DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPT. BK. NO. 87/61
CALCA GRANITE DEPOSITS -
DISCOVERY, GEOLOGY AND PRODUCTION
CALCA QUARRY - EML 4469,
SECTION 46 HUNDRED ROUNSEVELL
CALCA SOUTH - EML 5068, SECTION
48 HUNDRED WRENFORDSLEY

GEOLOGICAL SURVEY

By

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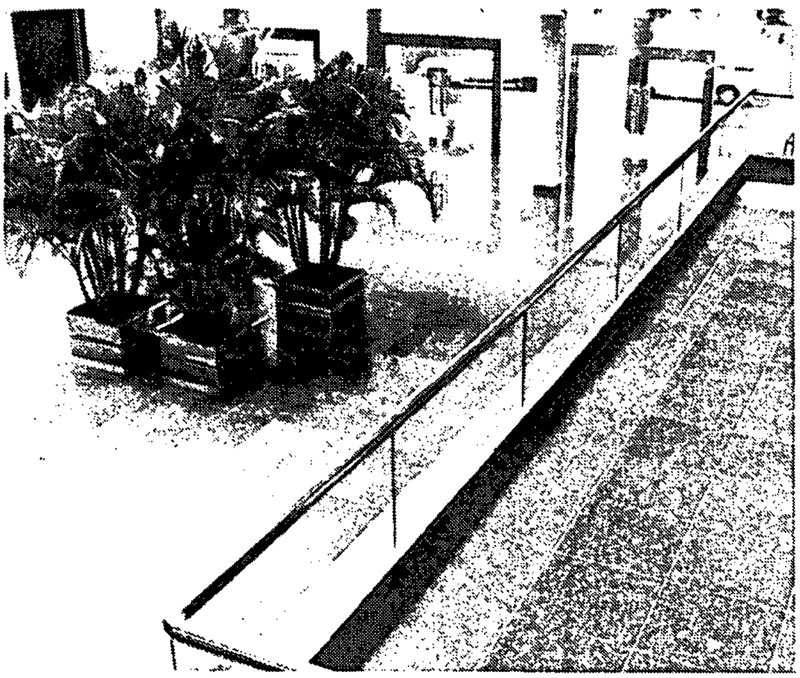

FRONTISPIECE: Polished Calca Granite in the foyer of the Regent Hotel, George St, Sydney.
Photograph courtesy Monier Granite.

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CALCA GRANITE DEPOSITS - DISCOVERY, GEOLOGY AND PRODUCTION
CALCA QUARRY - EML 4469 - section 46, hundred Rounsevell
CALCA SOUTH - EML 5068 - section 48 hundred Wrenfordsley.

ABSTRACT

Attractive red granite of the Hiltaba Suite of Middle Proterozoic age is quarried near Calca, 35 km southeast of Streaky Bay township on western Eyre Peninsula. The granite is ideally suited for use as dimension and monumental stone being fresh, uniform in texture and colour and comparatively free of defects such as xenoliths, joints and veining.

Calca red granite is hard, durable and takes an excellect polish, and has rapidly gained acceptance as a building stone, largely replacing imported red granite. To the end of 1985, 7 200 tonnes (2 800 m^3) of granite have been produced since operations commenced in 1975. Annual production has increased dramatically in the last few years, now being about 2 000 tonnes/year and expected to increase further as the stone gains greater acceptance.

Over the area of the outcrop at Calca Quarry in EML 4469, indicated recoverable reserves down to the floor of the third bench at RL89.5 m total 19 000 m^3 or 50 000 t. Additional reserves are available either by deepening the quarry or extending outside the outcrop to the northeast.

Calca Granite Quarry is well sited to minimise environmental impact. Relatively unweathered and joint-free red granite crops out in several locations near Calca and several other environmentally acceptable quarry sites exist.

At Calca South deposit, joints and xenoliths are more abundant than at Calca Quarry and relatively thick overburden will restrict development.

INTRODUCTION

As part of a program of mapping aggregate and dimension stone quarries on western Eyre Peninsula, Calca granite quarry was mapped on 21 September 1982 by the authors and A.J. Smith (Technical Assistant), using stadia theodolite. Calca South quarry site was surveyed on 22 September 1982 by the authors, A.J. Smith and J.G. Olliver (Chief Geologist).

Quarry plans were updated by L.C. Barnes, J.G. Olliver and E.A. Dubowski (Geologist) on 19 October 1984 and again by L.C. Barnes and P.P. Crettenden (Technical Assistant) on 12 November 1986.

During a brief inspection of the quarry on 11 September 1985, J.G. Olliver and A.M. Pain (Principal Geologist) selected a block of granite for test purposes. However, this block proved unsuitable and another block free of flaws was later selected by Bob Tillett (Manager, Calca Granite P/L).

Petrographic examination of samples from Calca and from nearby outcrops, was carried out by the Australian Mineral Development Laboratories (AMDEL), results comprise Appendices A and B respectively.

AMDEL undertook investigations into causes of the red colour of Calca granite and the reasons for colour fading. This work comprises Appendices D and E.

LOCATION, ACCESS, PHYSIOGRAPHY

Calca granite quarry is located in section 46, hundred Rounsevell, county Robinson, 35 km southeast of Streaky Bay township on western Eyre Peninsula (Fig. 1). The quarry is in the District Council of Streaky Bay, within the Eyre Planning Area. Section 46 is leasehold land, the present leaseholder being Mr. N. Cash of 'Chilba'.

Access from Streaky Bay is via the sealed Flinders Highway 21 km southeasterly, then turning southerly onto the all-weather road to Calca and Baird Bay. Turning off this road 19 km south of the highway, a graded road is followed easterly for 4.3 km to a gate on a track along the hundred boundary. This track is followed southwards for about 450 m, then through another gate and southeasterly for about 1 km to the quarry (Fig. 2). Calca South deposit is a further 1 km south along the hundred boundary.

The quarry is sited on the southern edge of a low granite whaleback which rises to a maximum height of about 5 m above the surrounding gently undulating, calcreted plain which slopes southwards to Baird Bay and the Southern Ocean (Plate 2). The outcrop is surrounded on all but the southern side by mallee eucalypt scrub. East and west of the quarry, the scrub has been cleared for cereal crop cultivation and grazing.

Calca South deposit is located on a gentle hill slope which rises about 20 m westwards from the track and fence. Most of the low granite outcrops are within, or close to a belt of thick mallee scrub running N-S through the central part of EML 5068, the rest of the area having been cleared for cultivation.

Rainfall in this part of western Eyre Peninsula averages about 375 mm per annum. There is no drainage network developed, all drainage being internal.

The authorised development plan for the District Council of Streaky Bay states:

> 'Quarrying and similar extractive and associated manufacturing industries should not mar the landscape unduly. Old structures should be removed and the natural cover of land restored after workings are finished.'

HISTORY, MINERAL TENURE

The widespread distribution of coarse grained, red granite on western Eyre Peninsula was recognised during helicopter mapping by SADME of coastal areas and offshore islands in early 1974. Samples collected from Anxious Bay (Fig. 1 and Plate 17) by geologists of the Regional Geology Division were polished and examined by Monier Granite (Monier) who expressed interest in obtaining a source of this stone to replace imported red granite.

Announcement of the discovery of potentially usable red granite deposits [The Australian, 15 May 1974] created considerable interest in the Streaky Bay district. Conservationists and the then SA Department for Environment and Conservation [SADEC] lobbied the Minister for the Environment opposing granite mining on Eyre Peninsula, particularly at sites such as Murphy's Haystacks, 35 km southeast of Streaky Bay (Fig. 1). Although the partly to deeply weathered nature of the outcrop at Murphy's Haystacks, and other prominent inselbergs, mitigated against mining as dimension stone, opposition to mining continued and SADEC proposed establishment of a task force to investigate all granite inselbergs on Eyre Peninsula.

Several companies and individuals continued the search for an unweathered deposit of granite that could be economically mined, with due regard for the environment.

Ultimately, Calca was selected as an environmentally suitable site.

Calca Granite Quarry - section 46, hundred Rounsevell

On 15 May 1974, Concrete Industries (Monier) Ltd. pegged a mineral claim (MC) but had not given the required 21 days notice of entry to the landowner. On 17 July 1974, the area was pegged again and MC 528 registered on 26 July 1974.

R.J. Tillett pegged the outcrop on 11 November 1974 and MC 611 was registered on 21 November 1974. An application for an Extractive Mineral Lease (EML) was lodged on 20 January 1975 and on 25 March 1975, Tillett was given approval to commence mining operations. On 11 April 1975, Monier formally lodged an objection to granting of a lease on the grounds that Tillett had overpegged MC 528. On 22 April, Monier withdrew their objection stating that the overpegging problem had been resolved and surrendered MC528.

EML 4469 of 2.4 ha as determined from Fig. 3, was granted covering MC 611 commencing 28 April 1975 for 7 years. Monier submitted application for transfer of the lease to them and requested that the lease be granted in their name. The Minister of Mines and Energy (MME) consented to the transfer on 30 April 1975. Monier then sought approval to sublease EML 4469 to R.J. Tillett operating as Calca Granite P/L, this sublease being approved on 11 November 1975. EML 4469 has been renewed to 27 April 1989.

To cope with the expanding quarry and waste dumps, and permit storage of equipment a larger claim, superimposed on EML 4469 was pegged on 19 December 1986. MC 2105 of 4.27 ha, calculated from Fig.3 was registered for Monier Ltd. on 13 February 1987.

Colley Hill - section 19, hundred Witera

On 5 July 1974, T.H. and L.S. Kelsh applied for a Private Mine (PM) covering an area of 5.76 ha over the northern slopes of prominent Colley Hill. PM 246 was proclaimed on 15 August 1974. On 18 July 1974, Monier applied for registration of two MC over undedicated Crown Land (a stone reserve and a road) at Colley Hill. MC 533 covering the stone reserve was registered on 1 August 1974.

Although Monier considered that the better mining site was on PM 246 adjacent to the west, they could not come to an agreement with Kelsh and on 15 July 1975 applied for an EML covering MC533. Kelsh objected to granting of the lease, and SADEC did not support the proposal suggesting that all granite inselbergs in the Streaky Bay area be reserved from the Operative Provisions of the Mining Act. On 12 October 1976, the MME advised Monier that he was going to refuse the lease application and on 13 January 1977, section 19 was reserved from the Operative Provisions of the Mining Act. MC 533 was cancelled on 28 January 1977.

In his mining return for June 1977, Kelsh reported that no work had been carried out on PM 246 and 'never will be'. The Mining Registrar wrote to Kelsh asking if he wanted PM 246 revoked. When questioned as to why a mining return for December 1977 had not been lodged, Kelsh again stated that no quarrying had been carried out and was never likely to be. Kelsh was again asked to revoke PM 246 and on 28 February 1978, he applied to the Warden's Court seeking revocation. On 25 May 1978, the Warden noted that there had been no production from PM 246 and there being no agreement with any other party to work the granite recommended that the proclamation of PM 246 be revoked. The revocation was approved by the Governor on 29 June 1978.

Calca South - section 48, hundred Wrenfordsley

MC 1584 of 2.89 ha, calculated from Fig. 5, was registered for M & D Granite P/L on 6 May 1982 and converted to EML 5068 commencing on 26 October 1982 for a term of 7 years.

Mineral tenure over Calca granite deposits is summarised on Table I.

TABLE I
MINERAL TENURE - CALCA GRANITE DEPOSITS

Tenement	Holder	Commencement	Expiry	Comments
CALCA GRANITE QUARRY				
MC 528	Concrete Industries (Monier) Ltd.	26/07/74	22/04/75	Surrendered.
MC 611	R.J. Tillett	21/11/74	9/07/75	Converted to EML 4469
EML 4469	R.J. Tillett	28/04/75	23/05/75	Transferred to Concrete Industries (Monier) Ltd.
	Concrete Industries (Monier) Ltd. 1/08/80. Name changed to Monier Ltd.	23/05/75	27/04/89	11/11/75 Sublet to Calca Granite P/L. (Sublease No.2896).
CALCA SOUTH				
MC 1584	M & D Granite P/L	6/05/82	26/10/82	Converted to EML 5068
EML 5068	M & D Granite P/L	26/10/82	25/10/89	
COLLEY HILL				
MC 533	Concrete Industries (Monier) Ltd.	1/08/74	28/01/77	Cancelled
PM 246	T.H. & L.S. Kelsh	15/08/74	29/06/78	Revoked

MINING OPERATIONS AND PRODUCTION - CALCA QUARRY

Operations began in April 1975 in the centre of EML4469 on western side of main outcrop. Initial bench was developed at RL 96.5 m (Plate 1). Lower bench at RL 93 m was established in 1983, creating two faces 3.5 m high.

By November 1986, the two bench quarry was about 50 m by 50 m (Fig. 2) and development of the third bench with floor at RL 89.5 m had commenced. An inclined access track from the south to the edge of moderately fresh granite, 28 m south of Station D, will produce a 3 m high face (Plate 3). All quarry development and extensions are now based on modules of 10 m by 10 m.

Blocks approximately 10 m by 10 m and 3 m high are separated from the granite body using a flame (jet) cutting torch. The torch consists of a hand-held hollow lance through which passes a mixture of compressed air at 8.5 m^3/min and diesel fuel, at 60 1/hour. The air/fuel mixture is ignited (initially using oxygen) and the resultant high temperature flame is directed onto the granite to 'cut' channels about 150 mm wide and up to 4 m deep. The 'cutting' action is due to breakdown of the granite into coarse sand resulting from differential expansion and decrepitation of crystals in the granite when exposed to the flame. The exfoliated rock and crystal fragments are removed by the air blast of the flame leaving channels which are linked to each other and the quarry face. The block is thus separated from the main mass on three sides (Plate 4).

A line of horizontal drillholes, about 8 m deep and 600 mm apart is drilled into the base of the block. Black blasting powder is packed into every third hole and when detonated electrically, the block splits from the main mass along the horizontal plane.

The block is cut into a series of slabs, each about 1 m wide, by drilling lines of very closely spaced drillholes parallel to the longest exposed face (Plate 5). The slab is wedged from the block with drifts and tipped over onto tyres (Plate 6).

Line drilling and wedging (Plates 6 and 7) divides the slab into blocks about 2-3 m long weighing about 6-8 tonnes. At this stage, granite with large xenoliths, aplite veining or with obvious joint planes is rejected. The cut blocks are then stockpiled ready for transport by truck to customers for further cutting and polishing.

Since production commenced in 1975 with mining of 240 tonnes, output has increased steadily and is now nearly 2 000 tonnes per year.

Production from EML 4469, based on returns submitted to the Department of Mines and Energy, is detailed in Table II.

TABLE II
PRODUCTION - CALCA GRANITE QUARRY

Year		Production (tonnes)
1975		240
1976		305
1977		279
1978		346
1979		393
1980		564
1981		559
1982		886
1983		688
1984		1 057
1985		1 903
	TOTAL	7 220
	EQUIVALENT TO	2 776 m^3

PREVIOUS INVESTIGATIONS

Jack (1912) first described granite in portions of counties Lehunte, Robinson and Dufferin, noting the occurrence of red granite in the Calca area and at Kattata Mine (Barnes and Flint, 1984) and commented on the potential as dimension stone as follows.

> 'Certain of these granites, notably at Weedina (Wudinna) and Minnipa are very handsome examples of red granite. They are capable of taking a high polish and have every appearance of durability.'

Granite at Wudinna and Minnipa although part of Hiltaba Suite are now recognised as being equivalent to Charleston Granite, differing slightly from the even redder granite in the Calca area.

Segnit (1938) referred to 'granites' cropping out at Calca Hill, 4 km west of the quarry, and Mount Cooper, 27 km ENE, and recognised the difference between 'very fine grained granite porphyry' at Calca Bluff and red Calca granite. Segnit described the rock on Calca Hill as

> 'very coarse even-grained granite which has a striking reddish-pink colour due to the deep tone of the included feldspars. The quartz crystals are clear to dark smoky in colour which stand out prominently in hand specimen. The mica is biotite. Crystals of hornblende are also present'.

Walker and Botham (1969) carried out a reconnaissance geological survey of western Eyre Peninsula including STREAKY BAY 1:250 000 map sheet area. ELLISTON and STREAKY BAY preliminary geological sheets were prepared in 1967 and 1969 respectively.

During helicopter reconnaissance mapping in 1974, the widespread distribution of coarse grained pink and red granite was recognised on western Eyre Peninsula and on numerous offshore islands (Flint and Crooks, 1981). Petrographic descriptions of samples from Anxious Bay and Mount Hall collected during this survey are included in Appendix B. An Anxious Bay sample was polished by Monier Granite and stimulated the search for red granite dimension stone (Plate 17).

The ill-informed public reaction this search generated resulted in SADEC commissioning AMDEL to assess granitic rocks on Eyre Peninsula as a source of dimension stone. This study by Steveson (1976) was concerned mainly with environmental aspects of mining. It is of little value in assessing the granites as potential dimension stone as most samples were partly or completely weathered, are poorly located, and may not be representative of any particular outcrop.

Steveson graded each potential site with regard to access, reserves, environmental impact of quarrying, freshness, colour and other features and concluded:

> 'All the samples examined are inferior to the granite currently being quarried by Tillett near Venus Bay (Calca Quarry). In general the Tillet sample is a better colour than the others and the environmental impact of the quarrying is very localised.'

Although Steveson's comments on colour are of little significance because of the weathered nature of most of the samples, his conclusion that Calca was the most suitable site environmentally for quarrying red granite did much to remove opposition to the existing operation.

REGIONAL GEOLOGY

Figure 1 has been compiled from STREAKY BAY and ELLISTON 1:250 000 preliminary geological sheets and recent 1:100 000 geological mapping. Regional geological mapping of STREAKY BAY is in progress.

Basement rocks on western Eyre Peninsula are part of the Gawler Craton, an ancient shield comprising Archaean to Middle Proterozoic metasediment, volcanics and granite. These rocks have been multiply deformed, the last major deformation being termed the Kimban Orogeny.

Concurrent with Kimban Orogeny (1800-1580 Ma), granitic gneiss and migmatite was developed containing relict older basement, and a suite of synorogenic granite. Foliated, medium grained granite crops out on the coast at Point Westall and Slade Point and is considered to be Lincoln Complex equivalent, representing the oldest rocks exposed in the Calca area.

Post dating Kimban Orogeny, there was a period of about 100 million years of widespread granite plutonism and volcanic extrusion, these rocks comprising most basement outcrops in the Calca area.

Gawler Range Volcanics are a sequence of rhyolite, rhyodacite, dacite and basalt. Although exposed over hundreds of square kilometres in the Gawler Ranges, outcrop in the Calca area is limited to Mount Cooper (Fig. 1) where feldspar porphyry (Samples 5831 RS29 and 30, Appendix B) and rhyolite (Sample 5831 RS34) are quarried for road construction purposes. Highly porphyritic red brown to grey granite and adamellite considered to be of similar age crop out at Calca Hill and Calca Bluff (Samples 5731 RS17 and 19, Appendix B and Fig. 2).

Gawler Range Volcanics are intruded by granite of the Hiltaba Suite, massive light red, pink and bright red high level granite, and adamellite.

Coarse grained pink granite, equivalent to Charleston Granite dated at 1550-1470 Ma, crops out near Wudinna (Sample 6031 RS29) 100 km east and near Minnipa (Sample P193/74) 38 km northeast of Calca. Small quantities of very coarse grained, purplish-pink granite have been quarried at Yarwondutta Rocks

4 km north of Minnipa (Tarvydas, 1970) and used on the steps of the Mitchell Building, University of Adelaide and as polished panels on Eudunda Farmers Building, North Terrace, Adelaide.

Mineralogically similar but slightly younger (Rb-Sr age 1456±26 Ma, Webb et al., 1982 and 1986), bright red granite of the Hiltaba Suite crops out boldly for 32 km from Cape Labatt through Anxious Bay, Mount Hall and Colley Hill to Snaglee Rock (Fig. 1). Isolated outcrops of red granite 40-44 km northeast of Calca, at Cocunda Rockhole [Sample 5832 RS17, Appendix B], Parla Peak and at Kattata Mine (Barnes and Flint, 1984) are presumed to be of similar age. The brighter red colour of the younger granite is because plagioclase, as well as potash feldspar is red, colour being related to fine hematite inclusions within feldspar (Appendix D).

With the exception of Calca Hill - Calca Bluff, all basement outcrops in the Calca area comprise bright red Hiltaba Suite granite (Fig. 2).

Outcrops comprise

- prominent hills with smooth slopes and rounded tors, and rocky outcrops such as Mount Hall and Colley Hill
- sculptured tors such as Murphy's Haystacks
- low smooth outcrops and whalebacks.

Several areas have potential for dimension stone. Outcrops are relatively free of joints, surface samples are either fresh or only slightly weathered and have good red colour, and a quarry could be developed with minimal environmental impact. The following sites, in order of priority, are worthy of investigation, (Fig. 2).

- section 92 hundred Wrenfordsley, 2 km NNW of the quarry - sample 5731 RS 59.
- section 46 hundred Wrenfordsley, 2.5 km NNW of the quarry - sample 5731 RS 61.
- section 48 hundred Wrenfordsley, 0.6 km W of Calca South deposit.

Hiltaba Suite granite also subcrops extensively, veneered either by weathered granite rubble or by calcrete (Fig. 2).

The crystalline basement surface is highly irregular and basement rocks are almost everywhere overlain by Bridgewater Formation, widespread soft, aeolian calcarenite and calcrete. Thickness varies from 0 to 80 m. Within Bridgewater Formation are numerous calcrete horizons including pink, hard, nodular Ripon Calcrete and softer, white Bakara Calcrete. Calcrete is also developed directly on weathered, or partly weathered, basement rocks.

Younger sediments include:

- Pleistocene colluvial clay and gravel surrounding exposed basement (not shown on Fig. 1).
- Yamba Formation; lacustrine gypsum deposits and gypseous dunes, developed in lakes south of Streaky Bay township (Olliver et al., 1985).
- Moornaba Sand; aeolian, pale grey and orange sand of the inland vegetated dunes.
- Semaphore Sand and St. Kilda Sand; calcareous and siliceous sand and mud of modern day beaches and coastal dunes.

SITE GEOLOGY - CALCA QUARRY, EML 4469

Calca granite quarry is sited on the western end of a low whaleback of red Hiltaba Suite granite, about 120 m east-west by 80 m north-south (Fig. 3), protruding up to about 5 m above the surrounding sandy soil covered aeolianite (Plate 2). Shallow channels developed along joints drain the central and eastern parts of the whaleback, the major channel being infilled with granitic talus and soil in several places.

About 25 m north of the main outcrop, another low smooth outcrop of fresh granite measures 30 m by 25 m. In the northern part of EML 4469 are numerous, poorly outcropping areas of moderately to strongly weathered, partly calcreted granite, and granite rubble. Partly to deeply weathered granite probably lies at shallow depth with degree and depth of weathering increasing away from outcrops of fresh granite [Section A-A' Fig. 3].

South of the main outcrop, granite is obscured by sandy soil littered with abundant feldspar fragments and calcrete rubble. The third bench access development exposes slightly to moderately weathered granite overlain by 0.3-1.5 m of highly weathered granite, granite rubble and calcareous soil extending southwards for about 28 m beyond survey station D. At this point, granite dips down sharply and the resultant hollow is infilled with grey-green and red mottled clay of probable Pleistocene age (Section A-A', Fig. 3). Further south, deeply weathered granite is exposed beneath 1-1.5 m of calcareous soil and calcrete, the top of the weathered granite being highly irregular. The southern part of the access track exposes only calcareous soil and massive calcrete. Soil and calcreted aeolianite cover thickens rapidly southwards.

Mineralogy

Petrographic examination [Samples 5731 RS58 and 62, Appendix A] shows equant, anhedral crystals of quartz and feldspar set in a granular mosaic, with a trace of biotite, chlorite and hornblende. Sample RS62 has quartz content of about 50%, slightly higher than typical red Hiltaba Suite granite which averages 20-45% quartz and 50 to 70% feldspar.

Feldspar is dominantly potassium feldspar (microcline) with only a few percent plagioclase both as discrete crystals and as exsolved blebs within potassium feldspar. Most potassium feldspar is perthitic, but the perthitic texture is generally obscured by pervasive brown, turbid alteration resulting from the presence of extremely fine minerals within the feldspar. Plagioclase also shows a distinctive, although paler, discolouration.

Electron microprobe point analyses and optical examination [Appendix D] have shown feldspar to contain numerous small iron-rich inclusions. The presence of numerous fine flakes and particles of hematite within potassium feldspar, and to a lesser extent within plagioclase, produce the striking pinkish-red colour. Minor alteration of hematite to goethite, which is more marked in weathered samples, results in an overall brownish colour in some of the granites, e.g. Anxious Bay, (Plate 17).

Biotite is the most common accessory mineral, being generally chloritised, with fluorite, epidote, apatite, zircon, allanite and opaques also being recorded [Sample RS 58, Appendix A]. Most accessory minerals result from late stage hydrothermal activity, either related to aplite veining, or postdating aplite.

Chemistry

Whole rock analyses of red Hiltaba Suite granite from Searcy Bay, Anxious Bay and Calca Quarry (Fig. 1) are remarkably similar (Appendix C). The granite is highly silicic with >75% SiO_2. The large excess of K_2O over Na_2O reflects the dominance of orthoclase feldspar. Sample 5731RS1, older Lincoln Complex equivalent granite from an island off Cape Blanche (Fig. 1) contains less silica and the $K_2O:Na_2O$ ratio is significantly lower.

Metalscan analysis of red Hiltaba Suite granite (Appendix C) shows trace element concentrations typical for granite, the anomalously high iron content being due to hematite inclusions in feldspar.

Steep Joints and Aplite Veins

These conspicuous features are partly responsible for stone wastage. There is no strongly preferred orientation, but most joints and veins belong to two broad sets

- trending 130°M-150°M, dipping moderately to steeply northeasterly
- trending 070°M-090°M, dipping steeply northerly.

Some joints and veins are arcuate, others branching, and in many cases, dip varies considerably (Plate 4).

Many joints are of limited lateral and vertical extent (Plate 11) being traceable for between 2 and 20 m. The exception is the joint 10-15 m east of the quarry, marked by a shallow southeasterly draining gutter which extends across the outcrop for 70 m.

The aplite-infilled joints are more continuous, many are traced for 30 to 50 m, and the main vein, trending 070°M extends for 100 m across the northern part of the outcrop.

Spacing varies widely from 1 to 30 m. Joints and veins are concentrated in the central part of the outcrop between the eastern edge of the quarry and the gutter, and thereby reduce the amount of dimension stone available. In contrast, the eastern and northern parts of the outcrop are comparatively free of joints and veins and yield of stone is expected to be similar to the present quarry.

Aplite Veins

The major east-west aplite vein (Fig. 3 and Plate 8) dips steeply northwards and varies in width from 0.2 m to 1.5 m. In the centre, the vein bifurcates with the northern branch trending 105°M linked with an arcuate aplite-infilled joint.

Petrographic examination of Sample 5731 RS37 (Appendix A) from this vein shows scattered clusters of medium grained, subhedral to anhedral crystals of quartz, orthoclase, perthite and chloritised hornblende in a fine grained micrographic groundmass of quartz and graphically intergrown orthoclase and plagioclase. Bright blue fluorite is an accessory mineral.

Most other aplite veins are straight, and generally less than 200 mm wide, many being only 20 to 50 mm wide. Many veins more than 100 mm wide contain numerous small cavities lined with well-formed clear and smoky quartz crystals [Plate 10]. The margins of these wider veins show evidence of modification during a later aqueous hydrothermal phase. Reddish brown aplite is bordered by pale grey to cream graphically intergrown quartz and feldspar (Plate 8) with, in places, coarsely crystalline biotite and tabular to acicular hornblende crystals up to 50 m long. The contact between this graphic zone and the enclosing granite is somewhat irregular and transitional over a few millimetres. Narrow aplite veins do not exhibit the marginal graphic zone and red-brown to grey aplite is in sharp contact with granite (Plate 9). Within some aplite veins, particularly those with numerous cavities, the joint along which the aplite was intruded has reactivated, resulting in a prominent parting along the vein (Plate 10).

Within the main aplite vein, a number of near vertical, en-echelon partings probably represent cooling joints (Plate 8). Two unusual arcuate joints within the adjacent granite probably developed at the time of aplite intrusion and may represent compressional structures.

Joints

Steeply dipping joints are of two types:

- dark coloured - the most common, are defined by concentrations of dark mica/chlorite and/or (?)iron oxides (Plate 11). Generally associated with a plane of parting, these structures are responsible for breakage of some blocks and in some cases make quarrying difficult. Often surface expression is minimal and tracing in outcrop is difficult.
- pale coloured - weathering down the joint has altered feldspar to white mica/clay resulting in a pale coloured band through the granite (Plate 12). These joints are traced easily as the joint forms a slight depression owing to preferential erosion along the less resistant rock. The main south-draining gutter has developed along joints of this type.

'Dark Lines'

The major cause of block breakage, probably being responsible for 60-70% of total stone wastage, 'dark lines' result from concentration of biotite and chlorite along a sharply defined plane (Plate 14). In many places, these planes have the appearance of a slickensided surface, but there is no evidence of movement. Lateral extent is limited to only a few metres. There is little or no evidence of their continuity through the granite and in most cases, their presence is not detected until the granite breaks (Plate 14).

Orientation is remarkably consistent at 060°M to 070°M. More than 90% exposed to date, dip southerly at 35° to 40° (Plate 13), the remainder dip northerly at similar angles.

Origin is uncertain, but probably related to late stage recrystallisation of biotite and subsequent alteration to chlorite along cooling or unloading joints.

Exfoliation Joints

Sheet exfoliation is not common but has been observed in several places parallel to and within 1 m of the surface generally as partings, highlighted by iron oxide staining (Plate 10 and 12). There is little evidence of exfoliation joints in deeper parts of the quarry although some steep joints flatten out rapidly with depth suggesting coincidence with poorly developed exfoliation joints.

Xenoliths

Compared to many other granite, xenoliths are not abundant at Calca.

The most common xenoliths are:

- highly porphyritic red granite from Calca Bluff and Calca Hill (Plate 15)
- grey feldspar porphyry comprising phenocrysts of red and cream feldspar up to 10 mm across set in a grey granitic matrix (Plate 16). These xenoliths have been derived from either

- finer grained variant of Calca Bluff granite or
- from stratigraphically equivalent Gawler Range Volcanics.

