DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPORT BOOK NO. 89/74
INDUSTRIAL AND NON METALLIC
MINERALS - OPERATIONS IN
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

BY

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MINERAL RESOURCES

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INDUSTRIAL AND NONMETALLIC MINERALS IN SOUTH AUSTRALIA

FOREWORD

Mineral resource development has been an important element in the growth and prosperity of South Australia since British settlement of the Colony in 1836. This was based initially on copper from Kapunda, Burra and the Moonta-Wallaroo mines during the period 1840 to 1920. Iron ore from the Middleback Ranges assumed dominant importance during the ensuing 50 years. Production of natural gas, crude oil, condensate and LPG from the Cooper Basin have been pre-eminent since 1970.

While perhaps less news-worthy, industrial minerals and non metallics have also assumed considerable economic importance in South Australia and provide raw material feedstocks for a range of important industrial applications.

Gypsum leases were first pegged at Lake Fowler in 1874; these deposits have provided a continuous source of supply since 1905. Talc was first produced form the Lipson deposits north west of Tumby Bay in 1909. Limestone was first quarried from Linwood for cement manufacture in 1892. Salt from lagoons on Kangaroo Island was first used by sealers as early as 1814; regular harvesting from salt lakes on southern Yorke Peninsula commenced in 1891.

In 1988, the ex-mine value of industrial and non metallic minerals in South Australia was $24.5 million. Barite, gypsum, salt and talc are exported interstate and overseas; other commodities are produced primarily for local consumption.

This report discusses mining and processing operations of the major non metallic and industral mineral commodities in South Australia and is expected to be of interest not only to those in the industry but also to manufacturers and suppliers of a range of machinery and processing equipment.

This report is the first of several volumes planned to cover aspects of the mineral industry in South Australia; others to follow include consideration of metallic minerals, construction materials and aggregates precious stones and coal.

R K JOHNS
DIRECTOR GENERAL
DEPARTMENT OF MINES AND ENERGY

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BARITE

In 1988, 9 840 tonnes were produced with an ex-mine value of $421 000; 100 tonnes of industrial grade with an FOB value of $26 700 were exported to New Zealand and South Africa.

About 90% of Australia's 1988 barite production was mined from South Australian deposits with the remainder from small and regular production from NSW. Deposits in WA have not been worked since 1982.

South Australia's principal deposits are:

- Oraparinna, 90 km by road NE of Hawker producing industrial grade barite and
- Dunbar (Linke's Lode) 75 km by road NE of Hawker, producing oil drilling grade barite.

Both are operated by Commercial Minerals Ltd. All barite is trucked to the company's mill at Quorn. Additional industrial grade ore is purchased from 5 smaller operations in the Flinders Ranges.

Oraparinna began production in 1940 and until 1976 was operated by South Australian Barytes Ltd. In 1981, all operations were acquired by Steetley Industries Ltd, which was taken over by Anglo American Pacific Ltd in 1984 and now trades as Commercial Minerals Ltd. Anglo American Pacific was acquired by Poseidon Ltd in 1988. In 1982 the mining method was changed from shrinkage stoping and adit haulage to leading stoping with the construction of a decline to provide access to deeper ore. 1988 production was 3 240 tonnes from an indicated resource of 140 000 tonnes.

After milling, the product is used as paper pigment, glass flux, and as a filler and extender in a wide range of manufactured goods including paint, paper, textiles, floor coverings, and brake linings. High purity barite is used medically in barium meals.

The Dunbar deposit was pegged originally in 1939; production commenced in 1962. Three operators worked the two deposits until acquisition by Steetley Industries Ltd in 1968 and 1982. The milled product is used as the weighting agent in drilling mud and demand fluctuates with the level of exploration and development in the oil industry. In 1988, 6 320 tonnes were mined from an indicated resource of 250 000 tonnes.

Annual barite production figures record only quantities trucked to the stockpiles at Quorn, and do not record sales of milled barite.

ORAPARINNA - COMMERCIAL MINERALS LTD

1. GENERAL

LOCATION	Oraparinna Mine (Bunkers Hill Mine), on Willow Springs Station, 35 km NE of Wilpena Pound, 160 km by road NE of Quorn (Fig. 1).
OPERATOR	Commercial Minerals Ltd
ADDRESSES	Local - Quorn 5 433 Tel. (086) 48 6053 (Mill) (086) 48 0032 (Mine). Head Office - 100 Eastern Pde, Gillman 5013 Tel. 47 5977.
MINERAL TENURE	MLs 2933-2936, 2996, 3235-3237, 4108, 4210, 5010

2. PRODUCTION

MINERAL PRODUCED	Barite ($BaSO_4$)
PRODUCT GRADE	4 level (McCallum, 1982)

	Sp. Gr.		% (Ba+Sr) SO_4		% SiO_2
	Range	Average	Range	Average	Average
1A Lode	4.24-4.41	4.34	97.9-98.5	98.3	0.38
1B Lode	-	4.40	-	97.7	0.45
1C Lode	4.28-4.40	4.36	94.6-98.4	97.2	1.43
Link Lode	-	4.37	-	96.3	0.90
Total	4.24-4.40	4.36	94.6-98.5	97.6	0.86

ANNUAL PRODUCTION (1988)	3 240 tonnes (Fig. 2)
RESERVES	Total potential ore above 4 level (RL 409 m) 20 400 tonnes in pillars and small blocks most of which is difficult to mine. Total potential ore below 4 level down to RL 333 m.

1A Lode	60 100
1B Lode	9 000
1C Lode	66 100
Link Lode	6 000
Total	141 200 tonnes (McCallum, 1982)

PRODUCT USES	White pigment in paper, flux in glass manufacture, filler and extender in rubber paint, paper, textiles, linoleum, brake linings etc; drilling mud. Highest grade used in barium meals.
DESTINATIONS	Throughout Australia. Also New Zealand, South Africa.
WORKFORCE	Mine 3 Mill 5

3. HISTORY

The following is based on the detailed account in McCallum (1982). First recorded production was in early 1940 by J. Tobin, followed by the Sturts Meadows Prospecting Syndicate in 1940-43 and by the Blinman Barytes Co in 1944. Output until 1945 was from open cutting the top of the hill. The Blinman Barytes Co changed its name to South Australian Barytes Ltd. in 1946, and operated the mine until 1976.

Driving commenced on 1 and 2 levels (RL 505m and 477m) in 1948. By 1950, open cutting had reached 1 level which by 1957 was inaccessible underground. The Quorn mill was built in 1957 with assistance from the S.A. government to treat dumps and lower grade ore. 3 level adit (R.L. 433 m) was commenced in 1962. Underground mining continued through the sixties and open cutting was again practised above No. 2 level between 1968 and 1973, ore being tipped down a chute to a loading platform located 15 m above No. 3 level adit. A large collapse partially blocked 2 and 3 levels in 1972, by which time development of 4 level (RL 409 m) had begun.

The increase in demand for oil drilling grade in the late 1960's slackened in 1971 and SABAR was placed in receivership in 1973. The mine and other assets were acquired by Australian Barytes Pty Ltd in 1977. All Oraparinna leases were sold to Steetley Industries Ltd in 1981.

Between 1978 and 1979 ore was won by robbing pillars. Underground work ceased at No. 1 Lode system in 1981 when work commenced on a new declined adit, and production was from Roberts Lode 500 m northeast of the main mine, until 1982. This decline, 400 m long 4.6 m wide by 4 m high and at a slope of 1 in 7, was completed at 371.9 m RL in late 1982.

The principal mining method used until 1981 at No. 1 Lode system was shrinkage stoping, whereby ore was used as a working floor to enable mining to proceed upwards. The ore was then removed to No. 3 level through ore chutes or hauled up a winze from No. 4 level and railed out through 3 level adit in 2 tonne, side tipper mine cars towed by 1½ tonne battery locomotives. By May 1982, the decline had advanced sufficiently to enable adoption of the new mining method.

Steetley was taken over by Anglo American Pacific Ltd in 1984 and now trades as Commercial Minerals Ltd. Anglo American Pacific Ltd was acquired by Poseidon Ltd in 1988.

4. GEOLOGY

The Oraparinna barite lodes, as described by McCallum (1982), lie within folded and faulted Wilpena Group sediments in the Bunkers Graben, a fault-bounded, cone shaped basin, structurally controlled by the Oraparinna Diapir. The host rock is the Bayley Range Siltstone Member, a sequence of siltstone, sandstone and shale near the top of the Brachina Formation of Marinoan age, which intertongues with the overlying ABC Range Quartzite. The barite veins have developed in tensional fractures on the axis of a northerly-plunging syncline, which approximates the central axis of the graben. Lode thickness averages 1-2.5 m with lode length up to 250 m. Barite has infilled and replaced breccia and has subsequently been deformed and moved along shears.

Economic barite has been mined out in all lode systems except No. 1 Lode at the Oraparinna Mine. The No. 1 lode system comprises, from west to east, 1A, 1B and 1C lodes, which strike north-northeast to north-northwest and dip vertically to steeply east, and Link Lode which strikes northwest and dips 55 degrees northeast between 1A and 1C lodes.

5. OPERATIONS

Cross cuts from the decline and drives on ore have been established at levels 5 to 7 in the interval RL 400 - 375 m.

Ore is extracted by leading stoping, the wall rocks being supported with rock bolts. A Wagner ST1.3 load, haul, dump (LHD) scoop-mobile is used in the drives, following drilling and blasting of 1.8 m holes. Ore or mullock is dumped in a cross cut, where it is picked up by a W60 Komatsu front end loader and dumped into a Volvo BM861 20 tonne dump truck which carts it out along the decline to stockpiles or mullock dumps.

The ore is loaded by front end loader, onto a 50 tonne road train and hauled to the treatment plant at Quorn.

6. MILLING

Milling operations (Fig. 3) have been updated from the description in McCallum (1982). Stockpiled ore is fed by front end loader into the feed hopper of a single toggle 0.5x0.7 m Jaques jaw crusher. Crusher product is conveyed to a double deck 2.4x1.2 m vibrating screen (top deck 25 mm, bottom deck 8 mm). Screen oversize is fed via conveyor belt to a secondary 0.7 mm gyratory cone crusher in closed circuit with the screen. Screen undersize is elevated to a distributor conveyor above a storage bin which is split into three 200 tonne capacity compartments, storing the -8+3.2 mm, -3.2+2.5 mm, and -2.5 mm fractions.

The bin is discharged by plate feeders, and the +2.5 mm and +3.2 mm fractions are conveyed via conveyor belt and screen elevator to a 2.1 x 0.76 m May double sided jig. The barite and shale contaminants are agitated in a water container in which the shale flows to the surface. Barite settles through a screen (8 mm mesh) while shale remains above the screen, and is removed by water flowing across the top.

Barite concentrate, i.e. the underflow from the jig, flows to two dewatering screws. Jig overflow is conveyed to a 0.46 mm wet cyclone, then to tails stockpiled outside the plant building. This material is recycled to the plant when low grade (oil drilling) run is carried out.

Overflow of barite concentrate from the two dewatering screws is removed by conveyor for stockpiling and draining outside the building prior to feeding to a dry grinding plant. Underflow from the dewatering screws contains dilute slimes and is pumped to the adjacent tailings pond. Water from this pond is recycled to the jigs.

The -2.5 mm fraction from the three storage bins is conveyed to two Wilfley tables. The fine barite and shale, together with water, is passed over shallow sloping vibrating decks in which the heavier barite drifts further down the slope grading upwards into shale with no barite. The barite concentrate from the two tables then passes to a dewatering screw, underflow from which flows to a tailings dam, and overflow (barite concentrate) is removed by conveyor belt to the concentrate stockpile. The tailings (shale and some barite) from the Wilfley tables is conveyed, together with the tailings from the May double jig to the tails stockpiled via the wet cyclone.

Material from the concentrate stockpile, which has been allowed to drain, is picked up by front end loader and loaded into the feed hopper of the dry grinding plant. The concentrate passes via a conveyor belt and surge bin into the burner and roller mill via a pneumatic feeder. The oil burner operates at 200°C to remove excess moisture and the dried barite is ground to specifications in the roller mill. The mill operates in closed circuit with a 1.2m dry cyclone classifier, overflow from which forms the barite concentrate, and underflow is fed back into the burner and mill. The pneumatic feeder regulates the quantity of barite entering the burner and mill by monitoring the volume of product passing through the cyclone classifier.

Barite concentrate from the dry cyclone classifier passes to a 10 cyclone filter system, which prevents excessive dust output. Underflow from the cyclone classifier is collected in a storage hopper then fed to a bagging machine for packaging into 40kg (industrial grades) and 50kg (oil drilling grade) multiwall paper bags or into 2 tonne bulker bags.

Grade control at the plant is achieved in several ways. Truck loads of barite from Oraparinna and other mines in the Flinders Ranges are assessed visually by the plant manager for potential grade and stockpiled separately. Input grade of ore to the plant can be controlled by selecting and mixing from stockpiles. Output from the Wilfley tables can be adjusted by varying water flow, table slope, and draw off point for concentrate and tailings. However, higher grade concentrate causes more barite to be lost in the tailings. Output from the May double jig is adjusted, by varying the agitation and water flow, with a similar relationship between barite concentration and loss.

An electro reflectance photometer is installed in the mine office and brightness is measured on selected samples of all industrial grades produced. Specific gravity is measured on selected oil drilling grade samples. There is no chemical testing carried out at the plant.

The following results of physical tests were for barite marketed in 1980 (McCallum, 1982).

Barite Grade	Brightness R457	Yellowness R57-R457	Specific Gravity
A Grade	75.3	7.1	4.36
Standard	75.2	9.3	4.35
B Grade	71.3	10.7	4.34
C Grade	58.0	15.1	4.13
Oil Drilling	46.6	18.2	4.35

The Quorn plant processes ore from Dunbar and other smaller Flinders Ranges deposits in addition to that from Oraparinna. Barite ore is also sent to Gillman for milling when increased production of oil drilling grade is required.

Bagged barite is despatched by road to Adelaide for local use, for export and for shipment to Bass Strait. Some product is exported directly from Port Pirie. Barite for N.T., Qld., NSW and other SA markets is sent direct, by road, from Quorn. In 1987, 23 tonnes was exported to New Zealand and 61 tonnes to South Africa.

LINKE'S LODE - COMMERCIAL MINERALS LTD

1. GENERAL

LOCATION	Linkes Lode (Dunbar deposit) about 22 km northeast of Wilpena 140 km by road NE of Quorn (Fig. 1).
OPERATOR	David Linke Contractor Pty Ltd for Commercial Minerals Ltd
ADDRESSES	Local - Quorn Mill, 5433. Tel. (086) 486053; (086) 480070 (Mine). Head Office - 100 Eastern Parade, Gillman, 5013. Tel. 475 977
MINERAL TENURE	MLs 3413, 3414

2. PRODUCTION

MINERAL PRODUCED	Barite
PRODUCT GRADE	Typical 93% $(Ba+Sr)SO_4$, 2% SiO_2, 3.5 - 7% Fe_2O_3, S.G.4.2. ie oil drilling grade on beneficiation.
ANNUAL PRODUCTION (1988)	6 320 tonnes (Fig. 4)
RESERVES	West of road (ML 3414) 54 600 tonnes probable, 151 200 tonnes possible East of road (ML 3413) 27 720 tonnes probable, 17 640 tonnes possible
PRODUCT USES	Oil drilling mud.
DESTINATIONS	Quorn for milling. Then Bass Strait, Cooper Basin etc. Also New Zealand.
WORKFORCE	4 part-time contractors.

3. HISTORY

The lodes were pegged originally in 1939 and tenure was held intermittently until 1950. Tenure was resumed, and production commenced, in 1962 from separate mining operations to the east and west of the Martins Well Road. To the west, the lode was worked by W.M. Sharp until 1968, when Steetley Australasia Pty Ltd acquired the operation (Scott, 1979b). The eastern deposit was worked by Heppner and Kuchel until 1968, when it was taken over by Universal Milling (S.A.) Pty Ltd, who sold to Steetley Industries Ltd in 1982 (Scott, 1979a).

Steetley was taken over by Anglo American Pacific Ltd in 1984 and now trades as Commercial Minerals Ltd. Anglo American Pacific Ltd was acquired by Poseidon Ltd in 1988.

4. GEOLOGY

The barite lode is in an east-west fault zone within the Oraparinna diapir. The lode is enclosed within a "raft" of siltstone of Tapley Hill Formation within Precambrian Umberatana Group, and barite formed by precipitation from solutions rich in sulphate and barium.

Scott (1979 a, b) describes the lode as a sub-parallel vein system up to 35 m wide extending east - west for about 250 m on either side of the road, diminishing into stringers and pods beyond the lease boundaries. The barite lode has a sharp footwall contact which dips 68-75 degrees southwards. Individual veins show variable dip but are generally sub-parallel to the footwall contact. The hanging wall is a breccia of dolomite, dolerite, marble, feldspathic sandstone and shale in a micaceous, siliceous dolomitic matrix which lies between Tapley Hill Formation and diapiric rocks. Calcareous veins are a common feature of the breccia and siderite veins with disseminated barite are found occasionally.

Barite veins contain about 25% inclusions of country rock and lenticular limonitic and goethitic zones, together with minor disseminated chalcopyrite.

5. OPERATIONS

Deposits are worked by open cut methods. Country rock above the hanging wall is removed by blasting and carted to a large overburden dump to the south of the leases. The barite is then loosened and brought down with a hydraulic rock pick and either stockpiled or loaded directly with a front end loader for transport to the mill at Quorn.

McCallum, W.S., 1982. Oraparinna Barite Deposits Geological Investigations at the Oraparinna (Bunker Hill) Mine Co. Taunton, Flinders Ranges. *South Australia. Department of Mines and Energy. Unpublished Report,* 82/52.

Scott, D.C., 1979a. Universal Milling (S.A.) Barite Deposit - Linke's Lode, Flinders Ranges ML3413. Co. Taunton. *South Australia. Department of Mines and Energy. Unpublished Report,* 79/46.

Scott, D.C., 1979b. Steetley's Barite Deposit - Linke's Lode, Flinders Ranges ML 3414 Co. Taunton. *South Australia. Department of Mines and Energy. Unpublished Report,* 79/98.

Thynne, D.S., 1985. Dunbar Barite Deposit (Linke's Lode). Results of a diamond drillhole programme on ML 3414. Geological report 24/85, for Commercial Minerals Ltd. South Australia. Department of Mines and Energy. Confidential Envelope 6527 (unpublished).

Thynne, D.S., 1986. Oraparinna Barite Mine - No. 5, 6 and 7 levels. Geological Mapping and comments on ore reserves. Geological Report 3/86, for Commercial Minerals Ltd. South Australia, Department of Mines and Energy. Confidential Envelope 6527 (unpublished).

DIMENSION STONE

Granite and Limestone

In 1988, 23 000 tonnes of granite, norite and sawn limestone with an ex-mine value of 1.87 million dollars were produced, of which about 80% was trucked interstate. South Australia supplies about 25% of Australian output; Western Australia, Victoria and New South are the other major sources.

90% of South Australian production is quarried at

- Calca on Eyre Peninsula near Streaky Bay (granite)
- Black Hill northeast of Mannum (norite)
- Mt Gambier (bryozoal limestone)

In addition, smaller scale granite quarries are worked near Sedan and Kingston (SE), and small tonnes of sandstone are cut from quarries in the Adelaide Hills and Mid-North.

Limestone at Mt Gambier is soft, porous and easily cut; its use as building blocks (ashlars) dates from 1844. Quarries were worked mainly by hand until power sawing began around 1919. The mining method has remained basically unchanged since the introduction of portable, self-propelled saws in 1950. Markets were temporarily boosted after WWII, when Government transport subsidies made Gambier Limestone competitive during a shortage of building materials in Adelaide. Currently, about half of the production is used for local house construction and the remainder trucked interstate. Only very small amounts are used in Adelaide. In 1988, six quarries produced 13 000 tonnes valued at $318 000 ex-mine.

Norite, also known as 'black granite', is a variety of gabbro, a coarse-grained, dark-coloured igneous rock, and is distinguished from other gabbros by the composition of its pyroxene minerals. First recorded production in the Black Hill area was in 1947. Martin's quarry began production in 1957 and Monier commenced quarrying in 1965 after a takeover of Tillett Masonry Ltd's operation. In 1988, 6 270 tonnes were produced from these quarries. R J Tillett has operated the Calca granite quarry since 1975. 1988 production totalled 3 640 tonnes.

Norite and granite are sawn and used as polished slabs and tiles for cladding, paving and monumental purposes and, to a lesser extent, as small cubic paving blocks. Total 1988 production of 10 000 tonnes was valued at $1.56 million ex-mine; 10-20% is used locally, mainly as polished slabs and the rest is trucked interstate either direct from the quarries or after polishing. Polished tiles and quarried blocks are exported to Asian countries.

Slate

A major component of Australian slate mining activity is located in South Australia. In 1988, recorded production of slate was 10 400 tonnes valued at $1.40m of which about 20% was sold interstate. All production is from deposits in the Adelaide Geosyncline, within which significant potential exists for further exploration and development.

Almost 90% of South Australian slate production is quarried at 4 locations:

- Mintaro, near Clare
- Jones Hill, 100 km northeast of Leigh Creek
- Wistow, 50 km southeast of Adelaide
- Kanmantoo, 50 km southeast of Adelaide

The remainder is obtained from seven smaller operations.

Australia's only significant deposits of roofing slate were opened in 1840 at Willunga, 50 km south of Adelaide. Economic depressions and the development of cheaper roofing materials led to cessation of roofing slate production, and only small quantities of walling and paving stone have been produced since 1949.

Production of paving slate began at Mintaro in 1856 and is Australia's oldest continuously operated quarry. Early use was mainly in tanks, vats, troughs and sills, but in the late 1890s slate was widely used for street paving material, particularly in Adelaide and Melbourne. The most notable use of Mintaro slate however has been as high quality billiard table tops. 1988 production totalled 1 550 tonnes.

Quarrying at Kanmantoo for house and fence construction began around 1900, but full time operations were not commenced until 1978. Operations at nearby Wistow began in 1963. 1988 production of walling and paving slate was 3 760 and 2 350 tonnes respectively.

Production of paving slate at Jones Hill commenced in 1976. In 1988, 1 048 tonnes were produced.

MOUNT GAMBIER - (SEVEN PRODUCERS)

1. GENERAL

LOCATION	Marte; 10 km west of Mt. Gambier (Fig. 5)
OPERATORS	See Table
ADDRESSES	See Table
MINERAL TENURE	See Table

2. PRODUCTION

MATERIAL MINED	Bryozoal limestone (calcarenite)
PRODUCT GRADE	There are no formal specifications for Australian building stone. The Mt. Gambier market requires the following properties for first grade ashlars: brilliant white; massive; of even medium grain; low bulk density; good coherent strength; non-fretting. Ashlars are normally produced at 660 x 290 mm and in thicknesses of 100 and 115 mm and then from 125 to 400 mm in 25 mm increments.
ANNUAL PRODUCTION	See Table and Fig. 6.
RESERVES	Reserves determination is prevented by a lack of borehole and groundwater information. (Flint 1988). Production of top quality ashlars is considered to be sustainable at present levels for many years.
PRODUCT USES	As ashlars and special sizes for house construction, walls, foundations, sculpturing.
DESTINATIONS	Local, central and western Victoria, Adelaide, Melbourne, Canberra, Sydney.
WORKFORCE	See Table

OPERATOR	ADDRESS	PRODUCTION (Tonnes, 1988)	MINERAL TENURE	WORKFORCE
R.L. Butler	1 Sutton Ave, Mt Gambier Tel. (087) 251691	900	PM 9	1
Bruhn Distributors	P.O. Box 412, Mt Gambier (087) 255333	2920	PM 15, PM 14	5 quarry 2 factory
Lorbar Nominees	"	3460	PM 153	
Limestone Products	P.O. Box 179, Mt Gambier Tel: Quarry (087) 399212 a.h. (087) 268328	1450	PM 115	3
A. Treffers	P.O. Box 1989, Mt Gambier	Not known	PM 132	Not Known
G.J. & B.J. Stafford D.J. & S.J. Earl	P.O. Box 943, Mt. Gambier Tel. (087) 399294, or 250084	2500	PM 125	2 part time
R.M. & J. Lawson	108 Jubilee Highway East, Mt Gambier Tel (087) 251292	1900	PM 134	1

3. HISTORY

Early quarrying, building and production methods are discussed in Mansfield (1961) and reviewed by Flint (1988). Limestone has been used for building since the earliest settlement of the South East of S.A., and production extends back at least to 1844. The oldest known limestone building (demolished in 1985), was the Sisters of Mercy Convent in Commercial St. East, built in 1856-57. Stone was won from quarries to the north of Mt. Gambier until about 1910 when high quality limestone was discovered near Marte, and the older quarries were gradually phased out.

Blocks were originally cut using single-handed cross-cut saws, and then wedged free of the quarry face as 1.5 x 1.2 x the full height of the quarry which could be as much as 6 m. The blocks were then sawn into 1.5 m cubes, or ashlars, by hand or by circular saws. It was then common practice to leave cutting of ashlars until the blocks were on the building sites. The first sawing plant was erected by Knight and Pritchard in about 1919 adjacent to the railway line near Marte, and consisted of a six-bladed gang saw with each blade separated by the width of an ashlar. From 1947, 2 h.p. petrol-driven reciprocating saws were used in the quarries to make the vertical cuts.

In 1950, experiments with a wire saw yielded promising results, but quarry operators were unimpressed by the high capital cost, and viewed more favourably the portable, later self propelled, 3-4 h.p. mechanical saws being developed at the same time by Ivan Ploenges. These revolutionised the industry, the basic mining method having remained virtually unchanged since 1950.

4. GEOLOGY

Tertiary sedimentation stratigraphy and petrology within the Gambier Embayment have been described by Flint (1988) beginning with the terrestrial and marginal marine coarse sand and carbonaceous clay of the Dilwyn Formation. Bryozoal colonies provided the source for the calcirudite, calcarenite, calcisiltite and marl of the Gambier Limestone which blanketed the terrestrial sediments during an Eocene-Miocene transgression. The base of the Gambier Limestone is marked by the Compton Conglomerate, a thin, locally conglomeratic, limonite cemented sand which overlies the carbonaceous clastics of the Dilwyn Formation with angular unconformity. Gambier Limestone sedimentation was terminated in the Middle Miocene by uplift and erosion.

Centres of Plio-Pleistocene volcanism in the Mount Burr Range have similar alignment to that of joints in the Gambier Limestone. Subsequent tectonic uplift and eustatic oscillations of sea level produced stranded barrier dunes, sub parallel to the modern day coast. One of these crosses the Marte area hindering quarry development by creating a greater thickness of overburden. A second volcanic phase which produced the Mt. Gambier and Mt. Schank vents is of Holocene age.

The Gambier Limestone ranges from a few metres thick along the northern margin of the Gambier Embayment to greater than 300 m along the coast. Three zones have been recognised viz: upper grey cherty zone, middle cream zone, and lower grey zone. The Marte quarries are sited within the middle zone comprising massive highly permeable bryozoal calcrenite with few chert bands. The middle zone is tens of metres thick but access is limited by a locally steep water table gradient. Best quality building stone comprises coarse grained skeletal material coated and cemented by calcite or dolomite. The calcarenite at Marte is massive and bedding is rarely seen. Regional dips vary from 1-3° southeast to southwest.

Overburden comprises red brown to grey sandy soil often humus-rich near the surface and frequently becoming clayey at the base due to leaching of clay through the soil profile. Iron is also leached and stains the upper weathered limestone zone. Dissolution of limestone has produced a variety of small solution features in the limestone surface. Total overburden thickness varies from 1.5 - 8 m.

5. OPERATIONS

Quarrying

Mining, depicted in Flint (1988), begins by stripping topsoil to expose weathered limestone. This is then ripped and if free of clay pockets can be crushed to produce agricultural lime or whiting. Dirty overburden is sometimes sold as road rubble. Removal of limestone blocks is then carried out using carbide-tipped circular saws. The top surface of the fresh bryozoal limestone is first levelled. This is accomplished by setting up a steel and wooden bridge above the area to be cut, levelling with a spirit level, and then using the bridge as a guide for a horizontally - rotating circular saw. A face is prepared with the self propelled vertical saw and this face is then used as a guide for vertical saw to cross-cut the quarry at spacing corresponding to the length of an ashlar (660 mm). Subsequent cuts are used in turn to guide the saw. A longitudinal working face is then established and undercut at the ashlar height (290 mm) using the hand-propelled horizontal saw. Wedges are inserted under each block. The ashlars are then cut longitudinally at the required thickness (100, 115 or 125 mm for housing) using the vertical cut saw guided by the working face. The wedges prevent the ashlars from moving and breaking irregularly during sawing. Ashlar orientation in the ground is maintained in walls, ie ashlars are laid on the 660 x 100 mm face with the 660 x 295 mm face exposed and bedding horizontal. The ashlars are then stacked on pallets to harden, whiten and lighten as a result of drying which takes 7-10 days. One quarry (Bruhn) produces blocks for subsequent cutting and rock facing of ashlars in a Mt Gambier factory. These are produced such that the rock faced surface is parallel to the bedding, and ashlars are laid with the bedding plane vertical.

Markets

Markets were mainly local, in western Victoria and Melbourne until after WWII when a building boom led to a shortage of building materials which, together with Government transport subsidies, made Gambier Limestone viable in the Adelaide market. The State Government built a railway siding at Marte, and in the early 1950s, 1/3 of all metropolitan houses built by the S.A. Housing Trust were of Gambier Limestone. Removal of the transport concessions and competition from concrete brick and block led to a decline in usage in Adelaide (Mansfield, 1961).

About 50% of current production is used for local house construction and the remainder is trucked interstate, where the greatest demand is for rock-faced stone. The main interstate market is in the country areas of Central and western Victoria, particularly on Mornington Peninsula south of Melbourne. Other markets are served in Adelaide, Melbourne, Canberra and Sydney.

CALCA - CALCA GRANITE PTY LTD

1. GENERAL

LOCATION	Calca, western Eyre Peninsula, 35 km southeast of Streaky Bay (Fig. 5)
OPERATOR	R.J. Tillett operating as Calca Granite Pty Ltd (on sublease from Amatek Ltd) at main quarry and as Calca Quarries for the southern quarry. Amatek are developing a quarry adjacent and to the SE of Tillett's main quarry. All data presented herein relate only to the major operations by Calca Granite and Calca Quarries.
ADDRESS	Quarry - P.O. Box 10 Streaky Bay, 5680 Tel. (086) 261087
MINERAL TENURE	EML 4469 (Main quarry area) EML 5068 (Southern quarry) EML 5501 (Amatek's quarry)

2. PRODUCTION

MATERIAL PRODUCED	Granite
PRODUCT GRADE	Attractive hard, durable red stone of uniform colour and texture which takes an excellent polish.
ANNUAL PRODUCTION (1987)	3640 tonnes dimension stone 195 tonnes rip rap and spalls (Fig. 7)
RESERVES	50 000 tonnes (19000 M^3 - indicated recoverable reserves down to RL89.5 m). More by deepening and widening quarry and from other nearby deposits. (Barnes and Young, 1987)
PRODUCT USES	Decorative cladding, monumental stone, frame - sawn and sett paving, special orders (eg. table tops, bollards, steps etc)

DESTINATIONS	(Approx) 80% - Granites of Australia, Canberra; 10% - Tillett, Brompton; 10% Melbourne, Brisbane and NSW for monumental use.
WORKFORCE	4-8 depending on market. Normally work 8.30 am - 5 pm, 5 days per week. 6-7 days per week if market warrants.

3. HISTORY

Exploration and tenement history is described in Barnes and Young (1987). Samples of coarse grained, red granite were collected on western Eyre Peninsula in 1974, by the Regional geology Division of SADME. The samples were polished and examined by Monier Ltd and found suitable to replace imported red granite.

The announcement of the discovery of potentially suitable red granite deposits led to the perception among conservationists of a threat to prominent granite inselbergs. The search for a relatively unweathered deposit continued, and Calca was selected as an environmentally suitable site.

Monier Ltd and R.J. Tillet pegged and registered claims in July 1974 and November 1974, respectively. A dispute by Monier (now Amatek) relating to overpegging was settled in 1975 with transfer of Tillett's lease to Monier.

Operations by Tillett began in April 1975 under a sub-letting agreement. The initial bench was developed at RL96.5 m on the western side of the main outcrop. A larger claim, superimposing the existing lease, was pegged by Monier in February 1987 in order to cope with increased waste and equipment storage for the expanding quarry.

In 1987, control of Monier Ltd was divided between the major shareholders, Redland and Equiticorp Tasman. The Monier name was reserved to the roof tile aspect of operations, now controlled by Monier-Redland Ltd, a UK-based company. The sand, clay and dimension stone operations became the province of Equiticorp Holdings, the industrial division of Feltrax International Ltd. These operations have traded under the name Amatek Ltd since July 1988.

