DEPARTMENT OF MINES
SOUTH AUSTRALIA

ASBESTOS: A REVIEW

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CONTENTS

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ABSTRACT

The properties, occurence, uses, benefication, specifications, world and Australian statistics of industrial grades of asbestos are summarised. In 1969, Australia consumed 59,411 tons of asbestos, 59,068 tons of which were imported. The relatively large imports, and the variety of uses illustrates the importance of this material to industry.

Total production of asbestos in South Australia up to the end of 1970 was 3,164 short tons valued at $61,740. In South Australia, chrysotile occurs in irregular veins scattered throughout serpentinised dolomite near Cowell and crocidolite and some tremolite as fibrous masses in metamorphosed carbonate rocks at a number of localities.

This review provides basic information for more particular investigations.

INTRODUCTION

"Asbestos" is a name applied to a variety of naturally fibrous minerals. It has a wide variety of uses some of which are vital to many industries, such as building construction, asbestos-cement pipe production and automobile manufacturing. Asbestos is also a strategic mineral.

Production of asbestos in Australia is very low compared to consumption by manufactures of asbestos-bearing articles. Thus imports are high.

In South Australia, several different types of asbestos occur in a number of geographically separated areas and in different geological settings.

This report gives consideration to the broader aspects of asbestos in order to provide the necessary background for more particular investigations. For further details the reader is referred to the several text books and articles listed in the references.

VARIETIES OF ASBESTOS

There are several varieties of asbestos, which differ considerably in composition and physical properties. The most important commercially is the fibrous serpentine mineral chrysotile, which constitutes about 95 percent of total world production. Its wide use is due to the fact that its fibres are generally strong and flexible and can be applied to many uses, such as manufacture of fireproof textiles and steam packing, for which weak and brittle fibres are not suitable.

Chrysotile is a hydrous magnesium silicate with the formula $Mg_3(Si_2O_5)\ (OH)_4$. It is a fibrous form of the mineral serpentine. Small replacements of the magnesium by iron, nickel, manganese or aluminium may result in some modifications in the physical properties of the fibres; but, in general, chrysotile is more constant and dependable in quality than other varieties of asbestos. Electron micrographs show that each crysotile fibre is a hollow cylindrical tube (Bates, et.al., 1950).

Species of asbestos other than chrysotile fall in the amphibole group of minerals. The varieties of amphibole having significant use are anthophyllite, amosite, tremolite, actinolite and crocidolite. Fibres of anthophyllite and tremolite are generally weak and brittle and their uses are limited. Amosite and crocidolite are mainly African varieties, exported to other countries in considerable quantities for specialised uses.

Anthophyllite is a fibrous orthorhombic amphibole with the formula $(Mg, Fe^{+}_{2}) (Si_8O_{22}) (OH,F)_2$. Isomorphic substitution of iron and magnesium is limited. Aluminium may replace magnesium or silicon.

Amosite is a fibrous form of the monoclinic amphibole grunerite which has the formula $(Fe^{+}_{2}; Mg)_7 (Si_8O_{22}) (OH)_2$. As it is monoclinic in crystallization it is not a true anthophyllite, although it is commonly classed as a high-iron anthophyllite. Amosite, unlike the true anthophyllites which are invariably weak and brittle, commonly consists of long, fairly strong fibres that have certain specialised uses. It is mined only in Africa.

Tremolite is a fibrous monoclinic amphibole with the formula $Ca_2(Mg, Fe^{+}_{2})_5 (Si_8O_{22}) (OH, F)_2$. Calcium may be replaced in small part by sodium. Tremolite usually consists of grey to white silky fibres which are for the most part weak and brittle, although fibres of considerable strength and flexibility are found at times. Both tremolite and anthophyllite are superior to chrysotile in resistance to chemical reaction.

Actinolite differs from tremolite in that a considerable part of the magnesium is replaced by iron.

Crocidolite or blue asbestos belongs to the riebeckite group of amphiboles. Its chemical formula is $Na_2Fe^{+2}_{3}Fe_2^{+3} (Si_8O_{22}) (OH)_2$. Crocidolite is a fibrous form of riebeckite in the same way that amosite and chrysotile are fibrous forms of grunerite and massive serpentine respectively.

As may be observed from the foregoing discussion, the replacement of one element by another in varying proportions is a prevalent characteristic of the several varieties of amphibole asbestos. This varation in composition results in corresponding changes in their physical properties. These properties may also be influenced by the presence of impurities. The somewhat erratic and unpredictable physical characteristics of the amphibole fibres have a profound influence on their use. An anthopyllite from one locality may give satisfactory service for some specific use, while one from another deposit - although appearing to be exactly the same - may be unsatisfactory. Thus problems in amphibole asbestos procurement are much more difficult and complex than the procurement of mineral products like iron or copper, which, when pure, have constant properties irrespective of the part of the world in which they may originate.