Grey and red feldspar porphyry (Samples RS29 and 30 Appendix B) at Mount Cooper 25 km east of Calca are mineralogically and texturally similar to the xenoliths, although phenocrysts in the latter are generally coarser.

- biotite and hornblende rich masses representing partly to completely assimilated fragments of older gneissic and granulitic basement.
- pink and white, feldspar-rich, biotite granite derived from older granite bodies.

Xenoliths vary in size from a few millimetres across up to feldspar porphyry about 1 m across.

SITE GEOLOGY - CALCA SOUTH

The main outcrop in the central part of EML 5068 measures about 35 m north-south by 15 m east-west and is up to 3 m high in the eastern side (Fig. 4). A (?) joint-controlled line of small outcrops is present about 60 m south-southwest of the main outcrop, extending beyond the southern lease boundary. Between these outcrops and the main outcrop, weathered granite crops out sporadically in the mallee scrub suggesting granite at shallow depth through most of this area. 90 m southwest of the main outcrop, beyond the western boundary of EML 5068, an isolated whaleback of granite 25 m long, 6 m wide and 2-3 m high crops out.

There is little outcrop over the rest of lease as granite is obscured by (?) aeolianite and soil cover of unknown thickness (Section A'-A, Fig. 4). Calcrete rubble is common in the northwestern part of the lease suggesting massive calcrete at shallow depth.

Granite is similar mineralogically and texturally to granite at Calca Quarry.

Jointing is common, join spacing ranging from 1 to 5 m. The main joint set trends 150°M-160°M, subparallel to the 130°-150°M set in Calca Quarry. Several conspicious joints trend 040°M-050°M across the main outcrop and this joint set is also present in outcrops southwest of the main outcrop. This joint trend has not been observed in Calca Quarry. A less well developed joint set trends 070°M-090°M, parallel to aplite veining.

Several thin, less than 50 mm wide, reddish brown aplite veins intrude the granite. Most trend 070°M-090°M parallel to the main aplite veining in Calca Quarry but on the eastern side of the main outcrop a meandering, branching aplite vein strikes 010°M-020°M.

Xenoliths, up to 0.5 m across, are of similar lithologies to those at Calca Quarry, but are more abundant.

'Dark lines' have not been recognised in outcrop but are expected to be present through the granite.

STONE QUALITY

Colour and Texture

Colour of red Hiltaba Suite granite varies between outcrops dependant upon degree of weathering, ranging from very pale pink at Cocunda Rock (5832 RS17, Appendix B) to dark reddish brown at North Anxious Bay (P194/74, Appendix B). Throughout the quarry apart from a thin (<0.2 m), slightly weathered, surface layer, granite is fresh and even in texture and colour.

Colour is uniformly pinkish red to pale brownish red (Plate 17).

Petrographic investigation by AMDEL (Appendix D) has shown that colour is due to tiny red flakes and particles within feldspar grains. Electron microprobe analyses have confirmed the particles to be iron oxide, probably hematite, which impart an overall pinkish colour to feldspar crystals. Cracks within feldspar are infilled with hematite particles and stained darker red.

Alteration of hematite to goethite produced brown staining within some feldspar crystals (Plate 17). More pronounced weathering resulted in significant alteration of hematite to goethite, imparting an overall brownish colour such as seen at Anxious Bay (Plate 17). Further weathering leached iron and altered feldspar to sericite and clay producing very pale coloured rock down some joint planes (Plate 12).

Texture is equigranular - hypidiomorphic to slightly porphyritic, typical of many coarse grained granites such as Murray Bridge Granite and Black Hill Norite. There is no apparent foliation or crystal alignment.

The uniform colour and texture of Calca red granite is such that the stone is much in demand for building and monumental purposes and has partly replaced imported red granite. However, a bright red granite suitable for dimension stone is still being sought by local stone producers.

Colour 'Fading'

During initial investigations in the Calca area, the red colour was observed to fade slightly after cutting, polishing and exposure to sunlight. Investigations by AMDEL (Appendix E) have shown that this 'fading' is due to dehydration. Fluid is lost from inclusions and voids, induced by either mild, dry heat or by lowering water vapour pressure by evacuation. Reabsorption of water restores or improves the colour. Prolonged heating at elevated temperatures results in complete dehydration accompanied by cracking, eventual decrepitation of the rock and irreversible loss of colour.

'Fading' is characteristic of all granite. The slightly darker colour of moist granite (Plate 19) is atypical, the 'faded' colour representing the true colour.

This colour variation between moist and dry granite does cause some problem in matching stone. Because polishing is a wet process, newly polished stone is darker than 'aged' stone and some builders/architects express concern when freshly polished stone is placed next to stone that has been in position for some time. Eventually, within 2-3 months, all the granite reaches the same dry state with a uniform, stable colour, and subsequently exhibits only slight, almost imperceptible, colour changes depending on atmospheric temperature and humidity.

Defects

Calca granite is fresh, uniform and generally free of major defects, the most significant in order of frequency are:

'dark lines' - In most cases, the granite parts along the well-developed chloritic plane during quarrying and is rejected. 'Dark lines' of limited extent, or those which are less well developed are difficult to recognise, may be overlooked. Incipient 'dark lines' and 'dry lines' - partly annealed joints without significant mineral accumulations may cause the block to break suddenly during processing. Although not common at Calca, 'dry lines' are a problem with other granite such as Murray Bridge (C. Tillett, S.D. Tillett Memorials P/L, pers. comm. 9 October 1986).

aplite veins - generally dark red to grey or brown and detract significantly from the stone's appearance. Being intruded along joints, many are also a zone of weakness and must be discarded. Very thin, pink aplite veins (Plate 9) are not always cut out, particularly if finish is gang-sawn or exfoliated.

joints - Although not common, the occasional joint through the quarry causes problems during quarrying. Parting along joints during slabbing of 10 m square blocks can produce wedge shaped pieces that have to be broken up to permit removal of adjacent slabs. In some places, notably along the joint dipping 60° northerly through the central part of the quarry (Fig. 3), stone wastage has reached 60%. Besides being a zone of weakness, most joints are characterised by an unacceptable coloured line or band. Blocks containing either dark (Plate 11) or pale (Plate 12) joints are rejected but these features are not a significant cause of wastage.

xenoliths - although not common, most xenoliths are dark coloured and detract from the finished appearance of the stone and are discarded at the quarry. Small pink and white patches of partly assimilated older granitic basement present little problem and are not removed.

red flares - dark red lines or zones formed by either feldspar veining and/or segregation or hematite staining along joints detract from the uniform pink colour. Red flares are mostly encountered in near surface material (R. Tillett, Calca Granite P/L. pers. comm. 15 October 1986) suggesting concentration of iron oxide by weathering. Red flares are rejected during either quarrying or processing.

Durability

A selected block 0.8 m by 0.9 m by 1.1 m from the RL 93 m bench is being tested by AMDEL to determine properties including compressive strength and modulus of rupture. Results are not yet available but are expected to show that quality is high with strength characteristics adequate for current uses.

Hardness

Because of the high quartz content of 30-50%, Calca granite is the 'hardest' granite dimension stone used in Australia. Within the stone industry, Calca granite is classed as highly abrasive and is the commercial granite most resistant to cutting and grinding.

Polishing Characteristics

With little if any clay mineral or cracked feldspar and low mica content, current blocks are uniform in texture and hardness taking an excellent polish with minimal undercutting.

Once the surface has been ground flat, the relative hardness of Calca granite ensures a rapid polish which holds for a long time. However, under abrasive conditions such as paving, the feldspar can lose its polish.

Like most granites, there are a few small voids. As corborundum stones are used for grinding and polishing, these present little problem. Previously, white polishing powders were entrapped in voids and had to be either removed or darkened.

PROCESSING

Rectangular blocks weighing approximately 8 tonnes are transported by road to Adelaide and other capital cities for processing.

For most uses, the granite block is slabbed by one of two methods, slab thickness being determined by end use, eg paving slabs are cut about 75 mm thick (Plate 19).

Frame (or gang) sawing - the traditional method of slabbing dimension stone. A reciprocating frame is used carrying a series of mild steel, notched blades. Water charged with steel shot is fed onto the blades as they are drawn back and forth across the granite. The steel shot fractures and acts as an abrasive slowly cutting the stone.

Because of the hardness of Calca granite, consumption of shot and blade wear are greater than for other granite, about 50% more than for most other granite and nearly twice that for Black Hill Norite.

Frame sawing produces a rough, textured finish and after washing with a mild acid (generally oxalic) is used mainly for paving.

Block sawing - diamond-tipped circular saws of 2-3 m diameter have been introduced recently for primary sawing (Plate 19).

These saws produce a smoother finish than frame saws, thus reducing the amount of grinding prior to polishing. Because of the abrasive nature of Calca granite, diamond wear is very high and block sawing is not economic. S.D. Tillett Memorials P/L use their block saw to cut all granite except Calca which is frame-sawn.

After slabbing, further processing involves surface finishing, cutting and shaping. Sawn, slabbed granite is ground flat, smoothed and polished by automatic and semi-automatic machines with rotating heads which carry successively finer carborundum abrasive blocks and polishing pads. Because of the rough, slightly uneven surface left by frame sawing and the abrasive nature, Calca granite takes a long time to grind flat compared to other stones, but once flat is quickly smoothed and rapidly takes an excellent polish.

For some uses requiring unpolished granite, the final polishing stage is omitted resulting in an honed finish.

An exfoliated finish is produced by passing a broad gas flame over the sawn slab. Small particles exfoliate along crystal planes and boundaries forming a rough natural appearance. Calca granite exfoliates well, particularly from a smoothed surface, leaving a flat, even surface.

Secondary sawing is carried out by diamond-tipped circular saws (Plates 21 and 22). Diamond cost is high for Calca granite. Based on Black Hill Norite as a standard of 1, the diamond cost factor for Calca granite is 7 (J. Hall, Monier Granite pers. comm. 21 October 1986).

USES

The consistent, uniform colour and texture has resulted in widespread acceptance and use of Calca granite in both the building and monumental stone industries. Consequently, Calca granite has almost completely replaced imported Balmoral Red from Finland and Swedish Rose Red granite particularly in Adelaide and Melbourne, although some is still imported into Sydney and Brisbane. Red granite, similar to Swedish Rose Red, has been recently imported from India.

Calca red granite has been used for

- polished flooring in the main foyer of the Regent Hotel Sydney (Frontispiece)
- steps, bollards and frame-sawn paving in the Sydney Opera House forecourt (Plate 24)
- frame-sawn panelling in the new shopping extension to the Colonial Mutual Building, King William Street, Adelaide
- Polished walling and frame-sawn paving in the new Parliament House in Canberra (South Australian Department of Mines and Energy, 1985a).
- 100 mm x 100 mm x 50 mm thick setts with an exfoliated finish for paving walkways surrounding new Parliament House, Canberra (Plate 22)
- a board room table, 2.74 m in diameter and 65 mm thick supported by six octagonal granite legs for the recently completed State Bank of N.S.W., Head Office in Martin Plaza, Sydney (Plate 25) (South Australian Department of Mines and Energy, 1985b).

A contract has been secured to supply 3 000 tonnes of crushed Calca granite for manufacture of reconstituted granite for a building project in Melbourne. This will enable disposal of a significant proportion of the waste blocks surrounding the quarry.

RESERVES, QUARRY DEVELOPMENT

Calca

Reserve calculations based on the cross sections on figure 4, are detailed in Appendix G, and assume sp. gr of 2.6 for granite.

To the end of 1986, an estimated 6 900 m^3 or 17 900 t of granite had been removed with an estimated 3 650 m^3 or 9 500 t being sold, for a recovery of 53%.

Over the area of the outcrop down to the floor of the third bench at RL89.5 m, indicated geological reserves total 36 000 m^3 or 93 000 t of granite.

For each deeper succeeding bench of 3.5 m, indicated geological reserves are 20 000 m^3 or 52 000 t.

Recoverable reserves will be significantly lower owing to wastage from:

- slightly or moderately weathered rock,
- pale colour, generally near surface,
- dark lines, joints and aplite veins,
- xenoliths.

Although intense jointing in the centre of the outcrop probably lowered recovery slightly, indicated recoverable reserves from the outcrop above RL 89.5 m based on a recovery of 53% total 19 000 m^3 or 50 000 t.

Below this depth, recovery should be slightly higher as the effects of weathering down joints are reduced. Indicated recoverable reserves for each 3.5 m bench will range from

- 10 000 m^3 or 26 000 t at a recovery of 50%

to
- 14 000 m^3 or 36 000 t at a recovery of 70%

with the most likely yield of

- 12 000 m^3 or 31 000 t at a recovery of 60%.

Additional reserves are available beyond the limits of outcrop. Considerable soil and weathered granite overburden would have to be removed, particularly to the south of the present southern quarry limits. Long term quarry development should proceed northwards towards the outcrops of fresh granite near the northern lease boundary.

Shallow drilling is required to determine overburden depth before extending the quarry beyond the limits of the main outcrop.

Calca South

Insufficient data are available to determine reserves. Over most of EML 5068 overburden, comprising (?) aeolianite, calcrete, sand, clay and soil will hamper mining. Beneath overburden granite may be partly or completely weathered for considerable depths and mining may be uneconomic.

The only area where quarrying may be viable is from the main outcrop extending south-southwesterly to the small outcrops on the southern lease boundary. Drilling and/or trenching through this area is required to test depth of overburden and degree of weathering.

The xenoliths, aplite veining and closely spaced jointing observed in the main outcrop would severely reduce stone recovery. However, detailed mapping following overburden removal may reveal an area where these deleterious features are less common.

CONCLUSIONS AND RECOMMENDATIONS

Red, coarse grained granite of the Hiltaba Suite of Middle Proterozoic age is quarried from Calca Quarry, 35 km southeast of Streaky Bay township on western Eyre Peninsula. Despite strong initial opposition from conservation groups, the quarry has been operating for 11 years with minimal environmental impact.

Calca granite is remarkably homogenous in colour and texture and contains comparatively few xenoliths, the main deleterious features being thin aplite veins and biotite/chlorite-coated joints. Joint spacing varies across the outcrop with joints being more concentrated in the centre. The western (present quarry) and eastern parts of the outcrop are comparatively joint free.

Calca granite is hard, strong, abrasion resistant, aesthetically attractive and takes a high polish and thus is ideal for building and monumental stone.

From opening in 1975 to 1985, 2 800 m^3 or 7 200 t have been produced at a recovery of 53% from the two bench quarry.

Indicated recoverable reserves, over the outcrop down to the floor of third bench at RL 89.5 m total 19 000 m^3 or 50 000 t. Large additional reserves are available by deepening the quarry, and by extending beyond the outcrop.

Future quarry extension should be northwards provided depth of overburden and weathering are not prohibitive. A program of grid drilling is recommended.

Should another quarry be required, investigations are recommended in order of priority at the following sites in hundred Wrenfordsley

- section 92
- section 46

- Calca South, EML 5068 on section 48 - where drilling and trenching is required to locate an area of fresh, comparatively joint and xenolith free granite at shallow depth.

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REFERENCES

Barnes, L.C. and Flint, R.B., 1984. Kattata Mine. Section 16, hundred Moorkitabie, Eyre Peninsula. S. Aust. Dept. Mines and Energy report 84/4 (unpublished).

Botham, S.J., 1967. ELLISTON preliminary geological map 1:250 000 series. Geol. Surv. S. Aust. (unpublished).

Flint, R.B. and Crooks, A.F., 1981. Geology of Waldegrove and Cap Islands (Elliston and Kimba 1:250 000 map sheets). S. Aust. Dept. Mines and Energy report 81/28 (unpublished).

Jack, R.L., 1912. The Geology of Portions of the Counties of Le Hunte, Robinson and Dufferin, with special reference to Underground Water Supplies. Bull. geol. Surv. S. Aust., 1.

Jack, R.L., 1923. The Building Stones of South Australia. Bull. geol. Surv. S. Aust., 10.

Olliver, J.G., Dubowski, E.A. and Barnes, L.C., 1985. Reappraisal of gypsum reserves, Streaky Bay Lakes, Eyre Peninsula. S. Aust. Dept. Mines and Energy report 84/80 (unpublished).

Segnit, R.W., 1938. Geology and Development of Ground Water in the Robinson Fresh Water Basin, Eyre's Peninsula. Part 1 Geology and Hydrology. Bull. geol. Surv. S. Aust., 17:12-13.

South Australian Department of Mines and Energy, 1985a. S.A. Building Stones for Canberra. Miner. Ind. Q. S. Aust. Dept Mines and Energy, 37:23-24.

South Australian Department of Mines and Energy, 1985b. Calca Red Granite. Miner. Ind. Q. S. Aust. Dept Mines and Energy, 39:16.

Steveson, B.G., 1976. Eyre Peninsula Inselberg Study. Amdel report No. 1124 to Department for the Environment, South Australia (unpublished).

Tarvydas, R.K., 1970. Investigation of overburden, Western Outcrop, Yarwondutta (Granite) Rocks. Mineral Resour. Rev., S. Aust. 129: 215-221.

Walker, N.C. and Botham, S.J., 1969. Reconnaissance Geological Survey of the Streaky Bay and Nuyts 1:250 000 areas. S. Aust. Dept. Mines and Energy report 68/25 (unpublished).

Webb, A.W., Thomson, B.P., Blissett, A.H., Daly, S.J., Flint, R.B. and Parker, A.J., 1982. Geochronology of the Gawler Craton, South Australia. S. Aust. Dept. Mines and Energy report 82/86 (unpublished).

Webb, A.W., Thomson, B.P., Blissett, A.H., Daly S.J., Flint, R.B. and Parker, A.J., 1986. Geochronology of the Gawler Craton, South Australia. Aust. J. Sci. 33 : 119 - 143.

APPENDIX A

Petrographic descriptions of rocks from Calca granite quarry

Sample	Description	Source
5731 RS62	Granite	Steveson, B.G., 1976. AMDEL report No. 1124 Eyre Peninsula Inselberg Study.
5731 RS37	Aplite	McColl, D., 1983. AMDEL report GS3259/83.
5731 RS58	Granite	Spry, A.H. 1986. AMDEL report C6034:Building Stone Project. Progress report No.3.

Sample: 5731 RS62; TS35714

Location:
Calca granite quarry.

Description:
Fresh red granitic rock taken from quarry face.

The mineralogical composition of this granite is as follows:

	%
Quartz	50
Potassium feldspar	45
Plagioclase	<5
Opaques	trace-1
Biotite	trace
Hornblende	trace
Chlorite	trace
Apatite	trace

Potassium feldspar is extensively altered and has an even brown colour in the thin section although there are some patches of this mineral which have a rather blotchy appearance due, apparently, to the irregular alteration of patchy perthite. Rare, relatively fine-grained plagioclase is altered to an even grey shade in thin section. Hornblende, biotite and chlorite all occur in relatively small patches commonly enclosed by potassium feldspar. Hornblende is generally fresh but biotite has been extensively chloritised and there are numerous places where these two minerals are closely intergrown with each other.

The polished slab of this rock is a distinctly brighter red than other granites from this area (Appendix B) and this appears to be due wholly to the brighter red shade of potassium feldspar crystals. The rock has taken a somewhat superior polish but this is probably due to the freshness of the sample rather than any inherent differences between this sample and the other granites as the rock is similar in terms of texture and proportion of accessory mafic minerals. There are a few patches of white to cream-coloured clay, particularly associated with ?biotite. Since the rock is fresh it contains fewer intercrystalline cracks and hence there is less grinding powder in the surface and consequently the rock has a distinctly brighter appearance.

Sample: 5731 RS37; TS44879

Location:
Calca granite quarry.

Field description:
Aplite vein.

Rock Name:
Altered granophyre

Hand Specimen:
A pink medium to fine-grained quartzo-feldspathic igneous rock with an irregular grain size and texture.

Thin Section:
A visual estimate of the constituents is as follows:

	%
Quartz	25-30
Feldspar (potassic)	50
Feldspar (soda-lime)	15
Hornblende (chloritic)	3-5
Fluorite	1
Opaques (sulphide plus goethite)	1-2

Crystals of quartz and feldspar of medium grain size and subhedral to anhedral form occur in scattered clusters and are enclosed in a fine-grained micrographic groundmass in this rock. Most of the coarser crystals are up to 3 mm diameter and consist of orthoclase or various perthitic intergrowths in which potassic feldspars are dominant. These are rather turbid and brownish with aleration products.

Most of the lamellar to elongate prismatic hornblende is also present in these somewhat coarser zones, although the hornblende is now altered to a semi-opaque and partially chloritised mass. A few rare crystals of plagioclase with a composition on the calcic side of oligoclase (Ab_{70}) are also present, although plagioclase is more abundant in the groundmass.

The micrographic groundmass itself consists of quartz and graphically intergrown orthoclase and plagioclase (?perthite). The orthoclase is turbid and considerably altered while most of the plagioclase is relatively fresh. The orthoclase is usually the optically continuous phase which may extend for over 5 mm and encloses rounded granules of quartz and more skeletal plagioclase.

Rare intergranular masses of fluorite occur in fragments up to 0.3 mm diameter, occurring principal in the vicinity of hornblende/quartz associations, and filling intergranular interstices. Some hydrothermal alteration of this rock has taken place, chloritising the amphibole and argillising the feldspars. Introduction of the fluorite probably also took place during this phase.

The rock appears to be a medium-grained rock of late-stage magmatic affinities such as an aplite or microgranite, but which has been modified during an aqueous hydrothermal phase which has resulted in a rock which may best be described as an altered granophyre.

Sample: Calca Granite 5731 RS 58; TSC47735-36

Rock Name:
Granite

Hand Specimen:
A pink-red (mass colour) medium- to coarse-grained rock composed mainly of brick-red potash feldspar intergrown with milky (medium) grey quartz with minor stilpnomelane, plagioclase, feldspar and chlorite.

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

	%	Size (mm) Range	Average
Potash feldspar	50	0.3-15	5
Quartz	35	0.1-6	3
Stilpnomelane	5	0.1-1	0.5
Plagioclase	5	0.3-1	0.5
Chlorite	2	0.1-1	0.3
Hornblende	Tr-1	0.1-1.5	0.5
Fluorite	Tr-1	0.1-1	0.5
Sericite/clay	Tr-1	-	-
Epidote	Tr	-	-
Apatite	Tr	<0.2	0.1
Zircon	Tr	<0.15	0.05
Allanite	Tr	<1	0.5
Opaques	Tr-1	0.1-1	0.5

This sample consists mainly of anhedral to subhedral potash feldspar crystals intergrown with anhedral quartz together with minor dark mica. The potash feldspar crystals have an untwinned character but typically exhibit a patchy to ribbon perthitic texture. In some cases the potash feldspar appears to be a replacement product of original plagioclase. Minor plagioclase is also present as irregular patches within potash feldspar which forms anhedral to subhedral crystals up to about 1 mm in size. The perthite is highly clouded with inclusions which are generally 1-2 μ m across or less and thus optically irresoluable Some may be of colourless low relief mineral but most appear to be bubbles (gas or liquid inclusions) reflecting hydrothermal alteration or possibly radiation damage.

Anhedral quartz occurs as polycrystalline aggregates up to several millimetres across.

The rock originally contained biotite as well developed flakes up to 1 mm in size which tend to be concentrated in aggregates up to 3 mm wide. It has been altered to chlorite and (from X-ray diffraction evidence) to stilpnomelane. Minor hornblende forms weakly prismatic crystals some of which occur as inclusions within feldspar crystals.

Most of the accessory minerals are associated with the altered biotite. Fluorite in particular tends to form anhedral crystals intergrown with the stilpnomelane although minor fluorite also occurs as interstitial fillings betwen quartz and feldspar crystals. Apatite and zircon form prismatic crystals which commonly occur as inclusions within stilpnomelane flakes. Allanite forms prismatic crystals which have a translucent reddish-orange colour.

Opaques are disseminated through the rock as anhedral to subhedral grains which are generally intergrown with stilpnomelane.

The presence of allanite, fluorite, cloudy feldspar and milky quartz indicate considerable alteration.

APPENDIX B

Petrographic descriptions of granitic rocks from western Eyre Peninsula

SOURCES

1. Steveson, B.G. and Lowder, G.G., 1971. AMDEL report 1/1/1222, progress report No. 6.
2. Steveson, B.G., 1974. AMDEL report 1/1/160, progress report No. 3 [S. Aust. Dept. Mines and Energy open file Env. 2394].
3. Steveson, B.G., 1974. AMDEL report 1/1/160, progress report No. 7 [S. Aust. Dept. Mines and Energy open file Env. 2394].
4. Cooper, R., Brown, R.N. and Schultz, P.K., 1975. AMDEL reports MP676/75 and 721/75.
5. Steveson, B.G., 1976. AMDEL report No. 1124. Eyre Peninsula Inselberg Study.
6. McColl, D., 1983. AMDEL report GS3259/83.

SUMMARY OF PETROGRAPHIC DESCRIPTIONS

Location	Sample No.	Rock name	Source
Unnamed porphyritic granite			
Calca Bluff	5731 RS17[P819/71]	Porphyritic acid rock	1
Calca Bluff	5731 RS19	Porphyritic acid rock	5
Gawler Range Volcanics			
Mount Cooper quarry	5831 RS29	Feldspar porphyry	6
Mount Cooper quarry	5831 RS30	Feldspar porphyry	6
Mount Cooper quarry	5831 RS34	Rhyolite	6
Hiltaba Suite			
?Charleston Granite equivalent.			
Minnipa granite quarry	P193/74	Granite	4
Little Wudinna Hill	6031 RS29	Granite	5
Bright red granite			
North Anxious Bay	P194/74	Granite	4
North Anxious Bay	5731 RS6[P1127/74]	Granite	2
Mount Hall	5731 RS5[P1126/74]	Granite	3
Mount Hall	5731 RS20	Granite	5
Cocunda Rockhole	5832 RS17	Granite	5
Sec.92, hd Wrenfordsley	5731 RS59	Granite	5
'Caltonee', Sec. 128, hd Rounsevell	5731 RS60	Granite	5
Sec.46, hd Wrenfordsley	5731 RS61	Granite	5
Chilba Waterhole, Sec. 31, hd Rounsevell	5731 RS63	Granite	5
?Colley Hill, Sec. 19, hd Witera	195/74	Granite	4
?Colley Hill, Sec. 19, hd Witera	203/74	Granite	4
Colley Hill, Sec. 19, hd Witera	5831 RS18	Granite	5

Sample: 5731 RS17; TS26355

Location:
Calca Bluff, ELLISTON, Calca 1:50 000 (5731-1)
Lat: 33°04'S, Long: 134°22'E.

Rock Name:
Altered, porphyroblastic acid rock

		%
Groundmass:	Phenocrysts (feldspar)	25
	Quartz	25
	Feldspar	50
	Chlorite	<1
	Epidote	Trace
	Monazite	Trace
	Opaques	Trace
	Unidentified Accessory	Very rare
	Apatite	Trace
	Biotite	Rare

All the feldspar in this rock is extensively altered to brown, fine-grained material, probably kaolinite in part. Amongst the phenocrysts both plagioclase and potash feldspar can be recognised, but for most crystals, no positive identification can be made. Similar restrictions apply to the groundmass feldspar.

Some phenocrysts are 4-6 mm in diameter but most are only 1-2 mm across; zoning, particularly in the extent and nature of alteration, is prevalent. The groundmass feldspars (0.5 mm across) are uniform. Texturally the groundmass have been extensively replaced by new quartz which now forms rather poikolitic patches enclosing much of the feldpsar.

Chlorite has replaced nearly all the original biotite and occurs as irregular and subhedral flakes, 0.2-0.3 mm long.

Geochronology:
The rock is unsuitable for dating.

Sample: 5731 RS19; TS35713

Location:
Calca Bluff, ELLISTON, Calca 1:50 000 (5731-1)
Lat: 33°04'S, Long: 134°22'E.

This sample is porphyritic, relatively fine-grained granitic rock which, in the monumental stone industry, would probably be referred to as a porphyry. The rock consists of an abundant fine-grained groundass with phenocrysts (i.e. larger crystals) of potassium feldspar. The overall mineralogical composition of the rock, as determined from visual examination of the thin section, is as follows:

	%
Quartz	45
Potassium feldspar	25
Plagioclase	20
Chlorite	5-7
Epidote	3
Opaques	2-3
Zircon	trace
?Allanite	trace

Much of the groundmass of the rock consists of potassium feldspar crystals 0.2 to 0.4 mm in diameter intergrown with somewhat coarser-grained quartz. The potassium feldspar is generally a deep red or brown colour and has been extensively altered by ferruginous material. Phenocrysts of potassium feldspar are commonly several millimetres in size and are characterised by their rather irregular shape. Like the potassium feldspar in the groundmass, the phenocrysts have been extensively altered, but, even so, the perthitic texture can still be identified. Plagioclase has been altered to a very fine-grained clay which gives it an overall grey appearance in the thin section; however, this alteration has nowhere been sufficiently intense to obscure the twinning of the plagioclase. Original mafic minerals have been altered to chlorite and epidote and these minerals are widely disseminated throughout the rock and occur as crystals generally less than 0.2 mm in size. There are on or two aggregates of epidote, chlorite and opaques which are approximately 1 to 1.5 mm in diameter but these are exceptional.

The polished slab shows the general size and disposition of the phenocyrsts; grey to reddish-brown potassium feldpsar phenocrysts are up to 2 cm in size whereas the sparser quartz phenocrysts rarely exceed about 3 mm in diameter. Many of the phenocrysts show colour zonation and it is likely that some of the altered cores of the phenocrysts would be sites of further weathering ofthe polished surface. The groundmass is a fairly even reddish colour and has an extremely fine-grained, speckled appearance due to the intergrowth of quartz and red potassium feldspar.

Under low-power stereobinocular microscope it can be seen that the groundmass contains numerous small patches of dark material which is rather soft and gives a pale green colour on scratching; these are clearly patches of epidote and chlorite which are much softer than the surrounding feldspar and quartz. It is not likely that these patches of epidote and chlorite would be less abundant in the unweathered material and hence even fresh samples of this rock would be likely to contain patches of dark material which would weather-out during exposure of the polished slab to the atmosphere.