Operations at the southern deposit began in May 1988.

4. GEOLOGY

Oldest basement rocks in the area comprise Archaean to Middle Proterozoic metamorphics, volcanics and granite of the Gawler Craton. The last of a number of major deformations, the Kimban orogeny, produced the foliated granite exposed on the coast west of Calca. Feldspar porphyry and rhyolite of the younger Gawler Range Volcanics, are quarried east-northeast of Calca and porphyritic granite of similar age crops out at Calca Hill and Calca Bluff to the west.

The building stone quarried at Calca is red granite of the Hiltaba Suite which intrudes the Gawler Range Volcanics in the region extending for 32 km between Cape Labatt in the west to Snaglee Rock in the east (Barnes and Young, 1987). The basement rocks are generally overlain by calcrete and aeolian calcarenite of the Bridgewater Formation. Localised younger sediments comprise Pleistocene colluvial granitic clay and gravel, aeolian and lacustrine gypsum deposits (Yamba Formation), aeolian sand of inland vegetated dunes (Moornaba Sand) and modern beach and dune deposits (Semaphore Sand and St Kilda Sand).

The Calca quarry is on the western end of a low whaleback protruding about 5 m above the aeolianite. The granite is pink-red to pale brownish red and averages 20-45% quartz, 50-70% feldspar and up to 2% chloritised biotite with accessory fluorite, epidote, apatite, zircon, allanite and opaques. Texture is equigranular to slightly porphyritic, and hypidiomorphic. The feldspar is mostly perthitic microcline with minor discrete plagioclase. The feldspars are pink or red, due to fine haematite inclusions or brownish where this has been altered to goethite. Planar joints, aplite veins and planes of chloritised biotite ("dark lines") are responsible for stone wastage. Xenoliths and exfoliation joints are not common.

A lease at Calca South 1 km south-southwest of the main quarry contains mineralogically and texturally similar granite but with more abundant xenoliths.

5. OPERATIONS

Quarrying

A three-bench quarry about 50 x 50 m has been established and all quarrying is in blocks 10 x 10 x 3 m high. These are separated from the main body of granite using a flame (jet) cutting torch, consisting of a hand-held annular lance. An oxy-acetylene probe is inserted down the centre of the lance, and diesel fuel is fed in, up to a rate of 60 litres/hour as the probe is slowly withdrawn. Air is fed down the annulus at 8.5 m^3/min and introduced to the central fuel stream through holes near the tip of the lance. The burner cuts channels about 150 mm wide and 3-4 m deep and operates at an angle within the angled cut, supported by the cushion of the air blast. The high temperature flame disintegrates the granite into coarse sand by differential expansion and decrepitation. The hot, exfoliated fragments are air-blasted free of the cuts, leaving the block separated from the main mass on three sides. One block takes 3-4 weeks to complete and comprises about 3 months' supply. Other quarry operations are substantially restricted during jet cutting due to scattering of hot dust and rock fragments. The block is then undercut with 50 mm diameter horizontal drillholes at about 150 mm centres. Every second hole is packed with black powder and detonated electrically, loosening the block in the horizontal plane. The depth of undercutting ranges between about 5-9 m to enable more even distribution of the charges.

The block is then vertically line-drilled at 150 mm centres about 1 m back from the face to the full depth of the block. About every sixth hole is bigger to allow insertion of wedges for splitting. These are 0.5 m long and are driven evenly and gradually with a jackhammer. The slab (about 10 m x 3 m x 1 m) is then jacked away from the block and pulled over onto a bed of old tyres. Each slab takes about a day to separate from the block and weighs approximately 130 tonnes. Dust is fed to a dust extractor. The slab is then further line-drilled into marketable blocks weighing 7-11 tonnes; jointed, xenolithic or aplitic granite is rejected at this stage. The blocks are most commonly 3 x 1 x (1-1.2) m, although the Sydney monumental market requires 3 x 1 x 0.8 m. Two Ingersoll Rand compressors operating in series supply air at 2000 c.ft./min to the drills. Lifting and stockpiling of blocks is accomplished using a 15 tonne tracked crane (which can lift 70 tonne close to the work area) and a Terex V12 wheeled loader with a 10 c.yd. bucket. The cut blocks are trucked to customers for further cutting and polishing.

Overburden was removed at the southern deposit prior to jet cutting which began late 1988.

Markets

About 80% of production is trucked to Granites of Australia (now owned by Boral through Melocco Ltd.) in Canberra for sawing and polishing for the eastern States' markets, where the material is in demand for building and paving (Opera House, Parliament House, Pitt St. Mall, Brisbane Commonwealth Bank). About 10% is trucked to S.D. Tillett, Brompton for the Adelaide market; Amatek and Martins are supplied by S.D. Tillett. The remainder is sent direct to monumental stone markets in Melbourne, Brisbane and N.S.W. A trial parcel of 2 container loads each containing twenty by eleven tonne blocks has been shipped to Asia. Should entry into this market be successful, opening of the Calca South deposit is planned to cater for the anticipated increased production of 30 blocks per month over a 2 year period. This would have the added benefit of being able to alternate the jet cutting between the two deposits, thereby removing the necessity to temporarily suspend operations while the torch is operating.

BLACK HILL - AMATEK LTD

1. GENERAL

LOCATION	Black Hill, 5 km north of the township, 85 km east-northeast of Adelaide (Fig. 5)
OPERATOR	Amatek Ltd
ADDRESSES	Head Office and Factory-Baulderstone Rd, Gepps Cross 5094 Tel. 2625622 Quarry - C/- P.O. Black Hill 5353 Tel. (085) 608076
MINERAL TENURE	EML 3223, 3360, 4383

2. PRODUCTION

MATERIAL PRODUCED	Norite, otherwise known as Imperial Black Granite, Royal Black Granite
PRODUCT GRADE	Durable, decorative black stone which takes a high polish
ANNUAL PRODUCTION (1988)	4210 tonnes (Fig. 8)
RESERVES	Not defined, but ample for many decades in view of the large areal extent of the intrusive
PRODUCT USES	Decorative cladding, monumental stone, paving stone.
DESTINATIONS	Adelaide, Melbourne, Canberra, Sydney Perth.
WORKFORCE	Quarry : 10-12 plus 4 splitters Factory : 23 plus 3 managerial

3. HISTORY

First production in the area was recorded in 1947 by J.B.L. Shelton initially by splitting of outcropping boulders. This operation was transferred to J. Swain and Sons in 1957. Tillett Masonry Ltd began production in 1962 and was taken over by Monier in 1965. A successful plaint by Monier in the

Warden's Court, relating to labour conditions, resulted in the closure of Swain's quarry in 1967.

In 1987, control of Monier Ltd was divided between the major shareholders, Redland and Equiticorp Tasman. The Monier name was reserved to the roof tile aspect of operations, now controlled by Monier-Redland Ltd, a UK-based company. The sand, clay and dimension stone operations became the province of Equiticorp Holdings, the industrial division of Feltrax International Ltd. These operations have traded under the name Amatek Ltd since July 1988.

4. GEOLOGY

The Black Hill Norite is a gabbroic Cambro-Ordovician intrusive emplaced about 486 million years ago during the closing stages of the Delamerian Orogeny. The deposit represents the outcropping late stage facies of a differentiated basic intrusion and comprises tors and boulders protruding through the overlying Tertiary carbonates and Pleistocene to Holocene sands.

The intrusive is dominated by labradorite gabbro containing pyroxenes of composition determined by the chemistry of localised areas of the crystallizing melt. Norite is a variety of gabbro in which calcium-poor orthopyroxene (hypersthene) predominates over calcium-rich clinopyroxene (augite).

Petrographic evidence (Farrand, 1986) indicates that plagioclase had already substantially crystallised before emplacement. The body exhibits flow banding dipping about 60° south, and seen as preferred orientation of tabular plagioclase crystals. The rock shows no metamorphic effect, indicating a late or post Delamerian age. Late stage volatile fluids crystallised interstitial biotites which have been partially replaced by zeolites. Thin pegmatites were forced into fractures developed by pressure changes late in the cooling history. Hydrothermal alteration of pyroxene to amphibole in fractures has produced "green lines" which are avoided during quarrying.

5. OPERATIONS

Quarrying

The norite is mined by air drill, plug and feather, and crane. The air drills are mounted on horizontal booms which are capable of directing the drill both vertically and horizontally. Norite is drilled out in cubes about 3-4 m square and 2-5 m deep.

Vertical holes are initally drilled at about 5 cm centres, and the intervening holes are drilled using the existing holes as pilots, thus completely freeing the block along all vertical faces. Horizontal holes at 10 cm centres are then drilled and the block wedged free with plug and feather. Blocks are then reduced into smaller units about 3 m long and 1.5 m square by drilling and wedging along vertical lines. These are then lifted from the quarry by crane and further subdivided into three one metre blocks of approximately 7 tonnes before loading onto semi trailers, up to 3 blocks at a time for transport to cutting and polishing factories.

Processing

Quarried rock is sent to Amatek's factory at Gepps Cross for cutting, polishing and engraving. Blocks are unloaded by crane and stored. When required the blocks are lifted onto a sawing trolley for cutting with a gang saw which is capable of 20 simultaneous cuts. The blades are of mild steel and last for about six blocks. A cutting rate of about 10 cm per hour can be achieved using water-borne chilled iron shot (2 mm diameter) as the cutting medium. Sawn slabs are stored inside the factory for subsequent surfacing.

The slabs are polished by a machine utilizing four planetary heads each fitted with a detachable silicon carbide grinding disc 120 mm diameter and 50 mm thick. Each slab is subjected to four stages of polish using progressively finer discs. A final non-planetary stage uses a felt-padded 300 mm diameter rotating steel disc which buffs the slab to a high polish using aluminium oxide powder.The polished slabs are then removed by gantry and either cut to size with a circular diamond saw or sold uncut.

Only 10-20% of the quarry output is trucked to Gepps Cross for finishing and about 5% is sold to Tilletts and other monumental masons. The rest is trucked direct from the quarry to interstate destinations.

BLACK HILL - MARTINS GRANITE QUARRIES PTY LTD

1. GENERAL

LOCATION	Black Hill, 5 km north of the township, 85 km east-northeast of Adelaide (Fig. 5)
OPERATOR	Martins Granite Quarries Pty Ltd.
ADDRESSES	Head Office: Stonecraft, 96 Unley Rd, Unley 5061 Tel. 2723400 Factory: London Road, Mile End, 5031 Tel. 3526337 Quarry: C/- P.O. Black Hill 5353 Tel. (085) 608091
MINERAL TENURE	EML 3072-3075, 3085, 3086

2. PRODUCTION

MATERIAL PRODUCED	Norite, otherwise known as Imperial Black Granite or Austral Black Granite.
PRODUCT GRADE	Durable, decorative black stone of uniform colour and texture which takes a high polish.
ANNUAL PRODUCTION (1988)	2060 tonnes (Fig. 9)
RESERVES	Not defined but known to be ample for many decades in view of larger area of outcrop and shallow subcrop.
PRODUCT USES	Decorative cladding, monumental stone, paving stone.
DESTINATION	75% to Adelaide (Mile End Factory, stonemasons) 25% to NSW direct from quarry
WORKFORCE	Quarry - 11 Mile End Factory - 11 Unley (Sales only) - 3

3. HISTORY

First production in the area, recorded in 1947 by J.B.L. Shelton, was initially by splitting of outcropping boulders. Quarrying by W.H. Martin began in 1957 and production was first recorded in 1958.

4. GEOLOGY

See Monier, Black Hill

5. OPERATIONS

Quarrying

The quarrying method has only slightly changed from that described in Falconer and Watkins (1978). Lines of 4.4 cm diameter vertical percussion holes are drilled to the depth of the selected block. Block dimensions vary according to constraints imposed by joints and rock quality but are typically 3 m deep by 4 m wide by 13 m long. The block is undercut using the same drill and freed with plug and feathers. The block is then cut into four 1 m slabs each of which is then cut into three 4m x 3m x 1m slabs of about 20 tonnes which are lifted from the quarry by crane onto rail - mounted trolleys. The blocks are pulled, two at a time, into the saw shed for cutting with a wire saw. The saw comprises a double stranded steel wire with a reverse twist every eight metres running at a speed of about 100 k.p.h. between two wheels located about 150 m apart. Water-borne silicon carbide is used as the abrasive feed to the saw which takes up to a day for each cut. The wire is replaced after about six cuts, during which about 320 kg of abrasive powder is consumed. The wire is also used to cut Calca and imported granites. Cut blocks are sent by semi-trailer to Mile End for polishing.

Smaller blocks of about 7 tonnes are also cut in the quarry for direct despatch to Adelaide or interstate for cutting with a block saw.

Processing

At Mile End, blocks are unloaded by jib crane and stockpiled. When required the crane lifts the blocks onto a rail-mounted trolley for transfer to the factory. They are then lifted onto a second trolley and wheeled to the diamond block saw for cutting into slabs.

After cutting the slabs are lifted out and stockpiled ready for polishing with a 6-disc planetary polisher. This takes place in three stages using sucessively finer grades of 7.5 cm carborundum discs lubricated and cooled with water. The slabs receive a final polish with tin oxide using a 37.5 cm felt pad and are then cut to size with a circular diamond saw. Edges are polished in three stages with a 7.5 cm carborundum disc polisher and finally by felt pad and tin oxide.

Crematorium stones are engraved by covering with stencilled rubber sheet and then shot blasting using zircon. The rubber sheet is peeled off and the engraved letters painted. Headstones are engraved by stonemasons who do their own finishing work on polished slabs purchased from the factory (Falconer and Watkins, 1978).

60-70% of quarry production is trucked to the Mile End factory for polishing and distribution, mainly to the eastern States. 5-10% is sold locally to stonemasons, sculptors and similar small users. 25-30% is trucked to Orange (NSW) direct from the quarry for the manufacture of polished tiles, 50% of which are exported.

MINTARO - MINTARO SLATE QUARRIES PTY LTD

1. GENERAL

LOCATION	Western outskirts of Mintaro, 12 km NE of Watervale (Fig. 5)
OPERATOR	Mintaro Slate Quarries Pty. Ltd.
ADDRESSES	Local - P.O. Box 8 Mintaro S.A. 5415. Tel. (088) 439077 Registered Office - 162 West Terrace, Adelaide, 5000 Distributor - Mintaro Slate Supplies, 3 Coglin St., Brompton, 5007. Tel. 464354 - Also distributing in Melbourne and Castlemaine -
MINERAL TENURE	PM 124

2. PRODUCTION

MATERIAL PRODUCED	Siltstone (known in the trade as "slate").
PRODUCT GRADE	Homogeneous, thinly bedded, strong, durable, cleanly-splitting "slate". Maximum size 1.8 x 3 x 0.25 m from quarry. Larger pieces can be manufactured by joining.
ANNUAL PRODUCTION (1988)	1550 tonnes (Fig. 10)
RESERVES	Adequate to sustain operations for many decades.
USES	Random and cut paving, billiard tables, architectural slate (walling stone, steps etc.), special orders.
DESTINATIONS	Adelaide and S.A. 50%, interstate 49%, overseas 1%.
WORKFORCE	12; 1 manager, 5 quarrying, 2 splitting, 4 cutting and surfacing (in factory).
WORKING TIMES	38 hours per 5 day week

3. HISTORY

Flagstones were first noticed in the bed of a creek on section 178, hundred of Clare around 1860 and exhibited in London in 1861 (Ward, 1914). Initially, there was not a great demand for the slate due to economic depression. However, in the late 1890's demand for paving stone increased from Melbourne (Mansfield, 1958), and the material was later extensively used in Adelaide for the same purpose. The slate has also been used for hearths, sills, steps, kerbing stones, shelves, cricket pitches, troughs, tanks, vats, billiard table tops, ledger and vault covers, lavatory slabs, switchboards, blackboards and monumental stones (Ward, 1914). Better or more fashionable materials have displaced slate for many of these uses, and the material is now principally used for paving and walling. The deposit remains a source of highest quality slate for billiard tables and architectural purposes, but is in competition with cheaper and imported alternatives.

The first quarry worked was the No. 1 quarry (also known as Priest's Quarry) immediately to the north of the site of the original discovery, and to the east of a meridional fault. No. 2 quarry was some distance to the north on the western side of the fault, and No's 3 and 4 and the present No. 5 in succession along strike to the north of No. 1.

The deposit was worked by the Mintaro Slate and Flagstone Co. Ltd. until mid 1980 when Western Australian interests, attracted by its small size together with its listing on the Adelaide Stock Exchange, bought a majority shareholding. On 1 September, 1981 the former principal shareholder in the original company bought the slate quarrying operations in the name of Toowong Pty. Ltd. which trades as Mintaro Slate Quarries Pty Ltd (D Young, pers. comm. 1987).

4. GEOLOGY

The No. 5 quarry lies within Mintaro Slate, part of the Belair Sub-Group of Sturtian age. The rock is a grey laminated siltstone, with sandstone beds and minor dark dolomite and black shale. The fissility in the quarry area is due to dark-coloured laminations, and dips at 17.5° west. The shale is slightly pyritic and contains rare rounded pebbles, which were probably ice-transported during glaciation; evidence of which is observable in nearby tillites.

The present area of working is about 60 m wide, to the east of a vertical, meridional crush zone, 3-5 m in width. Another crush zone is located within the eastern half of the quarry.

Water table is approximately 20 m below natural surface in the quarry area.

5. OPERATIONS

Slate is mined at a depth of about 15 m from the floor of an open pit which slopes to the west at an angle of 17.5 degrees. The slate is extracted by drilling holes in series with a hand held pneumatic drill to a depth of about 250 mm across the quarry. Plugs and feathers are driven into the holes to break the slate. It is then parted along its bedding by using gads, wedges and a paving breaker to produce slabs usually 150-250 mm thick with a maximum size of about 3 m x 1.8 m.

The slabs are lifted out by a five tonne crane, using a chain sling, placed on a trolley and towed or forklifted to the 'bankers' (stockpiled slabs stored on edge). The crane is mounted on the northern rim of the quarry. Where practical it is preferred to leave the slabs to dry out before splitting them with a hand wedge into sheets between 20 mm and 80 mm thick depending upon the natural parting. The split material is then allowed to stand prior to cutting as required by orders.

Off-cuts from the "bankers", and additional small pieces are used as random paving stones and are sold stacked on pallets. Other articles are cut and surfaced in the factory adjacent to the quarry. Initially the slabs are cut up to the required size and shape using diamond circular saws. The surface of the cut slabs is then smoothed with a set of six carborundum blocks attached to a rotating wheel which traverses the slab. With billiard tables, both sides are surfaced then drilled for screw and dowel holes, and surfaced again. Finally pockets are cut out with a hand held grinder. Walling stone is cut on one side only to the width of a standard brick (4").

All slate produced is trucked to its destination by outside hauliers using semi trailers and tray tops.

JONES HILL - PARACHILLNA SLATE

1. GENERAL

LOCATION	Moolawatana Station 40 km WSW Mt Fitton, 3.4 km southeast of Jones Hill Trig (Fig. 5)
OPERATOR	R and G Brandl (operating as Parachillna Slate)
ADDRESS	5 Westport Road, Elizabeth West 5113 Tel. 2521487
MINERAL TENURE	EML 4504, 4992

2. PRODUCTION

MATERIAL PRODUCED	Laminated siltstone commercially known as "slate".
PRODUCT GRADE	Homogeneous, tough strong durable "slate" which splits cleanly along planar bedding surfaces.
ANNUAL PRODUCTION (1988)	1050 tonnes (Fig. 11)
PRODUCT USES:	Sawn tiles, crazy paving, steps, sills, bench tops, walling stone
DESTINATIONS	All States
WORKFORCE	Quarry - 2 Factory - 6 full time, 1 part time.

3. HISTORY

In August, 1973, G. Brandl pegged a deposit of slate and flagstone south of the Parachilna Gorge Road, but conversion to an extractive mineral lease was refused on environmental grounds. A subsequent search for suitable "slate" within the Tapley Hill Formation led to pegging of the Jones Hill deposit in March, 1975 (Olliver and Young, 1978). Mining began in March, 1976.

4. GEOLOGY

Geology is described in Olliver and Young (1978) from which the following has been extracted:

The quarry is located near the axis of the westerly - plunging Gladstone anticline, within the Tapley Hill Formation (Umberatana Group) of Sturtian age. The dominant lithology is a grey flaggy carbonate-bearing siltstone, very fine grained with moderately well developed bedding. There is some variation in grain size and composition between layers which are emphasized by slight colour variations. These layers are generally 1 mm thick.

The rock splits along the bedding into smooth, straight and parallel sided slabs of varying thickness. The split is along either a darker more fine grained layer with a slightly higher content of carbonaceous material or a limonite coated surface. Where the rock is fresh, this limonite veneer is still in the unoxidised form as very fine grained pyrite and carbonaceous material.

Joint surfaces are smooth but are not as flat as bedding planes and are often encrusted with very fine grained calcite or orange stained clay with a trace of manganese oxides.

The rock consists of detrital quartz, lesser plagioclase feldspar, a few muscovite flakes and occasional heavy mineral grains in a recrystallized matrix of very fine grained chlorite and sericite. Relative abundance of minerals is:-

quartz	25-45 percent
chlorite	15-25 percent
muscovite & sericite	10-15 percent
plagioclase feldspar	10-15 percent
calcite	1-20 percent
dolomite	2-20 percent

Up to 3 percent carbonaceous material and traces of pyrite, leucoxene, zircon, tourmaline and rutile are also present.

Detrital flakes of muscovite which are oriented parallel to the bedding, are too few to affect the physical properties of the rock. In contrast, the interstitial chlorite and sericite, comprising up to 40 percent of the rock, have no preferred orientation. Hence there is no schistosity and no slaty cleavage.

Two sets of orthogonal, vertical joints divide the slate into rectangular slabs, and two additional but less persistent sets also orthogonal and vertical, trend diagonally across the first.

5. OPERATIONS

Overburden is first removed with a Komatsu D60A-3 bulldozer. The two sets of more prominent joints are utilized in mining as quarry walls and as convenient natural breaks in the slate. Rectangular blocks outlined by the joints are further subdivided to required slab area using a circular diamond saw. Slabs are then separated from the quarry floor by wedging along suitable bedding planes with hammer and bolster, gradual levering up with a crowbar and finally lifting out with a fork lift. Slab thickness is most commonly 80-90 mm, with a minimum thickness of 60 mm. The slabs are stored for up to 2 months during which the slate develops partings about 3 mm apart which results in easier splitting at the factory.

Extraction normally results in about 50% waste which is removed with the bulldozer. Major causes of waste are zones of quartz - rich beds and quartz/iron-healed joints. A mobile crane is used for general stockpile control and truck loading. Operations are suspended from about mid-December to mid-February.

Slate is trucked to the factory at Elizabeth West about 2 or 3 times a fortnight, where it is manually split to the required thickness. Slate for tiles is then sawn to size and then further split to required thickness ranging from 10-30 mm. The slate is distributed throughout Australia.

KANMANTOO/WISTOW - (THREE PRODUCERS)

1. GENERAL

LOCATION	Kanmantoo and Wistow areas, 50 km southeast of Adelaide. 4 km west of Kanmantoo and 6 km southeast of Wistow respectively (Fig. 5)
OPERATORS	See Table
ADDRESSES	See Table
MINERAL TENURE	See Table

2. PRODUCTION

MATERIAL MINED	Slabs of quartz-biotite-feldspar metasiltstone
PRODUCT GRADE	Durable stone of adequate strength in a range of slab thicknesses for paving and walling. Colours range from medium and dark grey when fresh to shades of red, yellow and brown. Slab thickness ranges up to 180 mm with dominant range 5-100 mm.
ANNUAL PRODUCTION	See Table and Figs 12 and 13
RESERVES (tonnes)	Possible; after Drexel (1985) and Young (1986) See Table
PRODUCT USES	Bookleaf walling stone, paving stone
DESTINATIONS	90% SA, 10% interstate
WORKFORCE	See Table

OPERATOR	ADDRESS	PRODUCTION (Tonnes, 1987)	RESERVES (Tonnes) million	MINERAL TENURE	WORKFORCE
National Quarry Industries (Aust) (R L Calabrese)	2A Charles Street Norwood SA 5067 Tel. (08) 362 9646 (08) 391 1668 (Quarry)	2350	10	PM 170 (Quarry No. 2)	8
Mount Barker Wistow Slate Pty Ltd (M G Keller Nominees Pty Ltd)	U1, 60 Richmond Road Keswick SA 5035 Tel (08) 297 0443 (08) 391 2109 (Quarry)	1000	0.97 (No. 3) 0.225 (No. 1	PM 194 (Quarries Nos 1 and 3)	4
Albern Slate Pty Ltd (Landowner B D Faulkner)	290 Military Road Grange SA 5022 Tel (08) 356 8835 (085) 38 5155 (Quarry)	3760	0.042	EML 4712	11

3. HISTORY

The history of operations at Kanmantoo and Wistow have been respectively described by Drexel (1985) and Young (1986).

Quarrying at Kanmantoo Quarry for house and fence construction reportedly began around the turn of the century. Operations were resumed by B D Faulkner in 1978 and were taken over by Albern Slate Pty Ltd in early 1983. EML 4712 was granted to Kallana Graziers Pty Ltd in 1979 and transferred to Faulkner in November 1983.

The first known quarrying activity in the Wistow area was at Petwood, about 6 km to the northeast of the current operations. The name 'Wistow Stone' was first applied to product from Kelley and Foale's quarry, about 4 km northwest of the current workings which was operated between 1963-68. Foale then worked Wistow No. 1 quarry until the lease was transferred to Germar Nominees in 1976. In April 1979, the lease was transferred to R Calabrese who operated the quarry until it was abandoned in favour of the No. 2 deposit in 1986. The No. 1 property had been acquired by A W Samuel in 1981 and then by Davin Investments Pty Ltd in 1985. In 1986, derivatives of this company began production at No. 3 quarry, located adjacent and to the south of No. 1. Production has not been sustained due to financial problems and consequent ownership changes.

Operations at No. 2 quarry, the most northerly of the current Wistow operations, began in 1974 and continued until 1981 when surrounding land was purchased by R Calabrese. Production began in 1983, and all operations were transferred from No. 1 in 1986.

4. GEOLOGY

Regional and local geology has been summarized from Young (1986). The rocks are within the Tapanappa Formation of the Kanmantoo Group of Cambrian age, and were originally deposited under marine conditions as interbedded sandy silt, silt and mud. Subsequent Delamerian metamorphism produced quartz/biotite/feldspar metasiltstone interbedded with bimica schist, together with lenticular andalusite-garnet-staurolite assemblages and pyritic zones, the most persistent of which is the Nairne Pyrite Member.

The 150 m thick 'flagstone zone' from which the stone is quarried overlies thickly bedded to massive quartzofeldspathic metasiltstone. The sequence strikes from 340° to 025° and dips 40-50°E. Bedding plane partings, developed at biotite schist-metasiltstone contacts, have produced a range of slab thicknesses up to 180 mm, most commonly between 5 and 100 mm. Two major joint sets restrict slabs to a maximum dimension of 1 m after blasting and handling.

5. OPERATIONS

Rock is blasted from the faces and carried by front end loader to picking bays where slabs are hand sorted, split, trimmed and stockpiled. At No. 3 quarry blasted stone is transported by front end loader to recently installed plant, where it is tipped via an apron feeder onto a 125 mm punched-plate vibrating screen. Undersize is rejected and oversize falls to a sorting belt, from which stone is hand selected and palletized.

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DOLOMITE

1988 production was 808 000 tonnes with an ex-mine value of $3.54 million. 60% of this was shipped to the eastern States and 187 000 tonnes was exported.

South Australia produces about 95% of Australia's dolomite. Tasmania is the only other producer of metallurgical grade dolomite and Queensland produces agricultural dolomite for local use.

The principal dolomite deposits for industrial use are:

- Ardrossan on Yorke Peninsula
- Tantanoola in the southeast of the State

In addition, BHP uses dolomite from the Iron Baron iron ore deposit as flux in its Whyalla blast furnaces and small quantities of dolomite are mined near Mount Gambier for agricultural use.

BHP began quarrying at Ardrossan 1950, and the operation is now Australia's largest producer with output of 0.74 million tonnes in 1988; reserves amount to 20 million tonnes. Lump ore is used as flux in basic oxygen steel making at Whyalla, Pt Kembla and Newcastle and a small amount of the fines is used in fluxed iron ore pellets and sinter. Dolomite with an FOB value of $1.68 million was exported to Japan in 1988.

The Tantanoola dolomite deposit has been worked for construction materials since before 1923 but its use as glass-making flux began after 1961 when mineral tenure was secured by Australian Glass Manufacturers. 33 000 tonnes of glass-grade screenings were shipped to Melbourne by ACI in 1988 together with 10 000 tonnes of fines for agricultural purposes. Reserves have been estimated at 400 000 tonnes.

ARDROSSAN - BHP LTD

1. GENERAL

LOCATION	5 km south of Ardrossan (Fig. 14)
OPERATOR	B.H.P. Ltd
ADDRESSES	Local - P.O. Ardrossan 5571 Telephone (088)) 37 3106 Head Office - Port Augusta Road, Whyalla (P.O. Box 21) 5600 Telephone (086) 40 4444
MINERAL TENURE	PM 291, ML 4040-4042, 4044-4046, 5317

2. PRODUCTION

MINERAL PRODUCED	Dolomite
PRODUCT GRADE	Average grade - 29% CaO, 21% MgO, 2% SiO_2, 0.8% Fe_2O_3, 0.7% P_2O_5 Max. - SiO_2 for Japanese flux, 1.2%; for Japanese fines, 1.5%; for Whyalla fines, 1.7%. Max. K_2O, 0.05%. Min. MgO, 20%. Practice is to grade on silica and K & Mg are then always within specification.
ANNUAL PRODUCTION (1988)	741 800 tonnes lump dolomite, 13310 tonnes fines (Fig. 16)
RESERVES	20 million tonnes
PRODUCT USES	90% as flux in Basic Oxygen Steelmaking at Port Kembla, Newcastle and Whyalla. A 60/40 dolomite/limestone mix has replaced the pure limestone flux previously used. Dolomite increases the life of furnace linings and shortens the time required to remove impurities from the furnace charge. - Fines used as flux in pellets and sinter - Occasional export contracts, for flux. Previous markets for use as flux in refractory bricks and ferro-alloys have now been lost to imported refractory bricks and local Tasmanian dolomite.

DESTINATIONS	Port Kembla, Newcastle, Whyalla, Bell Bay. Recently exported to Japan.
WORKFORCE	40
WORKING HOURS	3 shifts, 6 days per week.

3. HISTORY

The deposit was discovered in 1918 (Thomson, 1977) and was drilled by B.H.P. in 1945 (Armstrong, 1949). Bulk sampling and jetty construction began in 1948 and the crushing plant began operation in August 1950 (Anonymous, 1951).

4. GEOLOGY

The quarry is located within a broad syncline, plunging at a shallow angle to the south, in which Kulpara Limestone of the Lower Cambrian Hawker Group exceeds 300m in thickness. The unit is a yellow and buff dolomite in its upper part becoming grey and less dolomitic with depth.

Conformable siliceous lenses are scattered throughout the sequence which is characterised by a fauna of archaeocyathids and brachiopods. Manganese dioxide dendrites are common on joint planes. Silica contamination results from washing down of clayey alluvium, to a depth of up to 30 m below surface. Overall, total waste:ore ratio is 0.6:1.

5. OPERATIONS

The following account has been modified and updated from Falconer and Watkins (1978). Primary drilling is carried out using a Gardner Denver RCD 930 down-hole drill, and an Ingersoll-Rand LM300 Crawlair drill is used for secondary drilling. 167 mm diameter holes are drilled 10.5m deep on 9m benches with a 1.5m sub drill on a 5.0m by 5.0m square pattern and charged with ANFO. Blasting takes place approximately twice per month with sixty holes shot at a time. Broken ore is loaded with 2 Ruston RB54 electric shovels and a Caterpillar 966C front end loader, into three 15 tonne Kenworth and two 10 tonne Mack rear dump trucks. Oversize rocks are broken with an hydraulic impact breaker. Overburden is hauled to a dump adjacent to the pit, and the dolomite is carted 2.4 kilometres to the crushing plant.

The rock is dumped into a feed hopper and fed by means of an apron feeder to a Vickers Ruwolt 48 x 36" (1.2 x 0.9m) jaw crusher (Fig. 15). Crusher product is conveyed to a "live-roll" grizzly which has 54 mm circular spacing. Grizzly oversize goes to a 50t "roughs" storage bin. Grizzly undersize material (nominal -38mm) is fed over a double deck screen ("waste screen"). Oversize material (-38 mm + 25 mm) from the top deck goes to another 50 t "middlings" storage bin. Intermediate size material (-25 mm + 7.1 mm) feeds a conveyor which transports the material to a moving overhead tripper above No. 1 storage bin.

