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SOUTH AUSTRALIA

GEOLOGICAL SURVEY

NON METALLICS SECTION

LIMESTONE, DOLOMITE, AND MAGNESITE RESOURCES OF SOUTH AUSTRALIA

by

R. K. Johns, M.Sc.
Senior Geologist

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I INTRODUCTION

South Australia is well endowed with limestone, dolomite and magnesite deposits; they are widely distributed and occur in sufficient abundance to more than meet industrial requirements for a variety of purposes within the State.

This report has been prepared to collate the present knowledge on distribution, occurrence, accessibility and composition of these rocks and to bring together all relevant analytical data available with appropriate references where applicable. It was compiled in response to numerous requests for information, reflecting the growing interest in these commodities. To this end published and unpublished data have been assembled and assessed and sampling undertaken of hitherto unexploited deposits located within a radius of 50 miles of Adelaide or adjacent to the sea coast.

Many of the deposits considered are of high grade and of large dimensions, some are easily accessible and are generally being exploited while many of those listed may never be commercially used because of the limited nature of reserves, inaccessibility, presence of deleterious impurities etc. but until a recently completed sampling campaign was undertaken (Forbes, 1960, unpublished) little or nothing was known of many except of their existence. Deposits favourably situated as regards transport to the main consuming centres or to harbour facilities have been exploited to varying extend but a number of high grade deposits chiefly because of remote situation remain virtually untouched. Being commodities of low unit value which are required in large quantities in the metallurgical, chemical, building, cement and lime industries their ready availability is a major consideration in evaluating any deposit. Commonly, the most important factor determining the extent of use of a particular deposit is the distance to works or markets. Other factors include the chemical composition, accessibility, texture, hardness and colour of the rock as well as the thickness and extent of the formation.

The production, usage and distribution of limestone, dolomite and magnesite are described separately, though they are sometimes intimately related and grade from one to another gradually or abruptly.

The principal geographic regions in which the various deposits are considered are shown in Fig. 1.

II LIMESTONE

1. PRODUCTION, USAGE AND SPECIFICATIONS

With respect to the diversity of its uses limestone may well be regarded industrially as the most important of the non-metallic minerals mined today. Production in this State ranks second only to iron ore.

Pure limestones are composed of calcium carbonate ($CaCO_3$), (56% CaO) but in nature they invariably contain impurities - commonly silica (SiO_2), magnesia (MgO), alumina (Al_2O_3) with smaller contents of iron oxides, phosphorus, sulphur etc.

Limestone is used extensively in the construction, metallurgical, chemical and agricultural industries. It is also consumed by many other industries; production and usage has been dealt with in some detail by Willington (1953).

The rock may be used in large blocks for rubble, flagstone, kerbing, building, monumental or ornamental stone. For most other purposes it is crushed and sized.

South Australian limestone is used extensively for construction purposes, as concrete aggregate, ornamental and structural stone, terrazzo chips and in the production of lime and cement. High-calcium limestones are used as fluxes in the smelting of ferrous and non-ferrous ores, and in the alkali industry. They go into the production of glass and other ceramic products, and serve as filllers in paints, rubber, tiles, plastics etc. and for some of these purposes it is used as a whiting substitute.

Usage of high grade limestones with some specifications are dealt with more fully below.

Metallurgical limestone

The Broken Hill Associated Smelters Pty. Ltd. mine lime sand from Wardang Island for use as a flux in the smelting of lead ores at Port Pirie - the sand physically is admirably suited and in general maintains a $CaCO_3$ content of 80-85%.

The Broken Hill Proprietary Company Ltd. has established quarries at Rapid Bay for the production of limestone which is used as a flux in the smelting of iron at Newcastle, Port Kembla and Whyalla. The following details on specifications and comments are drawn from an unpublished report by Whitehead (1959).

(i) Blast furnace specifications

General requirements are CaO - high as possible

MgO - 4.0% maximum

SiO_2 - 5.0% maximum

"The purpose of the flux is to remove the gangue and other impurities by forming a slag. If iron ore were to be reduced without a flux the siliceous and argillaceous gangue would unite with the iron oxides to form silicates of iron and alumina which would involve a heavy loss of iron.

The addition of limestone permits the silica and alumina to form complex lime, magnesia and aluminous silicates. It also removes siliceous and aluminous impurities in the coke and sulphur from the coke and metal.

The effect of impurities in the fluxing limestone is

1. their presence reduces available lime and magnesia in the stone
2. they require a share of the lime to flux them off as the flux must neutralise its own impurities as well as those of the ore.

The table below shows how an increase in limestone impurity affects the effective carbonate content of the stone.

Impurities	1%	2%	3%	4%	5%	6%	7%	10%
Effective carbonate (%)	97.22	94.33	91.65	88.86	86.1	83.3	80.5	72.15

When using an impure stone additional slag is formed and therefore an increase in fuel consumption.

The effect of magnesia in limestone flux is not deleterious provided the lower limits of spinel formation are not approached. If this happens a thick ropy slag may be formed.

Dolomite is used quite satisfactorily in blast furnaces in England and U.S.A. where the alumina content of the coke and ores is not so high as in Australia. Theoretically magnesia would appear to be a better fluxing agent than lime for:

1 lb. of MgO will convert 1.51 lbs. SiO_2 --- $MgSiO_3$

whereas 1 lb. of CaO will convert 1.08 lbs. SiO_2 --- $CaSiO_3$

In practice, other silicates are also formed so that this ratio is not necessarily true.

The use of a constant grade of limestone permits better furnace performance and more accurate control of the iron produced."

(ii) Open hearth specifications

At Newcastle the following specifications are sought.

CaO	54.0% minimum
MgO	0.75% maximum
SiO_2	1.0% "
Al_2O_3	1.0% "
P_2O_5	0.05% "
S	0.05% "

The fluxing efficiency of a limestone at Newcastle (Whitehead, op. cit.) is calculated according to the formula

$$F.E. = CaO - 2(SiO_2 + Al_2O_3)$$
$$= 56 \text{ maximum}$$

"The effect of using limestones not meeting specifications is illustrated below:

SiO_2 content	1%	2%	3%	4%
CaO content	55%	54%	52%	49%
Efficiency Average	52.9%	49.8%	45.7%	40.5%

It is evident that the presence of impurities in limestones used in the open hearth is much more detrimental than when used in the blast furnace. Thus a limestone with 2% impurities used in the blast furnace has an available carbonate content of 94.4% while if used in a basic open hearth it would have only 89% available carbonate.

The chief purpose of open hearth flux is to remove the impurities sulphur and phosphorus. Magnesia has a lower affinity for phosphorus than lime and hence magnesian limestones are undesirable. Such limestones also produce a ropy slag resulting in increased heat times and poorer deoxidation efficiency.

The presence of alumina lowers the limestone efficiency but is less harmful than silica or magnesia."

(iii)Sinter specifications

"Increasing attention is now being paid to the use of prepared feed in blast furnace and open hearth practice being accentuated by the increasing proportion of fine grained haematite ores and jaspillites.

The addition of limestone or preferably lime in sinter increases the rate of sintering and it seems that there will be an increasing demand for limestone for this purpose. If taken to its logical conclusion, little or no limestone need be added directly to the blast furance.

The requirement for finely ground material (⅛ inch) suggests the use of soft limestone to be advantageous . Dolomite has been used satisfactorily as a flux additive in Canada and elsewhere but its use in Australia would seem undesirable because of the danger of spinel formation in the blast furnace."

Cement Manufacture

The two Companies engaged in the production of cement are the South Australian Portland Cement Co. Ltd. with quarries and works at Angaston and the Adelaide Cement Co. Ltd. who operate quarries at Klein Point on Yorke Peninsula and works at Birkenhead.

For cement making less stringent grade is demanded. Portland cement clinker is a compound formed by burning in kilns proportioned quantities of lime, silica, alumina and iron oxides provided by limestone and clays or shales as raw materials. Finished portland cement is made by intimately grinding together cement clinker and a small quantity of gypsum to retard the rate of setting.

As silica, magnesia and alumina are essential constituents, their presence in the raw limestone must be allowed for in deciding upon the suitability of a clay. The proportions of the essential constituents vary slightly but the carbonate of lime in the raw mixture should be 74%-77% of the total. The proportion of silica to alumina and ferric oxide should be 2½to 3:1. The nature and manufacture of cement has been dealt with in some detail by Armstrong, A.T.

(1952), Mining Review 92, pp. 116-144 and by Jack, R.L. (1926) Geol. Surv. S. Aust. Bull. 12.

Chemical Manufacture

I.C.I. Alkali (Australia) Pty. Ltd. operate a quarry at Penrice which supports the alkali manufacturing industry - the limestone consumed conforming to blast furnace specifications. Lime manufactured by the calcination of limestone is the cheapest of all alkalis and forms the basis of the chemical manufacturing industry and the production of soda ash and caustic soda.

Lime Manufacture

Limestone is burned at a number of centres for the production of lime and hydrated lime for use in the building industry. Kilns have been established in localities where limestone is readily available - kunkar being gathered from farmlands and burned in outmoded intermittent rectangular flare kilns; these are situated on Yorke Peninsula, along the eastern coast from Coobowie to Kulpara, and at Tailem Bend, Murray Bridge, Port Lincoln, Strathalbyn, and Gawler.

In order to market high grade lime at a competitive price to the industry thought is being given to the installation of a modern efficient continuous type of shaft kiln utilizing high grade limestone. Such practice will require high grade raw material which is physically hard, dense and of uniform size. Deleterious impurities include alumina, iron, silica and magnesia.

Consideration is also currently being given to fluid bed calcination technquies involving several stages wherein finely ground high grade limestone is fed into superimposed beds, each bed being maintained in a fluidized state by pressure-air from below with fuel oil for combustion. The soft limestones (eg. Mt. Gambier) and calcareous sands (eg. Coffin Bay) offer immediate sources of supply of raw material for this process.

The production of lime in South Australia has been discussed in detail by Willington((1953),pp.130-142).

Whiting

Whiting is an exceedingly fine grained form of limestone which may occur naturally or may be produced by the fine grinding of soft limestone. It is used as a filler in rubber goods manufacture, paints, kalsomines, for glaziers putter, and in manufacture of yeast, toothpaste, chemicals etc.

Mixed with oil whiting is used in the form of putty. Mixed with water, however, it has great covering power and is very largely used in water paints and kalsomines.

For most purposes high grade limestone is specified, hence the use of Mt. Gambier stone which has the added advantage of being readily ground to the required degree of fineness.

The requirements of whiting are as follows:

$CaCO_3$	90% minimum
$MgCO_3$	3% maximum
Moisture and volatile matter	3% maximum
Plus 200 Mesh (I.M.M.)	1.5% maximum

Whiting conforming to this specification is used in ceramics, paints, rubber and paper.