Sample: 5831 RS29; TS44870

Location:
Mount Cooper quarry, ELLISTON, Venus 1:50 000 (5831-IV)
Lat: 33°01'S, Long: 134°43'E.

Rock Name:
Altered feldspar porphyry

Hand Specimen:
A massive faintly mottled brown to pink porphyritic igneous rock with medium-grained phenocrysts in a fine-grained groundmass.

Thin Section:
A visual estimate of the constituents is as follows:

	%
Quartz	30
Feldspar (potassic)	40-50
Feldspar (soda-lime)	10
Hornblende	10
Biotite	1
Chlorite	1-2
Apatite	<1
Titanite (sphene)	1
Opaques (magnetite plus sulphide)	2-3

In this sample the porphyritic texture can be clearly seen both in hand specimen and in section. The feldspar phenocrysts are up to 3 to 4 mm diameter, and it is more obvious that the majority were originally potassic varieties although they are now mottled with zones of partially sericitic alteration. Virtually all the phenocrysts show marginal overgrowths of turbid pale brownish orthoclase, and the same mineral is very prevalent in granuloblastic intergrowths with quartz throughout the groundmass. Plagioclase feldspars are quite scarce and mainly occur as subhedral prisms up to 0.2 mm diameter, or very rare phenocrysts up to 1.0 mm diameter. Most of these are now grossly altered to metasomatic orthoclase, but a few multiple twinned remnants suggest a composition of calcic oligoclase (Ab_{75}).

Hornblende crystals are quite abundant, and are brightly pleochroic from green to colourless. Most are also rather poikilitic, bearing abundant rounded grains of quartz set principally around their outer margins. Biotite is relatively scarce, but several masses of chlorite are present which may have been derived from this mineral. Apatite and titanite are present as subhedral prisms and clusters of granules, closely associated with the amphibole. Magnetite granules and subhedral crystallites are common in the groundmass, but most are coarsely developed in association with the amphibole/mica clusters.

The rock is classified as a medium-grained granite porphyry which has been recrystallised and potassium metasomatised by post-magmatic hydrothermal solutions. This sample appears quite massive and contains only minute traces of pyrite and chlorite, with a few thin films of limonite and some bleaching along the weathered jointing planes.

Sample: 5831 RS30; TS44871

Location:
Mount Cooper quarry, ELLISTON, Venus 1:50 000 (5831-IV)
Lat: 33°01'S, Long: 134°43'E

Rock Name:
A massive faintly mottled grey and brown igneous rock of fairly fine grain size with a sparse scattering of medium to coarse-grained phenocrysts.

Thin Section:
A visual estimate of the constituents is as follows:-

	%
Quartz	20
Feldspar (potassic)	60
Feldspar (soda-lime)	5-10
Hornblende	8-10
Biotite	1
Chlorite	1-2
Epidote	trace
Apatite	<1
Fluorite	trace
Titanite (sphene)	<1
Opaques (magnetite)	1-2

This rock is similar to sample RS29 but does, however, have a scattering of much coarser phenocrysts, and in places the phenocrysts occur as clusters of various minerals. Potassium metasomatism is the principal alteration process, and much of the groundmass and phenocrysts are replaced with turbid pale brownish orthoclase. Outlines of subhedral feldspars up to 5 mm diameter, can still be seen in various stages of sericitisation and alteration. Clusters of poikilitic hornblende prisms with inclusions of rounded quartz grains and associated granular masses of magnetite are up to 3 mm diameter. These also frequently enclose prismatic inclusions of apatite with a few rare traces of fluorite.

Generally the hornblende crystals are smaller than in the other samples, but occur more frequently dispersed throughout the groundmass. Small amounts of biotite, chlorite and titanite are also in many cases associated with the hornblendes. The groundmass varies somewhat in grain size, but is generally a fine granuloblastic mass of turbid feldspars and quartz. A few areas contain crystals up to 0.3 mm diameter which is coarser than the two preceding samples. Most of the groundmass, however, is less than 0.1 mm.

The only opaque component present in this rock is magnetite, but as was the case in the preceding samples, it is partly present as sparse coarser masses associated with the ferromagnesians, and also an abundance of very fine crystallites dispersed throughout the groundmass.

The rock is classified as a granite porphyry recrystallised and potassium metasomatised by post-magmatic hydrothermal solution.

Sample: 5831 RS34; TS44875

Location:
Mount Cooper quarry, ELLISTON, Venus 1:50 000 (5831-IV0
Lat: 33°pl'S, Long: 134°43'E.

Rock Name:
Altered granite porphyry or ?rhyolite

Hand Specimen:
A massive fine-grained dark brown igneous rock with very sparse coarse to medium-grained phenocrysts, virtually unweathered.

Thin Section:
A visual estimate of the consituents is as follows:

	%
Quartz	30
Feldspar (potassic)	50
Feldspar (soda-lime)	5-10
Hornblende	5-8
Biotite	3-5
Titanite (sphene)	2-3
Opaques (magnetite)	1-2

A few coarse feldspar phenocrysts and medium-grained quartz phenocrysts are very sparsely distributed through the almost cherty microgranular groundmass in this rock. The feldspars are subhedral prisms up to 3 x 5 mm, although in section there is very little original feldspar remaining, and most consist of an intergrowth of fine sericite mesh with brown turbid orthoclase of metasomatic origin and a marginal rim of the same material. A few relicts of plagioclase with remnant multiple twinning appear to have had a composition near andesine. The quartz phenocrysts are up to 3 mm diameter and are in some cases of good euhedral form, but with corroded marginal embayments by reaction with the groundmass. Some of the phenocrysts show a slight degree of alignment, suggesting a possible volcanic fluidal texture.

The groundmass consists of a granitoid texture of ultrafine quartz and metasomatic brown turbid orthoclase, none exceeding 30 microns diameter. Trains of titanite granules and partially-formed crystals extend through many parts of the groundmass, along with a scattering of biotite flakes, poikilitic hornblendes and fine granular to cubical magnetite. The rock is unweathered, although there are some thin veinlets traversing the rock which have presumably been derived from the phase of metasomatic alteration.

The rock is classified as a granite or adamellite porphyry, although there are suggestions that it may be more of a porphyritic lava. It has experienced the same potassium metasomatism and hydrolytic alteration as is evident in all the preceding specimens.

Sample: P193/74; TS30513

Location:
Minnipa Granite quarry, section 117, hd Minnipa.

Rock Name:
Pink granite

Hand Specimen:
This sample has a fairly regular grain size and is composed of crystals which are typically in the size range 0.2 mm to 1 cm. The most abundant mineral phase present is potash feldspar, and the pink coloration of this mineral gives the rock its pinkish hue. The potash feldspar occurs as equant, sub-idiomorphic and xenomorphic crystals and as stumpy, prismatic laths. Present in lesser amounts are white plagioclase and off-white/grey, semi-translucent quartz, as well as a few flakes of black biotite. The quartz and plagioclase crystals are generally smaller than those of microcline and tend to be aggregated together. This means that the rock commonly consists of patches of pink potash feldspar which are up to 1 cm across and smaller, less well defined areas, of quartz and plagioclase which are commonly between 5 mm and 1 cm across.

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

	%
Quartz	10-20
Potash feldspar (perthitic microcline)	55-65
Plagioclase (oligoclase and albite)	15-25
Biotite	3-6
Sphene	1-2
Opaques	1-2
Apatite	trace
Zircon and/or monazite	trace
Feldspar alteration products; sericite, etc.	trace-4

This rock has an allotriomorphic-granular texture and is composed principally of potash feldspar with lesser amounts of plagioclase, quartz and biotite.

The potash feldspar is a perthitic microcline and occurs as equant, xenomorphic and stumpy, prismatic crystals, the largest of which are several millimetres across. The margins between adjacent microcline crystals are either highly irregular or there is a zone of finely crystalline microcline developed. Cross-hatch (microcline) twinning is well developed and in some of the larger crystals there are also simple Carlsbad twins. The exsolved perthite is albitic in composition and forms elongate patches and braids which are present throughout most of the crystals. Inclusions of plagioclase and quartz are common in the microcline and it appears as though the potash feldspar has engulfed these minerals. Minute opaque particles are present throughout the microcline crystals and are particularly abundant in the exsolved perthitic albite. The bulk of these inclusions would only be a few microns across and they are thought to consist mainly of iron oxides/hydroxides. A few minute translucent, brownish-red flakelets with a hexagonal shape and a few microns in size are visible in some zones of microcline. It is the presence of these minute iron oxide inclusions which gives the potash feldspar and the rock its pink coloration.

The plagioclase in the rock occurs as equant, xenomorphic and stumpy, prismatic laths which are up to several millimetres long but on average considerably smaller than the microcline. The plagioclase is polysynthetically twinned and the margins of the crystals are weakly zoned from oligoclase to albite-oligoclase. The cores of the larger plagioclase crystals are invariably sericitized and this may be the cause of, or at lease enhance, the minerals white opaque appearance as seen in hand specimen. Where plagioclase crystals are in contact with microcline and with quartz, the latter minerals both appear to be replacing the plagioclase. Also where plagioclase is in contact with microcline, small vermicules of quartz are often present in the plagioclase immediately adjacent to the microcline.

The quartz in the rock occurs characteristically as equant, xenomorphic grains, the largest of which are several millimetres across. The quartz is relatively clear and extinguishes evenly. In some quartz crystals "trails" of minute ?opaque granules are present lining fractures/cleavages. It is possibly these minute granules that give the quartz its grey tinge as seen in hand specimen.

The biotite in the rock occurs as sub-idiomorphic flakes which are up to 1 mm across. The mineral is brown, pleochroic, and contains inclusions of zircon about which there are brown halos. A few flakes show minor alteration to chlorite along cleavage planes.

Associated with the biotite are opaque grains, sphene, apatite, and zircon/monazite crystals. The opaque grains are equant, xenomorphic, and up to 0.3 mm across. The sphene crystals are yellow-brown, weakly pleochroic, and most occur as perfectly formed rhombic crystals. The largest of these sphene crystals are at least 1 mm long. The apatite is colourless and occurs as idiomorphic, prismatic crystals, the largest of which are 0.2 mm long.

The zircon/monazite is a neutral shade and occurs as equant, sub-idiomorphic and xenomorphic crystals which are up to 0.3 mm across. The presence of sphene and biotite with the opaques suggests the latter are titaniferous, either titaniferous magnetite or ilmenite.

This rock, from Section 117 in the Hundred of Minnipa, is a granite and its pink coloration is due to the presence of microcline containing clouds of minute particles probably mainly of iron oxide.

Sample: 6031 RS29

Location:
Little Wudinna Hill, 8 km northeast of Wudinna.
Map reference KIMBA, 920353.

Sample was collected from fresh to slighty weathered material at the top of the inselberg.

Mineralogical composition of this sample, as determined from the thin section, is as follows:

	%
Potassium feldspar	40-45
Quartz	35
Plagioclase	15-20
Biotite	1-2
Opaques	1-2
Zircon	trace
Apatite	trace
Clay	trace
Epidote	trace

This sample is relatively fresh and much of the potassium feldspar, particularly, is relatively free from brown turbid alteration products. Plagioclase, however, does show some patches of sericitic alteration which tends to be concentrated near the centre of the crystals.

Biotite flakes are generally 0.5 to 1 mm in length and, although the biotite is pleochroic in shades of brown, the colour intensity varies in different parts of the crystals and hence the biotite appears to have been partly altered during weathering. In the thin section, the biotite is more or less closely intergrown with opaques.

The polished slab of this sample has a rather unattractive appearance particularly in that it appears to be rather 'washed out' and consists mainly of pale pink potassium feldspar. The whole of the slabbed surface is transected by numerous fine fractures now filled with black material and the presence of these also detracts from the attractiveness of the surface. Quartz forms discrete patches which can be recognised fairly readily but these do not show a well-defined contrast with the feldspar. In addition, the plagioclase does not appear to be sufficiently abundant nor is it distinctively coloured so that it also is not especially distinctive. In general, therefore, the sample is a pink granite with a rather patchy and blotchy appearance due to slight variations in the concentration of potassium feldspar and in the pink colour of this mineral. It is likely that the hand specimen collected is slightly weathered, and the polished surface is transected by numerous thin fractures which would be sites of further deterioration of the polished surface. The sample is relatively free from biotite and other accessory minerals and these are not sufficiently abundant to be significant factors in estimating the long-term polishing characteristics of the rock.

Sample: P194/74; TS34123

Location:
North Anxious Bay. ELLISTON, Calca 1:50 000 (5731-1).
Lat: 33°09'45"S, Long: 134°23'45"E.

Rock Name:
Brown granite.

Hand Specimen:
This rock is composed of pink-brown feldspar, pale grey, semi-translucent quartz and dark mica flakes. The feldspar predominates and occurs as sub-idiomorphic phenocrysts, the largest of which are almost 2 cm across. The crystals of quartz are xenomorphic in shape and rarely more than 5 mm across. The mica flakes are typically between 0.5 and 1 mm long but they are aggregated into patches which are typically between 2 to 4 mm across. The predominance of feldspar gives the rock its overall brown coloration and although most of the feldspar crystals are fairly uniform in colour, there are a few crystals which have pale yellow cores and other crystals which have pale, off-white rims. The rock does not appear to be foliated although there are numerous micro-fractures within the feldspar crystals.

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

	%
Potash feldspar/microcline (mildly altered)	70-80
Quartz	5-15
Plagioclase (sericitized)	4-8
Biotite	2-5
Opaques	1-4
Accessories; apatite, zircon	trace-1

This sample has an allotriomorphic-granular texture and is composed principally of potash feldspar. Crystals in the rock range in size from 1 to 2 mm to almost 2 cm.

The potash feldspar occurs as equant to slightly elongate, sub-idiomorphic and xenomorphic crystals/laths which range in size up to almost 2 cm. The potash feldspar is untwinned, simply twinned (Carlsbad twins), or is cross-hatch twinned. Exsolved braids of perthitic albite are common in the microcline crystals. Inclusions of quartz are quite common within the microcline and margins between adjacent microcline crystals are usually finely irregular and highly complex. Alteration, in the form of clouds of minute opaque particles, is developed throughout the microcline crystals. This alteration is virtually absent from the untwinned zones of microcline which are relatively clear, but can be quite intense in crystals which have well developed cross-hatch twinning and/or contain a large amount of exsolved plagioclase. The exsolved plagioclase itself is usually relatively free of these inclusions. When the denser clouds of these minute inclusions are examined under high magnification with crossed nicols and with the feldspar in extinction position to exclude transmitted light, some of the clouds show a reddish-brown colour.

The plagioclase in the rock occurs as equant to slightly elongate lath-like crystals which rarely exceed 3 mm in length although they are often aggregated into patches which are several millimetres across. The plagioclase crystals are unzoned although they often have a narrow rim which is clear and relatively free of inclusions. The composition of the bulk of the plagioclase appears, on the basis ofrelief and the extinction angle of albite twins oriented normal to 010, to be oligoclase. Alteration to various extents is prevalent in all the plagioclase crystals and takes the form of small sericite flakes and minute opaque granules.

Quartz occurs as equant to highly irregularly shaped xenomorphic grains which range in size up to several millimetres across. Quartz crystals have particularly complex margins and appear to be corroded or replaced when they are adjacent to or partly engulfed by potash feldspar/microcline crystals. "Trails" of minute opaque granules are present within the quartz crystals and appear to have formed along small fractures in the quartz.

Biotite occurs as somewhat ragged, sub-idiomorphic flakes which range in size up to 1 mm. These are often aggregated together and closely associated with the opaque grains and accessory minerals in the rock. The biotite is pleochroic in shades of brown and yellow-brown but is often altered marginally and along cleavage traces. The alteration products include goethite/limonite and ?sphene. Inclusions of zircon in the biotite flakes have dark halos about them.

The opaques occur as equant, sub-idiomorphic and xenomorphic grains which range in size up to 1 mm across. They are closely associated with the biotite and the accessory minerals zircon and apatite which are present. The latter two minerals occur as idiomorphic crystals which rarely exceed 0.1 mm in length.

This granite consists primarily of microcline. This mineral has been extensively altered and the clouds of minute opaque particles that have formed within it are the primary cause of the pink-brown colour of the microcline and of the rock. These minute opaque granules are thought to consist of one or more iron oxides such as hematite and goethite.

Sample 5731 RS6; [P1127/74] TS31941

Location:
North Anxious Bay, ELLISTON, Calca 1:50 000 (5731-1)
Lat: 33°09'45"S, Long: 134°23'45"E.

Rock Name:
Granite

Hand Specimen:
A coarse grained pink igneous rock which is both massive and compact. Large amounts of pink potassium feldspar, glassy quartz and small crystals of biotite can be seen in the hand specimen.

Thin Section:
Kfs-qtz-pfs-bio; chlor-clay-sericite.

This sample is very similar to 5731 RS5 and hence only a brief description will be given here. The rock has a large average grain size probably about 3 mm and the texture is a closely interlocking random granular aggregate. The potassium feldspar is a brown turbid somewhat perthitic orthoclase. Exsolved albite has an irregular patchy pattern but commonly comprises a relatively large proportion of the orthoclase crystals. Against quartz the orthoclase has large embayments and clearly the orthoclase has been in part replaced by the quartz. This process has continued to such an extent that some orthoclase crystals are clearly only small relicts of originally larger crystals. Despite this process the potassium feldspar still constitutes more than 50% of the rock. Quartz occurs as large crystals which are equant anhedra with plane extinction. These crystals of quartz have very irregular shapes and bulbous protrusions against the adjacent feldspar. Quartz/quartz crystal boundaries are irregular in shape and in detail appear to show a little suturing. Plagioclase comprises only a very small proportion of the rock and is present as crystals generally less than 1.5 mm in size. Sericitic alteration is patchily distributed through the plagioclase but is rarely so intense as to obscure the twin plane traces. Myrmekitic textures where plagioclase meets orthoclase are not common but there is usually some kind of thin reaction zones between these two minerals.

The most abundant dark mineral in the rock is biotite and this mineral is present as individual flakes up to approximately 0.4 mm in length. The biotite is a brown pleochroic variety and is commonly fresh and unaltered; however some flakes consists of intergrown biotite, chlorite and opaque material. There is probably insufficient biotite in the rock for a concentrate for potassium argon dating to be produced but the rock is suitable for whole rock rubidium strontium geochronology.

In brief it is a typical coarse grained highly potassic granitic rock.

Sample 5731 RS5 [P1126/74] TS31940

Location:
Mount Hall, ELLISTON, Calca 1:50 000 (5731-1).
Lat: 33°03'45"S, Long: 133°28'50"E.

Rock Name:
Granite

Hand Specimen:
A coarse-grained and pink, igneous rock, clearly a granite. Large crystals of both pink potassium feldspar and glassy quartz can be distinguished in the hand specimen. Part of the sample's reddish colour may be attributed to some surficial weathering.

Thin Section:
The thin section has a rather simple texture and mineralogy; it comprises large crystals of potassium feldspar and quartz and the texture is dominated by the solution of adjacent K-feldspar by the quartz.

Quartz is present as crystals several millimetres in diameter and these are characterised by irregular shapes and bulbous and lobate outlines against the K-feldspar. The quartz generally has a plane extinction and grain boundaries which are overall quite smooth. In many places the quartz has replaced the feldspar to such an extent it almost encloses many feldspar crystals. The feldspar crystals themselves are several millimetres in size and are most commonly orthoclase perthite. The perthitic texture is not well developed and commonly the exsolved albite is present merely as isolated and discrete crystals randomly oriented in the orthoclase. Many of the orthoclase crystals show Carlsbad twinning and are a little elongate although, overall, the crystals in the thin section are equant and anhedra. Plagioclase feldspar is present only to a small extent and probably comprises less than 5% of the rock's volume. Crystals are equant anhedra commonly somewhat altered and generally less than 0.5 mm in size. Both plagioclase and K-feldspar are a pale brown in thin section and clearly contain dispersed alteration products. In one or two places in the thin section the rock has a finer grained texture than that described above and plagioclase is more abundant in such parts of the rock than in the bulk of the sample. These fine-grained patches probably represent slightly later crystallised parts of the rock. The texture of the finer-grained material is allotriomorphic-granular.

The rock has clearly suffered some alteration as a result of weathering and this is particularly apparent on examination of the mafic minerals in the rock. Biotite is fairly abundant and is present as clusters of small flakes commonly less than 0.1 mm in size. Closely intergrown with the biotite are opaques, sphene and chlorite as well as a considerable amount of semi-opaque ferrugionous material. One large crystal of amphibole is present in the thin section; this is about 1 mm in diameter and consists of a pleochroic green hornblende. Small flakes of biotite are abundant within this one crystal. Some reaction between feldspar and this hornblende crystal has occurred since the hornblende is surrounded by a broad zone of closely intergrown quartz, hornblende, feldspar and biotite. The mafic minerals overall are not widely distributed in the rock but occur in clusters particularly associated with intergranular areas and finer-grained parts of the sample. None of the minerals could be separated for K-Ar geochronology but the rock is suitable for Rb-Sr dating.

In brief, the rock is a typical coarse-grained granite but it has suffered some weathering and is hence less suitable for geochronology than a fresh equivalent rock might be.

Sample: 5731 RS20; TS35716

Location:
Mount Hall, ELLISTON, Calca 1:50 000 (5731-1).
Lat: 33°03'45"S, Long: 133°28'50"E.

Sample was collected from the top of the mountain east of Mt. Hall and considerable difficulty was experienced in obtaining a reasonably fresh sample.

This sample is unusually rich in potassium feldspar as is shown in the mineral proportions, given below:

	%
Potassium feldspar	75
Quartz	20
Plagioclase	<5
Opaques	2
Biotite	1
Chlorite	trace-1

The rock has a coarse-grained, granular texture and consists largely of potassium feldspar and quartz. The former is generally perthitic and has a mottled grey to brown colour in thin section. As far as can be determined from the section, the potassium feldspar is not as altered and has a weaker colour than in other reddish granites in this collection. In some places the potassium feldspar is transected by thin cracks, most of which contain opaque and semi-opaque ferruginous material. As far as can be determined in thin section, accessory mafic minerals are rather more abundant in this rock than in many others in this area and biotite forms loose clusters of flakes up to approximately 0.5 mm in length. Biotite is intergrown with opaques and with a little secondary chloritic material.

Although the slabbed and polished surface of this sample has an overall reddish colour and the rock has a coarse, granular texture, the sample is not as attractive as other red granite in this area because of the somewhat brownish and blotchy appearance of the potassium feldspar and because of the abundance of fractures and thin cracks filled with clay material and with polishing powder. In summary, therefore, this is not a very satisfactory red grannite, partly because of the abundance of cracking and partly because of the rather dull reddish-brown colour of the potassium feldspar crystals.

Sample: 5832 RS17

Location:
Cocunda Rockhole 12 km southwest of Poochera, STREAKY BAY, Morkitabie 1:50 000, (5832-11).
Lat: 32°48'40"S, Long: 134°45'00"E.

From visual examination of the thin section the mineralogical composition of this sample was estimated as follows:

	%
Potassium feldspar	60
Quartz	15
Plagioclase	15
Biotite	5-7
Allanite	1
Hornblende	trace
Zircon	trace
Opaques	trace
Apatite	trace

The feldspars in this rock show considerable alteration to fine-grained clays and sericite but, even in the most altered crystals, the twinning of the feldspar has not been completely obscured. The potassium feldspar is a microcline perthite which shows well-developed cross-hatch twinning, whereas the plagioclase is a sodic variety showing compositional zonation. In many of the plagioclase crystals the cores are somewhat more altered than the marginal areas. the rock has an essentially granular texture but in many places the contacts between feldspar crystals and between feldspar and quartz crystals have been modified by fine-grained intergrowths of quartz, some of which are myrmekitic. The accessory minerals are generally somewhat fine-grained but most are fresh and unaltered. ?Allanite forms rhombohedral and wedge-shaped crystals up to 1 mm in length. These have been extensively altered (?metamict) and the mineralogical identification is by no means certain.

The polished slab of this sample has a rather pale and dull buff colour overall, and a distinctly 'washed-out' and unattractive appearance. Most of the surface consists of dull brown to buff-coloured potassium feldspar crystals with grey quartz and fine-grained cream-coloured plagioclase. The surface is intersected by numerous small fractures which contain dark material and the presence of these accentuates the dull appearance of the sample. These fractures would probably not be present in the completely unweathered part of this rock but, even so, it is likely that the fresh material still has the rather dull brown colour which seems to characterise this rock.

Sample: 5731 RS59; TS35710

Location:

Section 92, hd Wrenfordsley, ELLISTON, Calca 1:50 000 (5731-1).
Lat: 33°02'45"S, Long: 134°22'45"E.

Sample taken from a prominent ridge 1.5 to 2.5 km long,several hundred metres wide and up to 30 m above surrounding plain. Granite is homogeneous, with a few aplitic dykes up to 3 m wide.

The mineralogical composition of this granite, as determined by visual examination of the thin section, is as follows:

	%
Potassium feldspar	50-55
Quartz	35-40
Biotite	5
Plagioclase	<5
Opaques	1-2
Zircon	trace
Chlorite	trace
Apatite	trace
Secondary clay	trace

This sample is a red granite deficient in plagioclase and relatively rich in potassium feldspar; most of the granitic rocks from the area are of the red type and this sample is one of the more attractive due to a discolouration of the potassium feldspar which is most probably due to the presence of very finely disseminated hematite. In the thin section, the potassium feldspar is largely obscured by a pervasive brown turbidity due to the presence of extremely finely divided minerals which cannot be defined optically. In this sample, the potassium feldspar crystals are transected by thin cracks filled with semi-opaque goethitic material but these are not abundant and it is unlikely that they detract much from the red colour of the sample. Plagioclase shows a significantly paler discolouration and this is probably due to the presence of clay and sericite rather than finely divided ?hematite as occurs in the potassium feldspar. Biotite forms flakes up to 1 mm in length but many of these are intergrown with secondary chlorite which has been derived from the alteration of biotite. Even where chlorite cannot be positively identified, the biotite shows discolouration and irregular patches with indefinite green to brown shades.

The polished slab of this granite is a relatively bright pink colour due to the dominance of hematite-bearing potassium feldspar and in overall characteristics this is one of the most attractive of the red granite rock types in this collection. Under the low-power stereobinocular microscope the surface can be seen to be relatively free from cracks, although there are a few small pits, partially filled with clay material. These pits are probably derived from the plucking out of biotite and chloritised biotite.

Sample: 5731 RS60; TS35711

Location:
'Caltonee', section 128, hd Rounsevell, ELLISTON, Calca 1:50 000 (5731-1).
Lat: 33°02'30"S, Long: 134°25'30"E.

Mineralogical composition of this granite, as determined by visual examination of the thin section, is as follows:

	%
Potassium feldspar	50-55
Quartz	45
Plagioclase	<5
Biotite	1
Hornblende	trace
Opaques	trace
Allanite	trace
Clay	trace

As the above proportions show, this is a potassium-rich granitic rock deficient in plagioclase feldspar. The rock has a coarse granular texture and consists essentially of clear quartz and potassium feldspar largely obscured by extensive brown turbidity. Much of the potassium feldspar appears to be perthitic but the texture is obscured by the secondary alteration products. The small amount of plagioclase forms equant crystals commonly no more than 1 mm in size and these contain abundant secondary clay which is grey in overall colour rather than being red as is the alteration product of the potassium feldspar. The accessory minerals generally occur in small clusters and relics of biotite predominate. These are commonly associated with brown-greenish secondary clay and brown iron oxide/hydroxide. ?Allanite forms fresh unaltered crystals up to 0.6 mm in size.

The polished slab of this sample is a distinct red colour but it is somewhat paler than the previous sample. Under low-power stereobinocular microscope the tabular crystals of pink potassium feldspar can be readily distinguished from the smaller grey crystals of quartz. The surface contains considerable amounts of fine-grained white to grey material which is soft. This material forms in irregular cavities and cracks and in many places is clearly associated with black to brown relics of biotite flakes. In some places this clay material has not polished at all and now forms shallow cavities in the surface of the slab. It is clear that the presence of this material would detract from the polishing characteristics of this rock; on the other hand, it is likely that much of this clay material is associated with the slight weathering of the specimen actually collected and it is possible that the fresh rock is relatively free from these disfiguring patches. Apart from this, the rock has a rather pale pink colour and hence, may not be of the highest quality from an aesthetic point of view compared with the best red granite used for monumental purposes.

Sample: 5731 RS61; TS35712

Location:
Sec. 46, hd Wrenfordsley, ELLISTON, Calca 1:50 000 (5731-1).
Lat: 33°03'45"S, Long: 133°28'50"E.

Homogeneous pink granite forming low, smooth outcrops on a low ridge covered with dense scrub.

Sample is a red granite comprising mainly potassium feldspar and quartz.

	%
Potassium feldspar	50
Quartz	45
Plagioclase	<5
Biotite	2-5
Secondary clay	1-2
Opaques	1
Zircon	trace
Chlorite	trace
Apatite	trace

The feldspar and quartz in this rock have an average crystal size of more than 1 mm, and consists essentailly of equant, anhedral crystals in a granular mosaic. The potassium feldspar commonly shows perthitic patterns but is characterised largely by the rather blotchy alteration to brown, fine-grained secondary products. Due to the presence of a patchy perthitic pattern and irregular variations in the alteration of the potassium feldspar, this mineral has a distinctly blotchy and patterned appearance in the thin section. The accessory minerals are relatively fine-grained and tend to occur mainly in small aggregates. Biotite forms flakes up to about 1 mm in length but these are commonly intergrown with chlorite and opaque minerals. Relicts of these patches of accessory minerals are represented in some places by small patches of iron-stained clay.

Examination of the polished surface with a low-power stereobinocular microscope shows the predominance of pink potassium feldspar and somewhat finer-grained quartz. The potassium feldspar has a variable pale pink colour and many crystals are partly veined by fractures filled with red material; elsewhere there are cracks in the potassium feldspar which are not filled with a black, soft material which is probably a product of the polishing process. The quartz in this sample is characterised by a rather cloudy, opalescent appearance which is probably related in some way to weathering of the rock but no reason for the cloudiness could be distinguished in the thin section or the polished slab.

The polished surface contains small patches of white to cream clay material partly an infilling in cavities and partly an integral part of the rock associated with the weathering of biotite and other accessory minerals. The presence of the cavities and of the numerous cracks would probably render this rock unsuitable for most monumental purposes. It is not clear to what extent the cloudiness of the quartz and other features of the rock are results of the weathering process and it is possible that relatively fresh rock may be similar to samples from Calca quarry and Caltonee.