Undersize material (fines) from the bottom deck (which is heated) is conveyed to a 240 t overhead storage bin. It is used for sinter flux, fluxed pellets and is sold locally for paving and fill.

Grizzly oversize from the "roughs" bin is fed through a 900 mm Traylor gyratory crusher, combined with material from the "middlings" storage bin, and fed to a secondary double deck screen ("product screen"). Oversize is fed to 2 x 900 mm Symons short head cone crushers in parallel, intermediate size (38 x 16) is fed into the No. 2 storage bin, and undersize is recirculated back to the"waste screen". Tertiary crusher material is conveyed to a third double deck screen ("clay screen"). Oversize and undersize are recirculated to the "product screen". The intermediate size is directed to No. 1 bin.

Products are stored in either the No. 1 or No. 2 storage bins which have capacities of 12 500 tonnes and 18 000 tonnes, respectively. The bins discharge through manually operated gates to underground conveyors for transport along the jetty to the shiploading boom. Ships are loaded about once per week. Because the shiploading boom is stationary ships are required to warp along the jetty to enable the load to be evenly distributed. Dolomite can be loaded at a rate of 2 400 tonnes per hour. Ships of up to 46 000 D.W.T. can berth at Ardrossan but loading is limited to approx. 30 000 tonnes by the depth of water which is 9.2 m M.L.W.S. The jetty is also used for loading wheat and barley from the adjacent grain terminal, and for loading salt from Cheetham Salt Ltd at Price.

TANTANOOLA - ACI RESOURCES LTD

1. GENERAL

LOCATION	Princes Highway, 3Km NE Tantanoola (Fig. 14)
OPERATOR	ACI Resources Ltd
ADDRESSES	Quarry - Tantanoola, S.A., 5280 Tel. (087) 344260 Administration - McDonald's Track (P.O. Box 192) Lang Lang. VIC. 3984 Tel. (059) 975402
MINERAL TENURE	ML 3253, 3254

2. PRODUCTION

MINERAL PRODUCED	Dolomite
PRODUCT GRADE	$CaCO_3$: 57.5% Mg CO_3 : 42%, SiO_2 : 0.3%, Fe_2O_3 : 0.25%
ANNUAL PRODUCTION (1988)	32830 tonnes glass grade 9780 tonnes agricultural grade, 180 tonnes chips (Fig. 18).
RESERVES	400 000 tonnes
PRODUCT USES	Plate glass, fibreglass, agriculture
DESTINATIONS	Pilkington ACI Operations, Dandenong (by rail) ACI Fibreglass, Dandenong (by road) Commercial Minerals, Melbourne (by road)
WORKFORCE	6
WORKING HOURS	8am - 4pm, 5 days per week

3. HISTORY

Small quarries were opened on section 213 prior to 1923. In 1930, section 213 was proclaimed a Tourist Reserve to protect the Tantanoola Caves. In 1946, the South Australian Railways leased sections 200 and 204 for ballast and let the crushing contract to Quarry Industries (Cochrane, 1952a). Mineral claims 3425-3428 were registered to Australian Glass Manufacturers in June 1961 and surrendered in May 1963 when ownership was transferred to A.C.I. Operations Pty. Ltd. Leases 3253 and 3254 were granted in July, 1964.

4. GEOLOGY

The quarry is located within the Oligo-Miocene Gambier Limestone. This formation is predominantly a white to grey bryozoal calcarenite which may grade into marl and includes siliceous horizons. These deposits have undergone irregular metasomatic dolomitization subsequent to deposition. The dolomite may be white, grey, pink or yellow brown and grades vertically and laterally into bryozoal limestone, generally obscuring its fossiliferous nature. Texture ranges from hard and crystalline to sandy and sugary. Relatively greater erosion of the limestone during post Miocene peneplanation has left the dolomitic area stranded as a cliff above the level of the surrounding plain (Cochrane, 1952a). The area was completely submerged during a Pleistocene marine transgression, as evidenced by scattered pockets of reef shells up to 2 m thick, overlying the dolomite deposits. At a slightly later period, a strand line existed along the base of the cliff where up to 2.5 m of shellgrit was deposited over the bryozoal bedrock.

The sequence is monoclinally folded along a NW-SE axis, with a maximum dip of 40°NE. Jointing is parallel to the fold axis, and is most strongly developed in hard dolomite, facilitating limestone solution and cave development. Localised brecciation in the quarry is consistent with the associated faulting in dolomitised areas elsewhere in the South East.

5. OPERATIONS

Mining is carried out in open pit using an Ingersoll-Rand Crawlair percussion drill. Holes are drilled on a three row, 2 x 2m pattern, approximately 8 metres deep, and charged with ANFO. Initiation is by electric delay detonators at the bottom of the holes. Blasting is carried out monthly. Oversize rock is broken with backhoe-mounted impact hammer. The broken rock is loaded with a front end loader and trucked the short distance to the crushing and screening plant (Fig. 17).

Broken dolomite is screened at 30 mm on a vibrating screen. Screen oversize is crushed in an Arbra jaw crusher and conveyed to a Hazemag impact crusher, the product of which is fed to a double deck (12 mm and 3 mm aperture) vibrating screen in closed circuit. Minus 3 mm is conveyed to blending piles in a storage shed, from which it is loaded into trucks for haulage to the Tantanoola railway siding, a distance of 8km. Minus 30mm material is passed over a 3mm aperture screen for sale as agricultural dolomite. Maximum plant capacity is 20 tonnes per hour. Normal production is 100 tonnes per day. Two wagons are loaded daily for despatch to Victoria.

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GYPSUM

In 1988, 1.28 million tonnes were produced with an ex-mine value of $3.50 million. 60% of this was shipped to the eastern States where almost all gypsum used in plaster and cement manufacture is of South Australian origin. Overseas exports, principally to Japan, New Zealand and the US, totalled about 220 000 tonnes with an FOB value of $3.3 million.

South Australian deposits account for about 80% of Australia's gypsum production. Western Australia is the only other significant producer, and most of that State's output is exported to SE Asian markets.

South Australia's principal gypsum sources for industrial use are:-

- Lake MacDonnell on Eyre Peninsula
- Kangaroo Island
- Marion Lake and Lake Fowler on Yorke Peninsula
- Blanchetown - in the Riverland

In addition there are 14 relatively small deposits, mainly in the Mid-North and Riverland areas, producing gypsum for agricultural use.

Lake MacDonnell is Australia's largest gypsum mine, producing 0.99 million tonnes in 1988 from a deposit with 575 million tonnes of reserves. Gypsum has been produced since 1919, although competition from the Yorke Peninsula deposits caused suspension of operations between 1930 and 1947. The deposit has been operated by Gypsum Resources of Australia Pty Ltd since 1984 when CSR Ltd and Boral Ltd combined their separate operations. Product is railed 70 km to port facilities at Thevenard for shipment interstate or overseas.

Mining commenced at Salt Lake on Kangaroo Island in 1957. Operations were transferred to New Lake in 1983 and suspended in late 1986. Both deposits are now worked out but CSR Ltd has 730 000 tonnes stockpiled at the mine sites and the Ballast Head ship loading facility. Most of the production is shipped interstate; 137 840 tonnes in 1988.

Gypsum has been produced from the Yorke Peninsula deposits since 1905, and plaster was produced at Inneston between 1916 and 1930. Shipments to markets interstate and overseas ceased in 1973, and all production is now used within S.A. (49 820 tonnes in 1988). Waratah Gypsum Pty Ltd (a Boral subsidiary) produces gypsum from Marion Lake for wallboard manufacture. Adelaide Brighton Cement Ltd produces gypsum from Marion Lake and Lake Fowler for cement manufacture.

The Blanchetown deposits have been producing since 1940. 36 790 tonnes were produced by David Linke Contractor Pty Ltd in 1988, principally for plaster manufacture at Port Adelaide, and cement manufacture at Angaston.

LAKE MACDONNELL - GRA

1. GENERAL

LOCATION	Lake MacDonnell, about 15 km south of Penong, Eyre Peninsula (Fig. 19)
OPERATOR	Gypsum Resources Australia Pty. Ltd. (GRA)
ADDRESSES	
Local	PO Box 174, Ceduna, 5690 Tel: (086) 25 2081. Telex-80651. Fax 253147.
Head Office	17-21 Bagot Street, North Adelaide, 5006 Tel. 267 3344
MINERAL TENURE	ML 99, 163, 292, 367-75, 378-81, 451-2, 454, 458, 481, 498-564, 511-15, 675-76, 680, 5401-04

2. PRODUCTION

MINERAL PRODUCED	Plaster grade (seed) gypsum (gypsarenite) Cement grade rock gypsum (selenite) X grade Coarse rock gypsum (selenite)
PRODUCT GRADES	Seed: Min. 93% $CaSO_42H_2O$, 0.02% max NaCl Rock: Min. 98.5% $CaSO_42H_2O$, 0.5-0.6% max NaCl

ANNUAL PRODUCTION
(1988) (tonnes)

	Export Sales	Aust Sales	Total
Seed (plaster grade)	123 260	422 110 (*)	545 370
Cement grade	96 410	345 940 (*)	442 350
X grade	-	4 550	4 550
	219 670	772 600	992 270 (Fig. 21)

* Includes 120 000 tonnes mixed 50/50 cement/plaster grade gypsum for use in plaster manufacture in Sydney.

D00069

RESERVES	575 million tonnes rock and seed gypsum below lake floor. Plus approx. 50 million tonnes seed gypsum in lunettes.
PRODUCT USES	Seed: Plaster of Paris, wallboard, chalk, agriculture. Rock: Cement, flux, glass filler, some blended with seed for use in plaster.
DESTINATIONS	Seed: Eastern States, New Zealand, Japan, US (for plaster) Cement grade rock gypsum: Eastern States, Fiji, Japan, US, Taiwan, Indonesia. Coarse rock gypsum (X grade): Eastern States, Seattle (US), New Zealand, Indonesia.
WORKFORCE	Mine: 21 (one 8 hour shift), 26 (when working 2 shifts) Port: 16 (two, 8 hour shifts. Afternoon shift worked as two separated sub-shifts) Contractors: 6 (Roche Bros Pty Ltd)), 4 (cartage contractor) 5 day week

3. HISTORY

The history of the operation to 1947 is detailed in Dickinson and King (1949). The Australian Gypsum Co began production at Lake MacDonnell in 1919. The gypsum was shipped from nearby Port Le Hunte for plaster manufacture in Sydney until 1923, when a railway line was completed to Thevenard and a plaster factory erected. The operation was suspended in 1930 due to competition from the Stenhouse Bay deposits. Waratah Gypsum Pty Ltd recommenced operations in 1947 due to an increase in demand and limitations imposed by the shallow Stenhouse Bay port facilities. CSR Ltd began mining gypsarenite from the southwest corner of the deposit in 1948. Plaster production ceased in the late 1950s and new bulk loading facilities were installed at Thevenard in 1961. Waratah was taken over by Boral Ltd in 1978. The two companies combined operations in 1984 as Gypsum Resources Australia Pty Ltd.

Boral and CSR now buy their gypsum from GRA. CSR control all shipping through a subsidiary, Austocean Pty Ltd.

4. GEOLOGY

Gypsum has been deposited within a 20 km northwest-southeast trending depression in the calcreted coastal dune of the Pleistocene Bridgewater Formation. During the last interglacial sea level high approximately 120 000 years BP the embayment was open to the southwest and its floor was covered by calcreted fossiliferous marine sand of the Glanville Formation which grades laterally into Bridgewater Formation. A barrier of Holocene Semaphore Sand cut off the depression from direct marine connection about 6000 years BP, and gypsum deposition commenced from seawater derived brines entering through the surrounding porous aeolianite (Warren, 1983).

In deeper parts of the embayment, selenite (rock gypsum) domes were initially deposited from a stable, gypsum-saturated brine. Domes pass upwards into laminated selenite comprising vertically orientated crystals with layers of aragonite pelletoids. As the volume of brine decreased, freshening by meteoric water resulted in cessation of laminated selenite deposition and formation of up to 1 m of laminated gypsarenite (seed gypsum).

Maximum total gypsum thickness is about 8 m with an average thickness of 3.9 m. The selenite is currently worked beneath a gypsum-saturated brine pond of 16% salinity. Main impurities are aragonite and salt which for most purposes must be reduced to less than 1%.

Shoaling of the gypsum surface reduced deposition and eventually the exposed gypsum surface was re-worked into gypsarenite lunettes which occur on the lake bed and along its north-eastern margin. Lunettes are capped by gypsite (fine silt-sized gypsum).

Although salt content of lunettes is low, the gypsum contains significant sand, clay and carbonate impurity which renders much of the product suitable only for agricultural purposes.

5. OPERATIONS

Mining

The top layer of gypsum silt overburden is stripped by Caterpillar D8L bulldozer to expose the underlying gypsarenite. The gypsarenite is sampled for purity and salt content, and if high in salt, is left in situ to allow leaching by rainwater. Owing to relatively low and unpredictable annual rainfall of about 320 mm initial leaching may take up to two years (Warren, 1983). The gypsarenite (at about 0.15% NaCl) is then bulldozed into stockpiles (currently at about 4.5 million tonnes - about 6 years' supply) for further leaching. Total leaching time is 2-3 years.

Salt content of lunettes is highest in areas of high gypsite content. Gypsite rich material is rejected during mining as it tends to clog handling machinery and leaches salt only slowly. Lunette material with higher gypsarenite content is blended with the plaster grade material from the lake bed. 100-200 tpa of the most granular gypsum is sold to local farmers as soil conditioner, because its free-running character makes it suitable for application through fertilizer spreaders.

Stockpiles are tested regularly and, when sufficiently leached of salt, the gypsum is loaded into International 30 tonne semi tipper trucks (6 available), dumped near the railhead, and tipped into rail wagons by means of Kawasaki K21-10 wheeled loader. Each rail wagon is sampled before it is despatched to the port at Thevenard.

Following removal of overburden and gypsarenite, the exposed selenite is drilled to within 0.5 m of the base and blasted then stockpiled by draglines (2 x Northwest 80D and 1 x Ruston Bucyrus 63). Hole depth averages 3-3.5 m with a maximum of 5.5 m. As the water table of the lake is not lowered by pumping, the shot selenite is removed from below 4-5 m of water; the dragline sits atop the unmined gypsum above the water table. Large selenite boulders are broken down further by a Ruston Bucyrus 22 drop ball. The selenite is loaded with Caterpillar 966 (x2) or Furukawa 320 (x2) loaders onto International 30 tonne semi tippers and a Kenworth W924 bottom dumper.

At the plant (Fig. 20) the selenite is dumped into a 25 tonne hopper by means of a roadbridge. The hopper discharges onto a 100 mm vibrating punched plate screen with oversize fed into a drum crusher. Crusher product and screen undersize are then fed into a 25 mm aperture vibrating screen. Oversize is fed to another drum crusher and returned to the screen. Undersize at about 0.9% salt is stored in a storage bin of 50 tonnes capacity, and removed regularly by semi-tipper for stockpiling. The stockpiles, are left to leach for up to twelve months, and are regularly sampled for salt content. About 0.5 million tonnes of rock gypsum is currently held in stockpile. Some rock gypsum is layered 50/50 with plaster grade gypsum in a stockpile for the Sydney plaster market.

The plant is nominally rated at 125 tonnes/hour depending on screen aperture.

Transportation

Two or three trains per day are loaded from stockpile by front end loader. Each train comprises 49 bottom-dump wagons, each containing 34 tonnes of gypsum. The train takes 1 hour 20 mins to cover the 70 km to Thevenard, and completes the round trip back to Lake MacDonnell in 5½ - 6 hours. The locos were previously used on the Port Augusta - Alice Springs railway (Ghan), and the trucks were obtained from the now closed Francis Creek (Northern Territory) iron ore operation.

At Thevenard, the trucks are unloaded in pairs as the train is slowly shunted over a 70 tonne bin which discharges to a 2 m-wide conveyor. The 1600 tph output is split into two conveyor lines from each of which a moveable stacker feeds stockpiles to each side. Total stockpile capacity is 160 000 tonnes. Stockpiles are reclaimed by front end loaders which load gypsum through hoppers onto each of the stockpile conveyors. The two conveyors feed the shiploading conveyor at 914 tph for transport to the adjacent Marine and Harbors shiploader. Cargoes of up to 26 000 tonnes have been loaded, depending on ship design and draught.

KANGAROO ISLAND - CSR LTD

1. GENERAL

LOCATION	Ballast Head, Kangaroo Island, 9 km by road northeast of American River (Fig. 19) Salt Lake, Kangaroo Island, 14 km by road southwest of American River. New Lake, Kangaroo Island, 20 km by road southwest of Penneshaw.
OPERATOR	CSR Ltd, Gypsum Products Group
LOCAL ADDRESS	PO American River, 5221. Tel. (0848) 33036
FACTORY & HEAD OFFICE	37 Plymouth road, Wingfield, 5013. Tel. 348 1400
MINERAL TENURE	ML 610, 4002

2. PRODUCTION

MINERAL PRODUCED	Rock gypsum (selenite)
PRODUCT GRADE	92% $CaSO_4 2H_2O$, 5-6% $CaCO_3$, 0.02% NaCl
ANNUAL PRODUCTION (1988)	137 840 tonnes (Fig. 22)
RESERVES (in stockpile 1988)	560,000 tonnes at Ballast Head 130,000 tonnes at Salt Lake 40,000 tonnes at New Lake
PRODUCT USES	Wallboard, casting plaster, plaster of Paris, cement manufacture (New Zealand)
DESTINATIONS	Victoria, WA
WORKFORCE	5
WORKING HOURS	8 hours per day, 5 days per week.

3. HISTORY

In 1814, sealers became the first mining operators on Kangaroo Island, producing salt from White Lagoon about 3 km west of the Bay of Shoals (Blainey, 1983). The product was shipped to Sydney and Hobart as a condiment and meat preservative. Salt Lake was operated by the Globe Salt Co. from 1897 and later by the Commonwealth Salt Refining Co Ltd and various other operators until 1960.

Following drilling by the Department of Mines in 1956 (Willington, 1958), the Ingham Plaster Co. Ltd began mining gypsum at Salt Lake, shipping the product from American River in shallow draught ketches. In 1959, CSR merged with the Ingham Plaster Co. and constructed the bulk loading installation, suitable for deep-draught ocean-going vesels, at Ballast Head, 3 km north-east of American River.

Salt Lake deposit was worked out by the end of 1982 and operations, including the washing plant were transferred to New Lake in early 1983. Mining was completed in September 1986 and stockpiles established at Ballast Head, New Lake and Salt Lake, sufficient for more than 10 years, at current rates of consumption.

4. GEOLOGY

Lake gypsum deposits are located in low-lying areas left stranded after retreat of the sea in Pleistocene times. Aeolian reworking of the exposed sea floor formed a series of coastal dunes with interdune corridors. Following the rapid rise in sea level at the end of the last glacial stage, these interdune corridors were flooded, either directly or by seawater seeping through surrounding porous dunes, forming a series of brine lakes, up to 10 m deep within which gypsum was deposited.

On Salt Lake and New Lake the initial volume of the brine lake was large, and little affected by input of rain water. In the deeper parts of the lake with stable, high salinity brine poorly layered domes of gypsum about 0.5 to 1 m across, were deposited.

Higher in the sequence, size of the domes decreases, aragonite pellets form distinct layers and domes pass upwards into laminated selenite formed when large selenite crystals grew upwards with the long axes of the crystals at right angles to bedding. Selenite crystals enclose aragonite laminae so that a single crystal can be 2 m long. Growth of selenite crystals was interrupted with each freshening of the brine pond, but then continued in crystallographic continuity with the previous deposition.

As gypsum deposition proceeded, volume of the brine lake decreased. Each freshening by meteoric water became more important in controlling sedimentation, growth of selenite crystals ceased and laminated selenite gave way to laminated gypsarenite. Eventually, the shoaling gypsum surface was not always covered by brine, and deposition slowed or ceased each year. As the sediment column approached present day sea level, the brine pond became ephemeral, chemical sedimentation stopped in winter and some surface gypsum was dissolved, or subjected to mechanical reworking, forming non-laminated gypsarenite.

Aeolian reworking of the gypseous sediments in the lakes has resulted in formation of cross-bedded gypsarenite dunes, generally on the eastern side. Vegetation covered dunes are capped by gypsite, or flour gypsum. Gypsite is formed by rapid dissolution and redeposition of gypsum in the zone of soil moisture.

5. OPERATIONS

Mining operations are now concluded and gypsum is stockpiled at Ballast Head, Salt Lake and New Lake. The operators at New Lake began by lowering lake water level 4 m by pumping 5 000 litres/min 3 km to the sea at American Beach. Exposed gypsum was then blasted or ripped and broken with a D7 bulldozer and trucked to the treatment plant. The gypsum was crushed and screened, sized material being fed to spiral classifiers for removal of 10% clay as overflow. Washed and drained gypsum was left to leach on site or trucked in 25 tonne semi-tippers to leaching sites at Salt Lake, New Lake or Ballast Head, before transfer to the 50,000 tonne Ballast Head shipping stockpile.

During shiploading, two Caterpillar 814 wheeled bulldozers are used to push the stockpiled gypsum downhill into a hopper which feeds the shiploading conveyor. The product is conveyed to the fixed shiploading boom at 9000 tonnes/hour maximum rate, as the ship moves along the wharf to evenly distribute the load. A minimum channel depth of 9.2 m enables loading of ships of up to 16 000 tonnes.

6. MARKETS

Demand for Kangaroo Island gypsum has been severely reduced as a result of cost-effective joint venture arrangements between C.S.R. and Boral at Lake MacDonnell. Gypsum can now be shipped from Thevenard to eastern States and New Zealand markets at only slightly higher rates than inferior material from Ballast Head. High export shipping costs from Australian ports are also a major factor in reducing competitiveness in the New Zealand market with overseas gypsum.

Large shipments by ketch to the Wingfield factory ceased in 1981. Only about 1 200 tonnes per annum is now trucked via ship to Port Adelaide to meet white plaster specifications not satisified by the yellowish gypsum from the factory's major source at Blanchetown.

MARION LAKE - WARATAH GYPSUM PTY LTD

1. GENERAL

LOCATION	Eastern end of Marion Lake, 3 km NW of Stenhouse Bay (Fig. 19)
OPERATOR	Waratah Gypsum Pty. Ltd.
ADDRESSES	
Local	Stenhouse Bay, 5577. Tel. Marion Bay 23
Head Office	17-21 Bagot Street, North Adelaide, 5006. Tel. 267 3344
Factory	Canal Road, Port Adelaide, 5015. Tel. 47 5800 Gillman Office 47 3333
MINERAL TENURE	ML 137, 138, 174, 623, 904, 979-81

2. PRODUCTION

MINERAL PRODUCED	Gypsarenite
PRODUCT GRADE	94-95% $CaSO_4$ $2H_2O$ after washing
ANNUAL PRODUCTION (1988)	19 000 tonnes (Fig. 24)
RESERVES	Approximately 300,000 tonnes
PRODUCT USES	Wallboard manufacture
DESTINATION	Australian Gypsum Ltd., Port Adelaide
WORKFORCE	3

3. HISTORY

In the 1890s, a tramline, jetty and loading facilities were erected at Marion Bay to handle Marion Lake gypsum. A plaster factory was built in Melbourne, but the company was liquidated before production commenced. First recorded gypsum production on Yorke Peninsula was from Lake Fowler and Marion Lake in 1905. In 1913 deposits were leased at nearby Inneston and treatment facilities and a plaster factory were built in about 1916. Plaster was shipped from Stenhouse Bay to the eastern States until the factory closed in 1930 (Dickinson and King, 1951). Shipments of gypsum to Australian and New Zealand markets continued until 1973.

Prior to 1961, only rock gypsum was extracted and the overlying flour gypsum ("caso") was dumped in mined - out cuts. Between 1961 and 1972 both selenite (rock) and flour gypsum were mined. The lack of a deep water harbour at Stenhouse Bay, which limited the maximum shipment to 3 000 tonnes, then led to uneconomic shipping costs and suspension of operations in 1972. Small shipments of stockpiled material, by ketch, were maintained until 1973.

In 1976, a sub-lease agreement was negotiated with Adelaide Brighton Cement Ltd. to work rock gypsum at the western end of Marion Lake. At about the same time, Waratah began construction of a washing plant, using old components from the previous operations. In 1977, reclamation and washing of previously rejected gypsarenite began, with the material being carted to Adelaide by road. Boral gained control of Waratah Gypsum Pty. Ltd in 1978.

4. GEOLOGY

The gypsum is contained within a low-lying area in the southwest of Yorke Peninsula, extending from the coast near Royston Head in the northwest to the coast near Stenhouse Bay in the southeast. This depression, which may be partly the result of faulting (Crawford, 1965) is underlain by granitic gneisses of the pre-Adelaidean metamorphic basement upon which Permian glacials and Tertiary limestone have been deposited.

Pleistocene dune development began during an interval of lowered sea level. This was followed in the late Pleistocene and Holocene by at least two marine transgressions during which the lakes area was a shallow strait separating the Cape Spencer headland from the rest of Yorke Peninsula. A decline in sea level resulted in blocking of the strait from the sea and gradual silting up by newer sand dunes. The water contained in the depression then began to deposit gypsum by evaporation. Brines were drained away to the sea through seasonal groundwater movement during summer and autumn and seawater admitted through the porous aeolianite during winter, when the sea level was higher, thereby allowing continuous deposition of gypsum.

After a particularly low sea level, crystallization is thought to have ceased, and weathering and redeposition produced flour gypsum as a partly aeolian and partly lacustrine deposit overlying the rock gypsum.

Dickinson and King (1951) recorded 2.4 m of flour gypsum overlying 1.2 m of rock gypsum near the centre of Marion Lake. At the western end of the lake in the area worked by Adelaide Brighton Cement, 1.2 m of rock gypsum overlies interbedded clay and gypsum and is overlain by up to 0.5 m of gypseous detritus and stromatolitic limestone.

5. OPERATIONS

A 1924 Ruston Bucyrus dragline excavates the gypsum into rills and then loads into semi-tipper trucks for cartage to the washing plant (Fig. 23). Substantial dewatering is necessary to prevent the 28 tonne dragline from becoming bogged. This is accomplished by pumping from an adjacent cut to discharge beyond a barrier mound which forms the road across the lake.

Gypsum is tipped into a hopper and conveyed to a double deck vibrating screen (25 mm and 12.5/6.3 mm) where it is wet-screened with brine pumped from the lake at 23-25 litres/sec (18 000-20 000 gph). Screen undersize falls to a concrete tank from which it is transferred by a Warman gravel pump to a 600 mm (24") hydrocyclone. Cyclone underflow is treated in a screw washer and conveyed to stockpile. The material is then picked up by front end loader and trucked to the main stockpile where it is left to leach by rainfall.

Screen oversize is either dumped or used to form roads or drainage floors for the stockpiles. The oversize comprises mainly fragments of rock gypsum, incorporated when the flour gypsum was originally removed as overburden, and vegetative material.

Approximately 20 x 27-tonne semi-trailer loads per week are hauled to the Australian Gypsum factory at Port Adelaide. The salt content of about 0.8% on delivery is reduced by spraying with fresh water.

MARION LAKE - ADELAIDE BRIGHTON CEMENT LTD

1. GENERAL

LOCATION	Western end of Marion Lake, 3 km NW Stenhouse Bay (Fig. 19)
OPERATOR	Adelaide Brighton Cement Ltd.
ADDRESSES	
Local	Klein Point, Stansbury, 5582 Tel. (088) 52 4104
Head Office	Charles Street, Birkenhead, 5015. Tel. 49 0400
MINERAL TENURE	Sublease from Waratah Gypsum Pty Ltd

2. PRODUCTION

MINERAL PRODUCED	Rock Gypsum (selenite)
PRODUCT GRADE	90 - 94% $CaSO_4 2H_2O$
ANNUAL PRODUCTION (1988)	14 640 tonnes (Fig. 25)
RESERVES	60,000 tonnes indicated (company estimate)
PRODUCT USES	Cement manufacture
DESTINATION	Birkenhead
WORKFORCE	Ex. Klein Point. Worked for 2 weeks every 2 years to establish stockpile.

3. HISTORY

See: Waratah Gypsum Pty Ltd, Marion Lake. ABC has worked the lake since 1976.

4. GEOLOGY

See: Waratah Gypsum Pty Ltd, Marion Lake.

5. OPERATIONS

A thin cover of gypseous detritus and stromatolitic limestone is windrowed exposing the hard surface of the rock gypsum which, although having a hardness of 2 on the Mohs scale, is very resistant to ripping. 30-40, 50 mm blast holes are drilled to 0.8-0.9 m with a jackhammer and star bit, and fired with gelignite and cordtex. The rock gypsum is about 1.2 m thick with water table at about the base of the gypsum. the blasted material is excavated by backhoe which stands on the unblasted surface and transfers the gypsum to stockpile to drain.

Mining takes place around April every two years. The stockpiles are reclaimed in winter by contractor and carted and stockpiled at Klein Point. The material is then blended by truckload into the Dixie hammer mill 50/50 with seed and flour gypsum from Lake Fowler, conveyed directly to the jetty, and shipped to Birkenhead in the Company's ship, Accolade II.

LAKE FOWLER - ADELAIDE BRIGHTON CEMENT LTD

1. GENERAL

LOCATION	Lake Fowler. 11 km west of Edithburgh (Fig. 19)
OPERATOR	Adelaide Brighton Cement Ltd. under sublease agreement with CSR Ltd.
ADDRESSES	
Local	Klein Point, Stansbury, 5582. Tel. (088) 524104.
Head Office	Charles St, Birkenhead, 5015. Tel. 49 0400
MINERAL TENURE	ML 38, 240, 599, 614

2. PRODUCTION

MINERALS PRODUCED	Seed (gypsarenite) and flour gypsum
PRODUCT GRADE	93% $CaSO_4 2H_2O$ (main dune)
ANNUAL PRODUCTION (1988)	16 190 tonnes (Fig. 26)
RESERVES	307,000 tonnes (company estimate, main dune, 1984)
PRODUCT USES	Cement manufacture
DESTINATION	Birkenhead
WORKFORCE	Ex. Klein Point

3. HISTORY

The SA Gypsum Co. acquired unworked gypsum leases at Lake Fowler in 1898 and began production in 1905, exporting most of the product to New Zealand for cement manufacture (King, 1952). CSR took over the leases in 1957 and sub-let production rights to Adelaide Cement Ltd from 1963. The leases were transferred to Adelaide Brighton Cement Ltd in 1984.

4. GEOLOGY

Lake Fowler is the largest of a number of shallow saline lagoons in the southeastern part of Yorke Peninsula. The lakes were developed initially as solution features, in a Miocene limestone bed, and were later enlarged by corrosion and wave action. The limestone is underlain by Permian glacial clay which forms a bed to the lakes.

The lake is inundated with water in winter, mainly by groundwater seepage, but dries out in summer depositing salt and gypsum. Summer winds blow the gypsum towards the southeastern margins of the lake, where extensive gypsum dunes have accumulated. The dunes extend for 3 km along the lake shore, but are of higher grade in the southern part which is known as the 'main gypsum dune'. The dune is composed of seed and flour gypsum in an estimated ratio of 2:1, and contains minor calcium carbonates, sodium chloride and clay bands (King, 1952).

A small secondary dune, to the south of the main dune, contains further reserves. The 'northern' dune of low quality gypsum to the northeast of the main dune is no longer worked.

5. OPERATIONS

The gypsum is first loosened and pushed into heaps with a D6 bulldozer, operated by the local council, and then picked up by front end loader and carted to Klein Point by contractor. The material causes handling problems due to the flour gypsum component which becomes sticky under damp conditions. Stockpiled Lake Fowler gypsum is therefore blended with rock gypsum from Marion Lake 50/50 by truckload into the Dixie hammer mill, and conveyed directly to the jetty for shiploading. Agitation with the coarser rock gypsum breaks up and mixes the flour gypsum producing a more easily handled product.

The gypsum is shipped to Birkenhead in the Company's ship, Accolade II.

BLANCHETOWN - DAVID LINKE CONTRACTOR PTY LTD

1. GENERAL

LOCATION	5-8 km east and southeast of Blanchetown (Fig. 19)
OPERATOR	David Linke Contractor Pty Ltd.
ADDRESSES	
Office	Angaston Road, Nuriootpa, 5355 Tel. (085) 62 1500
Plant	Blanchetown Road, Nuriootpa
MINERAL TENURE	RL 73, ML 650-653, 656-57, 738-39, 4920-22.

2. PRODUCTION

MINERAL PRODUCED	Gypsarenite
PRODUCT GRADE	Run of mine ore from the upper half of the gypsum bed averages 81-85% gypsum decreasing with depth as clay content increases. Two grades are produced at Nuriootpa: - Fine (minus 6 mm) 88% $CaSO_4 2H_2O$ - Coarse (plus 6 mm) 93% $CaSO_4 2H_2O$.
ANNUAL PRODUCTION (1988)	36 790 tonnes (Fig. 28)
RESERVES	9.6 million tonnes indicated, 20 million tonnes inferred plus substantial additional undefined reserves (Barnes and Warren, 1980).