Specifications for whiting for putty are less rigid and are as follows:

$CaCO_3$	51.6% minimum
Total carbonates	95.0% "
Moisture and volatile matter	2% maximum
Plus 325 mesh (Tuler)	30% maximum

The annual recorded production (tons) of limestone in the State for various purposes during the period 1950-1960 are tabled below:

	Usage					
	Flux	Chemical	Cement	Lime	Agricultural	Whiting
1950	482,409	54,493	142,979	14,000	3,812	5,243
1951	506,878	119,670	132,098	18,500	4,549	7,962
1952	517,237	139,884	151,904	21,464	2,947	3,383
1953	437,448	128,755	233,201	25,736	17,597	10,411
1954	438,313	161,684	313,580	21,550	4,487	10,588
1955	450,171	159,032	350,735	17,501	3,209	6,053
1956	489,838	184,956	378,894	15,647	3,750	3,237
1957	546,085	164,169	400,932	15,948	4,393	3,106
1958	650,403	182,538	370,504	8,572	5,294	3,066
1959	368,266	193,079	431,311	13,419	8,358	2,762
1960	297,793	211,511	532,628	11,858	7,153	2,765

2. GEOLOGICAL DISTRIBUTION

Limestones are widely distributed throughout the State having extremely variable physical forms and chemical composition and range from almost pure calcium carbonate rocks, with low siliceous or other impurities, and grade, with increasing magnesia contents, through magnesian limestones and dolomitic limestones to dolomite. Limestones generally contain less than 5.0% $MgCO_3$ or greater than 30% and rocks of intermediate composition are not common. They may grade laterally into dolomite, often with abrupt changes in facies.

Limestones are mostly of marine origin, the most important ones of a high degree of purity being shallow water or only moderately deep water deposits, the most important factor in formation under favourable bottom and temperature conditions being not the depth of water, but the outwash of siliceous, aluminous and ferruginous materials from the land. They are produced by mechanical, and organic and chemical processes. Those of organic origin are either accumulations of shelly matter which formed supporting or protective structures or precipitated as a consequence of certain vital activities of organisms, or from chemical processes initiated through decay of organic matter. Limestone of chemically inorganic origin result from changes in the conditions of water in which calcium salts are dissolved, from agitation of water, or from evaporation. Following deposition they may be transported through the agency of water or by wind.

Twenhofel (1950) suggests the relative absence of limestone in Archaeozoic rocks to be due to the absence of shell forming organisms and that the waters would have been highly charged with carbon dioxide thus holding in solution large quantities of calcium, magnesium, iron and other carbonates. The advent of plant life and their extraction of carbon dioxide led to precipitation of the carbonates of lime and magnesia giving rise to the great carbonate formations of the Proterozoic. He quotes the range of important constituents of the different groups of marine invertebrates and calcareous algae, some being composed essentially of calcium carbonate, others carrying a considerable content of magnesium carbonate. Foraminifera, sponges, corals, annelids, echinoderms, bryozoa, brachiopods and molluscs are important contributors to the formation of limestones more or less from the Cambrian to the present. In general the older rocks are higher in magnesia than those of later geological time.

In South Australia Archaeozoic carbonate rocks are dolomitic, the purest of these occurring on Eyre Peninsula. In the Proterozoic (Adelaide System) limestones are widely distributed; there are minor developments of dolomitic limestone in the Willouran Series, dolomites (with magnesites in part) characterise the upper part of the Torrensian, the most important member of the Sturtian is the Brighton Limestone while less important are the thin limestones of the Marinoan. Archaeocyathinae reefs of the Lower Cambrian constitute important limestone formations in the Adelaide Geosyncline and the major quarries are generally centred on recrystallized white Cambrian marbles. Tertiary marine limestone constitute enormous deposits in the Lower South East (Murray Basin) and on the Nullarbor Plain (Eucla Basin) with smaller developments on Yorke Peninsula (St. Vincent Basin). Quaternary calcareous aeolianites are distributed along the southern coasts while amorphous kunkar is widespread. Modern calcareous sands of parts of the coastal regions and continental platform and in particular on the floors of the gulfs constitute alternative sources.

The various deposits are dealt with in more detail below being arranged in order of antiquity and under subheadings according to their distribution in regions.

(1) PreCambrian and Cambrian limestones and marbles

(a) Fleurieu Peninsula - Kangaroo Island

Highly deformed marbles of the Kanmantoo Group (possible Archaeocyathinae limestone equivalent) are exposed in this region 55-65 miles south of Adelaide.

(i) Rapid Bay - Delamere - Second Valley (See fig. 2).

References:

ARMSTRONG, A.T. (1948) Mining Review 88 (pp. 215-218).

CAMPANA, B. and WILSON, R.B. (1953) Report of Investigations No. 3, Geol. Surv. S. Aust.

CAMPANA, B. and Wilson, R.B. (1954) Jervis Geological Map (1 in. = 1 mile series).

MADIGAN, C.T. (1925) Trans. Roy. Soc. S. Aust. Vol. 49, pp. 198-212.

General Notes, Mining Review 74, p. 11 (1941)

General Notes, Mining Review 76, p. 5 (1943)

During 1940 the Broken Hill Proprietary Company Limited commenced working an extensive high grade deposit of limestone situated adjacent to Rapid Bay (Hd. Yankalilla, secs. 1507, 1504 and 1509) and admirably situated for the large scale production of low cost stone. A jetty was constructed having a length of 1600 ft. with a T-head 656 ft. long and carrying a bulk loading belt conveyor installation. The limestone (marble) is shipped to Newcastle, Port Kembla and Whyalla for use as blast furnace flux.

The marble is white to grey in colour, of medium to coarse grain and usually fairly massive but it is intersected by joints which facilitate mining operations. It occurs as a lenticular body of stone being enclosed and in places broken by argillaceous beds, the great variations in thickness and local breaks in continuity being due principally to folding, shearing and thrusting of highly incompetent and plastic material. In particular the great thickness of the marble horizon worked at the quarry is the result of tectonic repetitions along the axis of the major anticline which dominates the structural pattern of the area. It is the intense and minute folding which makes this deposit relatively easy to operate and of a practically inexhaustible supply (Campana and Wilson, 1953).

Diamond drilling has been undertaken and large reserves of high quality stone outlined.

The following partial analyses indicate some variations in grade of the marble encountered in quarry operations:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
95.0	1.80	1.20	1.83	n.d.
92.58	1.01	4.16	0.80	1.66
70.00	20.90	5.10	1.20.	2.76
75.07	20.30	2.22	1.00	1.32
95.18	3.31	1.02	0.40	0.46

<u>Locality 1</u> (Secs. 1518, 1514, Hd. Yankalilla - 1 mile south of Delamere)

Quarry sites are readily available here in slightly weathered laminated cream and grey coloured marbles which dip 40^{o} to the south east. Exposures are not continuous and average perhaps 20% of the broken lines sampled from east to west. The quality deteriorates towards the base of the bed as disclosed by the following.

Sample length (ft.)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
50	96.6	0.96	1.82	0.30	0.71	0.07
100	91.0	3.50	3.75	0.45	1.55	0.06
100	92.1	2.35	3.90	0.35	1.49	0.06
100	86.7	5.70	5.70	0.44	1.69	0.13
100	82.1	7.50	6.65	0.73	2.45	0.12
300	81.1	9.10	7.05	0.74	2.20	0.12
240	88.4	3.75	5.80	0.49	2.15	0.09
270	91.0	3.30	3.80	0.43	1.75	0.06
300	86.2	5.20	5.05	0.63	2.30	0.10
300	74.1	5.70	12.7	1.22	5.00	0.18

Locality 2 (Sec. 1529, Hd. Yankalilla)

Thin siliceous marbles interbedded with quartzites which here outcrop at the top of a steep slope were sampled from east to west as below:

Sample length(ft.)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
30	-	-	25.8	-	-	-
60	78.3	4.30	12.4	0.94	3.35	0.04
30	80.2	3.95	10.9	1.03	3.20	0.06

Locality 3(Sec. 1529, Hd. Yankalilla)

Marbles here are too siliceous to be of interest, samples showing silica contents as below (east to west).

Sample length (ft.)	SiO_2
180	49.4
120	21.6
300	34.0

Locality 4 (Sec. 1557, Hd. Yankalilla, ½ mile S.W. Second Valley)

Marbles outcrop over about 10% of the sample line: analyses being as follows (from east to west).

Sample length (Ft.)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
270	86.0	4.75	6.45	0.54	1.94	0.08
270	88.3	2.00	6.12	0.61	2.30	0.08
300	75.1	2.20	18.8	1.39	2.55	0.21

<u>Locality 5</u> (sec. 1564, Hd. Yankalilla, Second Valley)

<u>Reference</u>

JOHNS, R.K. (1962) Mining Review 113 (in press)

Marble beds 200 ft. in thickness outcrop strongly in this locality, there being little or no overburden throughout. The basal beds are white, massive and coarsely crystalline and pass up into banded marbles, of blue-grey colour and of medium size grain. The beds dip south easterly at 20°.

The deposits were reported (Johns, 1962) to be of high and uniform grade but analytical data there quoted are now believed to be in error. Further samples were subsequently taken, the results of partial analyses being tabled below (Reid, I. 1961, unpublished). Reserves exceed 1¼ million cubic yards in a deposit which affords ready quarry sites.

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3
1	80.71	9.85	3.9	1.2
2	58.21	29.00	6.9	2.5
3	78.93	5.24	10.0	2.4
4	85.18	7.12	4.3	0.5

<u>Locality 6</u> (sec. 1455, Hd. Yankalilla)

The following analysis represents a single specimen of grey banded marble, a very thin bed exposed in a road cutting.

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
91.4	2.45	4.80	0.48	1.12	0.12

<u>Localities 7, 8, 9</u>

Sample 7 was taken from the western limit of the main marble lens being quarried at Rapid Bay. Sample 8 was taken from a prominent marble bed about 1 mile south of Rapid Bay where crossed by the main road. Sample 9 was taken from this same bed near Mt. Rapid. Partial analyses follow.

Locality	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3
7	83.93	5.21	6.8	1.5
8	41.08	4.19	41.0	8.0
9	83.92	6.69	6.4	0.7

(ii) Kangaroo Island (see fig. 3)

Reference

SPRIGG, R.C. 1953 Kingscote Geological Map (1 in = 4 mile series

White marble outcrops on the north eastern coast of Kangaroo Island at Cuttlefish Bay (Locality 3, fig. 3) and south west of Penneshaw (Locality 4). The beds are thin members of the Kanmantoo Group and are possibly Archaeocyathus limestone equivalents. On the north coast near White Point massive limestone with plentiful boulders containing Archaeocyathinae have been mapped.

