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# Wollastonite in Tasmania: an update

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# Abstract

Wollastonite occurrences in Tasmania are widespread and variable in nature, but are found mostly in skarns related to Devonian granite. The best potential for wollastonite in Tasmania is in contact metamorphosed Ordovician siliceous limestone and calcareous sandstone, although other deposit types are known.

Testing of bulk material from the Kara deposit indicates that it is suitable for beneficiation.

# Introduction

Following an approach by Peter Barrett, an industrial minerals dealer of Victoria, Jon Everett, then of Tasmania Development and Resources, and the author reassessed the potential for commercial wollastonite in Tasmania. There appears to be a shortage of this material in Australia, with an increasing demand. Prices for refined wollastonite products are up to \$500-\$600/tonne. The material is imported into Tasmania for use in the TEMCO metallurgical works at Bell Bay.

A previous report on wollastonite in Tasmania (Bacon and Bottrill, 1988) is partly updated here.

Wollastonite (CaSiO<sub>3</sub>) is a white fibrous calcium silicate formed mostly in thermally metamorphosed limestone. It is used in many applications, including as a whitener, filler, abrasive, flux, and particularly as a reinforcing agent. It has become increasingly important as an asbestos substitute in reinforcing uses as it has similar physical properties to asbestos but no known epidemiological problems.

# **Tasmanian deposits**

Wollastonite occurrences in Tasmania are widespread and variable in their nature, but are found mostly in skarns related to Devonian granites. The known occurrences (fig. 1) are summarised below.

## Devonian calcic skarns

Wollastonite is common where siliceous limestone has been intruded and contact metamorphosed by Devonian granite, as at Moina, Kara and Mt Lindsay. It is abundant in a calcite-wollastonite-diopside-feldspar skarn at Wollastonite Creek near the Kara mine at Hampshire (Thomas and Henderson, 1943; Longman, 1962; Bacon and Bottrill, 1988), and is found in association with pyroxenes at Highwood, in the same area. It was reported from the Shepherd and Murphy Sn-W-Bi-Au mine, in the Moina skarn, as forming a wollastonite-garnet rock (Jennings, 1979; Twelvetrees, 1908). Wollastonite skarns in the area contain up to about 80% wollastonite (Kwak and Askins, 1981). The above occurrences are in 'Transition Beds', siliceous limestones in the lower parts of the Ordovician Gordon Group. In the Mt Lindsay area, near Waratah, wollastonite is recorded as an abundant mineral in skarns with magnetite and garnet, in limey parts of the Neoproterozoic Crimson Creek Formation (Reid, 1927).

#### Devonian magnesian skarns

Wollastonite is less common where dolomite has been intruded and contact metamorphosed by igneous intrusive rocks. Wollastonite was reported from the Mt Bischoff (Waratah) and Tenth Legion (Zeehan) skarns, both magnesian skarns formed in Precambrian dolomite intruded by Devonian granite (Groves *et al.*, 1972; Kwak, 1987). Everard (1964) reported wollastonite from the Cleveland mine at Luina. At the Razorback tin mine at Dundas, hosted mostly by serpentinite and altered dolomite, wollastonite is one of the main gangue minerals (Purvis, 1980). Little is known of the distribution of wollastonite in any of these dolomite-related deposits, but it probably does not form major deposits.

## Jurassic skarns and calc-silicate hornfels

Wollastonite also forms by the contact metamorphism of Permian calcareous mudstone by Jurassic dolerite at many locations in Tasmania. It occurs as replacements of fossils and in rare coarse patches in quarries off Proctors Road at Hobart (Keid, 1950; Everard, 1950; Hughes, 1957), while brachiopods in impure limestone at Glenorchy have been similarly replaced by wollastonite (Hughes, 1957). It is present as coarse-grained, white, massive to fibrous material



**Figure 1** *Map of Tasmania, showing wollastonite occurrences.* 

with grossular, hedenbergite and calcite in a drill hole at Variety Bay on Bruny Island (Bottrill, 1995) and at Fossil Cove, near Blackmans Bay.

It is also present with xonotlite, quartz and diopside in altered Precambrian dolomite marble and skarn, intruded by Jurassic dolerite near Glovers Bluff in the Huon Valley (Bottrill and Woolley, 1997). The distribution of wollastonite in these deposit types is erratic and its proportion is probably always less than 10%.

Wollastonite was reported from Ordovician limestone intruded by Jurassic dolerite near Lake Sydney (Correy, 1983); little is known of this occurrence.

These Jurassic deposits may be locally moderately rich in wollastonite, but are mostly very impure and small, because the Jurassic dolerite metamorphic aureoles are mostly very limited in size.