PRODUCT USES & DESTINATIONS:

Cement (Angaston), plaster (Port Adelaide), soil conditioner (Adelaide & Tasmania).

WORKFORCE	2

3. HISTORY

Production of flour gypsum from the weathered surficial deposits was first recorded by C.D. Bartsch in 1940 and used for agricultural purposes and in the manufacture of tartaric acid (Johns, 1954).

The underlying rock gypsum has been used in cement manufacture at Angaston since 1955. David Linke Contractor Pty. Ltd. took over the leases in December 1977.

4. GEOLOGY

The gypsum deposits, described by Barnes and Warren (1980), are situated on the Blanchetown Plain within Quaternary sediments. The underlying Tertiary rocks comprise yellow brown calcarenites of the Morgan and Mannum Limestones overlain by the Pliocene North West Bend Formation which is characterised by marine sand and sandy limestone with oyster shell beds.

The weathered surface of the North West Bend Formation is overlain by Pleistocene Blanchetown Clay, a mottled red-brown and green clay containing sandy lenses. The Blanchetown Clay is obscured by Holocene units including calcrete of the Bakara Soil and red-brown aeolian sand of the Woorinen Formation.

The gypsum was deposited under evaporitic conditions in valley lakes developed during the latter stages of deposition of Blanchetown Clay. The exploitable gypsum forms a massive, well bedded gypsarenite unit, 1.1-3.6 m thick with intercalated clay. Development of depressions, to depths approximately equivalent to the upper weathered surface of the North West Bend Formation, was accompanied by removal of gypsum by aeolian deflation and groundwater solution. Mobilized gypsum was re-deposited above and below the main gypsum layer in clays and in Tertiary rocks. Weathered gypsum now crops out around the margins of depressions developed by solution of Tertiary limestone, and is found as individual crystals of seed gypsum or as gypsum flour, which in places has been reworked into low dunes.

5. MINING & PROCESSING

Following stripping and stockpiling of soil, calcrete, sand and clay, the massive crystalline gypsum is ripped with a bulldozer. The loose material is then dug out with a front end loader and passed over a double deck screen (152 mm; 20 mm). Oversize is loaded onto trucks for transport to the

Nuriootpa plant (Fig. 27). The intermediate fraction is stockpiled for possible later use and the undersize used for backfilling. Minus 152 mm is 5-40% of total feed, depending on whether it is dug from crystalline or interbedded clayey areas.

At Nuriootpa, the gypsum is stockpiled under-cover prior to transfer by front end loader to a truck for tipping to a jaw crusher of 35 t.p.h. capacity. The feed bin to the jaw crusher is equipped with a hand-manipulated grid to divert fines past the jaw crusher. Feed bin and crusher products feed a hammer mill, products from which are elevated to a 6.3 mm fixed screen. Products fall to fine and coarse stockpiles.

The crusher is operated on demand with 500-1,000 tonnes per week going to CSR, 1,200-1,500 tonnes per month to Adelaide Brighton Cement and small quantities despatched for agricultural uses.

6. MARKETS

The fines (88% $CaSO_4 2H_2O$) are sent to Adelaide and Tasmania for agricultural purposes, notably mushroom growing. Of the coarse material (93% $CaSO_4 2H_2O$) 75% is trucked to CSR at Port Adelaide for plaster manufacture and 25% to Adelaide Brighton Cement at Angaston.

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LIMESTONE

In 1988, 1.9 million tonnes of limestone, with an ex-mine value of $7.4 million were produced for industrial use. 68% was used in the manufacture of cement clinker from which about 15% of Australian cement production is manufactured in South Australia and Queensland. 25% is used at Australia's sole soda ash plant at Osborne. Most of the soda ash is used in Australia primarily in glass manufacture, but also in soap, detergent, pulp and paper, chemical manufacture, water treatment and acid neutralisation. 1987 exports of soda ash have been conservatively valued at $0.7 million FOB. The remainder of the State's limestone is used as flux in glassmaking and smelting, as a filler in plastics and other products, and as agricultural lime.

South Australia's principal limestone resources are:

- Klein Point, on Yorke Peninsula
- Penrice, near Angaston
- Rapid Bay, on Fleurieu Peninsula
- Coffin Bay, 40 km west of Port Lincoln
- Caroline, south of Mt Gambier
- Parham, 70 km northwest of Adelaide

The Adelaide Cement Co Birkenhead plant began cement production in 1915 using limestone from a quarry at Stansbury. Quarrying began at nearby Klein Point in the early 1920s. 0.84 million tonnes were produced in 1988 from an estimated reserve of 200 million tonnes and shipped to Birkenhead in the company ship Accolade II.

Penrice quarry was first worked for soda ash production by ICI in 1950. Its use in cement production followed completion of the SA Portland Cement Co plant at Angaston in 1954. 45% of the total 1988 production of 1.1 million tonnes was used in soda ash production at Osborne. Measured reserves exceed 20 million tonnes.

Rapid Bay quarry began production in 1943, supplying flux to the Whyalla steelworks. Adelaide Brighton Cement have been using the marble at Birkenhead since 1975 and acquired tenure of the deposits from BHP in 1981. Indicated reserves of about 100 million tonnes are ample to sustain current production (100,000 tonnes in 1988).

From 1966-72 limesand from Coffin Bay, was used as flux at BHP's blast furnaces at Whyalla, Newcastle and Port Kembla, and has been used by BHAS at Port Pirie since 1968. 17 220 tonnes were produced in 1988 from enormous reserves in coastal dunes.

The limestone at Caroline and the shellgrit at Parham are worked by ACI, primarily for flux in glass production. The current operation at Parham began in 1978 and around 16 000 tonnes are mined annually for use at the Croydon West plant. Mining at Caroline began in 1979 and 80% of production (40 000 tonnes in 1988) is trucked to glassmaking plants in Melbourne. Reserves at both deposits are estimated at 1 million tonnes.

KLEIN POINT - ADELAIDE BRIGHTON CEMENT LTD

1. GENERAL

LOCATION	Klein Point, 5 km southwest of Stansbury (Fig. 29)
OPERATOR	Adelaide Brighton Cement Ltd
ADDRESSES	
Local	Klein Point, Stansbury, 5582 Telephone (088) 52 4104
Head Office	Charles Street, Birkenhead, 5015 Telephone 49 0400 (P.O. Box 77, Port Adelaide, 5015)
MINERAL TENURE	ML 2912, 3028, 3029, 3180-3195, 3349-3358, 4012-4015 MPL 11 RL 27, 28, 41

2. PRODUCTION

MATERIAL PRODUCED	Limestone
PRODUCT GRADE	Min. burning grade 79% total carbonates (TC) Normally about 88% TC Max. SiO_2 12% Max. MgO 2% Max. Cl 0.08%
ANNUAL PRODUCTION (1988)	843 040 tonnes (Fig. 31)
RESERVES	Approx. 200 million tonnes (company estimate)
PRODUCT USES	Cement manufacture
DESTINATION	Birkenhead
WORKFORCE	21. Single shift. Overtime on weekends as required.

3. HISTORY

The Adelaide Cement Co Ltd was formed in 1913, and from 1914 to 1920, quarried limestone at Stansbury. Cement production commenced at Birkenhead in 1915. In 1925, the company commenced quarrying at Klein Point 6.5 km to the south of Stansbury (Armstrong, 1952). Drilling was carried out by SADME in 1947-48 and 1961-63 to establish quality and reserves (Anonymous, 1949; Johns, 1967).

Cement manufacture at Brighton, initiated in 1892, was expanded by the South Australian Portland Cement Co. in the late 1890's using locally quarried limestone and, later, material from an area near Reynella, 6.5 km to the south. Reserves were depleted by the late 1940's and the company transferred operations to Angaston in 1950 (Valentine, 1983).

The Adelaide Cement Co and the South Australian Portland Cement Co amalgamated in 1971 to form Adelaide Brighton Cement Ltd.

4. GEOLOGY

The material quarried is Tertiary fossiliferous limestone of the Port Willunga Formation. The limestone is offwhite, buff, yellow-brown and pink, variably consolidated with lenticular bands of hard pink limestone.

The fossiliferous calcarenite is around 30 m thick and grades downwards into about 8 m of yellow-brown ochreous marly limestone which overlies sandy limestone, grit and glauconite beds.

Overburden comprises 3-4 m of variably magnesian calcrete. The lower 2 m is high in clay, which also fills solution cavities and pipes extending up to 20 m below the surface.

The hard bands require blasting (about twice/year) and are more prevalent in the southern third of the quarry where high quality stone is blended with clayey and magnesian overburden to produce a product within chemical specification. In the northern part of the quarry the bands are thinner, and more frequent blasting (once a week) of lesser intensity is required.

5. OPERATIONS

Quarrying

The quarry is worked from three limestone benches with a total working face of 25 m, and one overburden bench below a 5 m face. Soil is stripped and stockpiled. Overburden is ripped with D10 and occasionally D9 bulldozers and stockpiled for blending or for use as backfill.

The limestone is cross-ripped with the bulldozer which then pushes the material down 25° faces to a lower bench where it is picked up by two 5.4 m^3 Caterpillar 988B front-end loaders and carted to the crusher in three 35 tonne Caterpillar 769B dump trucks. Hard layers are percussion-drilled by contractors using a Gardner-Denver machine. Holes are 127 mm diameter and up to 12 m deep on a 2.7 x 2.7 m pattern, and are fired with ANFO. Secondary breakage is carried out by a Mitsubishi rock-breaker.

Extension of the quarry to the west and south proceeds by negotiation with adjacent landowners. The market value of the land, assessed at current rates by independent valuation, is paid to the landowner who also receives royalties during quarrying. After backfilling and replacement of topsoil, the land is passed back to the landowner free of charge.

The effect of disturbance of the soil structure is illustrated by comparison of the reported yield of 4 bags of barley to the acre from the first planting of reclaimed land with that of 16-18 bags to the acre in the same season from undisturbed land.

Quality Control

Limestone is sampled from the face and tested for TC, SiO_2, MgO, Cl, Na_2O, K_2O, Fe_2O_3, Al_2O_3 using a Limestone Analyser, installed by Amdel in late 1986. Averages are taken for each shipload, enabling addition of "fringe materials" (SiO_2, Fe_2O_3, Al_2O_3) immediately on delivery at Birkenhead. Then only XRF verification and final adjustments are necessary before burning. The installation of the analyser has made it possible to blend some of the clayey and high MgO overburden into the shipments, and enabled quicker processing on delivery.

<u>Crushing</u>

Crushed rock is tipped onto an apron feeder and into a Dixie hammer mill rated at 700-800 tph in which the feed is reduced to 90% minus 25 mm. Average throughput of 480 t.p.h reduces to 200-300 tph when crushing the hard pink limestone. Milled rock is conveyed direct to the jetty for shiploading or to storage facilities for later reclamation. These comprise an overhead distributor over a 6 000 tonne storage bin from which the limestone is assisted by screw feeders, through manually operated gates, to the conveyor and shiploader (Fig. 30).

The rock is shipped to Birkenhead in the company-owned MV <u>Accolade II</u>. The ship is warped past a retractable boom to distribute the load which averages 5 000 tonnes per trip (maximum 8 000 tonnes). About 190 trips per year are made.

PENRICE - PENRICE SODA PRODUCTS PTY LTD

1. GENERAL

LOCATION	Penrice, 2 km north of Angaston (Fig. 29)
OPERATOR	Penrice Soda Products Pty Ltd
ADDRESSES	
Local	P.O. Box 234, Angaston 5353 Telephone (085) 64 2198
Head Office	Solvay Road, Osborne 5017 Telephone 248 8200
also	Industry House 12 Pirie Street, Adelaide 5000
MINERAL TENURE	PM 86, 104, 120

2. PRODUCTION

MATERIAL PRODUCED	Marble
PRODUCT GRADE	84-98% $CaCO_3$
ANNUAL PRODUCTION (1988)	489 500 tonnes by rail to Osborne for chemical manufacture. 227 390 tonnes to Adelaide Brighton Cement at Angaston by road for cement manufacture (also trucked to Birkenhead when "Accolade II" not operating). 80 500 tonnes by road to Adelaide Brighton Cement at Angaston for lime manufacture. 4 180 tonnes "calcite" by rail to ACI Pilkington Dandenong. 37 720 tonnes "whiting" by road to Commercial Minerals, Beverley and Gillman. 12 390 tonnes flux to BHP Whyalla, Mitsubishi Motors Australia Ltd, ANR and Mason and Cox by road. 4 220 tonnes by road to David Linke Contractor for agricultural use. 61 860 tonnes screenings 136 760 tonnes rubble 23 220 tonnes crushed rock
TOTAL PRODUCTION	1 077 740 tonnes (Fig. 33)

D00069

RESERVES	25 million tonnes measured plus additional large indicated tonnage
PRODUCT USES	Na_2CO_3 (Soda Ash), $CaCl_2$, cement, roadstone, lime, whiting, glass, tiles, concrete aggregate, flux.
DESTINATION	See attached sheet.
WORKFORCE	39
WORKING HOURS	8am - 4pm, 7 days per week.

"whiting" is minus 43 mm plus 32 mm gravel and 250 mm quarry spalls.
"flux" is gravel, sold in a range of sizes depending on customer preference.
"calcite" is minus 2.6 mm produced in a separate plant from minus 32 mm gravel.
agricultural lime is produced from surplus gravel as minus 2.6 mm for soil conditioning and minus 3.5 mm plus 2.6 for poultry feed.

3. HISTORY

Planning for the construction of an alkali plant by I.C.I. on Lefevre Peninsula at Osborne began in the early 1930's. By 1936, factory construction had begun and salt fields laid out and equipped at Dry Creek (Anonymous, 1936a). In 1939 a marble quarry was opened at Angaston and salt stockpiled at Dry Creek (Anonymous, 1939; 1940). The factory began operation in 1941 (Ward, 1941).

Departmental drilling of another large marble deposit close to Angaston at Penrice began in 1945 (Miles, 1949). I.C.I. began using marble from Penrice in 1950, having sold their Angaston quarry to S.A. Portland Cement Co. in 1949. The cement company then built a plant at Angaston, which began operation in 1954.

In 1989, ICI sold its soda ash business, including the Penrice marble and Dry Creek salt deposits, to Penrice Soda Products Pty Ltd.

4. GEOLOGY

The marble deposits are part of the Early Cambrian Normanville Group, deposited originally as reef limestone and later recrystallised in Cambro-Ordovician times. The marble comprises three main horizons, collectively termed the Angaston Marble, interbedded with greywacke, siltstone, schist, quartzite and calc-silicate (Scott, 1982). The marble at Penrice varies from 180 m to 280 m in the south of the quarry area, and reaching a maximum of 750 m further to the southeast beyond the quarry.

The marble is white, pink, pale brown and grey and is located on the near-vertical eastern limb of a southerly plunging, partially overturned anticline. The marble bed comprises a high grade central zone flanked by narrower zones up to 85 m thick, with $CaCO_3$ content less than 95 per cent. The lower grade zones are darker in colour due to contaminant minerals and interbedded calc-silicate rocks. Contamination is also caused by steeply dipping hematite/goethite veins which diminish with depth.

5. OPERATIONS

Mining

108-114 mm diameter holes are drilled on a 3.3 x 4 m pattern using an Atlas Copco ROC 604 downhole hammer drill or a Damco tracked rotary drill. Holes are drilled at 80° from horizontal to a total depth of 15 m including 1.5 m subgrade, and charged with ANFO, with molanite in wet holes. Average bench height is around 14 m. Firing usually takes place twice a week.

Broken rock is loaded by an O&K RH 75 5.3 m^3 hydraulic shovel and one Komatsu WA 600 wheeled loader into three 35 tonne Wabco, two 50 tonne Terex and one 50 tonne Komatsu dump trucks for cartage to the crushing plant (Fig. 32). A 1¼ tonne hydraulic rockbreaker is contracted to reduce oversize blocks to about 250 mm diameter. An RB 100 electric face shovel and two Wabco 35 tonne dump trucks are used for overburden removal and one Wabco has been converted to a water truck. A Furukawa 230 front end loader and a Mercedes truck are used for stockpile control.

Workings in the southern quarry have been suspended at RL 300, at approximately 85 m below surface. Current operations at RL 328, to the north of the main quarry, are nearly completed. Deepening of the northern quarry will continue to level RL 300 when both quarries will join and be worked concurrently. The southern pit is being widened by 40 m to the east and overburden used for screening mounds. These are covered with topsoil and sown to grass. Native trees are then planted, currently at a rate of about 1 000 per year.

Hematite from vertical veins is sold to Adelaide Brighton Cement for cement manufacture.

Processing

Broken rock is tipped through an Allis Chalmers 78 x 54 hydraulic cone crusher on the twin vibrating feeders which discharge to a conveyor and 750 tonne surge pile of 225 mm rock.

The surge pile is reclaimed by two vibrating feeders which discharge on to the conveyor from the old, now disused jaw crusher to a double deck vibrating screen (114 and 38 mm decks). Undersize is fed to a two way distributor, feeding an overhead bin and stockpile for use as roadbase, and in cement. Oversize is reduced in a secondary roll crusher (set at 127 mm) and fed, with the intermediate fraction, to a double deck vibrating screen (105 mm and 43 mm decks).

Oversize is recrushed in a 1.2 m Traylor cone crusher in closed circuit with the screen. The intermediate size (minus 105, plus 43 mm) is sent to an overhead stacking conveyor where it is discharged to stockpile by a moving tripper. This stockpile is discharged through 14 manually operated gates onto a conveyor which runs through a concrete tunnel under the stockpile. The intermediate sized material may also be fed directly to the tunnel conveyor during trainloading which takes place between 11 am and 3 pm, seven days a week.

At these times undersize is retained in a bin for use in lime manufacture by Adelaide Brighton Cement; otherwise it is fed directly through the tunnel conveyor to the gravel plant.

The tunnel conveyor feeds a small 50 mm vibrating screen, oversize from which falls into a bin which loads 55 tonne rail wagons through two discharge gates located over a double railway track. The wagons are winched down the tracks on wire hawsers operated from a winding house. 28 wagons per day are despatched to the Osborne kiln which, due to the heat transfer characteristics of the marble, can only use the minus 105 mm plus 43 mm screenings which constitutes about 40% of total production. A relatively small amount of undersize passes the 50 mm screen during trainloading due to the large volume of material passing over it and feeds the gravel plant. Plant capacity of about 3 000 t.p 12 hour day using a jaw primary crusher was improved to 5 000 t.p 8 hour day after installation of the Allis Chalmers hydraulic cone primary crusher. This resulted from no longer having to free large rocks caught in the old primary jaw crusher.

Feed to the gravel plant is first sieved on a triple deck vibrating screen (43 mm, 32 mm and 20 mm decks). Feed may also be directed to a Pegson cone crusher and minus 43 mm is either re-crushed in the Pegson or fed to the 43 mm bin. Minus 32 mm is fed to the 32 mm bin and undersize to the scalps bin. The cone crusher feeds another triple deck vibrating screen (20 mm, 10 mm and 4 mm decks), producing 32 mm 20 mm, 10 mm and sand. Gravel plant capacity is 250,000 tonnes per year.

Gravel is sold for roadbase or concrete and to B.H.P. Whyalla, Mitsubishi Motors, ANR and other Adelaide foundries for flux and to Commercial Minerals as whiting. Surplus gravel is sold to ABC for lime manufacture or hammer milled and screened in a separate plant producing a minus 8 mesh product ("calcite") for ACI Pilkington, Melbourne, a minus 2.6 mm agricultural lime and a minus 3.5 plus 2.6 poultry feed.

At Adelaide Brighton's cement plant at Angaston the marble is tipped into a 42 x 30" Hadfield 112 HP jaw crusher set at 6". This discharges into a 300 HP Jaques hammer mill, from which the material is conveyed to a storage gantry. Ironstone from Penrice and shale from Truro and Moculta are crushed by the same equipment. The gantry is serviced by an overhead crane which feeds the blending section of the cement plant.

The plant produces lime and a range of cements. The main product is Portland cement which may be mixed with 20% Port Augusta fly ash (which has cementitious properties) to produce blended cement which is used for all but the strictest specifications. Finer grinding of clinker produces a High Early Strength cement. Oil-well cements and sulphate-resistant cements are manufactured to pressure-resisting specifications and an off-white cement called Brightonlite is also made. Two lime products, quicklime and hydrated lime, are manufactured. Plant capacity is 300,000 tonnes per year.

RAPID BAY - ADELAIDE BRIGHTON CEMENT LTD

1. GENERAL

LOCATION	Rapid Bay (Fig. 29)
OPERATOR	Adelaide Brighton Cement Ltd.
ADDRESSES	
Local	Rapid Bay, 5024 Telephone (085) 59 4056
Head Office	Charles Street, Birkenhead, 5015 Telephone 49 0400
MINERAL TENURE	PM 11, 12

2. PRODUCTION

MATERIAL PRODUCED	Marble
PRODUCT GRADE	(Typical),%: SiO_2-4; Al_2O_3-0.8; CaO-51; MgO-1.3, K_2O-0.28; Fe_2O_3-1.8; P_2O_5-0.02; MnO-0.05; ZnO-0.005; SO_3-0.11. Loss -41.4 90.5% $CaCO_3$
ANNUAL PRODUCTION (1988)	91 050 tonnes (cement), 10 860 (crushed rock), 2 380 (agricultural) (Fig. 35)
RESERVES	100 million tonnes
USES	Cement manufacture
DESTINATION	Birkenhead
WORKFORCE	13
WORKING HOURS	5 days per week, 8 hours per day.

3. HISTORY

B.H.P. commenced excavation and plant installation in 1940 (Anonymous, 1941). Production commenced in August, 1942 (Anonymous, 1943), supplying flux to the Whyalla Steelworks and, from about 1975, cement raw materials to Adelaide Cement Co. Ltd. at Birkenhead. The quarry was sold to Adelaide Brighton Cement Ltd. in 1981.

4. GEOLOGY

The material is quarried from a body of grey, white and brown, medium to coarse grained, banded, heavily jointed Cambrian marble of the Normanville Group. The marble displays abundant manganese dendrites and is contained as a lens, 200-300 m thick, within a northeasterly-trending overturned syncline. The unit is overlain by phosphatic shale, and overlies Adelaidean quartzite and siltstone of Marinoan age.

5. OPERATIONS

The five-bench quarry is worked 5 days per week for eight hours per day. 76 mm diameter blastholes are drilled with a crawl I.R. percussion drill on a 2.6 m square pattern (fired diagonally) to 11 m including 2 m sub-grade. 60-70 holes are fired every 3 weeks using ANFO, producing 12-15 000 tonnes of shot rock. Secondary breakage is carried out using an air hammer as required.

The broken rock is loaded with either a 3 m^3 Ruston Bucyrus electric shovel or a 5 m^3 Hough 560 B front end loader into two 35 tonne Euclid dump trucks for cartage to the crushing plant (Fig. 34). Haul roads are maintained with a Caterpillar grader.

The rock is tipped via an apron feeder into a 1.5 x 1.2 m (60" x 48") Vickers Ruwolt jaw crusher, product from which is stored in a 100 tonne surge bin. The surge bin discharges into a 1.2 m (4") Jaques TY gyratory crusher which feeds 3.7 m x 1.4 m double deck screen. Screen apertures vary according to gyratory settings but most commonly are 38 mm and 19 mm. Plus 19 mm is stored in a 10700 tonne capacity bin with the aid of a distributing conveyor. Material greater than 50 mm cannot be used by the wet kiln at Birkenhead and when produced by the gyratory, is rejected by a 50 mm upper deck for stockpiling and re-crushing. Minus 19 mm is screened on a 6.3 mm screen (3 x 1.2 m) and both oversize and undersize are stored separately in 1600 and 200 tonne bins respectively for use as road rubble. Surplus material is stockpiled on the beach.

The storage bins discharge through twenty manually operated gates onto a conveyor which carries material along a T-head jetty, 488 m long with a T-head length of 224 m. Four ships per month are loaded with approximately 6000-8000 tonnes for shipment to Birkenhead in the company ship, MV Accolade.

During 1988, ABC Ltd. scaled down quarrying operations at Rapid Bay in favour of increased production of limestone from the Klein Point quarry for cement manufacture at Birkenhead works (Anonymous, 1987). Crystalline marble from Rapid Bay requires additions of alumina, silica and iron not readily available within the quarry area and currently supplied, in part, from local Adelaide quarries. In contrast, overburden at Klein Point is selectively blended with limestone and can be made ready for firing at lower cost. Annual production is expected to decrease by half with a reduction in the workforce to 5. The bulk of production will continue to be used in cement manufacture at Birkenhead but supplies of other quarry products such as coarse aggregate, fill and agricultural limestone will be maintained for local markets.

A proposal to ship about 1.5 million tpa of Rapid Bay marble to Brisbane for manufacture of clinker is under consideration.

COFFIN BAY - BHP LTD

1. GENERAL

LOCATION	7 km southeast of Coffin Bay (Fig. 29)
OPERATOR	B.H.P. Ltd.
ADDRESSES	
Local	B.H.P. c/- P.O., Port Lincoln. Tel. (086)822444
Head Office	B.H.P. c/- Coffin Bay Post Office 5607 Tel. (086)854006 B.H.P. Ltd. Port Augusta Road, Whyalla (P.O. Box 21) 5600 Telephone (086) 40 4444
Shipping Terminal	B.H.P. Box 231, Port Lincoln 5606
MINERAL TENURE	ML 3259-3328

2. PRODUCTION

MATERIAL PRODUCED	Limesand
PRODUCT GRADE (%)	CaO 51.2, Fe_2O3 0.1-0.2, SiO_2 0.84-0.86, Al_2O_3 0.14-0.21, P_2O_5 0.046, MgO 2.8%, MnO 0.02, S 0.133, TiO_2 0.01, Cu 0.005, Zn 0.003, K_2O 0.038. Max. moisture 5% for Pt. Pirie, usually 4% indune and 3% onship.
ANNUAL PRODUCTION (1988)	17 220 tonnes (Fig. 37)
RESERVES	350 million tonnes.
PRODUCT USES	Flux in smelting
DESTINATION	Port Pirie
WORKFORCE	4:- Manager (drives trucks and operates shiploader), train driver/electrician, shovel driver (permanently at Coffin Bay), mechanic.

3. HISTORY

A large deposit of chemically suitable limesand was located at Coffin Bay in 1959 (Johns, 1961) during exploration for soft limestone suitable for blast furnace flux, and was subsequently drilled by SADME (Johns, 1963, 1967). Leases were granted to BHP in 1965 and operations commenced in 1966, supplying blast furnaces at Whyalla, sinter plants at Newcastle and Port Kembla and, from 1968, the BHAS lead smelters at Port Pirie. However from 1972, following the development of coal exports, the 500 000 tonnes shipped annually to the Whyalla and eastern States' smelters was replaced by backloaded Japanese limestone fines, and fines from Marulan. Coffin Bay now supplies only BHAS and local farmers and councils.

4. GEOLOGY

Exposure of broad expanses of the continental shelf in the Middle and Late Pleistocene resulted in the accumulation of extensive dunes (Bridgewater Formation) composed of shell fragments which now cover large areas adjacent to the coast of southern Eyre Peninsula. The dunes consist of loosely aggregated or unconsolidated white to buff coloured well-sorted calcareous sand, and are over 200 m thick in places (Johns, 1961). A thin crust of calcrete has developed as a result of near surface solution and recrystallization.

Mobile dunes equivalent to the Holocene Semaphore Sand, derived from blowouts in the older dunes are encroaching in a northeasterly direction over the older system in the area between Coffin Bay and Shoal Point to the south. These dunes, up to 60 m high, have moved to 10 km inland along a 13 km front, and are composed almost entirely of calcium carbonate grains. The limesands are easy to mine and are generally free of overburden and vegetation. Further to the west, the dunes are fixed by a thin vegetative cover, and contain a small proportion of impurities.

5. OPERATIONS

The limesand is mined directly from the dune with a 3½ c.yd RB54 electric shovel and loaded into three 18 tonne Scamel Himalayan dump trucks. The material is dumped through a grid into a hopper and elevated to three 1000 tonne overhead storage bins (Fig. 36). 80 tonnes are loaded into each of twelve 26 tonne rail trucks for the 1.3 hour journey to the Port Lincoln shipping terminal on a 1.43 m gauge track.

4 trains per week are despatched in the weeks preceding shipments to Port Pirie in January and October.

At the shipping terminal, the trucks are unloaded by a tipper into a hopper. The hopper discharges via two vibrating feeders onto an elevating conveyor which feeds the 28000 tonne storage bin. Limesand is discharged onto the jetty conveyor through 25 manual gates along the base of the bin. Shiploading is achieved using a moveable gantry allowing the ship to remain stationary. Loading rate is 1800 tonnes per hour.

Superphosphate from Top Australia's Port Lincoln plant is also loaded at the terminal. Truck loads are tipped onto the ground adjacent to the conveyor and the material fed by front end loader through a hopper mounted above the conveyor. About 360 tonnes per hour can be loaded in this manner.

CAROLINE - ACI RESOURCES LTD

1. GENERAL

LOCATION	Caroline area, 28 km southeast of Mount Gambier on Nelson Road (Fig. 29)
OPERATOR	ACI Resources Ltd.
ADDRESSES	
Local	P.O. Box 2173 Mount Gambier 5290 Telephone (087) 38 4096
Administration	McDonald's Track (PO Box 192), Lang Lang VIC 3984 Tel. (059) 97 5402
MINERAL TENURE	ML 4810-4811, 5155, EML 5180

2. PRODUCTION

MATERIAL PRODUCED	Limestone
PRODUCT GRADE	CaO: 54%, MgO: 0.9%, SiO_2: 0.7% - 1.9%, Fe_2O_3: 0.08% - 0.1%, Brightness 70
ANNUAL PRODUCTION (1988)	40 050 (28000 tonnes glass grade to A.G.M., 4 620 tonnes fines to ACI Fibreglass, 3 282 tonnes agricultural, 4 150 tonnes to Commercial Minerals as filler (Fig. 39).
RESERVES	1 million tonnes
PRODUCT USES	Glass, filler, agricultural lime
DESTINATION	Australian Glass Manufacturers, Melbourne; ACI Fibreglass, Melbourne; Commercial Minerals, Adelaide; Commercial Minerals, Melbourne.
WORKFORCE	4 in 2 shifts, plus mining contractors.

3. HISTORY

ACI have been working the Caroline deposit adjacent to the Nelson Road since 1979 and current production is from this deposit. Minerals Pty Ltd began extracting limestone from the Honeysuckle deposit, 6 km to the northeast, in 1981 and these leases were acquired by ACI later in the same year.

4. GEOLOGY

The deposit is in the Gambier Limestone, a marine Oligo-Miocene formation consisting almost wholly of bryozoal and shell remains. In the Caroline area, the limestone is exceptionally white, contains a significant silt-sized and finer carbonate fraction and is low in deleterious non carbonate materials such as sand, silt, clay, dolomite, flint, iron and manganese.

The limestone is cut by a prominent set of joints oriented at 125° which have been re-cemented and stand in relief from the limestone surface. Overburden, comprises about a metre of soil and discoloured limestone. The depth to water table is about 8 metres.

5. OPERATIONS

After removal of topsoil and overburden, the limestone is ripped with a bulldozer and carried by scraper to a stockpile adjacent to the plant (Fig. 38). A front end loader tips stockpiled material over a 35 mm vibrating scalper, oversize passing through a Jaques jaw crusher. The limestone is then elevated to a 40 tonne bin which feeds two 0.9 x 12.2 m, Armstrong Holland gas-fired rotary driers via a screw conveyor system. Dried material is elevated to a 1.8 m diameter Kason screen with a 10 mm upper deck and interchangeable 1.2 and 2.0 mm lower decks for glass grade and agricultural grade production respectively. Undersize is stored undercover for despatch to Australian Glass Manufacturers, Spotswood while oversize is passed through a hammer mill and returned to the driers. Middlings are fed by screw conveyor to a Raymond mill which discharges to an Alpine air classifier. This feeds a 100 tonne silo from which pressure tankers are loaded for delivery to Australian Fibreglass Melbourne. The Raymond mill is also fed from the pit stockpile when increased silo production is required. When the Raymond mill is full or not working, middlings are discharged to a stockpile for sale as filler grade.

Exhaust gases from the driers, containing limestone dust, are blown into two cyclones from which oversize is screw-fed to the air classifier from which undersize goes to the silo. Classifer oversize in returned to the Kason screen. Cyclone undersize is passed to two dust collectors and exhaust gases are vented to the atmosphere.

