Mapping of naturally occurring asbestos in NSW

Known and potential for occurrence

Serpentinised ultramafic rock likely containing few asbestiform fibres. (left)

Asbestos-bearing rock. (right)

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Mapping of Naturally Occurring Asbestos in NSW – Known and Potential for Occurrence

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Acknowledgments

Cover image: Derelict Mines Program, Woodsreef Asbestos Mine, Northern NSW

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Note - The areas shown on maps with this report were based on the published geological mapping which was completed at different scales and may not be recent.

Foreword

The purpose of this report is to accompany state-wide mapping of naturally occurring asbestos (NOA) in NSW. A review was completed by the Geological Survey of NSW, part of the Division of Resources and Energy in NSW Trade & Investment in order to provide maps and a geographic information system (GIS) product for the Heads of Asbestos Coordination Authorities (HACA).

The Geological Survey of NSW has identified:

1. sites where asbestos is known, and
2. identified areas (previously termed 'tracts') based on existing geological mapping where the potential for naturally occurring asbestos in the near surface environment has been identified.

Most of NSW, has very little or no potential for NOA. Areas where any potential has been identified cover about 0.83% of NSW and these have been determined on a high, medium and low potential basis.

Relevant petrological data is also included with the report. In some cases mineral species have been identified from petrology but the systematic mapping of mineral species that occur as NOA was beyond the scope of this study.

Previous mapping had been completed by Downes (2010). This mapping identified many areas with potential for NOA but was only a first pass assessment at a statewide scale, which was not reproducible as a GIS product.

Contents

Introduction

The NSW Government supports a whole-of-government approach to managing asbestos through a statewide asbestos plan. The plan establishes the safe management of asbestos to reduce the incidence of asbestos-related diseases in NSW.

NOA includes silicate minerals of the serpentine and amphibole group that are asbestiform or fine, fibrous and separable with high heat and chemical resistance. It also includes other fine fibrous mineral that are not strictly asbestiform. NOA is generally found when building roads, working on civil construction projects and undertaking excavation activities.

It can also be disturbed in rocks and soil during farming, forestry work, mining, quarrying or urban development. An assessment of the known and likely occurrence of NOA was necessary to inform those involved in such activities and to inform land use planning more generally.

This report, accompanying maps, and GIS file geodatabase/shapefiles have been prepared by the Geological Survey of NSW, part of the Division of Resources and Energy in NSW Trade & Investment. The NOA report was prepared for the Heads of Asbestos Coordination Authorities (HACA) and improves on previous mapping included in the consultation draft of the statewide asbestos plan (see figure 6 of the statewide plan). The mineral resource mapping program conforms broadly to the regional assessment programs which were recently completed by the Geological Survey of NSW to assist all councils in land use planning.

Role of Trade & Investment

NSW Trade & Investment is the principal government agency responsible for the administration of the state's primary industries – agriculture, fisheries, forestry and mineral resources. 'Minerals' and 'petroleum' are defined under the *Mining Act 1992* and the *Petroleum (Onshore) Act 1991* respectively. NSW Trade & Investment maintains databases of mineral and construction material that provide a basis for informing land use planning and encourages mineral exploration. The Geological Survey of NSW also undertakes regional scale mapping and mineral deposit projects that provide a framework for sustainable development of mineral resources and to inform land use planning more generally. The identification of known NOA sites and mapping of rocks likely to contain NOA was completed based on these datasets and geological knowledge of the Geological Survey of NSW.

Background – NOA in NSW

Although asbestos is a commercial term, all asbestos is of natural origin. The term 'naturally occurring asbestos' (NOA) seeks to differentiate natural sources of fibre from commercial or industrial sources. It refers to fine fibrous minerals of the serpentine and amphibole groups that occur in rocks or soil that may be disturbed by human activities or weathering processes. NOA also includes other fine fibrous minerals that are not strictly asbestiform.

The National Occupational Health and Safety Commission (NOHSC) cites fibres used for asbestos monitoring in Australia fibre as being less than 3 µm in width, more than 5 µm in length and with a length to width ratio of more than 3 to 1. Under this scheme, cleavage, mineral fragments fine acicular (needle like) crystals of the serpentine and amphibole groups such as antigorite and lizardite can also be as classed asbestos. Table 1 summarises the main asbestos minerals known in NSW.

Table 1 Main asbestos minerals

Mineral	Formula	Characteristics	Occurrences
*Actinolite	$Ca_2(Mg,Fe_{2+})_5Si_8O_{22}(OH)_2$	Long-bladed crystals, fibrous or thin columnar aggregates	Contact and regional metamorphosed dolomite, magnesian limestone, low-grade ultrabasic rocks
Amosite	$(Mg,Fe,Mn)_7[Si_8O_{22}](OH)_2$	Variable fibre length, and a coarse texture	Contact and regional metamorphosed iron-rich rocks
?Anthophyllite	$(Mg,Fe_{2+})_7Si_8O_{22}(OH)_2$	Massive fibrous or lamellar; short harsh poorly flexible fibres	Metamorphosed schists and gneisses or metasomatic rocks
*Chrysotile	$Mg_3Si_2O_5(OH)_4$	Fibrous, commonly silky	Veins and veinlet and stockworks in serpentinite
Crocidolite	$Na_{2+3}Fe_3Fe_2Si_8O_{22}(OH)_2$	Short to long flexible fibres	In granite, syenite, rhyolite, trachyte, banded ironstone, regionally metamorphosed schists
*Tremolite	$Ca_2(Mg,Fe_{2+})_5Si_9O_{22}(OH)_2$	Long-bladed crystals and short and stout crystals, fibrous or thin columnar aggregates	Contact and regional metamorphosed dolomite, magnesian limestone, low-grade ultrabasic rocks

Source: Modified after MacNevin (1970)
Note: Crocidolite, 'blue asbestos', is the highly fibrous variety of riebekite.
*Asbestiform occurrences identified in this study to occur in NSW;
?unconfirmed in NSW

The scientific aspects of NOA in eastern Australia with respect to health and their potential implications for government authorities have been discussed by Hendrickx (2009). Inhalation of Asbestos is listed as a category 1 carcinogen by world health authorities (IARC 1987). If NOA is not disturbed and fibres are not released into the air, then it is not a health risk. The main human exposures to NOA are related to the disturbance of fibres present in ultramafic rocks. The health effects of agricultural disturbance of NOA are relatively poorly documented (Hendrickx 2009); but fibres have been found in the lungs of livestock in areas where fibres persist in soils that have developed over tremolite asbestos-bearing rocks (McConnochie et al. 1987).

The geological occurrence of asbestos

Although asbestos and asbestiform minerals may form in a wide range of rock types, large accumulations of such minerals are associated with ultramafic rocks. Ultramafic (or ultrabasic) rocks are typically dark rocks rich in magnesium and iron with relatively low silica and potassium and composed mostly of minerals such as olivine and pyroxene. Mafic rocks may also host such minerals if certain metamorphic conditions have been met. Many occurrences are associated with ultramafic rocks of the peridotite association (O'Hanley 1986 — peridotite are a series of mafic to ultramafic rocks derived from Earth's mantle) that contain minerals such as olivine and pyroxene, which have been serpentinised. Serpentinisation is a form of metamorphism whereby minerals in the rock react to form minerals such as serpentine ($Mg_3[Si_2O_5](OH)_4$) along with tremolite, lizardite, antigorite and chrysotile in the presence of mesothermal hydrothermal fluids. The processes related to the formation of such minerals are associated with intermediate grades of metamorphism (Deer et al. 1992).

The detailed processes that form minerals classed as asbestos and that are asbestisform are only partly understood and vary between the mineral species (See Deer et al. 1965; 1992; MacNevin; 1970). In general, asbestos is commonly produced by shearing stresses late during the deformation of ultramafic rocks of the peridotite association. Smaller masses of peridotite, once serpentinised, weaken, develop a foliation, but larger economic deposits commonly have both slip fibre and cross-fibre accumulation with the latter representing a major proportion of the asbestos. Larger peridotite masses will be stronger, less serpentinised and will develop cross-

fibre veins (Glen & Butt 1981; O'Hanley 1986). Key processes in the formation of chrysotile, the most abundant asbestiform mineral in NSW, include fissure-filling and partly from wall rock replacement in the presence of mesothermal hydrothermal fluids (Riordan 1954). Amphibole asbestos, including tremolite, actinolite and anthophyllite is associated with the serpentinised ultramafic and mafic igneous rocks, metamorphosed mafic and ultramafic intrusive and volcanic rocks along with some association with carbonate lithologies (Virta 2005; Hendrickx 2009).

Naturally occurring asbestos in NSW

Major deposits in NSW include slip fibre and cross-fibre accumulations at Woodsreef and Baryulgil Chrysotile Asbestos deposits (Appendix IA). Tremolite is known to be associated with Ordovician Byng Volcanics, with the Ordovician to Early Silurian Rockley Volcanics, the Fifield Alaskan ultramafic complexes west of Dubbo and is also associated with amphibolites in the Curnamona Geological region around Broken Hill. Anthophyllite has been noted at a few locations but no significant accumulations of this mineral are known in NSW.

Introduction to potential areas mapping

Aim

The aim of the mapping is to identify areas according to the potential for NOA in rocks and sediments that are less than about 10 metres below the natural surface. These areas may be subject to ground-disturbing activities such as road building, agriculture, forestry, mining quarrying and urban development.

Known NOA-bearing sites (point data) and potential NOA-bearing areas (polygon data) are identified. The sites include:

i) known locations where asbestos has been identified

ii) probable sites where asbestos indicator minerals and/or textures have been identified that warrant further investigation. Where available, the known quantity of asbestos in these deposits stated.

Area or "tract" mapping completed in this assessment aimed to predict areas (or polygons) with the potential for NOA to occur, on a high, medium and low basis.