PHYSICAL PROPERTIES

The outstanding physical characteristic of asbestos is its fibrous structure. However there are two significant differences between asbestos and the fibrous products of animal or vegetable origin. Non-flammability is the most striking difference, but perhaps of equal importance is the difference in structure. Each filament of cotton or wool is of measurable and fairly constant diameter and is indivisible into finer sizes. On the other hand, fibres of chrysotile asbestos can be divided and subdivided until a fineness is attained that is limited only by the delicacy of the machinery used and the skill of manipulation. The ultimate fibre size is presumably the size of the crystal lattice of asbestos.

With respect to use,fibre size is important and the size will depend upon the degree of fiberisation attained in milling. Fibres obtained from different deposits vary in the ease with which they may be fiberised. Thus two samples of asbestos given exactly the same mill treatment may furnish products differing considerably in fibre diameter because on of them separates or fiberises more easily than the other. Such differences may have great practical importance because an asbestos that is difficult to fiberise may require such intense milling to reduce the fibres to desirable fineness that they may be broken into undesirable short lengths. Ease or difficulty of fiberisation is therefore an important property of asbestos.

The use to which asbestos may be applied depends largely on fibre length. The longest fibres command the highest prices and the shorter grades progressively lower prices. Apparently, therefore, primary attention must be given to milling processes that will separate the fibres from the parent rock and will fiberise them adequately with a minimum of fibre breakage.

The heat resistance of asbestos is important in many applications. Some users of asbestos confuse non-flammability with refractoriness. Nevertheless, many substances that will not burn will melt or decompose at relatively low temperatures. The fireproof property of asbestos is one of its chief assets; but, although unburnable it will decompose and lose its essential physical properties at moderately high temperatures.

Anthophyllite and tremolite are highly resistant to chemicals. It is claimed that crocidolite resists chemicals and sea water very well. Chrysotile is affected more readily by acids and other chemicals than are the amphibole varieties.

GEOLOGY OF ASBESTOS

Chrysotile, a serpentine mineral, is principally associated with altered ultrabasic rocks, e.g. dunites, pyroxenites and peridotites. The sequence of events which leads to the formation of chrysotile asbestos fibre veins is not known with certainty, although various possibilities have been discussed (e.g. see Riodon, 1955). The fibre may form at the same time as the matrix serpentine rock from the same parent material, or it may form later. In the latter case the fibres may replace existing matrix material, perhaps starting at a fissure and growing inwards or they may grown in pre-existing fissures from solutions which permeate the rock. Certain serpentinites are found in metamorphosed limestones or dolomites. For example, where serpentinised dolomitic rocks are associated with dolerite sills, veins of chrysotile may develop parallel to the contact. The siliceous dolomite is transformed to forsterite which is subsequently serpentinised.

Anthophyllite with an asbestiform habit develops during the regional metamorphism of ultrabasic rocks. Here it is usually associated with talc. Tremolite occurs mainly in metamorphosed carbonate rocks. Anthophyllite and tremolite commonly occur as slip fibre along foliation or shears, although veins of cross-fibre tremolite may occur in serpentine.

Crocidolite and amosite, the most important of the amphibole asbestos minerals, are commonly found as interbedded cross-fibre veins in ferruginous slate or quartzite associated with dolomite.

ESSENTIAL REQUIREMENTS OF NEW DEPOSITS

Exploration for asbestos is governed largely by the nature of the deposits. Most of the commercial asbestos deposits in the world are associated with massive serpentine, peridotite and similar rocks. The other environment in which asbestos may be found is that of metamorphosed carbonate rocks.

Bowles (1955, p.70) lists the following conditions that must be satisfied before successful operation of a new deposit can be reasonably assured.

1. Quality of fibre, especially strength and flexibility.
2. Length of fibre. Spinning grade 3/8 inch or more in length is highly desirable even if only in small amounts relative to shorter grades.
3. Proportion of fibre in the rock. This should not be less than 4½ to 5 per cent of the rock milled - unless the fibre is of exceptionally high grade.
4. Extent of reserves. As determined by core drilling, reserves should be enough to support the investment needed, and yield an adequate return for at certain period of time.

5. Economic factors. These include mining costs, power and water supply, transportation facilities and availability of labour.

USES

Two classes of asbestos are recognised on the basis of use; spinning and non spinning fibre. Each has scores of applications which can only be briefly indicated. A more detailed discussion is given by Bowles (1955).

Spinning fibre comprises the longer grades of chrysotile and crocidolite. It is made into asbestos thread, yarn, tape and cloth. A few of the products in which these are used, are woven brake linings and clutch facings, fireproof theatre curtains and scenery, gaskets, safety clothing, blankets and draperies, chemical filters and heat-resistant conveyor belts. Yarn is twisted and braided to form various types of packing.

