DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPT.BK.NO. 86/93
WISTOW FLAGSTONE QUARRIES - GEOLOGICAL INVESTIGATIONS 1984-1986

GEOLOGICAL SURVEY

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MINERAL RESOUURCES

DECEMBER, 1986

DME.253/83

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DME NO. 253/83
DISC NO. 53

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ABSTRACT

The name 'Wistow Stone' was first given to metasiltstone from a quarry opened in 1963 by Kelley and Foale, 4km ENE of Wistow Post Office, and 4km NW of the present quarries. Operations were transferred to the present quarry 1 in 1968.

A distinctive range of paving, veneer and walling materials is won from three quarries located on a 150m thick band of interbedded metasiltstone and bimica schist forming part of Tapanappa Formation of Kanmantoo Group of Cambrian age.

Similar material is won from the Kanmantoo Quarry 7km to the north, and probably within the same 'flagstone zone', but geological mapping is needed to confirm this.

Current production of flagstone totals approximately 4-5 000 tonnes per year from Quarries Nos. 1 and 2 operated by Wistow Stone and Slate Quarries on Private Mines 194 and 170 respectively.

Quarry 3 was opened by Wistow Stoneworks (S.A.) Pty. Ltd. in mid 1986 on PM 194, immediately south of quarry 1.

Reserves of stone are large:

- 225 000 tonnes at quarry 1
- 10 million tonnes within the part of PM 170 which contains quarry 2
- 4 million tonnes within the part of PM 194 which contains quarry 3

In addition there is considerable potential for other quarry sites in the Kanmantoo - Wistow district.

INTRODUCTION

Wistow flagstone quarries produce a distinctive range of paving, veneer and walling materials often referred to as slate, bluestone, or more correctly, flagstone.

Geological mapping of quarry 1 was undertaken on 27, 28 and 29 November 1984 and quarry 2 on 8 and 9 January 1985 by A.M. Shepherd (Geologist) and P.P. Crettenden (Field Assistant).

Boundaries of the flagstone zone were mapped by A.M. Pain (Principal Geologist, Extractive Minerals) and D.A. Young (Senior Technical Officer) during an inspection of development work at quarry 3 on 8 April 1986, when property boundaries were surveyed by P.P. Crettenden.

The only previous Departmental investigation was a brief report on quarry 1 by Nichol (1973).

A summary of the geology is included in an ore reserve estimate of PM 194 including quarry 3, prepared by a consulting economic geologist for the land owners (Rogers, 1984).

Kanmantoo flagstone quarry 7 km to the north was mapped by Drexel (1985).

LOCATION, ACCESS AND TOPOGRAPHY

Wistow quarries are 50 km by road south-east of Adelaide (Fig. 1). Access to the township of Wistow is via the South Eastern Freeway, exiting at Mount Barker and continuing 6.8 km south-easterly along the Mount Barker-Wellington road.

Quarries 1 and 3 are on section 1376 and quarry 2 on section 2202, hundred Strathalbyn, county Hindmarsh in the District Council of Strathalbyn part of the Outer Metropolitan Planning Area (Fig. 2).

Access to quarries 1 and 2 from Wistow township is 5.6 km south-easterly along the Mount Barker-Wellington road, turning left onto Klenke Road which is followed north-easterly for 1.9 km before turning north through a gate onto Frames Fire Track, which forks 0.7 km north-eastwards. The right fork, leads 0.4 km to quarry 1, and the left fork passes through a gate and leads 0.8 km to a private track on the right. Quarry 2 lies a further 0.2 km along this track (Fig. 1).

Quarry 3 is reached by turning left from the Mount Barker-Wellington road 6.6 km south-east of Wistow onto Red Creek Road (to Hartley) for 200m and then left again onto Ridgetop Road for 1.7 km joining Klenke road 200m before the entrance to the quarry.

The peneplained, undulating landscape, characteristic of the Mount Lofty Ranges, drops gently from a maximum elevation of 500 m at the summit of Mount Barker, to 250 m in the vicinity of the quarries, 7.5 km to the south. The quarries are in rounded hills which are deeply dissected by a major, north-easterly draining tributary of Mount Barker Creek (Plates 3 and 7).

Land has been extensively cleared of vegetation and is used for stockgrazing (Plate 3).

HISTORY

In the 1950s and early 1960s, a small quarry was worked near Petwood by Mr. Coventry and later by his son. This quarry in the SW corner of section 4417 hundred of Kanmantoo, 2 km SE of Petwood Siding is immediately north of the Adelaide - Melbourne Railway line and adjacent to Dawesley Creek. Petwood quarry is probably located in the same stratigraphic zone of flagstone as the Wistow and Kanmantoo quarries.

The name 'Wistow Stone' was first given in 1963 to grey micaceous metasiltstone obtained from a quarry in section 2904 hundred Strathalbyn. This quarry, 7.5 Km SE of Mount Barker Post Office and 4 Km ENE of Wistow Post Office was opened by Kelley and Foale in January 1963 (Fig 1 and Plate 2). Thickly bedded and cross bedded in part, the stone was mostly used for walling. The other differences to current Wistow Stone in that colour is darker grey and iron oxide colouring is significantly less.

The quarry, 30 m long, 20 m wide and 2-7 m in depth would have produced about 4 000 tonnes of stone. The Kelley and Foale partnership was dissolved in March 1964. Jeff Foale continued to work this site until transferring his activities to the present Wistow quarry 1 in 1968 where he worked until 1976.

New operators of quarry 1, Germar Nominees (G.B. and M.J. Roebuck) continued trading as Jeff Foale Quarries and negotiated with the landowners, W.A. and H.A. Samuel, a private lease which provides for mining operations within the fenced area that surrounds the quarry 1 (see Figs 2 and 4). The lease is current for 10 years from July 1977 with a conditional right of renewal for a further 10 years.

In April 1979, the lease was transferred to R. Calabrese who continued trading as Jeff Foale Quarries until adopting the name Wistow Stone and Slate Quarries in 1980. Operations continued until mid - 1986 when the quarry 1 was abandoned in favour of quarry 2, one kilometre to the north.

Ownership of the land was transferred to A.W. Samuel in August 1981 and then to Davin Investments Pty. Ltd. in November 1985. In mid 1986, this company adopted the name Wistow Stoneworks (S.A.) Pty. Ltd. and began production from the quarry 3.

W.D. Bates and E. Lans commenced operations at quarry 2 (on land owned by K.W. Klenke) in October 1974 and worked until early 1978 when a new partnership was formed by E. Lans and D.W. Jarmyn trading as Wistow Slate and Walling Stone Quarries.

Production continued until 1981 when the surrounding land was purchased by R. Calabrese, section 2202 having been subdivided into four allotments by Klenke and initially sold in 1977 and 1978.

Calabrese began working quarry 2 in late 1983 and transferred all operations to this quarry in mid 1986.

LAND AND MINERAL TENURE

Sections 2202 and part 1376 hundred Strathalbyn are freehold land, over which Private Mines (PM) were proclaimed in 1973 under the Mining Act 1971, as amended.

Quarries 1 and 2 are held by Wistow Stone and Slate Quarries and quarry 3 by Wistow Stoneworks (S.A.) Pty Ltd.

Land ownership, PMs and quarry operators are summarized on figure 2 and Table 1.