Data sources

Identification of NOA sites and areas is based mainly on NSW Trade & Investments' mineral occurrence database MetIndEx, which is maintained and developed by the Geological Survey of NSW. This database provides a basis for informing land use planning and encouraging potential mineral exploration in the state. Other important data sources include:

1) published geological mapping by the Geological Survey of NSW.
2) technical reports of the Geological Survey of NSW and Division of Resources & Energy — including technical rReports, scientific papers and resource audits to aid in land use planning.
3) environmental impact statements and environmental assessments for quarrying and mining operations.
4) data held by local and state government authorities.
5) mineral exploration reports; including those archived in the DIGS database.
6) reports for local councils by quarry or mine operators and geological/geotechnical consultants.
7) scientific literature — including theses.

Mineral occurrences

Mineral occurrences are defined as locations where minerals of economical importance have been identified. Of the approximate 32,000 occurrences in the database, 30 listed asbestos as a major commodity and two as a minor commodity.

Appendix 1A of this report includes areas identified with known substantial asbestos deposits and includes additional sites where asbestos minerals have been identified in this assessment. These sites have been defined using GIS with reference to geological boundaries or, where appropriate, cadastral boundaries to facilitate definition on the ground with cross checking as necessary against the available literature to facilitate definition on the ground.

Note: NOA could also be present considerable distances from the identified occurrences.

Geological tracts

Tract maps have been used in this study to highlight areas that have potential for certain commodities. The use of tracts is adopted from numerous regional assessment projects undertaken by the Geological Survey of NSW and are defined as geological areas (tracts) with the potential to contain particular types of economic deposits (e.g. lead, copper, limestone, asbestos — McEvilly et al. 2003). Areas identified in this report were based on existing lithological polygons (enclosed areas on a map that denote a particular rock type).

Resource assessment procedures - methodology

Stage 1 mapping — first pass assessment

Site identification — mineral occurrences

NSW Trade & Investment maintains databases of mineral and construction material that helpinform land use planning, and informs potential mineral exploration in the state. Point data was initially extracted from The MetIndEx database which was the primary repository of mineral deposits in NSW. Initially, 65 sites were identified as from the MetIndEx database where asbestos-type minerals have been recorded (mineral terms included actinolite, amosite, anthophyllite, chrysotile, crocidolite, picrolite and tremolite). Two of these (actinolite and tremolite) are common rock forming minerals and would be commonly found as an integral part of many metamorphosed ultramafic and basaltic rocks (such as serpentinites and metamorphosed basalts) which occur in many parts of NSW. Textural terms that are associated with asbestos include asbestiform, fibre fibrous, matted, sheared, serpentine and serpentinised. Research of the Division's literature (mostly held in DIGS) and the general scientific literature, identified additional NOA sites with numerous deposits removed as asbestiform minerals could not be confirmed. As far as possible, occurrences identified at greater than about 10 metres below surface such as from drilling and underground workings were excluded from the dataset.

Mapping of areas with potential for NOA (based on geological polygons from the state-wide 1:1000 000 geological layer) were identified by the use of spatial queries on lithological fields. These queries included key terms that are associated with the geological occurrence of NOA which were used to identify a subset of polygons with such potential. That subset of polygons was then reduced based on geological understanding of the occurrence of NOA in general and in eastern Australia in particular, to produce a refined set of polygons that are identified as having potential according to a low-medium and high basis. During this process, those identified polygons identified as having potential were exported as shapefiles and organised in logical directories for later use. Draft state-wide NOA potential maps (Figure 1) were thus produced with additional detail to those by Hendrickx (2009) and by Downes (2010).

Stage 2 — Detailed assessment of potential NOA areas

1:250 000 scale assessment

Following the 1:000 000 scale assessment, based on understanding of the geological environments and processes that favour the occurrence of asbestos (see also Hendrickx 2009) polygons were again investigated to a limited extent based on 1:250 000 scale geological datasets using GIS according to similar methodologies as described above. Assessment was based on detailed information from GSNSW maps and their attendant explanatory notes, the scientific literature and theses. Although the mapping was based on the existing polygons, modifications to a few polygons were made to reduce edge match conflicts between different map sheet areas.

Factors used in the assessment of tracts included the presence of known occurrence of asbestiform minerals, the chemistry of the host rocks, the lithostratigraphic setting of the host rocks, the degree of hydrothermal alteration, regional metamorphism and the structural history of the area. In NSW, older ultramafic and mafic rocks generally have greater potential for NOA than younger such rocks. Assessment was based on mapping of areas known and/or likely to contain asbestos on a high, medium and low potential basis (see definitions — Appendix II).

1:25 000 scale assessment

The geological province that surrounds Broken Hill, Curnamona Craton, has mostly been geologically mapped at 1:25 000 scale. Given the huge quantity of data available only a preliminary assessment was completed. However, the area is characterised by low population density and good quality aggregate is readily available from many sources unlikely to host NOA.In this region, NOA is mainly restricted to very small areas associated with ultramafic rocks of probable Early Palaeozoic age (G. Burton pers. comm. 2013 — see discussion).

Petrological observations

Petrological observations by government staff stored in the PETROCKS database held by GSNSW proved useful in this assessment. The data reflect sites where chrysotile and fibrous tremolite have been identified in thin section (Appendix III). Preliminary checking of these sites was completed in this assessment using GIS against mapped geology, MetIndex and data stored in DIGS.

Mineral occurrences

The MetIndex database has six size categories which range from very large mines where substantial quantities of economic ore have been produced, to occurrences where such minerals have been identified but the size of the occurrences has not been confirmed. Appendix IA lists 50 sites where asbestos minerals have been identified as a commodity based on this assessment.

An example of a large or very large deposit would be where mining or quarrying has been undertaken to recover an economically important mineral or material commodity. The largest deposit is the Woodsreef Asbestos deposit which is estimated to be 24.4 Million tonnes and produced over 5.5 million tonnes of chrysotile asbestos. The two major mines, Woodsreef and Baryulgil asbestos quarry hold mainly serpentinised harzburgite.

An example of a small occurrence is the Irene Asbestos Occurrence which is a small occurrence reflecting the general area of four partly filled in scrapes where asbestos minerals were identified by government geologists during field work.

It should be noted that the smaller size estimates are general in nature and were originally based on 1967 commodity prices which have changed substantially generally and for asbestos minerals in particular. They therefore provide a general but useful guide to the known size of the occurrence based on the available geological data.

Appendix 1 includes additional mineral occurrences where serpentinite was cited as a host rock. As serpentinite is a very common host rock to NOA, these occurrences represent potential sites for NOA with further investigation recommended.

Areas with the potential to host naturally occurring asbestos

Based on this assessment, 6 694 479 626 km2 or about 0.83% of NSW is affected by rocks with significant potential to host naturally occurring asbestos. The largest areas are assessed as low potential, comprising 0.56% of NSW, with 0.16% medium potential and 0.11% high potential.

The main NOA areas with potential impacts from g-disturbing activities based on this assessment are:

1) The major serpentinite belts including the Great Serpentinite Belt in the New England region along with the Coolac Serpentinite in southwest NSW and serpentinites associated with the Gilmore Suture in south central NSW.
2) Ordovician to Early Silurian rocks east of Orange.
3) Ultramafic complexes in central west NSW including areas near Fifield southwest of Dubbo.

Many areas close to these Sediments, such as the Great Australian basin and most sedimentary rocks such as occur around Greater Sydney and many parts of NSW have no potential for NOA.

Discussion and recommendations

This assessment has generated a GIS product that identifies areas with the potential for NOA. The mapping of low and medium potential areas identifies additional areas compared with Hendrickx (2009 — 0.2% of eastern Australia) who focused on the main rock types with highest potential. The areas identified overall are considerably smaller compared with first pass mapping by Downes (2010) the greatest reduction is in areas of low potential. Many “low” potential areas have been included to account for geological uncertainty.

A list of local government areas that have been identified in the GIS product with areas of high, medium or low potential for NOA is provided at Appendix 2.

Several key features of the various mineral potential categories are discussed.

Areas of high potential for naturally occurring asbestos

Many of the areas attributed high potential include major serpentinite belts which typically have poor soils and steep topography. Key potential sources of disturbance of NOA in many such areas include road building related to forestry. High potential areas that have mixed land use may have a wide range of potential modes of disturbance.

Affected local government areas (LGAs) include Blayney, Cabonne, Clarence Valley, Cootamundra, Greater Taree, Orange City, Port Macquarie-Hastings, Harden, Tamworth, Tumut and Weddin. The unincorporated Far West region is also an area of high potential for NOA.

Areas of medium potential for naturally occurring asbestos

Many medium potential areas include theoretically less favourable rock types such as sandstones which could include ultramafic material which is high potential. They also include areas of poor outcrop where ultramafic rocks are physically resistant and subtly emergent. In such cases material with medium (and possibly high) potential to contain NOA could represent sources of construction aggregate and therefore be subject to quarrying.

In general, areas assessed with medium potential occur near areas attributed as high potential. The main exceptions are areas over parts of the Rockley and Sofala Volcanics in the Bathurst

Regional and Mid-Western Regional LGAs. There are also some areas with poor outcropping rocks in flat country in Bogan and Lachlan LGAs which could represent sources of aggregate of marginal quality and therefore be subject to quarrying.

Areas of low potential for naturally occurring asbestos

Areas attributed as low potential for NOA have been determined based on the mineralogy and geological history of the host rocks.

Large areas of the Wellington, Walcha and Cowra LGAs have little or no known NOA but nonetheless could have potential in small areas. Some areas attributed with low potential have been included to account for geological uncertainty where the geology is broadly favourable for NOA to occur.

Low potential areas include thin sediments that overlie parts of the main serpentinite belts along with the Tout and Owendale Igneous complexes west of Parkes within the Bogan, Lachlan, and Young LGAs.

