in general - and to all those who are individually being made to suffer for no reason other than political expediency.

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