TABLE 1

Land and Private Mine Ownership

Quarry	1	2	3
Operator	Wistow Stone & Slate Quarries (R. Calabrese)	Wistow Stone & Slate Quarries (R. Calabrese)	Wistow Stoneworks (S.A.) Pty Ltd
Landowner	Wistow Stoneworks (S.A.) Pty. Ltd.	As Above	As Above
Title	C.T. 4242/455	C.T. 4188/454	C.T. 4242/455
PM	194	170	194
Gazetted	30 Aug 1973	11 Oct 1973	30 Aug 1973

STONE PRODUCTS AND PRODUCTION

Quarry 1 on the southern flank of a westerly draining gully is 120 m long and 100 m wide (Fig. 4). The floor is at RL 213 m and the upper bench at RL 228 m resulting in a maximum vertical exposure of 24 m (Plate 3). The waste dump extends northwards beyond the boundary fence into section 2202 for 80 m.

Quarry 2 on the eastern flank of a northwesterly draining gully is 70 m long and up to 50 m wide (Fig. 5). The floor of this single bench quarry is at RL 205 m. Maximum face height is 20 m (Plate 8).

Quarry 3 is being developed immediately south of the boundary fence to quarry 1 (Fig. 4). The floor of the proposed single bench quarry at RL 238 m will provide a maximum face height of 20 m.

The five stone products currently produced from quarries 1 and 2 by Wistow Stone and Slate Quarries are listed below.

Product	Thickness (mm)
WALLING STONE	
Small bookleaf	25-75
Large bookleaf	75-200
PAVING SLATE	
Driveway pavers	50-75
Thin pavers	25-50
Veneer	10-25

A similar range is produced from quarry 3 by Wistow Stoneworks (S.A.) Pty. Ltd as detailed below.

Product	Thickness (mm)
WALLING STONE	
Small Bookleaf	25-75
Large Bookleaf	75-200
PAVING STONE	
Driveway pavers	75 (nominal)
Patio Pavers	50 "
Patio Pavers	38 "
Veneer	25 "

Thick slabs and blocks are used for walling, and thin slabs are selected for paving and veneering stone.

Nichol (1973) estimated that about 60% of material quarried was marketable and that since 1968 about 18 000 tonnes had been marketed by Jeff Foales Slate Quarry - now Quarry No. 1.

Output since 1974 based on six monthly production returns submitted to SADME is presented in Table 2 and summarized in Table 3.

Production from quarry 3 commenced in mid 1986.

Based on figures supplied from Quarry 1 between 1980 and 1984, production ratio of Walling stone: Paving stone ranges from 4:1 to 2:1, whereas approximately equal amounts of walling and paving were produced from quarry 2 in 1984 and 1985.

TABLE 2

PRODUCTION (Tonnes)

	Quarry 1			Quarry 2	Total Flagstone	Total
	Flagstone	Roadstone	Total	Flagstone		
1968-73	*18 000	-	18 000	-	18 000	18 000
1974	4 018	-	4 018	334	4 352	4 352
1975	3 675	-	3 675	1 934	5 609	5 609
1976	2 969	-	2 969	1 745	4 714	4 714
1977	2 089	-	2 089	523	2 612	2 612
1978	2 538	2 288	4 826	813	3 351	5 639
1979	2 168	2 391	4 559	886	3 054	5 445
1980	2 700	790	3 490	928	3 628	4 418
1981	3 650	210	3 860	120	3 770	3 980
1982	4 330	560	4 890	-	4 330	4 890
1983	4 449	760	5 209	200	4 649	5 409
1984	3 400	660	4 060	1 550	4 950	5 610
1985	968	-	968	3 310	4 278	4 278
TOTAL	54 954	7 659	62 613	12 343	67 297	74 956

TABLE 3

PRODUCTION SUMMARY

	Flagstone		Roadstone		Total
Quarry	Period	Tonnes	Period	Tonnes	
1	1968-85	53 946	1978-84	5 628	59 574
2	1974-85	12 693	-	Nil	12 693
Total	1968-85	66 639		5 628	72 267

GEOLOGICAL SETTING

The quarries are within Tapanappa Formation (formerly part of Brukunga Formation) of Kanmantoo Group of Cambrian age. Kanmantoo Group is predominantly greywacke facies, attaining a thickness of about 18 000 m (Parkin, 1969). The dominant rock types are metasediments composed of quartz, mica and feldspar in varying proportions and grain sizes. Minor lenses contain porphyroblastic andalusite-garnet-mica-staurolite assemblages (Drexel, 1981). Thin, lenticular pyrite-bearing lithologies are relatively common, the largest and most persistent being Talisker Calc-Siltstone, which includes Nairne Pyrite Member and is basal to Tapanappa Formation (Fig. 3). Wistow quarries are approximately 500 m stratigraphically above Talisker Calc-Siltstone.

Regional strike varies along an arc from south-southwest (025°) near Archer Hill, 3 km south to NNW (345°) at Petwood, 6 km north as shown on figure 3 adapted from Belperio (1985), Sprigg & Wilson (1954) and Thompson & Horwitz (1962).

At quarry 1, the following conformable units of Tapanappa Formation have been mapped.

A 10 m wide bed of pyritic schist, quartzofelspathic rock with accessory pyrite is the most westerly unit mapped.

The overlying thickly bedded to massive quartzofeldspathic metasiltstone is succeeded by the mined 'flagstone zone', interbedded quartz-biotite-feldspar metasiltstone and bimica schist. This 'flagstone zone' is approximately 150 m thick and dips easterly at 45° near the quarries, outcropping over a width of approximately 210 m. Extent of the 'flagstone zone' in the two private mines is shown on figure 2. This is based on mapping near quarries 1 and 3 and photo-interpretation to north and south.

The 'flagstone zone' is overlain by strongly foliated bimica schist, 28-34 m wide, which forms the eastern limit of quarry 1. Further east is another band of thickly bedded to massive quartzofeldspathic metasiltstone.

Quarry 2 occupies a slightly lower stratigraphic position within the 'flagstone zone' than quarry 1.

Similar rock is worked at the Kanmantoo Flagstone Quarry, 7 km to the north (Drexel, 1985). This quarry is believed to lie along strike within the same 'flagstone zone' but geological mapping is needed to confirm this.

SITE GEOLOGY

LITHOLOGY

The rocks were originally deposited as sediments in the sea floor during Cambrian times as a sequence of impure sandy silt interlayered with thin beds of mud and silt. Subsequent consolidation, uplift and metamorphism during the Delamerian orogeny converted these sediments to metasiltstone with bimica schist interbeds.

Detailed petrography is presented in the Appendix.

Metasiltstone

The principal rock type at Wistow and Kanmantoo quarries is grey quartz-biotite-feldspar metasiltstone (Plate 5) which provides almost all of the product.

Medium to dark grey metasiltstone is somewhat massive generally exhibiting only vague foliation. Quartz is the main component with lesser amounts of plagioclase and biotite. Microscopic examination shows a granoblastic quartz mosaic with typical grain size ranging between 0.1 and 0.3 mm, intergrown with biotite flakes. Run-of-quarry material was described as quartz-felspar-biotite schist in Nichol (1973) but the term metasiltstone is used here.

Bimica schist

Metasiltstone is interbedded with grey bimica schist (Plate 6), fissile rock which splits readily to free the adjacent slabs of metasiltstone. Almost all of this schist is discarded as waste. Most extensive development is at quarry 2, where schist, in places, comprises 30-40% of rock volume.