Sample: 5731 RS63; TS35715

Location:

Chilba Waterhole, sec 31, hd Rounsevell, ELLISTON, Calca 1:50 000 (5731-1).
Lat: 33°05'30"S, Long: 134°26'25"E.

Sample collected from a smooth flat outcrop of homogeneous granite with a few thin shear zones and one quartz vein.

The mineralogical composition of this sample, as determined from visual examination of the thin section, is as follows:

	%
Potassium feldspar	60-65
Quartz	30-35
Plagioclase	<5
Biotite	2
Opaques	1
Zircon	trace
Chlorite	trace
?Allanite	trace

This sample is a coarse-grained, granular rock which consists very largely of potassium feldspar and quartz. Plagioclase is confined to a few crystals less than 1.5 mm in size and to exsolved blebs in the potassium feldspar. Plagioclase is altered to a grey, turbid material whereas the potassium feldspar has an even brown colour in thin section. The rather speckled appearance of much of the potassium feldspar is due to the perthitic texture of this mineral and the slight differences in alteration of potassium feldspar and the exsolved plagioclase. Quartz forms relatively clear crystals and monomineralic aggregates but there are commonly thin, fine-grained zones between the potassium feldspar and the quartz. The accessory minerals occur in relatively fine-grained aggregates and biotite is by far the most abundant of these minerals. Biotite forms subhedral flakes commonly less than 0.5 mm in size. In many places the biotite shows partial alteration and includes small crystals of chlorite and zircon as well as patches of metamict (?)allanite.

The polished surface of this sample is similar in many respects to that of the sample from Calca quarry but the potassium feldspar has a somewhat duller red shade and a greater tendency towards a brown colouration rather than a bright red. The polished surface contains a few intergranular cracks and small patches filled with white powdery material but these are neither particularly abundant nor large, especially in comparison with the abundance of such features in some of the more weathered granites.

Sample P195/74; TS34124

Location:
?Colley Hill, Section 19 hundred Witera, ELLISTON, Venus 1:50 000 (5831-1).
lat: 33°05'30"S, Long: 134°45'E.

Rock Name:
Mildly altered granite (rose red granite)

Hand Specimen:
These samples are a pink-red colour and are composed principally of feldspar, with a lesser amount of quartz, and minor amounts of phyllosilicates and other minerals. The feldspar crystals range in size up to 1.5 cm and are opaque (non-translucent) and mottled in shades ranging from off-white to deep red. It is this feldspar which gives the rock its coloration. There is also a lesser amount of feldspar which is semi-translucent and pale green to pale brown in colour. Quartz crystals are translucent and grey in colour and are typically equant in shape and between 3 and 6 mm in diameter. The largest quartz phenocrysts are up to 8 mm across. The phyllosiliscates occur as flakes which are less than 1 mm long and these are aggregated into patches which rarely exceed 2 mm.

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

	%
Quartz	20-30
Potash feldspar (perthitic in places)	40-50
Plagioclase	5-15
Biotite (in parts chloritized)	2-4
Opaques	1-2

This rock has an allotriomorphic-granular texture and consists predominantly of quartz and potash feldspar crystals which are typically several millimetres across.

The quartz crystals are typically equant in shape and usually between 3 and 6 mm across, although the largest are at least 8 mm across. Most of the quartz crystals show slight undulose (strain) extinction and they often contain small inclusions of feldspar. Within the quartz itself there are numerous minute ?opaque granules and minute voids which occur as a network of anastomosing "trails". These "trails" presumably formed along fractures and parting directions in the quartz. The margins of most quartz crystals are highly irregular and locally there are small protrusions extending from the quartz crystals into adjacent crystals, especially into potash feldspar. Bipyramidal faces are well developed on many of these projections.

Potash feldspar occurs as sub-idiomorphic and xenomorphic phenocrysts, the largest of which are up to 1.5 cm across. A typical potash feldspar phenocryst consists of a relatively clear, untwinned core and a semi-opaque rim which is heavily ferruginized and partly ?albitized. Most of the potash feldspar crystals are untwinned although a few contain simple Carlsbad twins. The cores of the crystals, or at least the unaltered parts, contain no exsolved albite. In the altered rims of the potash feldspar crystals however, patches of albite up to 0.3 mm across are common and the shape of these patches of albite appears to be controlled by the cleavage in the potash feldspar. These patches of albite contain some opaque dust but not nearly as much as the associated potash feldspar. Most of this is semi-opaque because of the high concentrations of minute dust-like iron oxide particles. There may also be minute voids which would increase the opacity. Plagioclase occurs as stumpy, sub-idiomorphic and xenomorphic laths which are up to 1 mm long, as well as occurring as patches in the altered margins of the potash feldspar crystals. These plagioclase laths appear to have a composition of albite-oligoclase, are lightly dusted with opaques, and usually contain minor amounts of sericite. The plagioclase crystals are unzoned although in places they are seen to be optically continuous with patches of albitic feldspar in the margins of some of the potash feldspar crystals. There are also places where quartz appears to have partially engulfed plagioclase crystals.

The phyllosilicate in this rock was originally biotite but much of this mineral is now chloritized. It occurs as equant, sub-idiomorphic and xenomorphic flakes which are up to 0.5 mm across. These are characteristically aggregated into patches, the largest of which are 2 to 3 mm across. Ths fresh biotite is brown and pleochroic but when altered (chloritized) it is coloured various shades of green and yellow-brown. A common byproduct of this alteration is sphene, or at least a titanium mineral, which occurs as granules and lamellae which are aligned parallel to the cleavage in the biotite.

Associated with the biotite are opaque grains, apatite, and zircon. The opaque grains are up to 0.5 mm across, composed of hematite, and are sub-idiomorphic to xenomorphic in shape. The apatite and zircon occur as small idiomorphic crystals which are typically less than 0.1 mm across. Small patches and veinlets of geothite/limonite seen in potash feldspar crystals often appear to be emanating from the patches of biotite, opaques, and accessory minerals.

This rock is a granite, the red coloration of which is thought to be due to iron oxide/hydroxide (hematite and/or goethite) dust in the rims of the potash feldspar crystals. This dust may have formed when the rock suffered mild hydrothermal alteration. (At high temperature, potash feldspar can hold a certain amount of Fe in solid solution but on cooling and/or alteration this is exsolved as minute particles of Fe_2O_3. Albitization of the potash feldspar also appears to have occurred at that time and much of the biotite has been chloritized.

Sample 203/74

Location:
?Colley Hill, section 19, hundred Witera, ELLISTON, Venus 1:50 0-00 (5831-IV).
Lat: 33°05'30"S, Long: 134°45'E.

Rock Name:
Granite

Red granite containing patches, up to 5 mm across, filled with a pale yellow to off-white clay-like mineral. The identity of this mineral was determined by X-ray diffraction techniques.

Initially some of this material was extracted from the rock and an X-ray diffraction photograph was taken. From this photograph no satisfactory interpretation of the minerals present could be made. Subsequently the rock was broken up and sufficient material was obtained to enable a sample to be placed on the X-ray diffractometer heating stage. X-ray diffractometer traces were prepared of the material as it was, after heating to 130°C, and after overnight glycerol vapour treatment at 110°C. From these diffractometer traces the yellow clay-like mienral was interpreted as consisting principally of a mixed layer of mica-chlorite and minor montmorillonite.

From examination of the sample with a stereo binocular microscope and from examination of thin sections of this granite it is clear that this clay-like mineral is forming from the breakdown of the biotite in the rock.

Sample: 5831 RS18; TS35717

Location:

Colley Hill, section 19, hundred Witera, ELLISTON, Venus 1:50 000 (5831-IV).
Lat: 33°05'30"S, Long: 134°45'E.

The granite forms a bare, wholly exposed outcrop which is approximately 150 m long and 20 m wide. The outcrop has oversteepened faces, particularly on the northern side and forms a well-developed whale-back. The granite contains some joints which are fairly steep and parallel to the length of the outcrop but, in general, these joints appear to be at least 6 or 7 m apart. In some places on the granite outcrop some small pieces have been either split or drilled off and a fresh sample was taken from one of these places.

The mineralogical composition of this sample, as determined from visual examination of the thin section, is as follows:

	%
Potassium feldspar	50
Quartz	45
Plagioclase	5
Biotite	1
Opaques	trace-1
Clay	trace-1
Chlorite	trace
Allanite	trace

Much of the potassium feldspar in this rock has a rather mottled and irregular appearance in thin section due to the variable pattern of perthitic alteration and the way in which the potassium feldspar shows a brown turbidity whereas the exsolved plagioclase is paler and greyer in colour. In some places there are intimate intergrowths of the two types of feldspar but, elsewhere, apparently exsolved plagioclase forms crystals up to 1 mm in size. The potassium feldspar shows a red to brown turbidity and in some places the potassium feldspar is almost completely obscured by the density of this fine-grained secondary material. Plagioclase (both in perthitic textures and as discrete crystals) shows a pale grey colour in thin section and it is clear that the plagioclase is less altered than the potassium feldspar. Overall the rock has a coarse-grained, granular texture and consists largely of potassium feldspar and quartz.

Accessory minerals occur in small clusters which commonly have a crystal size ofless than 0.5 mm. Opaques and biotite are relatively abundant and there are numerous small patches of iron-stained clay. In one place in the thin section there are some small altered crystals which may be amphibole.

The polished slab of this sample is fairly distinctive in that the potassium feldspar has a somewhat variegated and mottled appearance; as described above, this is due to he variations in the amount of alteration in the potassium feldspar. In some parts of the polished slab the potassium feldspar has a bright, brick-red colour but elsewhere there is mottling due to the presence of small patches which have a brown and paler type of alteration. The polished surface (Plate 15) shows a little intercrystalline cracking but is disfigured mainly by the presence of small pits now filled with clay material and polishing powder. These pits are due, probably, to the alteration of feldspar along cracks which has resulted in small chips of feldspar (and of accessory minerals) being removed during the polishing process.

As mentioned above, relatively fresh samples of this granite have been obtained, but even so, potasium feldspar shows irregular alteration and colouration and accessory minerals have also been partially altered. The polished slab of this granite has a relatively deep red colour characterised by a somewhat mottled and variegated appearance.

APPENDIX C

Whole rock and Metalscan analyses of Hiltaba Suite red granite, and whole rock analysis of Lincoln Complex equivalent granite.

Sample	Location	Source
1/1/166 PR1.29	Calca granite quarry or Colley Hill	AMDEL report 1/1/166 PR No. 1 [Spry, 1975]
5731 RS3 (A540/75)	Searcy Bay, 5 km north of Cape Labatt	AMDEL report AN 2956/75
5731 RS6 (541/75)	North Anxious Bay	AMDEL report AN 2956/75
5731 RS18 (A516/75)	Cape Labatt	AMDEL report AN 3618/71
5731 RS1	Island off Cape Blanche	AMDEL report AN2956/75

WHOLE ROCK SILICATE ANALYSES [CODE H3]
Wt %

	1/1/166 PR1.29	5731 RS3	5731 RS6	Average
SiO_2	75.16	76.34	74.66	75.39
Al_2O_3	11.98	12.29	12.94	12.40
Fe_2O_3	0.85	0.46	0.49	0.60
FeO	0.80	0.40	0.65	0.62
MgO	0.22	0.10	0.22	0.18
CaO	0.54	0.53	0.69	0.59
Na_2O	3.20	3.34	3.44	3.33
K_2O	5.40	5.30	5.34	5.35
P_2O_5	0.05	0.03	0.06	0.05
H_2O^+	0.14	0.56	0.38	0.36
H_2O^-	0.19	0.04	0.02	0.08
CO_2	0.05	0.00	0.00	0.02
S(as SO_3)	0.11	0.00	0.00	0.04
TiO_2	0.24	0.25	0.27	0.25
MnO	0.07	0.03	0.04	0.05
TOTAL	98.99	99.67	99.20	99.31

X

Move to 99.31

TRACE ELEMENT ANALYSES [ppm]

Sample	5731 RS3	5731 RS6	5731 RS18
Cu	4	4	300
Zn	100	36	40
Co	<2	<2	5
Cr	<5	<5	110
V	<10	10	20
Li	11	33	
Rb	350	310	
Sr	42	105	
Ba	230	650	100
Pb	60	36	100
U	8	4	
Th	32	22	
Zr	350	230	
Ni			10
Fe			<10 000
Ag			0.1
Mo			3
Mn			300

Sample 5731 RS1

Location - Island off Cape Blanche
?Lincoln Complex equivalent granite

	%
SiO_2	72.53
Al_2O_3	13.18
Fe_2O_3	0.85
FeO	1.55
MgO	0.30
CaO	0.88
Na_2O	4.00
K_2O	4.96
P_2O_5	0.08
H_2O^+	0.41
H_2O^-	0.01
CO_2	0.00
S(as SO_3)	0.00
TiO_2	0.30
MnO	0.08
TOTAL	99.13

	ppm
Cu	4
Zn	75
Co	<2
Cr	<5
V	<10
Li	15
Rb	170
Sr	80
Ba	500
Pb	22
U	<4
Th	16
Zr	330

APPENDIX D

Investigation into the cause of the red colour of Calca granite

Extracted from

Schultz, P.K., 1978. AMDEL report GS1491/76 (Part 2).

Sample P353/75 from Calca granite quarry.

AN INVESTITGATION TO DETERMINE THE CAUSE OFTHE RED COLOUR OF THE EYRE PENINSULA ROSE-RED GRANITE

1. INTRODUCTION

Part 1 of this report (completed on 23 March 1976) was concerned with the cause of fading in a sample of Eyre Peninsula rose-red granite. This report (Part 2) is concerned with the cause of the red colouration in the granite. In Part 1 the fading was found to be due to dehydration effects and not be any chemical reaction/s taking place within the colouring agents present in the component mineral.

The object of the experimental procedures in Part 2 was to isolate and identify, if possible, the compound or compounds responsible for the red colouration in the granite.

2. PROCEDURES

A piece of the red granite was crushed and sieved at 200 and 300 mesh. The -300 mesh fraction was washed and deslimed at 10)m. Both the -10)m and -300 mesh + 10)m fractions were separated into >3.3 and <3.3 sp. gr. products.

The -200 + 300 mesh fraction was separated by flotation into two products, largely quartz and feldspars. Next density gradient column was used to fully separate out the feldspars; four separate fractions were obtained, the densest (fraction 1) have a sp.gr. >2.65, with fraction 4 being the lightest. Fraction 3 was also separated into magnetic and non-magnetic fractions, using a Frantz Isodynamic Separator.

X-ray diffraction powder photography was undertaken on the -300 mesh +10)m heavy fraction (>3.3 sp.gr.) and on the -200 + 300 mesh fraction 3 of the density gradient column; powder photographs were also obtained of hand picked red grains from the above fraction 3.

A polished section (PS 24673) was made of the -200 + 300 mesh fraction 3 and the grains examined under a stereo binocular microscope and reflecting microscope, using objectives yielding up to 1250X magnification. A few of the reddest grains were marked, and the sample was carbon coated and examined further using the electron microscope.

Two polished thin sections were made from a fresh piece (untreated) of red granite (No. 12) and from a treated piece heated to 300°C (No. 6). The above two numbers refer to slabs of granite cut from the single large piece obtained for the inevestigation and their relationship is explained more fully in Part 1 of this report. the polished thin section (PTS 35602) obtained from the fresh granite (No. 12) and the polished thin section (PTS 35612) made from the treated granite (No. 6) were examined in transmitted light and areas of clear and cloudy K-feldspar and plagioclase were circled for later electron microprobe analysis.

The electron microprobe work consisted of point analyses of clear feldspars for Fe only, and of line traverses across both clear and cloudy feldspars for Fe and K, recording the intensities of these elements on charts. The line traverses were undertaken at a speed of 20)m per minute and a chart speed of 2 cm per minute,hence 20)m of sample corresponds to 2 cm of chart.

3. RESULTS

The -10)m fraction (slimes) did not appear red or even pale pink to the naked eye, and the >3.3 sp.gr. fraction yielded only a few isolated opaque grains. (Heavy liquid separation of -10)m material is notoriously ineffective because of problems of flocculation/aggregation).

The -300 mesh +10)m fraction appeared quite reddish and, when split into light and heavy fractions at sp.gr. 3.3, the light fraction appeared similar to the total fraction, whereas the heavy fraction (about 1.5% of the total) consisted almost entirely of dark opaque grains. X-ray diffraction analysis of this heavy fraction yielded the following minerals: magnetite, ilmenite, amphibole, chlorite, K-feldspar, quartz, zircon, sphene, plus traces of iron.

The feldspar -200 + 300 mesh fraction separated from the quartz by flotation and then split into four more fractions in the density gradient column exhibited the following optical features. Fraction 1 (heaviest, >2.65 sp.gr., was almost entirely composed of black opaque grains; fraction 2 was a little lighter but still largely composed of black opaque grains; fractions 3 and 4 were reddish in appearance being by far the reddest of any of the four fractions, with fraction 3 representing more than 90% of the total weight. The magnetic fraction of fraction 3 contained only a few dark grains.

X-ray diffraction analysis of the -200 + 300 mesh fraction 3 sample indicated the presence of albitic plagioclase plus microcline as co-dominant phases associated with a trace of quartz (hematite was not recorded). A powder photograph of the hand picked red grains from the above fraction also yielded no hematite.

Examination of the polished section (PS 24673) obtained from the same -200 + 300 mesh fraction 3 under a stereobinocular microscope indicated that most of the grains were white or pale pink with some showing darker red colours. These grains were circled and further examined using a reflecting microscope. The best results were obtained using a X100 oil objective and crossed polarizers. Small intensely red flakes were noted to be present in the feldspar grains. These grains, to the naked eye, give the overall red appearance to the rock. Most of these red flakes were tentatively identified optically as hematite in probable association with minor goethite.

Examination of the two polished thin sections (PTS 35602 and 35612) indicated that the cloudy areas seen in transmitted light are enriched in the above-mentioned red flakes in feldspar whereas the clear areas correspond to patches of unaltered feldspar and quartz.

Electron microprobe point analyses of unaltered K-feldspar and plagioclase areas showed iron concentrations varying between 0.06 to 0.13%. Line traverses across unaltered areas in feldspar showed fairly uniform low concentrations of Fe with minor local concentrations. The cloudy areas, on the other hand, were noted to contain numerous small Fe-rich inclusions (see Charts 1-4). These cloudy areas correspond to the red flark-enriched grains as seen in reflected light. The density of grains actually present on the surface of the section corresponds well with thenumber of high iron inclusions detected in the line traverses. These inclusions were, however, too small for full quantitative microprobe analyses to be undertaken.

No significant difference in the abundance of red flakes (optical examinations) or high iron inclusions (microprobe traverses) was observed between the fresh and heat treated granites.

4. SUMMARY AND CONCLUSIONS

Physical separation (crushing, magnetic and density separation) of the red granite failed to liberate the compound/s responsible for the red colouration or to concentrate it sufficiently for it to be identified by X-ray diffraction analysis. Optically, however, it was established that the red colouration of the feldspar grains is due to tiny red flakes and particles present within the larger feldspar grains. Electron microprobe analyses confirmed these as being iron oxide but the identity of the iron oxide could not be established due to the small size of the particles concerned. It is, however, concluded that these colour-inducing particles are composed largely or entirely of hematite.

APPENDIX E

Investigations into the cause of fading of Calca red granite

Extracted from

1. Cooper, R., Brown, R.N. and Schultz, P.K., 1974. AMDEL reports MP676/75 and 721/75.

2. Schultz, P.K., 1976. AMDEL report MP1491/76 (Part 1).

3. Steveson, B.G., 1976. Eyre Peninsula Inselberg Study. AMDEL report No. 1124.

1. Investigation into the reason for fading of Calca red granite

Sample: Unlabelled.

Location: Calca granite quarry.

This sample 'faded' markedly when newly sawn and broken surfaces were exposed to sunlight. The bulk of this 'fading' appeared to take place within the first 48 hours of exposure. Various tests were carried out to determine the nature ofthe minerals involved in this colour change and which external factors, e.g. sunlight, ultraviolet light, and heat, were most effective in promoting this 'fading'.

Investigations of the 'Fading' of the Granite:

A smooth surface was prepared on a portion of the sample. This was then sawn into four pieces. One piece was kept in a cupboard away from light and heat and used as a standard, whereas the other pieces were exposed to sunlight, ultraviolet light, and a warm, humid atmosphere respectively. The procedure and results of these tests are as follows:-

(a) Sunlight - the sample was exposed to sunlight for 2 days (approximately 26 hours of direct sunlight) and it was found that in this time the maximum amount of 'fading' occurred. This result was compatible with the information received from the client, Mr. Douglas Nichol, on this phenomenon.

(b) Ultraviolet light - ultraviolet light of 2 wave lengths, 366.0 nm and 253.7 nm, was used. In each case half the sample was screened with lead sheeting and the length of exposure was 48 hours. At the end of each 48 hour period the sheeting was removed and the portion of the sample that had been exposed to he ultraviolet light was compared with the portion of the sample that had been shielded. Neither of the ultraviolet wave lengths employed appeared to have affected the sample at all.

(c) A warm, humid atmosphere - a piece of the sample was suspended over a basin of water, and the basin and the piece of rock then placed in an oven the temperature of which was maintained at 100°C. After 2 days (48 hours) there appeared to be slight changes in the colour of the sample but they were not as distinct as those obtained when the sample was exposed to sunlight. After a further 3 days (5 days/120 hours) the rock had distinctly faded but still not to the same extent as the sample exposed to sunlight for 2 days.

X-Ray Diffration and Electron Probe Microanalysis Results:

An X-ray diffractometer trace of the sample confirmed the identity of the major mineral constituents but provided no information on the nature of the alteration products in the potash feldspar crystals which are causing the 'fading'.

Line traverses with the electron probe microanalyser in which potassium and iron were recorded were run from the core to the margin of two microcline crystals. The traces (one of which is attached to the report) showed that the microcline crystals contained numerous small inclusions of an iron mineral, the largest of which were about 0.002 mm across. The variations in the amount of potassium present are due to the presence of perthitic albite in the microcline.

Conclusions:

The colour in these granites is almost certainly due to the presence of clouds of minute particles of iron oxide (or hydroxide) in microcline crystals and there is some opacity which is probably caused by the presence of minute voids, some of which may contain fluid (fluid inclusions were definitely noted in the quartz).

The exact cause of the 'fading' which is induced mainly by exposure to sunlight (dry heat) has not been definitely established but it could be tentatively suggested that the drying out or the evaporation of fluid from very small voids could increase the white opacity (due to internal reflection) and thus cause an apparent 'fading' or lightening of the red colour.

DESCRIPTION OF LINE TRACE

Electron-probe microanalyser line scan from the margin to the core of a potash feldspar crystal. The numerous peaks on the iron trace are due to minute particles of iron-bearing minerals (from oxides/hydroxides) in the feldspar. The particles are so small that the instrument cannot properly resolve their iron content.

The 'plateau' on the potassium trace at 13% potassium corresponds to potash feldspar. The small troughs are caused by small flaws in the crystal and by impurities whereas the larger troughs are due to patches of albite.

2. AN INVESTIGATION TO DETERMINE THE CAUSE OF FADING OF THE EYRE PENINSULA ROSE-RED GRANITE

1. INTRODUCTION

Four pieces of rose-red granite (one large and three small ones) were received from the South Australian Department of Mines on 10th November 1975 (delivered to Amdel by D.C. Scott) in order to determine the cause of fading of this granite. The granite was labelled P353/75 and its location was Hundred Rousevell, Section 46, EML 4469 from an open cut quarry operated by Calca Granite Pty. Ltd.

2. EXPERIMENTAL PROCEDURES

The large piece of granite from the four pieces received was cut up into thin plates, roughly 5 x 8 cm and less than 1 cm in thickness, ground on one face and ground and polished on the other face. Twenty plates were thus prepared, numbered 1-20, wrapped up in foil and put into a refrigerator. The three smaller pieces were not used at all since not enough plates could be cut from any of them to keep as reference samples and to experiment with.

The twenty plates prepared were first studied visually for any colour differences and then subjected to the following experiments:

1. Heating - dry heat.
2. Heating - humid heat.
3. Immersion in water.
4. Immersion in aqueous solutions of different pH levels.
5. Evacuation (under high vacuum).
6. Immersion of faded samples in water.
7. Weighing samples before and after heating (dry heat).
8. Immersion in 5% hydrochloric acid solution.
9. Examination of 100)mthick sections on a heating stage of an optical microscope.

3. RESULTS

Visual examination of the twenty plates cut showed them to be of the same colour except plate No. 17 which looked somewhat faded and plate No. 13 which looked a little darker. Also plates 1, 18, 19 and 20 looked just a little paler than the remaining samples which could not be distinguished from each other by visual means.

The results obtained from the various experiments carried out on the visually indistinguishable plates were as follows:

3.1 Effect of dry heat

Plate No. 4 was put into an oven at 40°C (in total darkness) and when inspected after 22 hours was seen to have visibly faded. Small cracks were also visible. A further heating (at 45°C for another 26 hours) did not result in any appreciably greater fading.

Another plate (No. 6) was put into an oven at 300°C and when ispected after half an hour was seen to have faded markedly and also to have cracked. A further half an hour in the oven did not result in any greatly increased fading.

Another plate (No. 11) was put into an oven for 4 hours only at a temperature of 37±2°C and when withdrawn was also visibly faded.

3.2 Effect of wet heat

Plate No. 5 was put into an oven at 40°C for 4 days resting on a beaker of water. Virtually no fading at all took place.

3.3 Effect of immersion in water

One plate (No. 7) was immersed in a beaker of distilled water (pH7) and kept there for a total of 21 days. The beaker was kept in an air conditioned room out of direct sunlight. The plate was inspected daily and it appeared to have gone slightly darker during the first day, with possibly some more darkening in the second day, and then stayed the same for the remaining 19 days.

3.4 Effect of immersion of different pH levels

Two other plates were immersed in water kept at different pH levels: plate No. 8 at pH 3.5 and plate No. 9 at pH10. These plates were kept in the same room as the plate immersed in distilled water (pH 7) and kept for the same length of time and inspected and compared daily with each other and with the plate kept in the water. No differences were noticed between the three plates. All three darkened slightly and to the same extent.

3.5 Effect of evacuation

One sample (No. 3) was put into the bell jar of a vacuum coating unit and subjected to a vacuum of about 10^{-3} mm of Hg using a rotary pump only for 19 hours, in order to subject it to a dehydration process. After 19 hours the sample had visibly faded; to the same extent in fact as plate No. 4 heated at 40°C for one day.

3.6 Effect of immersion of faded samples in water

Sample No. 6, which had previously been kept at 300°C for 1 hour and which was badly faded, was put into a beaker of water and kept there for 5 days to establishe whether it would regain its original colour when immersed. It did not, being nearly as pale at the end of the five days immersion as before immersion. The water was then boiled for 30 minutes, in order to expel any air trapped in the sample, and then allowed to cool and the sample left in the water for another three days, but again no significant colour change was observed.

Next plate No. 3, which had been faded by vacuum drying, was boiled for 20 minutes in water, allowed to cool, and inspected after one hour. The sample regained its colour noticeably. It was then left in the water for 24 hours and when inspected again was seen to have fully regained its original colour.

Plate No. 11, which was kept as 37±2°C for 4 hours only and which had also faded, was also boiled in water for 30 minutes and then left in the water. When inspected after 7 hours it was seen to have regained its original colour fully except for one edge which was not immersed wholly in the water.

3.7 Weighing of sample before and after dry heating (fading)

Plate No. 11 was taken out of the refrigerator and left on a bench in an air conditioned room without windows (no direct sunlight) for three days and then weighed. The weight recorded was 84.6500 gm.

The sample was then put in an oven, kept at 37±2°C, for four hours and then left out on the bench for another 24 hours and then weighed. The weight recorded was 84.6382 gm. After another 24 hours the weight was 84,6383 gm.

The sample was then boiled in water and allowed to regain its original colour and then weighed again after being left for 24 hours on the bench as before to regain the room temperature and humidity. The weight was 84.6621 gm. After another 24 hours the weight was 84.6600 gm.

The sample was then left on the bench for a further 10 days (including a hot weekend when the air conditioning in the building was switched off) after which time it looked faded. It was then weighed giving the following results:

84.6150 gm

A slight weight loss is therefore apparently associated with fading and a slight gain on recovery of colour. Although the weights obtained were not strictly reproducible, they support the view that the colour change in the granite is related to dehydration/hydration.

3.8 Effect of immersion in 5% hydrochloric solution

Plate No. 10 was put into a beaker containing 5% HCl solution for a total of 7 days. Initially the colour seemed to have gone darker (same as in distilled water) but after 5 days the sample looked paler and somewhat eaten away, especially the mica flakes.

The sample was next transferred into a beaker of water and kept there for 12 days but no further colour change was observed.

3.9 Heating stage examination of the granite plates

Three doubly polished thick sections of granite were examined; these were from three different plates that have been held at different temperatures:

(a) TS35487 (Plate No. 6) held at 300°C for one hour
(b) TS35486 (Plate No. 4) held at 40-45°C for 48 hours
(c) TS35512 (Plate No.12) no heating.

Microscopic examination revealed no apparent colour differences between the pink feldspars in the three sections.

Fluid inclusions, averaging 5-10) in diameter, were numerous in all sections; these were seen in quartz, but not feldspar, the opacity of the feldspar preventing examination. Most inclusions contained liquid, and a vapour bubble which was 2-5% by volume of the inclusion. Some inclusions contained only one phase; the nature of this was not determined. In section (a), there were many planes of inclusions which were streaked out and interconnected, as well as inclusions which had decrepitated; these effects were due to the preheating.

The three sections were heated slowly to 40°C. In section (b), hairline cracks passing through inclusions were visible at 50°C. Decrepitation occurred on a large scale at 300°C, releasing water. Homogenization temperatures of up to 321°C were determined, giving a minimum temperature of trapping of the fluids within the inclusions. Within the feldspar, slight "cracking" was visible at 37-39°C, more at 100°C; while "cracking" was occurring, patches of pink feldspar became lighter in colour suddenly, suggesting a connection between cracking and fading.