Research as part of this assessment has confirmed very few occurrences of asbestiform minerals or asbestos in many areas identified as LOW potential by Downes (2010). This was in large part responsible for the significant reduction in these areas. Most significant occurrences of NOA are held in rocks that have been affected by significant regional metamorphism. This largely excludes many areas of NSW including the major sedimentary basins such as the Sydney and Clarence – Morton Basin and mafic rocks younger than about Permian in age such as Tertiary Basalts. Although NOA does occur outside the areas attributed with potential, any unidentified occurrences would most likely be small.

Larger quarries

Although not the focus of this study, the excavation of larger quarries to depths greater than about 10 metres in or near areas with potential could disturb NOA - particularly along major geological boundaries where they are obscured by shallow sediments. By contrast, the East Guyong hard rock quarry southeast of Orange is an example of a hard rock deposit that encountered tremolite asbestos in underlying Ordovician rocks to Tertiary Basalt, which is the main source of aggregate.

Future work

Systematic mapping for the occurrence of and potential for mineral species was beyond the scope of this mapping. However, there are many avenues for further work regarding the geological occurrence of NOA. The most common asbestiform mineral in NSW is chrysotile which occurs in many serpentinites in NSW. Fibrous tremolite is found in many areas and is particularly common in Ordovician to Early Silurian rocks east of Orange and in Serpentinites around Coolac. Tremolite is relatively resistant to weathering in many cases compared with other forms of NOA including chrysotile (MacNevin 1970). The health effects of agricultural disturbance of NOA, including tremolite are poorly documented in Australia (Henrickx 2009). Further work including mineralogical studies to better constrain the potential for agricultural and other disturbance of NOA in such areas may be warranted. Example with potential tremolite asbestos rocks and soil include:

1) the Coolac Serpentinite

2) Ordovician Volcanic rocks east of Orange

3) Devonian mafic rocks west of Bega and;

4) possibly, sediments near the Fifield, Tout and Owendale igneous complexes in Central West NSW.

Systematic mapping of the occurrence of mineral species would be a key avenue for further work.

Predictive mapping of the various mineral species would require a major research effort.

The Broken Hill region

Proterozoic rocks of the Curnamona Craton around the Broken Hill region mostly preserve amphibolite-facies and higher metamorphism (Stüwe & Ehlers 1997). Such metamorphic grades are generally too high for most forms of NOA. NOA identified in this study is restricted to small ultramafic intrusions of late Neoproterozoic to Cambrian age that post-date peak metamorphism which occurred around 1590–1595 Ma (Forbes et al 2007; GA record 2007/06).

In addition, Hendrickx (2008; 2009) noted NOA associated with carbonate rocks in the Gawler Craton, South Australia. These rocks have close analogues in the Broken Hill Region of NSW (GA Record 2007/06), but although fibrous textures have been recorded from petrology, no NOA has been confirmed. Given the complexity of the geology of and the very detailed geological information available, further assessment of the Curnamona Craton NOA may be warranted.

Conclusion

Most of NSW, has very little or no potential to host naturally occurring asbestos. Areas of identified potential cover about 0.83% of NSW which have been mapped on a high, medium and low potential basis. Ground disturbing activities, particularly in areas assessed as having high and medium potential (about 0.27% of NSW) should be managed to prevent exposure to NOA.

Reducing possible exposure to NOA is highlighted in a series of factsheets issued with this report and mapping.

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Appendix I

Mineral occurrences that include naturally occurring asbestos

NAME(S): 14 Mile asbestos prospect

Size: occurrence

LOCATION: 462505 mE, 6760187 mN

Location method: 25K Topo Map

MINING HISTORY

Workings: Small underground mine

Rock type — serpentinite - Gordonbrook Serpentinite Belt

DEPOSIT CHARACTER

Ore: chrysotile

Gangue: unkown

Resources: unkown

Production: 0t produced

Operating Status — Not operating

REMARKS: Extent unknown, outcrops rare. Exposed in adit, over 18m length Fibre occurs in slightly brecciated serpentinite. Fibre is exposed in first 18 m of a 27 m adit, which trends 174 deg (m). Fibre count over 13 m: 10 @ 1.5mm, 3 @ 3mm, 5 @ 4.5mm, 8 @ 6mm, 5 @ 7.5mm, 1 @ 10mm, 2 @ 11mm, 1 @ 12.5mm (lengths converted from imperial). A 9m deep shaft is located 140m @ 140 deg (m) From adit (GS1966/188).

NAME(S): Argalong Quarry

Size - Medium -unprocessed construction materials

LOCATION: 622935 mE, 6093248 mN

Location method: Henrickx 2009 – confirmed with air photo location.

MINING HISTORY

Workings: Four benches

Rock type — serpentinite – Coolac Serpentinite

DEPOSIT CHARACTER

Ore: unprocessed construction materials

Gangue: Asbestos

Resources: unknown

Production: unknown.

Operating Status — Not operating

REMARKS: Four benches Argalong Pit ceased operation in 2005 due to asbestos in the rock being quarried (Tumut Shire Council correspondence)

REFERENCES:Henrickx 2009

NAME(S): Asbestos Hill Mine

Size: small

LOCATION: 599263 mE, 6121983 mN

Location method: 25K Topo Map

Locality: Approximate location

MINING HISTORY

Workings: underground mine

Rock Type: Hostrock(s): serpentinite - Gundagai Serpentinite

DEPOSIT CHARACTER

Ore: asbestos, tremolite, (gold)

Gangue: calcite, siderite

Resources: unknown

Production: unknown produced for 72.4t asbestos

Operating Status – Not operating

SUMMARY: Asbestos vein strikes NE. Gold occurs as very fine grains coating hornblende and calcite crystals. Talc and calcite veins in footwall of asbestos vein become gold-bearing when they intersect a fissure or lode.

REMARKS: The asbestos is the tremolite variety (references in Degeling, 1982). Murray and Bowditch also prospected calcite veins in serpentinite 0.8km to the SE, on portions 14, 17 (Parish North Gundagai, County Clarendon).

REFERENCES: Geological Survey of New South Wales(1977), Basden H.(1990), GS1961/077, Winward K.(1972), Degeling P.R.(1982), Department of Mines New South Wales(1886), GS1955/050, GS1967/044, Parish Card.

NAME(S): Baryulgil asbestos deposit (Hardies asbestos quarry)

Size – Medium

LOCATION: 460805 mE, 6766287 mN

Location method: 25K Topo Map

MINING HISTORY

Workings: pit(s)

Rock type: Hostrock(s): serpentinite - Gordonbrook Serpentinite Belt

DEPOSIT CHARACTER

Ore: chrysotile

Gangue: unknown

Production: 19432t produced for 19400t asbestos

Operating Status – unknown

REMARKS: Area of fibre development exceeds 210m x 75m (drilled area). Two zones of fibre development: surface to about 22m and 60m to >75m (limit of drilling). Originally worked by tunnelling about 1918 (Lloyd 1950). This was probably by D.A. Porter, who gained a lease in 1919. Deposit comprises a stockwork of irregularly orientated cross fibre chrysotile asbestos veins up to 50mm wide. Oblique shears in asbestos fibre limit unbroken fibre to <25mm and generally 6 to 12mm. Fibre formed 2-3% of rock, and was hand picked to about 6 to 7% before milling. MacNevin (1971, 1975a,b). Dry processing reputedly efficient, owing to long, free milling fibre. Ore body relatively unexplored. Magnetic high over orebody. Magnesite also occurring: grab sample assayed 96.72% MgCO3 (Fitzpatrick 1969). Used principally in asbestos cement building products. Portions - EL188,EL1867,EL4560

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NAME(S): Berthong Creek Asbestos Occurrence

Size: Occurrence

LOCATION: MGA 599663 – 6189583

Location method – unknown

MINING HISTORY

Workings: pit(s) Never worked

Rock type: Serpentinite and alluvium

DEPOSIT CHARACTER

Ore: chrysotile

Gangue: unknown

Production: unknown

Operating Status – unknown

REMARKS: A thin vein of asbestos near the head of Berthong Creek near Berthong Estate (ARDM 1895 p. 180).

NAME(S): Byng

Size: small

LOCATION: MGA 713088 – 6312883 (centre of deposit)

Location method:

MINING HISTORY

Workings: pit(s) Never worked

Rock type: Talc Schist - ultramafic

DEPOSIT CHARACTER

Ore: asbestos — probably tremolite

Gangue: probably tremolite

Production: 19432t produced for 19400t asbestos

Operating Status – unknown

REMARKS: The asbestos is probably amphibole variety (MacNevin 1970) and was used in manufacture of boiler lagging. Production for this site reported under SITE 10204.

JT Pienmunne 02/09/1999.

REFERENCES: MacNevin 1970.

NAME(S): Church Hill asbestos deposit

Size: small

LOCATION: 454605 mE, 6773987 mN

Location method: 25K Topo Map

MINING HISTORY

Workings: no workings

Recorder(s): JW Brownlow 21/02/1990

Rock type: Hostrock(s): serpentinite - Gordonbrook Serpentinite Belt

DEPOSIT CHARACTER

Ore: chrysotile

Gangue: unknown

Production: 0t produced

Relation to Host: discordant

Operating Status – unknown

REMARKS: No extensive zones of mineralisation, but gash veins reaching 4.5 mm wide and 100 mm long recognized in vicinity, generally on ridge tops. Fibre content at this locality, over 3m, yielded 9 @ 0.75mm and 5 @ 1.5mm. (GS1966/188).

REFERENCES: Facer R (Ed), Henley H.F., Brown R.E., Brownlow J.W., Barnes R G and Stroud W J(2001), Henley H.F., Brown R.E., Brownlow J.W., Barnes R.G. & Stroud W.J.(2001), GS1982/409, GS1966/188a, GS1989/308, GS1966/188b. Stevens, B.P.J., 1968.District. - 10 - The geology of the Byng-Guyong B.Sc.(Hons) Thesis, University of Sydney (unpublished).

Stevens, B.P.J., 1975. A Metallogenic Study of the Bathurst1: 250,000 Sheet, Geological Survey of NSW, Sydney.