This strongly foliated rock, medium to dark grey, is composed of about 50% mica (biotite and muscovite), and 45% quartz with traces of other minerals. The pronounced fissile nature is due to parallel orientation of most biotite and muscovite flakes.

Minor rock types, all of which are discarded as waste include:

• Muscovite-pyrite schist; three lenses, 0.3-0.5 m thick are exposed in the faces of quarry 1. The yellowish iron-streaked 'earthy' weathering colours are due to disseminated pyritic sulphide.

• Quartz veins Milky quartz veins generally as pods or lenses 0.5-1.5 m wide and up to 15 m long are exposed at all quarries.

• 'Plagioclasite' This unusual rock composed almost entirely of plagioclase, is exposed in the western edge of the lower face of quarry 1 as a 0.5 m thick vein.

BEDDING THICKNESS

Thickness of slabs available for paving and walling is determined by thickness of metasiltstone beds. Ranges and averages of bedding thickness for both major rock types at quarries 1 and 2 are listed in Table 4. Quarry 3 is expected to be similar to quarry 1.

TABLE 4
SLAB THICKNESS

Rock type		Bedding thickness (mm)	
		Quarry 1	Quarry 2
Metasiltstone	Size range	15-180	15-180
	Dominant size	15-100	30-80
	Average	50	55
Bimica Schist	Size range	1-60	5-100
	Dominant size	5-30	10-70
	Average	12	30

FOLDING

Folding has produced a moderate easterly dip. Bedding orientation is relatively constant with dip ranging from 40°-60°E and strike northwards from 008° to 025°. Averages are:

Quarry	Dip	Strike
1 (&3)	45°E	020°
2	50°E	010°.

Foliation, which is defined by preferred orientation of biotite and muscovite flakes, is generally parallel to bedding.

Two sets of flexures are visible in quarry faces. The more common has open concentric style with amplitude of 50 mm, width 0.5-1 m, and plunging 20° to southeast, 150°. The less common set has tight to isoclinal style, width of 1 m and plunges 50° to northeast, 065°.

Buckling is more apparent in quarry 1 where some warped, curved stone is rejected as waste. The largest visible flexure has a width of 5 m, amplitude of 4 m and extends for 20 m along the western quarry face (plate 7).

JOINTING

Size and shape of metasiltstone slabs are determined mainly by spacing and orientation of joint sets as detailed in Table 5. Two major sets (A & B) approximately perpendicular to bedding are well developed in quarries 1 and 2. A third subsidary set is only weakly developed in quarry 2.

TABLE 5

JOINT SETS

Joint set	Strike	Dip	Spacing (m) Range	Average
A	060°	50°NW	0.3-2	0.5
B	110°	80°N	1-3	1.5
C	095°	70°N	1-2	1.5

Although slab sizes up to 3 m wide occur in situ, very few slabs with maximum dimension greater than 1 m are recovered after blasting and handling.

WEATHERING

Fresh broken surfaces of metasiltstone are generally medium to dark grey with some of the more quartz-rich variants having a paler appearance. Bimica schist is generally slightly darker.

Weathering is responsible for the characteristic earthy hues which result when iron oxides derived from weathering of biotite and pyrite are deposited along bedding planes, joints and fractures. These colours appear to be most strongly developed along joint set B. In places, iron oxide coats quartz which infills some of the more persistent joints.

Overburden comprises mainly weathered rock and averages about 1.5 m thick. Only a thin veneer, generally less than 0.3 m of silty brown soil overlies weathered rock.

Weathering generally persists to greater depth in bimica schist, and accentuates the fissile nature of this rock (plate 6).

STONE QUALITY

Wistow Flagstone has been sampled and laboratory testing is in progress to determine physical properties including compressive strength and modulus of rupture. Results are not yet available but are expected to show that the rock is of good durability with adequate strength characteristics for current uses.

MINING AND PRODUCTION TECHNIQUES

Similar techniques have been used at quarries 1 and 2 operated by Wistow Stone and Slate Quarries.

Rock is blasted from the face, picked up by bucket loader and tipped along picking bays (Plate 4). Rock is hand sorted, split, trimmed and stockpiled alongside the bays. Waste which remains in the bays after picking is bulldozed forward onto waste dumps.

Quarry 3 owned by Wistow Stoneworks (S.A.) Pty. Ltd. employs partly mechanized sorting techniques. Stone is picked up from the face by bucket loader and tipped into an apron feeder from which it passes over a vibrating punched steel screen. 125 mm undersize is rejected and oversize is fed onto an endless steel sorting belt from which suitable stone is hand selected, trimmed and stacked onto pallets (Plates 9 and 10)

RESERVES

Reserves have been calculated for the three quarries based on-

- Overburden thickness of 1.5 m
- Product : waste ratio of 1:1
- Proven reserves are limited to existing workings or immediately along strike.
- Probable reserves are within the flagstone zone but off strike from the adjacent workings.

Quarry 1 (Wistow Stone and Slate Quarries)

By agreement with the landowner, quarry extensions are confined to the fenced area shown on figure 2 and 4. Reserves above the present floor level at RL 213 m are listed in Table 6.

TABLE 6
RESERVES OF FLAGSTONE (tonnes) ABOVE FLOOR (RL 213 m), QUARRY 1

	Flagstone	Overburden
Proven	150 000	20 000
Probable	70 000	25 000
Total	225 000	45 000

Quarry 2 (Wistow Stone and Slate Quarries)

The flagstone zone crops out over a strike length of almost 800 m on that portion of PM 170 owned by Wistow Stone and Slate Quarries. A four bench quarry developed over this entire length is expected to yield 10 million tonnes of flagstone.

However, the proposed quarry development as shown on figure 5 will yield 40 000 tonnes of flagstone beneath 17 000 tonnes of overburden.

Quarry 3 (Wistow Stoneworks (S.A.) Pty. Ltd.)

Reserves based on the Company's development plan as shown on figure 4 together with further possible extensions are listed in Table 7.

TABLE 7

RESERVES OF FLAGSTONE (tonnes), QUARRY 3.

STAGE	CLASS	LIMIT	FLAGSTONE	OVERBURDEN
1	Proven	Development Plan	220 000	68 000
2	Proven	Above RL 213 m	300 000	nil
3	Probable	To western limit of flagstone zone	450 000	51 000
Total			970 000	119 000

A four-bench quarry developed over the 400 m strike length between quarry 1 and the southern boundary of PM 194 is expected to yield 4 million tonnes of flagstone.

CONCLUSIONS AND RECOMMENDATIONS

Flagstone has been produced from two quarries in the Wistow area since 1968.

Current production is 4-5 000 tonnes per year from two quarries operated by Wistow Stone and Slate quarries (quarries 1 & 2).

Production has recently commenced from quarry 3 opened by Wistow Stoneworks (S.A.) Pty. Ltd.

Quarry 1 has to date been the largest producer, and has proven and probable reserves totally 225 000 tonnes within a fenced area leased from the landowner.

Reserves within the part of PM 170, which contains quarry 2 exceed 10 million tonnes. A suggested development to yield 40 000 tonnes is outlined in this report.

Reserves within the part of PM 194 which contains quarry 3 exceed 4 million tonnes. A suggested development to yield 970 000 tonnes is based on the operator's proposal.

There is considerable potential for other quarry sites in the Kanmantoo - Wistow district, and geological mapping is recommended to delineate the extent of the flagstone zone.