Non-spinning fibre consists of the shorter grades of chrysotile and crocidolite and both the long and short grades of anthopyllite, tremolite and amosite. Most of it is used in compressed, molded or cast products in which the asbestos fibres make up a felted mass in a binder. Roofing shingles, mill-board and corrugated panneling are made up from asbestos and portland cement; a popular modern floor tile consists of about 35 percent asbestos in asphalt or plastic; insulating material is made from a mixture of magnesia and asbestos (amosite is favoured for this application). Other uses include asbestos - cement pipe, moulded (rather than woven) brake linings and clutch facings and paper for a variety of uses.

MINING, MILLING, GRADING, CLASSIFICATION AND PRICES

Asbestos deposits throughout the world differ widely in character; and, as the mining method must be adapted to the prevailing conditions, a great variety of methods is followed. Open-pit quarry methods, underground mining, shrinkage stoping, block caving and other methods are represented.

Once mined, asbestos fibres can be divided into two main groups - crudes and mill fibres. The term "crude" is applied to fibre of spinning grade, measuring three-eighths inch or longer, which is hand cobbed and not passed through a mill. Mill fibres are obtained by crushing and beating the fibre-bearing rock until the asbestos is freed and then removing the fibre from the rock by screening and air separation. The milling process is designed such that fiberisation (fibre opening) may be accomplished with minimum breakage of fibres.

The standard grades used in Canada and U.S.A. are as follows:

Group 1. (Crude No.1) - Asbestos fibre greater than 3/4 inch in length. It should be silky and have enough tensile strength to permit its use for making asbestos yarn, tape, cloth, carded fibre and other textiles.

Group 2. (Crude No. 2) — Generally referred to as fibre that has not been milled and that has a length of 3/8 to 3/4 inch. It must have good tensile strength. Unsorted and sundry crudes are included with Group 2.

Group 3. Milled spinning or textile fibre.

Group 4. Known as shingle fibre; includes fibre suitable for the manufacture of asbestos - cement products such as pipe, shingles, compressed sheet packing and high temperature molded pipe covering.
These fibres are also used with portland cement for manufacturing asbestos corrugated and flat interior and exterior sheets, wallboard, switchboard, panels and other products.

Group 5. Known as paper stock. They are chiefly for the manufacture of asbestos paper and millboard and sometimes are mixed with higher grades for the manufacture of asbestos-cement shingles.

Group 6. Known as stucco or plaster fibre. This is also used in the manufacture of asbestos-cement products.

Group 7. These are known as refuse and shorts and are used in manufacturing asbestos boiler and roofing cements, roofing paints asphalt floor tiles and occasionally for making millboard.

Group 8 and 9. Known as sand and gravel, and stone. They contain a preponderan of rock and sand. These materials are used chiefly in manufacturing asbestos flooring and wall tiles and similar products.

Further subdivision of the above groups may be based on tests on what is known as the Quebec Standard Testing Machine.

As there are many grades and types of asbestos fibre, price trends are difficult to evaluate. Published prices for Quebec fibre are shown in the following table:

Prices of Quebec Chrysotile Asbestos

(Australian dollars per short ton f.o.b.)

Grade (Group)	Jan 1st 1969	Jan 1st 1970
1 (crude)	1,237	1,275
2 (crude)	669	690
3	405	416
4	234	245
5	141	145
6	92	94
7	51	53
8	23	23
9	-	-

The average value of asbestos exported from Australia in 1969 is given by Kalix (1970) as $205 per short ton f.o.b.

PRODUCTION

World Production

The annual rate of growth in world asbestos consumption is 5 per cent. Approximately 90 per cent of total output comes from Canada, the U.S.S.R. and Southern Africa. Most sources of information give Russia's production as equal to or higher than Canada's; but one source (Statistical Summary of the Mineral Industry, 1970) suggests that Russia is still second to Canada. The following table is taken from Piuze (1971).

Estimated World Production of Asbestos (Tons)

	1969	1970
U.S.S.R.	2,000,000	2,100,000
Canada	1,596,450	1,660,000
Republic of South Africa	285,000	310,000
Rhodesia	150,000	150,000
United States	127,000	130,000
Other countreis	390,000	430,000
Total	4,548,450	4,780,000

The 1970 world asbestos is valued at approximately $(AUST.) 540 million.

Australian Production

Production figures for asbestos are available to 1969 (Kalix, 1970) and are presented in the following table of salient statistics.