## Other

Wollastonite was reported from hornfelsed fossiliferous mudstone intruded by Cretaceous porphyry south of Mt Windsor (Leaman and Naqvi, 1968). This occurrence is probably similar in nature to the Jurassic occurrences in Permian limey calcareous mudstone described above.

Wollastonite was also reported in small amounts in altered basaltic and gabbroic rocks on Macquarie Island (B. D. Goscombe, pers. comm.).

# **Mining potential**

The major known deposit in Tasmania is at Wollastonite Creek, near the Kara mine at Hampshire in northwest Tasmania. None of the other deposits have received much mineral exploration attention for wollastonite, consequently their reserves and grades are unknown. Another calcic skarn in Ordovician limestone at Moina has some rich wollastonite concentrations and thus high potential. The Mt Lindsay skarns and dolomite skarns are poorly studied but probably have low concentrations and thus rather low potential. The Parmeener-hosted deposits, such as that at Bruny Island, contain some good quality material but have limited size potential. The best potential appears to be in contact metamorphosed parts of the 'Transition Beds', the siliceous limestone in the lower parts of the Ordovician Gordon Group, as at Kara and Moina.

# The Kara Deposits

It has long been known that a large wollastonite deposit lies near Wollastonite Creek (formerly known as Limestone Creek) near the Kara tungsten-magnetite mine, where it occurs with calcite, diopside, feldspars and quartz in calcic skarns (Bacon and Bottrill, 1988; Appendix 1). This deposit was first noted by Thomas and Henderson (1943), although Petterd (1910) recorded wollastonite in the Hampshire Hills, perhaps referring to the same deposit. Further studies were reported by Hughes (1950) and Longman (1962). Reserves are unknown but Longman (1962) estimated about one million tonnes of wollastonite ore while Everett and Shaw (1985) estimated 1-2 Mt @ 30-40% wollastonite. A drilling program to evaluate the resource was not completed, being confined to nine shallow percussion holes and two diamond-drill holes at three of the known deposits (Anon., 1990). These holes were encouraging, with some petrological studies and partial analyses suggesting most contained abundant wollastonite (up to 70%) throughout the holes (from 9 to 40 m in depth). As the results were not finalised, they have not been used to upgrade the earlier reserve estimates and more drill testing with mineralogical evaluation of the deposits is required.

Some test work was done on the beneficiation of this material by the Department of Mines laboratories, AMDEL and The Mineral Sands Consultancy. The Department of Mines tests indicated that the wollastonite ore could be upgraded to about 94% wollastonite by a combination of magnetic separation and flotation (Anon., 1990). Similar tests by The Mineral Sands Consultancy and AMDEL failed to reach this grade, producing concentrates with about 57 and 70 mass% wollastonite (Anon., 1990). More recent test work is discussed below.

# **Recent geological investigations**

A short visit was made to the Kara mine area to investigate the wollastonite occurrences and collect samples for further testing, with Cliff Whitehead (formerly mine geologist at Kara) and Barry Mollison and Kevin Pinder of the Kara mine. Samples were collected from the main outcrop on Wollastonite Creek (site A: 399 900 mE; 5 428 200 mN), and from two skarn outcrops further south (site B: 399 800 mE; 5 426 900 mN and site C: 399 500 mE; 5 426 400 mN) (fig. 2). A small bulk sample (~15 kg) was collected from the main deposit. A sample of white skarn from drill core from Natone (near AMG 410 000 mE; 5 442 000 mN) was also collected. Another occurrence reported to lie west of the Kara Road (~398 700 mE; 5 426 250 mN) was not examined.

The samples were analysed by X-ray diffraction (XRD) and optical microscopy. The samples of white to bluish calcic skarn from the main deposit contain about 25–70% wollastonite, in accord with previous work. Pink quartzo-feldspathic skarn associated with the calcic skarn contains 5–10% wollastonite. One of the southern deposits (site C) contains about 50% wollastonite, the other (site B) <5% wollastonite. The Natone skarn is visually similar but the sample tested contained no detectable wollastonite. The sample descriptions are included as Appendix 1.

The wollastonite in both deposits is medium to coarse grained ( $\sim 0.5-5$  mm), and contains some metallurgically undesirable inclusions of diopside



# **Figure 2** Wollastonite Creek deposits

(0.02–0.1 mm), calcite (0.02–10 mm), and lesser feldspar (~0.02–0.1 mm) and quartz (~0.02–0.2 mm). The diopside inclusions represent the biggest problem. Their removal will require extensive comminution, which will decrease the final grain size and increase processing costs.