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APPENDIX

Petrological descriptions of samples 6627 RS 629-33
extracted from AMDEL report G 6262/85 by Frank Radke.

PETROGRAPHIC DESCRIPTIONS

Sample: 6627 RS 629; TSC44424

Rock Name:
Biotite schist (meta-siltstone)

Hand Specimen:
A medium to dark grey rock with a somewhat massive character although a vague foliation is evident particularly along some surfaces which exhibit a sheen due to oriented mica flakes.

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

	%
Quartz	55
Biotite	20
Plagioclase	20
Apatite	1
Chlorite	trace-1
Zircon	trace
Tourmaline	trace
Sericite	trace
Opaques	1

This sample consists mainly of a granoblastic quartz mosaic with a typical grain size ranging between 0.1 and 0.3 mm intergrown with well developed biotite flakes up to 0.2 mm long. A lepidoblastic foliation is defined by a preferred orientation of the biotite flakes and a very vague secondary foliation is also evident. Moderate amounts of plagioclase are intergrown with the quartz as xenomorphic crystals up to 0.3 mm long. At least some of the plagioclase exhibits well developed polysynthetic twinning but it is thought that the rock contains a significant proportion of untwinned plagioclase making the exact proportions of quartz and plagioclase difficult to determine. A small proportion of the plagioclase contains small, poikiloblastic quartz inclusions.

The biotite forms well developed flakes which have an intensely pleochroic brown to reddish-brown colour. A small proportion of the biotite shows alteration to chlorite which also occurs as well developed flakes up to 0.3 mm long. This chloritization occurs locally and has generally completely replaced biotite flakes with chlorite. The plagioclase at least locally shows incipient alteration to finely divided sericite which occurs as small inclusions in the plagioclase crystals. Some of the plagioclase also has a slightly turbid character produced by very finely divided micron-sized inclusions.

Zircon and apatite form small, disseminated crystals up to 0.1 and 0.2 mm long respectively. Traces of tourmaline were also noted as xenomorphic crystals up to 0.3 mm long which have a pleochroic orange to brown colour. Opaques are disseminated through the rock as anhedral to slightly prismatic, elongate crystals up to 0.2 mm long.

This is a low-grade metamorphic rock of approximately upper greenschist facies grade which would represent a metamorphosed, fine-grained detrital sediment.

Sample: 6627 RS 630; TSC44425

Rock Name:
Mica schist (Bimica Schist)

Hand Specimen:
This is a very well foliated rock with a medium grey colour.

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

	%
Quartz	45
Biotite	25
Muscovite	25
Tourmaline	1
Chlorite	trace-1
Apatite	trace
Zircon	trace
Opaques	1

This is a very well foliated rock comprised of muscovite and biotite flakes with a strong lepidoblastic foliation intergrown with granoblastic quartz. The quartz forms a mosaic with a typical grain size of 0.2 mm and tends to be concentrated in elongate discontinuous bands and lenses separated by undulose, mica-rich bands.

The biotite exhibits an intensely pleochroic reddish-brown colour and is intimately intergrown with the muscovite forming lamellar textured flaky aggregates. Virtually all of the muscovite and biotite shows a strong lepidoblastic foliation but a very small proportion of stubby biotite and muscovite flakes are oriented at a high angle to the foliation direction. Muscovite is very fresh only locally showing alteration to a weakly pleochroic green chlorite with low birefringence.

Accessory tourmaline forms disseminated crystals up to 0.15 mm long which generally exhibit prismatic shapes and a zoned green to orange, pleochroic colour. Traces of apatite and zircon form small disseminated crystals up to 0.2 and 0.1 mm long respectively. Opaques are disseminated through the rock as anhedral grains and aggregates up to 0.3 mm wide.

This is a metamorphosed detrital sedimentary rock with a higher proportion of mica than sample 6627 RS 629 most likely reflecting a higher pelitic content in the original sediment.

Sample: 6627 RS 631; TSC44426

Rock Name:
Mica schist (interbedded meta-siltstone and bimica schist)

Hand Specimen:
A medium grey coloured rock with a weakly developed foliation which contains some mica-rich bands parallel to the general foliation direction.

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

	%
Quartz	45
Plagioclase	20
Biotite	20
Muscovite	15
Apatite	trace-1
Tourmaline	trace
Chlorite	trace
Zircon	trace
Sericite/clay	trace
Opaques	1

This sample consists mainly of granoblastic quartz intergrown with smaller amounts of granoblastic plagioclase and well developed muscovite and biotite flakes. A strong lepidoblastic foliation is defined by a preferred orientation of the muscovite/biotite flakes. Some of the mica flakes and the muscovite in particular tend to be concentrated in narrow bands up to 0.5 mm wide.

The quartz and feldspar forms a recrystallized mosaic with a typical grain size between 0.1 and 0.3 mm. Some of the plagioclase exhibits well developed polysynthetic twinning but a significant proportion is untwinned making it difficult to distinguish from quartz. Some plagioclase shows incipient alteration to very finely divided sericite/clay.

Both the biotite and muscovite form well developed flakes up to 0.3 mm long which have a strong preferred orientation although a smaller proportion of relatively large flakes up to 0.4 mm long are oriented at a high angle to the foliation direction. The biotite exhibits an intensely pleochroic brown to reddish-brown colour and is very fresh only locally showing alteration to a pale green chlorite.

Accessory apatite and zircon form small disseminated crystals up to 0.2 and 0.1 mm long respectively. Minor tourmaline is also present as small, disseminated crystals which rarely exceed 0.2 mm in size although a few larger crystals up to 0.5 mm long are present. The tourmaline typically has a zoned green to orange colour with a pleochroic character. Opaques are disseminated through the rock as small, anhedral grains up to 0.15 mm wide.

This is a low-grade metamorphic rock somewhat similar to sample 6627 RS 629 although it has a relatively higher proportion of muscovite as well as biotite.

Sample: 6627 RS 632; TSC44427

Rock Name:
Mica schist (muscovite-pyrite schist)

Hand Specimen:
A medium grey coloured rock with a well developed schistose foliation. The rock also contains moderate amounts of disseminated, pyritic sulphides. The weathered surface of the sample has a greenish-yellow, earthy colouring.

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

	%
Quartz	40
Muscovite	30
Biotite	15
Plagioclase	10
Tourmaline	trace-1
Apatite	trace
Zircon	trace
Opaques	4

This is a very well foliated rock comprised of mica intergrown with granoblastic quartz. The mica forms elongate flakes which tend to be concentrated in bands or lamellae separating elongate lenticular bodies of granoblastic quartz. The mica consists of both muscovite and smaller amounts of pleochroic brown biotite which generally form flaky, lamellar intergrowths oriented parallel to the foliation direction. Although the foliation is very well developed it has a slightly undulose character and locally is weakly contorted.

The quartz has a typical grain size of 0.1 to 0.2 mm and is intergrown with smaller amounts of granular, untwinned plagioclase. The exact proportion of plagioclase present is difficult to determine but the plagioclase generally has a slightly more turbid character than the quartz.

Tourmaline is disseminated through the rock as prismatic crystals up to 0.3 mm long which are oriented parallel to the foliation direction and generally have a zoned orange to green, pleochroic colour. Minor apatite and zircon form small disseminated crystals up to 0.1 mm wide. Opaques are disseminated through the rock as elongate grains and aggregates up to 0.5 mm wide which are oriented parallel to the foliation direction. Some opaques form narrow, discontinuous bands. These opaques consist largely of a yellow sulphide believed to be pyrite.

