DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY
ENVIRONMENT AND RESOURCE DIVISION

WOLLASTONITE AT ETHIUDNA

OLARY PROVINCE

By

J.G. OLLIVER
SENIOR GEOLOGIST

INDUSTRIAL MINERALS SECTION

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ABSTRACT

Wollastonite ($CaSiO_3$) is a mineral with a wide and increasing range of uses. U.S.A. is the world's major producer and consumer.

At Ethiudna in the Olary Province, wollastonite is associated with diopside, calcite, quartz and feldspar in the Ethiudna Calc Silicate Group, part of the Willyama Complex of Carpentarian age. This occurrence is similar to the two major operating mines in U.S.A. and Finland.

Mapping and sampling are required at Ethiudna to determine extent and grade of wollastonite bearing rocks.

INTRODUCTION

Wollastonite is a naturally occurring calcium silicate ($CaSiO_3$), with a theoretical composition of 48.3% CaO and 51.7% SiO_2. Although a constituent of many rock types, few workable deposits are known.

Wollastonite is usually found as aggregates of white, bladed or needle-like crystals with a vitreous to pearly lustre. Hardness is 4½-5 on Mohs scale, specific gravity 2.87-3.09 and melting point about 1540°C.

The deposit was investigated for base metal in 1951 (Campana & King, 1954) when tremolite was recorded. Subsequently J.E. Johnson (former Field Assistant S.A.D.M.) recognised wollastonite.

The only other record of wollastonite in South Australia is from section 116, Hd. Minbrie near Cowell.

Ethiudna is 5 km west of Plumbago Homestead and 83 km by road north of Yunta (see Locality Plan, Fig. 1). On 27th August, 1974, a suite of six samples were collected by the author and M.N. Hiern (Supervising Geologist, Environment and Resource Division). Petrographic descriptions of these samples by AMDEL are appended. Chemical analyses, x-ray diffraction analysis and physical testing of a selected sample are incorporated in this report.

USES

Wollastonite has a wide range of uses as listed below, which have been developed only over the last 20 years.

Ceramics - particularly wall tiles and dinner ware. Wollastonite has a brilliant permanent white colour and offers the following advantages over kaolin, talc etc.

- improved bonding through drying and pressing.
- high strength in both green and fired stages.
- low moisture expansion of fired body (maximum moisture content of wollastonite is 4%).
- less firing time.
- specific shapes for electrical insulators such as spark plugs can be produced by either dry or wet pressing.

Glazes

Wollastonite based glazes

- flow over the body with minimum interaction because fusion point of the glaze is below maximum firing temperature of body.

- improved spraying characteristics due to lower viscosity of glaze.
- avoid crazing, coefficient of expansion of glaze approximates that of body.
- are high compression glazes.
- have no harmful gas emissions, ignition loss being less than 1%.

Paints

Wollastonite is used as an extender in both oil and water - based exterior emulsion paints and in latex paints, road-making paint and caulking compounds due to

- pure white colour.
- acicular nature provides good flattening qualities.
- low oil absorption reduces amount of binder required.
- alkalinity of suspension gives better colour dispersion, makes steel less susceptible to corrosion and neutralises any acids formed by decomposition of polyvinyl acetate paints.

Plastics

Wollastonite's use as a functional filler in plastics and rubber is a new development based on good electrical and dielectric properties and favourable flexural and tensile strength, impact resistance and flex modulus.

The need for fillers has been strengthened by the quadrupling of the price of oil, the basic raw material for plastics, in 1974.

Asbestos Replacement

Asbestos has dangers to health and new laws in U.S.A. covering the use of asbestos products, have resulted in its replacement by wollastonite in

- vinyl-asbestos systems, particularly caulking compounds.
- sealants.
- joint cements.
- casting plaster.
- roofing compounds.

Abrasives

High thermal shock resistance and low coefficient of expansion enable up to 20% wollastonite to be included in ceramic bonded abrasives particularly wheels, stones, emery paper and industrial pumice.

Wollastonite replaces whiting as a source of CaO in silicon carbide wheels and being a silicate does not attack the silicon carbide grains.