## Metallurgical test work

In 1997 some of the samples collected from Wollastonite (Limestone) Creek during this investigation were submitted to Oretest Pty Ltd for beneficiation test work (Anon., 1997). This showed that the head sample contained about 20% wollastonite and 80% calcite, and after grinding to 80% passing 75  $\mu$ m and flotation, a concentrate containing about 96% wollastonite could be produced. Fibres (length/width ratio of >3:1) comprised about 70% of the concentrate. Despite this good result the management of Tasmania Mines considered that the large investment in plant needed for treating the wollastonite ore could not be economically justified. The petrology of the head sample is described in Appendix 1.

#### Conclusions

The best potential for wollastonite in Tasmania is in contact metamorphosed Ordovician siliceous limestone and calcareous sandstone, although other deposit types are known.

The major known deposit in Tasmania is at Wollastonite Creek near the Kara mine at Hampshire in northwest Tasmania. The bulk material from this deposit is variable in composition but is typically 20–50% wollastonite. Test work indicates it is suitable for beneficiation, producing a product with about 96% wollastonite.

It is worth noting that the Kara deposit is well situated with regards to infrastructure. Good road and rail links are close at hand; it is only 30 km from the port of Burnie, and is situated in a recently logged forestry area close to existing mining operations.

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# **Appendix 1**

# Mineralogy and petrography of some wollastonite skarns, northwest Tasmania

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## Introduction

Nine samples of skarn from the Kara mine area in northwest Tasmania were collected and studied for their wollastonite content. The details of the sample are shown in Table 1.

#### Preparation

The rocks were prepared as polished thin sections and examined by transmitted and reflected, polarised light microscopy. They were also crushed and analysed by XRD (Table 2).

Sample G402493 was used for the mineral processing tests (Anon., 1997).

#### **Results**

#### Sample G400325: wollastonite-calcite skarn

In hand specimen this rock is white, massive and medium to fine grained. It contains about 60% wollastonite, in prismatic crystals and plumose aggregates to about 2 mm length, poikiloblastic with inclusions of diopside and quartz (fig. 1).

Diopside (~5%) occurs as amoeboid to subrounded, poikiloblastic grains up to 0.2 mm in size. Calcite (~30%) occurs as blebs, clasts and possible dismembered veins or elongate fossils (<1 mm), and as subrounded inclusions in wollastonite, up to 0.05 mm in size. There is minor feldspar (~2%; including both anorthite and albite) as very fine-grained brown aggregates less than 0.05 mm in grain size. Accessories (<2%) include small grains of disseminated pyrrhotite, chalcopyrite, sphene and amphiboles. It appears that more calcitic clasts or fossils (to a few millimetres) are enclosed in a wollastonite-rich matrix, and the rock may have originally contained limestone clasts or fossils in more siliceous matrix.

#### G400326A: Calcite-wollastonite skarn

In hand specimen this rock is medium to fine grained and is banded with pink and white layers. The white part of the rock is described as G400326A with the pink part described as G400326B.

The white part contains about 30% wollastonite, in prismatic crystals to about 2 mm length, poikiloblastic with inclusions of diopside and quartz. Calcite (~60%,

| Table 1   Sample details |                                    |                           |                                  |  |  |  |  |  |  |
|--------------------------|------------------------------------|---------------------------|----------------------------------|--|--|--|--|--|--|
| Reg. No.                 | Sample name                        | AMG Ref                   | Location                         |  |  |  |  |  |  |
| G 400325                 | Wollastonite skarn                 | 397 200 mE, 5 425 700 mN  | Wollastonite Creek, Longman's W2 |  |  |  |  |  |  |
| G 400326                 | Wollastonite skarn                 | 397 200 mE, 5 425 700 mN  | Wollastonite Creek, BH520        |  |  |  |  |  |  |
| G 400335                 | Wollastonite skarn                 | 397 200 mE, 5 425 700 mN  | Wollastonite Creek               |  |  |  |  |  |  |
| G402489                  | Wollastonite skarn                 | 399 900 mE, 5 428 200 mN  | Wollastonite Creek               |  |  |  |  |  |  |
| G402490                  | Quartzo-feldspathic hornfels       | 399 800 mE, 5 426 900 mN  | Valentines Farm                  |  |  |  |  |  |  |
| G402491                  | Quartz-wollastonite skarn/hornfels | 399 500 mE, 5 426 000 mN  | Kara Road, near main pit         |  |  |  |  |  |  |
| G402492                  | Tremolite skarn                    | ~410 000 mE, 5 442 000 mN | Natone DDH2, 466'6"              |  |  |  |  |  |  |
| G402493                  | Wollastonite skarn, banded         | 399 900 mE, 5 428 200 mN  | Wollastonite Creek               |  |  |  |  |  |  |
| G402494                  | Skarn                              | 399 900 mE, 5 428 400 mN  | Wollastonite Creek (north)       |  |  |  |  |  |  |
| G402495                  | Wollastonite skarn                 | 399 900 mE, 5 428 200 mN  | Wollastonite Creek               |  |  |  |  |  |  |