This is a metamorphic rock somewhat similar to sample 6627 RS 630 although it has a much higher proportion of opaques comprised largely of pyrite.

Sample: 6627 RS 633; TSC44428

Rock Name:
Plagioclasite

Hand Specimen:
A dull white to pale tan coloured rock with some reddish-brown limonitic staining along irregular fractures and patches.

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

	%
Plagioclase	95
Biotite	2
Rutile	trace-1
Zircon	trace
Opaques and semi-opaques	1

This rock consists mainly of a granular plagioclase mosaic with a grain size ranging up to 0.4 mm. Most of the plagioclase forms recrystallized, coarser-grained mosaic with concavo-convex grain boundaries. Along narrow vein-like structures or fractures fine granulation of plagioclase has occurred producing granular aggregates with a typical grain size of 0.05 mm. There tends to be a subparallel orientation of these narrow granulation zones although some vein-like granulation areas are oriented at an angle to this general direction.

Minor biotite occurs as well developed flakes up to 0.5 mm long which tend to be concentrated in aggregates and discontinuous vein-like bands. Most of the biotite has a degraded, reddish-brown, pleochroic colour and is intergrown with opaque to translucent iron oxides. Somewhat translucent to opaque iron oxides form narrow fracture and vein fillings. Rutile is disseminated through the rock as subhedral grains and aggregates up to 0.3 mm wide which have a translucent orange colour. Traces of zircon form small disseminated crystals up to 0.1 mm long.

This is a plagioclase-rich rock most likely of late-stage igneous origin which has been subjected to metamorphic recrystallization with the development of narrow veinlets along which fine granulation has occurred.

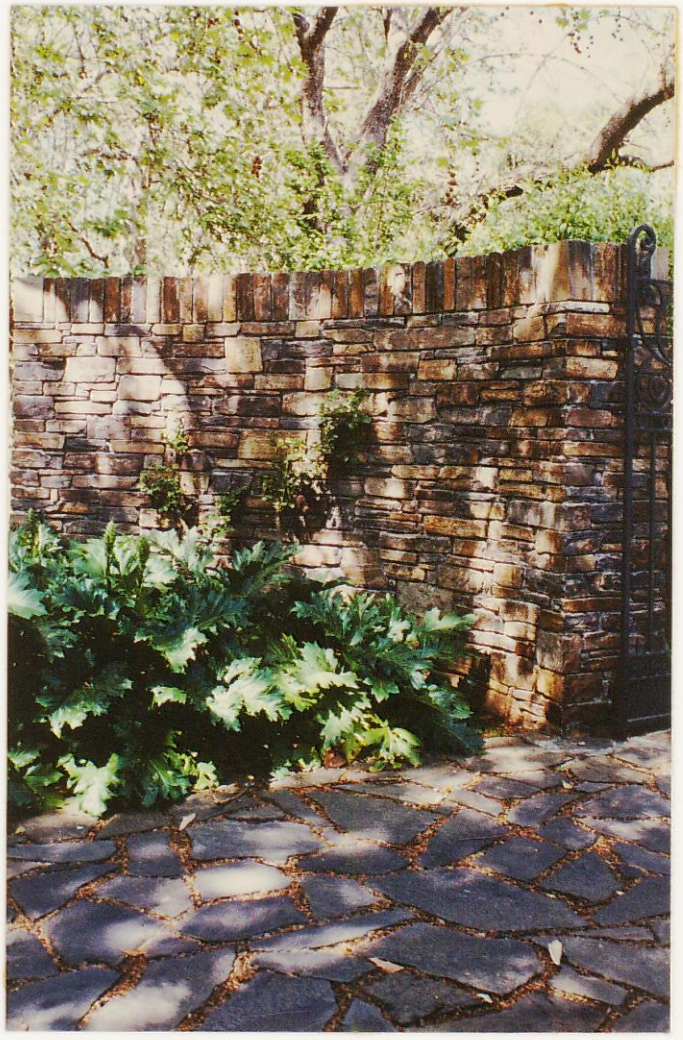


PLATE 1. FRONTISPIECE. Wistow stone used for walling and paving. Note brown iron oxide coating on joint plane faces of walling stone. Driveway paving has been laid on concrete base without pointing between pavers. Stone supplied by Wistow Stone and Slate Quarries.
Slide No. 35436

PLATE 2. Kelly and Foale's Abandoned Wistow Quarry. View to west. Operated from 1963-1968. First material to be marketed as 'Wistow Stone'. Slide No. 35439.

PLATE 3. Wistow No. 1 quarry, view south, showing the main lower working face and upper bench, with mullock dumps and picking bays in the foreground.

SLIDE NO. 35006

PLATE 4. Wistow No. 1 quarry, view north-west, showing lower bench, picking-bays and stockpiles in right foreground. Gently undulating terrain in background with Mount Barker summit in far background.

SLIDE NO. 35007

PLATE 5. Fresh massive metasiltstone interbedded with bimica schist from No. 1 quarry. Darker coloured, thin bands are bimica schist.

SLIDE NO. 35008

PLATE 6. Weathered massive metasiltstone interbedded with bimica schist from No. 1 quarry. Contrast between the two units is marked with the metasiltstone more resistant to weathering.

SLIDE NO. 25009

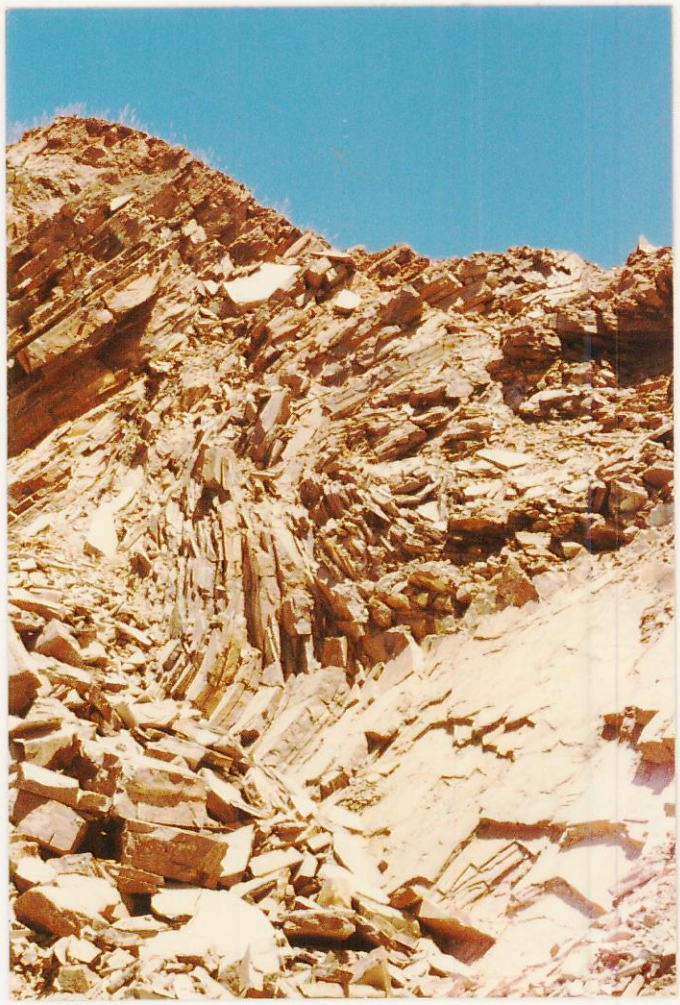


PLATE 7. Large tectonic buckle along western face of No. 1 quarry. Amplitude of 4 m, width of 5 m and length of approximately 20 m. SLIDE NO. 35010

PLATE 8. Wistow No. 2 quarry, view north-west. Evenly dipping strata. Mount Barker summit in background. SLIDE NO. 35011

PLATE 9. Wistow No. 3 Quarry. View of apron feeder, vibrating screen and shed containing sorting belt. Quarry in background. Slide No. 35437.