Available partial analyses follow.

Locality	$CaCO_3$	$MgCO_3$	SiO_2
3	62.79	4.83	n.d.
4	51.97	23.08	n.d.

(iii) Normanville - Sellick Hill

A belt of tightly folded sediments comprising blue and grey mottled Cambrian limestones (including the Archaeocyathus horizon) which outcrop along and near the coast over a length of some 15 miles were sampled at intervals; only one sample showed $CaCO_3$ in excess of 90%. They are generally siliceous and range from dolomitic limestones to dolomites and are discussed under III Dolomites (and see fig. 27).

(b) Central Region

Generally thin and discontinuous lenses of limestone occur within a radius of 30 miles of Adelaide. The Brighton limestone provides a number of quarry sites, formerly for cement production but current use is restricted to general civil construction and road building aggregate. It is invariably siliceous. The formation generally contains in excess of 4% $MgCO_3$ and passes up abruptly into dolomite.

Cambrian marbles are also described below - the most important being the Macclesfield marble.

(i) Macclesfield (See fig. 4)

References

JACK, R.L. (1923) Geol. Surv. S. Aust. Bull 10, pp. 45-47

RIDGWAY, J.E. (1953) Mining Review 94 (pp. 41-43)

SPRIGG, R.C. and WILSON, B.R. (1954) Echunga Geological Map (1 in. = 1 mile series).

WARD, L.K. (1922) Mining Review 35 (pp. 67-68)

Discontinuous lenses of marble up to 300 ft. in width and dipping easterly at moderate to high angles are traceable from near Macclesfield (40 miles from Adelaide) to beyond Paris Creek over a length of some five miles. The stone has been long used in polished slabs and for rough exterior and interior decoration and as a monumental stone, the colourings and markings being quite distinctive. Quarry sites are readily accessible from good roads - established quarries being located in secs. 2827, 3348 and 3343, Hd. Macclesfield, and secs. 3337 and 3338, Hd. Kondoparinga.

Locality 1 (secs. 3335 and 1912, Hd. Kondoparinga)

Pyritic "sea wave" marble beds here dip easterly at 50^o, the marble being cream to grey in colour. It is generally poorly outcropping; samples taken across the deposit from west to east showed the following contents:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	-	-	34.0	-	-	-
2	87.2	1.37	9.60	0.41	1.03	0.04
3	91.5	1.19	5.10	0.30	1.29	0.05
4	95.3	1.28	2.30	0.21	0.88	0.03

Locality 2 (secs. 3337 and 3338, Hd. Kondoparinga, Paris Creek)

South of the Paris Creek quarries where "sea-wave" marble is being quarried the stone outcrops poorly, the main bed being nearly 300 ft. wide and dipping easterly at 70^o. Reserves of 280,000 tons are indicated (Ridgway, 1953). The marble is of medium to fine grain and exhibits a range of colour from pure white or cream to various shades of bluish grey. Very dark grey and a little pink marble also occur.

Partial analyses of a line sampled from west to east in sec. 3338 follow:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	94.3	0.91	2.80	0.27	1.29	0.04
2	84.6	1.37	10.9	0.38	2.00	0.06
3	87.9	2.45	6.20	0.41	2.75	0.06

The main bed is here separated by greywackes from a thin marble bed containing $CaCO_3$, 86.8%; $MgCO_3$, 3.35% and SiO_2, 8.45%.

Locality 3 (secs. 3343 and 1921, Hd. Macclesfield)

Old quarries in sec. 3343 expose foliated dark blue marble. A sample from sec. 1921 showed $CaCO_3$, 96.54%; $MgCO_3$, 0.76%; SiO_2, 1.78%

Locality 4 (secs. pt. 2827 and 3348, Hd. Macclesfield)

Fawn, pink, grey and blue, medium grained marbles have been quarried from three main pits. The beds dip southeasterly at 35°.

Samples taken across the deposit from west to east over 100 ft. intervals showed the following on analysis.

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	94.7	2.30	1.66	0.23	1.05	0.08
2	94.3	3.35	1.54	0.54	0.50	0.04
3	91.5	2.45	3.25	0.42	1.90	0.02
4	94.5	1.46	2.60	0.21	1.01	0.02

(ii) Wistow (See fig. 4)

Several limestones, the upper one of which is possibly equivalent to the Brighton Limestone outcrop as narrow discontinuous lenses in the Wistow-Philcox Hill - Mt. Barker region.

Locality 5 (Sec. 2915, Hd. Macclesfield)

An old quarry south of Wistow Cemetery has exposed white and cream marble over a width of 20 feet. The beds dip south easterly at 10°; prominent joints are vertical. A sample taken showed the following:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
88.7	0.73	7.40	0.36	2.20	0.02

Locality 6 (sec. 4455, Hd. Macclesfield)

Numerous shallow pits here expose grey limestone that showed on partial analysis.

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
91.5	0.73	5.30	0.70	1.05	0.03

(iii) Willunga (see fig. 5)

Thin grey limestones (the Brighton Limestone equivalent) outcrop at intervals over a distance of about five miles along the Willunga scarp in secs. 751, 748, 746, 701, 306, 765, 769 etc., Hd. Willunga.

Reference

HORWITZ, R.C. (1960) Milang Geological Map (1 in. = 1 mile series)

Analyses of two samples are tabled below

<table>
<tr><th>Locality</th><th>$CaCO_3$</th><th>$MgCO_3$</th><th>SiO_2</th><th>Fe_2O_3</th><th>Al_2O_3</th></tr>
<tr><td>1, sec. 549, Hd. Willunga</td><td>34.74</td><td>7.40</td><td>35.54</td><td>3.99</td><td>15.41</td></tr>
<tr><td>2, sec. 507, Hd. Willunga</td><td>58.64</td><td>1.88</td><td>n.d.</td><td colspan="2">4.22</td></tr>
</table>

(iv) Mt. Magnificent (See fig. 6)

References

JOHNS, R.K. (1950) Mining Review 89 (pp. 120-121)

MAWSON, D. (1939) Trans. Roy. Soc. S. Aust. Vol. 63 (1)(pp.69-78)

Several narrow discontinuous and thin lenses of marble which outcrop in the Mt. Magnificent locality are at about the same stratigraphic level as the Macclesfield Marble. White, pink and grey marble has been quarried by the Finniss River for the production of terrazzo chips in a desultory manner in secs. 1965, 1966 and 1961, Hd. Kondoparinga. Two beds, 10 ft. and 12 ft. thick respectively and separated by a thin band of slate dip 75°E and showed the following on analysis:

	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3 Al_2O_3
White marble	98.67	0.47	0.36	0.11
Pink marble	87.51	0.80	10.69	0.60

A maximum thickness of 130 ft. is recorded.

Thin lenses of blue and grey marble also outcrop in the Mt. Magnificent ridge in secs. 12, 1962, Hd. Kondoparinga and sec. 294, Hd. Kuitpo.

(v) <u>Bull Creek</u> (See fig. 7)

Thin white, cream and pink medium grained limestones equivalent to those of the Wistow locality outcrop along the valley of Bull Creek near Ashbourne and McHarg Creek in Hd. Kondoparinga secs. 3263-3265, 1759, 3273, 3278 etc.

The following partial analyses are available:

Locality		$CaCO_3$	$MgCO_3$
1, sec. 3265	white marble	97.0	1.0
" " "	pink marble	98.0	0.8
2, sec. 3264		97.0	0.5
" " "		54.80	44.78

(vi) <u>Marino - Hallett Cove - Reynella</u> (See fig. 8).

<u>References</u>

ARMSTRONG, A.T. (1952) Mining Review 92, pp. 125-134.

CORNELIUS, H.S. (1928) Mining Review 48, pp. 66-70.

HOWCHIN, W. (1904) Trans. Roy. Soc. S. Aust. 28, pp 253-280.

HOWCHIN, W. (1920) Trans. Roy. Soc. S. Aust. 44, pp. 313-315

JACK, R.L. (1926) Geol. Surv. S. Aust. Bull. 12, pp.104-108

JOHNS, R.K. (1961) Mining Review 112, pp. 123-126

MILES, K.R. (1946) Mining Review 82, pp. 68-75

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NIXON, L.G. (1959) Mining Review 106, pp. 70-73

SEGNIT, R.W. (1940) Trans. Roy. Soc. S. Aust. 64 (1), pp.3-45

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References (Contd.)

SPRIGG, R.C. and WILSON, B.R. (1954) Echunga Geological Map (1 in. = 1 mile series).

General Notes, Mining Review 37, (1923), pp. 13-14

General Notes, Mining Review 44 (1926), p. 26

The Brighton Limestone in the type locality (Howchin, 1904) outcrops southwards from near Marino to Hallett Cove, thence easterly to Reynella. Further south the beds are exposed between Noarlunga and Hackham. It has provided raw materials for the cement industry from quarries situated at Marino and at a number of localities between Hallett Cove and Reynella where fold structures have provided favourable sites. Current usage is for the production of road construction and civil construction aggregate.

The S.A. Portland Cement Co. first established works at Brighton in 1894, the Brighton quarries being situated in secs. 197, 215 and 245, Hd. Noarlunga, ½ mile east of Marino R.S. Later, limestone was produced from the Reynella quarries (secs. 521, 507 and 519, north west of Reynella R.S.) and from the Hallett Cove quarries (secs. 519, 533, 574 and 580, 1 mile S.E. of Hallett Cove). These were connected to the works at Brighton by an aerial tramway 3½ miles long. This area had been tested by diamond drilling in the period 1939-1947. During the period 1949-1952 the operations of the S.A. Portland Cement Co. were transferred to Angaston to deposits formerly operated by I.C.I. Alkali (Aust.) Pty. Ltd. and in 1953 the Hallett Cove and Brighton quarries closed to cement production.

Locality 1 (Brighton or Linwood quarry)

The main limestone is underlain by a series of banded and siliceous limestones and is overlain by purple slate. The limestone may be subdivided into three beds, the lowest member being 15-20 ft. thick, siliceous and of dark blue grey colour. This is succeeded by the middle member 15-40 ft. thick, buff in colour and often oolitic in grain, and this by a dolomitic bed about 10 ft. thick being buff to brown in colour.

The following analyses typify the grade of the various members.