NAME(S): Confluence Shaft; Buttress Pit

Size : Occurrence

LOCATION: Mapsheet: 8528-III-S,SI/55-11

Coordinates: 611741 mE, 6130208 mN

Location method: 100K Topo Map

Locality:Approximate location,

MINING HISTORY

Workings: shafts

Recorder(s): KR Fitzpatrick 30/05/1974

Rock type: Hostrock(s): serpentinite - Honeysuckle beds

DEPOSIT CHARACTER

Ore: chromite, chrysotile, (awaruite, magnetite)

Gangue: chlorite

Resources: unknown

Production: 0t produced

Operating Status: unknown

SUMMARY: Low grade, platy, and schlieren-banded ore. Alternate chromite-rich and chromite-poor layers with a matrix of pale-green chrysotile-bearing asbestos. Most grain boundaries are pull-apart fractures (Golding 1966).

REMARKS: Cootamundra 100,000 No 218. Basden et al 1975. Nearest town is Coolac. Deposit No. 144 Warren 1995(Warren Combines Basden sites 218, 219, 92 and 212)

REFERENCES: GS1973/479, Fitzpatrick K.R.(1976), Fitzpatrick K.R.(1979), Warren A.Y.E., Gilligan L.B., Raphael N.M.(1995), Basden H., Adrian J., Clift D.S.L. & Winchester R.E.(1978), Golding H.G.(1966)

NAME(S): Coolac Cr Occurrence

Size: Occurrence

LOCATION: Mapsheet: 8528-III-S,SI/55-11

Coordinates: 611613 mE, 6130483 mN

Location method: 100K Topo Map

MINING HISTORY

Workings: unknown

Recorder(s): RP McEvilly 30/09/1999

Rock type: Hostrock(s): unknown - Honeysuckle beds

DEPOSIT CHARACTER

Ore: chromite

Gangue: unknown

Resources: unknown

Production: 0t produced

Operating Status: unknown

REMARKS: Cootamundra 100,000 No 92. Basden et al 1975. Nearest town is Coolac. Deposit No. 144 Warren 1995(Warren Combines Basden sites 218, 219, 92 and 212)

REFERENCES: GS1973/479, Basden H., Adrian J., Clift D.S.L. & Winchester R.E.(1978)

NAME(S): Curries Hill asbestos prospect

Size: Occurrence

LOCATION: Mapsheet: 9439-IV-S,SH/56-6

Coordinates: 461875 mE, 6764437 mN

Location method: 25K Topo Map

MINING HISTORY

Workings: pit(s) scapes.

Recorder(s): JW Brownlow, K Ringwood & HF Henley 21/02/1990

Rock type: Hostrock(s): serpentinite - Gordonbrook Serpentinite Belt

DEPOSIT CHARACTER

Ore: chrysotile

Gangue: unknown

Resources: unknown

Production: 0t produced

Operating Status: unknown

SUMMARY: Fair quality fibre suitable for manufacture of building materials.

REMARKS: Fibre zone is narrow (max 3m wide), strikes about 120 deg T and dips about 60 deg ne. Fibre zone is about 30m long. Fibre occurs in a poorly outcropping brecciated zone. A small pit, 36 m away along same line contains only very long picrolite fibres. About 150 m on bearing 048 deg t, some 12mm fibre was found adhering to boulders; extent appears limited (GS1966/188, 1976/194). Fibre in main workings up to 40mm, but mainly 3-10mm and of fair quality suitable for manufacture of building materials. (AR 1939-45/p80)

REFERENCES: GS1966/188a, Titles, Mineral Resources NSW, Facer R (Ed), Henley H.F., Brown R.E., Brownlow J.W., Barnes R G and Stroud W J(2001), GS1970/468b, MacNevin A.A.(1975a), Henley H.F., Brown R.E., Brownlow J.W., Barnes R.G. & Stroud W.J.(2001), GS1978/187, GS1982/409, Department of Mines New South Wales(1946a), GS1989/308, GS1976/194, MacNevin A.A.(1975b), GS1966/188b, GS1970/468a, MacNevin A.A.(1971a)

NAME(S): Dog Trap asbestos prospect

Size: Occurrence

LOCATION: Mapsheet: 9439-III-N,SH/56-6

Coordinates: 465125 mE, 6754187 mN

Location method: 25K Topo Map

Locality: County: Drake, Parish: Yarrcalkiarra, Portion: 121; EL30;

MINING HISTORY

Workings: pit(s)

Recorder(s): JW Brownlow 07/02/1990

Rock type: Hostrock(s): serpentinite - Gordonbrook Serpentinite Belt

DEPOSIT CHARACTER

Ore: chrysotile

Gangue: unknown

Resources: unknown

Production: 0t produced

Operating Status: unknown

REMARKS: 120m long zone of parallel fibre veins striking about 045 deg (m). Fibre count over representative 1.5m: 20 @ 1.5mm, 130 @ 3mm (GS1966/188). Deposit apparently between 3 and 15m wide and comprises parallel veins (GS1966/188). JWB89/C002

REFERENCES: Facer R (Ed), Henley H.F., Brown R.E., Brownlow J.W., Barnes R G and Stroud W J(2001), Henley H.F., Brown R.E., Brownlow J.W., Barnes R.G. & Stroud W.J.(2001), GS1989/308, GS1966/188a, GS1966/188b

NAME(S): East Guyong Quarry, Guyong Quarry Proposal

Size: Large

LOCATION: Mapsheet: 8731-II-S,SI/55-8

Coordinates: 709413 mE, 6300773 mN

Location method: Digital GIS Layers

MINING HISTORY

Workings: Open Pit drilling — unprocessed construction materaials

Rock type: Hostrock(s): basalt - Tertiary Basalt – Tremolite identified in footwall Byng Volcanics

DEPOSIT CHARACTER

Gangue: (tremolite)

Resources: 15.0Mt coarse aggregate

Production: Nil of asbestos.

Operating Status: unknown

SUMMARY: Proposal by Hanson Construction Materials to develop a quarry in basalt E of village of Guyong in Cabonne LGA.

REMARKS: Proposal by Hanson Construction Materials (previously Pioneer) to develop a quarry in basalt E of Guyong in Cabonne LGA. Resources of 15Mt & production rate of 100,000 tpa

rising to 400,000 tpa over 15 yrs. Quarry will supply the Bathurst and Orange markets and will replace Hanson's Orange Road, Bathurst quarry (site 1990).

REFERENCES: Noel Arnold and Associates 2012 for Hanson Pty Ltd

NAME(S): Emily Downs Workings (Smelter Workings)

Size: Occurrence

LOCATION: Mapsheet: 8731-II-S,SI/55-8

Coordinates: 713813 mE, 6304733 mN

Location method: 25K Topo Map Accuracy 1000 m

Recorder(s): MJ Drummond 1994

MINING HISTORY

Workings: underground mine

Rock type: Hostrock(s): andesite - Byng Volcanics, felsic intrusive - Icely Granite

DEPOSIT CHARACTER

Ore: pyrite

Gangue: tremolite

Resources: unknown

Production: 0t produced

Operating Status unknown

SUMMARY: Icely Granite outcrops only 150m-200 m to the east. Workings include smelter and shaft.

REMARKS: Sheared, carbonated volcanics with tremolite – little information is available Asbestos is likely near this location but further investigation is required.

REFERENCES: GS1985/182, GS1993/179

NAME(S): Fine Flower asbestos prospect

Size: Occurrence

LOCATION: Mapsheet: 9439-III-N,SH/56-6

Coordinates: 465775 mE, 6753667 mN

Location method: 25K Topo Map

Recorder(s): JW Brownlow, K Ringwood 07/03/1990

MINING HISTORY

Workings: pit(s)

Rock type: Hostrock(s): serpentinite - Gordonbrook Serpentinite Belt

DEPOSIT CHARACTER

Ore: chrysotile

Gangue: unknown

Resources: unknown

Production: 0t produced

Operating Status: unknown

REMARKS: Central part of a 130m zone of fibre bearing serpentinite, parallel fibre veins. Deposit on ridge. Parallel fibre veins. Vein counted in a shallow trench, over a distance of 3m: 37 @ 1.5mm, 2 @ 3mm (GS1966/188). Width of fibre zone unclear, but between 3 and 15m (GS1966/188). Diamond drilling in vicinity (narrow core with poor recovery) and costeaning revealed minor fibre development (probably <1%), but could be slightly higher due to core loss. Some fibre up to 13mm, but 90% <3mm (mr 4199).

REFERENCES: Facer R (Ed), Henley H.F., Brown R.E., Brownlow J.W., Barnes R G and Stroud W J(2001), MacNevin A.A.(1975a), Henley H.F., Brown R.E., Brownlow J.W., Barnes R.G. & Stroud W.J.(2001), MR00199, GS1966/188a, MR04199, GS1974/525, MacNevin A.A.(1975b), GS1989/308, GS1966/188b, MacNevin A.A.(1971a)

NAME(S): Five Mile asbestos prospect

Size: Occurrence

LOCATION: Mapsheet: 9439-IV-S,SH/56-6

Coordinates: 460805 mE, 6770487 mN

Location method: 25K Topo Map

Locality: County: Drake, Parish: Ogilvie, Portion: 46, 47; PML1, PML2; ML1; EL188, EL1004, EL1867;

Recorder(s): JW Brownlow 21/02/1990

MINING HISTORY

Workings: unknown

Rock type: Hostrock(s): serpentinite - Gordonbrook Serpentinite Belt

DEPOSIT CHARACTER

Ore: chrysotile

Gangue: unknown

Resources: unknown

Production: 0t produced

Operating status: unknown

REMARKS: Minor development of 2-3mm chrysotile fibre in massive serpentinite.