PARHAM - ACI RESOURCES LTD

1. GENERAL

LOCATION	4 km north of Parham, 60 km NW of Adelaide (Fig. 29)
OPERATOR	A.C.I. Resources Ltd.
ADDRESSES	
Local	C/o Post Office, Dublin 5501. Telephone: (085) 29 2188
Head Office	Birralee Road (cnr. Myuna Street), Regency Park 5010 Telephone: 268 3443
MINERAL TENURE	ML 4613-4621

2. PRODUCTION

MATERIAL PRODUCED	Shellgrit
PRODUCT GRADE	CaO 49-50%, MgO 1.5-2%, SiO_2 5-7%, Fe_2O_3 0.07%, Al_2O_3 0.2%, Na_2O 0.4%, organic matter 1-2%.
ANNUAL PRODUCTION (1988)	13 540 tonnes glass grade. 2184 tonnes agricultural grade (Fig. 41)
RESERVES	1 million tonnes (approx.)
PRODUCT USES	Low-iron flux for glassmaking. Agricultural lime.
DESTINATION	Australian Glass Manufactures, Croydon West. Primary producers.
WORKFORCE	3
WORKING HOURS	7 am - 3.30 pm, 5 days/week.

3. GEOLOGY

The shellgrit is a Holocene beach deposit of the St. Kilda Formation, up to 1.5 metres in thickness and extending more than 500 metres inland from the present coastline. The deposit comprises moderately compacted unconsolidated shell fragments with up to 10% silica sand, overlying calcreted calcarenite of the Glanville Formation and mottled, calcreted Hindmarsh Clay (Belperio, 1985).

4. HISTORY

Shellgrit deposits to the north of Adelaide on the eastern shore of Gulf St. Vincent have been exploited since 1939, first for agricultural purposes (soil conditioning, paths, poultry feed), glass manufacture, and from the early 1950's for cement manufacture.

A.C.I. began operations at Port Parham in 1978. The plant was modified to its present form in late 1984 because the coarse silica grains in Parham shellgrit were coarser than the Normanville sand and caused melting problems. The resultant finer-grinding plant produced more dust, and a de-dusting unit was installed.

5. OPERATIONS

The upper 10 cm which contains organic matter and plant seed is removed by scraper and spread on a previously mined area. The shellgrit is then mined by scraper and spread in layers on a stockpile adjacent to the plant. The scraper contractors visit the deposit 4 to 5 times per year, and mine at right angles to the coast to optimise blending.

Stockpiled shellgrit is reclaimed by a Kawasaki front end loader and introduced to the plant (Fig. 40) over a 50 mm inclined screen which rejects plant matter and large stones. The shellgrit falls into a receiving bin and is transferred by vibrating feeder and bucket elevator to a feed bin. Any remaining trash is rejected by a 25 x 38 mm weldmesh screen and undersize falls to a vibrating feeder which feeds a Teco oil-fired rotary drier which dries the shellgrit to about 0.1% moisture. Drier exhaust is de-dusted in a cyclone. The drier output is bucket-elevated to a 4 mm aperture trommel oversize from which is reduced in a Van Gelder grated hammer mill and screw fed with the trommel undersize to a bucket elevator. This feeds two parallel secondary trommels of 0.85 mm aperture, oversize from which passes through a roll crusher and falls with the secondary trommel undersize to a further screw feeder and bucket elevator

This elevator feeds a Buell screw classifier, product from which is de-dusted, moistened to 2% moisture and screw fed to a stockpile conveyor for storage under cover. Dust is collected in bulker bags for sale as agricultural lime.

Plant capacity is 13 t.p.h.

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MAGNESITE

In 1988, South Australia produced 3 120 tonnes with an ex-mine value of $27 000. This accounted for about 4% of Australia's production, most of which is mined in New South Wales. Australia currently imports about 15 000 tonnes of dead-burned magnesia per annum, equivalent to 30 000 tonnes of raw magnesite, for refractory manufacture mostly for the steel industry.

South Australia has large reserves of magnesite in the Flinders Ranges. Mining at Copley began in 1918. F H Faulding and Co worked these deposits between 1941-55, and those at nearby Myrtle Springs between 1955-79, for use in leather treatment and pharmaceuticals. The Myrtle Springs deposit remains South Australia's principal source of magnesite supplying about 30% of total production. This is milled by Commercial Minerals at Gillman for use in Melbourne as caustic calcined magnesia (by heating to 650°C) in welding electrodes, agriculture and acid neutralisation. 30 000 tonnes were shipped to Gladstone, Queensland in 1984 and 1985 for water filtration trials for alumina production. The rest of the State's production is low value material mined by Jomoco Pty Ltd from two deposits at Robertstown for use in raw form in agriculture and animal feed supplements. Further deposits are known at 23 other localities.

South Australian magnesite has been sporadically used for refractory manufacture. Further development is constrained by the thinly bedded nature and remoteness of many of the deposits, lack of basic geological, chemical and beneficiation data and potential competition from large deposits in Queensland.

MYRTLE SPRINGS - COMMERCIAL MINERALS LTD

1. GENERAL

LOCATION	3 km north of Myrtle Springs H.S., about 25 km by road NW of Copley (Fig. 29)
OPERATOR	David Linke Contractor Pty Ltd for Commercial Minerals Ltd.
ADDRESS	100 Eastern Parade, Gillman 5013 Tel 47 5977.
MINERAL TENURE	ML 4149-52, 4998-5001, 5181 MPL 18, 27 MC 2198, 2199

2. PRODUCTION

MINERAL PRODUCED	Magnesite
PRODUCT GRADES	38-47% MgO. Up to 10% SiO_2, lower if selectively mined.
ANNUAL PRODUCTION (1988)	1260 tonnes (Fig. 42)
RESERVES	Not determined, but substantial
PRODUCT USES	As raw magnesite - agricultural fertilizers and animal feeds. As caustic - calcined magnesite (heated at 650°C) - welding electrodes, water filtration, agriculture, acid neutralization.
DESTINATION	To Gillman for milling, then mainly to Melbourne.
WORKFORCE	2 (when producing).

3. HISTORY

Pegging of the area began in 1945 and production was first recorded in 1947 (Crettenden, 1985). Pegging and production by F.H. Faulding and Co. Ltd began in 1955. This company's Adelaide factory became Australia's major producer of $MgSO_4$ for use in leather treatment and pharmaceuticals and was using all magnesite from the Myrtle Springs region until 1979. In 1980, the northern three leases and the southern five leases were tranferred to Minerals Pty Ltd and Steetley Industries respectively. Steetley was acquired in 1984 by Anglo American Pacific Ltd which trades as Commercial Minerals Ltd. This company took over ACI's leases in 1986. The major production in 1984-85 was for a contract with Queensland Alumina for water filtration trials at their Gladstone plant. This contract was not renewed and most is now used in welding electrodes, acid neutralization and agriculture. Anglo American Pacific Ltd was acquired by Poseidon Ltd in 1988.

4. GEOLOGY

A description of similar deposits near Copley is presented in McCallum (1986). The magnesite is formed as sedimentary interbeds in the upper part of the blue-grey Skillogalee Dolomite, within the Late Proterozoic Burra Group. The beds dip 70° northeast and range in thickness from several centimetres to 3 metres. Thicker beds persist along strike for several kilometres. The magnesite is an intraformational pelletal conglomerate reworked from soft semi-lithified sediments with a matrix of detrital quartz and feldspar silt and micritic magnesite. Pellets are commonly 2-5mm ranging up to 30mm in grainsize, and are generally rounded as a result of rolling during extended periods of desiccation and erosion.

5. OPERATIONS

Magnesite was first mined from outcrops and loaded by hand. At later operations on flat terrain, overburden was stripped along the hanging wall and the magnesite bed was mined in a long narrow slot at depths of up to 8 m below plain level.

Current practice is to bench a hillslope to a dipping bed and then to knock down the exposed magnesite onto the bench with a hydraulic rock pick. Selective mining is necessary to exclude siliceous beds.

The magnesite is first passed over a 75 mm scalping screen, from which oversize is fed through a jaw crusher and over a double deck vibrating screen, producing a minus 50 mm plus 10 mm product. Oversize is returned to the crusher and fines are dumped on site. Product is trucked to Gillman for milling. Mining is on a campaign basis to replenish stockpiles.

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SALT

1988 salt production totalled 0.88 million tonnes with an ex-mine value of $3.24 million. 65% of this was used, with marble from Penrice, in the manufacture of soda ash at Osborne.

The 1988 FOB value of soda ash exports has been conservatively estimated at $0.7 million. Bulk salt exports to Japan, Malaysia and New Zealand in 1988 totalled 204 000 tonnes with an FOB value of $4 million.

In 1966, South Australia produced 80% of Australia's salt production. However, following major expansion of solar salt operations in Western Australia, South Australia's contribution had fallen to 68% in 1968, and had stabilised at about 12% of Australian production by 1977. Although Western Australia now produces 80% of Australia's salt, almost all is exported to SE Asia. South Australia still supplies 60% of domestic requirements with most of the remainder produced in Queensland and Victoria.

All South Australian salt is produced by solar evaporation of sea water. The principal sources are:

- Dry Creek, in metropolitan Adelaide
- Price, on Yorke Peninsula
- Whyalla, on Eyre Peninsula
- Lake MacDonnell, on Eyre Peninsula
- Lochiel, (Lake Bumbunga) 30 km north of Port Wakefield

ICI has produced salt at Dry Creek for soda ash production since 1940. The salt is pumped 12 km as brine to Osborne, where Penrice Soda Products Pty Ltd operates Australia's only soda ash plant. Most of the soda ash is used in Australia, primarily in glass manufacture but also in soap, detergent, pulp and paper, chemical manufacture, water treatment and acid neutralisation.

Salt has been produced at Price since 1919. The salt fields have been operated by Cheetham Salt Co Ltd since their acquisition of Ocean Salt Co Ltd in 1971. 130 040 tonnes were harvested in 1988. Bulk and processed salt are despatched to mainland destinations either direct from the plant at Price or from distribution facilities in Adelaide. Bulk shipments are also sent from the BHP shipping facilities at nearby Ardrossan to Tasmania and New Zealand.

First production was recorded by BHP at Whyalla in 1951. Pacific Salt built a processing plant adjacent to the crystallisers in 1979, began using BHP's salt in 1980, and purchased the evaporating pans in 1988. Bulk salt and packaged salt for industrial and household use are marketed through warehousing facilities in NSW, Qld, North Melbourne, Adelaide and Whyalla. 52 290 tonnes were harvested in 1988.

Production at Lake MacDonnell began in 1920. A number of operators worked the deposits until Waratah Gypsum gained sole control in 1976. The deposit is now managed by GRA, formed by the combination in 1984 of all Waratah and CSR's operations in the area. In 1988 98 800 tonnes were shipped in bulk from Thevenard to Malaysia and Japan.

Australian Salt Co Ltd began production on Lake Bumbunga, near Lochiel, in 1913 and took over other operators in the area in 1930. Cheetham Salt Co Ltd took over Australian Salt in 1971 and works the deposit in conjunction with its Price operation. 15 760 tonnes were harvested in 1988.

Salt has been produced at the Mulgundawa Saltworks since before 1940 from a groundwater-fed lake adjacent to the northern shore of Lake Alexandrina (Betheras, 1954). 4 860 tonnes were produced in 1988, mainly for the tanning and butchering trades.

A number of South Australia's earlier salt harvesting operations have ceased production. Earliest production was from White Lagoon on Kangaroo Island in 1814 and an operation begun at nearby Salt Lake in 1897 was active until 1961. Prior to the establishment of a salt industry at Edithburgh on Yorke Peninsula in 1891, as many as 60 lakes were harvested by the local farming community. Production from brines at Peesey Swamp and Marion Lake and from Lake Fowler ceased with the closure of the Edithburgh works in about 1965. Salt was produced by solar evaporation of sea water at Yorkey Crossing (1915-1930) and Port Paterson (1951-1963).

DRY CREEK - PENRICE SODA PRODUCTS PTY LTD

1. GENERAL

LOCATION	Numerous sections along about 60 Km of coastline extending north from North Arm Creek in the hundred of Port Adelaide, across the hundred of Port Gawler to Parham in the hundred of Dublin (Fig. 43)
OPERATOR	Penrice Soda Products Pty Ltd
LOCAL ADDRESS	Penrice Soda Products Pty Ltd, Magazine Road, Dry Creek, 5094. Tel. 262 2405
HEAD OFFICE	Solvay Road, OSBORNE 5017 Tel. 248 8200
MINERAL TENURE	PM 199, 248; MLs 234-5, 237, 346, 350, 354-63, 388-421, 439-448, 587, 600-8, 613, 617-8, 693-702, 717-8, 722-5, 5089-93, 5205-10.

2. PRODUCTION

MINERAL PRODUCED	Salt
PRODUCT GRADE	99% NaCl (Fig. 44)
ANNUAL PRODUCTION (1988)	573 340 tonnes
RESERVES	Not applicable
PRODUCT USES	Manufacture by the Solvay Process (with marble from Penrice) of sodium bicarbonate and carbonate (soda ash) and calcium chloride.
DESTINATION	ICI Alkali Factory, Osborne
WORKFORCE	26
WORKING HOURS	Harvesting is six days/week, eight hours/day for 15 weeks. Normal maintenance 5 days/week, 8 hours/day. Dissolving and pumping to Alkali Factory 7 days/week, 24 hours/day.

3. HISTORY

The operation was established between 1935-38 and salt production commenced in 1940. The original area, about 810 hectares, has been steadily expanded to over 4000 hectares.

In 1989 ICI sold its soda ash business, including the Penrice marble and Dry Creek salt deposits, to Penrice Soda Products Pty Ltd.

4. OPERATIONS

Pumping

Salt water is pumped from the sea at two pumping stations located approximately 20 km and 30 km along the coast from the final crystallising area. The pump-houses contain nine pumps, with no. 1 station having five pumps each capable of pumping 900 litres/sec. and No. 2 station having four pumps each capable of pumping 1800 litres/sec.

Concentrating

Salt water from the pumping stations gravitates, or where necessary to gain height or overcome flood gaps is pumped, so that it progresses slowly through a series of approximately 25 ponds towards the crystallising area, and increases in salinity by evaporation. At selected points gates are installed in the pond banks so that the flow of water can be regulated to control salinity. By the time the brine has reached the last of the concentrating ponds most of the calcium salts have precipitated and the water has a high sodium and magnesium salt content.

Crystallising

Crystallising takes place during the summer months, and depending upon the weather usually begins in October. The salt is continually deposited on the bed of one of eight crystallising pans and is harvested in March. Initially the pans are primed using brine from deep storage ponds to provide an initial bed depth of 10 cm. Maiden brine from the final concentrating ponds is then pumped into the crystallising pans to maintain a level of brine approximately 15 cm above the salt bed throughout the crystallising period. The thickness of the salt bed increases by between 10 cm and 20 cm depending upon the weather.

Harvesting

Harvesting of the salt begins in the middle of March and takes about fifteen weeks to complete. Before harvesting, the liquor covering the surface of the crystallising pans, which contains chiefly magnesium and potassium salts (bitterns), is drained off by opening gates located in the side embankments of the pans. Final drainage is then achieved by cutting drains across the beds at 4 m intervals.

Harvesting involves the use of three mechanical salt harvesters. These operate together in conjunction with a conveyor belt and stacker and traverse across and along the crystallising pans. As the harvesters move across the pans the salt bed is lifted and broken by a spiral screw and then elevated by means of a slatted belt to the conveyor. The harvesters are located on each side of the central conveyor and discharge into it from their respective sections of the pan.

Leaching and Dissolving

The stockpiled salt is generally left for several months to enable leaching of impurities by rain. As required, salt is dissolved by spraying fresh and bore water onto the stacks. The brine is collected in drains and pumped to a reservoir which has a capacity of 5 400 cubic metres. Simultaneous multiple spraying from different sections of the stockpile facilitates blending. This process takes place continuously throughout the year. Dilution of the brine with rain water during winter months is mitigated by use of a salt basket.

Pumping

Brine from the reservoir is pumped a distance of 12 kilometres to the Penrice Soda Products alkali factory at Osborne. The pipeline runs mainly above ground level but also passes along the bed of the Port River, where it is split into three smaller lines as a precaution against damage. Initially the line has a diameter of 38 cm but this is reduced progressively to maintain pressure and is only 20 cm by the time it reaches the reservoir at the Alkali Works. Pumping is continuous at a rate of 40 000 cubic metres per day.

PRICE - CHEETHAM SALT LTD

1. GENERAL

LOCATION	Price is located on the east coast of Yorke Peninsula, 20 km north of Ardrossan (Fig. 43)
OPERATOR	Cheetham Salt Ltd (owned by Industrial Equity Ltd.)
LOCAL ADDRESS	Registered Office: Fowler Terrace, Price 5570 Tel. (088) 376511
SALES ADDRESS	60 Grand Junction Road, Kilburn, 5084 Tel. 349 6001
MINERAL TENURE	ML 94, 95, 483, 493, 531, 552-3, 556-7, 588-9, 596, 615-16, 5043, 5069-73, 5277-79.

2. PRODUCTION

MINERAL PRODUCED	Salt
PRODUCT GRADE	98.5-99.8% NaCl, dependent upon screening (minus 25 mm to 50 microns) Max. $CaCO_3$ 600 ppm Max. $MgCO_3$ 100 ppm
ANNUAL PRODUCTION (1988)	130 040 tonnes harvested (Fig. 46) 12 000 processed ex Lochiel.
RESERVES	Not applicable
PRODUCT USES	Foodstuffs, chemical, dyes-pigments, tanning, agriculture, metallurgy, ceramics, explosives, soaps, oils & fats, (S.A. and Interstate), paper making (Tasmania), water softeners (S.A.).
DESTINATIONS	45 000 tonnes to Australian destinations including 15 000 to Cheetham's Geelong refinery. Transport is by road direct to Australian destinations or by road to Dry Creek and then by rail. The salt is also transported by road to Ardrossan or Port

	Adelaide for shipping to Tasmania (26 000 tonnes) and New Zealand (105 000 tonnes salt).
WORKFORCE	Total 53
WORKING HOURS	Refinery:- 5 days/week, 16 hrs/day Field:- 5 days/week, 8 hrs/day

3. HISTORY

The Gulf Salt Co. Ltd began salt production at Price in 1919 by evaporation of sea water captured at high tide by a dam across Wills Creek (Jack, 1921). In 1923, operations were transferred to Ocean Salt Co. Ltd. and a refinery was subsequently established in 1930 (Willington, 1960). In 1971, Ocean Salt Pty Ltd and its sister company Australian Salt Co Ltd at Lochiel became wholly owned subsidiaries of Cheetham Salt Co Ltd.

4. OPERATIONS

Between September and April sea water is channelled to two pumping stations located approximately 3 kilometres apart and gravitated through a 964 hectare series of concentrating ponds (condensers) controlled by gates. On its journey through the concentrators, the brine precipitates iron oxides, calcite and gypsum and reaches saturation with respect to NaCl in the final concentrator where it contains about 22% NaCl and 6% magnesium and potassium sulphates, chlorides and bromides (bitterns). The "maiden brine" is then pumped onto 12 crystallizing pans of total area 102 hectares to a depth of about 20-25 cm. Evaporation and salt deposition proceed until the SG reaches about 1.25, at which time bitterns are discarded and replaced with fresh brine. A thickness of about 15 cm accumulates between September and April when the crystallizers are finally drained, one at a time, prior to harvesting.

The following description has been updated from Falconer and Watkins, (1978). The salt is harvested using a mechanical harvester. It is removed in one cut and elevated using a slatted inclined conveyor and discharged into 2 or 3 trucks. The complete annual deposit is harvested in one operation. The harvested salt is hauled to the washing plant located adjacent to the crystallising pans.

At the washing plant (Fig. 45), the salt is tipped into a feed hopper and is conveyed to an agitator where it is washed in a saturated brine solution. The washed salt falls to a woven wire mesh feeder, through which the brine drains. The salt is then centrifuged and conveyed to a mobile stacker mounted on rails which discharges the salt onto stockpiles.

The stockpiled salt is left to leach by rain (up to 8 months) to remove water soluble impurities. Salt is removed from the stockpile by mechanical shovel and loaded into semitrailers for bulk transport or into 15 tonne dump truck for feeding to the adjacent refinery (Fig. 45). Salt is dumped into the feed hopper and elevated to a 300 tonne capacity storage bin. The bin discharges through six gates controlled by slides onto two conveyors which discharges the salt into a trommel screen where oversize material is rejected. Trommel screen undersize is fed into a brine bath, from which it is pumped with more brine solution to a slotted dewatering screen. Screen undersize consists mainly of brine and fine salt which generally contains more impurities. Screen oversize is distributed to a centrifuge which spin-dries the salt. At the completion of the cycle the dewatered salt usually has a moisture content of about 2 per cent and is discharged onto a conveyor. The conveyor discharges into an elevator which feeds into an overhead trommel splitting off coarse and fine material into two storage bins. The salt is then conveyed and elevated to three oil-fired dryers which remove remaining moisture.

Dryer product is conveyed and elevated to a spiral which distributes the salt to two parallel three-stage roll crushing circuits. Product from the crushing rolls is then distributed by means of a spiral to the screening plant which consists of four double deck screens and one kason screen. The screens produce a series of sized salt grades which are sent to elevators by screw feeders. The bottom deck undersize from the three double deck screens combine and the top deck oversize from all four screens combine and are sent to respective elevators. Intermediate sized material and kason screen undersize are fed to separate elevators. Each of the five elevators discharges into a separate 45-50 tonne storage bin which contains a specific graded salt product.

Salt from these bins is bagged as separate grades in 25 kg and 50 kg or one tonne bulk bags, palletised and stored ready for trucking to various destinations by semi trailer. Household and table salt is also drawn from the bins for packaging in 500, 750 gm and 1 kg plastic bags or cannisters under a number of well known supermarket brand names.

WHYALLA - BHP LTD

1. GENERAL

LOCATION	Whyalla, about 4 Km NE of the steelworks (Fig. 43)
OPERATORS	The B.H.P. Co. Ltd., and Pacific Salt Pty Ltd
ADDRESSES	BHP - Port Augusta Road, Whyalla (P.O. Box 21) 5600. Tel.(086) 404444 PACIFIC SALT PTY LTD Local: Port Augusta Road Whyalla (P.O. Box 386) 5600. Tel.(086) 455044 Head Office: 29 Booka Ave., Yennora NSW 2161, Tel.(02) 6320441.
MINERAL TENURE	ML 548, 549, 637, 638, 765-776, 687, 688; EML 4487

2. PRODUCTION

MINERAL PRODUCED	Salt: In order of decreasing grain size:- Water softener, crushed coarse, coarse refined, flossy & pool salt, dairy and table salt, fine (cooking) salt.
PRODUCT GRADE	99% NaCl
ANNUAL PRODUCTION (1988)	52 290 tonnes (Fig. 49)
RESERVES	Not applicable
PRODUCT USES	Paper manufacture (Tasmania), water softening, tanning, butchering, baking, dairy products, table salt, foundry use, stock licks.
DESTINATIONS	Tasmania (by sea), warehouses at Yennora (west of Sydney), Hemmant (Qld), Angle Park, Whyalla, North Melbourne by road and rail.

WORKFORCE — BHP - 2 full time. (One Shift, 5 day week). During harvesting, outside contractors plus 2 re-assigned from steelworks

PACIFIC SALT - 30 (2 shifts, 6am-midnight, 5 day week)

3. HISTORY

Investigation by BHP of the area near Whyalla, for solar salt production began in 1946 and first production was recorded in 1951 (Betheras, 1956). Until 1979, Pacific Salt produced salt by solar evaporation of groundwater brine at Warooka on southern Yorke Peninsula and trucked it to their processing plant at Angle Park. The company then moved operations to Whyalla, adjacent to B.H.P.'s crystallizers. Processing commenced in February, 1980. Pacific Salt acquired the brine ponds and crystallizers from BHP in July, 1988.

4. OPERATIONS

Production

Concentrator and crystallizer layout is presented in Fig. 47 and described by Falconer and Watkins (1978), from which the following has been updated. The bulk of feed water is sea water from the steelworks cooling system which gravitates 4 km via an earthen channel to number 1 pond. About 10% is pumped directly from the sea. Salt water flows into pond 1 and gravitates to pond 2. From here the water flows to brine storage pond number 1 and to brine storage pond number 2. This latter pond is tested daily for specific gravity while the others are tested weekly. When the specific gravity of the brine has reached 1.218 it is pumped to ten crystallising pans each of 2 ha. Here the specific gravity of the brine solution is checked weekly to determine when most of the NaCl has crystallised. (Maximum specific gravity 1.240). The remaining solution which is rich in magnesium salts is drained out and more liquor pumped in until the salt bed is approximately 20 cm deep. The pan is then drained, ripped and graded into windrows to allow final drainage and the harvested salt is trucked to the washing plant (Fig. 47). The washed salt is then trucked to stockpiles and allowed to drain for about 3 months prior to final processing (Fig. 48).

Harvesting is undertaken by contractors and takes about ten weeks starting in April.

Construction of an eleventh 8 ha crystallizer began in June 1986 to raise production by 30 000 tonnes annually. The initial salt bed was established in 1987-88, and the first harvest was carried out in August 1989. Of the 3094 ha under lease, 240 ha are occupied by brine ponds and 20 ha by ten crystallizers. A twelfth crystallizer of 5 ha is planned.

Washing

Harvested salt is front-end-loaded into trucks and tipped into the feed hopper at the washing plant. The hopper discharges to a conveyor which feeds a screw classifier in which the salt is washed using saline water from the crystallizers. The washed salt is augered onto a stainless steel mesh conveyor on which the salt is rinsed and drained prior to trucking to stockpile.

Processing

Raw washed salt from stockpile is trucked to a hopper which feeds a rinse tank from which the salt is augered to a conveyor and thence to a bin. About 25% of the harvested salt is lost in the washing and rinsing processes. Rinsed salt is conveyed to a centrifuge from which it is augered and elevated to a second bin which feeds a gas-fired rotary drier. Dried salt is fed to a cooler, from which the flue dust is collected for use in stock licks. Cooled salt is elevated to the undercover section of the plant and introduced to the processing "tower". Here the salt is first screened through two double concentric trommels from which oversize is rejected, intermediate size stored for bagging as HG (water softener) salt and undersize is passed to three rolls crushers.

Crusher product falls to four double concentric trommels from which coarse refined, flossy and fine salt products are delivered to bins prior to bagging. The coarse and flossy salt and some crusher product can be sent to a second bank of four double trommels, which produce flossy salt as oversize, dairy salt as the intermediate product and table salt as undersize. Table salt is withdrawn by auger and fed to the packing plant where plastic bags and cannisters are packed and labelled for the supermarket trade. Coarse, flossy, dairy and fine salt products are palletised in 25 kg bags (60 bags per pallet) for shipment to Tasmania (by sea) or to warehouses at Yennora (west of Sydney) Hemmant (Qld), Angle Park, Whyalla, and North Melbourne by road and rail. Salt can be delivered in Sydney within one day by road or within 3 days by rail.

Flue dust from the cooler is mixed with bentonite (from Commercial Minerals, Winjin, N.S.W.), lime, magnesium carbonate, phosphoric acid, gypsum and molasses and pressed into 20 kg stock lick blocks for shipment on 100-block pallets.

LAKE MACDONNELL - GRA

1. GENERAL

LOCATION	Lake MacDonnell, about 15 Km south of Penong on Eyre Peninsula (Fig. 43)
OPERATOR	Gypsum Resources of Australia Pty. Ltd.
ADDRESSES	Local: Box 174, Ceduna, 5690. Tel. (086) 25 2081 Head Office: 17-21 Bagot St; North Adelaide 5006. Tel. 267 3344
MINERAL TENURE	ML 706-714, 756-763

2. PRODUCTION

MINERAL PRODUCED	Salt
PRODUCT GRADE	99% NaCl
ANNUAL PRODUCTION (1988)	100 100 tonnes (Fig. 50)
RESERVES	Not Applicable
PRODUCT USES	Stock licks, water treatment, chemical uses, paper and ice manufacture, ceramics.
DESTINATION	Bulk: Japan, Malaysia, Geelong Bagged: Melbourne, NSW, Qld
WORKFORCE	Drawn from GRA's gypsum workforce.

3. HISTORY

In 1920, leases over the salt deposit were held by C.W. Lovell and Australian Gypsum Co Ltd. By 1925 operations by the Lake MacDonnell Salt Co had begun (Winton, 1926). In 1934 Seesalt Ltd was also working leases in the area. By 1949, Australian Salt Co Ltd held leases in the area, acquiring those of Seesalt in 1968. Waratah Gypsum Pty Ltd entered the area in 1965 and took over Australian Salt's interests in 1976. Waratah Gypsum and CSR Ltd combined in 1984 to form Gypsum Resources Australia Ltd to more efficiently manage the resource. In 1988, Diamond Salt Pty Ltd constructed a coarse salt production plant incorporating screening centrifuging and bagging.

4. GEOLOGY

Lake MacDonnell occupies a northwest - southeast trending topographic depression within the calcreted coastal calcarenite dunes of the Pleistocene Bridgewater Formation. During the last period of high sea level the depression was probably a coastal embayment the floor of which was covered by calcreted marine sand grading laterally into Bridgewater Formation. The embayment was later cut off from the sea by a Holocene dune barrier (Semaphore Sand).

5. OPERATIONS

Sea water and evaporated brines seep through the dunes into the shallow "blue lake" and then gravitate through "garden No. 1" into "garden No. 2". Saline water from the gypsum cut can also be pumped during periods of reduced seepage. When the salinity reaches the required level the brine is fed through valves into a lime pond in which calcium salts are precipitated. Total area of "gardens" and lime pond is 680 ha. The brine is then pumped to three crystallizing pans of total area 71 ha where a water depth of 23 cm is maintained. After a period of salt crystallization the bitterns, together with some salt, are pumped out. The salt bed is ripped with a bulldozer, graded into windrows, removed by front end loader and trucked to the processing plant.

The harvested salt is dumped into a hopper via a road bridge and fed into a twin screw washer, where it is washed in a saturated salt solution. Magnesium salts contained in the salt dissolve in the wash water and are thereby removed to leave a high purity salt product which is stockpiled, ready for bulk shipment, or for feeding to the bagging plant. Bulk salt is then railed 70 km in 35 tonne wagons to Thevenard where each wagon is unloaded with a fixed backhoe and salt conveyed to stockpile. The salt trains work an irregular schedule according to production and demand. Bagged salt is trucked to the eastern states on semi trailers returning empty from W.A. or to Adelaide for containerised rail transport to Sydney and Melbourne.

Harvesting of the salt takes place annually, usually at the end of February and takes 6-7 weeks to complete. Approximately 25% of the salt is lost between harvesting and shipment due to dissolution during washing and stockpiling.

LAKE BUMBUNGA - CHEETHAM SALT LTD

1. GENERAL

LOCATION	Lake Bumbunga, extending about 9 Km north from Lochiel (Fig. 43)
OPERATOR	Cheetham Salt Ltd. (owned by Industrial Equity Ltd.)
LOCAL ADDRESS	Lochiel, 5510. Tel (088) 662201. Registered Office: Fowler Tce, Price 5570. Tel (088) 376511
SALES OFFICE	60 Grand Junction Road, Kilburn, 5084. Tel. 349 6001
MINERAL TENURE	ML 7, 18, 54, 55, 224

2. PRODUCTION

MINERAL PRODUCED	Salt
PRODUCT GRADE	97% NaCl in coarser grades for commercial use only.
ANNUAL PRODUCTION (1988)	15 760 tonnes (Fig. 52)
RESERVES	Not known
PRODUCT USES	Hide and skin tanning, water softening, butchering, snow clearing, paper making, metallurgy.
DESTINATIONS	N.S.W., N.T. (hides and skins) Adelaide (water softening, butchers). Peko, Tennant Creek (metallurgical purposes). Tasmania (paper making). Trucked to Price during periods of high demand. Transport to Australian mainland destinations is direct by road or to Dry Creek by road and then by rail. The salt is also transported by road to Port Adelaide for shipping overseas.
WORKFORCE	7

WORKING HOURS Five days per week, one shift per day; plus 48 hrs overtime per week.

3. HISTORY

Australian Salt Co Ltd began operations on the southern part of Lake Bumbunga in 1912 (Anonymous, 1913a), leases over the northern part of the lake being held at that time by The Castle Salt Cooperative Ltd. Salt was transported to a refinery at Port Wakefield until 1926 when the refinery was relocated to Lake Bumbunga (Anonymous, 1927). In 1930, Australian Salt Co Ltd absorbed Castle Salt, together with Standard Salt and Alkali Ltd and the Commonwealth Salt Refining Co Ltd (Betheras, 1951). In 1971, Australian Salt Co Ltd and its sister company Ocean Salt Pty Ltd at Price, became wholly-owned subsidiaries of Cheetham Salt Co. Ltd.