Bed	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
bottom - siliceous limestone	34.74	5.74	43.26	5.72	8.80
	39.83	4.94	41.12	4.96	7.58
	36.73	5.70	43.16	5.46	7.86
	34.14	6.00	44.64	5.09	8.79
	38.14	4.94	44.44	4.63	7.25
	21.96	5.16	58.42	5.14	8.42
	32.15	5.90	46.90	5.L7	8.99
	52.81	5.80	31.14	4.07	6.17
Middle - buff limestone	84.84	4.80	7.62	2.80	1.20
	82.27	3.90	9.57	2.38	1.90
	83.95	5.60	6.64	2.17	1.83
	80.55	4.10	9.96	2.38	2.28
Top - dolomitic limestone	41.71	42.74	9.10	4.52	1.82
	53.02	28.80	11.76	2.88	3.88

Locality 2 (Reynella-Hallett Cove Quarries)

A number of quarries have exploited the corrugated outline of limestone in this locality, principally in the exposed troughs of synclinal folds.

The highest grade limestone is massive, pink, buff, grey or dark blue in colour and occurs in a bed about 50 ft. thick - this is overlain by brown magnesian limestones about 35 ft. in thickness.

Diamond drilling was undertaken to confirm geological boundaries and to procure samples. This indicated that contacts between the stratigraphically lower high grade limestone and the overlying dolomitic members are gradational and, in general, the latter, which are too low grade for economic (cement) use, extend well beyond the boundaries of what in surface outcrops appears to be satisfactory limestone (Miles, 1947).

The reserves of high grade stone are very limited.

Chemical analysis shows the following range of constituents in the high grade stone.

$CaCO_3$ 80.8 - 90.9% (average 85%)

$MgCO_3$ 2.0 - 10.8% (average 5%)

A typical analysis being as below:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
81.74	5.86	8.30	2.12	1.50

(vii) <u>Hackham - Noarlunga</u>

<u>Locality 3</u> (Fig. 8)

The Brighton Limestone formation which outcrops strongly on both sides of the River Onkaparinga in this locality is 70 to 110 ft. in thickness, dolomitic and buff to grey in colour.

Road making materials have been quarried from this bed near Hackham. Diamond drilling of the deposits situated Hd. Willunga, sec. 56 has confirmed geological structure and the quality of the stone (Johns, 1961).

Samples taken here from east to west across a deformed area where drag fold structures have locally thickened the outcrop showed the following on analysis:

Sample	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	61.7	26.3	6.55	2.10	1.76	0.12
2	61.4	24.8	8.45	2.35	1.63	0.09
3	52.9	34.9	6.90	1.81	2.15	0.07
4	52.5	33.9	7.75	2.60	1.91	0.07
5	49.8	35.1	9.20	2.22	2.55	0.08
6	45.9	31.1	15.8	3.00	3.90	0.11

Reserves of dolomitic limestone are here large and readily accessible.

(viii) <u>Woodside - Mt. Torrens</u> (See fig. 9)

<u>References</u>

HIERN, M.N. (1959) Mining Review 106, pp. 65-66.

SPRIGG, R.C., WHITTLE, A.W.G. and CAMPANA, B. (1951) Adelaide Geological Map (1 in. = 1 mile series).

Locality 1

A thin bed of grey fine grained limestone equivalent to the Brighton Limestone is traceable from near Woodside southerly over a distance of about 6 miles.

A quarry situated in Hd. Onkaparinga sec. 5294 yielded stone which was burned locally for lime. Outcrops hereabouts are poor, the rock showing the following on analysis.

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
81.1	1.09	14.7	0.50	2.55	0.03

Locality 2

White coarsely crystalline marble is exposed in a quarry in sec. 6505, Hd. Talunga, 1 mile southwest of Mount Torrens. The stone has been burned locally for the production of lime (Hiern, 1959).

Outcrops are sparse and reserves appear to be very small. A composite sample taken from the quarry face over a width of about 100 ft. showed the following on partial chemical analysis.

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
88.3	2.5	8.0	0.46	0.18

(ix) Tungkillo - Milendella - Cambrai - Keyneton (see figs. 10, 11)

Marbles and impure limestones within the Kanmantoo Group of sediments are exposed in a belt extending from Milendella northwards to Keyneton near the eastern flanks of the Mount Lofty Ranges. A further occurrence near Tungkillo has also been mapped. These occurrences are approximately 50 miles from Adelaide.

References

JACK, R.L. (1923) Geol. Surv. S. Aust. Bull. 10, p. 54

WHITE, A.J.R. (1957) Mannum Geological Map (1 in. = 1 mile series)

Locality 1 (sec. 7075 and 7050, Hd. Tungkillo)

The white Tungkillo marble has been quarried immediately north of the main road; the marble bed is narrow, lenticular and poorly exposed beyond the quarries. A partial analysis of a sample taken over a width of

70 ft. is as below:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
90.4	2.20	5.50	0.68	1.34	0.02

Some two miles south west of Tungkillo white grey and pink variants outcrop.

<u>Localities 2 and 3</u>

At locality 2 (1 mile NNW of Milendella) grey green calc-silicate rocks were sampled. Impurities consist of diopside and in places sphene, garnet and epidote; insolubles exceed 20% over the sampled section of 500 ft.

At locality 3 (Blk. 1, Hd. Tungkillo) a thin, medium grained pale grey, somewhat micaceous marble was sampled over a width of 110 ft., having an [illegible];

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
79.3	0.82	9.10	1.17	7.25	0.05

Extensions of these beds northwards towards Keyneton have not been sampled (Fig. 11).

(c) <u>Lower North</u>

Large reserves of regular and also tightly folded beds of Cambrian marble occur in this region 50-60 miles N.N.E. of Adelaide.

Proterozoic limestones are of little importance.

(i) <u>Kapunda</u> (See fig. 12)

Cambrian marbles are exposed over a length of nine miles extending south easterly from Allendale North. These beds also outcrop over a length of 2½ miles to the east of Koonunga where they occupy the complementary limb of a faulted synclinal structure. The marble has been quarried for monumental and building purposes.

Irregular, lenticular pre-Cambrian marbles which are generally siliceous and flaggy and are possibly equivalent to the Brighton limestone outcrop to the north and to the south of Kapunda.

References

DICKINSON, S.B. and COATS, R.P. (1957) Kapunda Geological Map (1 in. = 1 mile series)

JACK, R.L. (1923) Geol. Surv. S. Aust. Bull. 10, pp. 48-49

JACKSON, N. (1951) Mining Review 91, pp. 212-219.

Locality 1 (Sec. 89, Hd. Belvidere, Koonunga)

A sample taken from an area in which the marble is poorly exposed showed on partial analysis the following:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
96.9	1.91	0.60	0.32	0.62	0.06

Locality 2 (sec. 116, Hd. Belvidere)

Marble outcrops are poor. The samples taken over a width of 310 ft. maintain a high grade as follows:

No.	Sample width (ft.)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	100	97.9	1.45	0.26	0.33	0.28	0.04
2	100	97.0	0.82	1.28	0.37	0.37	0.02
3	110	96.0	not detected	1.97	0.42	0.56	0.04

Locality 3 (secs. 25, 16, Hd. Belvidere) - the Carrara quarry

Exposures here are good; this is the principal source of Kapunda marble used for building and ornamental purposes, marble for the construction of Parliament House in Adelaide being provided by these quarries. The stone is generally grey to white in colour and of medium size grain. Small pyrite crystals are discernible in parts of the deposits.

Samples taken over 100 ft. lengths from west to east analysed as below:

No.	Sample width (ft.)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	100	83.3	8.10	5.15	0.23	1.59	0.04
2	100	84.3	6.65	6.35	0.25	1.82	0.04
3	100	85.9	6.45	5.30	0.23	1.72	0.05
4	100	90.4	4.55	3.70	0.50	0.97	0.05
5	100	80.9	12.2	4.05	0.90	1.88	0.08

Laboratory investigation to observe calcining characteristics of this marble at temperatures ranging from 900°C to 1200°C and subsequent hydration gave a quicklime described as being of fine grain, very lean and not a good building lime (Jackson, 1951).

Locality 4 (sec 1514, Hd. Kapunda)

In this area the Kapunda marble is dolomitic and largely silicified; there are copper workings nearby.

Analyses of samples from east to west are as follows:

No.	Sample width (ft.)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	100	44.6	37.0	0.02	9.65	7.55	0.33
2	100	-	-	33.8	-	-	-
3	100	-	-	27.9	-	-	-
4	100	46.8	38.6	4.10	0.30	7.70	0.02

Locality 7 (Hd. Belvidere, sec. 1521)

Samples taken from a quarry at this locality showed the following:

$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3
87.5	6.3	3.2	0.4

Locality 8 (Hd. Belvidere, sec. 164)

An analysis of a sample from this locality is as below:

$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3
94.3	1.0	2.5	0.3

(ii) Angaston (See fig. 13)

The Angaston marble is a prominent member of the Kanmantoo Group of Cambrian age which is exposed in the Angaston region, 30 miles north-north east of Adelaide. The marbles and enclosing beds (schists, greywackes and calc-silicates principally) are tightly folded so that the beds are generally inclined at high angles. The marble bed in some areas is heavily crushed, elsewhere deformed by plastic flowage, in places faulted and occasionally intruded by basic dykes. The bed thins or thickens abruptly and shows marked facies changes over short distances.

It is the locus of intensive quarrying activity, providing a source of distinctive building and monumental stone and supporting a chemical and a cement industry.

References

CAMPBELL, J.D. (1945) unpublished report.

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JACK, R.L. (1923) Geol. Surv. S. Aust. Bull 10. (pp. 48-53)

JACKSON, N. (1951 Mining Review 91 (pp. 212-219)

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MANSFIELD, L.L. (1953) Mining Review 95 (pp. 114-118)

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NIXON, L.G. (1961)a Mining Review 113 (in press)

NIXON, L.G. (1961)b Mining Review 113 (in press)

NIXON, L.G. (1962) Unpublished report.

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WILLINGTON, C.M. (1953) Mining Review 94 (pp. 150-154)

General Notes, Mining Review 45 (pp. 27-29)

General Notes, Mining Review 63 (p. 48)

General Notes, Mining Review 64 (p. 37)

General Notes, Mining Review 70 (p. 45)

Localities 1 and 2

The deposits in this area were considered (Johns, 1961) to be a possible source of raw material for the production of lime. Detailed mapping and diamond drilling was subsequently undertaken on behalf of Hydrated Lime Ltd. in secs. 113, 341 and 343, Hd. Moorooroo (Nixon, 1961a). Though high grade marble occurs at the southern end of the area much of the stone contains siliceous impurities.