PLATE 10. Wistow No. 3 Quarry. Sorting belt. Vibrating screen in background. Slide No. 35438.

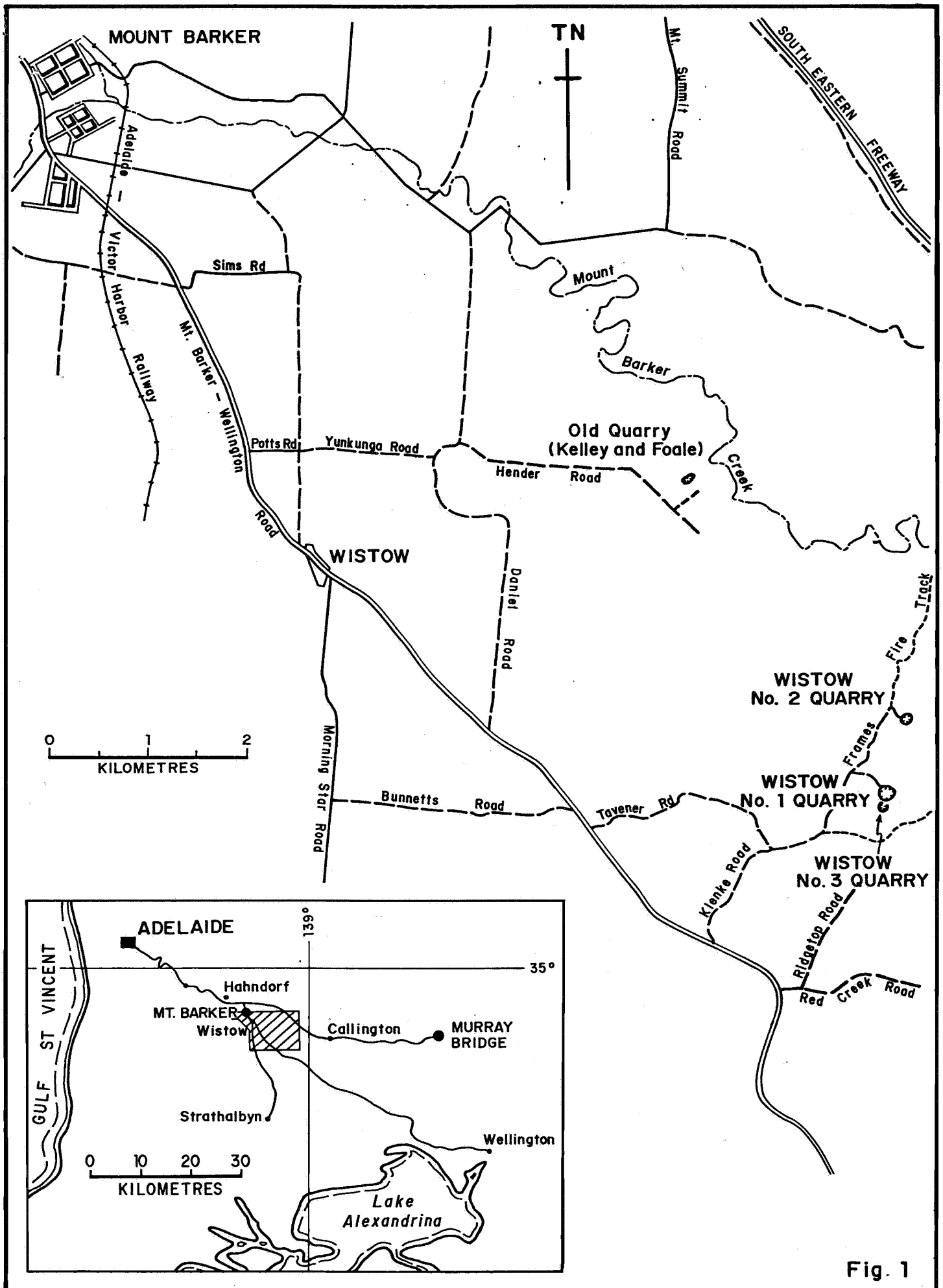


Fig. 1

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

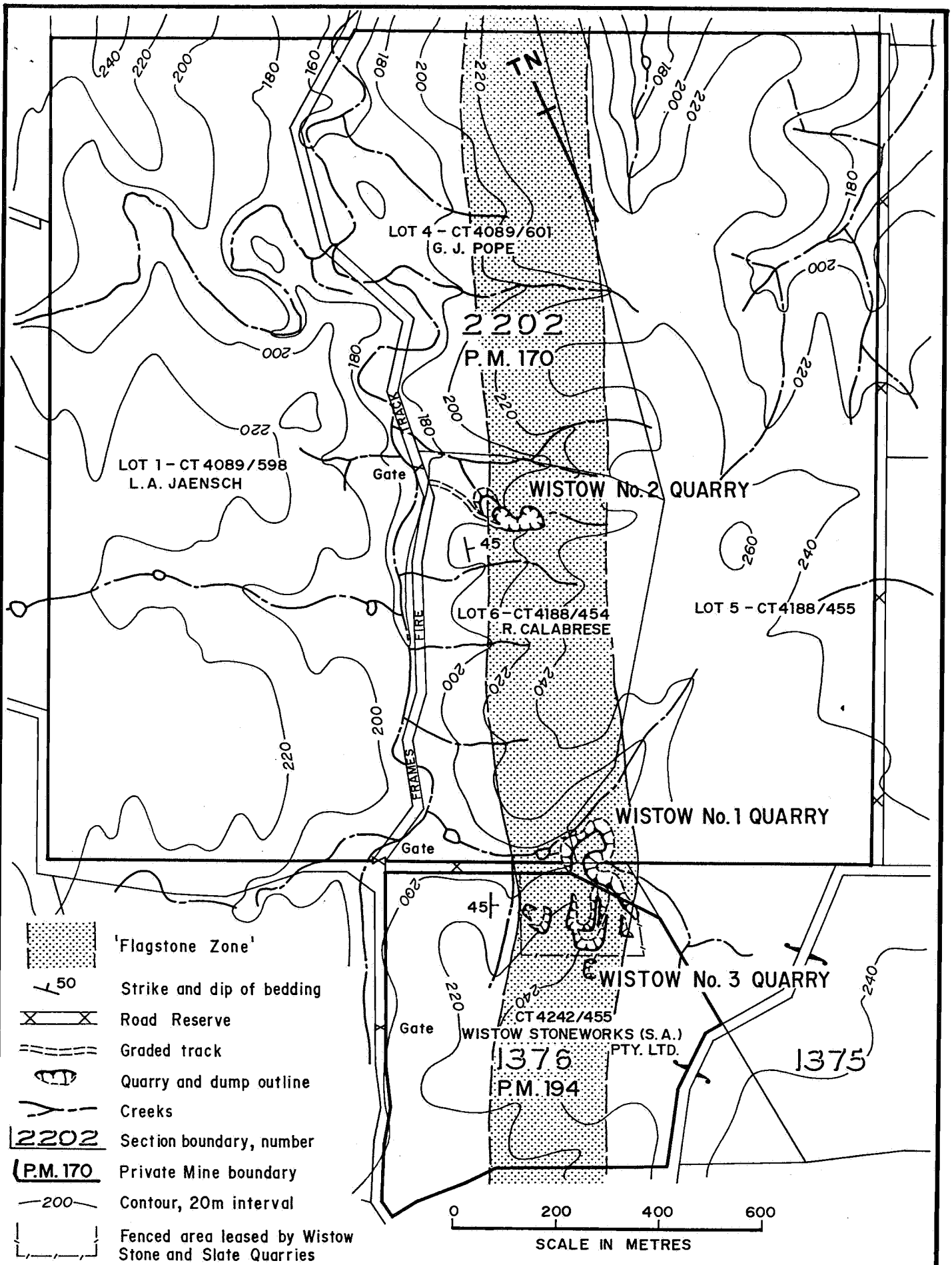
WISTOW FLAGSTONE QUARRIES

SEC. 1376, 2202 HD. STRATHALBYN

LOCATION AND ACCESS PLAN

COMPILED A.S.	C.D.O. 19·1·87 DATE
DRAWN M.B.	SCALE 1 : 50 000
DATE Mar '86	PLAN NUMBER S18587
CHECKED	

4043



Adapted from Cadastral orthophoto Sheet No. 6627-15

Fig. 2

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

WISTOW FLAGSTONE QUARRIES
SEC. 1376, 2202 HD. STRATHALBYN
LAND TENURE AND LOCATION OF PRIVATE MINE BOUNDARIES

COMPILED A. S.	C.D.O. 19.1.86 DATE
DRAWN M.B.	SCALE 1:10000
DATE Mar '86	PLAN NUMBER S18588
CHECKED	

4043

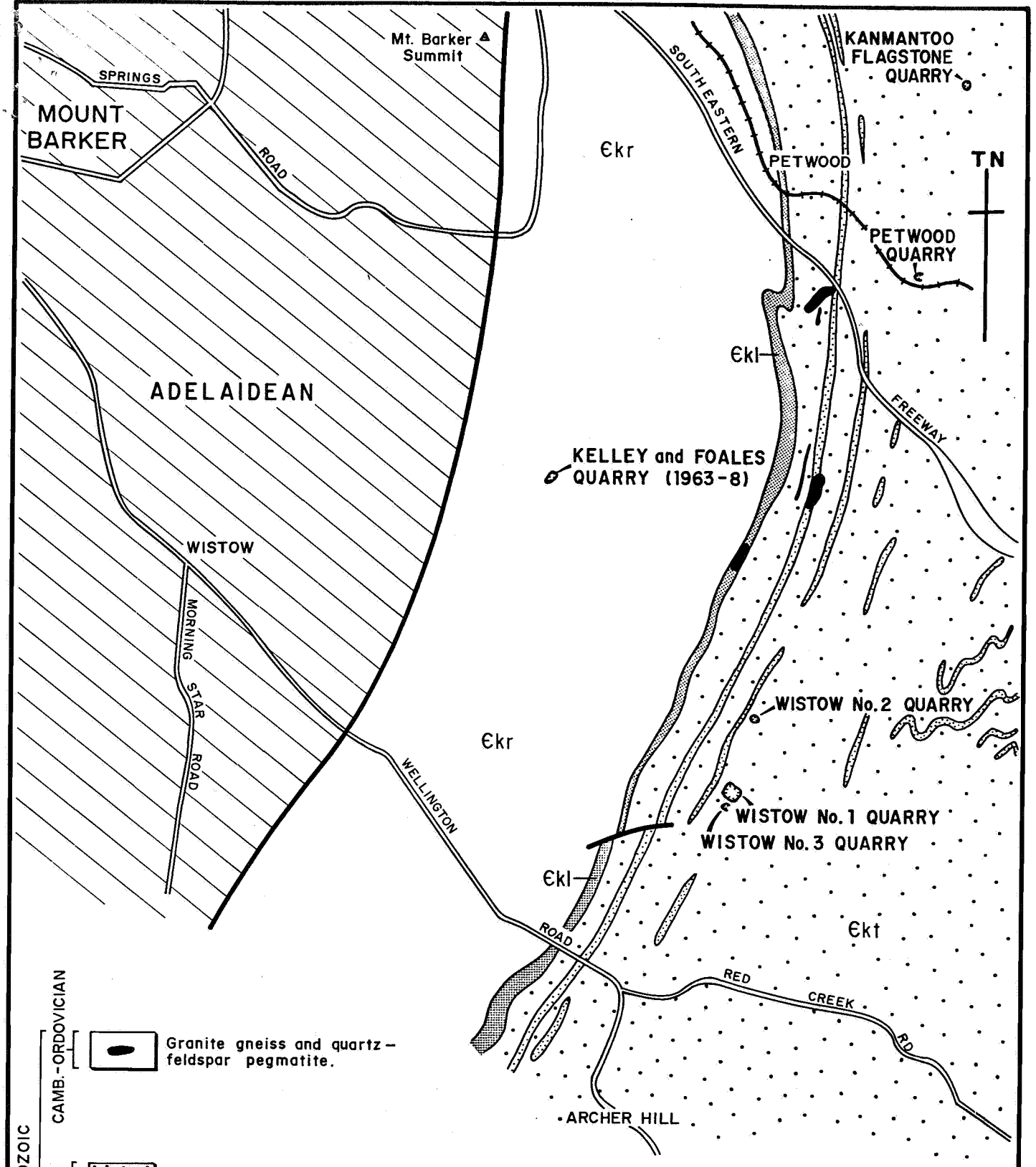


Fig. 3

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

WISTOW FLAGSTONE QUARRIES
SEC. 1376, 2202 HD. STRATHALBYN
REGIONAL GEOLOGY AND LOCATIONS OF WISTOW AND KANMANTOO QUARRIES

COMPILED A.S.	C.D.O. 19-1-87 DATE
DRAWN M.B.	SCALE As shown