In section (a), no changes were apparent in feldspar up to 200°C. In section (c), cracking commenced at 57°C, along planes connecting inclusions; cracks went through quartz and feldspar. Decrepitation of many inclusions occurred around 200°C. After heating, some patches of feldspar were not as dark as before, but the transition was not noticed.

4. SUMMARY AND CONCLUSIONS

From the experiments carried out it became apparent that the fading of the granite is induced by mild dry heat (a temperature of less than 40°C was sufficient to produce quite marked fading) or by dehydration e.g. by evacuation of the sample. The presence of moisture does effectively prevent fading, and the fading could be eliminated by boiling the samples in water, to expel air, and then allowing the samples to re-absorb the water. The regaining of colour did not take place in samples heated to very high temperatures e.g. 300°C however. At these elevated temperatures the fading of this granite takes place throughout the entire thickness of the place and not just at the surface as is the case with granites heated to low temperatures e.g. 40°C. This phenomenon was confirmed by cutting cross-sections of the plates and polishing to make visual observation possible.

Immersion of the granite in water improves the colour somewhat but varying the pH of the water has no effect on fading. The action of strong acid for prolonged periods involves some fading, however.

Observation of the granite with an optical microscope while being heated revealed cracking and loss of moisture and some gas from the numerous fluid inclusions present; the loss of water on heating is also supported by the weight loss following fading.

The conclusion drawn from the experiments carried out is that the fading of this granite is due, beyond any reasonable doubt, to the dehydration of the granite, i.e. fluid loss from fluid inclusions and voids, induced by mild dry heat (with or without sunlight), or by a lowering of the water vapour pressure by evacuation. Reabsorption of water restores or improves the colour. The dehydration is accompanied by cracking and eventual decrepitation of the sample making eventual colour reversal impossible. The fading of the granite is most certainly not due to a chemical reaction taking place in the colouring agent of the feldspar (?hematite) induced by sunlight or different pH solutions. Strong HCl is expected to react with hematite producing $FeCl_2$ and therefore result in some fading.

AN INVESTIGATION TO DETERMINE THE CAUSE OF FADING OF THE EYRE PENINSULA ROSE-RED GRANITE

(CHARTS OF ELECTRON-PROBE SCAN)

1/16/14/0-GS1491/76 March 1976

3. FADING TESTS ON RED GRANITES FROM EYRE PENINSULA

Sample locations

Sample 1: Calca granite quarry; Section 46, hundred Rounsevell.
Sample 2: Section 92, hundred Wrenfordsley.
Sample 3: Tcharkulda Hill.

Introduction

One of the most significant factors influencing the quality of red granites is the extent to which they fade on exposure to sunlight, heat or rain. Amdel has, in the past, carried out some empirical tests to assess the extent and cause of fading and an abbreviated series of such tests was carried out on three selected granites.

A few small blocks of each of three samples were cut and polished. Visual comparison showed that the blocks of each sample were the same in colour; consequently, one randomly selected sample of each graninte was wrapped in foil and placed in a refrigerator as a standard. Other blocks were stored in the refrigerator before testing.

Test 1

A block of each granite was placed in an oven kept at 30°C for 24 hours.

Results: Sample 1 - Fading (compared to the standard sample) was readily visible: quartz was clouded (before it was largely glassy) and the potassium feldspar was paler and more brown.

Sample 2 - also faded but not as much as sample 1. Quartz was not clouded but potassium feldspar was paler than in the standard sample.

Sample 3 - showed no fading.

Test 2

It will be recognised that the conditions used in fading the two red granites are extremely mild. Most monumental stone, if used out-of-doors in South Australia, would probably be exposed to dry heat sufficient to raise the rock temperature to 30°C (even if the site was completely shaded).

Sample 3 was exposed to increasingly more rigorous conditions of dry heat being placed in an oven at 50°C for two days.

Result - No fading was perceptible.

Test 3

In order to assess the effects of more moist conditions and to examine the possible cause of fading, the faded blocks of the first two samples were placed in distilled water at 30°C for 24 hours.

Result: After this treatment the colour was almost completely restored; after two more days the sample 1, was still just a little faded but the colour of sample 2 had been restored.

Test 4

The fading (in oven, dry) and colour-restoration (using distilled water) process was repeated, but the samples were weighed at different points in the process.

Results are tabulated below.

	Sample: Wt g Sample 1	Sample 2	Sample 3
Slab kept in air-conditioned room to equalibriate for 24 hrs.	328.84	227.17	60.5022
Faded at 30°C for 2 days, then placed in air-conditioned room for 4 hours.	328.70	226.85	60.4842
After 4 hours further in air-conditioned room	328.70	226.87	60.4856
After 2 days in distilled water at 30°C - equilibriated in air-conditioned room for 24 hours.	328.84	227.08	60.5260

The results clearly show that the faded granites are all lighter in weight than the brighter, redder, original granites. From the restoration of both weight and colour that occurs after treatment with distilled water it is postulated that fading is related to dehydration of the granite. However, sample 3 shows no fading even though it, too, undergoes ?dehydration, and it appears, therefore, that dehydration is not the only factor involved. Restoration of colour and water (as expressed by the difference between the second and third sets of data in the tabulation) is either very slow or, in fact, negligible, in an air-conditioned atmosphere.

APPENDIX F

Calculation of Reserves

Calculations are based on specific gravity for Calca granite of 2.6.

Volume is area measured by planimeter from cross section on figure 4 multiplied by distance of influence (total of half the interval to adjacent cross sections).

(1) VOLUME OF GRANITE QUARRIED TO END 1986.

Area	Area m^2	Volume m^3	Tonnes
B	11	55	140
C	23	115	300
D	34	170	440
E	156	780	2 000
F	204	1 020	2 600
G	268	1 340	3 500
H	263	1 578	4 100
I	176	704	1 800
J	152	1 140	3 000
		6 900	17 900

Production totals to 1985	2 776	7 220 t
and estimated 1986 production	885	2 300 t
TOTAL	3 654	9 500 t

Proportion usable material : waste

9 500 :18 000

i.e. 52.8 : 47.2

Therefore overall recovery to end of 1986 is 53%.

(2) TOTAL INDICATED RESERVES IN OUTCROP ABOVE RL 89.5 m

Area No	Area m^2	Volume m^3	Tonnes
1	72	720	1 900
2	182	2 275	5 900
3	286	1 430	3 700
4	320	4 000	10 400
5	395	3 950	10 300
6	387	3 096	8 000
7	487	5 844	15 200
8	475	4 750	12 400
9	462	4 620	12 000
10	281	2 810	7 300
11	241	1 808	4 700
12	200	1 000	2 600
13	47	118	300
	TOTAL	35 700	92 800
	SAY	36 000	93 000

(3) RECOVERABLE RESERVES ABOVE RL 89.5 M

Based on recovery of 53% of 36 000 m^3

19 000 m^3 or 50 000 t

(4) TOTAL INDICATED RESERVES FOR EACH 3.5 m BENCH BELOW RL89.5 m.

Area No.	Area m^2	Volume m^3	Tonnes
1a	35	350	900
2a	88	880	2 300
3a	145	1 450	3 800
4a	205	2 050	5 300
5a	240	2 400	6 200
6a	241	2 410	6 300
7a	288	2 880	7 500
8a	263	2 630	6 800
9a	232	2 320	6 000
10a	147	1 470	3 800
11a	119	893	2 300
12a	102	510	1 300
13a	28	70	200
TOTAL		20 313	51 800
	SAY	20 000 m	52 000

(5) RECOVERABLE RESERVES FOR EACH 3.5 M BENCH BELOW RL 89.5 M

- Pessimistic case with only 50% recovery.

  10 000 m^3 or 26 000 t

- Expected case with 60% recovery.

  12 000 m^3 or 31 000 t

- Optimistic case with 70% recovery

  14 000 m^3 or 36 000 t

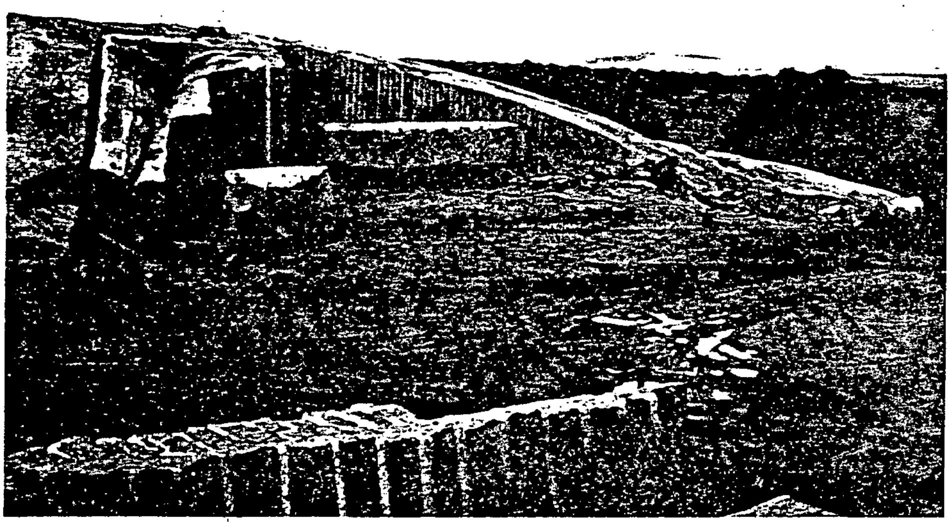

PLATE 1 - CALCA GRANITE QUARRY

View east-northeast of initial development on western side of whaleback.
Mount Hall, also pink Hiltaba Suite granite, on skyline in background.

1 October 1975 Negative No. 35743

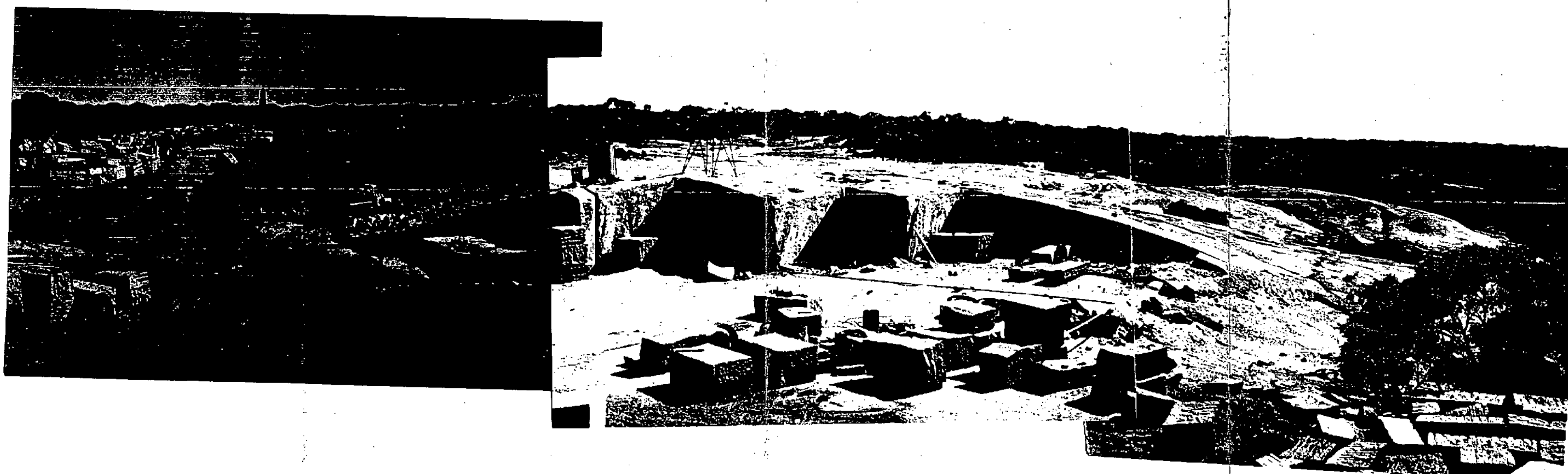

PLATE 2 CALCA GRANITE QUARRY
View northeast across one bench quarry. Blocks on quarry floor ready for transport to Adelaide for processing.

January 1978 Slide Nos 35744-35746

PLATE 3 - CALCA GRANITE QUARRY
View north into two bench quarry. Clearing of overburden to permit development of third bench in foreground.
Large mobile crane can easily handle 6-10 tonne blocks of granite.

12 November 1986 Slide No. 35747

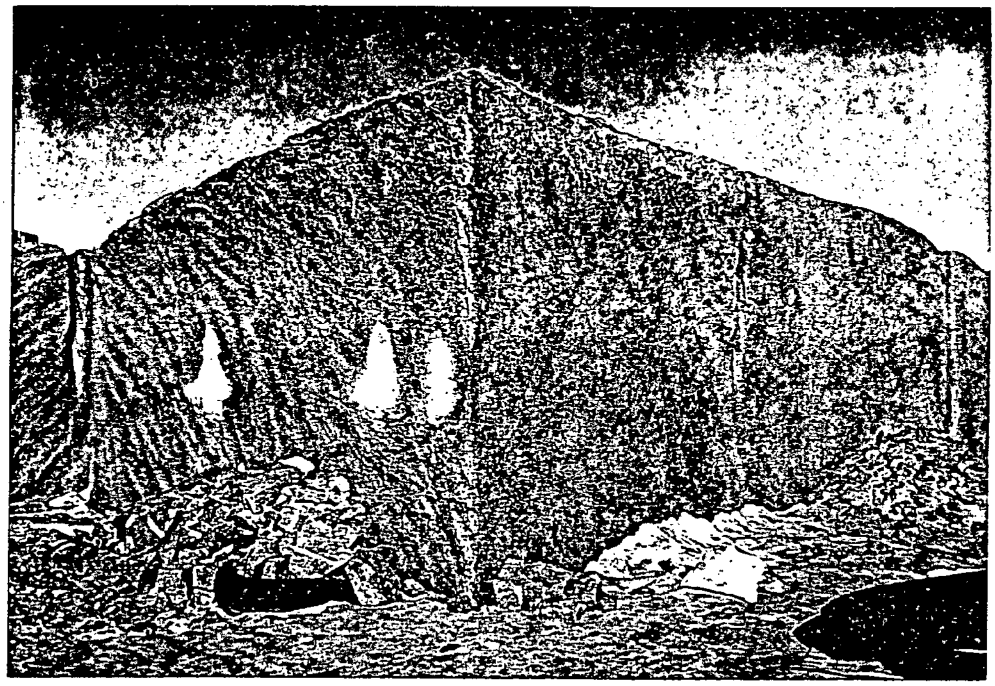

PLATE 4 - CALCA GRANITE QUARRY
Granite block at completion of jet cutting, ready for drilling of horizontal holes at base then blasting with black powder to break block free. Note flame cut (exfoliated) surface on granite and branching, dark joint with variable dip exposed in face.

September 1982 Slide 35748

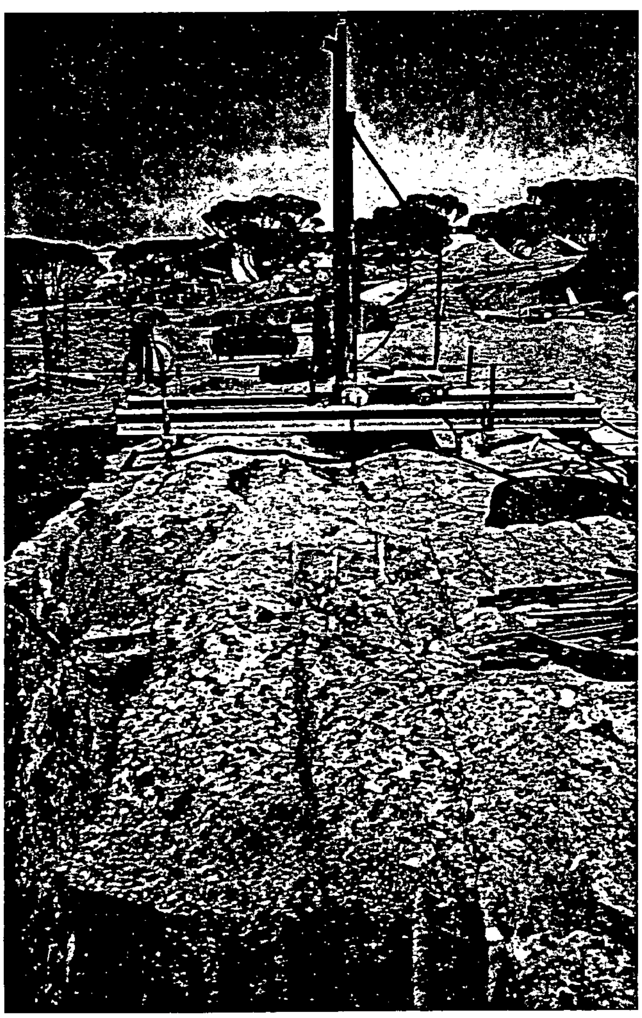

PLATE 5 - CALCA GRANITE QUARRY
Drilling line of closely spaced drillholes, then wedging to split block into slabs about 1 m wide and 10 m long.

November 1986. Slide No. 35749

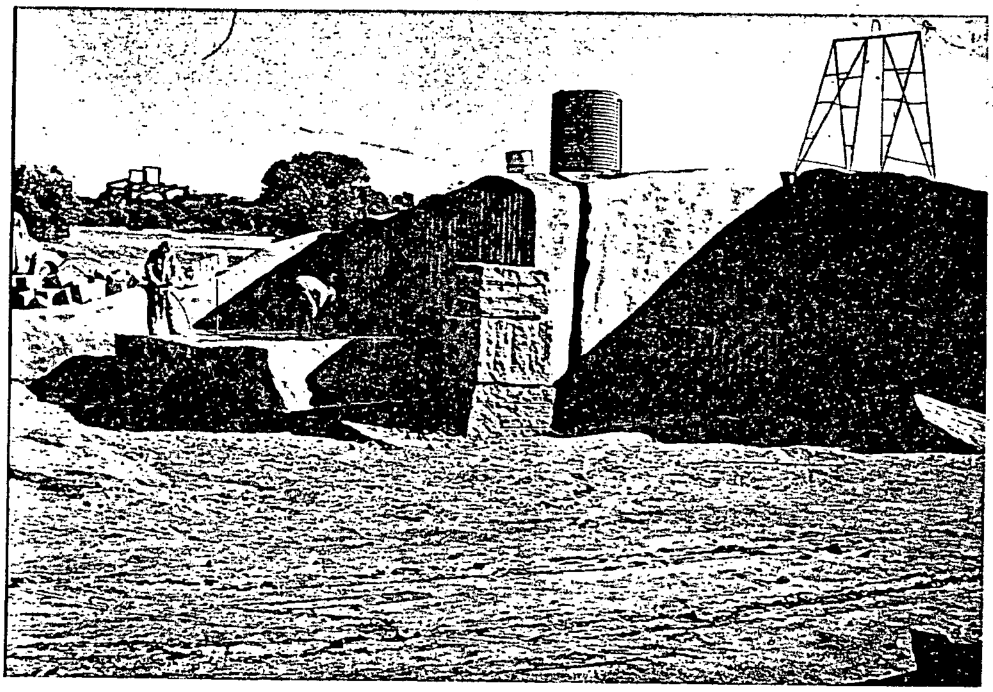

PLATE 6 - CALCA GRANITE QUARRY
Hand drilling: Freed slab pulled over onto tyres with measuring and hand drilling in progress to divide slab into marketable blocks.

January 1978 Slide No. 35750

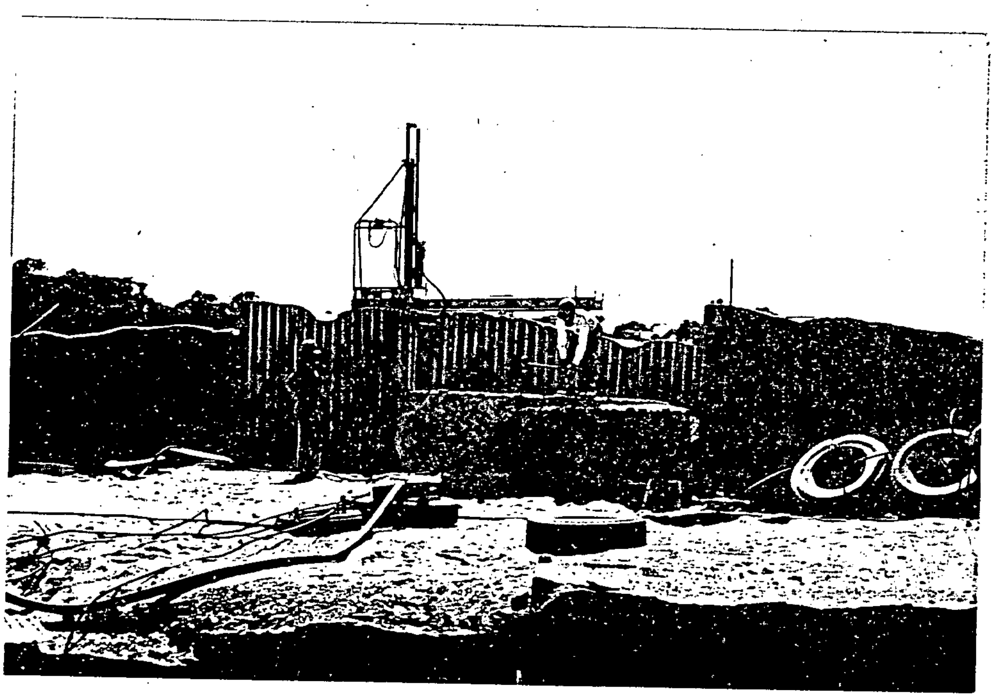

PLATE 7 - CALCA GRANITE QUARRY
Hammering wedges to split slab along line of drillholes. Note drillhole spacing in quarry face.

October 1984 Slide No. 35751

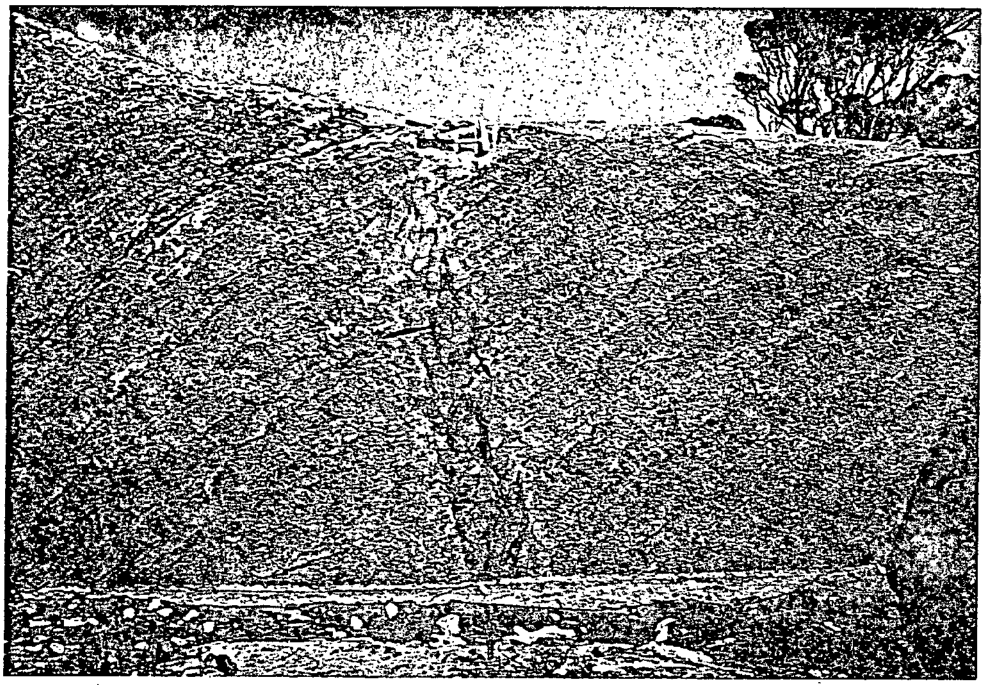

PLATE 8 - CALCA GRANITE QUARRY
Main aplite vein with steep northerly dip exposed in northwest corner of quarry. Note pale coloured graphic zone on margin of vein, steep en echelon joints within vein and unusual arcuate joints within granite around vein.

October 1986 Slide No. 35752

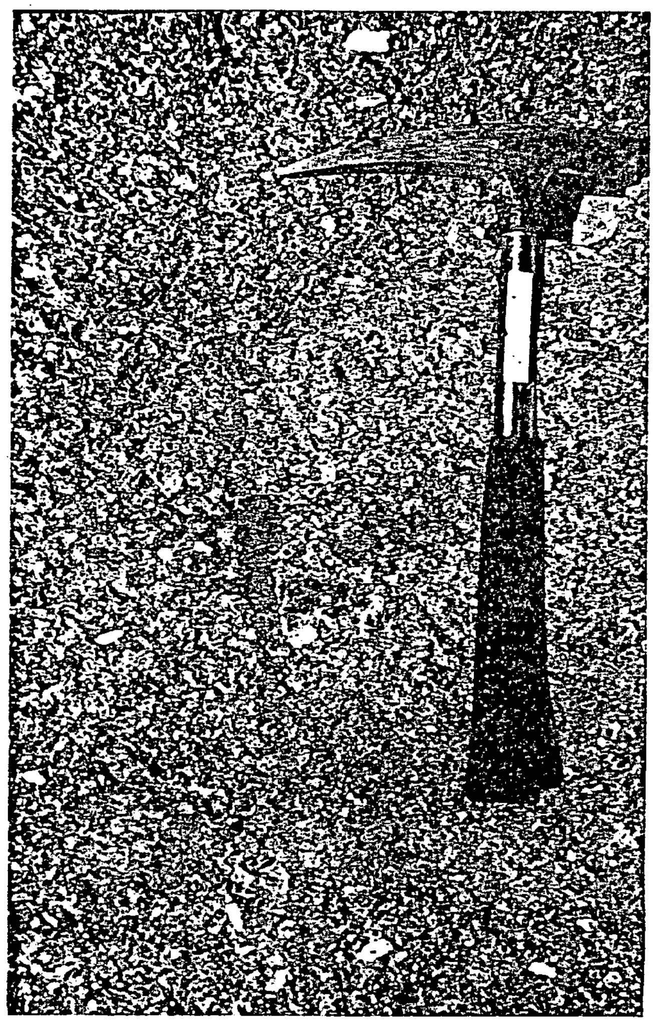

PLATE 9
CALCA GRANITE QUARRY
Aplite vein: 10 mm wide red brown aplite vein in pink granite. Vein is not a line of weakness and may be incorporated in finished dimension stone.

October 1986.
Slide No. 35753

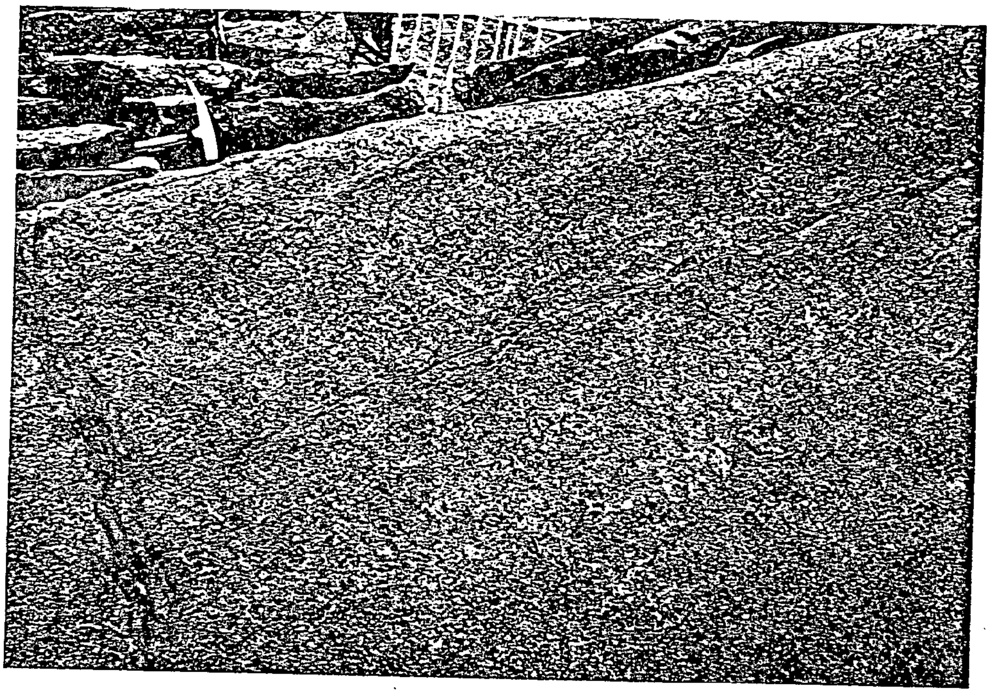

PLATE 10 - CALCA GRANITE QUARRY
Pink and grey aplitic vein within massive granite.
Note . crystal lined voids within, and parting developed along, vein.
. iron stained exfoliation joint sub-parallel to outcrop surface on right hand side of vein.

November 1986 Slide No. 35754

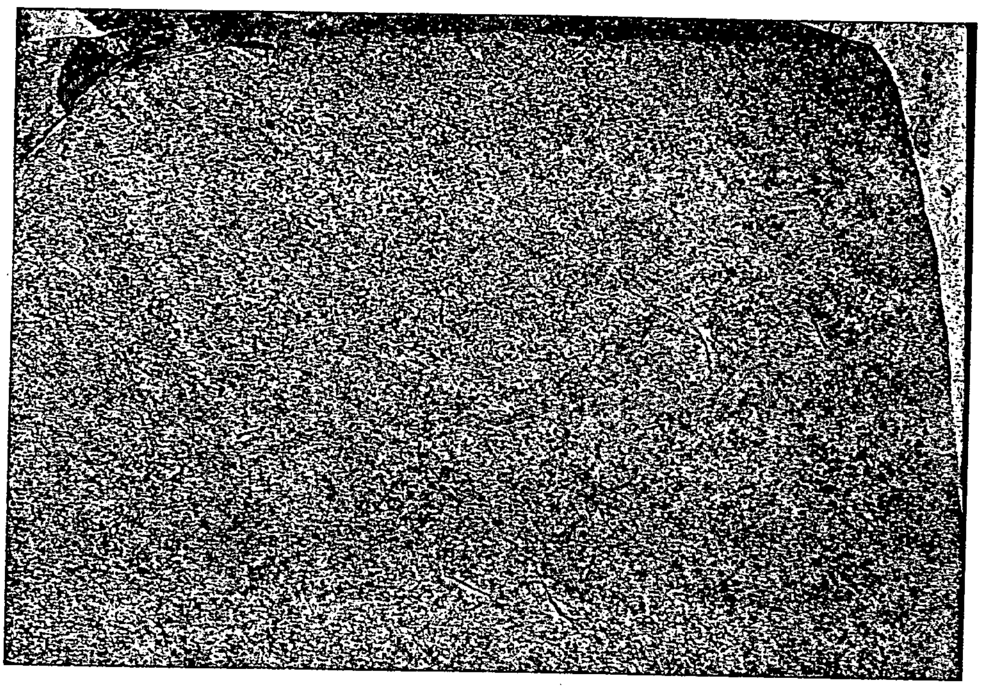

PLATE 11 - CALCA GRANITE QUARRY

'Dark joint - resulting from concentration of biotite, chlorite, hornblende and (?) iron oxides in zone 5-20 mm wide.