REFERENCES: Titles, Mineral Resources NSW, Facer R (Ed), Henley H.F., Brown R.E., Brownlow J.W., Barnes R G and Stroud W J(2001), GS1970/468b, Henley H.F., Brown R.E., Brownlow J.W., Barnes R.G. & Stroud W.J.(2001), GS1978/187, GS1982/409, GS1989/308, JWB(1989), GS1970/468a

NAME(S): Forners Prospect

Size: Occurrence

LOCATION: Mapsheet: 7234-III-N,SH/54-15

Coordinates: 560031 mE, 6477228 mN

Location method: 50K Topo Map

Recorder(s): RG Barnes 09/08/1977; SA Mills 03/05/1998

MINING HISTORY

Workings: underground mine

Rock type: Hostrock(s): ultramafite - Thorndale Composite Gneiss, retrograde schist - Thorndale Composite Gneiss

DEPOSIT CHARACTER

Ore: azurite, malachite, (limonite)

Gangue: (chrysotile, quartz)

Resources: unknown

Relation to Host: intrusive contact

Operating status: unknown

SUMMARY: Shaft and pits sunk on PT-Cu-Ni bearing ferruginous material, related to nearby ultrabasic body. Platinum minerals reported, also possible pyromorphite/plumbojarosite.

REMARKS: Estimated production 0-10 tonnes
From field notes - 3m shaft and pits on either side of u/basic body. Sunk on Pt-Cu-Ni bearing ferruginous material in rba and retrograde schist.

REFERENCES: GS1976/189, GS1978/400

NAME(S): Freemantle Asbestos, Lewis Ponds - GF Fletcher

Size: Small

MINING HISTORY

Minerals P/L. Ceased (pit).

MGA 712363 mE – 6313283 mN 144 to 150.

Centre of area. 50m accuracy. 25k 8731-II-N.

PML 1 converted to PLL 639 in 1924. Originally worked by Fletcher and others, later taken over by Minerals P/L. Production for this site and SITE 10203 reported here. JT Pienmunne 02/09/1999

Resources:

Production: 338.2 Tonnes of Asbestos

REFERENCES: GS1976/189, GS1978/400

NAME(S): Goobarragandra Mine, Pattons Mine

Size: Small

LOCATION: Mapsheet: 8527-II-N,SI/55-15

Coordinates: 626813 mE, 6086583 mN

Location method: 25K Topo Map

Locality:Approximate location,

Recorder(s): PR Degeling 06/02/1974

MINING HISTORY

Workings: underground mine

Rock type: Hostrock(s): amphibolite - Coolac Serpentinite, granite - Bogong Granite, serpentinite - Coolac Serpentinite, hornfels - Honeysuckle beds

DEPOSIT CHARACTER

Ore: digenite, covellite, chalcopyrite, azurite, pyrrhotite, pyrite, malachite, magnetite, (violarite, cubanite, pentlandite, sphalerite, chromium spinel, mackinawite)

Gangue: amphibole, talc, tremolite

Resources: unknown

Production: 800t produced for 80t Cu

Relation to Host: fault contact

Operating status: unknown

SUMMARY: Ashley (1974)-suggested to have formed in a volcanic exhalative environment associated with submarine abyssal tholeiitic volcanism.

REMARKS: Beams and Lesh (1996)-volcanogenic, 10% Cu grade, ore interstitial to silicates, strike 340mag. For a discussion of mineragraphy see Ashley (1973). Mineralization occurs in a metamorphosed reaction zone to 2m wide between thermally metamorphosed amphibolite and metaserpentinite. Apophyses of micro-adamellite (sulphide free) from the Bogong Granite cut the sulphide-bearing zone. Migration of elements during serpentinitization of harzburgite and their subsequent concentration along the margins of tectonic inclusions of country rock in the serpentinite, forming reaction zones (Ashley, 1973).

REFERENCES: Degeling P.R.(1982), GS1967/044, GS1980/257, GS1986/106, GS1986/133, Department of Mines New South Wales(1905), Department of Mines New South Wales(1916), Department of Mines New South Wales(1917), Department of Mines New South Wales(1918), Department of Mines New South Wales(1919), Department of Mines New South Wales(1920), Department of Mines New South Wales(1921), Adamson C.L.(1960a), Lawrence L.J.(1972), Geological Survey of New South Wales(1977), GS1970/403, Beams S.D. & Lesh R.H.(1996), Ashley P.M.(1973), Ashley P.M.(1974), Basden H.(1990)

NAME(S): Goobarragandra Gold Mine

Recorder(s): LB Gilligan 22/04/1972

Locality:Approximate location,

MINING HISTORY

Workings: underground mine

LOCATION: Mapsheet: 8627-III-S,SI/55-16

Coordinates: 640142 mE, 6075924 mN

Location method: 100K Topo Map

Rock type: Hostrock(s): granite - Broken Cart Granodiorite, diorite - Goobarragandra Volcanics

DEPOSIT CHARACTER

Ore: pyrite, (gold, malachite)

Gangue: quartz

Resources:

Production: 0t produced for 0t Au

Alteration: unknown

Relation to Host: unknown

SUMMARY: 4 reefs were developed, these reefs included Nos 1, 2, and 3 (MR1879).

REMARKS: 'Stokes and Sons' were winning Au from a number of small quartz veins in 1913 in this general area (Harper 1913). The lodes were small and lenticular, in Silurian diorite.

REFERENCES: MR01879, Gilligan L.B.(1975), Gilligan L.B.(1974)

NAME(S): Irene Asbestos Occurrence

Size: Occurrence

LOCATION: Mapsheet:

Coordinates: 741963mE, 6266183 mN

Location method: 25K Topo Map

MINING HISTORY

Workings: pit(s)

Rock type: Hostrock(s): serpentinite related - asbestos

DEPOSIT CHARACTER

Ore: asbestos,

Gangue: unknown

Resources: unknown

Production: 0t produced

Relation to Host: discordant

Operating status: unknown

NAMES(S) Ivy Hill asbestos prospect

Size: Occurrence

LOCATION: Mapsheet: 9439-III-N,SH/56-6

Coordinates: 461705 mE, 6762787 mN

Location method: 25K Topo Map

Locality: County: Drake, Parish: Yulgilbar, Portion: 111, 139, 144; PML22; EL188;

Recorder(s): JW Brownlow & K Ringwood 07/03/1990

MINING HISTORY

Workings: pit(s)

Rock type: Hostrock(s): serpentinite - Gordonbrook Serpentinite Belt

DEPOSIT CHARACTER

Ore: chrysotile

Gangue: unknown

Resources: unknown

Production: 0t produced

Operating status: unknown

REMARKS: Localised occurrence. Trench 7.6m long extends 2.4m into hill as a tunnel; strikes 119 deg. Fibre veins seemingly not oriented. Grade could reach 2%, but area very limited (GS1966/188). Note this reference refers to PML22 in Ph Ogilvie but presumably means Ph Yulgilbar.

REFERENCES: Titles, Mineral Resources NSW, Facer R (Ed), Henley H.F., Brown R.E., Brownlow J.W., Barnes R G and Stroud W J(2001), GS1970/468b, Henley H.F., Brown R.E., Brownlow J.W., Barnes R.G. & Stroud W.J.(2001), MacNevin A.A.(1975c), GS1989/308, MacNevin A.A.(1975b), GS1966/188a, GS1966/188b, GS1970/468a, MacNevin A.A.(1971a)

NAMES(S): Long Tunnel Mine, Kenny and Frewins Mine, Robinson and Rice Mine

Size: Medium

LOCATION: Mapsheet: 8527-IV-N,SI/55-15

Coordinates: 592363 mE, 6122683 mN

Location method: 25K Topo Map

Locality: Main workings,

Recorder(s): PR Degeling 07/03/1974

MINING HISTORY

Workings: underground mine

Rock type: Hostrock(s): serpentinite - Long Tunnel Metabasic Igneous Complex, diorite - Kimo Diorite, slate - Jackalass Slate, schist - Jackalass Slate

DEPOSIT CHARACTER

Ore: sphalerite, galena, gold, (chalcopyrite)

Gangue: pyrrhotite, pyrite, calcite, talc, quartz, limonite, tremolite, (violarite, cobaltite, millerite)

Resources: unknown

Production: 9189t produced for 0.42t Au

Extent: Strike: 315 Dip/punge: 40 Dip/direction: 225

Operating status: unknown

SUMMARY: GS1995/172-mine occurs on W contact of narrow body of serpentinite emplaced in a NW trending shear zone. There appears to be some confusion in records for this mine versus the Robinson and Rices Mine to the E. Beams and Lesh (1996).

REMARKS: Ore lenses steeply pitching. Au in talc-rich zones in quartz veins. Gold is richest at the intersection of the faulted quartz-calcite veined serpentinite-diorite contact with minor cross-faults. Ore channel was persisting at 168m depth. Pittman (1901) noted the similarity to the

Lucknow Gold Mine. Some very rich ore was obtained from this mine, including around 2300oz from very rich specimens recorded in 1900 and 1911. GS1983/402-cobalt-copper-zinc-nickel credits. GS1989/157-drillholes: DD90LT4: 1m at 5ppm Au. Hydrothermal activity during metamorphism, with serpentinite favourable trap for gold (Degeling 1982). GS1961/077-many barren zones, irregular masses of enriched ore, sph-gal abundant at 120m. Mine Record 1624-assays to ~2081ppm Au, ~61ppm Ag at 160m. Frewen and party worked a lease adjoining on the SE.