Asbestos: Australia: Salient Statistics (Tons)

	1966	1967	1968	1969
Production	13,468	600	896	825
Exports	4,644	2,524	804	482
Imports	55,152	52,584	66,741	59,068
Apparent consumption	63,976	50,660	66,833	59,411

Production of asbestos in 1969 was 825 tons of which 795 tons were produced by Asbestos Mines Pty. Ltd. at Baryulgil in the /Copmanhurst mining division, New South Wales, and 30 tons were produced from old dumps at Lionel in the Pilbara district, Western Australia. Although production of asbestos in Australia is at a low level, a chrysotile asbestos deposit at Woodsreef near Barraba, New South Wales, is being developed by White Asbestos (Mining) Pty. Ltd. a subsidiary of Pacific Asbestos Ltd. of Canada. Reported reserves are given as 27.0 million tons. The company plans to commence production by late 1971 and mine 1.5 million tons of ore per year yielding about 70,000 tons of fibre.

The relatively high production figure for 1966 marks the end of production of crocidolite from Wittenoom Gorge and Colonial Gorge in the Hammersley Ranges, Western Australia (Miles, 1942; Foxall, 1942).

Production Of Asbestos In South Australia

Chrysotile and amphibole asbestos have been produced in South Australia. Most of the output has been crocidolite, the bulk coming from the Truro district. Total production up to the end of 1970 is 3164 short tons having a total value of $61,740.

Numerous small crocidolite deposits have been described from the Robertstown district, 70 miles north-east of Adelaide. (King, 1956; Johns 1960). These deposits take the form of veins in fractured and highly metasomatised zones in dolomitic marble and they are confined to a stratigraphic horizon containing abundant magnesite. The fibre consists of a mixture of glaucophane and crocidolite. Cross fibre veins are the most common but the quality is considered generally poor and the higher grade material so far produced came mostly from slip-fibre veinlets throughout a shear zone in sandstone, tuff and tuffaceous and dolomitic conglomerate. Reserves in 1948 were estimated as 5750 tons of rock containing 10 percent asbestos. Other deposits are recorded at Arkaba 10 miles north-north-east of Hawker (Crawford, 1959), Shaggy Ridge,25 miles east-north-east of Hawker (Crawford, 1958), Umberatana, 70 miles by road north-east of Copley (Armstrong, 1938) and Mount Lyndhurst railway station on the Alice Springs line (Johns, 1956).

Several crocidolite deposits similar to those near Robertstown occur near Truro, 30 miles south of Robertstown (King, 1957). Some have yielded a small amount of fibre. Tremolite, which forms fibrous aggregates in talcose marble, has been won from the Truro deposits, and from deposits in the surrounding district, including Kapunda, Keyneton, Kenton Valley (Ward, 1937a), Lyndoch (Ward, 1937b) and Nuriootpa.

Asbestos deposits are situated a few miles north-west of Cowell on the eastern side of Eyre Peninsula. (Miles, 1952; Russel, 1965).Chrysotile forms cross-fibre veins up to 1½ inches wide, along narrow steeply-dipping shear zones in highly altered serpentinised dolomites and talcose marble. Numerous similar deposits occur several miles to the south of Cowell (Armstrong, 1943).

Crocidolite deposits are known near Oodla Wirra, 20 miles east-north-east of Peterborough; in the Hundred of Coomooroo (Cornelius, 1941, Nixon, 1958).

SUMMARY AND CONCLUSIONS

"Asbestos" is a name applied to a variety of naturally fibrous minerals. Because it is fibrous and at the same time will not burn and has other advantageous properties as well, asbestos has specialised uses for which no adequate substitutes are yet available. Asbestos furnishes a major raw material for a great variety of essential products involving many lines of industrial activity.

Asbestos generally occurs in irregular veins scattered throughout rock masses. The fibre-bearing rock may be mined in openpit or underground workings. The fibres are separated from the rock and sorted into groups, according to length, in complex mills. The longer fibres are used in making unburnable textiles and the shorter fibres are used in asbestos-cement building materials, in heat insulating products and for a multitude of other applications.

Production of asbestos in Australia is very low compared to consumption by manufacturers of asbestos-bearing articles. As a result imports are very high. However a chrysotile asbestos deposit at Woodsreef near Barraba, New South Wales is being developed and production is expected to commence late in 1971.

Total production of asbestos in South Australia up to the end of 1970 is 3164 short tons having a total value of $61,740. Chrysotile occurs in irregular veins scattered throughout serpentinised dolomite near Cowell, and crocidolite and some tremolite as fibrous masses in metamorphosed carbonate rocks in the Robertstown district and in several other areas.

Because of the size of asbestos imports into Australia, and the essential and valuable qualities of the material, it is recommended that all deposits known in the State be reviewed in terms of geological setting, and those deposits previously regarded as uneconomic should be re-examined in the light of present day specifications.

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