#### Table 2 XRD analyses

| Reg. No. | wollastonite | pyroxene | calcite | quartz | K-feldspar | Plagioclase | Amphibole | Other                |
|----------|--------------|----------|---------|--------|------------|-------------|-----------|----------------------|
| G402489  | ***          | ***      | **      |        | ?          | ?           |           |                      |
| G402490  |              | ***      |         | ***    | ***        | ***         | 5         | scapolite, prehnite? |
| G402491  | ***          | ***      |         | ***    | ***        | ***         |           |                      |
| G402492  |              | ***      | **      | *      | **         | **          | ***       |                      |
| G402493a | ***          | ***      |         |        | ***        | **          |           | ?smectite            |
| G402493b |              | ***      |         | ***    | ***        | ***         |           | ?mica                |
| G402495  | **           | **       | ***     | *      | **         | **          |           |                      |

(\*\*\* Major, \*\* minor, \* trace)

<1 mm) comprises the bulk of the rock, and also occurs as subrounded inclusions in wollastonite, up to 0.05 mm in size. Coarser-grained calcite-rich patches could represent fossils and/or clasts. Diopside (~5%, <0.2 mm) occurs as amoeboid to subrounded grains mostly as inclusions in wollastonite. There are minor feldspars (~1%; including both anorthite and albite) as murky fine grained aggregates and disseminated, subrounded grains less than 0.05 mm in size. Accessories (<2%) include small grains of disseminated pyrrhotite, leucoxene, sphene, zircon, epidote and amphiboles.

## G 400326B: Quartz-feldspar-wollastonite hornfels

This rock contains about 20% wollastonite in prismatic crystals to about 0.3 mm in length. The rock is dominated by very fine-grained quartzo-feldspathic material. Feldspars (~40%), including both K-feldspar and albite, are less than 0.05 mm in grain size. Quartz (~30%) occurs as subangular-rounded (detrital?) grains up to 0.1 mm in size. Calcite (~5%) occurs as subrounded inclusions in wollastonite, up to 0.05 mm in size. Diopside (~5%, <0.2 mm) occurs as amoeboid to subrounded grains. Accessories (<2%) include small grains of disseminated diopside, pyrrhotite, sphene, zircon and epidote.

# Sample G 400335: wollastonite-calcite skarn

In hand specimen this rock is white, massive and medium to fine grained. It contains about 70% wollastonite, in prismatic crystals and plumose aggregates to about 2 mm length, poikiloblastic with inclusions of diopside and quartz. Diopside (~5%) occurs as amoeboid to subrounded, poikiloblastic grains up to 0.2 mm in size. Calcite (~20%) occurs as blebs, clasts and possible dismembered veins or elongate fossils (<1 mm), and as subrounded inclusions in wollastonite, up to 0.05 mm in size. There is minor feldspar (~2%; including both anorthite and albite) as very fine-grained brown aggregates less than 0.05 mm in grain size. Accessories (<2%) include small grains of disseminated pyrrhotite.

## G402489: Wollastonite-diopside skarn

In hand specimen this rock is bluish white, massive and fine to medium grained. This rock contains about 70% wollastonite, in prismatic to equant crystals to about 5 mm length, poikiloblastic with inclusions of diopside and quartz. Diopside (~15%) occurs as subrounded grains mostly as inclusions in wollastonite, up to 0.2 mm in size. There are patches of quartz (~10%, detrital?) as subrounded grains, also mostly in wollastonite and less than 0.2 mm in size. There are some small grains of disseminated pyrrhotite (~5%), traces of calcite (veinlets?) and of zircon, leucoxene and possibly feldspar. This sample is variable in grain size, with a possible breccia texture.

# G402490: feldspar-pyroxene hornfels

In hand specimen this rock is pink, fine grained and has patchy, weak lamination. The bulk of the rock comprises diopside (~50%) and feldspars (~30%, K-feldspar and plagioclase), as fine to very fine-grained material (<0.1 mm). Quartz (~10%) occurs as subrounded (detrital) grains up to 0.2 mm in size. There are some small grains of disseminated pyrrhotite (~5%) and traces of calcite. No wollastonite was detected but there is some possible prehnite and scapolite in patches (altered fossils?).