Glass

Wollastonite may replace limestone and sand as a source of lime and silica and is included in fibre glass to improve the surface. In glass making, wollastonite requires significantly less heat than limestone i.e. much less wollastonite than limestone is required to produce the same amount of melt.

Other uses

Wollastonite reduces raw material cost with no detrimental effect on the finished product in the following

- asphalt and vinyl floor tiles.
- polyesters.
- epoxy resin compounds.
- mild scouring agents and dental cleaners.
- replacing phosphates as a lining material in the fertiliser industry.
- substituting for alpha cellulose and wood flour in the manufacture of plywood.
- safety element in matches.
- certain adhesives.
- cold-setting insulating foams.
- load-bearing refractories.
- wall-board requiring good acoustical and fire resistant properties.

WORLD SOURCES

Most of the world's production is obtained from one mine in U.S.A. and one mine in Finland. Other producing countries in recent years have been Mexico, India and Kenya. (See Table 1, adapted from Fleming, 1975). The U.S.A. is, by far, the major producer and consumer of wollastonite.

TABLE 1

Production of Wollastonite (tonnes)

	1969	1970	1971	1972	1973
U.S.A. (estimated)	30 000	40 000	50 000	60 000	60 000
Finland	5 200	6 051	10 399	6 491	6 547
Kenya	690	100	-	-	55
India	448	576	2 042	3 326	476
Mexico	4 567	6 562	3 224	559	1 593

U.S.A.

More than 80% of annual world output of almost 70 000 tonnes in 1973 was produced at the Fox Knoll Mine near Willsboro, New York State, U.S.A.

Expansion to a capacity of 100 000 tonnes per year is in progress. However, with the discovery of new uses for wollastonite, demand is expected to exceed supply.

Standard room and pillar mining methods are used at Willsboro to a depth of 244 m below surface. Proved reserves containing 55-65% wollastonite total 7 million tonnes with a further 10 million tonnes classed as probable reserves. Wollastonite is associated with garnet and diopside in bands within Precambrian limestone. Crude wollastonite rock is crushed, milled and upgraded by magnetic separation of garnet and diopside followed by flotation of quartz and calcite.

FINLAND

The other major operating mine in the world is at Lappeenranta in south-eastern Finland.

Plant capacity of 12 000 tonnes per year will be boosted by further extensions to 40 000 tonnes per year.

Mining is by conventional open cut operation except that blasted material is transported underground for primary crushing and hand sorting.

The deposit is a north-south orientated elliptical body about 3 km long by 1 km wide. The wollastonite zone, in the centre of the deposit, extends for about 600 m by 45 m. Drilling indicates a thickness of 45 m giving an estimated 4 million tonnes. Wollastonite content averages 18-20% but, in places, reaches 60%.

Bands of wollastonite and diopside are inter-bedded with calcite, dolomite, leptite (fine grained, granular metamorphic rocks composed mainly of quartz and feldspar) and quartz-bands enclosed in limestone which is completely surrounded by a rapakivi granite.

Crushed rock is wet ground in a rock mill, hydro-cycloned and the calcite flotated. The wollastonite concentrate is then treated in a wet magnetic separator, thickened and vacuum filtered.

PRICES

The latest price of wollastonite, ground and bagged and delivered at European ports is:

from U.S.A. - £ (Sterling) 90 (about $A150)

from Finland - £ (Sterling) 60-70 (about $A100-120).

Domestic price in U.S.A. varies from $U.S.33-44 per tonne ex works depending on quality.

GEOLOGICAL SETTING AT ETHIUDNA

Ethiudna, on Plumbago (Campana, 1956) part of OLARY, is the site of copper, cobalt, nickel and tungsten mineralisation mined during 1889-1908. All productive workings are confined to calc-silicate rocks below a massive quartzite within a sequence of sandstone quartzites, calc-silicate quartzites, minor thin dolomites and mica schists intruded by pegmatites. This sequence is referred to as the Ethiudna Calc-Silicate Group which is part of the Willyama Complex (Campana & King, 1958, p.16-17), now considered to be of Carpentarian age.

Wollastonite is one of the main minerals in the basal calc-silicate unit. Associated minerals in approximate order of abundance are quartz, potash feldspar (microcline), diopside and calcite. Accessory minerals comprise apatite, plagioclase, sphene, iron oxides/hydroxides, zircon and epidote.