Note
- conspicuous parting in upper and central part of joint
- minimal surface expression
- changing dip and petering out of joint with depth.

November 1986 Slide No. 35755

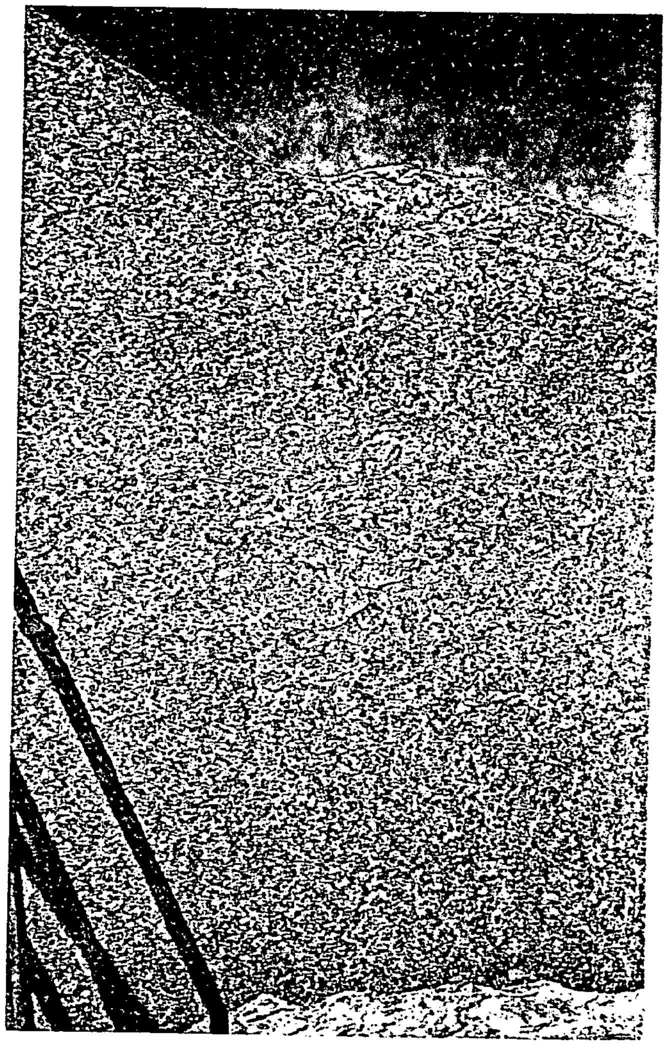

PLATE 12 CALCA GRANITE QUARRY
Pale joint - resulting from weathering and kaolinisation down joint.

Note
- distinct depression at surface resulting from preferential erosion along weathered zone
- exfoliation joint parallel to, and about 0.2 m below, outcrop surface.

September 1982 Slide No. 35758

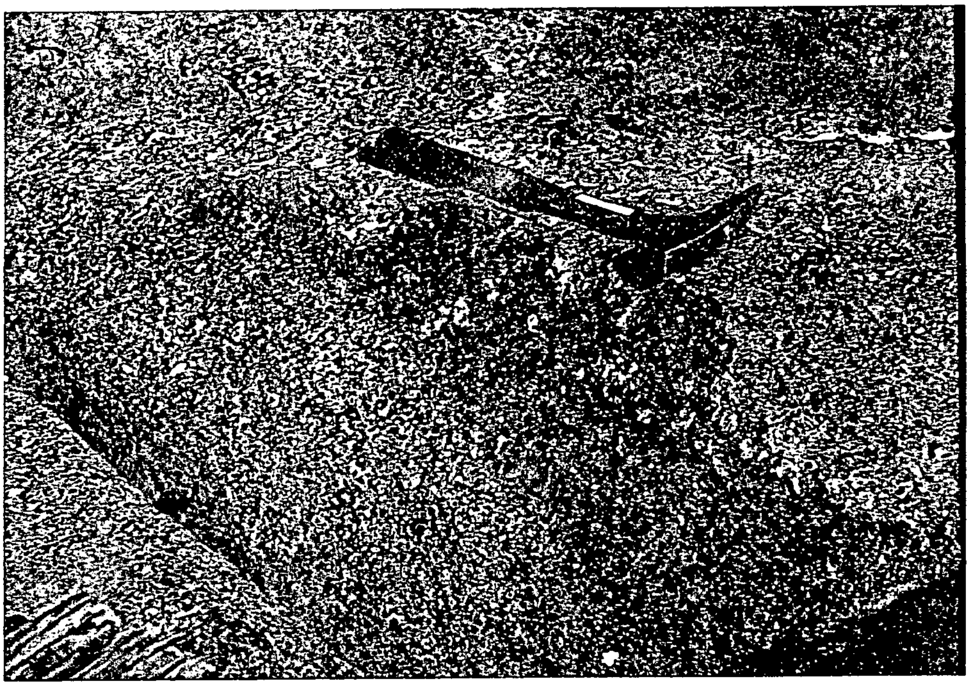

PLATE 13, CALCA GRANITE QUARRY
'Dark line' resulting from sharply defined concentration of biotite and chlorite along incipient joint plane, dipping 40° southerly.

November 1986 Slide No. 35756

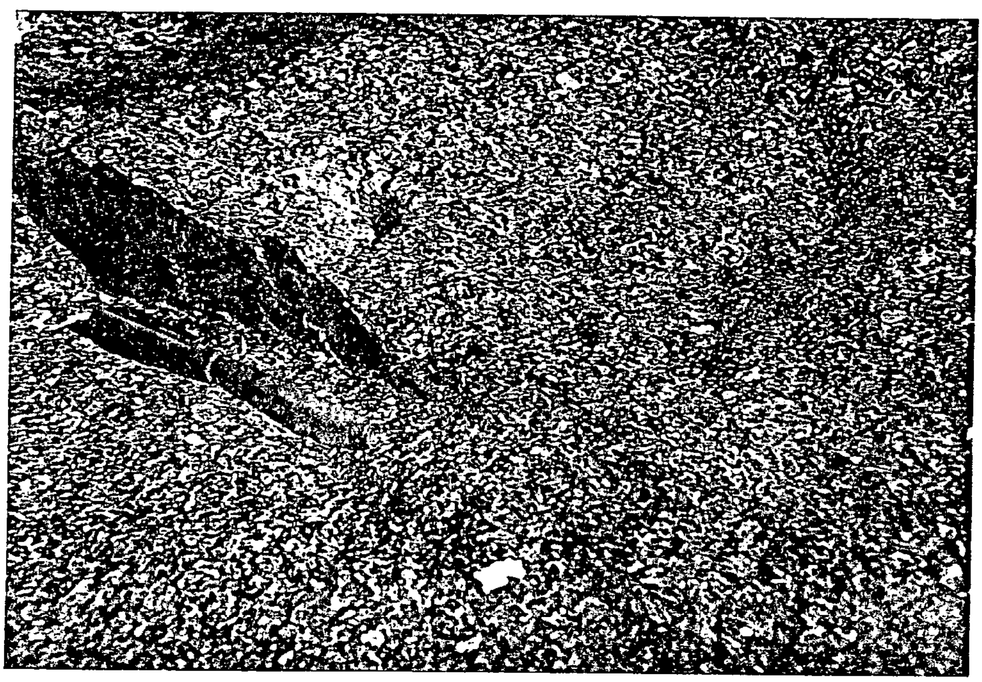

PLATE 14 CALCA GRANITE QUARRY
'Dark line' showing well developed parting which is the major cause of stone wasteage.
Note: 'dark line' cannot be traced for any distance into adjacent granite.

November 1986 Slide No. 35757

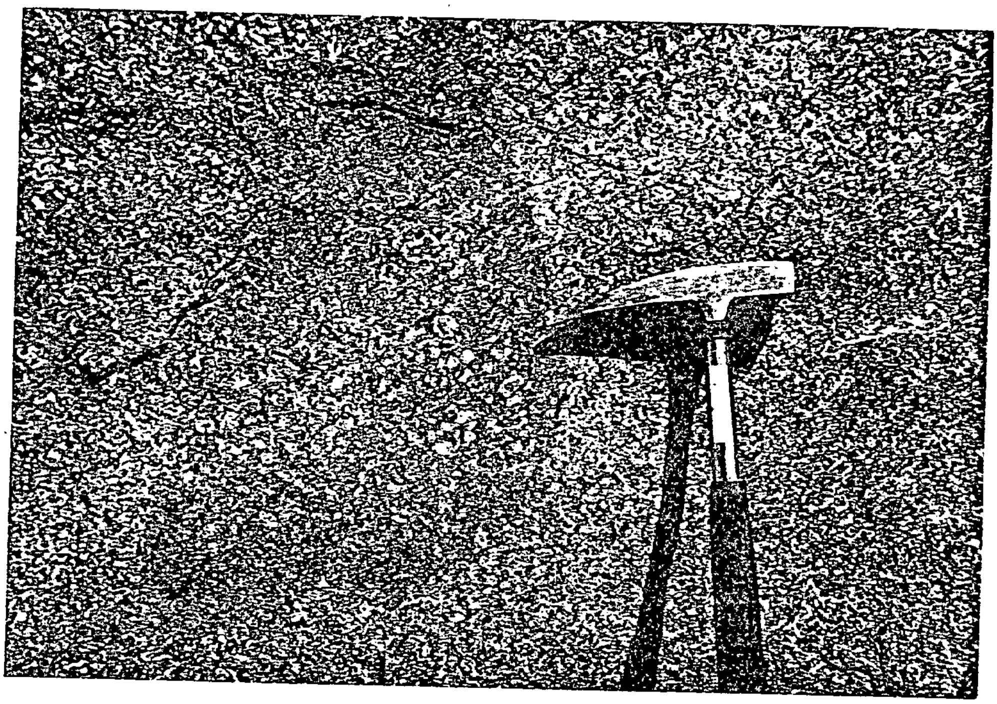

PLATE 15 CALCA GRANITE QUARRY
Xenolith of red brown, highly porphyritic Gawler Range Volcanics equivalent granite identical to granite cropping out at Calca Hill.

October 1986   Slide No. 35759

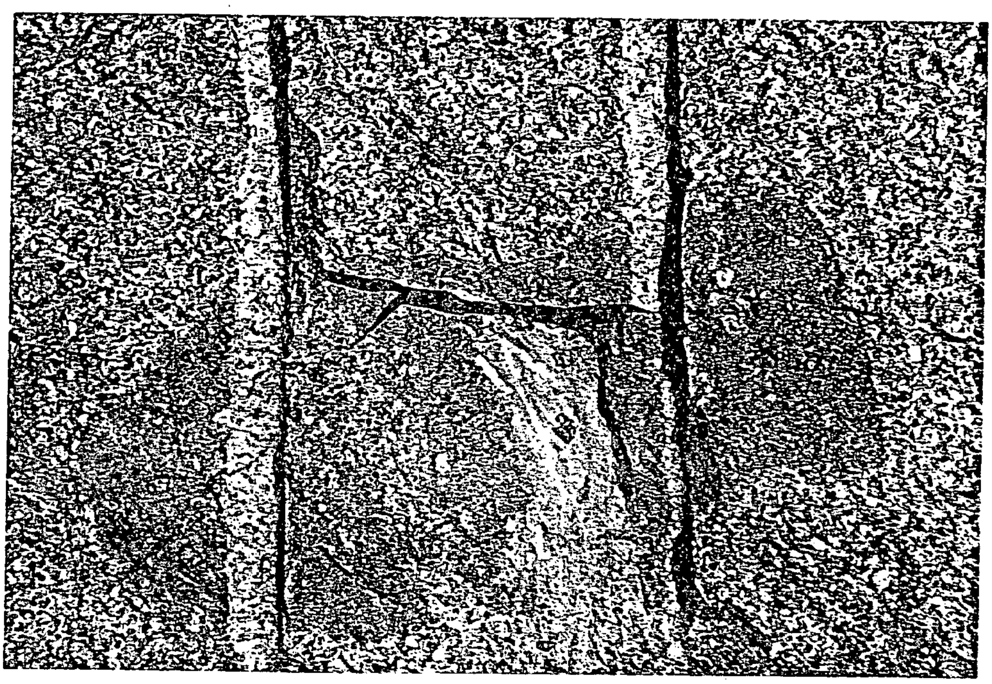

PLATE 16 CALCA GRANITE QUARRY
Xenolith of grey feldspar porphyry, Calca Hill granite or Gawler Range Volcanics equivalent. Xenolith, about 0.4 m across, cracked and veined by pink granite.

October 1986   Slide No. 35760

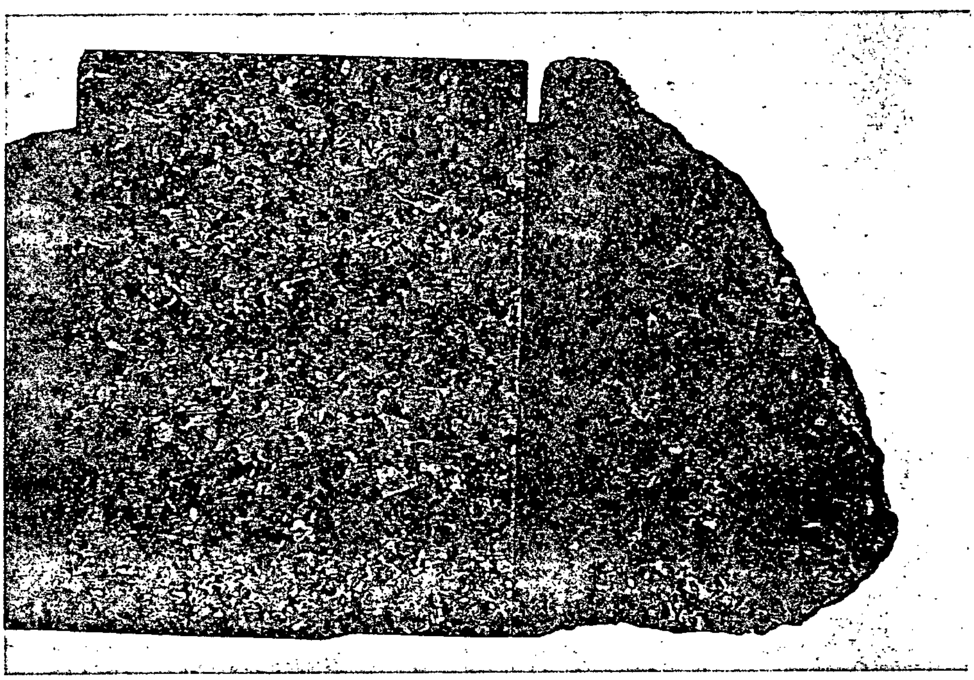

PLATE 17 CALCA GRANITE
Polished slab of fresh pink Hiltaba Suite granite from Calca Granite Quarry (left) compared with polished sample of slightly weathered reddish brown granite taken from outcrop in Anxious Bay. (Sample P194/74). Sample on right is from piece, polished by Monier Granite in 1974, which stimulated search for red granite on Eyre Peninsula.

Note:
- even, equigranular texture of fresh granite
- brown goethite alteration within some feldspar crystals.

November 1986 Slide No. 35761

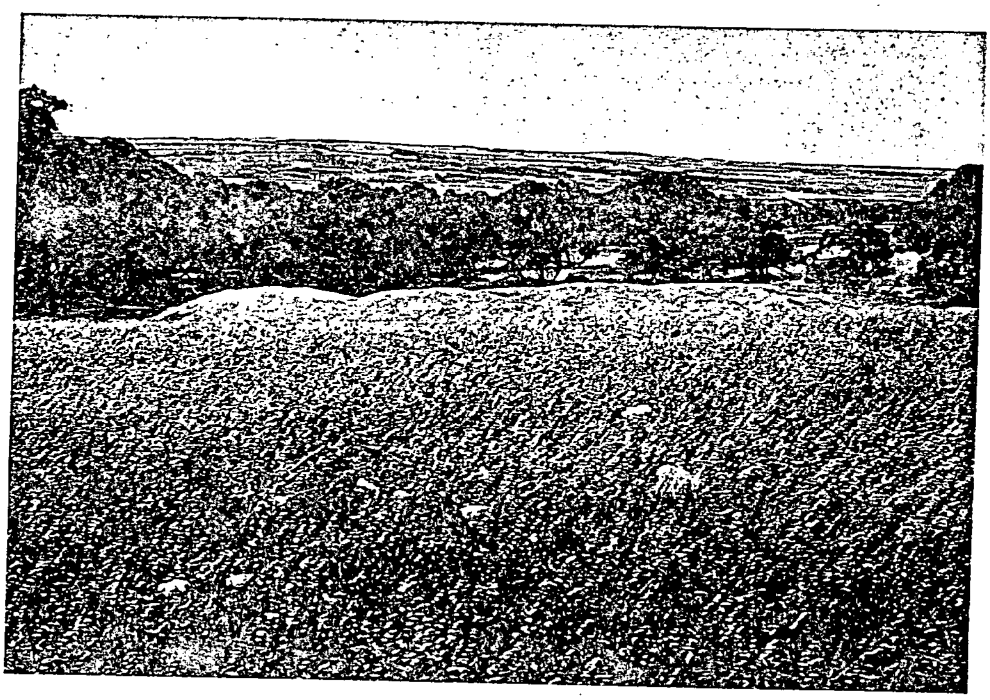

PLATE 18 CALCA SOUTH GRANITE DEPOSIT
General view southeast from Station A, (Fig 4) over EML 5068. Soil and calcrete rubble in foreground, largest outcrop of pink granite forms low whaleback in centre.

September 1982 Slide No. 35762

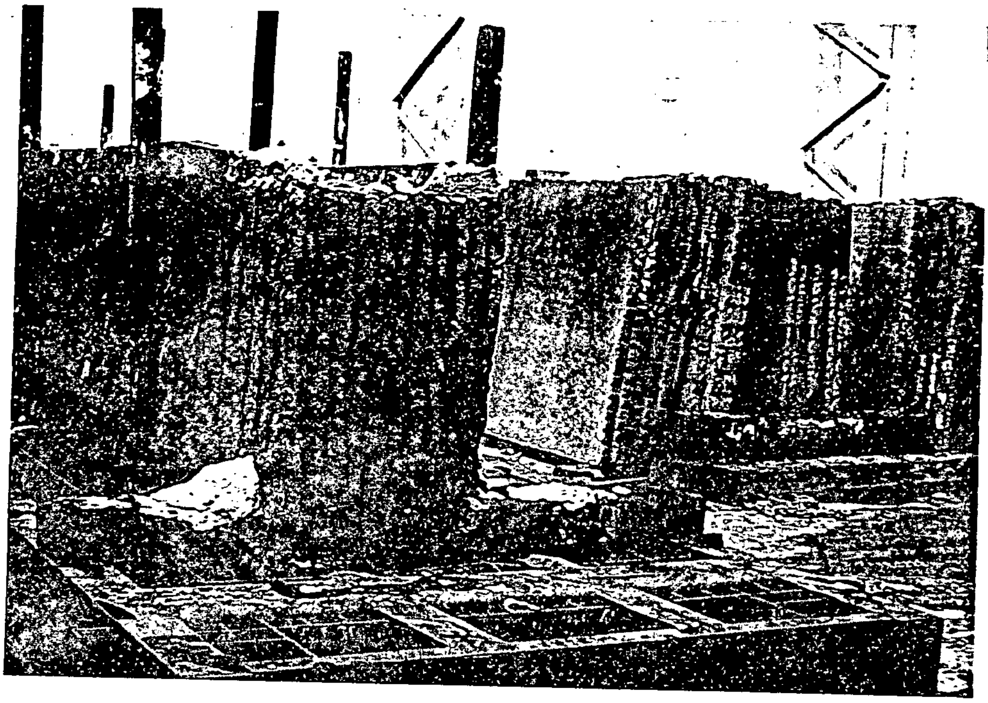

PLATE 19 CALCA GRANITE
Block after frame sawing into 75 mm thick slabs for use as paving. After removal from frame slabs are separated by wedging. Sawn paving slabs in background are finished by acid washing to remove iron staining caused by sawing and trimmed by diamond saw.
Monier Granite, Gepps Cross, Sth. Aust.

October 1986 Slide No. 35763

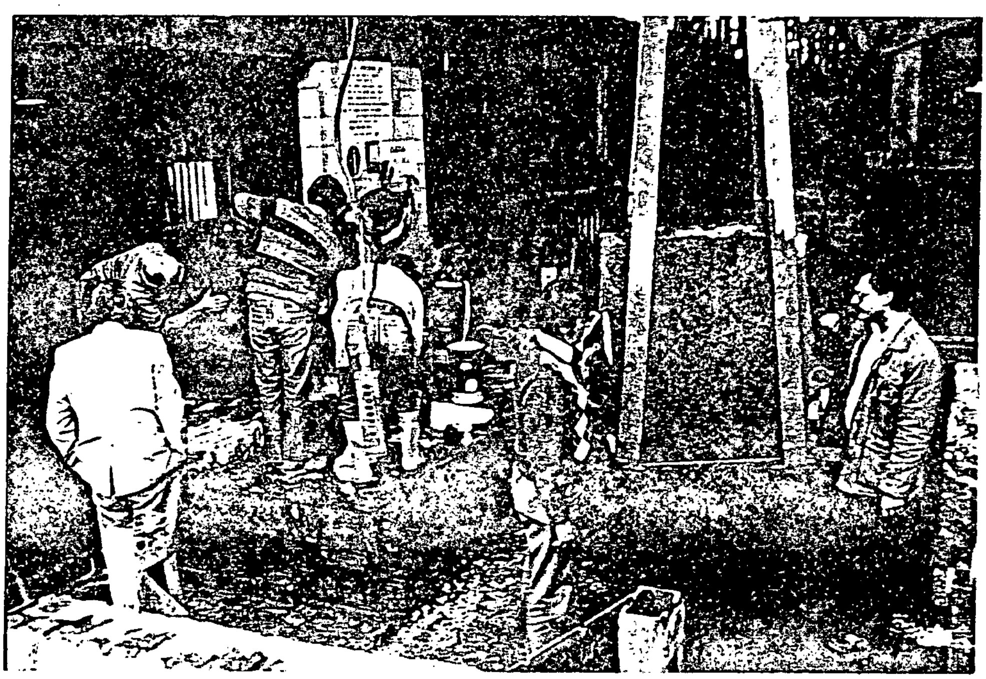

PLATE 20 CALCA GRANITE
Slab after block sawing, S.D.Tillett Memorials Pty. Ltd., Brompton, Sth. Aust.
Note smooth sawn surface and darker red brown colour of wet granite.

June 1986 Slide No. 35764

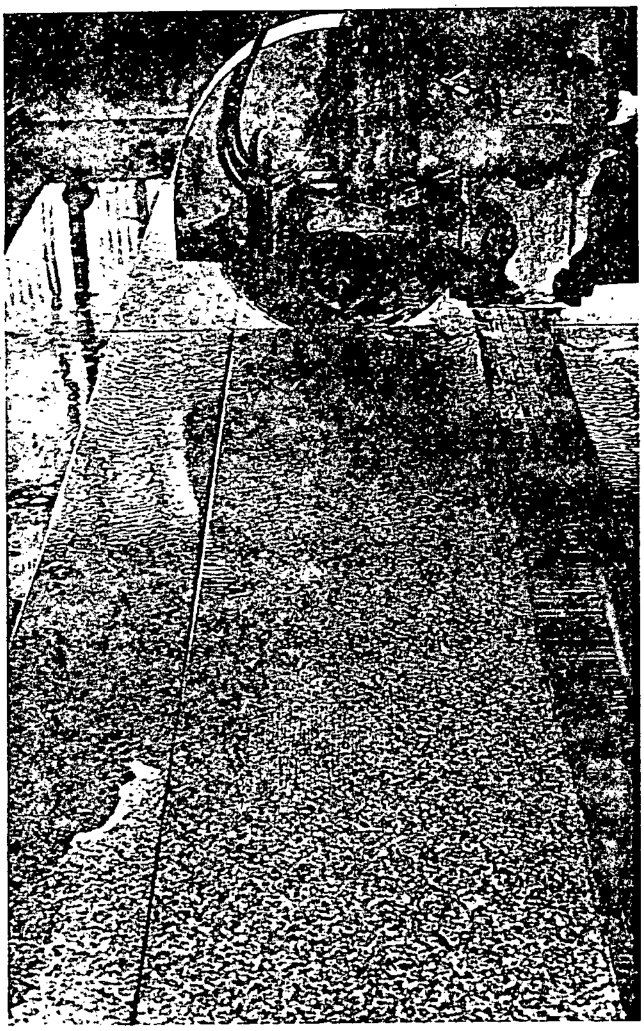

PLATE 21   CALCA GRANITE
Cutting paving slabs into required size and shape using diamond saw. Monier Granite, Gepps Cross.

October 1986 Slide No. 35765

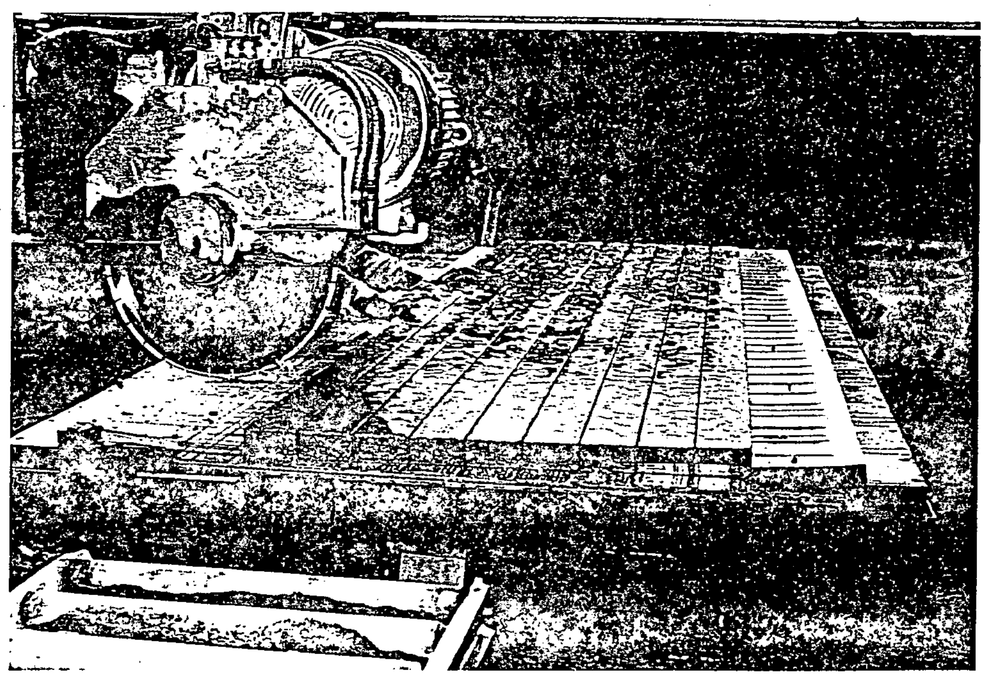

PLATE 22 CALCA GRANITE
Cutting paving setts. Diamond tipped saw cutting 50 mm thick exfoliated slab into 100 mm square paving setts. Monier Granite, Gepps Cross

October 1986   Slide No. 35766

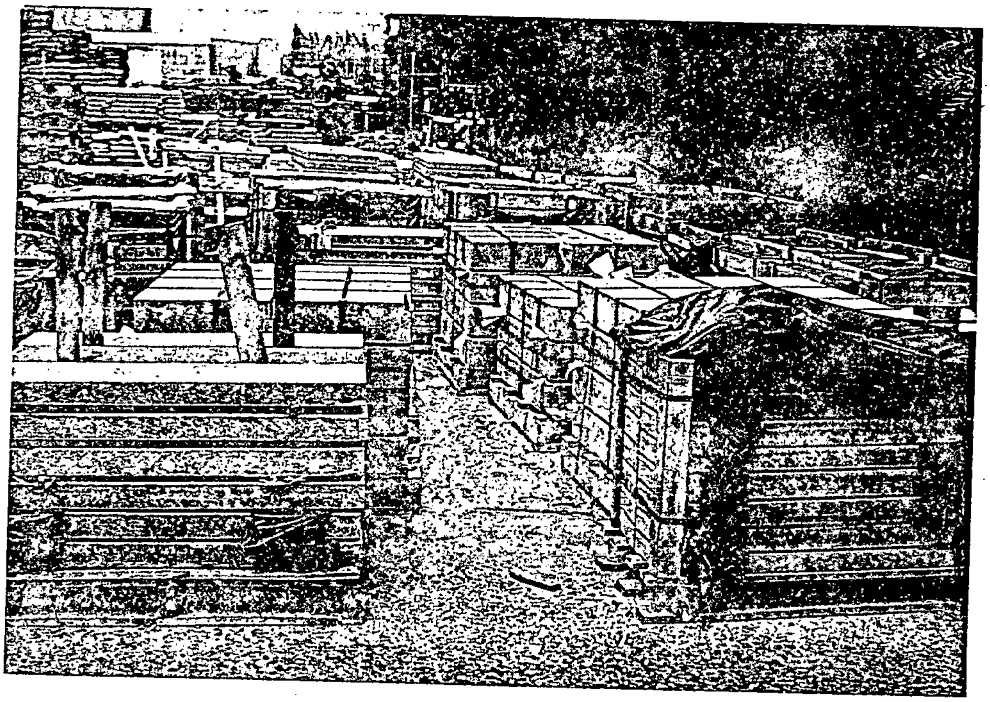

PLATE 23 CALCA GRANITE
Finished frame sawn paving slabs and steps stacked ready for transport to Opera House, Sydney and new Parliament House, Canberra.
Monier Granite, Gepps Cross

October 1986 Slide No. 35767

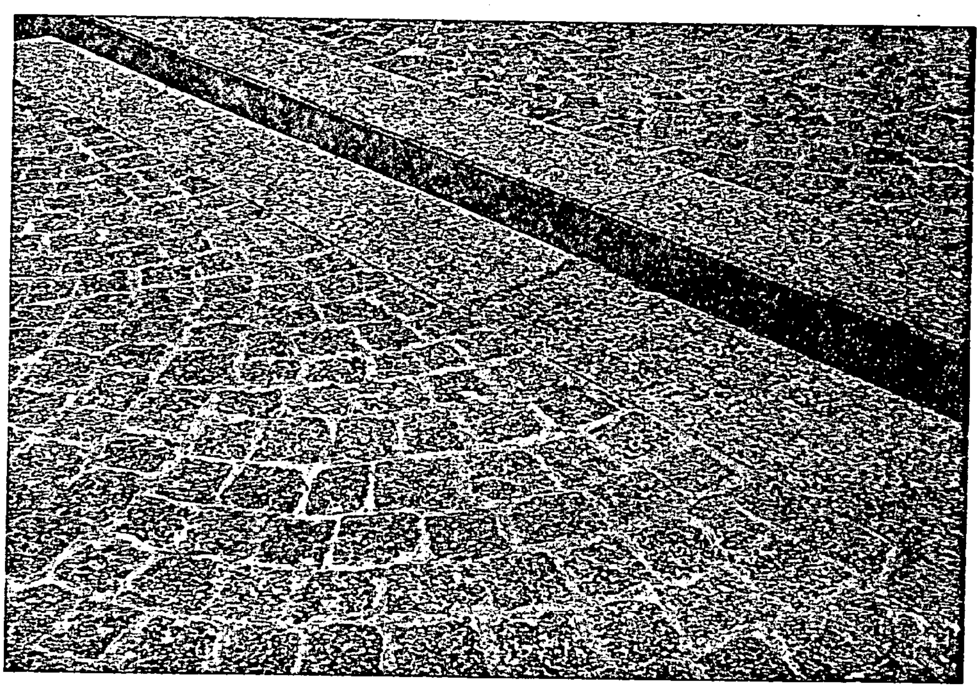

PLATE 24 CALCA GRANITE
Opera House Forecourt, Bennelong Point, Sydney. Frame sawn paving slabs used as border for paving setts of Sienna Brown Granite from Long Ridge, South Australia. Step face is polished.