REFERENCES: Parish Card, Degeling P.R.(1982), GS1961/077, GS1987/175, McEvilly R.P.(1997-98), Department of Mines New South Wales(1899), Department of Mines New South Wales(1901), Department of Mines New South Wales(1903), Department of Mines New South Wales(1904), Department of Mines New South Wales(1900), Department of Mines New South Wales(1902), Department of Mines New South Wales(1942), Pittman E.F.(1900a), Pittman E.F.(1901e), Kenny E.J.(1938a), Kenny E.J.(1950m), Department of Mines New South Wales(1940), Department of Mines New South Wales(1939), Department of Mines New South Wales(1938), Department of Mines New South Wales(1928), Department of Mines New South Wales(1918), MR01624, Geological Survey of New South Wales(1977), GS1997/554, GS1980/009, GS1980/043, GS1989/157, GS1995/172, GS1983/402, GS1996/476, Beams S.D. & Lesh R.H.(1996), Basden H.(1990)

NAMES(S): McAlpine Copper Mine

LOCATION: Mapsheet: 8527-I-S,SI/55-15

Coordinates: 619713 mE, 6112133 mN

Location method: 25K Topo Map

Locality:Approx. location,

Recorder(s): PR Degeling 04/01/1974

MINING HISTORY

Workings: underground mine

Rock type: Hostrock(s): serpentinite - Coolac Serpentinite, schist - Coolac Serpentinite, granodiorite - Coolac Serpentinite, trondhjemite - Coolac Serpentinite, diorite - Coolac Serpentinite

DEPOSIT CHARACTER

Ore: malachite, chalcopyrite, sphalerite, limonite, smithsonite, cubanite, azurite, (violarite, chromite, pentlandite, goslarite, galena, covellite, nickeline)

Gangue: calcite, tremolite, serpentine, quartz, chlorite

Resources: unknown

Production: 38t produced for 0t Ag, 4.06t Cu, 0t Zn

Relation to Host: fault contact

Operating status: unknown

SUMMARY: Mineralization in a narrow, altered serpeninite wedge in the reaction zone between a tectonic inclusion, containing deformed and variably metasomatised granodiorite, trondhjemite, and diorite, and massive and schistose serpentinite (Degeling 1982).

REMARKS: GS1967/044-DDH1: (main shaft): 30m at 0.5-0.55% Zn, and 0.1-0.12% Ni. GS1997/006-hazburgite with intrusions of dunite and chromite, appear to be shear controlled.

GS1968/125-dump assays to: 2.03% Cu, 0.2% Ni, 0.6ppm Ag. GS1986/173-rock chips: ore: 0.21ppm Au; serpentinised hartzburgite: 0.27ppm Au. Basden (GS1986/106)-serpentinite cutting gabbroic complex. Assay at 32m level drive from 1.8m wide lode: 13.74% Cu, 18.73% Zn, 18.62% Fe, 22.48% S, 8.15% SiO2, tr Au, 5.0ppm Ag, (Carne, 1908). Narrow elongate zone of mineralisation striking ~075mag, subvertical dip (references in Degeling, 1982). For discussion on mineragraphy see Ashley (1969, and 1973).

REFERENCES: Degeling P.R.(1982), GS1986/106, GS1980/257, GS1996/123, GS1986/173, Carne J.E.(1908a), Lawrence L.J. & Golding H.G.(1969), GS1967/044, MR01814, Geological Survey of New South Wales(1977), GS1997/006, GS1970/403, Ashley P.M.(1969), Ashley P.M.(1973), Basden H.(1990)

NAME(S): Nogrigar asbestos deposit (Hamiltons asbestos deposit)

Size: Occurrence

LOCATION: Mapsheet: 9439-IV-N,SH/56-6

Coordinates: 455375 mE, 6778417 mN

Location method: 25K Topo Map

Locality: County: Drake, Parish: Ewingar, Portion: 56; PML1; EL30, EL188, EL1003, EL1867, EL4560;

Recorder(s): JW Brownlow & HF Henley 07/02/1990

MINING HISTORY

Workings: no workings

Rock type: Hostrock(s): serpentinite - Gordonbrook Serpentinite Belt

DEPOSIT CHARACTER

Ore: chrysotile

Gangue: unknown

Resources: unknown

Production: 0t produced

Relation to Host: discordant

Operating status: unknown

REMARKS: Network of small veins exposed in two pits Chrysotile asbestos occurring as a network of small veins less than 3mm, and generally lenticular. Generally <1 % fibre. Low grade and short fibre suggest that it would be uneconomic to exploit (GS1941/042). Exploration in EL30 (GS1966/188) indicated fibre to 6 mm. References to fibre with a maximum length of a little more than 25 mm appear to be a misquote of McClatchie (1965).

REFERENCES: Titles, Mineral Resources NSW, Facer R (Ed), Henley H.F., Brown R.E., Brownlow J.W., Barnes R G and Stroud W J(2001), GS1970/468b, Henley H.F. & Brown R.E. fieldwork 1993(1993), Henley H.F., Brown R.E., Brownlow J.W., Barnes R.G. & Stroud W.J.(2001), GS1978/187, GS1982/409, MacNevin A.A.(1975b), GS1989/308, MacNevin A.A.(1975c), GS1965/116, GS1966/188a, GS1966/188b, GS1970/468a

NAME(S): Pettitt

Size: Occurrence

LOCATION: Mapsheet:

Coordinates: 605943 mE, 6130877 mN

Location method: GDA 94

MINING HISTORY

Workings: pit(s)

Rock type: Hostrock(s): Serpentinised harzburgite

DEPOSIT CHARACTER

Ore: Chrysotile/Tremolite

Resources: unknown

Production: 0t produced

Relation to Host: discordant

Operating status: unknown

REMARKS: Site identified by Hendrickx 2009

REFERENCES Hendrickx 2009

NAME(S): Port Macquarie

Size: Occurrence

LOCATION: Mapsheet: SH-56-14

Coordinates: 492901 mE, 6522129. mN

Location method GDA 94

MINING HISTORY - Nil

Rock type: Hostrock(s): Serpentinised harzburgite

Operating status: unknown

DEPOSIT CHARACTER

Ore: Chyrsotile

Resources: unknown

Production: 0t produced

REMARKS: unknown

REFERENCES Henrickx 2009

NAME(S): Ravenscroft asbestos prospect

Size: unknown

LOCATION: Mapsheet: 9439-IV-S,SH/56-6

Coordinates: 460805 mE, 6765287 mN

Location method: 25K Topo Map

Recorder(s): JW Brownlow 21/02/1990

Locality: County: Drake, Parish: Yulgilbar, Portion: 49; ML2; PML11-13, PML18, PML23, PML28, PML31; EL1

MINING HISTORY

Workings: underground mine

Rock type: Hostrock(s): serpentinite - Gordonbrook Serpentinite Belt

DEPOSIT CHARACTER

Ore: chrysotile

Gangue: unknown

Resources: unknown

Production: 0t produced

Operating status: unknown

REMARKS: Fibre is developed over an area not less than 90m x 75m and 75m deep. 'The exploration completed indicates that the area has good potential for proving of a significant tonnage of economic grade fibre-bearing serpentinite' (GS 1976/194). A magnetic high coincides with the mineralisation (GS1976/194). Deposit is probably an extension of the Yulgilbar deposit.

REFERENCES: Titles, Mineral Resources NSW, Facer R (Ed), Henley H.F., Brown R.E., Brownlow J.W., Barnes R G and Stroud W J(2001), GS1970/468b, Henley H.F., Brown R.E., Brownlow J.W., Barnes R.G. & Stroud W.J.(2001), GS1978/187, GS1982/409, GS1989/308, GS1976/194, GS1970/468a

Red Hill Three sites

Red Hill (part) - lease holders; Thiermann, F. Wildman & Co, M. Bourke, ceased (pits).

MGA 555511 – 6454478, 50m, 138 to 144. 25k 7233-IV-N. Size occurrence. Shallow pits averaging 2m x 1.5m x 1.5m deep. Chrysotile, Serpentinized ultrabasic intrusive. Department of Mines New South Wales 1932 Annual report of the Department of Mines, New South Wales, for the year 1931. Department of Mines New South Wales, Annual Report for 1931, Bartholomaeus M.A. 1987 GS1987/068 Mineral deposits of the Rockwell 1:25,000 sheet area. Geological Survey of New South Wales, Report GS1987/068 (unpublished).

Estimated production 0-10 tonnes. From field notes - "In 1931 8 tons of asbestos, valued at 64 pounds were obtained from the area" (AR 1931 p33). Total value obtained from the area was approx. $1,870. It has been noted that "the asbestos is rather matted and metamorphism has rendered the fibre strong and hard" (GS1967/346). Fibrous veins are 10-400mm thick. Fibrous veins of asbestos (chrysotile) in serpentinised ultrabasic; It has been noted that "the asbestos is rather matted & metamorphism has rendered the fibre strong & hard; fibrous veins 10 to 40 mm thick (GS1967/346). Pit 2m x 1.5m, 1.5m deep. Production from this site included under INDMIN SITE 176

Red Hill (part) - lease holders; Thiermann, F. Wildman & Co, M. Bourke

MGA 555731 – 6454328, 50m. 138 to 144. 25k 7233-IV-N. Size small. Series of pits, shafts and surface stopes (approx. 7 workings) over a large area. chrysotile (major) - magnesite (minor). Serpentinized ultrabasic intrusive. Dickson T.W. 1967d GS1967/346 Non-metallic mines of the

Broken Hill district. Geological Survey of New South Wales, Report GS1967/346 (unpublished). Workings for asbestos on serpentinized ultrabasic intrusive with serpentinized pyroxene and black phenocrysts pseudomorphed by amphibole. Estimated production 0-10 tonnes. From field notes - "In 1931 8 tons of asbestos, valued at 64 pounds were obtained from the area" (AR 1931 p33). Total value obtained from the area was approx. $1,870. It has been noted that "the asbestos is rather matted and metamorphism has rendered the fibre strong and hard" (GS1967/346). Fibrous veins are 10-400mm thick There is also possible silicified magnesite as an alteration product. Asbestos (chrysotile). Serpentinised ultrabasic intrusive with serpentinised pyroxene and black phenocrysts pseudomorphed by amphibole. In 1931, 8 tons of asbestos (value $128) mined in the area (ARDM 1931 p33). Production for INDMIN SITE 161 included in this figure. Asbestos rather matted & metamorphism has rendered fibre strong & hard (GS1967/346). Locality 76 on Figure 19 (Lishmund 1982).