The wollastonite bearing beds outcrop at three separate localities viz Main shaft, immediately south of the central workings, and Piper shaft.

Structurally, the area consists of a complex anticline with axis striking east-west and plunging to the east. Small scale folding on the northern limb has contorted the wollastonite bearing beds into three tight overturned anticlines separated by broader synclines (see plan and section A-A', Fig. 1 after Fig. 67 in Campana & King, 1958).

Diamond drillhole EML 1 was drilled in 1951 on an azimuth of 090^{o} magnetic, depressed 45^{o} to a depth of 35 m to test for base-metals. Siliceous marble and "tremolite"-diopside-garnet marble was intersected for 9.6 m in the interval from 13.7 m to 23.3 m (Campana & King, 1954).

SAMPLING

The description of the six samples from 1974, which were collected within 30 m east of the Main Shaft, are summarised below from the Appendix.

Sample No.	Description
P483/74	Pale brown with lesser green banded diopside-wollastonite-microcline-quartz hornfels containing 15-25% wollastonite. The pale brown

	bands are rich in wollastonite and the green bands rich in diopside.
P484/74	Mainly pale brown calcite-wollastonite-diopside hornfels containing 50-60% wollastonite. Although not markedly banded, late stage shearing and fracturing is strongly developed. Light coloured veins and segregations up to 2 mm across and patches of green diopside up to 2 cm are common.
P485/74	Pale brown with green diopside patches up to 1 cm across - a carbonate-wollastonite-diopside hornfels containing 10-20% wollastonite. Weak banding is evident with an even grain size in a particular band but variable between bands.
P486/74	Pegmatitic granite - light coloured, coarsely crystalline consisting essentially of potash feldspar (70-80%) and quartz (15-20%).
P487/74	Light, fine grained weakly foliated diopside and carbonate-bearing metaquartzite containing no wollastonite.
P488/74	Selected wollastonite rock consisting of pale grey prismatic crystals several cm long.

MINERALOGY OF THE WOLLASTONITE

Wollastonite from Ethiudna is colourless to pale grey and predominates in the brown layers of the calc silicate beds. The crystals are stumpy to elongate and xenoblastic to subidioblastic prisms (see Appendix). Hand selected wollastonite rock (P488/74) consists of interlocked crystals 0.5 to 1 cm across and up to 5 cm long. Freshly broken surfaces are slightly lustrous whereas weathered surfaces are dark grey stained with iron and manganese oxides/hydroxides and pitted and corroded with cavities up to several mm deep.

The wollastonite is altered in places and contains inclusions of carbonate and quartz and also carbonate and iron oxide/hydroxide along fracture and cleavage planes. The presence of silica and calcite has been confirmed by electron-probe micro analysis of sample P488/74.

Under the microscope, Ethiudna wollastonite displays:

- typically straight or slightly oblique extinction,
- first order interference colours,
- a biaxial negative interference figure,
- moderately small 2V,
- relief higher than quartz and feldspar but lower than diopside.

CHEMICAL COMPOSITION

Chemical analysis of selected wollastonite from Ethiudna is compared in Table 2 with average commercial grade material produced from Willsboro, New York, U.S.A. and Lappeenranta, south-eastern Finland (Andrews, 1970, p.3) and theoretical pure wollastonite. Wollastonite is $CaSiO_3$ but generally there is some substitution of Ca by Fe and Mn and to a lesser extent by Mg.

TABLE 2

Chemical Analysis of Wollastonite

	Ethiudna P488/74	Willsboro U.S.A.	Lappeenranta Finland	Theoretical
SiO_2	47.23	50.90	47.79	51.7
Al_2O_3	0.06	0.78	0.62	-
Fe_2O_3	0.23	0.64	0.47	-
FeO	0.21	n.d.	n.d.	-
CaO	44.22	46.82	45.07	48.3
MgO	0.12	0.85	0.71	-
Na_2O	0.01	0.08	0.05	-
K_2O	0.03	n.d.	0.05	-
TiO_2	0.01	0.08	n.d.	-
MnO	0.30	0.20	n.d.	-
P_2O_5	0.06	n.d.	n.d.	-
H_2O+	0.97	n.d.	n.d.	-
H_2O-	0.15	n.d.	n.d.	-
CO_2	6.40	n.d.	n.d.	-
TOTAL	99.99	100.35	93.75	100.0

The composition of Sample 488/75 is consistent with the wollastonite standard used for electron-probe micro-analysis.