DATE Apr '86	PLAN NUMBER S18589
CHECKED	

4043

MN

SEC 2202

PM 170

ROAD

ACCESS TRACK

RESERVE

DAM

DUMP

Stn. C

Stn. D

Stn. E

Stn. A

Stn. B

Tank

Shed

Crusher

Office

Stockpile Picking Bay

BENCH

FLOOR LEVEL 213m

BENCH LEVEL 228 m

PROPOSED BENCH LEVEL 238 m

PROPOSED DUMPING AREA

collapsed area

plagioclasite

muscovite-pyrite schist

quartz vein

quartz veins

Fuel Tanks

PROPOSED ACCESS TRACK

WESTERN LIMIT OF FLAGSTONE ZONE

EASTERN LIMIT OF FLAGSTONE ZONE

SEC 1376

PM 194

SEC 1375

A

A′

B

B′

ELEVATION IN METRES (A.H.D.)

Fence

FLOOR LEVEL 213m

FLOOR LEVEL 238m

Flagstone : Interbedded Meta-siltstone and Bimica Schist

Meta-siltstone : thickly bedded to massive quartzofeldspathic rock

Bimica Schist : strongly foliated rock

Pyritic Schist : Quartzofeldspathic rock with accessory weathered pyrite

Trace of strata (Cross sections only)

Area used in Reserve estimates – Proven Reserves

Area used in Reserve estimates – Probable Reserves

Strike and dip of bedding

Creek

Fence

Contour, 5m interval (A.H.D.)