Compiler. MA Bartholomaeus 22/11/1984; SA Mills 01/06/1996

Red Hill (part) – Never worked. MGA 555751 – 6454288 50m. 138 to 144. 25k 7233-IV-N.

Size:- occurrence. chrysotile gangue major, magnesite gangue minor, malachite ore major, chrysocolla ore major. Serpentinized ultrabasic intrusive. Mulga Springs Type (PGE-Cu-Ni-Au). Shaft sunk on serpentinized ultrabasic intrusive with secondary malachite and chrysocolla. From field notes - The host rock contains serpentinized pyroxene and black phenocrysts pseudomorphed by amphibole. Possible silicified magnesite also present.

NAME(S) Rockley Asbestos Mine

Size: unknown

LOCATION: Mapsheet: 8830-IV-S,SI/55-8

Coordinates: 740791 mE, 6270265 mN

Location method: 25K Topo Map

Recorder(s): A Bush 1994

Locality:Stevens (1972) [ref id=1148] GR converted to AMG.,

MINING HISTORY

Workings: underground mine

Rock type: Hostrock(s): schist - Rockley Volcanics

DEPOSIT CHARACTER

Ore: tremolite

Gangue: host

Resources: unknown

Production: 0t produced

Operating status: unknown

REMARKS: Small occurrence with little production dates unknown. No 341 on Bathurst metallogenic map.

REFERENCES: Stevens B.J.P.; Geological Survey of New South Wales(1968), Stevens B.P.J.(1972), GS1982/384

NAME(S): Serpentine Hill asbestos prospect

Size: unknown

LOCATION: Mapsheet: 9439-III-N,SH/56-6

Coordinates: 464705 mE, 6756687 mN

Location method: 25K Topo Map

Recorder(s): JW Brownlow 07/02/1990

Locality: County: Drake, Parish: Yarrcalkiarra, Portion: 127; EL30

MINING HISTORY

Workings: unknown

Rock type: Hostrock(s): serpentinite - Gordonbrook Serpentinite Belt

DEPOSIT CHARACTER

Ore: chrysotile

Gangue: unknown

Resources: unknown

Production: 0t produced

Relation to Host: discordant

Extent: Strike: Dip/punge: Dip/direction:

Operating status: unknown

REMARKS: A 900m long zone extending northwesterly from Serpentine Hill Trig, forms patches up to 3m across containing up to 2% fibre. Not inspected.

REFERENCES: GS1966/188a, Facer R (Ed), Henley H.F., Brown R.E., Brownlow J.W., Barnes R G and Stroud W J(2001), Henley H.F., Brown R.E., Brownlow J.W., Barnes R.G. & Stroud W.J.(2001), GS1989/308, GS1976/194, GS1966/188b

NAME(S): Spring Creek Asbestos

Size: Occurrence

LOCATION

MGA 401505 – 6506188

250m accuracy. 25k 9234-I-N.

MINING HISTORY

Occurrence. Gilligan L.B. & Brownlow J.W. 1987 Tamworth-Hastings 1:250,000 Metallogenic Map. SH 56-13, SH 56-14: Mineral deposit data sheets and metallogenic study. Geological Survey of New South Wales, Sydney, MacNevin A.A. 1971a Mineral Industry 4: Asbestos. Geological Survey of New South Wales, Mineral Industry 4. Cross fibre chrysotile asbestos and picrolite veins occurring in massive serpentinite. INDMIN: Cross-fibre chrysotile & picrolite veins occur in massive serpentinite. The chrysotile veins (generally of good quality) are often in parallel groups & vary from extremely fine veinlets up to a quarter of an inch wide veins. The picrolite veins are parallel to or transect the chrysotile veins at angles in the vicinity of 90 degrees. JJ Watkins, September 1983.

Rock type: Serpentinite

DEPOSIT CHARACTER – serpentinite hosted asbestos

Ore: asbestos – cross fibre chrysotile

Gangue: unknown

Resources: unknown

Production: unknown

Relation to Host :Discordant

Operating status: unknown

REMARKS: Cross fibre chrysotile asbestos and picrolite veins occuring in massive serpentinite.

REFERENCES: Gilligan L.B., Brownlow J.W. & Cameron R.G.(1987), MacNevin A.A.(1971a), Gilligan L.B. & Brownlow J.W.(1987)

NAME(S): Thomsons Gully, Rockley

Size: Small

MINING HISTORY

Thompsons Gully, Rockley - EM Phyland, E Le Vine (lease holders), ceased.

LOCATION

Coordinates MGA 744913 – 6265533

Location method: 25K Topo Map

100 m 144 to 150 25k 8830-IV-S. Small deposit $10,000 in 1942. MacNevin A.A. 1971a Mineral Industry 4: Asbestos. Geological Survey of New South Wales, Mineral Industry 4.

HOST: Serpentinite . Tuffs, serpentinites, talc schists & altered limestones. Workings in talc schist & serpentinite.

DEPOSIT CHARACTER – serpentinite hosted asbestos

Ore: asbestos – cross fibre chrysotile

Gangue: unknown

Resources: Occurs in several areas – but poor quality.

Production: In 1952, 50 tons of ore were raised but the fibre was of low tensile strength & was not sold. JT Pienmunne 02/09/1999.

Relation to Host: discordant

Operating status: unknown

REMARKS: Serpentinite partly altered to low-grade amphibole asbestos within slippage planes. The asbestos is usually brittle and of low tensile strength.

REFERENCES: MacNevin 1970; Noakes 1948.

NAME(S): Turnbull and Gordons Mine

LOCATION: Mapsheet: 9136-III-S,SH/56-9

Coordinates: 327605 mE, 6570188 mN

Location method: 250K Topo Map

Recorder(s): JP Krynen, JW Brownlow, April 1988

Locality: County: Inglis, Parish: Danglemah, Portion: 49; MLA 191;

MINING HISTORY

Workings: pit(s)

Recorder(s): JP Krynen, JW Brownlow, April 1988

Locality: County: Inglis, Parish: Danglemah, Portion: 49; MLA 191;

LOCATION: Mapsheet: 9136-III-S,SH/56-9

Coordinates: 327605 mE, 6570188 mN

Location method: 250K Topo Map

HOST: Hostrock(s): chert - Equiv Cara, argillite - Equiv Cara, siltstone - Equiv Cara

DEPOSIT CHARACTER

Ore: manganite, neotocite, pyrolusite, pyroxmangite, rhodochrosite, rhodonite, kutnohorite, cryptomelane, bustamite, tephroite, birnessite

Gangue: spessartine, anthophyllite, grunerite, quartz

Resources: 8300.0t exploration result at 8.4g/t Au, 0 rhodonite

Production: 0t produced for 0.45t rhodonite

Relation to Host: stratiform

Extent: Strike: 10 Dip/punge: Dip/direction:

Operating status: unknown

SUMMARY: Mineralization is confined to four lenticular bodies in cherts, striking 10 and dipping steeply east and west. Fold axis strikes 60 (Brown et al 1992).

REMARKS: The deposit is located and visible at a distance of about 50m from the west bank of the Little Oakey Creek. The lenticular ore bodies principally consist of an intergrowth of rhodonite and quartz in various proportions together with oxides of manganese. Precipitation of manganese minerals in a volcanic submarine exhalative environment, stratiform lenticular massive (Brown et al 1992). Production by P.W.Turnbull and A.N. Gordon 1966. exploration by P.Turnbull (1965-1966); P.W.Turnbull and A.H.Gordon (1968).

REFERENCES: Fitzpatrick K.R.(1975b), Fitzpatrick K.R.(1975a), MacNevin A.A. & Holmes G.G.(1980), Brown R.E., Brownlow J.W. & Krynen J.P.(1992), MR03311, GS1985/150

Appendix II How to use this map

This mapping refers to occurrences within about approximately 10 m of the surface. Many areas will likely have potential for NOA at greater depths (see Hendrickx 2009) but this is beyond the scope of this assessment.

Site identification — Mineral Occurrences that host naturally occurring asbestos

Appendix 1 of this report lists sites from the MetIndex database where asbestos and asbestos minerals have been identified in this assessment. No field checking was conducted during this assessment but the locations have been checked using GIS with reference to geological boundaries or, where appropriate, cadastral boundaries to facilitate definition on the ground and as necessary against the available literature.

The size attribute provides, as a general guide, the known size of the occurrence. It should be noted that the smaller size estimates are general in nature and were originally based on 1967 commodity prices which have changed substantially generally and for asbestos minerals in particular. They therefore provide a general but useful guide to the known size of the occurrence based on the available geological data.

Note: asbestos fibres could be also present considerable distances from the occurrences.

Mineral occurrences where serpentinite is listed as a host rock

Appendix 1 lists mineral occurrences from MetIndex where serpentinite, a common host rock to NOA, has been identified as a host rock have been included in Appendix III). Where NOA has not been identified for these occurrences they represent potential NOA locations that warrant further investigation.

Other localities

Several descriptions of poorly documented occurrences where NOA has been identified are cited in MacNevin (1970). Some of these such as Kyogle and Pennant Hills are not well located. Although likely small, some of these occurrences may warrant further investigation. There may also be some limited potential for NOA near Kiama.

Potential asbestos areas

Potential asbestos areas (Polygon data) show the assessed potential for naturally occurring asbestos on a low, medium and high basis (See definitions below).

These areas have the potential for NOA within about 10 metres of the surface based upon current knowledge.

Away from identified NOA occurrences these areas do not necessarily determine that asbestos is present nor absent. However, rocks such as serpentinites, all of which are attributed as high potential are likely to contain some NOA.

Areas of high potential for naturally occurring asbestos

High potential areas or polygons have been assessed to have the highest potential for asbestos and asbestiform minerals (NOA). The distribution of asbestos in a “high” area is most likely to be widespread. Where present, large accumulations of asbestos are possible. However, asbestos/ asbestiform minerals will mostly only constitute a small proportion of the rock overall (< 0.1% — See also Hendrickx 2009).