In Table 3, the mineral content of Sample 488/74 is recalculated based on the results of chemical analysis.

TABLE 3

Recalculated Mineral Content

Mineral	%CaO	%SiO_2	%CO_2	Weight %
Wollastonite	36.1	38.6	-	74.7
Quartz & amorphous silica	-	8.6	-	8.6
Calcite	8.1	-	6.4	14.5
TOTAL	44.2	47.2	6.4	97.8

PHYSICAL PROPERTIES

Specific Gravity: 2.91 (determined by pyconometry in tetra-chloroethylene). Theoretical range is 2.87-3.09 (Andrews, 1970).

Hardness: 5 on Moh's scale using a scratch test. Theoretical range is 4.5-5 (Andrews, 1970).

Brightness: A sample was ground to -0.075 mm and measured against standard MgO.

R_{457}	66.9%
R_{570}	74.5%
Yellowness =	7.6%

Brightness for material with 99% passing 0.045 mm is reported as 92-96% G.E. reflectance rating for commercial grade wollastonite (Andrews, 1970).

Fusibility: During determination of pyrometric cone equivalent (P.C.E.), the sample disintegrated at Cone 14 following high shrinkage due to decarbonation of calcite which is intimately associated with wollastonite. Removal of the calcite would be required before the wollastonite would be suitable for ceramic purposes.

CONCLUSIONS

Wollastonite, a calcium silicate-$CaSiO_3$, has formed by metamorphism of impure limestones and calcareous sediments of Carpentarian age at Ethiudna in the Olary Province.

Wollastonite has been used industrially for only 20 years. Higher performances in a wide range of products have been obtained by replacement of traditional minerals such as asbestos, talc, kaolin and silica by wollastonite.

Although major increases in output are planned in the U.S.A. and Finland, demand is expected to outstrip supply.

The occurrence at Ethiudna is similar geologically to the deposits being worked in U.S.A. and Finland. The wollastonite content of the initial samples is comparable to these two deposits. As the wollastonite is contained within an extensive mappable bed that could be worked by open cut methods, the following steps are recommended to establish the possibility of worthwhile deposits of wollastonite in South Australia, particularly in the Olary Province.

(1) Re-examination and testing of drill core from drillhole EML 1.

(2) Detailed mapping and sampling at Ethiudna to outline reserve potential and determine average wollastonite content.

(3) Inspection of other outcrops of Ethiudna Calc-silicate Group in the Olary Province.

(4) Inspection of the occurrence near Cowell and calc-silicate rocks elsewhere in South Australia reported to contain tremolite.

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J.G. OLLIVER
SENIOR GEOLOGIST
INDUSTRIAL MINERALS SECTION

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APPENDIX

PETROGRAPHIC DESCRIPTIONS

extracted from

AMDEL Report MP2336/75

by R. Cooper

Sample: P483/74; TS33279

Location:
Within 100 feet of the main shaft of the Ethiudna Mines, Olary Province.

Rock Name:
Banded diopside-wollastonite-microcline-quartz hornfels.

Hand Specimen:
This rock has a grain size of 1 to 3 mm, and is banded with the bands being typically between 1 and 4 cm thick. The dominant bands are pale brown in colour and contain clots up to 5 mm across of a green mineral which is possibly pyroxene. The intervening bands are pale green in colour and relatively homogeneous. On external exposed surfaces the sample is stained with iron oxide/hydroxides and slightly

pitted/leached for depths up to 5 mm.

Thin Section:

An optical estimate of the constituents gives the following:-

	%
Wollastonite	15-25
Diopside	15-25
Carbonate	2-6
Sphene	1-3
Potash feldspar (microcline)	15-25
Quartz	40-50
?Apatite	trace-1
Plagioclase	trace

This sample although weakly foliated has essentially a granoblastic texture. It is composed principally of quartz but contains in addition significant quantities of wollastonite, diopside and potash feldspar. The grain size is variable but in the pale green bands, which consist principally of quartz, potash feldspar and diopside, most crystals are between 0.1 and 0.5 mm in diameter, whereas in the brown coloured bands, which contain appreciable wollastonite and also some carbonate, the grain size is coarser with crystals ranging in size between 0.2 and several millimetres.