4. GEOLOGY

A system of saline lakes drains an area to the east of the Barunga Range extending for about 30 km north of Lochiel. The largest of these, Lake Bumbunga is 9 km long and 2.5 km at its widest point. The lake is underlain by about 1.5 m of black, gypsiferous and saline mud, and evaporation of the solution formed by winter flooding yields salt. A probable source of the salt is from aeolian dust which has been rendered saline by contact with sea spray ("cyclic" salt). Solution of salt from the dust by rainfall and concentration in the lake sediments by surface drainage and evaporation has been proposed as the method of salt accumulation.

5. OPERATIONS

Three crystallizers of about 25 hectares each have been constructed by raising banks on the bed of the lake. Pumping from the lake into the salt pans begins in about August, using a slatted pump. The ability to pump depends to a large extent on the direction of the prevailing winds which influence the depth of water at the pumping points.

Pumping is only carried out when the S.G. of the lake brine is less than 1.208 at 60°F. Water level in the crystallizers is at 22.5-25 cm above the bed until the brine supply is exhausted in about December. The pans are then left to dry out so that a salt layer of about 7 cm remains. Harvesting is carried out under contract and takes place in January and February over about eight to ten weeks. The salt is picked up by a mechanical harvester which cuts and then elevates it onto a slatted inclined conveyor and discharges it into trucks.

2 or 3 trucks are used in conjuction with the harvester. The trucks tip the salt into a hopper which feeds a stacker/elevator which discharges onto the stockpile.

Movement of salt from stockpile is carried out by a mechanical shovel which breaks the salt up and transfers it to semi trailers for bulk shipment or to a small truck to the adjacent processing plant (Fig. 51). Salt in the feed hopper is broken up by means of two sets of toothed rolls and removed by a slatted belt and conveyor and elevated to a 75 tonne double wooden storage bin. Manual slides control the discharge from the bin and feed salt via a conveyor to a hopper into which a saturated brine wash liquor is also added. The pulp is pumped over a screen where undersize is removed as reject. Screen oversize is transported to small hoppers which feed batchwise two 'hydro' spin drying machines. Each machine takes a charge of about ½ tonne of salt and rotates up to 700 rpm for about five minutes so that the salt is dewatered by centrifugal forces pushing the brine through small holes in the side of the bowl.

The brine flows indirectly to a well located beside the plant, to enable some salt to deposit prior to reaching the well thereby reducing build up. The well water is recycled to the plant. At the end of of a spin drying cycle the salt is discharged through the base by means of internal scrapers and transported by a screw and elevated to a rotary screen. Screen oversize goes to a hopper and is bagged as water softener salt in 25 kg bags. Screen undersize is screw fed to an elevator and fed to two sets of rolls for further size reduction. Rolls product is either elevated to a hopper for bagging into 25 kg 50 kg and bulker bags as coarse salt or screw fed to a small hopper where additives are included, usually ½-1 per cent by weight to eliminate organisms on the animal skins. The materials are mixed in a screw conveyor before feeding to a hopper and bagger which produces 25 kg and 50 kg bags for tannery use.

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SILICA

South Australia's 1988 silica production of 174 300 tonnes was valued at $1.51 million ex-mine. 22 000 tonnes with an FOB value of $185 000 was shipped to Tasmania for ferroalloy manufacture, and the rest used within the State for glass, foundry moulds, iron ore smelting and water filtration.

South Australia produces around 6% of Australia's silica. Both Western Australia and Queensland export large quantities of sand to Japan, and New South Wales and Victoria produce large tonnages for their glass and foundry industries.

South Australia's principal silica sources are:-

- Mt Compass, 50 Km south of Adelaide
- 23 mile deposit, between Whyalla and Iron Knob on upper Eyre Peninsula

Production of glass and foundry sand near Adelaide was originally from coastal dunes in the Grange - Royal Park area. In the late 1960s, depletion of reserves and residential pressure forced the industry to seek more distant sources of sand. ACI began mining beach dunes at Normanville in 1970 to supply their glass plant at Croydon and numerous local foundries. Dwindling reserves and environmental pressure forced a move to a new deposit at Mt Compass in 1987. ACI produced 47 180 tonnes in 1988 comprising most of the State's glass sand and 20% of the foundry sand. The rest of the foundry sand is now being mined from Holocene dunes at 8 smaller operations at Wellington and Nalpa near Lake Alexandrina, at Stow to the north of Balaklava and at Reeves Plains, Angle Vale and Sandy Creek.

The 23 mile deposit (37 km from Whyalla) was opened by BHP in 1949 to supply a ferro-alloy plant at Newcastle. The quartz is now crushed at Iron Knob and 44 080 tonnes was used in 1988 for ferro-alloy production at Bell Bay (Tasmania) and for slag control at the Whyalla blast furnaces. BHP also uses small amounts of foundry sand at Whyalla, from deposits in the Whyalla and Port Augusta areas.

Small quantities of flint pebbles for grinding media and ceramic use have been produced from beaches near Port MacDonnell for over 70 years. Filter sand is produced in the Riverland, notably for use in filtration plants for Adelaide's water supply.

MOUNT COMPASS - ACI RESOURCES LTD

1. GENERAL

LOCATION	Glenshera, 3 km west of Mount Compass (Fig. 53)
OPERATOR	A.C.I. Resources Ltd.
ADDRESS	Plant and pit: Lanacoona Rd, Mt. Compass 5210 Tel (085) 56 8484. Production Management: ACI Resources Ltd, Biralee Rd., Regency Park 5010 Tel. 268 3443 Glassworks: Australian Glass Manufacturers, 617 Port Rd., West Croydon 5008 Tel 268 2755.
MINERAL TENURE	EML 5465, ML 5327

2. PRODUCTION

MATERIAL PRODUCED Quartz Sand

PRODUCT GRADE

	AMBER	WHITE	AMBER AND WHITE	
			BSS	% Ret
SiO_2	99.67	99.80	18	2 grains
Fe_2O_3	0.09	0.024	25	0.27
Al_2O_3	0.13	0.071	36	9.61
TiO_2	0.014	0.011	52	28.60
Cr_2O_3	<0.001	<0.001	72	31.21
CaO	<0.01	<0.01	100	19.78
MgO	<0.01	<0.01	150	8.78
Na_2O	<0.01	<0.01	200	1.71
K_2O	<0.01	<0.01	Pan	0.14
L.O.I.	0.08	0.08	TOTAL	100.10

ANNUAL PRODUCTION (1988)	- 28550 tonnes glass sand - 18630 tonnes foundry sand (Fig. 55)
RESERVES	Inferred, above water table:- amber 2.6 million tonnes white 14.9 million tonnes

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PRODUCT USES	White sand - clear glass containers Amber sand - coloured glass containers - foundry sand used in production of motor car engines and alloy castings.
DESTINATIONS	Australian Glass Manufacturers, West Croydon; Mitsubishi Motors, Lonsdale; Castalloy, Plympton.
WORKFORCE	4 (plant manager, weighbridge operator, plant operator, driver).

3. HISTORY

ACI began using sand from beach dunes at Normanville in 1970, following depletion of deposits near Grange. In the early 1980s, an on-going search for alternative deposits was intensified as a result of dwindling reserves in the northern dune at Normanville together with resistance on environmental grounds to mining of the southern dunes (Johnson, et al 1984). A search by ACI of thousands of microfilmed departmental logs of drillholes in the Mt. Compass area pinpointed several promising prospects and fourteen holes were drilled at the Glenshera deposit in November 1983. This program and follow-up 50m grid drilling and testing proved a large deposit of Permian sand comprising up to 10m of yellow and orange sand overlying pale cream and cream brown sand suitable, respectively, for upgrading to amber and white glass sand (Johnson, 1984).

Plant construction began in April, 1986 and in March 1987, ACI Resources Ltd transferred its glass and foundry sand production from its freehold Normanville location to a new 3 million dollar operation at Glenshera, 3 km west of Mount Compass.

4. GEOLOGY

Johnson (1984) has described the geology of the mine area. The pit is situated within Permian fluvioglacial sand which infills a deep, westerly trending glacial valley, cut through Barossa Complex metamorphic rocks of early Proterozoic age. Maximum thickness of glacial sediments exceeds 200 m. A thin ferruginous cemented gravel of probable Tertiary age caps the Permian sand and has protected the sand from widespread erosion. The gravel-capped ridge top, known as Glenshera, is at about the same elevation as probable Early Tertiary landsurfaces identified in surrounding basement rocks.

The Permian sediments are white, cream, pale yellow or pale brown, fine to medium grained, subrounded to well rounded quartz sands with around 10% kaolinitic clay. Thickness of mineable white sand is determined by depth to water table which ranges from about 10-80 metres. The pale sands are overlain by between 2-10 metres of orange and yellow fine to medium grained sand capped by about 1.5 m of surficial pale coloured sand.

Heavy minerals comprise less than 0.1% of raw sand. Tourmaline predominates with ilmenite, rutile, iron oxide/hydroxide and leucoxene in decreasing abundance. Iron in the light fraction of attritioned samples is mostly in the form of coating on sand grains.

5. OPERATIONS

Mining

Mining began in April 1986 with stockpiling of amber sand from initial excavations associated with access road and plant construction. Quick access to white sand has been achieved by the excavation of a steep-sided pit about 60m x 25m x 20m deep and accumulation of a stockpile of 30,000 cubic metres of amber sand. Present pit slope is too steep to allow use of self loading scrapers for mining, however, pit design will be optimized as the amber sand stockpile is reduced. White sand is currently extracted as required by loading the scrapers with a Caterpillar 966c front end loader. Amber sand is handled with a Hanomag 66D loader, and a small Fiat-Allis bulldozer is used for general control of the plant and stockpile areas.

Processing

At the plant (Fig. 54), raw sand is fed by front end loader over a 200 mm grizzly into a feed hopper which discharges via a conveyor belt to a 25-30 mm aperture trommel. Oversize is stockpiled as gravel and undersize conveyed to a 250 tonne surge bin. Surge bin discharge is slurried with water and pumped via a cyclone to a 5mm punched hole trommel from which oversize is again stockpiled as gravel. Minus 5mm is distributed to four 0.5mm Vibramech water-sprayed polyurethane vibrating screens from which oversize is cycloned and stockpiled. Minus 0.5mm is then pumped to a 45-tonne constant density tank and through a monitor which maintains pulp density at 80%. The pulp is then cycloned into each of two attrition cells in turn, and through a further cyclone into a 0.8mm wedge-wire trommel. Any oversize is cycloned and stockpiled with Vibramech oversize. Undersize is monitored at 38% pulp density and distributed to eight triple start primary spirals. The fines, which collect on the inside of the spirals are fed to the wedgewire trommel/Vibramech oversize stockpile. Product gravitates to the outside of the spirals and is fed to one of three cyclones over the product stockpiles. A middle fraction is also collected and fed via a pressure distributor to four more triple start spirals from which fines and product are treated as before, and middlings recycled to the primary spiral distributor.

Overflow from all cyclones, containing slimes, is pumped to a delta stack clarifier containing a flocculant polymer. The flocculated slimes are pumped to the drying dams for later blending with reject sand for backfilling of pit slopes. Clarified water is recycled to the plant via two tanks which are topped up as required from a bore-fed concrete tank.

Present plant capacity of 60 tph is lower than expected due to an excess of 0.4mm sand at the Vibramech screens. A hindered settling tank planned to be installed after the punched hole trommel will remove this excess and raise output to about 100 tph. Extraction of a product, possibly for foundry use, by treatment of spirals rejects in Reichert cones, is also under consideration.

Markets

White (0.024% Fe_2O_3) and amber (0.09% Fe_2O_3) products are used by ACI at Kilkenny in the production of clear and amber coloured bottles for the wine, brewing, dairy, food and soft drink industries. 65% of this production is used in wine bottles, most of which are used in South Australia which packages 60% of Australia's wine. Amber sand is also sold to foundries, predominantly Mitsubishi Motors' Lonsdale engine plant and to Castalloy Ltd at Plympton who make a variety of castings including motor vehicle wheels and manifolds.

23 MILE - BHP LTD

1. GENERAL

LOCATION	23 mile deposit. 37 km (23 miles) northwest of Whyalla on the Iron Knob road (Fig. 53)
OPERATOR	B.H.P. Ltd.
ADDRESS	Port Augusta Road, Whyalla (PO Box 21) 5600 Tel. 40 4444
MINERAL TENURE	ML 2924

2. PRODUCTION

MINERAL PRODUCED	Quartz
PRODUCT GRADE	+ 38 mm: 98% SiO_2, Max. Al_2O_3 0.7% (Tas); -38 mm +12.5 mm: 96% SiO_2, Max. Al_2O_3 1.6% (Whyalla)
ANNUAL PRODUCTION (1988)	21 770 to Bell Bay, 22 540 tonnes to Whyalla, 3700 tonnes fines (Fig. 56)
RESERVES	1 million tonnes in current 10 year development plan. 400 000 ferro-alloy grade, 300,000 blast furnace grade, 300,000 waste.
PRODUCT USES	Ferro-alloy manufacture, blast furnance additive (slag control).
DESTINATIONS	Bell Bay (Tasmania), Whyalla.
WORKFORCE	Drilling and blasting carried out by personnel from iron ore mines. Loading and carting to Iron Monarch contracted to Brambles.
WORKING HOURS	8am - 4pm, 5 day week.

3. HISTORY

The quarry commenced intermittent production in 1949 (Miles, 1955) to supply the ferroalloy plant in Newcastle. An additional ferro alloy plant was opened at Bell Bay in 1962. Shipments of quartz from Whyalla to Bell Bay commenced in 1976 when additional feroalloy capacity was commissioned at Bell Bay, and the Newcastle plant closed (Hooper, 1980).

4. GEOLOGY

A quartz reef about 8 km long within dark grey volcaniclastic grit and sandstone of the Proterozoic Moonabie Formation trends approximately north-south across the Whyalla-Iron Knob railway, about 37 km from Whyalla. The outcrops constitute a line of discontinuous ridges standing about 15 m above the surrounding plain and consist of bands of quartz, 15-20 m wide. The quarry has been opened up in the southern end of a long ridge about 1.6 km north of the railway.

5. OPERATIONS

The quartz is extracted from a 300 x 100 m single bench quarry. Drilling and blasting of overburden and quartz is carried out by BHP and quartz is loaded and carted to the "scree" plant at Iron Monarch by Brambles (contractors) for crushing.

Broken rock is fed through a 2.15 x 1.5 m Morgardshammar jaw crusher onto a grizzly, oversize from which feeds a 760 x 460 mm Hadfield jaw crusher. Crusher product and grizzly undersize feed a double deck vibrating screen with 12.5 and 38 mm top and bottom decks respectively. Oversize is railed to Whyalla and shipped to the Tasmanian Electrometallurgical Co Pty Ltd at Bell Bay for the manufacture of ferrosilicon. The intermediate fraction is railed to Whyalla where 30 kg per tonne of hot metal is added to the blast furnance charge to control slag chemistry. Undersize is rejected.

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SILLIMANITE (and associated minerals)

A deposit near Williamstown, 60 km by road northeast of Adelaide is the only Australian source of refractory grade sillimanite and "kaosil". 50 tonnes of sillimanite with an ex-mine value of almost $5 500 were produced in 1988. Shipments to Melbourne for manufacture of porcelain insulators for spark plugs have ceased and sillimanite is now marketed in W.A. 6 320 tonnes of altered sillimanite with an ex-mine value of $531 000 were also produced. This product is a mixture of sillimanite and kaolin known as 'kaosil'. 1 800 tonnes valued at $200 000 FOB were exported in 1988, principally to the UK and New Zealand, for use as a filler and refractory. The deposit also produced 129 tonnes of mica valued at $13 600 ex-mine, most of which was sent to Melbourne for filler and non-adhesive uses. 3 900 tonnes of feldspar was also used locally as flux in brickmaking.

Kaolin was first mined by BHP in the early 1900s and later by BHAS, for refractory use at Port Pirie. BHAS ceased mining in 1936 and subsequent operators combined in 1947 to form Australian Industrial Minerals NL. This company became a wholly owned subsidiary of Ausmintec Corporation Ltd in 1986.

WILLIAMSTOWN - AUSMINTEC CORP LTD

1. GENERAL

LOCATION 40 km northeast of Adelaide, 4 km southeast of Williamstown (Fig. 53)

OPERATOR Commercial Minerals Ltd.

ADDRESS 19 Bowyer Road, Wingfield 5013
Tel. 268 8954
Fax (08) 268 1264
Telex 186363
Mt Crawford Mine
Tel. (085) 246305

MINERAL TENURE PM 13

2. PRODUCTION

MINERALS PRODUCED Kaolin/Sillimanite ("Kaosil"), sillimanite, muscovite, biotite, vermiculite, feldspar (Kaolinised pegmatite).

PRODUCT GRADES

	Kaosil 150	Calc Kaosil	Sillimanite	Weath Shale Kaolin KB65	Mica Gr 1	Mica Gr 2	Feldspar 'Soda Spar'
SiO_2	45.8	49.8	41.3	54.7	66.7	60.9	61.8
Al_2O_3	42.8	46.6	54.3	28.6	23.0	27.4	23.5
Fe_2O_3	0.41	0.45	0.59	0.93	0.29	0.76	0.36
TiO_2	1.04	1.13	2.70	1.59	0.96	0.95	0.02
Na_2O	0.28	0.30	0.20	0.10	0.66	0.61	6.95
K_2O	0.44	0.48	-	2.66	2.80	3.94	1.25
MnO	<0.01	<0.01	-	0.01	0.02	0.01	0.01
MgO	0.22	0.24	0.08	0.72	0.30	0.24	0.55
CaO	0.07	0.07	0.44	0.16	0.14	0.14	0.49
P_2O_5	0.04	0.04	-	0.06	<0.01	<0.01	0.07
LOI	8.0	-	0.40	11.30	4.63	5.50	4.95

ANNUAL PRODUCTION (1988)	Sillimanite	49 tonnes (Fig. 57)
	Kaosil	6320 tonnes (Fig. 58)
	Muscovite	129 tonnes (Fig. 59)
	Feldspar (kaolinised pegmatite)	3910 tonnes

RESERVES — Mt. Crawford and Springfield: 25 - 40,000 tonnes ore, depending on size and grade of northeastern ore body. (Barnes and Olliver, 1989)

PRODUCT USES — Kaosil - refractories, filler in paint, plaster, plastic, rubber, paper, floor coverings glass, cosmetics, ink
Sillimanite - refractories
Muscovite - filler in paint plasterboard, and welding rods. Non-adhesive agent in foundry moulds, and rolled adhesives
Biotite/Vermiculite - soil conditioner
Kaolinised Pegmatite - flux in brickmaking

DESTINATIONS — Kaosil - Japan, Taiwan, New Zealand, U.K. Melbourne, Adelaide (Beverley)
Sillimanite - WA
Muscovite - Melbourne, Adelaide (Gillman)
Biotite/Vermiculite - Adelaide
Feldspar - Adelaide (Golden Grove)

WORKFORCE — 10

3. HISTORY

The following has been adapted from Olliver et al. (1983). White kaolinitic clay was discovered on the property of Mr. G.K. Warren in the early 1900's. Clay was first mined by BHP from the Reservoir mine. Operations were transferred to the larger Mt. Crawford deposit in 1906. The clay was used for making refractories for BHP's Port Pirie smelters. BHAS was founded as a co-operative in 1915, and took over smelting operations at Port Pirie together with the mine at Mt. Crawford. BHAS also worked high grade clay at the Springfield mine.

BHAS ceased operations in 1936 and the deposit was worked by the landowner and several small companies. Industrial Minerals NL took over the Mt. Crawford mine in 1938-39. Kaolin Corporation NL began producing washed clay from a plant adjacent to the mine in 1946, and amalgamated with Industrial Minerals in 1947 to form Australian Industrial Minerals NL.

From 1953 to 1955, the Mount Crawford Kyanite Co. worked a small kyanite deposit to the southwest of the Mount Crawford mine.

The Warren mine was worked for fireclay from 1933 to 1960 by the Torrens Mining Co using underground methods. Clay, sillimanite and mica were later extracted by open cut. Newbold General Refractories Ltd took over in 1960 but removed only sillimanite stockpiles.

In October 1972, Private Mine 13 was granted to the landowner B.H.McLachlan covering Mt. Crawford, Springfield, Warren and Reservoir mines. AIM continued as sole operator under agreement with the landowner.

NGM Pty Ltd, a wholly owned subsidiary of Norreman Gold Mines Pty Ltd, began operating the mine when Norreman became a major shareholder in AIM in 1982. Ausmintec Corporation Ltd acquired NGM Pty Ltd as a wholly owned subsidiary in 1986. In October 1987, Commercial Minerals Ltd purchased all assets of NGM Pty Ltd.

4. GEOLOGY

The Williamstown deposits described by Olliver, et al (1983), are contained within a faulted, northerly extension of the Warren Inlier, in Barossa Complex metamorphic rocks of Proterozoic age.

Host rocks comprise quartz - mica schist, quartz sillimanite gneiss and sillimanite quartzite with accessory kyanite, rutile and garnet. The initial high grade metamorphism produced segregations of sillimanite, kyanite, rutile and quartz within the schist and smaller sillimanite - kyanite segregations in the quartzite. Both the schist and segregations subsequently underwent hydrothermal alteration probably associated with pegmatite intrusion during the Cambro-Ordovician Delamerian Orogeny.

The main orebodies (Mt. Crawford, Springfield) resulted from alteration of the schist to a kaolin-mica-quartz rock in which the sillimanite has been largely altered to "kaosil", a mixture of sillimanite-quartz-kyanite rock to daolin and kaosil with remnant sillimanite boulders. Sillimanite from the Springfield mine and kyanite from the Mt Crawford mine were obtained from segregations within sillimanite quartzite.

The kyanite has been altered to green muscovite, and biotite to vermiculite. The principal source of mica is the muscovite-rich shear zones produced by late stage faulting.

The main orebody is 50-70 m across and dips steeply to the east with a northerly plunge of 70°. Minor folding is common locally, particularly near major faults.

5. OPERATIONS

By the early 1980s, the continued viability of the operation was threatened by extremely limited pit floor space and oversteep faces (Barnes and Olliver, 1989). Consequently, a major program of overburden removal was initiated in 1983, beginning with stockpiling of several years supply of ore. Mining was resumed in late 1987 and current efforts are aimed at gaining access to the northeastern part of the orebody. A significant additional orebody has been defined by drilling at the Springfield deposit, about 500 m southwest of the Mount Crawford pit.

Overburden is broken by blasting, loaded by two Caterpillar 977 Traxcavators into four trucks (Mac, Leader and Ford 17 tonne and one International 13 tonne) and carted to the dump. Where pods of white clay and mica are large enough to be selectively mined by the Traxcavators, they are carted directly to stockpiles, mica being classified by colour at the face into four grades. Mica is also mined from a shear zone in the upper part of the northern face of the pit. Boulders of sillimanite are selectively mined and stockpiled, the larger being reduced to a maximum diameter of about 0.5 m (50 kg) using explosive. The remainder of the orebody, comprising a mixture of kaosil, sillimanite and kyanite boulders and muscovite is trucked to stockpile. The ore is then spread, crushed by running over with a Traxcavator and passed over a 100 mm screen (hired as required).

Undersize is stockpiled undercover as kaosil and oversize is stored for checking by knapping during winter to separate kaosil lumps from pure sillimanite. The kaosil lumps are passed through a jaw crusher (hired) prior to stockpiling. Ore contaminated by country rock from the margins of the ore zone is processed separately because it yields a product of too variable an alumina content for export markets. Screened fines from marginal ore are carted out to a stockpile near the overburden dump and oversize is checked by knapping as for uncontaminated ore.

A pegmatite intrusion is worked in the northwestern face of the pit and stockpiled near the overburden dump in two grades based on colour.

Kaosil for export is packed in 2.1 tonne bulker bags and containerised (10 bags per container). Approximately 100 containers are shipped annuallly to the U.K. from Melbourne. Kaosil for Taiwan, Japan and New Zealand is milled by Commercial Minerals at Wingfield and Beverley before shipment.

Sillimanite has an interlocking fibrous habit and cannot be crushed without prior calcination at 1100-1200°C. This was formerly carried out by Non-Porite in Melbourne for aggregate for the manufacture of refactory castables. AIM has recently entered a joint venture with Ref-Crete Services Pty Ltd, a Western Australian refractory manufacturer which has constructed a top hat kiln at Wingfield, and agreed to purchase all sillimanite production of 300-500 tpa (Anonymous, 1989).

The kiln is a gas-fired, ceramic-wool-lined type which is lowered over a 4-5 tonne pile of sillimanite boulders hand stacked on a bed of kaosil. The kiln is sealed around the base with kaosil, fired to 1150°C with a three hour soak and then lifted off with a forklift. The thermal shock of cool air on red hot sillimanite aids decrepitation. The calcined sillimanite is then crushed, milled and screened into four size gradings at Wingfield, and railed to WA in 1 tonne bulker bags.

Other products are sold in bulk and are loaded from stockpile by Caterpillar 966 and Terex rubber-tyred loaders. Muscovite is trucked to Commercial Minerals at Gillman and Melbourne. Kaolin is also obtained from Hallett's southern Birdwood deposit and stockpiled at the Williamstown pit before transfer to Wingfield for milling.

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TALC

In 1988, 19 000 tonnes were produced with an ex-mine value of $1.41 million. 70% of this was shipped to the eastern States, mainly for pharmaceuticals and as a filler in paints. Exports of 390 tonnes, valued at $92 000 FOB, were mainly to New Zealand, South Africa and Fiji.

South Australia produces 10% of Australia's talc production, but supplies nearly all of Australian domestic requirements. Western Australia, the largest producer, ships all of its output to Europe and the UK.

90% of South Australia's talc is mined by Commercial Minerals Ltd from 3 of over 40 known deposits at Mt Fitton, 140 km east-northeast of Leigh Creek. These deposits were discovered in 1944 and have been worked by the present operators since 1984. Small quantities of lower grade talc are mined near Adelaide at Gumeracha and Lyndoch.

MT FITTON - COMMERCIAL MINERALS LTD

1. GENERAL

LOCATION	Mount Fitton, Northern Flinders Ranges, about 130 km east of Lyndhurst, 30 km west of Moolawatana H.S. and 8 km northwest of Mt. Fitton H.S. (Fig. 53).
OPERATOR	Commercial Minerals Ltd.
ADDRESSES	Mine - Flinders Talc Mine via Lyndhurst, 5732 Head Office - 100 Eastern Parade, Gillman 5013 Tel. 475 977
MINERAL TENURE	ML 3076, 3155-68, 3467-73, 3497-3500, 4135-40, 4580, 4604, 5079 . MPL 20-23, 30

2. PRODUCTION

MINERAL PRODUCED	Talc
PRODUCT GRADES	QS, super white paint grade (colour is major criterion). J & J, pharmaceutical grade (colour is important; acid solubles eg dolomite, and tremolite are deleterious). XL, medium grade, coloured talc. CC, low grade, contains impurities.
ANNUAL PRODUCTION (1988)	11490 tonnes (Fig. 61)
RESERVES	Not defined.
PRODUCT USES	Cosmetics, filler in paints, plastic, paper, adhesives, rubber, diluent and carrier of agricultural chemicals, many minor uses.
DESTINATION	To Gillman for milling and bagging. Then mainly to interstate markets.
WORKFORCE	15

3. HISTORY

The tenement history has been detailed in a report of McCallum and Oors, (1980). Talc was discovered in the Mount Fitton district in 1944 by J.G. Ford, the manager of Wooltana Station. Samples sent to the Department of Mines and to the C.S.I.R. by G.A. Greenwood, were found to be of high grade. Ford and Greenwood prospected and pegged a number of deposits, the most favourable being Nos. 4 and 5. The Flinders Talc Syndicate began production in January, 1947 and subsequently negotiated an agreement with John Dunstan & Son (W.A.) Ltd. to work the deposits. All leases were transferred to Industrial Rock Mines Pty. Ltd. in April, 1963, and were subsequently transferred to Steetley Australasia Pty Ltd, the parent company. In the latter half of 1972 Steetley were acquired in 1984 by Anglo American Pacific Ltd which operated the deposit as Commercial Minerals Ltd. Anglo American Pacific was acquired by Poseidon in 1988.

GEOLOGY

McCallum (1988) has described the geology of the Mount Fitton area.

Talc deposits were formed in the Late Cambrian/Early Ordovician Delamerian Orogeny associated with widespread folding and low pressure/high temperature regional metamorphism. Talc is hosted by Balcanoona Formation (Umberatana Group) comprising pale grey dolomite and dolomitic marble with massive to thinly bedded blue grey algal limestone at the base. This unit thins rapidly north and south of the talc deposits. Balcanoona Formation is conformably overlain by Amberoona Formation, a finely laminated deep green and grey-green siltstone, which in the area of the talc deposits shows a prominent surface hardening (silicification) and dark brown weathering up to several metres deep. Balcanoona Formation rests unconformably on Sturtian Bolla Bollana Tillite, a massive blue-green greywacke tillite containing abundant erratics 10 to 50 mm diameter, and includes minor siltstone and quartzite.

The sequence has been folded around shallow westerly plunging axes and contrast between Balcanoona Formation and the more competent enclosing units has resulted in a series of disharmonic folds along the contacts. Talc has formed by siliceous hydrothermal replacement at the top and base of Balcanoona Formation in fold cores near the contacts, and has also been emplaced along adjacent faults and fractures. Deposits are usually 10-50 mm stratigraphically from the contacts with the enclosing formations, from which the silica was probably derived. Within Balcanoona Formation, dolomite is coarsely recrystallised or silicified, with massive outcrop, along east-west fractures parallel to fold axes.

Addition of silica to the dolomite and dolomitic marble initially produced tremolite, and subsequent removal of calcite produced talc and chlorite.

Bedding, which on a regional scale dips west, is locally difficult to determine, and lodes are parallel to the metamorphic foliation in country rock. The larger deposits which are generally 10-15 m wide, more than 20 m deep and several hundred metres long (east-west). Plunge is moderately to the west, and dip steeply south, parallel to regional fold axes.

Talc is fine grained, massive or weakly to strongly foliated parallel to lode orientation. Colour ranges from clear translucent pale grey to opaque light grey, off white, or grey green where chlorite is present. Talc can grade into talcose dolomite, or can have sharp margins into recrystallised or relatively unaltered dolomitic marble. Other impurities, beside tremolite, dolomite and chlorite are iron staining, apatite and rutile.

5. OPERATIONS

Over 40 individual deposits have been worked since 1947. Talc is currently mined by open cuts at the No. 5, No. 17 and Lewis workings. Faces are established by drilling and blasting and talc is selectively loosened and dropped from the face using a Komatsu hydraulic rock pick. At the Lewis deposit, QS grade is hand-picked into skips for direct transfer into the truck to the Lyndhurst railhead. The Lewis talc is grey due to chlorite content but it mills white and is used in paint, and to upgrade other products to specification. The No. 17 deposit talc is of cosmetic grade (J & J) because, although not exceedingly white, it is low in acid - soluble minerals (eg dolomite, tremolite) and can be blended with other whiter talcs. Other talc is pushed up with Caterpillar 955K and Komatsu D75S bulldozers and picked up by front and loader and trucked to the plant (Fig. 60) in two Volvo BM articulated trucks.

The talc is rock-picked through a grizzly onto an 80 mm and 20 mm double deck screen. Oversize, some of which comprises boulders up to 0.5 m diameter, is conveyed under a water spray to the picking belt. The pickers (up to 5) stand undercover, adjacent to the conveyor and separate cosmetic grade (J & J), medium grade (XL), coloured talc and waste by pushing the product through chutes to the respective stockpiles outside the picking shed. Low grade (cc) talc is allowed to fall from the end of the conveyor. The minus 80 mm is stockpiled for later picking into waste and marketable talc and the undersize is stockpiled for possible later use.

Product is transferred by front end loader to road train for the daily 130 km trip to Copley, mostly along unsealed road. The talc is then loaded by front end loader to 40 tonne wagons and railed about 615 km to Gillman for milling and blending to specifications of fineness, bulk density, absorbence, colour and reflectance. Product is bagged and trucked to markets, mainly interstate. 390 tonnes were exported in 1988, mainly to New Zealand, but also to Fiji, South Africa and Poland.

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PLATE 1. Barite, Oraparinna Mine, view north, showing mine on left with workshops below. The large open cut on 1C Lode is on the upper slopes of the hill above the mine. Roberts Lode is at right with No. 3 and No. 4 Lodes adjacent to the left. Bainbridge (No. 2) Lode is out of sight in the saddle between Roberts Lode and the Oraparinna Mine.

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PLATE 2. Barite, Oraparinna Mine. Drilling stope on 1A Lode at 7 level.

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PLATE 3. Barite, Oraparinna Mine. Komatsu wheeled loader loading Volvo BM 861 20 tonne articulated dump truck in 7 level stope at bottom of decline.