Features of the sediments mapped are rapid changes of facies along bedding planes and abrupt thickening and thinning of beds. Folding is complex and intense. Basal members include impure limestones, greywackes, arkoses and quartzites; these are succeeded by actinolitic marbles with lenses of white or pink marble, grey, white and pink coarsely crystalline and high grade marbles. The purer marbles pass up into calc-silicates, actinolitic marbles and siltstones, schists and greywackes. Pink marble is being won from the southern end of the deposit (Sec. 113, Hd. Moorooroo) for monumental purposes.

In the adjoining section (422, Hd. Moorooroo) pink marble is being quarried for monumental purposes (Nixon, 1961b).

Surface samples from west to east have been cut across the deposit including grey and pink marble and impure limestones; partial analyses are tabled below.

Locality 1 (Hd. Moorooroo, sec. 113)

Sample No.	Width (ft)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_3
1	200	81.2	4.90	4.40	6.30	2.10	0.35
2	200	-	-	52.4	-	-	-
3	210	79.3	2.90	8.90	1.59	5.20	0.16
4	200	-	-	29.2	-	-	-
5	190	89.6	3.45	4.80	0.84	1.16	0.07
6	200	94.2	2.10	2.55	0.78	0.59	0.25
7	200	80.2	4.35	7.90	4.45	1.73	0.23
8	200	78.5	2.45	11.3	1.39	2.75	0.11
9	200	74.7	1.18	14.9	1.97	3.35	0.14
10	200	88.7	1.82	5.40	1.05	1.27	0.07
11	200	94.0	1.64	2.75	0.50	0.81	0.03

Locality 2 (sec. 105, Hd. Moorooroo)

Samples taken from east to west include impure limestones, calc-silicates rocks and grey marbles with results as below:

Sample No.	Width (ft.)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	200	97.5	0.08	1.10	0.40	0.30	0.03
2	230	-	-	27.6	-	-	-
3	200	-	-	31.9	-	-	-
4	200	-	-	32.8	-	-	-
5	200	62.4	17.4	18.5	0.43	0.17	0.02
6	200	-	-	25.0	-	-	-
7	200	81.1	1.27	17.2	0.34	0.13	0.04
8	120	82.1	2.70	10.8	1.33	2.10	0.13
9	115	87.1	2.25	8.30	0.95	1.48	0.39
10	170	89.8	2.35	4.80	1.96	0.99	0.25
11	100	96.1	not detected	2.70	0.75	0.41	0.45

Locality 3 (sec. 226, Hd. Moorooroo)

Paucity of outcrops inhibited the taking of continuous samples over a line cut from east to west over weathered stone. There are small asbestos showings in this area of generally low grade limestone.

All samples showed 20-40% insolubles except for a narrow bed at the eastern extremity which contained:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
87.4	2.55	6.05	0.43	0.17	0.02

Locality 4 (secs. 140, 200, 207, 219 and 220, Hd. Moorooroo, Stockwell)

The Stockwell marble occurs as a lens stratigraphically below the Angaston marble. Detailed mapping undertaken by Shepherd (1959) at the request of the S.A. Portland Cement Co. Ltd. indicated reserves of 9 million tons. White, grey and pink massive, coarse grained marble with a poorly outcropping thin bedded grey member are here enclosed by mica schists, the whole dipping westerly at a high angle. Amphibolite dykes have been noted.

A composite sample taken from the old quarry near Stockwell had the following composition.

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
92.4	1.0	5.24	0.32	0.20

Locality 5 (secs. 1740, 1741, 303 and 349, Hd. Moorooroo, Penrice)

The operations of I.C.I. Alkali (Aust.) Pty. Ltd. were transferred to the Penrice area in 1950 following the diamond drilling of 61 holes on a grid pattern to prove this deposit over the period 1945-1949. A large deposit of uniformly high grade limestone was outlined.

A bed of marble about 1000 ft. thick is here exposed round the nose of a south plunging anticline. Though dykes and ironstone lodes occur, this large deposit of marble has been proved to be of high and fairly uniform grade. Partial analyses based on diamond drill cores (Miles, 1949) generally show the following ranges of composition.

$CaCO_3$	$MgCO_3$	SiO_2	Fe) Al) $_2O_3$
88 to 98	1 to 2	0.5 to 8.0	0.5 to 1.0

Locality 6 (secs. 1734, 1735, Hd. Moorooroo)

Geological mapping augmented by diamond drilling has proved reserves here of coarsely crystalline white marble in excess of 1½ million cub. yds. (Johns, 1950). The folded bed of marble averages 100 ft. in thickness. A typical section of drill core showed on partial analysis:

$CaCO_3$	$MgCO_3$	SiO_2	Fe) Al) $_2O_3$
95.3	1.1	1.5	0.7

Locality 7 (sec. 1734, Hd. Moorooroo)

A faulted segment of marble forming the western limb of a steeply inclined bed of marble west of Angaston showed the following on partial analysis:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
96.3	1.7	0.76	0.35	0.55

Locality 8 (secs. 333, 334, 167, Hd. Moorooroo)

When the alkali industry started in South Australia in 1935 this deposit was selected as a source of high grade limestone. Drilling was initiated in 1936 and quarrying by I.C.I. Alkali (Aust.) Pty. Ltd. in 1939. In 1949 their operations were transferred to Penrice and the quarry and works of S.A. Portland Cement Co. were established at this site.

The marble bed which dips westerly at 70^0 to 80^0, is 300 - 400 ft. wide. Faulting determines its northern and southern limits. A number of basic dykes which intrude the otherwise coarsely crystalline white marble have been exposed during quarrying operations. Marble and schist are quarried together to maintain 80 - 85% carbonate.

A typical partial analysis is as below:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
95.8	1.5	1.28	0.24	0.90

Locality 9 (secs. 339 and 506, Hd. Moorooroo)

A number of operators have quarries in this area (Sibleys), a source of high quality building and monumental stone since 1893. The marble varies from pale blue grey to white and pink and is generally coarse grained. It is sound almost from the surface and though containing clay pockets it is otherwise virtually free of waste.

A typical partial analysis is as below:

$CaCO_3$	$MgCO_3$	SiO_2	Fe) Al)$_2O_3$
96.71	1.48	0.90	0.54

Locality 10 (sec. 305, Hd. Jellicoe, 5 miles east of Truro)

Pale grey saccharoidal marble stratigraphically above the Angaston Marble and a member of the Kanmantoo Group has been exposed here in a roadside quarry. The beds are traceable to the north and south for some miles.

Sampled over a width of 100 ft. the rock showed the following:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
95.6	not detected	2.60	0.44	0.81	0.02

Locality 11 (section 697, Hd. Jellicoe)

Outcrops are poor and insolubles content of 38.6% over the sampled width of 95 ft. may not be a true indication of the average composition of the bed.

(d) Yorke Peninsula (see fig. 14).

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Fine grained grey Cambrian limestones outcrop at several centres on Yorke Peninsula. Grey and blue Kulpara Limestones outcrop at Wallaroo, Winulta, Ardrossan, Urania and at Curramulka. Mottled dark blue and buff Parara Limestone is well exposed at Ardrossan and at Curramulka. The Ramsay Limestone (mottled dark blue or buff in colour) outcrops south of Curramulka.

Locality 1 (section 55 and 345 etc. Hd. Curramulka).

Samples taken from a road metal quarry in a deposit at Curramulka (Parara Limestone) and tested by five shallow diamond drill holes (Johns,(1949) unpublished) showed the following ranges of composition.

$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3
86.0 - 90.0	1.0 - 4.4	3.7 - 9.4	0.50 - 1.50	0.10 - 2.25

Locality 2 (sec. 153, Hd. Ramsay)

The Minlaton stratigraphic bore penetrated siliceous limestones and dolomites below Permian glacigenes. The main formations penetrated in boring with analyses of samples taken at depths indicated are tabled below:

Footage	Remarks	Sample at	$CaCO_3$	$MgCO_3$	SiO_2
615 - 724'	Ramsay limestone	616 ft.	69.2	7.25	22.2
		721	5.7	5.6	31.2
724 - 1087'6"	(Red bed clastics and (evaporites (with thin shaley dolo- (mitic limestones	743	48.9	26.6	22.9
		766	51.8	29.1	10.0
		772	35.4	12.4	35.8
		810	22.3	11.8	54.2
		864	10.4	11.1	72.7

Footage	Remarks	Sample at	$CaCO_3$	$MgCO_3$	SiO_2
1087'6" - 1117'	Conglomerate				
1117' - 1177'	Laminated shales Calcareous shale	1151	1.5	3.8	85.1
1177' - 2123'	Parara Limestone	1177	2.0	4.6	82.8
		1254	53.3	6.1	35.9
		1303	74.5	10.8	13.0
		1304	6.0	3.5	83.5
		1485	82.2	9.3	7.3
		1578	68.9	10.6	18.8
		1721	75.2	7.4	14.9
		1920	84.6	5.2	8.3
		2118	88.4	5.8	4.6
2123' - 3176'	Kulpara Limestone	2221	87.7	8.4	3.0
		2362	78.2	17.3	4.2
		2480	61.7	31.8	5.3
		2635	53.8	38.1	6.5
		2815	51.8	37.9	8.8
		3029	47.8	36.4	13.0
		3075	49.1	36.0	12.8
		3096	41.0	29.2	27.2
		3121	35.5	26.4	35.7
		3141	32.0	23.6	42.2

Locality 17 (sec. 4, Hd. Curramulka, sec. 83, Hd. Ramsay etc.)

The obviously siliceous Ramsay Limestone outcropping in this locality has been sampled - partial analyses being as follows:

Sample	CaC03	$MgCO_3$	SiO_2
sec. 4, Hd. Curramulka	45.2	2.55	n.d.
sec. 83, Hd. Ramsay	52.1	13.5	n.d.

Locality 13 (secs. 21, 22, Hd. Cunningham), Ardrossan

Extensive deposits of Parara limestone overlie the Cambrian (Kulpara) dolomitic formation at Horse Gully. Diamond drilling has disclosed a thickness of 150 ft. over an area of about one square mile. Outcrops are discontinuous (Whitehead, 1959).

Diamond drilling and sampling have shown the following ranges of composition.

$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe
80.4 - 91.8	2.4 - 9.2	0.86 - 6.84	0.72 - 4.00	0.25 - 0.70

Locality 18 (sec. 182 E, etc. Hd. Cunningham, Winulta)

Locality 19 (sec. 128, Hd. Cunningham, Dowlingville)

Analyses of Kulpara Limestone taken from these localities of poorly outcropping cream, blue and grey siliceous and in part dolomitic limestones are as below:

Locality	$CaCO_3$	$MgCO_3$	SiO_2
18	30.4	20.6	n.d.
19	48.9	1.86	n.d.