The wollastonite is colourless and occurs typically as stumpy, subidioblastic, prismatic crystals. These crystals typically have straight or slightly oblique extinction, first order interference colours, a biaxial negative interference figure with a moderately small 2 V, and are higher in relief than the quartz and feldspar but lower in relief than the diopside. The wollastonite probably accounts for the brown colouration of some of the bands in this rock.

The diopside occurs as equant to slightly elongate xenoblastic crystals which range in size up to several millimetres across. The larger crystals, those over 1 mm in diameter, are typically slightly poikiloblastic and contain inclusions of quartz. Compared to the wollastonite the diopside is a very pale green colour, has second order interference colours, and is of higher relief. The diopside is probably responsible for the green colouration of some of the bands in the rock and it is aggregates of large poikiloblastic diopside crystals which form the green patches in the brown coloured bands.

Quartz and potash feldspar occur as equant to slightly elongate xenoblastic and subidioblastic crystals which are typically between 0.1 and 0.5 mm in diameter. The quartz is clear and extinguishes evenly whereas the microcline is also clear but has weakly developed cross-hatch twinning. There is also a small amount of plagioclase present, but as the bulk of this is untwinned and is optically very similar to the quartz, the exact proportions could not be determined.

Carbonate occurs in small amounts in equant to slightly elongate subidioblastic crystals which are typically less than 0.5 mm across. In a few instances it is seen as inclusions in the pyroxene and in particular, in the wollastonite. Small droplets and larger idioblastic crystals of sphene, up to 0.3 mm long, are present throughout the rock. A few crystals of an unidentified phase which is optically similar to apatite are present. The largest crystal of this phase was over 1 mm long and subidioblastic in shape.

This rock has pyroxene hornfels mineral assemblage and probably represents a metamorphosed immature sediment composed of alternating marl and arkosic/pelitic layers.

Sample: P484/74; TS33281

Location:
Within 100 feet of Main Shaft, Ethiudna Mines, Olary Province.

Rock Name:
Calcite-wollastonite-diopside hornfels.

Hand Specimen:
This sample is mostly pale brown in colour, has a grain size between 0.5 and 5 mm, and although not markedly banded or foliated appears to have been strongly sheared and fractured at some late stage. The sample contains a number of light coloured veins and segregations some of which are up to 2 mm across and also a number of patches of a green mineral, the largest of which are at least 2 cm across. On exposed external surfaces the sample is pitted and corroded and the rock beneath these surfaces is a darker hue for depths of up to 1 cm.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Diopside	10-20
Wollastonite	50-60
Carbonate	0-10
Quartz	4-8
Feldspar	10-20
Iron oxides/hydroxides	2-4

This sample has a granoblastic texture and is composed of crystals up to several millimetres across. As well as wollastonite the rock also contains appreciable amounts of diopside and feldspar.

The wollastonite is colourless, has lower relief and interference colours than the diopside, and forms elongate xenoblastic and subidioblastic crystals the largest of which are at least 5 mm long. The wollastonite is altered in places with carbonate and iron oxides/hydroxides occuring along fractures and cleavage planes.

The diopside is a very pale green colour, has higher relief than the wollastonite and contains numerous minute inclusions along fractures and cleavage traces.

Carbonate occurs as equant, xenoblastic crystals up to 0.5 mm across the bulk of which are situated along the boundaries of the pyroxene and wollastonite crystals. Similarly situated are the small amounts of quartz and feldspar in the rock.

Along one edge where the sample is heavily weathered the rock is replaced by iron-stained carbonate. This carbonate is finely crystalline and turbid, and differs in these respects from the carbonate in the fresher parts of the rock. Seated in this carbonate are a few crystals of diopside and potash feldspar. The junction between this altered zone and the rest of the rock is fairly sharp and is possibly not entirely due to weathering; there may have been some mineralogical banding in the rock.