Slide No. 38181

PLATE 4. Barite, Oraparinna Mine. Wagner ST1.3 load, haul dump (LHD) scoop-mobile used for pick up of ore in the lower-roofed cross-cuts and cartage to trucks in the decline.

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PLATE 5. Barite, Dunbar deposit (Linke's Lode). Westerly view along Universal Milling's open out on eastern side of road. Faces of Steetley's deposit visible in background.

Slide No. 38183

PLATE 6. Barite, Dunbar deposit (Linke's Lode). Westerly view of Universal Milling's open cut showing mining with rock pick and loading.

Slide No. 38184

PLATE 7. Barite, Dunbar Deposit (Linke's Lode). North easterly view of Steetley's open cut on western side of road.

Slide Nos. 38185, 38186, 38187

PLATE 8. Barite, Quorn Mill. Northerly view showing stockpiles and conveyor to jaw crusher (out of view) at left, screen and cone crusher at centre. Storage bins are in western building with jigs, tables, burner, mill and baggers in eastern building.

Slide No. 38188

PLATE 9. Barite, Quorn Mill. Crusher product being sluiced into May double jig for separation into a lighter fraction (shale etc) and barite (settles through bottom of tank).

Slide No. 38189

PLATE 10. Barite, Quorn Mill. Minus 2.5mm barite being concentrated on Wilfley table.

Slide No. 38190

PLATE 11. Barite, Quorn Mill. Dewatered jig and Wilfley table concentrate being drained, outside plant.

Slide No. 38191

PLATE 12. Barite, Quorn Mill. Roller mill and burner, left background, bagging machines at left and centre.

Slide No. 38192

PLATE 13. Dimension Stone (Granite), Calca. Slab about 10x3x1m has been line-drilled free of jet-cut block and pulled over onto tyres. Further cutting by line drilling in progress. 15 tonne crane, upper benches and undisturbed mallee in background.

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PLATE 14. Dimension Stone (Granite), Calca. Jet-cut channel, about 3m deep x 0.15m wide.

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PLATE 15. Dimension Stone (Norite), Black Hill. General view of Martin's quarry showing cut blocks and crane. Wire sawing is carried out in building on right hand side in background.

Slide No. 38195

PLATE 16. Dimension Stone (Norite), Black Hill. Martin's quarry showing block extraction by line-drilling.
Slide No. 38196

PLATE 17. Dimension Stone (Norite), Black Hill. General view of Amatek's quarry showing crane and stockpiled blocks.
Slide No. 38197

PLATE 18. Dimension Stone (Norite), Black Hill. Amatek's quarry, drilling operations.
Slide No. 38198

PLATE 19. Dimension Stone (Limestone), Mount Gambier. Blocks have been sawn at spacing corresponding to ashlar length (660mm) and are being undercut at ashlar height (290mm). Wedges visible on top of face will be placed in undercut prior to cutting to width. Limestone Products' Quarry.
Slide No. 38199

PLATE 20. Dimension Stone (Limestone) Mount Gambier. Final stage of cutting where blocks are sawn to width (100, 115 or 225mm). Wedges prevent the ashlars from moving and breaking irregularly during sawing. Limestone Products' Quarry.
Slide No. 38200

PLATE 21. Dimension Stone (Limestone), Mount Gambier. General view of Bruhn's quarry showing pallets of ashlars awaiting shipment.
Slide No. 38201

PLATE 22. Dimension Stone (Slate), Mintaro. General view down dipslope showing two benches.
Slide No. 38202

PLATE 23. Dimension Stone (Slate), Mintaro. View down dipslope showing jackhammer and plugs and feathers.
Slide No. 38203

PLATE 24. Dimension Stone (Slate), Mintaro. Slab being lifted from quarry on crane cable. Dipslope in foreground.
Slide No. 38204

PLATE 25. Dimension Stone (Slate), Mintaro. Slab polisher in factory near quarry.
Slide No. 38205

PLATE 26. Dimension Stone (Slate), Jones Hill. General easterly view of workings.
Slide No. 38206

PLATE 27. Dimension Stone (Slate), Jones Hill. Driving wedge along bedding.
Slide No. 38207

PLATE 28. Dimension Stone (Slate), Jones Hill. Levering slab free with jemmy bar.
Slide No. 38208

PLATE 29. Dimension Stone (Slate), Jones Hill. Moving slab to stockpile with forklift.
Slide No. 38209

PLATE 30. Dimension Stone (Slate), Wistow No. 1. View northwest showing picking bays and stockpiles at right.
Slide No. 35007

PLATE 31. Dimension Stone (Slate), Wistow No. 2. View northwest.
Slide No. 35011

PLATE 32. Dimension Stone (Slate), Wistow No. 3. Sorting belt with vibrating screen in background.
Slide No. 35438

PLATE 33. Dimension Stone (Slate), Wistow. Wall and paved driveway showing brown iron oxide coating on joint plane faces of walling stone, and paving laid on concrete base without pointing.
Slide No. 38210

PLATE 34. Dimension Stone (Slate), Kanmantoo. Westerly view of main working face and partly developed upper bench.
Slide No. 24952

PLATE 35. Dimension Stone (Slate), Kanmantoo. Main working face.
Slide No. 24953

PLATE 36. Dolomite, Ardrossan. Southwesterly view of quarry showing blasthole drilling and overburden removal.
Slide No. 38211

PLATE 37. Dolomite, Ardrossan. Storage bins and jetty, looking east. Surplus 25x7mm flux in stockpiles at right.
Slide No. 38212

PLATE 38. Dolomite, Tantanoola. Southerly view of quarry.
Slide Nos. 38214, 38215, 38316

PLATE 39. Dolomite, Tantanoola. Southerly view of plant.
Slide No. 38213

PLATE 40. Gypsum, Lake MacDonnell. Gypsarenite exposed following stripping of gypsum silt overburden. Reclamation of leached crushed selenite stockpiles in background.
Slide No. 38217

PLATE 41. Gypsum, Lake MacDonnell. Gypsarenite windrowed to leach salt. Unworked lake bed in foreground.
Slide No. 38218

PLATE 42. Gypsum, Lake MacDonnell. Selenite, blasted from face into lake, being stockpiled by dragline.
Slide No. 38219

PLATE 43. Gypsum, Lake MacDonnell. Crushing plant showing feeding of plant through roadbridge at right and loading truck for cartage to leaching stockpiles. Trainloading bins at left now used only for storage.
Slide No. 38220

PLATE 44. Gypsum, Lake MacDonnell. Loading train by front end loader.
Slide No. 38221

PLATE 45. Gypsum, Thevenard. Splitting station, where stockpile conveyor is split into two lines. Train unloader in background.
Slide No. 38222

PLATE 46. Gypsum, Thevenard. One of the two gypsum stockpile conveyor lines showing hopper used to feed shiploading conveyor (at right). Moveable twin stacker in background.
Slide No. 38223

PLATE 47. Gypsum, Thevenard. Shiploading conveyor with shiploader in background.

Slide No. 38269

PLATE 48. Gypsum, Kangaroo Island (Ballast Head). Aerial view of jetty, conveyor and loading stockpiles with leaching stockpile behind.

Slide No. 23075

PLATE 49. Gypsum, Kangaroo Island (Ballast Head). View along jetty conveyor, showing feed bin and loading stockpile.

Slide No. 38224

PLATE 50. Gypsum, Blanchetown. Screening and loading rock gypsum for transport to Nurioopta plant. Workings in background.

Slide No. 38225

PLATE 51. Gypsum, Marion Lake, Waratah's pit. 28 tonne dragline adjacent to mined out cut used for dewatering.

Slide No. 38226

PLATE 52. Gypsum, Marion Lake, Waratah's pit. Washing plant.

Slide No. 38227

PLATE 53. Gypsum, Marion Lake. Adelaide Brighton Cement's cut at eastern end of lake. 1.2m face awaiting blasting.

Slide No. 38228

PLATE 54. Gypsum, Lake Fowler. Southerly view of main dune.

Slide Nos. 38229, 38230

PLATE 55. Limestone, Klein Point. Office, workshops crusher, 6000 tonne storage bin and jetty.
Slide No. 13550

PLATE 56. Limestone, Klein Point. D10 bulldozer ripping and pushing up overburden at northern end of pit.
Slide No. 38231

PLATE 57. Limestone, Klein Point. Pushing ripped limestone down 25° face for pick up by loader on lower bench.
Slide No. 38232

PLATE 58. Limestone, Penrice. Northwesterly view of quarry showing Allis Chalmers primary cone crusher top left.
Slide No. 38233

PLATE 59. Limestone, Penrice. 750 tonne surge pile showing conveyor from primary crusher at top, reclaim tunnel and conveyor to rolls crusher.
Slide No. 38234

PLATE 60. Limestone, Penrice. Overhead stacking conveyor and tripper with stockpile of 105x43 mm product beneath. Stockpile discharges to tunnel conveyor, visible bottom right, to trainloading bin. Gravel plant left background.
Slide No. 13525

PLATE 61. Limestone, Penrice. 55 tonne rail wagons of 105x43 mm marble at trainloading bin, bound for Osborne soda ash plant.
Slide No. 13526

PLATE 62. Limestone, Rapid Bay. Southeasterly view of quarry.

Slide Nos. 38235, 38326, 38327

PLATE 63. Limestone, Rapid Bay. Jaw crusher at left, gyratory crusher and surge bin at centre, screenhouse and distributor at right.

Slide No. 38238

PLATE 64. Limestone, Rapid Bay. Jetty (488 m long) and T-head (224m long).

Slide No. 38239

PLATE 65. Limesand, Coffin Bay. View from top of storage bins showing bin conveyor, feed hopper, workshop, electric shovel and extensive limes and dunes.

Slide Nos. 38240, 38241

PLATE 66. Limesand, Coffin Bay. Storage bins, conveyor and workshops.

Slide No. 13359

PLATE 67. Limesand, Coffin Bay. Train unloader at Proper Bay (Port Lincoln).

Slide No. 9877

PLATE 68. Limesand, Coffin Bay. Jetty and shiploader at Proper Bay (Port Lincoln).
Slide Nos. 38242, 38243

PLATE 69. Limestone, Caroline. Southerly view of pit.
Slide Nos. 38244, 38245, 38246

PLATE 70. Limestone, Caroline. Southerly view of plant.
Slide No. 38247

PLATE 71. Shellgrit, Port Parham. Southeasterly view of plant with stockpile sheds at left and office in background.
Slide No. 38250

PLATE 72. Shellgrit, Port Parham. Northwesterly view of pit.
Slide Nos. 38248, 38249

PLATE 73. Magnesite, Myrtle Springs. General northwesterly view.

Slide No. 38251

PLATE 74. Magnesite, Myrtle Springs. Hydraulic rock pick loosening steeply dipping magnesite beds. View north-northwest.

Slide No. 24956

PLATE 75. Salt, Dry Creek. Aerial view, looking northerly showing crystallizers with evaporating pans in background.

Slide No. 38252

PLATE 76. Salt, Dry Creek. Salt harvester in operation.

Slide No. 33851

PLATE 77. Salt, Price. Harvesting operations showing stripped area in foreground and 15cm thick deposit yet to be harvested.

Slide No. 38253

PLATE 78. Salt, Price. Brinewasher and centrifuge with leaching stockpiles in background.

Slide No. 38254

PLATE 79. Salt, Whyalla. Windrowing of crystallized salt with front end loader.

Slide No. 38255

PLATE 80. Salt, Whyalla. Processing plant, showing truck tipping to rinse tank, centrifuge, and rotary drier. Screening "tower" in large building at left.

Slide No. 38256

PLATE 81. Salt, Whyalla. Trommel screens inside "tower".
Slide No. 38257

PLATE 82. Salt, Lake MacDonnell. "Blue Lake", looking south towards coastal dunes.
Slide No. 38258

PLATE 83. Salt, Lake MacDonnell. Roadbride and brinewasher. Trucks being loaded for cartage to trainloading stockpile.
Slide No. 38259

PLATE 84. Salt, Thevenard. Train unloading Lake MacDonnell salt. Stockpiles at right awaiting shipment.
Slide No. 38260

PLATE 85. Salt, Lochiel (Lake Bumbunga). Aerial view northwest during stockpiling. Lake at bottom and right.
Slide No. 38261

PLATE 86. Salt, Lochiel (Lake Bumbunga). Northerly view of plant, stockpiles and lake.
Slide No. 38262

PLATE 87. Salt, Lochiel (Lake Bumbunga). Interior of plant showing water softener salt bagged and palletised with screening, washing and centrifuging plant behind.
Slide No. 38263

PLATE 88. Silica, Mount Compass (Glenshera). Southerly view of pit showing white sand in bottom bench.
Slide No. 38264

PLATE 89. Silica, Mount Compass (Glenshera). Easterly view of plant showing dry-screening section and surge bin at left. Trommel, constant density tank and water clarifier outside building. Vibrating screens, attritioners and spirals inside building. Product cyclones in background.

Slide No. 36118

PLATE 90. Silica, Mount Compass (Glenshera). Distributor feeding four 0.5 mm Vibramech polyurethane vibrating screens.

Slide No. 38265

PLATE 91. Silica, Mount Compass (Glenshera). Eight primary spirals.

Slide No. 38266

PLATE 92. Silica, Whyalla (23 mile deposit). Southerly view along quartz vein towards quarry.

Slide No. 38267

PLATE 93. Silica, Whyalla (23 mile deposit). Southerly view of quarry.

Slide No. 38268

PLATE 94. Sillimanite, Williamstown (Mount Crawford). Southerly view of ore zone from stockpile sheds.

Slide No. 38271

PLATE 95. Sillimanite, Williamstown (Mount Crawford). Northerly view of ore zone. Muscovite obtained from face at right of centre and pegmatite from bench at upper left.

Slide No. 38272

PLATE 96. Sillimanite, Williamstown (Mount Crawford). Kaosil stockpile sheds, knapping and sorting sheds at right and Leader 17 tonne truck. View southwest.

Slide No. 38273

PLATE 97. Sillimanite, Williamstown (Mount Crawford). Caterpillar 977 Traxcavator in stockpile area. View easterly.
Slide No. 38274

PLATE 98. Sillimanite, Williamstown (Mount Crawford). Lifting kiln from red hot sillimanite boulders at Wingfield plant.
Slide No. 38327

PLATE 99. Talc, Mount Fitton. General view of No. 5 workings.
Slide No. 38275

PLATE 100. Talc, Mount Fitton. Face at Lewis (No. 17) workings showing high grade talc.
Slide No. 32276

PLATE 101. Talc, Mount Fitton. Hand picking QS grade talc into skips at No. 15 deposit.
Slide No. 22660

PLATE 102. Talc, Mount Fitton. Screening and washing plant at left, picking shed at right.
Slide No. 38277

PLATE 103. Talc, Mount Fitton Plant, showing screens, waterspray and picking shed.
Slide No. 38278

PLATE 104. Talc, Mount Fitton. Inside picking shed. Talc is pushed down chutes at right according to grade.
Slide No. 38279


PLATE 1


PLATE 2


PLATE 3


PLATE 4


PLATE 5


PLATE 6


PLATE 7

PLATE 8

PLATE 9

PLATE 10

PLATE 11

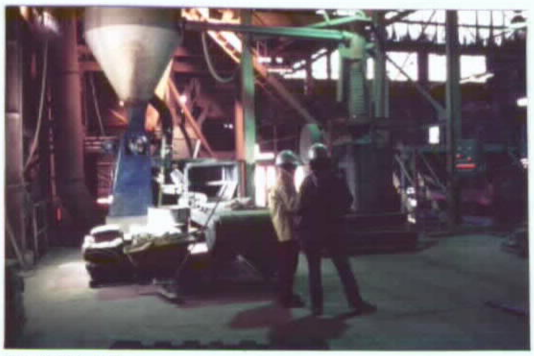

PLATE 12

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PLATE 60

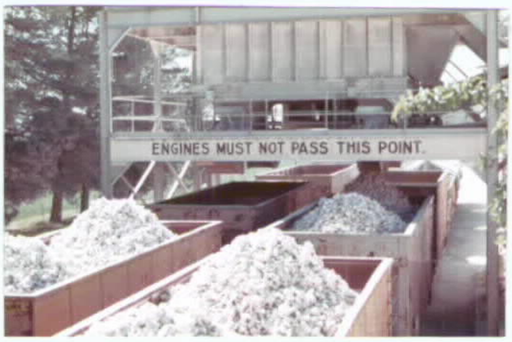

PLATE 61


PLATE 62


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PLATE 89


PLATE 90

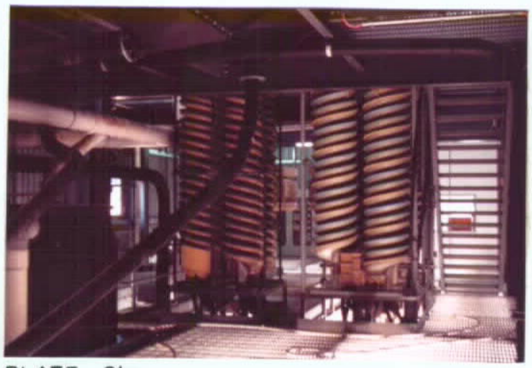


PLATE 91


PLATE 92


PLATE 93


PLATE 94


PLATE 95


PLATE 96


PLATE 97


PLATE 98


PLATE 99

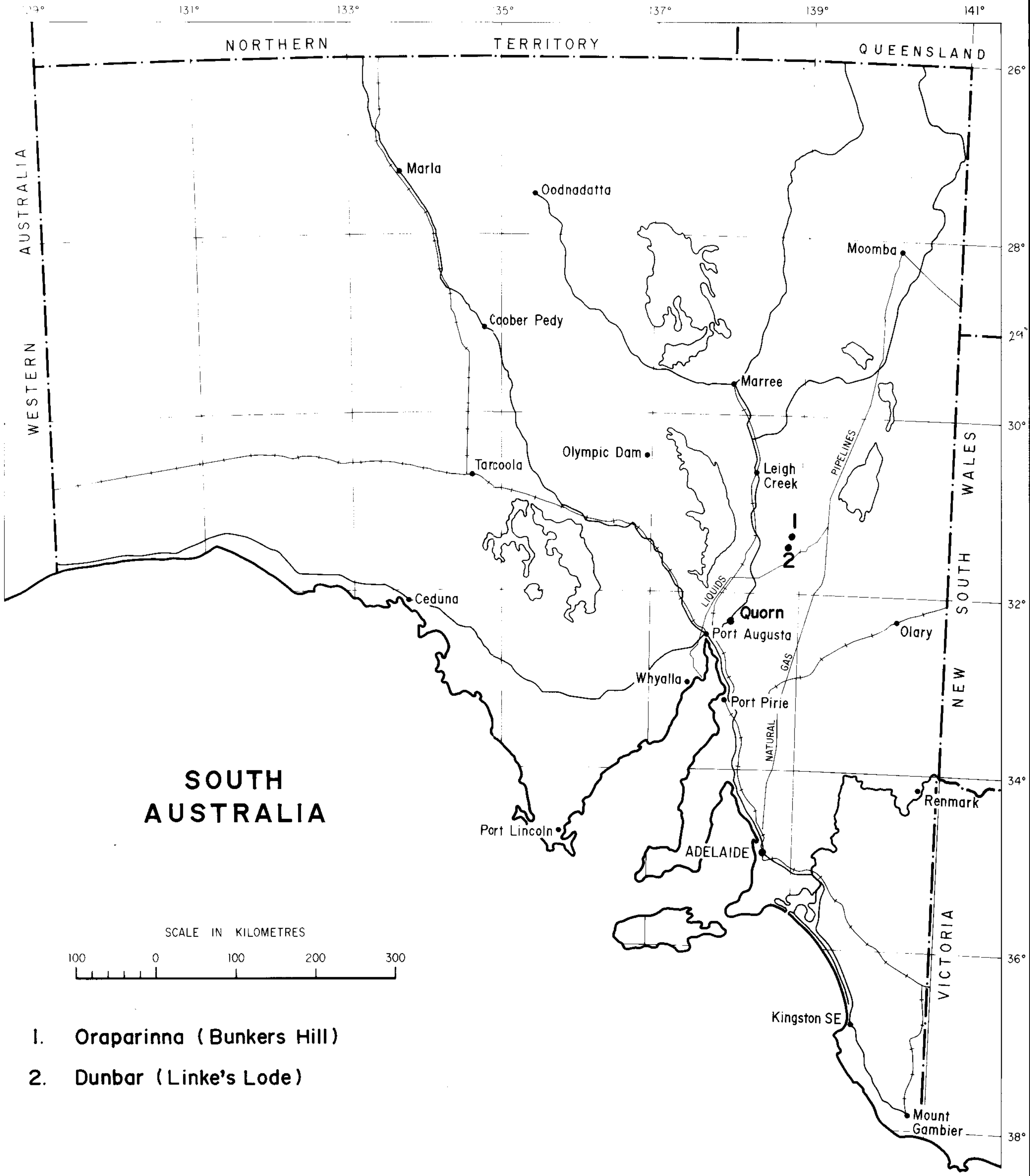

PLATE 100


PLATE 101


PLATE 102


PLATE 103


PLATE 104



1. Oraparinna (Bunkers Hill)
2. Dunbar (Linke's Lode)

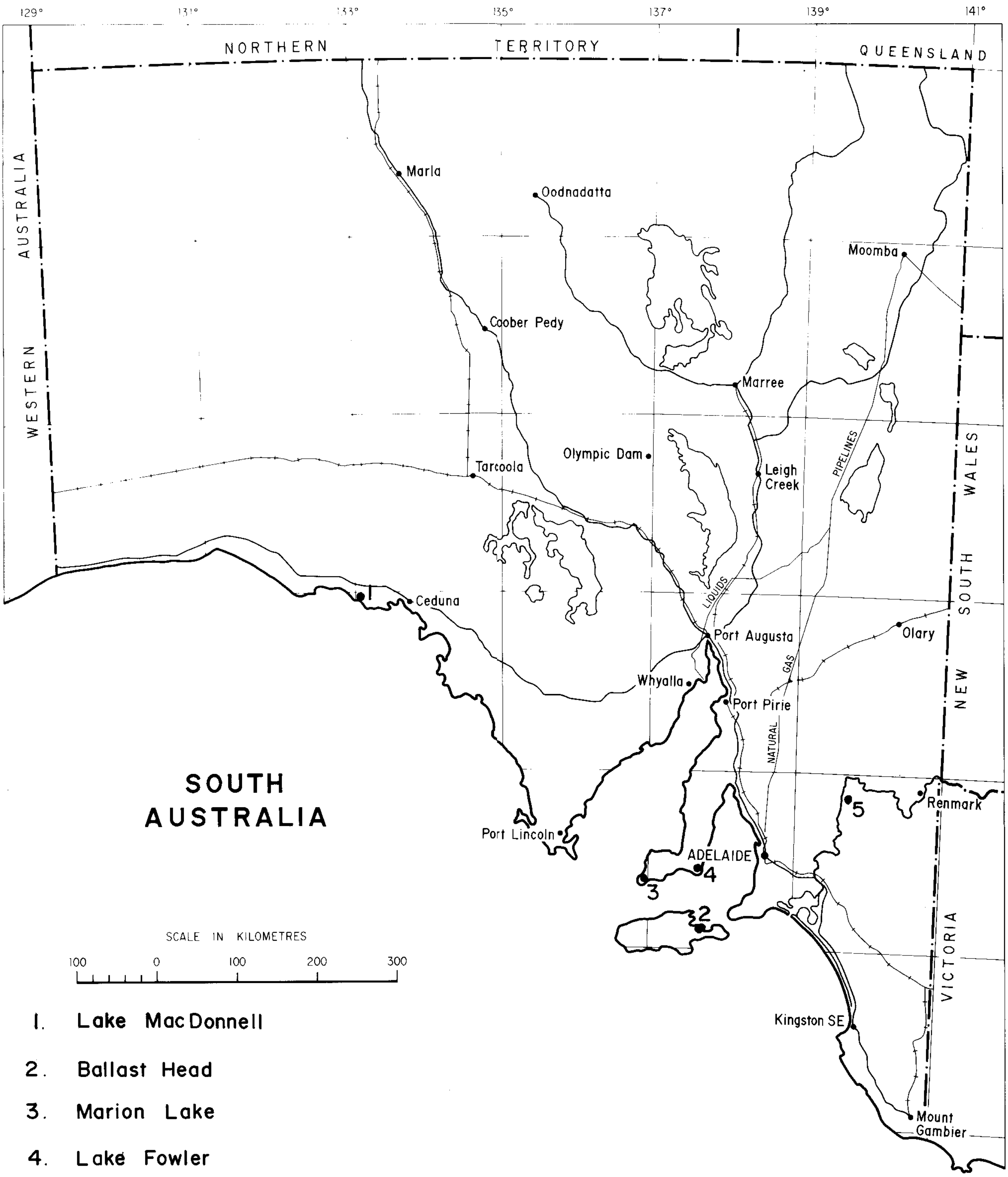
Figure. 1

4846

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

PRINCIPAL INDUSTRIAL MINERALS OPERATIONS IN S.A.
BARITE
LOCALITY PLAN

COMPILED J.V.	12.9.90 C.D.O. DATE
DRAWN D.S.L.	SCALE as shown
DATE June 89	PLAN NUMBER S20835
CHECKED	



1. Lake MacDonnell
2. Ballast Head
3. Marion Lake
4. Lake Fowler
5. Blanchetown

Figure 19.

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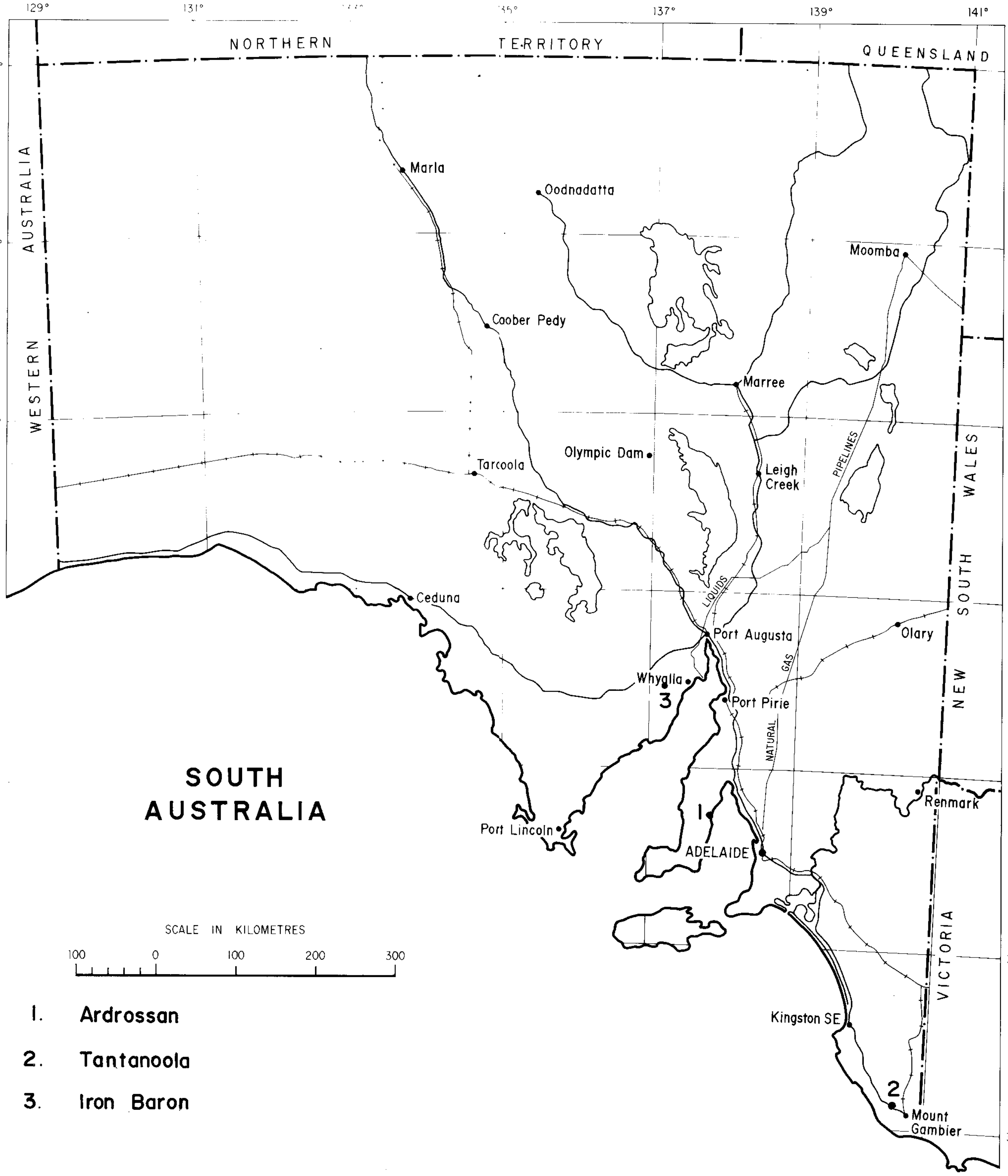
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

PRINCIPAL INDUSTRIAL MINERALS OPERATIONS IN S.A.

GYPSUM

LOCALITY PLAN

COMPILED J.V.	12.9.90 C.D.O. DATE
DRAWN D.S.L.	SCALE as shown
DATE June 89	PLAN NUMBER S20838
CHECKED	

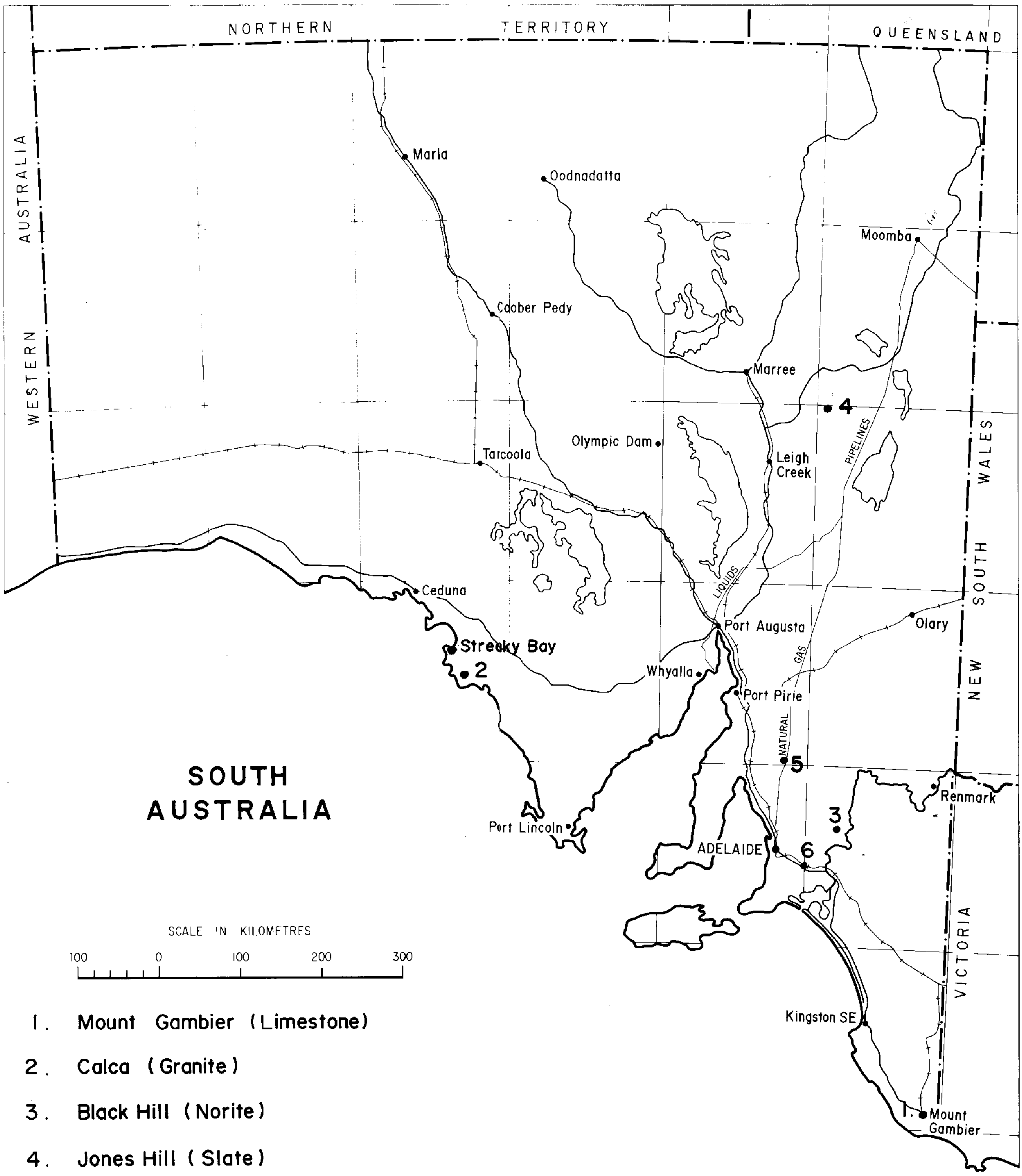


1. Ardrossan
2. Tantanoola
3. Iron Baron

Figure 14.