(e) Flinders Ranges - Olary Province - Lake Torrens Region (see figs. 15, 16 and 17)

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Enormous deposits of carbonate rocks occur in the region extending from the Crystal Brook locality in northerly (Flinders Ranges) north easterly (Olary Province) and north westerly directions (west and north of Lake Torrens). Little analytical data are available and at this time it is not possible to define the highest grade deposits nor to differentiate between dolomite and limestone. Limestones and dolomites are hence considered here together. The early work of Howchin and more especially Mawson defined type sequences within the Adelaide System sediments while more recently mapping by the South Australian Geological Survey has indicated the extent of the major carbonate formations - references to published geological maps being listed above;- mapping in other areas is in progress.

The Willouran Series which are well developed in the Willouran Ranges (and further north west in the Peake and Denison Ranges but not considered here) include a number of dolomite members.

The Torrensian Series immediately overlying the Thick (Copley) Quartzite comprise dolomite members and are characterised by the development of magnesite beds (see under IV Magnesite) Mawson (1941) lists analyses of a number of these beds in the section extending from near Aroona Waters to near Copley and these are reproduced below (Fig. 15, Locality 5)

Thickness of bed (ft.)	$CaCO_3$	$MgCO_3$	Insolubles
1	44.8	49.8	13.75
40	47.7	40.3	12.3
"thin"	54.5	43.0	2.5
12	27.0	25.0	48.0
32	53.5	42.5	3.88
4	54.14	42.72	3.82
7	54.1	43.1	3.06
3	45.0	33.7	n.d.
3	29.8	30.8	n.d.
10	28.3	28.6	n.d.
6	40.9	29.1	17.0

Near Yednalue (Fig. 15, Locality 11), dolomites (the Montacute Dolomite equivalent) which enclose magnesite beds showed the following on analysis (Spry, 1952).

	$CaCO_3$	$MgCO_3$	SiO_2
Fine grained dark blue dolomite	55.6	41.0	3.0
Arenaceous oolitic dolomite	39.0	30.1	28.6

Towards the top of the Sturtian Series the Brighton Limestone equivalent is generally present. It may be thin and lenticular or elsewhere traceable in outcrop over many miles. In the northern Flinders Ranges often several prominent dolomites appear at about this stratigraphic horizon. These beds may contain thin shale bands but are commonly massive and in places include oolitic or brecciolic varieties. They are variable in colour from brown to pink, buff, grey or cream. Some occurrences are obviously arenaceous.

Localities in which samples have been taken for analysis include Mt. Fitton (Locality 3), Balcanoona (Locality 4), Holowilena (Locality 11), Carrieton (Locality 13), and Pekina (Locality 15) - (see fig. 15) - available analyses being tabled below:

Locality	$CaCO_3$	$MgCO_3$	SiO_2	P_2O_5
3	47.9	34.7	n.d.	n.d.
4	54.4	45.0	n.d.	n.d.
11	98.2	n.d.	n.d.	n.d.
13	49.5	39.9	6.90	0.06
15	98.8	n.d.	n.d.	n.d.

The high grade limestone recorded near Holowilena (Spry, 1952) is a buff oolitic member 240 - 300 ft. in thickness. Near Braemar (Whitten 1961), Sturtian dolomites are rather siliceous as indicated below - see fig. 16.

Locality		$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
1	2 m. S.E. Mulga Hill H.S.	34.9	27.3	21.5	6.0	8.62
2	2 m. N.E. Braemar H.S.	34.4	24.8	26.1	2.39	7.58
3	6m. N.W. Braemar H.S.	39.0	28.2	18.9	3.78	7.96
4	2½ m. N.E. Braemar H.S.	38.4	29.3	19.8	3.65	6.75

Buff and brown dolomites which outcrop near Woocalla and northwards near Pernatty lagoon (see fig. 17) showed the following on analysis:

Locality	$CaCO_3$	$MgCO_3$	SiO_2	P_2O_5	Mn
1	56.3	21.9	12.1	0.16	0.60
2	48.7	38.9	4.2	0.05	1.17
3	47.6	36.3	8.2	0.04	1.39
4	48.3	37.2	1.15	0.08	1.76
5	49.6	30.6	0.18	0.15	2.36
6	51.7	38.4	1.9	0.06	2.05
7 (20 miles NE of loc. 6)	51.5	39.8	4.3	0.03	0.40

Within the Marinoan Series Mawson (1939) records massive grey microcryptozoon limestones in the Brachina - Orraparinna region having low contents of magnesia. Samples of this limestone (locality 7, fig. 15) showed:

$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3
84.9	2.6	2.30	8.44
83.9	2.3	11.46	2.27
71.6	2.3	15.38	10.75

Cambrian (Archaeocyathus) limestones make up very extensive deposits in the Flinders Ranges and also north and west of Lake Torrens. Some of the more accessible deposits located near the railway line on the western flanks of the Flinders Ranges have been sampled by Whitehead (1939) who reports that they "are mostly dolomitic but include some purer beds and essentially represent blast furnace limestones but some lenses of higher grade, less siliceous limestones are available." Topography is generally rugged thus affording ready quarry sites and reserves at most localities are almost unlimited.

East of Edeowie the limestone attains a thickness of 3,500 ft. but much of this is dolomitic, and parts are arenaceous. A bed 300 - 400 ft. thick of grey fine grained massive limestone sampled in Bunyeroo gorge and in Edeowie Creek (Locality 8, fig. 15) showed the following:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe	Al_2O_3	P
1	94.7	1.3	2.0	0.15	0.6	0.02
2	53.0	42.9	1.8	0.72	0.7	0.02

Near Mern Merna (locality 8A, Fig. 15) light grey fine grained massive limestone forming part of a sequence of strongly mottled and brecciated limestones, sandy and oolitic in part, was sampled over a width of 375 ft. with the following results:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe	Al_2O_3	P
1	89.28	6.1	2.3	0.2	1.0	0.02
2	90.36	3.6	2.9	0.3	1.2	0.03
3	84.28	10.0	2.9	0.4	1.2	0.02

At Warrakimbo (locality 9, fig. 15) brown and dark grey fine grained limestone sampled over a width of 400 - 500 ft. showed the following:

$CaCO_3$	$MgCO_3$	SiO_2	Fe	Al_2O_3	P
55.9	38.8	1.6	1.7	0.7	0.25

Siliceous limestones east of Yadlamulka (locality 10, Fig. 15) were analysed with results as below:

$CaCO_3$	$MgCO_3$	SiO_2	Fe	Al_2O_3	P
53.7	7.9	27.1	-	2.96	0.9

Mawson (1939) sampled the Cambrian Archaeocyathus limestone and overlying carbonate beds near Wirrealpa (locality 6, Fig. 15) with results as follow:

	$CaCO_3$	$MgCO_3$	SiO_2	Al_2) Fe_2) O_3
Archaeocyathus - white marble	98.3	0.8	0.5	0.3
pink marble	97.4	1.2	1.6	0.4
dark grey marble	92.7	6.0	1.6	0.4
Flaggy limestone	81.5	5.7	11.6	1.1
Massive dolomite	36.1	26.8	34.5	3.1
Dark limestone	92.6	3.2	2.1	0.5
Obolella limestone	89.5	5.6	3.5	1.5
Dolomite	51.3	29.6	13.6	4.1

Near Kanyaka, (localities 10a, 10b and 10c, Fig. 15) between Quorn and Hawker, 50 miles north east of Port Augusta massive fine grained grey and blue limestones (Archaeocyathus horizon) are preserved in a series of tight folds. The main beds have steep dips on the eastern limb and moderate dips on the west limb. Continuous chip samples were taken at three places with results as below (Nixon, 1961).

Locality 10a

Sample width(ft.)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
100	87.5	2.62	6.42	0.36	2.46	0.16
100	73.9	17.76	4.48	0.77	2.11	0.08
100	92.1	2.51	3.01	0.33	1.41	0.04
100	90.9	3.14	3.37	0.46	1.42	0.04
100	92.2	2.19	3.05	0.28	1.43	0.03
100	89.3	4.09	4.01	0.47	1.60	0.02
100	93.9	2.51	2.24	0.30	1.05	0.03
100	90.1	3.03	4.28	0.46	1.65	0.17
100	81.5	2.40	13.48	0.57	1.97	0.16
100	68.6	3.66	24.02	0.66	2.49	0.07
100	85.3	2.40	8.96	0.55	2.27	0.08
100	80.3	2.51	12.64	0.67	3.38	0.11
100	70.5	2.19	23.83	0.59	2.42	0.07
100	87.5	1.57	8.10	0.39	1.91	0.12
100	86.8	2.24	7.90	0.41	1.69	0.18

Sample width(ft)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
100	80.9	0.84	14.45	0.49	1.64	0.13
100	95.5	1.26	1.91	0.22	0.76	0.26
100	95.0	1.57	2.39	0.27	0.82	0.22

Locality 10b

Sample width (ft.)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
100	83.0	4.39	3.18	0.83	3.18	0.15
100	90.9	2.72	1.54	0.74	1.54	0.10
100	88.9	5.12	1.65	0.49	1.65	0.06
100	86.8	7.22	1.39	0.53	1.39	0.04
100	92.0	2.41	1.36	0.63	1.36	0.04
100	90.8	3.89	1.33	0.35	1.33	0.03
100	92.2	2.30	1.50	0.31	1.50	0.03
100	93.9	2.50	1.22	0.29	1.22	0.02
100	90.1	2.14	1.56	0.53	1.56	0.09
100	87.5	1.81	2.65	0.55	2.65	0.07
100	85.0	1.33	2.10	0.53	2.10	0.09
100	82.5	2.06	2.25	0.51	2.25	0.12
100	82.5	0.67	2.20	0.62	2.20	0.10
100	91.7	0.72	1.09	0.37	1.09	0.14
100	91.6	1.41	1.33	0.40	1.33	0.25

Locality 10c

Sample width (ft.)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
300	86.7	6.70	3.65	0.42	2.10	0.05
300	88.9	4.39	3.85	0.47	1.93	0.04
300	93.8	0.99	3.10	0.51	1.52	0.05
300	92.9	1.25	3.65	0.39	1.62	0.03
300	92.2	2.06	3.35	0.42	1.38	0.02
300	92.1	7.98	4.45	0.39	1.60	0.05
300	82.5	1.80	10.4	0.82	3.60	0.07
300	80.9	1.73	13.3	0.81	3.05	0.08
300	81.4	0.92	14.0	0.87	2.50	0.14

Selected beds within the thick massive formation constitute potential sources of fairly high grade limestone. Reserves are very large and quarry sites readily available.