September 1986 Slide No. 35768

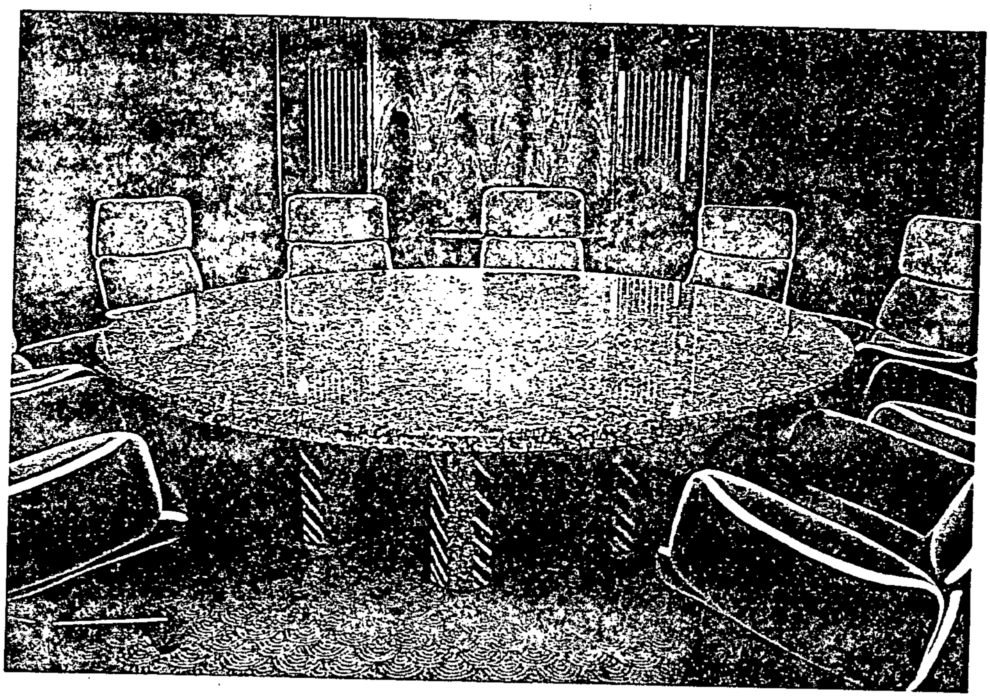

PLATE 25 CALCA GRANITE
Board room table, 2.74 m in diameter, made from single slab of Calca Granite. Table legs are polished Calca Granite, with etched stripes.
State Bank of N.S.W., Head Office, Martin Plaza Sydney.

December 1986   Slide No. 35727

To. L. Barnes – Mineral Resources

The Australian Mineral Development Laboratories

Flemington Street, Frewville, South Australia 5063
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Telex AA 82520

Please address all correspondence to
P.O. Box 114 Eastwood SA 5063

amdel

3 February 1983

In reply quote: GS 1/16/0

Your Ref: 12.03

Director-General,
Department of Mines & Energy,
PO Box 151,
EASTWOOD, SA 5063.

Attention: Mr L. Barnes

REPORT GS 3259/83

YOUR REFERENCE:	Application dated 19 October 1982
MATERIAL:	Rock samples
LOCALITY:	Aggregate quarries, Eyre Peninsula
IDENTIFICATION:	Various numbers as in text
DATE RECEIVED:	2 December 1982
WORK REQUIRED:	Preparation of thin sections and routine petrographic description (MA1.3)

Investigation and Report by: Don McColl

Chief - Geological Services Section: Dr Keith J. Henley
Manager, Mineral and Materials Sciences Division: Dr William G. Spencer

Keith Henley

for Norton Jackson
Managing Director

jd/12

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PETROGRAPHIC DESCRIPTIONS OF ELEVEN AGGREGATE SAMPLES FROM EYRE PENINSULA

Sample: 5831 RS 28; TS44869

Rock Name:
Altered feldspar porphyry

Hand Specimen:
A massive grey and pink streaked igneous rock of fairly fine grain size, with a scattering of medium-grained phenocrysts.

Thin Section:
A visual estimate of the constituents is as follows:

	%
Quartz	20-30
Feldspar (potassic)	~60
Feldspar (soda-lime)	5-10
Hornblende	3-5
Biotite (chloritic in part)	2
Epidote	<1
Apatite	<1
Titanite (sphene)	<1
Opaques (magnetite, plus trace sulphide)	1-2

Gross potassium metasomatism has affected this rock replacing many of the components with turbid pale brownish orthoclase, and recrystallising a formerly aphanitic groundmass to a fine granuloblastic intergrowth of quartz and feldspars. The outlines of former subhedral feldspar phenocrysts up to 3 mm diameter, although now broken and ?brecciated, can be seen scattered in the variously recrystallised and altered groundmass. Most of these phenocrysts appear to have been of potassic composition, and although they are now much crowded with flakes of fine sericite, have grown authigenically along their margins at the expense of the groundmass. Soda-lime feldspars are rarer, and generally no more than 1.5 mm diameter. They are grossly occluded with alteration products, but the few remaining which show multiple twinning suggest a composition corresponding to oligoclase (Ab_{80}). The groundmass is of variable grain size, but generally consists of a mass of quartz and feldspar grains each no more than 0.1 mm diameter, with masses of finer crystals along the intergranular boundaries and a sparse spotting of similarly fine granules of epidote and hornblende throughout.

A scattering of ferromagnesian phenocrysts up to 1 mm diameter was also present, but these are now represented by ragged crystals of hornblende and biotite, which may or may not have been the original components. The hornblende is strongly pleochroic in shades of green and yellow, and frequently is associated with tufts of chlorite, euhedral crystals (prisms) of apatite up to 0.2 × 1.0 mm, fine granules of epidote and occasional clusters of titanite.

The opaques are principally sparse rounded granular masses of magnetite up to 0.1 mm diameter, but there is a pervasive dusting of much finer grains (less than 20 microns) throughout the groundmass, which appears to be a product of the alteration. A very few grains of sulphide (?pyrite) are also present.

The rock appears to have been a fairly normal porphyry of siliceous potassic composition, which has been grossly altered and potassium metasomatised by post-magmatic hydrothermal solutions. Although there has been a great deal of alteration the rock appears quite massive and inert, the only commonly accepted secondary minerals present are a small amount of chlorite and pyrite, along with thin films of limonite along the weathered jointing planes.

Sample: 5831 RS 29; TS44870

Rock Name:
Altered feldspar porphyry

Hand Specimne:
A massive faintly mottled brown to pink porphyritic igneous rock with medium-grained phenocrysts in a fine-grained groundmass.

Thin Section:
A visual estimate of the constituents is as follows:

	%
Quartz	30
Feldspar (potassic)	40-50
Feldspar (soda-lime)	10
Hornblende	∿10
Biotite	1
Chlorite	1-2
Apatite	<1
Titanite (sphene)	1
Opaques (magnetite plus sulphide)	2-3

This rock is extremely similar to the previous sample RS 28, the differences being merely a difference of degree of alteration, than an intrinsic compositional difference. In this sample the porphyritic texture can be more clearly seen both in hand specimen and in section. The feldspar phenocrysts are up to 3 to 4 mm diameter, and it is more obvious that the majority were originally potassic varieties although they are now mottled with zones of partially sericitic alteration. Virtually all the phenocrysts show marginal overgrowths of turbid pale brownish orthoclase, and the same mineral is very prevalent in granuloblastic intergrowths with quartz throughout the groundmass. Plagioclase feldspars are quite scarce as was suggested in sample RS 28, and mainly occur as subhedral prisms up to 0.2 mm diameter, or very rare phenocrysts up to 1.0 mm diameter. Most of these are now grossly altered to metasomatic orthoclase, but a few multiple twinned remnants suggest a composition of calcic oligoclase (Ab_{75}).

Hornblende crystals are quite abundant, and as was the case for the previous sample, are brightly pleochroic from green to colourless. Most are also rather poikilitic, bearing abundant rounded grains of quartz set principally around their outer margins. Biotite is relatively scarce, but several masses of chlorite are present which may have been derived from this mineral. Apatite and titanite are present as subhedral prisms and clusters of granules, closely associated with the amphibole. Magnetite granules and subhedral crystallites are common in the groundmass, but most coarsely developed in association with the amphibole/mica clusters.

The rock is classified as a medium-grained granite porphyry which has been recrystallised and potassium metasomatised by post-magmatic hydrothermal solutions. Like sample RS 28, this sample appears quite massive and contains only minute traces of pyrite and chlorite, with a few thin films of limonite and some bleaching along the weathered jointing planes.

Sample: 5831 RS 30; TS44871

Rock Name:
Altered feldspar porphyry

Hand Specimen:
A massive faintly mottled grey and brown igneous rock of fairly fine grain size with a sparse scattering of medium to coarse-grained phenocrysts.

Thin Section:
A visual estimate of the constituents is as follows:

	%
Quartz	20
Feldspar (potassic)	∿60
Feldspar (soda-lime)	5-10
Hornblende	8-10
Biotite	1
Chlorite	1-2
Epidote	trace
Apatite	<1
Fluorite	trace
Titanite (sphene)	<1
Opaques (magnetite)	1-2

This rock is virtually identical with sample RS 28 in respect to the degree of alteration. It does, however, have a scattering of much coarser phenocrysts, and in places the phenocrysts occur as clusters of various minerals. Potassium metasomatism is the principal alteration process, and much of the groundmass and phenocrysts are replaced with turbid pale brownish orthoclase. Outlines of subhedral feldspars up to 5 mm diameter, can still be seen in various stages of sericitisation and alteration. Clusters of poikilitic hornblende prisms with inclusions of rounded quartz grains and associated granular masses of magnetite are up to 3 mm diameter. These also frequently enclose prismatic inclusions of apatite with a few rare traces of fluorite.

Generally the hornblende crystals are smaller than in the other samples, but occur more frequently dispersed throughout the groundmass. Small amounts of biotite, chlorite and titanite are also in many cases associated with the hornblendes. The groundmass varies somewhat in grain size, but is generally a fine granuloblastic mass of turbid feldspars and quartz. A few areas contain crystals up to 0.3 mm diameter which is coarser than the two preceding samples. Most of the groundmass, however, is less than 0.1 mm.

The only opaque component present in this rock is magnetite, but as was the case in the preceding samples, it is partly present as sparse coarser masses associated with the ferromagnesians, and also an abundance of very fine crystallites dispersed throughout the groundmass.

The rock is classified as a granite porphry recrystallised and potassium metasomatised by post-magmatic hydrothermal solution.

Sample: 5831 RS 31; TS44872

Rock Name:
Altered feldspar porphyry

Hand Specimen:
A massive brown porphyritic igneous rock of fine grain size, with a few areas of greyish mottling in the groundmass, and a fairly sparse spotting of coarse feldspathic phenocrysts.

Thin Section:
A visual estimate of the constituents is as follows:

	%
Quartz	20-25
Feldspar (potassic)	50-60
Feldspar (soda-lime)	10-15
Hornblende	5-8
Biotite (chloritic in part)	1-2
Apatite	1
Titanite (sphene)	<1
Opaques (magnetite and sulphide)	1-2

This rock appears to be a still coarser equivalent of the preceding three samples. Many of the phenocrysts are up to 1 cm diamter, and the groundmass contains vermicular zones of medium-grained micrographic quartz-feldspar intergrowths which are several centimetres long. Alteration by potassium metasomatism is still intense, although the cores of many of the feldspar phenocrysts are still clear and unaltered. Turbid pale brownish orthoclase is again common throughout the groundmass and is apparently responsible as in the previous samples for the colour. Plagioclase with multiple twinning is present quite abundantly, and although clouded with alteration products, appears to have a composition between oligoclase and andesine (approximately Ab_{70}). Quartz anhedra up to 0.2 mm diameter are abundant in the groundmass with similarly fine crystals of altered feldspar, a few hornblendes and a scattering of dusty to granular opaques. Hornblende phenocrysts are quite sparse, and intergrown with altered feldspars in a micrographic to poikilitic fashion. Some also show alteration to ?biotite and/or chlorite. In places there is a cluster of hornblende and the other ferromagnesians up to 5 mm diameter. Such mineral groupings frequently contain prominent prismatic apatite crystals and massive opaques, which are mainly magnetite, but do include a few subhedral crystals of sulphide (?pyrite).

The rock is a siliceous porphyry, classifiable as of granitic or adamellitic composition, which has been altered and potassium metasomatised by post-magmatic hydrothermal solutions. As for the previous samples, the only significant secondary minerals present are a small amount of pyrite and chlorite.

Sample: 5831 RS 32; TS44873

Rock Name:
Altered porphyritic ?rhyolite

Hand Specimen:
A massive fine-grained pink to brown porphyritic igneous rock with very sparse medium-grained phenocrysts and a broad bleached weathering zone around the external sample surface.

Thin Section:
A visual estimate of the constituents is as follows:

	%
Quartz	∿40
Feldspar (potassic)	40-50
Feldspar (soda-lime)	10-15
Biotite	2
Leucoxene (or ?titanite)	<1
Limonite	<1
Opaques (magnetite)	2-3

A sparse distribution of medium-grained quartz and feldspar phenocrysts in a fine microgranular groundmass characterises this rock. Some of the phenocrysts of quartz are euhedral to subhedral forms up to 1.5 mm diameter, but the feldspars and most of the quartz grains are angular fragments of no specific form, suggesting that they may have been fractured during volcanogenesis. A few rare shreds and poikilitic platelets of biotite are also present, up to 0.5 mm diameter. Many of these showing degradation to clay and/chlorite minerals.

The groundmass is a very fine granitoid intergrowth of quartz and feldspars. The feldspars are a pale brown turbid orthoclase produced from metasomatic alteration as for other rocks in this sequence. The feldspar phenocrysts show only varying degrees of metasomatic alteration, and most have at least some clear unaltered original zones, showing that both potassic and soda-lime varieties were present, several of them being in perthitic intergrowths.

The opaques appear to be entirely granules of magnetite up to 0.1 mm diameter, some having cubical forms, and these are disseminated fairly regularly throughout the groundmass. Similar irregular masses of high refractive index, which are cream to white in oblique illumination, are possibly leucoxene in process of transition to titanite. Traces of limonite exsolved during the alteration are also widely disseminated and contribute to the colour. The weathered zone around the outer margin of this sample is approximately 1 cm thick, and is generally inproverished in iron minerals except for a few thin films of limonite along fractures. The rock is concluded to be a porphyritic lava from the brecciated condition of the phenocrysts. It has been altered by potassium metasomatism from hydrothermal solutions, and also appears to be rather brittle and weakened by incipient fractures and minor weathering.

Sample: 5831 RS 33; TS44874

Rock Name:
Altered granite porphyry or ?rhyolite

Hand Specimen:
A massive fine-grained brown igneous rock with very sparse coarse-grained phenocrysts, superficially similar to sample RS 32 but much less weathered.

Thin Section:
A visual estimate of the constituents is as follows:

	%
Quartz	20-30
Feldspars (sericitic)	∿70
Biotite (chloritic in part)	1-2
Epidote	trace
Titanite (sphene)	trace
Zircon	trace
Opaques (magnetite)	2

A sparse distribution of coarse feldspar phenocrysts and medium-grained quartz phenocrysts in a very fine microgranular groundmass characterises this rock. The feldspars are up to 5 × 10 mm, and in many cases show perfect euhedral forms, although all have been so intensely altered either by potassium metasomatism to brown turbid orthoclase, or hydrolytically to masses of sericite, that their former identity is almost totally obscured. Some even show relict zoning, twinning and perthitic intergrowth textures in the replacing material. The quartz phenocrysts have a maximum diameter of 2 mm, and although are some grossly rounded by reaction with the groundmass, others show reasonably good euhedral to subhedral form, with just occasional corrosion embayments.

The groundmass consists of a granitoid mosaic of quartz and metasomatic orthoclase, which is very fine-grained and almost cherty in texture, having an average grain size of 20 to 50 microns. A few poikilitic ovoid grains of greenish biotite are up to 0.3 mm diameter, and enclose abundant fine quartz producing a virtual sieve texture. Rounded granular to cubical crystals of ?magnetite opaques up to 50 microns diameter, are moderately plentiful and are only superficially altered to limonite. Most of the biotite is more or less chloritised, and some flakes are crowded with very fine granules of epidote in addition. Very rare prisms of zircon are also present among a few of the chlorites, and there are traces of titanite in the groundmass.

The rock appears to be a granite porphyry or porphyritic lava, which has been more gently emplaced than the previous specimen, and the phenocrysts, although quite altered, are relatively unbroken. The alteration is the same potassium metasomatism and hydrolytic effects which have been evident in this entire suite.

Sample: 5831 RS 34; TS44875

Rock Name:
Altered granite porphry or ?rhyolite

Hand Specimen:
A massive fine-grained dark brown igneous rock with very sparse coarse to medium-grained phenocrysts, very similar to samples RS 33 and RS 32, but virtually unweathered.

Thin Section:
A visual estimate of the constituents is as follows:

	%
Quartz	30
Feldspar (potassic)	∿50
Feldspar (soda-lime)	5-10
Hornblende	5-8
Biotite	3-5
Titanite (sphene)	2-3
Opaques (magnetite)	1-2

A few coarse feldspar phenocrysts and medium-grained quartz phenocrysts are very sparsely distributed through the almost cherty microgranular groundmass in this rock. The feldspars are subhedral prisms up to 3 × 5 mm, although in section there is very little original feldspar remaining, and most consist of an intergrowth of fine sericite mesh with brown turbid orthoclase of metasomatic origin and a marginal rim of the same material. A few relicts of plagioclase with remnant multiple twinning appear to have had a composition near andesine. The quartz phenocrysts are up to 3 mm diameter and are in some cases of good euhedral form, but with corroded marginal embayments by reaction with the groundmass. Some of the phenocrysts show a slight degree of alignment, suggesting a possible volcanic fluidal texture.

The groundmass consists of a granitoid texture of ultrafine quartz and metasomatic brown turbid orthoclase, none exceeding 30 microns diameter. Trains of titanite granules and partially-formed crystals extend through many parts of the groundmass, along with a scattering of biotite flakes, poikilitic hornblendes and fine granular to cubical magnetite. Apart from a slightly increased proportion of ferromagnesian components, this sample is virtually identical to sample RS 33. It is unweathered, although there are some thin veinlets traversing the rock which have presumably been derived from the phase of metasomatic alteration.

The rock is classified as a granite or adamellite porphyry, although there are suggestions that it may be more of a porphyritic lava. It has experienced the same potassium metasomatism and hydrolytic alteration as is evident in all the preceding specimens.

Sample: 5334 RS 04; TS44876

Rock Name:
Adamellite

Hand Specimen:
A massive coarse-grained leucocratic siliceous intrusive igneous rock.

Thin Section:
A visual estimate of the constituents is as follows:

	%
Quartz	25-30
Feldspar (potassic)	30-35
Feldspar (soda-lime)	25
Biotite (chloritic)	3
Muscovite and sericite	5-8
Apatite	<1
Zircon	trace
Opaques (magnetite plus ?leucoxene)	1

This rock consists of an allotriomorphic mosaic of medium to coarse-grained polygonal crystals of quartz and feldspars. A few of the feldspars show slightly blocky outlines tending toward subhedral form, but most are of quite random polygonal shapes. The potassic feldspars appear to be dominantly of the microcline variety, and the few plagioclases have a composition between oligoclase and andesine ($Ab_{\sim70}$). Most of the feldspars are relatively clear and unaltered but there are a few patches of turbid sericitic alteration, particularly within some of the plagioclase crystals. Trains of similar ?clay minerals also follow some of the intergranular boundaries suggesting a very slight degree of late-stage hydrothermal alteration.

Biotite is the principal ferromagnesian mineral, occurring in flakes up to 1 mm diameter. It is a dark greenish-brown colour, and most crystals contain a sparse scattering of ultrafine zircons, each of which is surrounded by darker brown coloration halos. A few biotite crystals contain interlaminations of chlorite in small amounts, some are also associated with sparse finer flakes of muscovite, and a few occasional hexagonal prisms of apatite. The opaques also tend to be clustered with the phyllosilicates. They appear to be principally magnetite, with a few ultrafine granular inclusions of ?leucoxene. The magnetite is unsually brittle and friable, and has in many places partly crumbled out of the section during preparation.

The rock is a typical coarse to medium-grained siliceous intrusive, with a granitoid texture and composition intermediate between granite and adamellite. The magma may have originally incorporated a small proportion of xenolithic contaminants, but the amount of secondary alteration is very slight.

Sample: 5334 RS 05; TS44877

Rock Name:
Contaminated and altered microgranodiorite

Hand Specimen:
A massive medium-grained grey siliceous intrusive igneous rock with a plentiful scattering of coarser xenolith and xenocryst inclusions.

Thin Section:
A visual estimate of the constituents is as follows:

	%
Quartz	30-40
Feldspar (soda-lime)	40-50
Feldspar (potassic)	15
Biotite	2-3
Chlorite	<1
Titanite (sphene)	trace
Opaques (magnetite)	1-2

A very widely varied mixture of grain sizes of quartz and feldspars make up this rock. Subhedral prisms of plagioclase of 1 to 2 mm diameter, having a composition near andesine ($Ab_{\sim 65}$), are set in a finer matrix of orthoclase and granular to allotriomorphic quartz. Most of the orthoclase is in thin layers overgrown around the margins of the plagioclase crystals, and also permeating intergranular veinlets. The quartz is mainly as rounded polygonal grains of average diameter 0.1 mm. The biotite has the form of ragged flakes growing around and enclosing the quartz. Very few crystals are coarser than 0.5 mm, and many have been partly or wholly converted to a finer mesh and intergrowth of pale green chlorite. Granules of titanite are also scattered irregularly among the micas.

The various xenocrysts and xenoliths are up to 2 cm diameter, and are randomly but plentifully scattered in the rock. In the hand specimen it can be seen that some of these are zoned subhedral feldspar crystals, but in the section area, however, the coarsest xenolith is a 1 cm diameter mass of granoblastic quartz grains with thin intergranular fillings of potassic feldspar.

There is a moderate amount of alteration among some of the components in some areas of this rock. In patches the feldspars are grossly turbidified with sericitic alteration, while a few centimetres away the same feldspars are fresh and unaltered. Likewise some biotite is fresh, while in other areas it is totally converted to chlorite. Possibly during the contamination of the original magma, small amounts of water were introduced which led to the development of these localised patches of alteration.

The rock is classified as a microgranodiorite on the basis of the preponderance of soda-lime feldspar, but it is difficult to estimate how much contamination has affected the composition.

Sample: 5434 RS 05; TS44878

Rock Name:
Porphyritic adamellite

Hand Specimen:
A slightly porphyritic leucocratic siliceous igneous intrusive in which pale pink feldspar phenocrysts are enclosed in a slightly finer white feldspathic matrix.

Thin Section:
A visual estimate of the constituents is as follows:

	%
Quartz	25
Feldspar (potassic)	35-40
Feldspar (soda-lime)	25-30
Biotite (chloritic in part)	5-8
Apatite	trace
?Titanite (sphene)	<1
Opaques (magnetite)	2

Subhedral rectangular phenocrysts of orthoclase up to 10 × 15 mm are scattered in a granitoid matrix of plagioclase, quartz, minor potassic feldspars and biotite. The grain size of the matrix is up to approximately 5 mm. It contains an assortment of feldspars, although the main one is plagioclase of close to oligoclase composition (Ab_{80}). Various perthitic intergrowths, and a few crystals of microcline are also present. The feldspars are generally fresh and unaltered although there are a few random patches of slight turbid argillisation, some of which has developed into a mesh of sericite. The degree of alteration is, however, very slight to insignificant by comparison with the other samples in this suite.

The biotite flakes are generally finer than the other components, only being up to 2 mm in diameter. Interlaminated inclusions of chlorite are present in a few flakes, but most are unaffected. Granular trains of ?titanite (or ?leucoxene) are also enclosed within some of the biotite flakes, and a sparse scattering of irregular prisms of apatite frequently occur as inclusions or in association with clusters of the mica.

The rock is classified as a porphyritic adamellite, with a very slight degree of hydrothermal alteration.

Sample: 5731 RS 37; TS44879

Rock Name:
Altered granophyre

Hand Specimen:
A pink medium to fine-grained quartzo-feldspathic igneous rock with an irregular grain size and texture.

Thin Section:
A visual estimate of the constituents is as follows:

	%
Quartz	25-30
Feldspar (potassic)	∿50
Feldspar (soda-lime)	15
Hornblende (chloritic)	3-5
Fluorite	1
Opaques (sulphide plus goethite)	1-2

Crystals of quartz and feldspar of medium grain size and subhedral to anhedral form occur in scattered clusters and are enclosed in a fine-grained micrographic groundmass in this rock. Most of the coarser crystals are up to 3 mm diameter and consist of orthoclase or various perthitic intergrowths in which potassic feldspars are dominant. These are rather turbid and brownish with alteration products.

Most of the lamellar to elongate prismatic hornblende is also present in these somewhat coarser zones, although the hornblende is now altered to a semi-opaque and partially chloritised mass. A few rare crystals of plagioclase with a composition on the calcic side of oligoclase ($Ab_{\sim 70}$) are also present, although plagioclase is more abundant in the groundmass.

The micrographic groundmass itself consists of quartz and graphically intergrown orthoclase and plagioclase (?perthite). The orthoclase is turbid and considerably altered while most of the plagioclase is relatively fresh. The orthoclase is usually the optically continuous phase which may extend for over 5 mm and encloses rounded granules of quartz and more skeletal plagioclase.

Rare intergranular masses of fluorite occur in fragments up to 0.3 mm diameter, occurring principal in the vicinity of hornblende/quartz associations, and filling intergranular interstices. Some hydrothermal alteration of this rock has taken place, chloritising the amphibole and argillising the feldspars. Introduction of the fluorite probably also took place during this phase.

The rock appears to be a medium-grained rock of late-stage magmatic affinities such as an aplite or microgranite, but which has been modified during an aqueous hydrothermal phase which has resulted in a rock which may best be described as an altered granophyre.