This sample although slightly altered/weathered has a pyroxene hornfels mineral assemblage and was probably derived through the metamorphism of a calcareous sediment.

Sample: P485/74; TS33280

Location:
East of and within 100 feet of the main shaft, Ethiudna Mines, Olary Province.

Rock Name:
Carbonate-wollastonite-diopside hornfels.

Hand Specimen:
This sample is very similar to some of the bands in sample P483/74. It consists of grains, or granular aggregates, up to 1 cm across of a green mineral which are seated in a pale brown coloured matrix with a grain size between 1 and 4 mm. There are only the very faintest signs of a foliation and of a mineralogical banding in the rock.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Wollastonite	10-20
Diopside	5-15
Carbonate	3-6
Sphene	1-3
Potash feldspar (microcline)	20-30
Plagioclase?	<5
Quartz	35-45

This sample although weakly foliated has essentially a granoblastic texture. It is composed principally of quartz but in addition contains significant amounts of potash feldspar, wollastonite, and diopside. In thin section a weak mineralogical banding is evident, there being layers which are richer in wollastonite and diopside relative to the leucocratic components. In any particular band the grain size of an individual mineral is fairly even but between bands the grain size of individual minerals can vary considerably. The actual width of the bands varies from less than 1 mm to several millimetres.

The wollastonite occurs as xenoblastic prismatic crystals which range up to several millimetres in length. The wollastonite is colourless, has first order interference colours, and a moderately small biaxial negative interference figure. The crystals of diopside are typically more equant in shape than those of wollastonite and the mineral has slightly higher relief, second order interference colours, and is very pale green in colour. Both minerals appear reasonably fresh although the wollastonite crystals sometimes contain inclusions of quartz and carbonate and the largest diopside crystals are poikiloblastic with inclusions of quartz and carbonate.

The quartz occurs as equant to slightly elongate xenoblastic and subidioblastic crystals and with the potash feldspar forms an interlocking mosaic in the rock. The quartz crystals vary in size from 0.1 mm to 0.4 mm and as already mentioned are relatively uniform in size along any particular band in the rock. The potash feldspar (microcline) occurs as equant to slightly elongate xenoblastic grains in which cross hatch twinning is generally weakly developed. A few crystals of plagioclase were recognized and, as these were untwinned and optically similar to the quartz, the amount of plagioclase present could not be accurately estimated.

Carbonate occurs as elongate subidioblastic crystals, up to 0.4 mm long, which are dispersed throughout the sample. Sphene occurs as droplets and larger idioblastic crystals which are up to 0.3 mm long. No ?apatite was identified in this sample.

This sample is similar to sample P483/74 and has a pyroxene hornfels mineral assemblage. It was probably derived through the metamorphism of an immature weakly bedded calcareous sediment.

Sample: P486/74; TS33282

Location:
East of and within 100 feet of the main shaft of the Ethiudna Mines, Olary Province.

Rock Name:
Pegmatitic granite.

Hand Specimen:
This sample is light coloured, coarsely crystalline, and contains crystals of potash feldspar up to several millimetres across.

Thin Section:
An optical estimate of the constituents gives the following:-

	%
Potash feldspar (perthitic)	70-80
Quartz	15-25
Phyllosilicates (?sericite)	trace-2
Carbonate	trace-2
Unidentified phase(s)	trace

This sample has a highly irregular grain size and an allotriomorphic-granular texture and is composed principally of potash feldspar and quartz.

The potash feldspar occurs as xenomorphic, lath-like crystals the largest of which are at least 2 cm long. The potash feldspar crystals have weakly developed cross-hatch twinning and are perthitic (they contain innumerable small braids and patches of plagioclase). The quartz occurs as equant xenomorphic crystals of varying size up to at least 1 cm. Many of the crystals show pronounced undulose (strain) extinction and in places, especially around large potash feldspar crystals, mortar texture is apparent.

There are trace amounts of a number of other phases, included among which are carbonate and phyllosilicates/?sericite which occur in patches that are generally less than 0.1 mm across. There is also a colourless, isotropic phase which occurs as equant xenomorphic crystals which are up to 0.3 mm across. This phase is probably a variety of garnet. There is also another phase of high relief and moderate interference colours which is possibly epidote. This occurs as irregularly shaped crystals the largest of which is 0.6 mm across.