# G402491: wollastonite skarn /hornfels

In hand specimen this rock is mottled grey, massive and fine to medium grained, and contains quartzo-feldspathic and wollastonite-rich skarn bands or patches. Overall the rock contains about 50% wollastonite, in prismatic crystals to about 2 mm length, poikiloblastic with inclusions of diopside and quartz. Diopside (~10%) occurs as irregular grains, up to 0.1 mm in size, in both quartzo-feldspathic bands and as inclusions in wollastonite. There are patches of quartz (~30%) as subrounded, detrital grains, also mostly in wollastonite and less than 0.2 mm in size. Feldspar (~10%) occurs as fine-grained patches (<0.1mm). There are abundant small grains of disseminated pyrrhotite (<5%, <0.2 mm) mostly in quartzo-feldspathic laminae) and traces of calcite and clinozoisite.

# G402492: tremolite-diopside skarn

In hand specimen this rock is mottled grey, massive and fine to medium grained. Despite resembling the wollastonite skarns in hand specimen, it contains no detectable wollastonite. The rock is banded or zoned, from a quartz arenite to diopside, feldspar and tremolite-rich zones. Tremolite ( $\sim$ 30%) occurs as fibrous, coarse-grained masses and crystals up to 2 mm in length and intergrown with (and altering to?) calcite. Diopside ( $\sim$ 10%) occurs as coarse grains up to 2 mm in size. Quartz ( $\sim$ 50%) represents a recrystallised quartz arenite or quartzite about 0.2 mm in grain size. Feldspar ( $\sim$ 5%) occurs as fine-grained patches (<0.1 mm). Calcite comprises about 5%. There are abundant small grains of sphene.

# G402493: feldspar-pyroxene hornfels

In hand specimen this rock is banded, pink and grey and is fine to medium grained. It contains bands of medium to coarse-grained diopside, wollastonite and quartz alternating with bands of fine-grained quartz, diopside and feldspars. The sample contains about 10% wollastonite, as prismatic crystals to about 5 mm length in patches, and bands to ~5 mm across. The crystals are highly poikiloblastic with inclusions of diopside and quartz. Diopside (~30%) occurs as irregular grains to ~1 mm in size, some highly poikiloblastic with inclusions of quartz. Feldspars (K-feldspar and plagioclase, ~30%) are fine to very fine grained (<0.1 mm) and quartz (~20%) occurs as



### Figure 3

Wollastonite skarn, showing prismatic, poikiloblastic wollastonite (W) crystals about 1 mm long, with calcite  $\bigcirc$  ) and diopside. Sample G400325, cross polarised light, field of view:  $0.7 \times 0.5$  mm.

subrounded, detrital? grains up to 0.2 mm in size, and also minor veinlets. There are some small grains of disseminated pyrrhotite ( $\sim$ 5%) and calcite ( $\sim$ 5%) and traces of clinozoisite and sphene.

#### G402495: wollastonite-diopside skarn

In hand specimen this rock is white, massive and fine to medium grained. It contains about 50% wollastonite, in prismatic crystals to about 5 mm length, poikiloblastic with inclusions of diopside and quartz. Calcite (~30%) occurs as patches and veins (<2 mm), and as subrounded inclusions in wollastonite, up to 0.05 mm in size. Diopside (~15%) occurs as subrounded grains mostly as inclusions in wollastonite, up to 0.1 mm in size. There are patches of quartz (~5%, detrital?) as subrounded grains, also mostly in wollastonite and less than 0.2 mm in size. Feldspar (<5%) occurs as fine-grained patches (<0.1mm). There are abundant small grains of disseminated pyrrhotite (<5%, <0.2 mm) mostly in quartzose laminae.

#### Summary

The assemblages reported here are typical of those resulting from granite-related contact metamorphism of siliceous limestone and are mostly a mixture of wollastonite-calcite skarn and quartzo-feldspathic hornfels. The rounded quartz, plus zircon, sphene and other detrital minerals suggests that the silica contributing to the formation of wollastonite may have largely been an original rock component. The feldspathic layers were probably originally clayey layers. The diopside may derive from original dolomitic carbonates or magnesian clays, but may also result, in part, from the hydrothermal introduction of iron and magnesium. The wollastonite-rich skarns were thus probably derived from impure, variably sandy to clayey and dolomitic limestone, contact metamorphosed by the underlying granite to form wollastonite-rich skarns and hornfels.