CHART NO 1
Line traverse
across clear K feldspar
PTS 35602
(fresh granite)
K →
Fe →
K_2O
0
15 %
Fe
0·2
0·1
0
distance in mm
0
0·1
0·2
0·3
0·4
0·5
0·6

LINE TRAVERSE THROUGH
POTASH FELDSPAR CRYSTAL
2cm = 0·1mm
0%
Fe
Iron
Intensity
10%
13%
Potassium
Intensity
0%
K

line traverse
across clear K feldspar
PTS 35602
(fresh granite)
K→
Fe→
K_2O
15%
0·2
Fe
0·1
0
distance in mm
0·1
0·2
0·3
0·4
line traverse
across cloudy K feldspar
PTS 35602
0·5
0·6
0·7
0·8
0·9
line traverse
across cloudy K feldspar
PTS 35602
line traverse
across cloudy plagioclase

Line traverse
across clear K feldspar
granite)
Line traverse
across cloudy K feldspar
Line traverse
across cloudy plagioclase

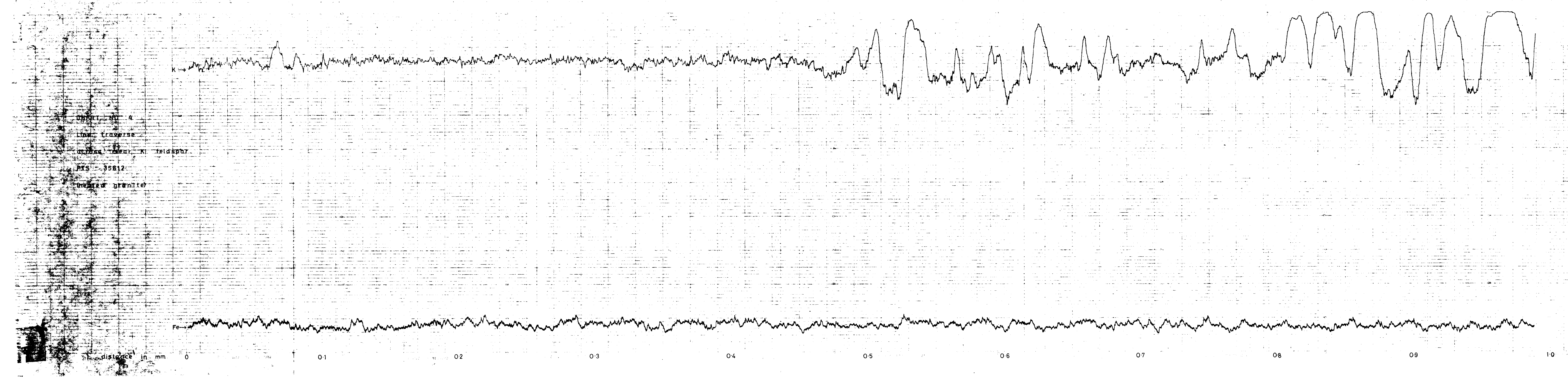
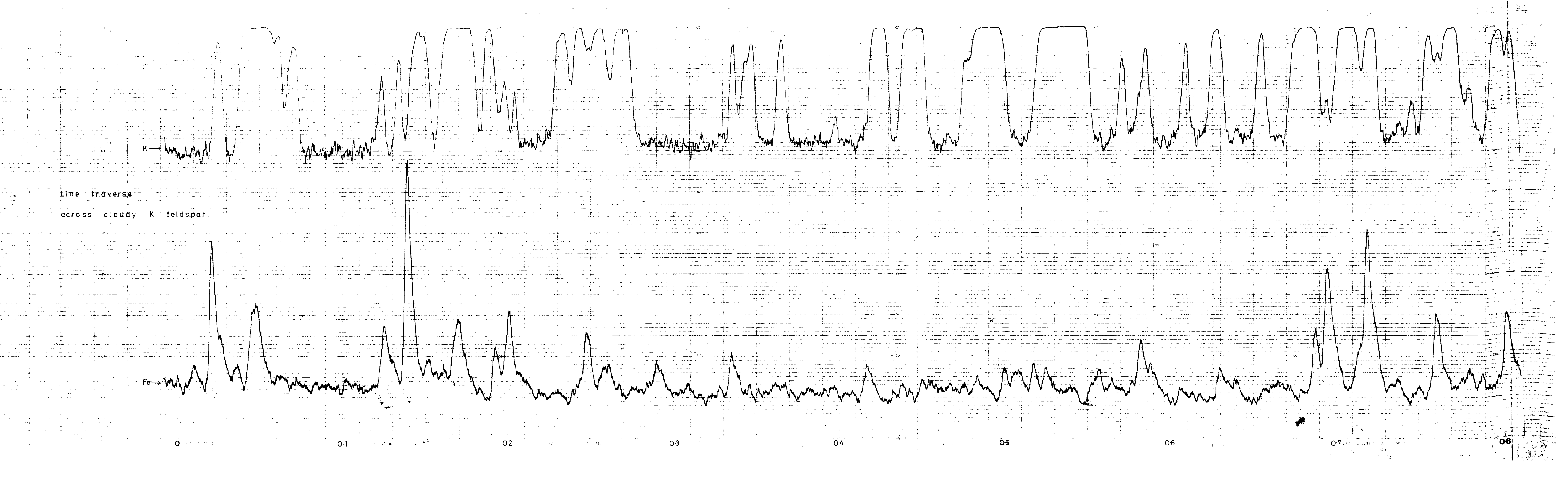
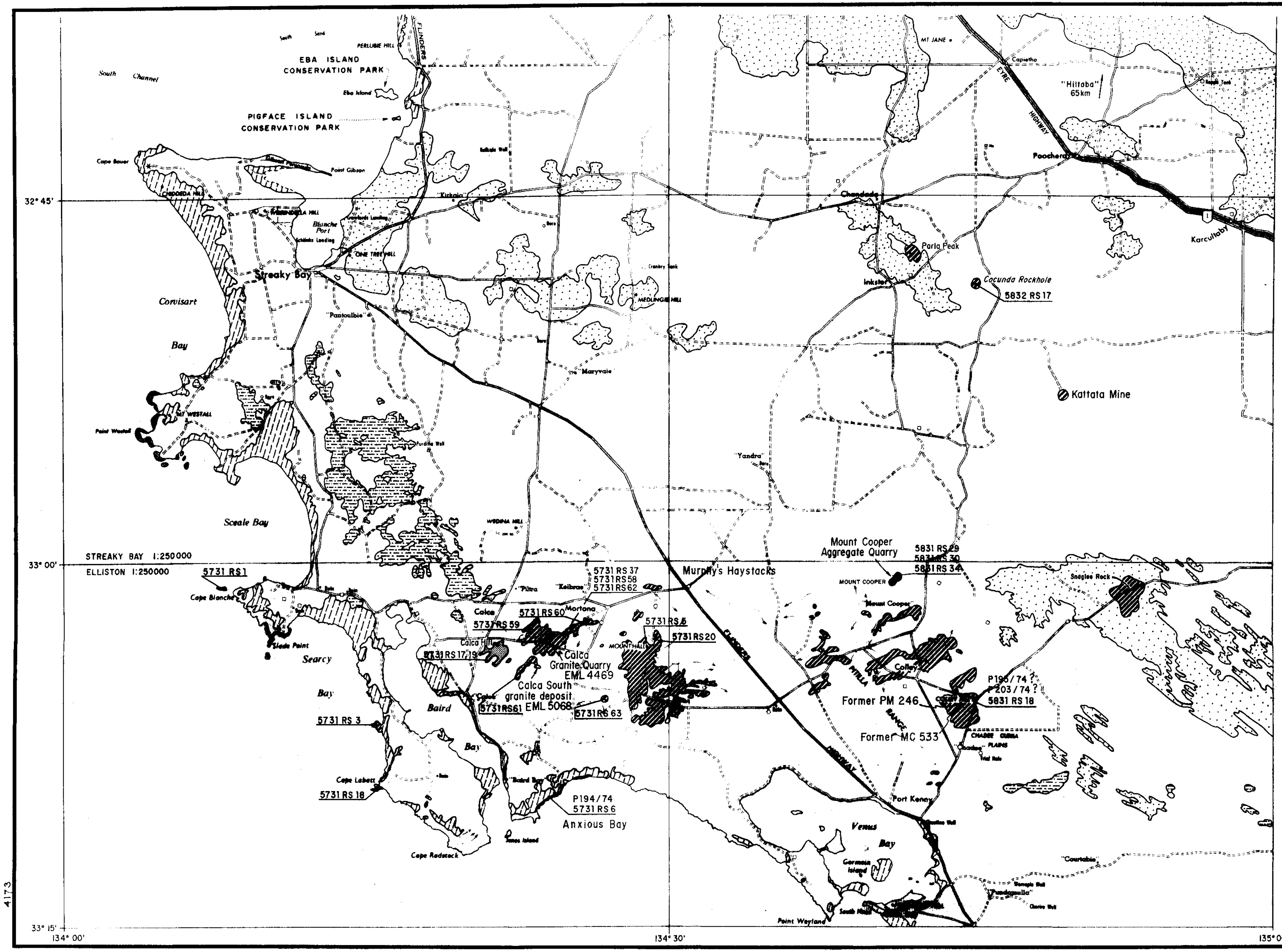


CHART NO 4
Line traverse
across clear K feldspar
PTS - 35812
(heated granite)
Fe
distance in mm
0
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0


K
Time traverse
across cloudy K feldspar
Fe
0
0·1
0·2
0·3
0·4
0·5
0·6
0·7



REFERENCE

SEMAPHORE SAND and ST. KILDA FORMATION: Calcareous and siliceous sand of beaches and coastal dunes. Estuarine mud and sand.

MOORNABA SAND: White, pale grey and orange quartz sand of vegetated dunes.

YAMBA FORMATION: Lacustrine and aeolian gypsum.

BRIDGEWATER FORMATION: Soft aeolian calcarenite with marine shell beds. Includes soft BAKARA CALCRETE and hard RIPON CALCRETE.

HILTABA SUITE: Massive pink, red and bright red granite and adamellite. Age about 1450 – 1550 Ma.

GAWLER RANGE VOLCANICS: Grey to dull red flow banded porphyritic rhyolite and rhyodacite. Unnamed: Highly porphyritic granite and adamellite.

Unnamed: Massive – foliated medium to coarse-grained granite and adamellite. Age about 1585 Ma.

5731 RS 61 — Sample Location

SCALE 1:250 000

km 5 0 5 10 15 km

Fig. 1

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED L. C. B.	C D Q 19·5·87 DATE
CALCA RED GRANITE DEPOSITS	DRAWN M. B.	SCALE 1:250 000
LOCATION AND REGIONAL GEOLOGY	DATE July '86 / CHECKED	PLAN NUMBER 86 – 439

4173

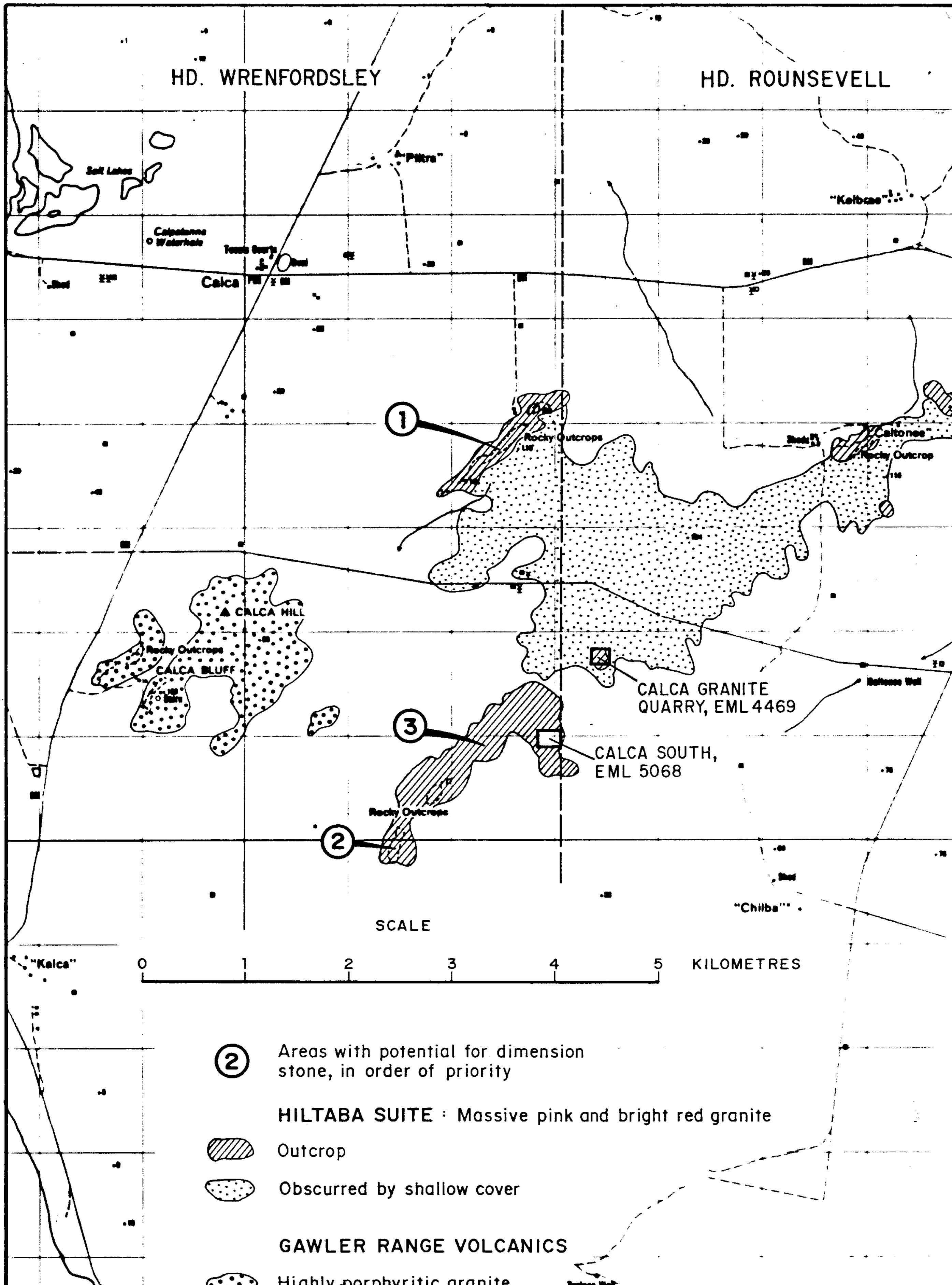


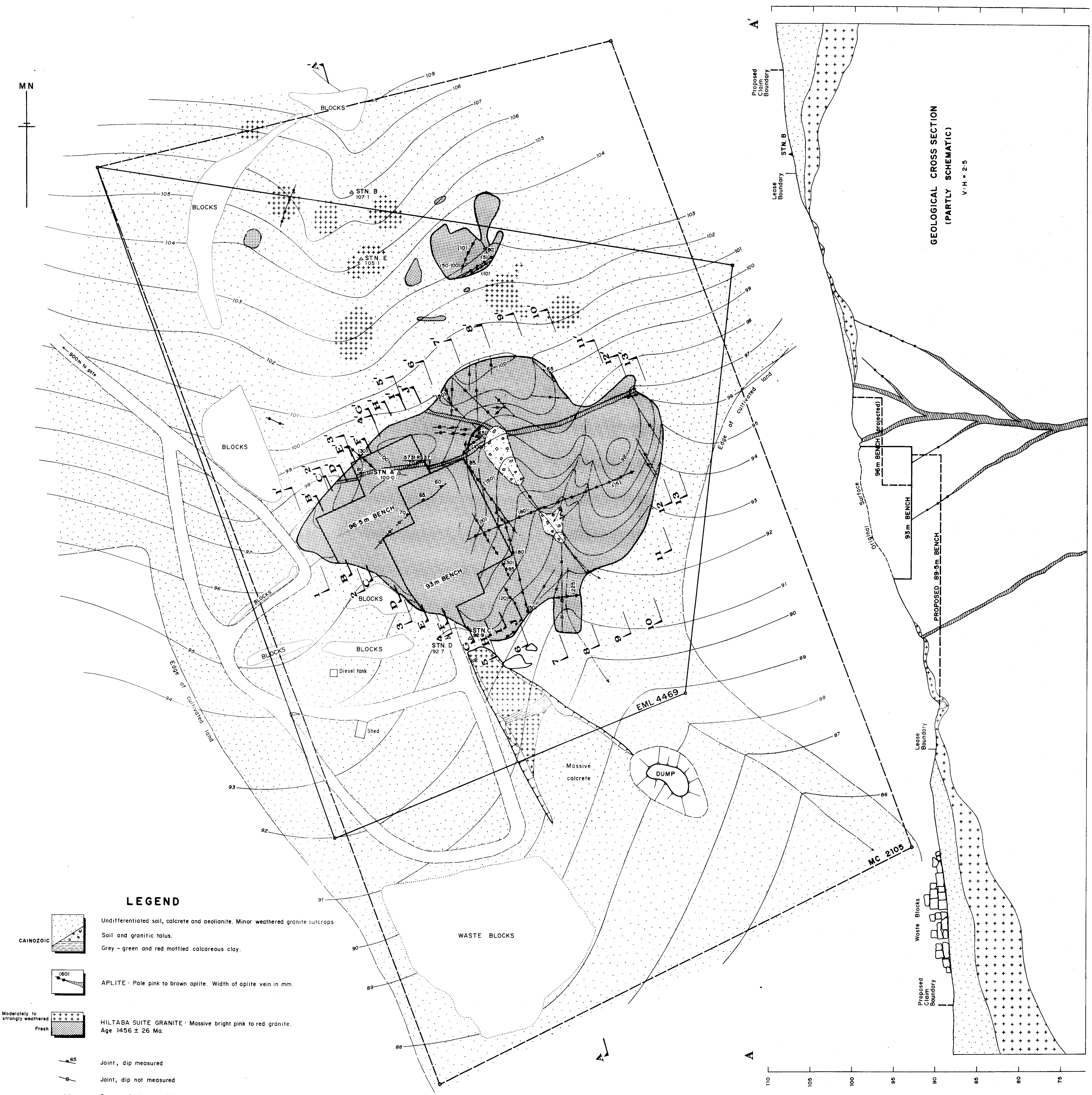
Fig. 2

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

CALCA RED GRANITE DEPOSITS
EXTENT OF GRANITE

COMPILED L.C.B.	CDO 19.5.87 DATE
DRAWN M.B.	SCALE 1 : 50 000
DATE March '87	PLAN NUMBER
CHECKED	S 19140

4173



LEGEND

CAINOZOIC: Undifferentiated soil, calcrete and aeolianite. Minor weathered granite outcrops.
Soil and granitic talus.
Grey - green and red mottled calcareous clay.

(60) APLITE : Pale pink to brown aplite. Width of aplite vein in mm.

Moderately to strongly weathered / Fresh: HILTABA SUITE GRANITE : Massive bright pink to red granite. Age 1456 ± 26 Ma.

65 Joint, dip measured

Joint, dip not measured

94 Contour, 1m interval. (Datum - arbitary, STN. A 100·0m)

Watercourse

STN. A 100·0 Survey Station, elevation in metres

Lease peg, lease boundary

Claim peg, claim boundary

5731 RS 37 Rock Sample location

Geology by D. A. Young and L.C. Barnes.
Original survey by A.J. Smith, 21-9-82 (SFB 350)
Updates by J.G. Olliver, 19-10-84 (SFB 350) and
P.P. Crettenden, 12-11-86 (SFB 814)

For Cross sections, see Plan no. 87 – 122

SCALE 0 10 20 30 40 50 METRES

Fig. 3

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

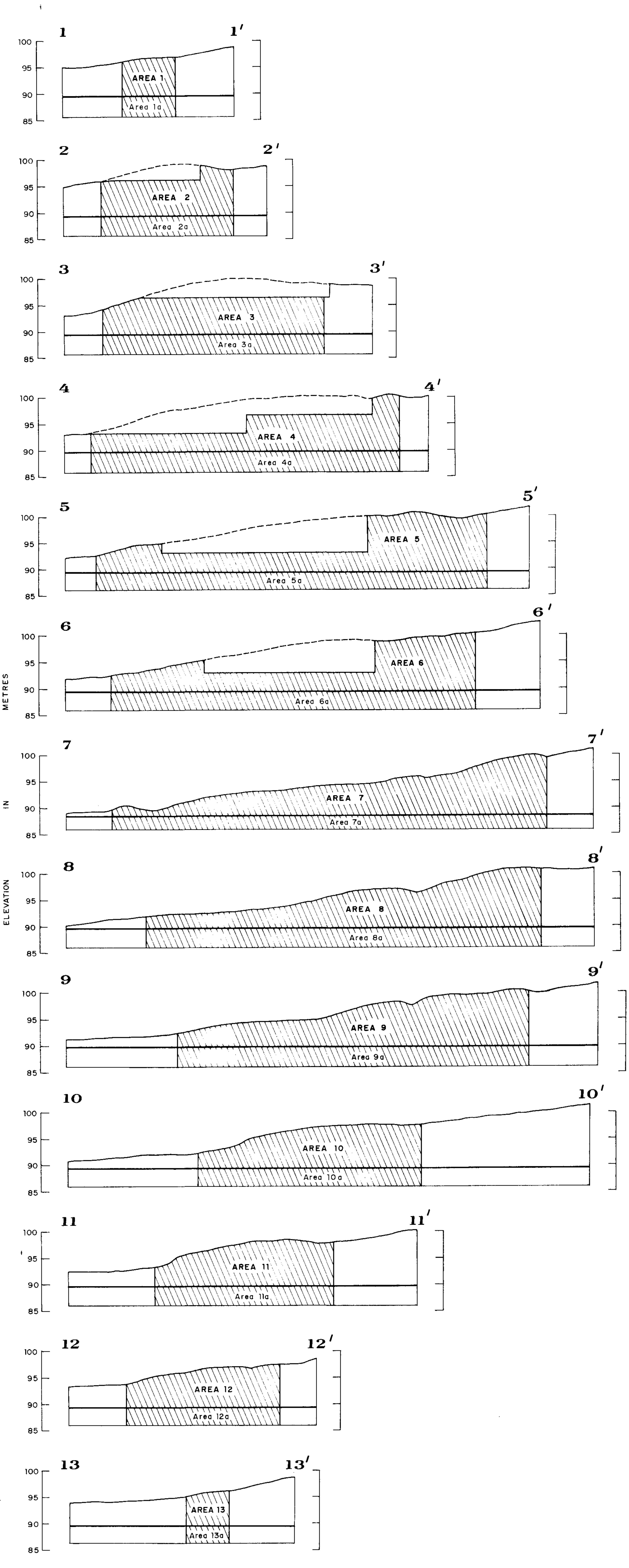
CALCA RED GRANITE DEPOSITS

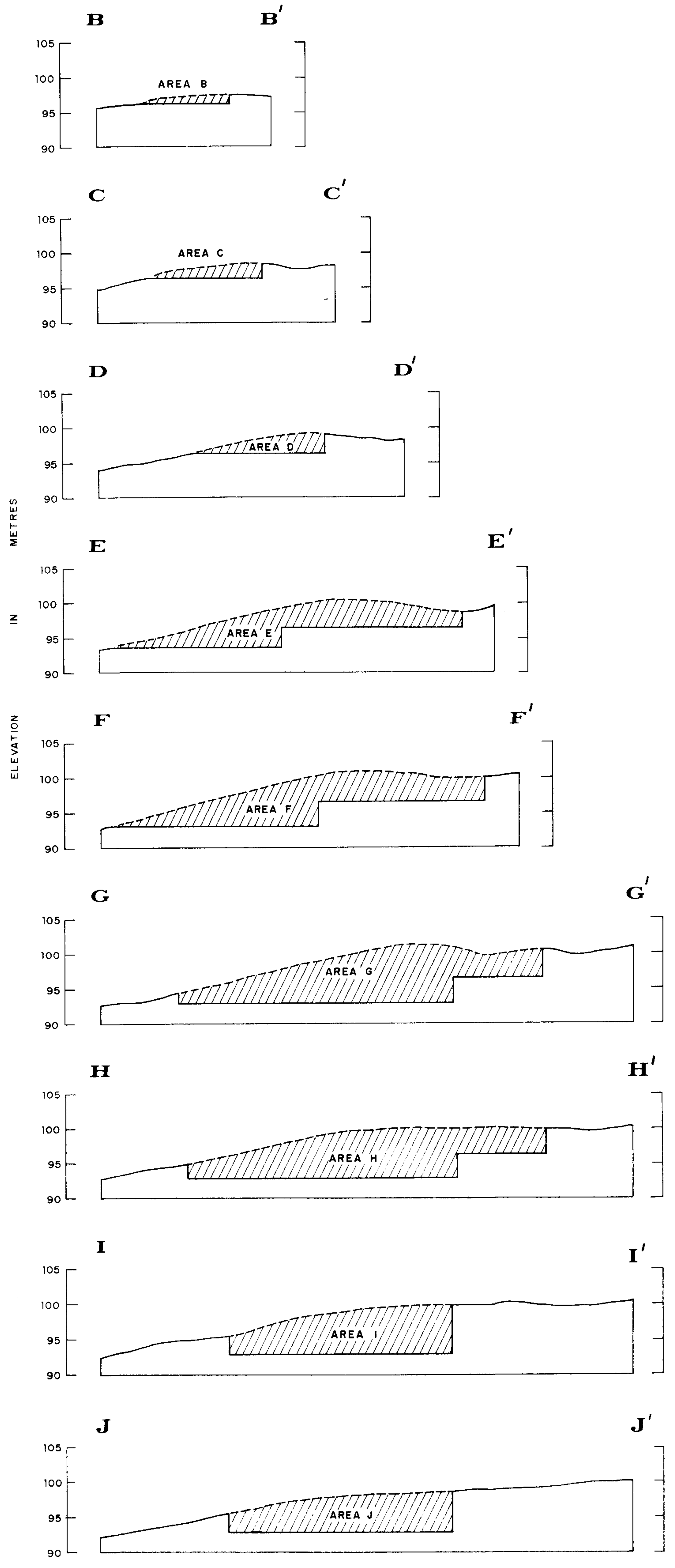
CALCA GRANITE QUARRY

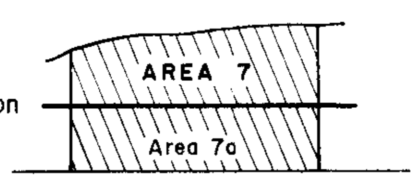
EML 4469 - GEOLOGICAL PLAN AND CROSS SECTION

COMPILED	L. C. B.	C.D.O. 19-5-87	DATE
DRAWN	M. B.	SCALE 1:500	
DATE	March '87	PLAN NUMBER	
CHECKED		86 - 440	

RESERVE CALCULATIONS







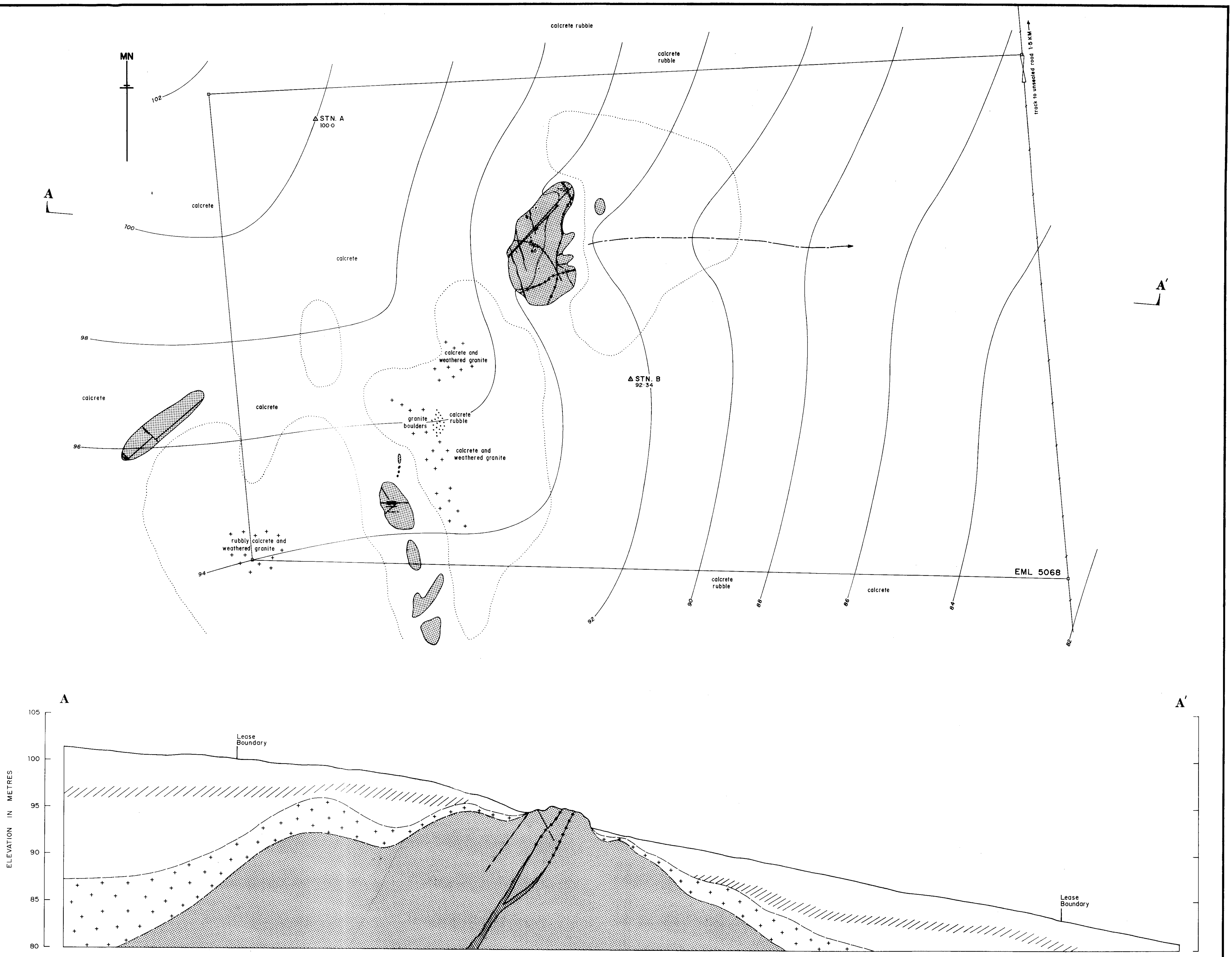
Reserves based on — AREA 7 to RL 89·5m; Area 7a below RL 89·5m

For location of sections, see Plan no. 86-440

Fig. 4

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED L.C.B.	C.D.O. 19.5.87 DATE
CALCA RED GRANITE DEPOSITS	DRAWN M.B.	SCALE As shown
'RESERVE CALCULATION' CROSS SECTIONS	DATE March '87 CHECKED	PLAN NUMBER 87-122

4173



Soil, calcrete rubble, clay and aeolinite. Minor weathered granite. Rubbly and sheet calcrete.

APLITE : Pale pink to brown aplite.

weathered / fresh — HILTABA SUITE GRANITE : Massive bright pink to red granite. Age = 1456 ± 26 Ma

Xenolith

Joint, dip not measured

Strike and dip of bedding

STN.A 100·0 — Survey Station, elevation in metres

Lease peg, boundary

Granite outcrop boundary

Limit of trees

—96— Contour, 2m interval, arbitrary 100 datum

A A' — Cross section

Stadia Survey by J. G. Olliver and A. J. Smith S. F. B. 701

Geology by D. A. Young and L. C. Barnes, 22-9-82

SCALE

0 10 20 30 40 50 METRES

Fig. 5

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED L. C. B.	C.D.O. 19·5·87 DATE
CALCA RED GRANITE DEPOSITS	DRAWN M. B.	SCALE 1 : 500
EML 5068, CALCA SOUTH DEPOSIT	DATE March '87	PLAN NUMBER
GEOLOGY AND CROSS SECTION A-A'	CHECKED	87-123

4173