This rock is light coloured, coarse-grained and thought to be a pegmatitic granite. It contains trace amounts of a number of phases including carbonate, ?garnet and ?sphene.

Sample: P487/74; TS33283

Location:
To the east of and within 100 feet of the main shaft of the Ethiudna Mines, Olary Province.

Rock Name:
Diopside and carbonate-bearing metaquartzite.

Hand Specimen:
This sample is light coloured, fine-grained and, although not banded or foliated, contains numerous fine fractures. Adjacent to exposed external surfaces the rock has been leached away and contains small voids, up to 1 mm across, for depths up to 5 mm below the surface.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Diopside	2-6
Carbonate	5-15
Quartz	60-70
Potash feldspar	15-25
Opaques	1-3
Sphene	trace-1
?Plagioclase	<5
Zircon	trace

Although there is a weak foliation in this rock it has essentially a granoblastic texture. The rock has a fairly regular grain size and is composed principally of quartz, with significant amounts of potash feldspar, diopside and carbonate as well. Potash feldspar and diopside crystals tend to be randomly distributed but the carbonate does occur to some extent in patches and foliae.

The quartz occurs as equant to slightly elongate xenoblastic and subidioblastic crystals which form an interlocking mosaic. The quartz crystals range in size from 0.02 mm to 0.3 mm with the bulk being between 0.1 and 0.2 mm in diameter. Undulose (strain) extinction is present in some of the larger quartz crystals but is not particularly marked in this rock. The potash feldspar occurs as crystals of similar size and shape to those of quartz. It is distinguished by its slightly lower relief, lower interference colours, and by the fact that the bulk of the potash feldspar crystals are slightly altered and are partly turbid with minute inclusions of iron oxides/hydroxides. In a few of the potash feldspar crystals cross hatch (microcline) twinning is weakly developed. A few crystals of plagioclase were detected, and these were of similar size and shape to those of quartz and potash feldspar, but the exact proportions of the mineral could not be determined because of its optical similarity to quartz when untwinned.

Diopside occurs as equant and stumpy subidioblastic crystals which are up to 0.3 mm long. The diopside is neutral to very pale green in colour and has second order interference colours. No wollastonite was detected in this sample. The carbonate occurs as equant to slightly elongate xenoblastic and subidioblastic crystals, the largest of which are at least 0.5 mm long. It occurs as single grains, patches, and in veins, some of the latter extending through the rock for at least several centimetres and infilling fractures in crystals of quartz, potash feldspar and diopside. Present in trace amounts are small crystals of opaques, sphene and zircon.

This rock is a diopside and carbonate-bearing metaquartzite which was probably derived through amphibolite facies or hornblende hornfels facies metamorphism of an impure marly sandstone. The rock appears to have suffered minor late stage deformation, evidence of which are the signs of strain in the quartz crystals and the presence of carbonate veins which infill fractures in crystals of quartz, potash feldspar and diopside.

Sample: P488/74; TS33284; PTS34018

Location:

To the east of and within 100 feet of the Main Shaft, Ethiudna Mines, Olary Province.

Rock Name:

Wollastonite (hand selected sample).

Hand Specimen:

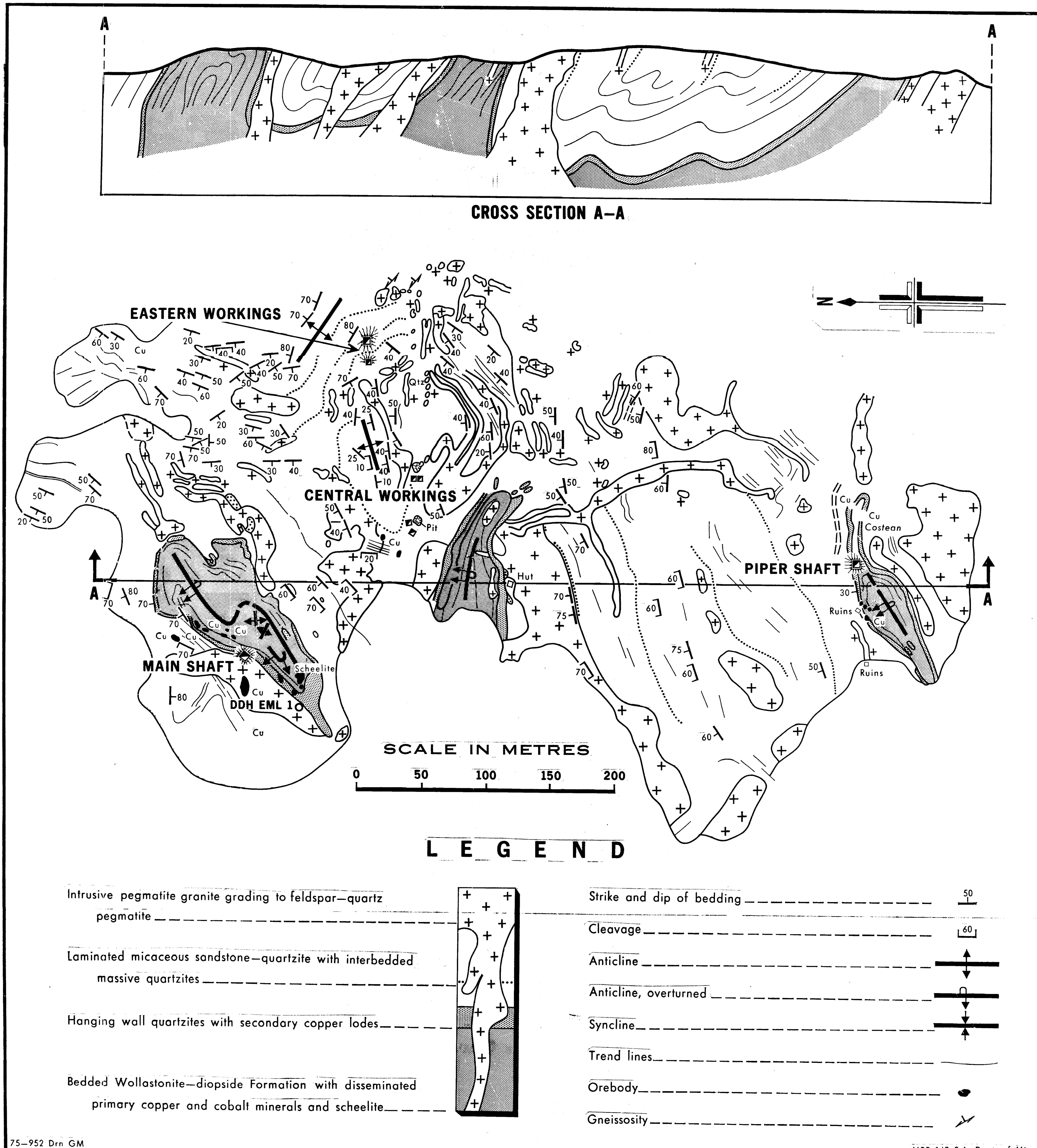
This sample consists essentially of pale grey prismatic crystals of wollastonite. These are up to several centimetres long and are interlocked and slightly lustrous on broken surfaces. Externally the sample is dark coloured with iron and manganese oxide/hydroxide staining and is pitted and corroded with cavities up to several millimetres deep.

Thin Section:

An optical estimate of the constituents gave the following:

	%
Wollastonite	80-90
Carbonate (calcite)	10-20
?Quartz and amorphous silica	6-8
Epidote	trace
Opaques (iron oxides/hydroxides)	trace

This sample consists of large, interlocked, prismatic crystals of wollastonite. The largest crystals are 0.5 to 1 cm across and 3-5 cm long. The wollastonite is altered/replaced along cleavage planes/fractures and grain boundaries by a carbonate (calcite) and amorphous silica. There are also trace amounts of ?quartz, ?epidote and opaques (principally iron oxides/ hydroxides) associated with the wollastonite.



Reduce to ~~39 cms~~

165 mm

ETHIUDNA WOLLASTONITE DEPOSIT *Geological Plan & Section*

75/136

MRR 143

Corrected B.T. 27/9/77

GM 75-952

30·6·76