Criteria

The criteria for an assessment of “high” lithologies included geological units with the following characteristics.

1) Geological units that host asbestos occurrences.

2) Include indicator minerals such as serpentine, tremolite, antigorite or multiple instances of descriptive terms such as serpentinised, fibrous, matted and sheared.
3) Favourable lithology and chemistry — for example, serpentinites and ultramafic rocks which typically contain minerals such as olivine and pyroxene, which can react to form asbestiform minerals and favourable chemistry (e.g. high Mg and Fe and high Mg/Fe ratios).
4) Favourable geological age and geological setting. (In general, older rocks in NSW are more likely to host NOA).
5) Favourable metamorphic grade

Most areas attributed as “high” potential satisfy at least three of the above criteria.

Advice — Specialised geological assessment should be sought prior to the commencement of significant ground-disturbing activities.

Areas of medium potential for naturally occurring asbestos

Definition — MEDIUM POTENTIAL areas have the potential for previously unidentified NOA, but the potential is low overall. Any size of occurrences of NOA are possible –although NOA is unlikely extensively throughout.

Criteria

Medium potential areas have the same criteria as for high potential areas but generally satisfy only two of the criteria outlined above. The most common of these criteria were:

1) Favourable lithology and chemistry (such as ultramafics, ultramafites, dunites, lherzolites and harzburgites) and favourable known metamorphic grade, but with few known asbestos occurrences and/or the areas are away from major faults or metamorphic complexes that are associated with NOA.
2) Appropriate rock types but less favourable age and geological history for NOA.
3) Geological setting. The geological setting was a key factor. Many areas mapped as medium potential are dominated by sedimentary rocks that would otherwise have low potential, but which contain or could contain blocks of ultramafic rocks of high potential. Examples include “melanges” which are geological settings that host a wide variety of rock types.

Medium potential areas include some sediments that thinly overlay “high potential” rocks such as serpentinites.

Advice — All should be alert for the presence of fibrous minerals. Specialist geological advice is recommended for ground disturbing activities and must be commissioned near known asbestos occurrences or if ultramafic or mafic rocks (usually dark in colour) are excavated.

Areas of low potential for naturally occurring asbestos

Areas of LOW potential have some potential but this is assessed as being lower than for HIGH and MEDIUM areas. The majority of areas with LOW potential will not have any NOA. Where present, occurrences are likely to be localised in these areas but larger occurrences are possible.

Low potential areas cover a wide range of rock types, although most are of mafic composition, or are sedimentary rocks that include or may include minor amounts of ultramafic material.

Criteria

The selection of low-potential areas was generalised, but most of these areas satisfy only one or possibly two of the above criteria.

They also include:

1) Rocks that host a small number of mineral occurrences indicator minerals and/or textures typically associated with NOA, but have not undergone geological history that would be favourable to asbestos formation.
2) Have less favourable lithology and chemistry but are physically adjacent to known NOA occurrences and/or areas assessed with high potential.
3) Thin sediments that overlie rocks assessed as high potential and lesser medium potential.
4) NOA is known in the geological region and there is such uncertainty of the geology (e.g. in rugged and remote areas) that the possibility of NOA cannot be discounted.

Advice — All should be aware of the possibility of NOA. If asbestiform and/or indicator minerals and/or textures are encountered, specialist geological advice should be sought.

Areas with no potential shown

Areas without polygons have been assessed with the lowest potential for NOA within about 10 metres below the natural surface. However, importantly, a few NOA occurrences are present in these areas — any unidentified occurrences are likely very small or in areas where geological mapping is coarse.

Advice — Potential of NOA is very low. If asbestiform and/or indicator minerals and/or textures are encountered, specialist geological advice should be sought.

NSW councils identified as high, medium or low potential NOA areas

High potential areas	Medium potential areas	Low potential areas
Blayney Shire Council	Bathurst Regional Council	Bega Valley Shire Council
Broken Hill City Council	Bellingen Shire Council	Bombala Council
Bogan Shire Council	Cooma-Monaro Shire Council	Central Darling Shire Council
Cabonne Council	Lachlan Shire Council	Cobar Shire Council
Clarence Valley Council	City of Lithgow Council	Cowra Shire Council
Cootamundra Shire Council	Mid-Western Regional Council	Eurobodalla Shire Council
Gloucester Shire Council	Oberon Council	Forbes Shire Council
Greater Taree City Council	Snowy River Shire Council	Guyra Shire Council
Gundagai Shire Council	Weddin Shire Council	Kempsey Shire Council
Gwydir Shire Council		Nambucca Shire Council
Harden Shire Council		Palerang Council
Junee Shire Council		Parkes Shire Council
Narromine Shire Council		Wellington Council
Orange City Council		Yass Valley Council
Port Macquarie-Hastings Council		
Tamworth Regional Council		
Tumbarumba Shire Council		
Tumut Shire Council		
Unincorporated Far West Region		
Upper Hunter Shire Council		
Walcha Council		
Young Shire Council		

Other geological data related to potential for NOA

Faults

There is also a close physical association between NOA and major fault structures that are mapped at or near the surface which was taken into account. However, as many faults are interpreted and not directly evident on the ground they were not directly used to attribute

potential NOA. Rather, the lithological units they juxtapose were attributed with potential. Only a few faults were attributed in this assessment and these have been merged with polygon data.

Near surface sedimentary cover

Overall, near surface sediments have low potential for NOA and therefore, they have not been systematically mapped in this assessment. However, in areas where sediments thinly cover rocks with high potential there is the possibility that fibres may persist (McConnochie et al. 1987). Therefore, in some such areas surface sediments have been assessed and in some cases attributed potential.

Petrological observations

Petrological observations reflect sites where asbestos, asbestiform minerals and fibrous chrysotile, and tremolite have been identified by government geologists (Appendix III). Note: these sites are a guide only, NOA may not be present on the surface, may be present in insignificant amounts and should be considered unconfirmed, with further investigation recommended.

Appendix III Petrological observations

Petrological observations by government staff stored in the PETROCKS database held by Geological Survey NSW proved useful in this assessment. The data reflects sites where chrysotile and fibrous tremolite have been identified within sections (Appendix III). Preliminary checking of these sites was completed in this assessment using ARCGIS against mapped geology, MetIndex and data stored in DIGS.
www.resourcesandenergy.nsw.gov.au/miners-and-explorers/geoscience-information

Appendix IV Glossary of geological terms

(simplified for the purposes of this study)

Cainozoic — The Epoch of the geological time scale after the Mesozoic. Has been used in this study to refer to all rocks and sediments younger than about 65 million years.

Fault — A fracture in rocks with an observable amount of displacement. Interpreted faults describe suspected faults that cannot be demonstrated on the ground.

Geodatabase — A common data storage and management format used by GIS platforms including ARCGIS for spatial data. It combines "geo" (spatial data) with "database" (data repository) to create a repository for spatial data storage and management.

GIS — Geographic information system, a system for storing and manipulating geographical information on computer.

Lithology — Loosely means the rock type — usually based on the description rock of larger rock samples rather than microscopic observations.

Lithostratigraphic — is a sub-discipline of stratigraphy, the geological science associated with the study of strata or rock layers.

Line data — A vector format storing linear data in GIS formats.

Mesothermal — Fluids and rocks at intermediate temperatures in Earth's crust — for geological purposes in this study about 200 – 500°C.

Mafic — Describes ferrogmagnesian minerals (rich in iron and magnesium). "Mafic" is also used as general term applied to rocks rich iron and/or magnesium, but less so than ultramafic rocks. The term melanocratic more correctly describes such rocks which are typically rich in ferromagnesian minerals.

Naturally occurring asbestos — (NOA) is asbestos and asbestiform minerals that are natural in origin. For the purposes of this study the term refers to material which in situ — or in its natural location. Thus, it excludes any material quarried or otherwise moved by humans such as material used as road base or present in stockpiles.

Palaeozoic — Part of the geological time scale that includes the Cambrian, Ordovician, Silurian, Devonian, Carboniferous and Permian periods (about 650–250 million years ago).

Peridotite — a series of mafic to ultramafic rocks derived from Earth's mantle that contain iron and magnesium-rich minerals such as olivine and pyroxene.

Petrology — The study of rock in all their aspects including mineralogy, textures and structures. Typically involves the examination of rocks using special petrological microscopes that pass light through a thin section.

Petrological — The study of rocks, of petrology.

Point data — A vector format for storing point data on a computer using GIS.

Proterozoic — The aeon of the Geological Time scale that includes the Neoproterozoic and Palaeoproterozoic between the Archaen and Palaeozoic from about 2500 to 650 million years ago.

Serpentinisation — The process of converting serpentine (a magnesian silicate) into serpentinite. The process involves hydrothermal fluids that pass through and react with the rock at mesothermal temperatures.

Shape file — An ESRI™ proprietary database format for spatial data which has become a de-facto standard for spatial data exchange.

Silicate minerals — The most important and abundant group of compounds in the crust of the Earth if the Silica (SiO2) group is included. They may be regarded as being derived from the unit SiO4 with various chain linkages.

Stratigraphy — The branch of geology concerned with the order and relative position of strata and their relationship to the geological timescale.

Thin section — A thin slice of rock (usually 30 µm thick) mounted on a glass slide used by geologists, mineralogists and petrologists to observe rocks in detail under transmitted and reflected light.

Ultramafic (or ultrabasic) rocks — are typically dark rocks rich in magnesium and iron with relatively low silica and potassium. These rocks are composed mostly of minerals such as olivine and pyroxene and rock types include dunites, lherzolites and harzburgites.

Appendix V map and GIS data

Appendix V includes all GIS data sets utilised to construct the polygons where the potential for the naturally occurring asbestos to occur has been identified based on this assessment. In order to access this data go to www.resourcesandenergy.nsw.gov.au/miners-and-explorers/safety-and-health/topics/NOA