(2) Tertiary Organic Limestones

(a) Lower South East (See Fig. 18)

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In the extreme south east of the State are extensive deposits of high grade polyzoal Oligocene - Lower Miocene limestone - the Mount Gambier Limestone - which outcrops fairly continuously from near Tantanoola southwards to the coast and in a south easterly direction to the Victorian border (Sprigg, 1951 a & b, 1952). They also outcrop over a similarly large area in a belt extending in an easterly direction from Naracoorte to beyond the border into Victoria; here they are overlapped by the Naracoorte Limestone Member.

The Mount Gambier limestone constitutes enormous deposits, economically accessible over large areas, being over 500 ft. in thickness in the Mount Gambier region and flat lying or only gently folded. It is generally mantled by only thin overburden.

The stone is white or ivory coloured, extremely porous and uniformly even textured and contains up to 50% pore space. The ease with which it is quarried and dressed with mechanical saws and finally handled by the builder makes it an extremely attractive material for house construction for which it has been quarried for over 90 years. As far as strength is concerned it might well be used for larger buildings but the porosity of the stone and consequent necessity of building with cavity walls introduces a method of construction that would probably limit the height of a building. It is less durable than the softest freestones in current use but it can be quarried, dressed and erected at a cost unapproached by other stone. It is readily cut into ashlars or structural shapes by means of hand saws or mechanical means. The stone is quarried principally in an area adjacent to the railway line 5 to 7 miles north west of Mount Gambier, Co. Grey, Hd. Blanche, secs. 121, 119, 524, 382, 381, 148, 35, 141, 192, 28, 26, 134, 141, 145, 144, 138 and 136 and in Hd. Young, sec. 92; north west and north of Mount Gambier in secs. 715 (28), 321 and 652, and Hd. Hindmarsh, secs. 11 and 388; north east of Mount Gambier in Hd. Gambier, secs. 275; west of Mount Schank in Hd. MacDonnell, secs. 32, 750, 734 and 736; aouth east of Mount Schank in Hd. Caroline, sec. 327; and east of Tantanoola in Hd. Hindmarsh, secs. 335, 450, 337, 210, 209, 388 and 11.

The texture and colour vary to some extent in the stone from different localities and what is regarded as the highest quality stone occurs in Hd. Blanche. A much finer textured and lighter coloured stone is quarried one mile west of Mount Schank.

At Naracoorte the Mount Gambier Limestone has been formerly quarried for use as a building stone. The overlying Naracoorte Limestone (here about 50 ft. thick) is cream-coloured, of less even texture, somewhat rubbly, and though previously used for lime burning, now finds use as road aggregate.

In general the polyzoal limestone varies little in chemical composition and may be regarded as one of the purest available in the State. The stone is locally dolomitized in some places (see under III) and elsewhere carries flints.

Available partial analyses are as under (for locations, see Fig. 18).

Locality	Hundred	Section	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	Blanche	134	97.21	1.62	0.64	0.16	0.16	0.03
	"	"	94.39	2.62	0.80	0.16	0.08	n.d.
1a	"	"	94.80	1.69	0.88	0.17	0.28	0.04
2	"	141	97.34	1.54	0.44	0.18	0.16	0.02
3	"	145	96.91	1.99	0.64	0.18	0.12	0.03
3a	"	28	97.69	1.62	0.36	0.13	0.25	n.d.
	"	"	97.62	1.46	0.42	0.18	0.26	n.d.
	"	"	97.21	1.30	0.62	0.18	0.38	n.d.
	"	"	96.89	1.41	0.84	0.30	0.60	n.d.
4	Hindmarsh	335	92.68	3.40	1.50	0.44	0.45	0.11
	"	"	97.20	1.62	0.64	0.16	0.16	0.03
5	Blanche	138	97.1	1.59	0.32	0.16	0.26	0.02
6	MacDonnell	750	91.4	5.72	0.50	0.12	0.16	n.d.
7	Naracoorte	28	98.05	1.04	0.44	0.24	0.24	n.d.
	"	Bk.60	97.16	1.68	n.d.	n.d.	n.d.	n.d.
4	Hindmarsh	204	92.46	3.85	n.d.	1.30		n.d.
4	"	213	94.68	1.55	n.d.	n.d.	n.d.	n.d.
21	Caroline	331	97.36	1.12	n.d.	n.d.	n.d.	n.d.
22	Jessie	418	98.03	0.04	n.d.	n.d.	n.d.	n.d.
23	Joanna	188	98.48	0.07	n.d.	n.d.	n.d.	n.d.

Investigations undertaken by Blaskett (1941) showed that a satisfactory whiting could be prepared provided the limestone was sufficiently finely ground. Subsequently precipitated chalk was prepared in four stages - calcination, slaking, carbonation and drying - the product being considered suitable for most of the uses to which chalk and whiting are applied - glazes and enamels for ceramic products, paints, fillers for rubber, paper, metal polish, toothpaste, explosives, stockfeeds etc. (Madigan, 1957).

Preliminary laboratory work indicated that the limestone burned to a firm quicklime which hydrated readily to a good white lime - the best colour and texture being obtained with low temperature calcination (900°C - 1000°C). Further investigations (Read, 1957) comparing results achieved from burning various Mount Gambier limestones with a sample from Naracoorte produced satisfactory hydrates. Because of lack of strength and friable nature of the stone burning in a rotary kiln was recommended. The stone has a low density and is highly porous thus allowing poor heat transfer and inefficient burning; pilot scale calcination is being currently undertaken utilizing fluid bed techniques to overcome these disabilities.

(b) <u>River Murray Valley</u> (Fig. 19)

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Tertiary limestones are exposed more or less continuously in the cliffs of the River Murray downstream from Overland Corner to beyond Murray Bridge. The limestones have been quarried at a number of centres for road building and for the production of building stone, though thickness of overburden, variability of texture and hardness has limited its exploitation somewhat.

At Overland Corner (Locality 1, fig. 19) (Hd. Parcoola, secs. 13, 75 and 33) the Morgan Limestone has been quarried and sawn to produce building blocks. An analysis of this stone follows:

$CaCO_3$	$MgCO_3$	SiO_2	$(Fe,Al)_2O_3$
87.18	2.77	4.80	3.06

Quarries on the northern side of the river two miles north-north west of Waikerie (Locality 2) (Hd. Markaranka, secs. J6, 45, I4, 63, 8, 60, J3 and 22) have been exploited for the production of uniform fine textured freestone, siliceous limestones and calcareous sandstone from the North West Bend Formation At Ramco (Hd. Waikerie, sec. 451) the same formation yields cross bedded and irregularly colour banded stone.

Near Morgan (Hd. Cadell, secs. 131, 130, O^E and K^W and Hd. Eba, secs. 259, 238, 236 and 234) sandy limestones and calcareous sandstones have been utilized to a small degree for production of building stone (Whitten, 1959). At Swan Reach (Hd. Nildottie, secs. 50 and 125) sandy limestones have been quarried for building stone . Below are tabled partial analyses of limestone from the Blanchetown -Swan Reach vicinity - the samples from locality 6 being from the Black Hill oyster beds.

Locality	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3) Al_2O_3
3 Hd. Paisley, sec. 48	90.54	4.59	n.d.	0.36
4 Hd. Paisley, sec. 4	88.54	5.83	n.d.	1.08
5 Hd. Nildottie, sec. 165	86.43	5.37	n.d.	1.74
6 Hd. Paisley, sec. 63	87.06	n.d.	n.d.	n.d.
" " " "	72.93	n.d.	n.d.	n.d.

The cliffs at Murray Bridge on both sides of the river, localities 7 and 8, (Hd. Burdett, secs. 138, 139, 145, 55NW, 59 etc. and Hd. Mobilong, secs. 84, 67, 66 etc) have provided numerous quarry sites in limestone of the Mannum Formation. This stone was formerly burned for lime production and used quite extensively as a building material. Current use is confined to production of road making materials. It is typically fine grained, dense and durable, of light and uniform colour, fairly hard but capable of being readily sawn and carved.

Typical analyses of Murray Bridge limestone are as below:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
88.64	0.88	n.d.	1.52		
86.54	1.71	0.56	2.40		
85.93	1.48	n.d.	1.42		
90.71	2.36	4.98	1.68		
80.50	7.02	n.d.	1.56		
59.93	3.41	n.d.	0.72		
87.21	2.35	6.60	1.41	0.70	0.02
80.01	0.11	n.d.	n.d.	n.d.	

Calcination and subsequent hydration tests undertaken by Kaiser (1956) indicated the most suitable calcination temperature to be 1100°C. The products from three separate quarries were discoloured due to the presence of iron oxide (1.0 to 1.7%), alumina (0.5 to 1.2%) and silica (6.8 to 11.7%).

Calcination of this stone to produce material for lime silica brick manufacture (Mackie, 1954) showed that an offwhite gritty product could be produced which was suitable for the purpose but not suitable for high grade building lime.

(c) Kangaroo Island (See Fig. 3)

Occurrences of Tertiary polyzoal limestone are restricted to isolated outcrops in the Kingscote-Cygnet River locality and at Cape Willoughby((Sprigg, R.C., 1954) Kingscote Geological Map (1 inch = 4 miles series)).

(d) Yorke Peninsula (See Fig. 14)

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Flaty lying early Tertiary (Oligocene-Miocene) polyzoal limestones outcrop in the cliffs on the east coast of Yorke Peninsula between Pine Point and

Troubridge Point and extend inland for a distance of 3 to 6 miles maintaining a thickness of 100-130 ft. over large areas under a cover of Quaternary sediments of variable thickness, Crawford (1960a). Klein Point, situated 4 miles south of Stansbury is the source of raw material for the Adelaide Cement Co. Ltd. works which are situated at Birkenhead.

Similar limestones are exposed in quarries at Point Turton where there are extensions inland beyond Warooka, and also in the Wallaroo vicinity where thin remnants occur.

The limestones are generally soft, open textured and quite porous but hard, dense purer beds occur. Kunkar is widely developed and with red brown clays, which occur as near surface sheets and as infillings of solution cavities in the polyzoal limestones, constitute overburden.

Locality 3 (see Fig. 14) (Hd. Curramulka, Hbrs. Bd. Res., Pt. Julia)

Approximately 15 ft. of clay and kunkar overlie calcareous sandstones in cliffs 35-40 ft. in height. Glauconitic beds form the base of the cliffs (Nixon, 1961).