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED J.V.	C.D.O. 12.9.90 DATE
PRINCIPAL INDUSTRIAL MINERALS OPERATIONS IN S.A.	DRAWN D.S.L	SCALE as shown
DOLOMITE LOCALITY PLAN	DATE June 89' CHECKED	PLAN NUMBER S20837

4846



1. Mount Gambier (Limestone)
2. Calca (Granite)
3. Black Hill (Norite)
4. Jones Hill (Slate)
5. Mintaro (Slate)
6. Kanmantoo/ Wistow (Slate)

Figure 5.

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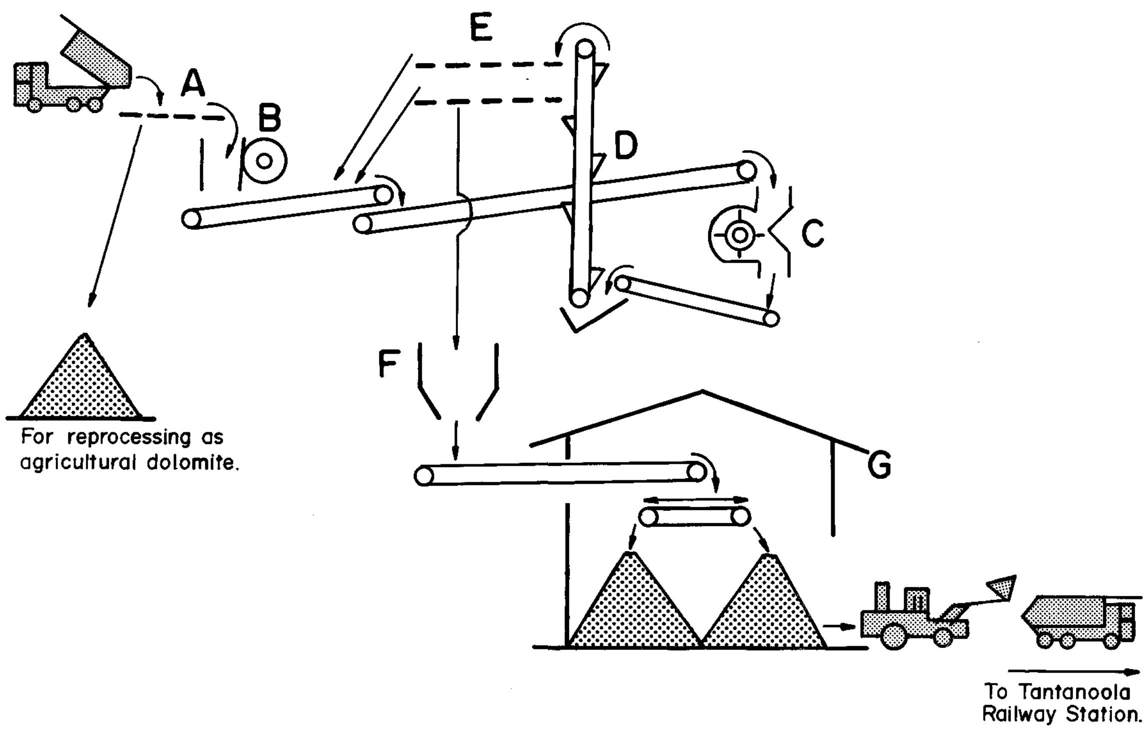
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

PRINCIPAL INDUSTRIAL MINERALS OPERATIONS IN S.A.
DIMENSION STONE
LOCALITY PLAN

COMPILED J.V.	[signature] 12.9.90 C.D.O. DATE
DRAWN D.S.L.	SCALE as shown
DATE June 89'	PLAN NUMBER S 20836
CHECKED	



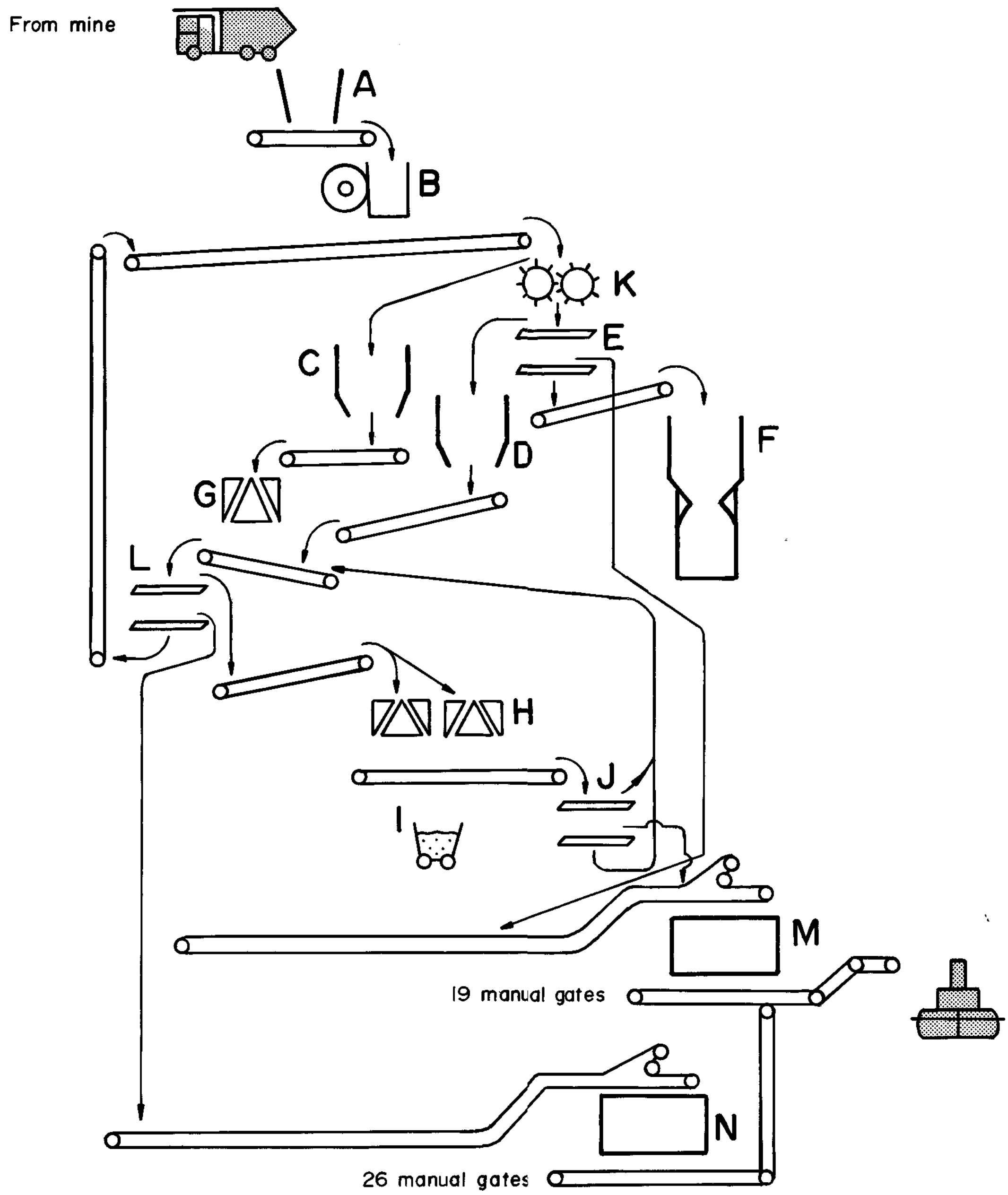
A. Vibrating screen, 30mm.
B. Jaw crusher (Arbra 24x18).
C. Hazemag impact crusher.
D. Bucket elevator.
E. Double deck vibrating screen 12mm, 3mm.
F. Surge bin.
G. Blending shed.

A.C.I., TANTANOOLA
CRUSHING PLANT FLOWSHEET

Figure 17

S.A. Dept. of Mines and Energy.

S 19658



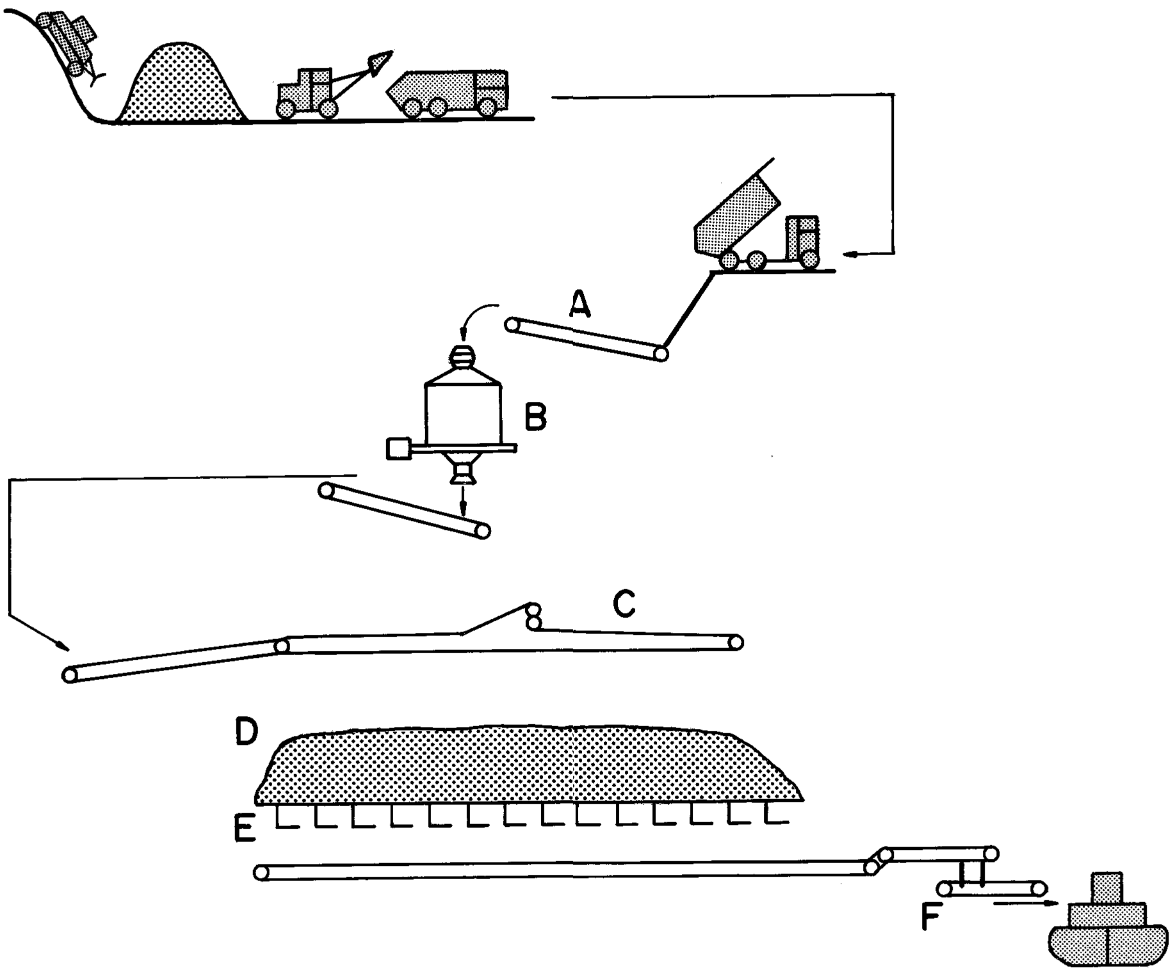
A. Pan feeder.
B. 48 x 36 Vickers Ruwolt jaw crusher.
C. 50 tonne 'Roughs' Bin.
D. 50 tonne 'Middlings' Bin.
E. 'Waste' screen (25mm, 7mm).
F. 240 tonne fines bin.
G. 0·9m Traylor gyratory crusher.
H. Two 0·9m Symons shorthead cone crushers.
I. Trailer for clayey oversize.
J. "Clay" screen (25mm, 7mm).
K. Live roll grizzly (38mm).
L. "Product" screen (38mm, 16mm).
M. No.1 Bin (12500 tonne).
N. No.2 Bin (18000 tonne).

B.H.P., ARDROSSAN.
CRUSHING PLANT FLOWSHEET

Figure 15

S.A. Dept. of Mines and Energy.

S19657



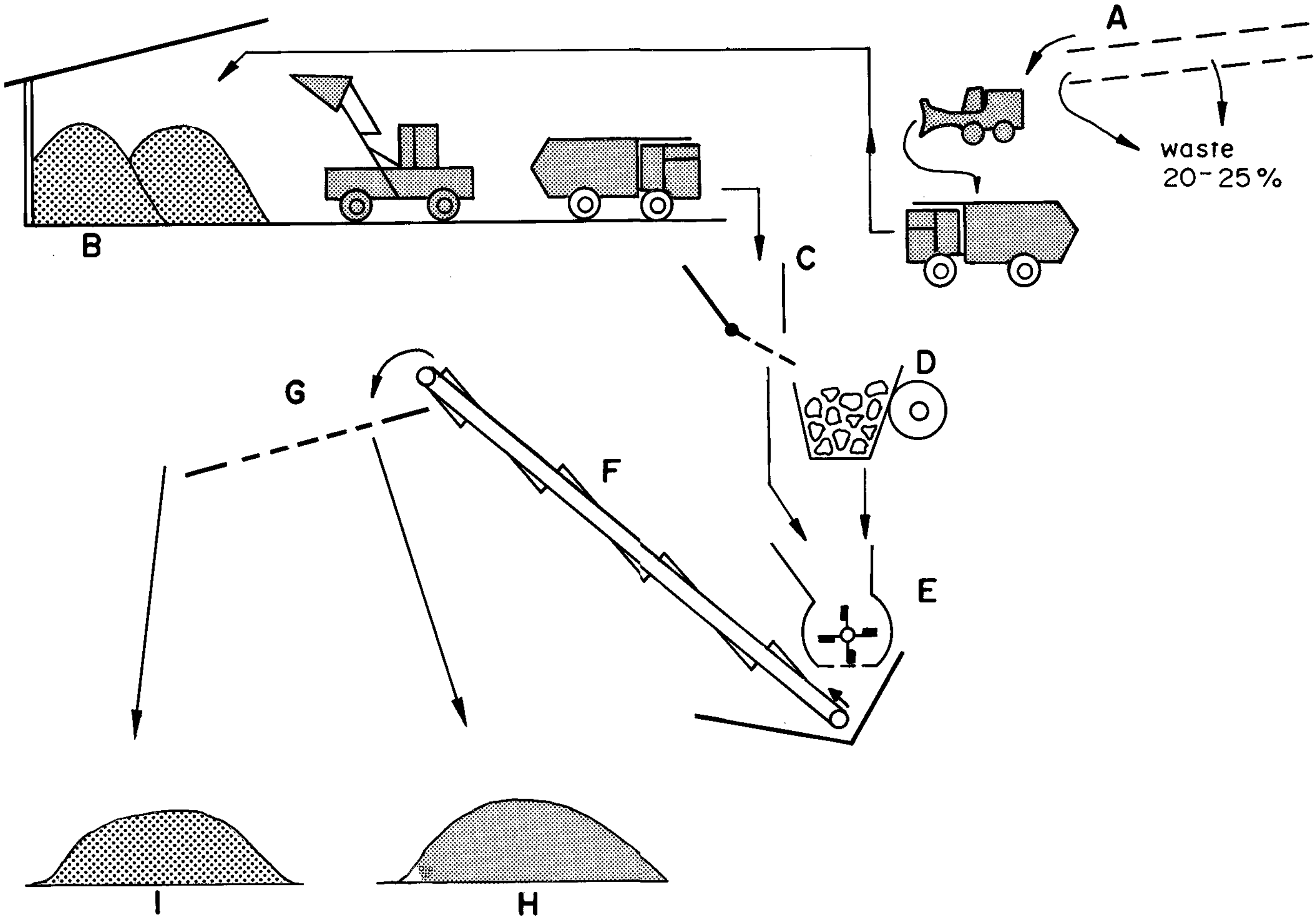
A. Apron feeder.
B. Dixie hammer mill.
C. Distributor.
D. 6000 tonne stockpile.
E. Fourteen manually operated gates.
F. Shiploader with retractable boom conveyor.

ADELAIDE BRIGHTON CEMENT LTD., KLEIN POINT, PLANT FLOWSHEET.

Figure 30

S.A. Dept. of Mines and Energy

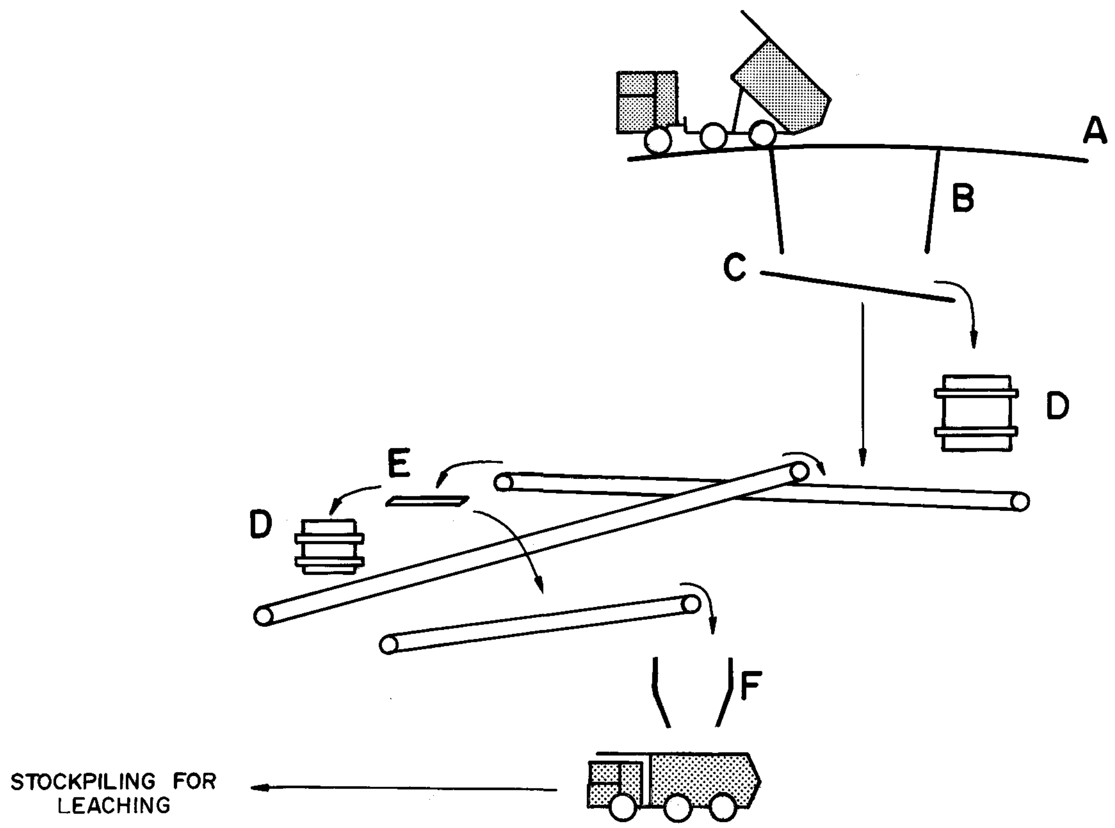
S 19653



A. Double deck screen at Blanchetown pit. Apertures 6" (152mm), 3/4" (20mm).
B. Covered stockpile of R.O.M. ore at Nuriootpa.
C. Feed bin with hand manipulated grid to divert fines directly to hammer mill.
D. Jaw crusher. (35 t.p.h. capacity)
E. Hammer mill.
F. Bucket elevator.
G. 1/4" (6·3 mm) fixed screen.
H. Fines stockpile.
I. Coarse stockpile.

DAVID LINKE CONTRACTOR P/L
GYPSUM TREATMENT AT BLANCHETOWN AND NURIOOTPA

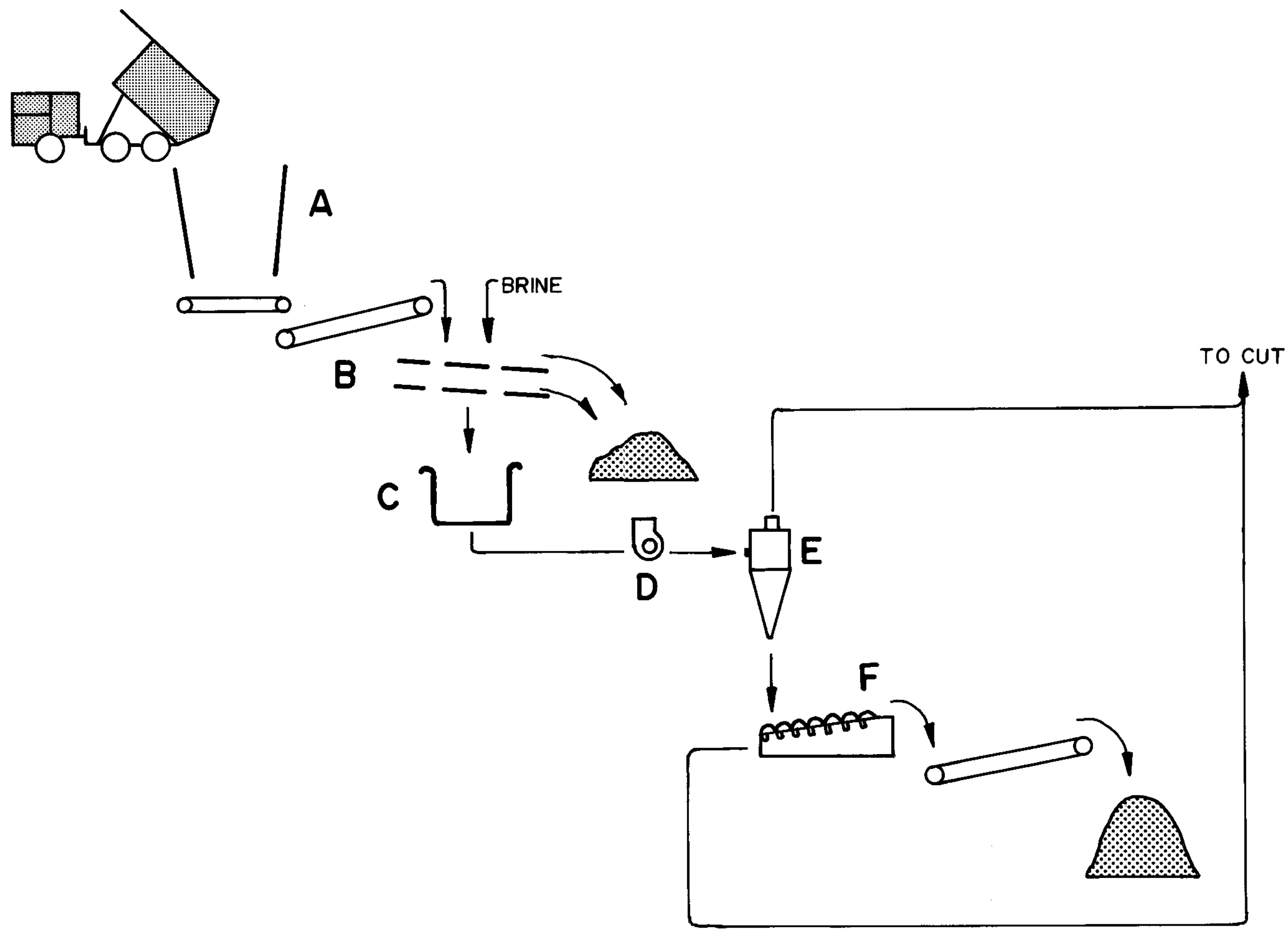
Figure 27



A. Roadbridge.
B. 25 tonne hopper.
C. 100mm vibrating punched plate screen
D. Drum crusher.
E. Vibrating screen (25mm aperture).
F. 50 tonne hopper.

G.R.A., LAKE MACDONNELL
CRUSHING AND SCREENING FLOWSHEET

Figure 20



A. Hopper.
B. Double deck vibrating screen (25mm, 12·5/6·3mm)
C. 1·2m cubic concrete tank.
D. Warman slurry pump.
E. 0·6m (24") hydrocyclone.
F. Screw washer.

WARATAH GYPSUM, MARION LAKE
WASHING PLANT FLOWSHEET

Figure 23

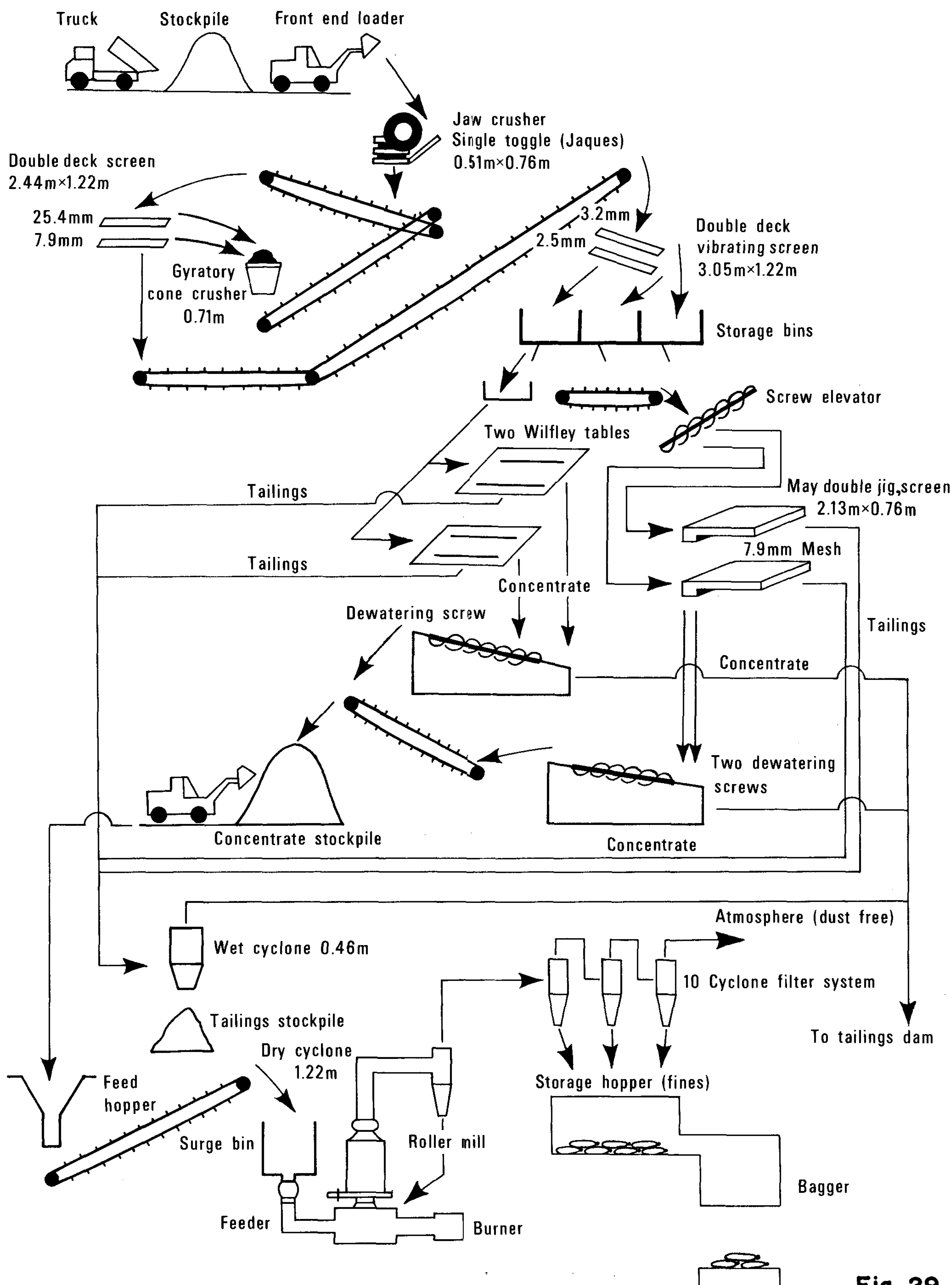
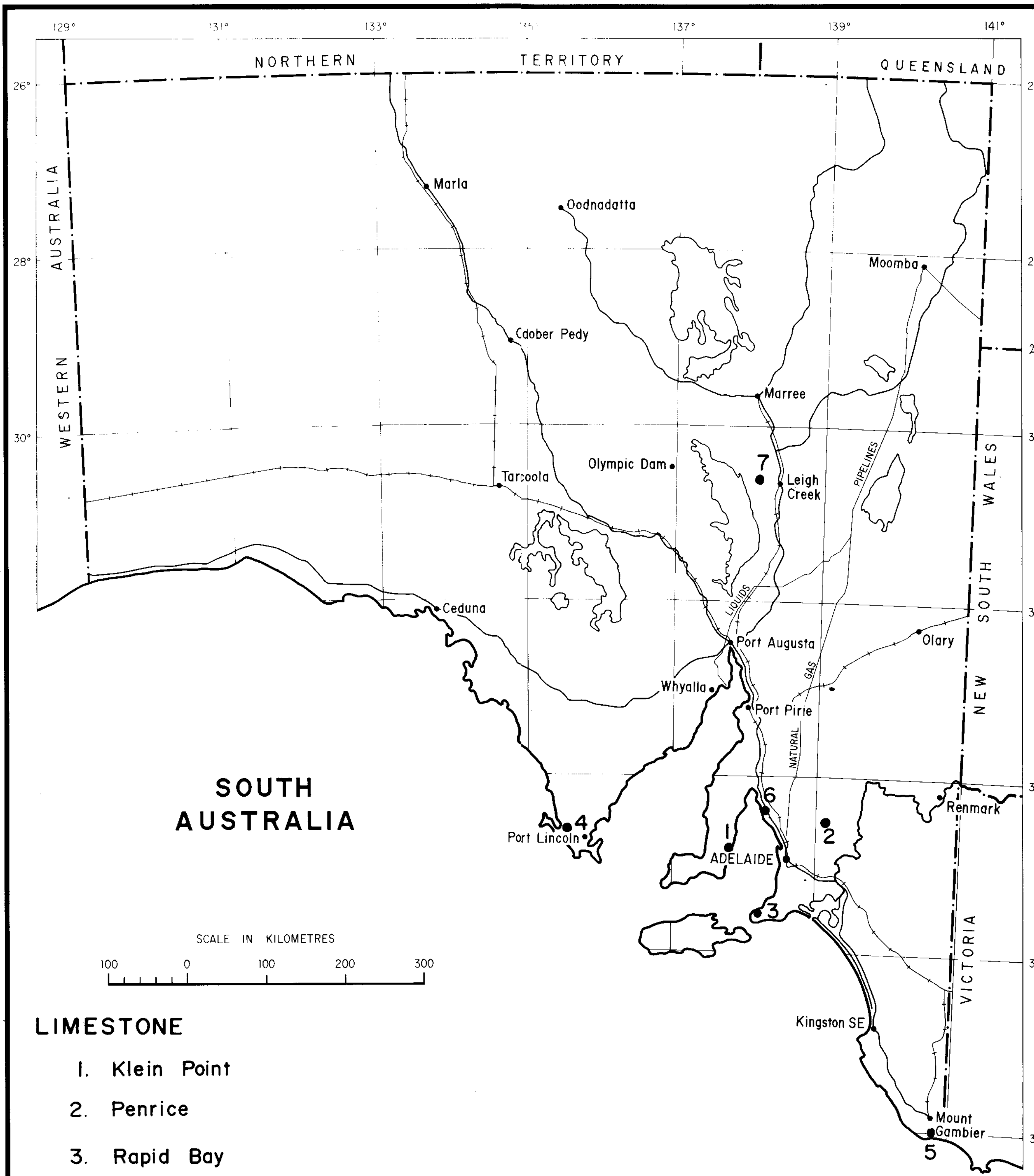


Fig. 29

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

ORAPARINNA BARITE DEPOSITS TREATMENT PLANT QUORN

COMPILED P.P.C.	C.D.O.	DATE 26.7.82
DRAWN G.E.B	SCALE	
DATE 10·4·81	PLAN NUMBER S15477	
CHECKED		



LIMESTONE

1. Klein Point
2. Penrice
3. Rapid Bay
4. Coffin Bay
5. Caroline
6. Parham

MAGNESITE

7. Myrtle Springs

Figure 29.

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DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED J.V.	C.D.O. 12.9.90 DATE
PRINCIPAL INDUSTRIAL MINERALS OPERATIONS IN S.A.	DRAWN D.S.L	SCALE as shown
LIMESTONE and MAGNESITE	DATE June 89'	PLAN NUMBER
LOCALITY PLAN	CHECKED	S20839