Quarry face

Dump outline

Proposed quarry development

Cross section

SCALE

0 20 40 60 80 100 METRES

Fig. 4

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

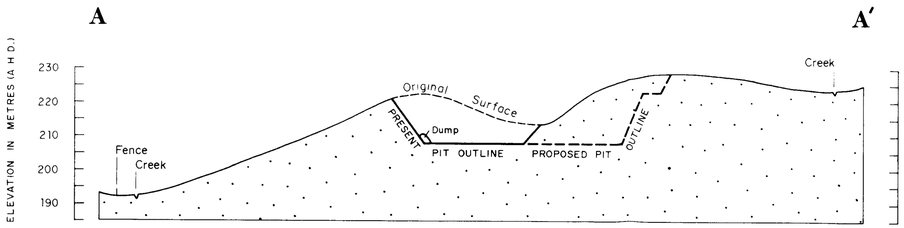
WISTOW FLAGSTONE QUARRIES

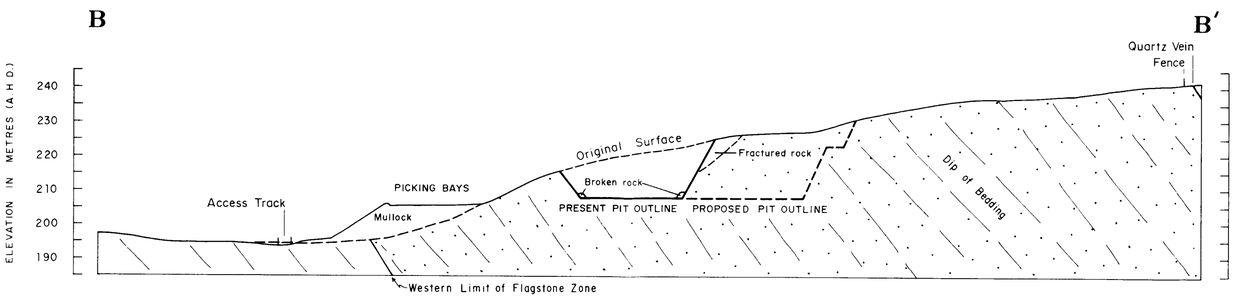
SEC. 1376, 2202 HD. STRATHALBYN

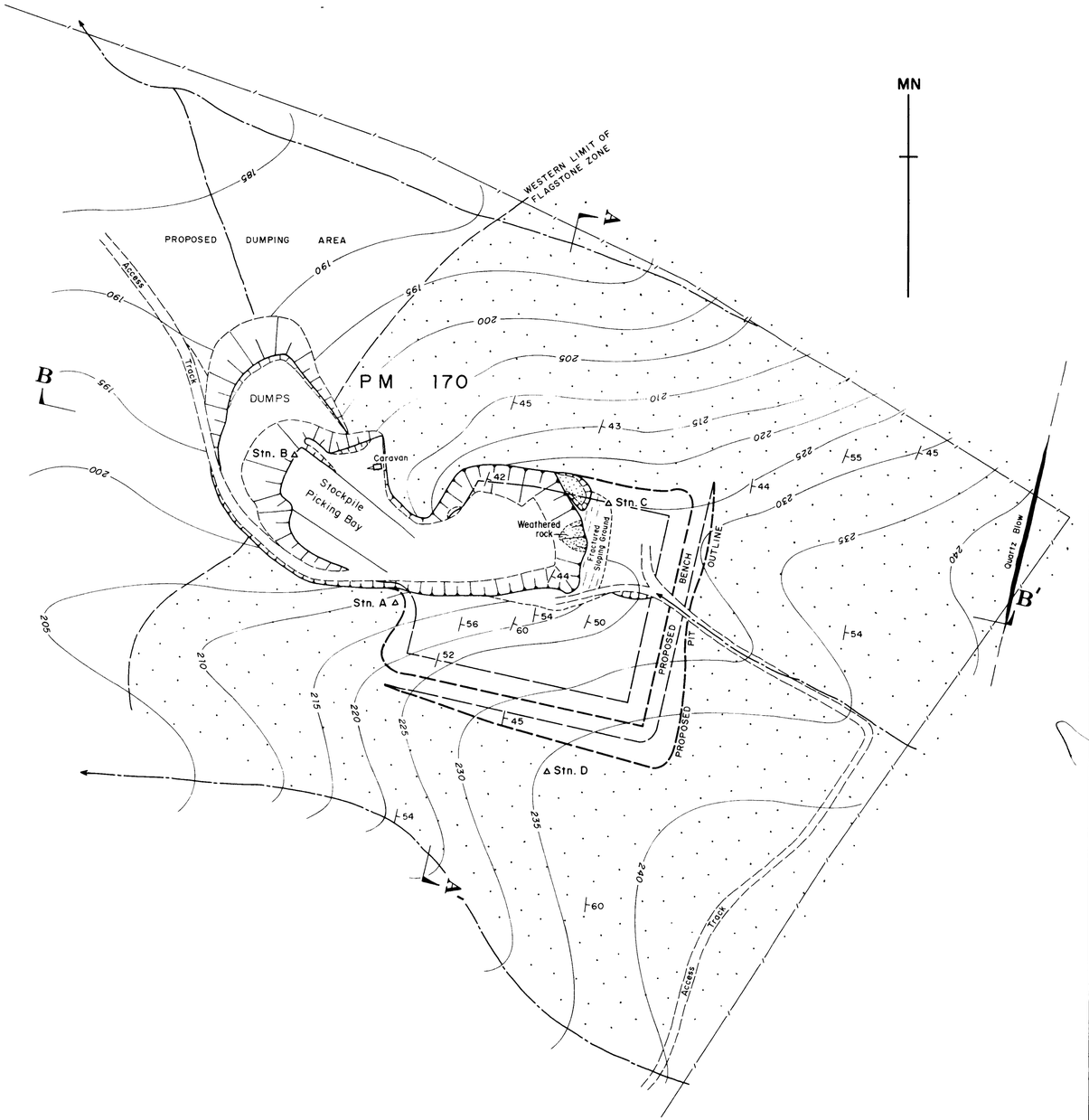
WISTOW No.1 QUARRY AND PROPOSED No.3 QUARRY

COMPILED A.S	K.D.O. 19/1/87 DATE
DRAWN M.B.	SCALE 1 : 1000
DATE July '86	PLAN NUMBER 86-169
CHECKED	

1043







Massive metasiltstone (biotite schist) thinly interbedded with bi-mica schist (Tapanappa Fm)

43 Strike and dip of bedding

Creek

Fence

240 Contour, 5m interval (A.H.D.)

Quarry face

Dump outline

A A' Cross section

SCALE

0 20 40 60 80 100 METRES

Fig. 5

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

WISTOW FLAGSTONE QUARRIES
SEC. 1376, 2202 HD. STRATHALBYN
WISTOW No. 2 QUARRY
PRESENT AND PROPOSED DEVELOPMENT

COMPILED A.S.	K.C. 12.1.87 CDO DATE
DRAWN M.B.	SCALE 1 1000
DATE Mar '86	PLAN NUMBER 86-170
CHECKED	

4043