The following analyses are of samples taken down the cliff face:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	37.0	1.92	39.9	3.85	5.90	0.03
2	9.90	1.83	58.9	6.00	8.00	0.03
3	13.3	1.56	63.5	4.10	7.25	0.02
4	3.50	2.00	60.9	9.70	10.50	0.02
5	0.43	0.46	81.4	2.20	4.30	0.01
6	16.7	1.10	67.0	2.75	5.55	0.01

Locality 4 (Hd. Ramsay, Bk. B)

Cliffs 50 ft. high are here capped by 16 ft. of kunkar and clay. The limestones sampled are less siliceous than the above:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	87.5	2.45	7.3	1.38	1.90	0.04
2	66.8	10.5	15.3	0.95	3.00	0.02

Locality 5 (Hd. Dalrymple, Hbrs. Bd. Res., Stansbury)

Polyzoal limestones 40 ft. thick are here covered by 5-10 ft. of clay and kunkar, with clays filling solution channels that extend 30 ft. deep. The Adelaide Cement Co. Ltd. which was formed in 1913 first quarried limestone from a quarry with a 40 ft. face near this locality during the years 1914-1925.

A channel sample cut from the cliff showed the following:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
88.5	1.63	5.20	0.85	1.76	0.03

Locality 6 (Hd. Dalrymple, sec. 8, Klein Point, 4 miles south of Stansbury)

Byrozoal limestones have been quarried by the Adelaide Cement Co. Ltd. here since 1925 from the cliffs over a length of almost one mile, the thickness of workable limestone being 70-100 ft. Conditions are ideal for cheap quarrying operations; the stone is trucked to the crushers from where it is taken by belt conveyors to a storage bin for delivery by another conveyor belt along the jetty into barges and transported to the plant at Birkenhead 50 miles distant by sea.

The limestone varies in quality in the quarry face; there being soft, less consolidated bands alternating with harder and denser layers of different lime content. Generally a soft shelly limestone occurs near the base of the worked deposit and this is succeeded by about 30 ft. of hard dense limestone and this by somewhat softer stone, the topmost 15-20 ft. being friable nodular limestone carrying an excess of magnesia and this is discarded as unsuitable for cement manufacture. The hard lenticular limestone in the middle of the section shows $CaCO_3$ - 92.5%, $MgCO_3$ - 1.84%, silica - 2.50% and Al_2O_3 0.55%.

Diamond drilling undertaken in 1947-1948 on sec. 8, Hd. Dalrymple indicated large reserves on this property (Min. Rev. 87, 1949). Analyses of these cores reveal an improvement in grade below a depth of 15-25 ft. - $MgCO_3$ being as high as 25% in this section. Further drilling is being undertaken to outline areas underlain by the dense limestone (January, 1962).

A typical analysis of this limestone is as follows:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
92.0	1.0	4.0	0.70	1.50

Locality 7 (Sec. 393, Hd. Dalrymple, Wool Bay)

Cliffs 45 ft. high composed of limestones with kunkar and clay overburden 15ft. in thickness. Samples of limestone showed the following:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	94.4	1.81	1.00	0.47	0.39	0.04
2	92.3	0.76	4.00	0.47	0.93	0.02
3	89.8	1.81	4.70	0.75	1.67	0.04

Locality 8 (Sec. 257, Hd. Melville, Coobowie)

Fine grained cream coloured polyzoal limestone similar in texture and composition to Mt. Gambier stone outcrops at a number of places in this vicinity. A small quarry from which sawn building stone has been taken exposes fairly dense and fine grained limestone with a coarse shell rich band at the base (Miles (1951), Armstrong (1951), unpublished reports).

One diamond drill was sunk to a depth of 24 ft. adjacent to the quarry in an area where there are considerable reserves of good quality stone, typical analyses of which follow:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
92.09	1.76	4.95	0.58	1.04
93.50	1.20	4.00	0.50	0.81
94.32	1.76	3.05	0.42	0.68

Experimental work has shown that a satisfactory lime can be made.

Locality 9 (Hd. Melville, Bk. C, Troubridge Point)

Bryozoal limestones 20 ft. in thickness and covered by 6 ft. of kunkar are exposed in a cliff face on the south coast. Samples channelled down the cliff showed the following on analysis:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	94.4	1.81	1.00	0.47	0.39	0.04
2	92.3	0.76	4.00	0.47	0.93	0.02
3	89.8	1.81	4.70	0.75	1.67	0.04

<u>Locality 10</u> (sec. 70, Hd. Para Wurlie, Pt. Turton)

The fossiliferous Tertiary marine limestone of Pt. Turton has been described in some detail by Denholm (1957). A quarry was opened up on this deposit during the period 1906-1919 when over 120,000 tons were produced for use as a flux by the Broken Hill Proprietary Co. Ltd. and the Broken Hill Associated Smelters Pty. Ltd. at Port Pirie. Reddish highly fossiliferous limestone outcrops in the coastal cliffs over a length of two miles and up to 50 ft. high. They extend inland beyond Warooka a distance of eight miles. The basal bed, about 6 ft. thick, consists of hard compact limestone which is suitable, both chemically and physically for metallurgical use. Immediately overlying this bed are 35 ft. of porous limestones. The uppermost 10-15 ft. thick band is generally hard and rubbly but it has a higher silica and magnesia content. Partial chemical analyses from channel samples taken down the quarry face are set out below.

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	75.44	5.53	11.44	0.41	2.06	0.03
2	83.18	6.69	5.28	0.38	0.95	0.03
3	95.25	0.19	1.64	0.78	0.43	0.02
4	97.04	0.19	0.60	0.40	0.20	0.03

<u>Locality 11</u> (sec. 925, Hd. Wallaroo)

An isolated remnant of hard white dense limestone outcrops here over a length of about ¼ mile in low cliffs north of Wallaroo. In a quarry from which stone for flux in the Wallaroo smelters was taken 17 ft. of limestone are exposed, overlying basement Archaean metasediments and covered by 10 ft. of rubbly and massive kunkar with clay. A partial analysis is as follows:

$CaCO_3$	$MgCO_3$	SiO_2
96.61	1.75	2.02

Locality 23 (Point Hughes, Hd. Tiparra)

Approximately 5 ft. of Tertiary siliceous limestone are here exposed at the base of the cliffs beneath a cover of about 25 ft. of Quaternary strata. A partial analysis of this limestone follows:

$CaCO_3$	$MgCO_3$	SiO_2
56.2	3.96	37.7

(e) Nullarbor Plain (Fig. 20)

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The Eucla Basin in which marine limestones were deposited during the Tertiary period constitutes unlimited reserves of hard and soft limestone. These underlie the Nullarbor Plain, a vast treeless plateau, which extends inland from forbidding cliffs up to 250 ft. in height of the Great Australian Bight. The limestone cliffs extend in an unbroken line for 125 miles westerly from the Head of Bight to Wilson Bluff on the Western Australia border. The limestone of the cliffs comprises two members - the lower, Wilson Bluff limestone and an upper, Nullarbor limestone.

The Wilson Bluff limestone is a white chalky calcarenite with minor flint bands. At Wilson Bluff 188 ft. are exposed above sea level but at Head of Bight only 20 ft. are exposed beneath the Nullarbor limestone. A random sample from the Hampton Scarp (W.A.) showed on analysis:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P
97.32	0.94	1.16	0.20	0.91	0.02

The Nullarbor Limestone is cream to light grey in colour and is a hard crystalline rock which appears to retain a remarkably uniform character over thousands of square miles. Its thickness varies from 70 to over 200 ft. and in Head of Bight area is 120-150 ft. thick. It forms a horizontal bed with occasional clay pockets and like the Wilson Bluff limestone is cavernous (Jennings, 1961; King, 1949).

At Watson, situated on the East-West Transcontinental railway almost 400 miles from Port Augusta quarries have exposed the limestone over an area of fifty thousand square yards up to a depth of about 25 ft. Benches in the upper 12 ft. disclose dense fine grained and fossiliferous limestone while the lower section is more porous and generally richer in shell remains.

This limestone constitutes the largest and is among the highest grade deposits in the State, the following partial analyses being available:

Locality	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	P
Madura (W.A.)	96.79	0.89	1.72	1.58	1.40	0.02
1 Eucla Scarp	96.79	1.63	1.22	0.85	0.58	0.02
2 South of Koonalda H.S.	98.04	0.79	1.38	1.20	0.28	0.02
3 Head of Bight (100 ft. thickness)	94.64	2.01	0.30	0.44	0.75	0.11
4 Watson quarry (25 ft)	92.50	6.76	1.03	n.d.		
Watson quarry top bench	94.1	4.50	0.36	n.d.	0.10	0.01
Watson quarry bottom bench	93.6	4.00	0.64	n.d.	0.09	0.01

Isolated remnant outliers of late Tertiary or Pleistocene oolitic and brecciolic dolomites outcrop in the Maralinga area, one sample from a deposit situated 35 miles north of Watson (locality 5, fig. 20) showed on partial analysis:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	P_2O_5
53.8	42.8	0.82	0.19	0.006

Diamond drilling has been undertaken and reserves outlined (Johns, 1961, 1962).

(3) Pleistocene Amorphous limestones

Kunkar ("travertine") is the most widespread form of limestone in the State. It occurs as a surface or shallow sub-surface sheet from several inches up to over 20 ft. in thickness in association with calcareous soils and generally overlying lime-rich geological formations. Sheet kunkar or nodular pisolitic variants are ubiquitous in the South East, Yorke Peninsula, Eyre Peninsula and parts of Kangaroo Island. In these areas it provides a ready, and often the only, source of road metal and is used widely as a construction material for walls of dwellings, public buildings, etc.

To the present time kunkar has provided the main source of local raw material for lime burning.

Available partial analyses of this variety of limestone from various sources are tabled below:

Locality	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
Prospect (near Adelaide)	76.96	4.88	12.6	1.12	2.53
Warooka Lime Kiln (Hd. Carribie) sec. 158 (locality 22, fig. 14)	86.9	1.94	4.98	n.d.	n.d.
	88.7	2.32	3.18	n.d.	n.d.
Yamba (Hd. Paringa) (locality 10, fig. 19)	58.36	22.29			
Tailem Bend (Hd. Seymouy) sec. 12 (locality 9, fig. 19)	79.61	3.28	9.66	0.99	2.85
	70.17	3.09	17.86	0.69	3.81
	80.61	3.19	10.12	0.69	2.19
	76.84	2.99	13.02	0.64	2.98
	79.25	3.72	10.40	0.74	2.22
	85.00	2.26	6.02	0.60	3.20
	86.21	1.89	6.28	0.34	1.84
North of Keith (Hd. Makin) sec. 14 (locality 11, fig. 19)	82.6	n.d.	n.d.	n.d.	n.d.
Arno Bay (Hd. Boothby) sec. 229.	53.19	45.41	0.56	0.06	0.26
Pt. Neill, (Hd. Dixson) sec. 34.	52.89	45.34	0.74	0.37	0.38

(4) Pleistocene - Recent - Modern Calcareous Sands

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During the Pleistocene, as a consequence of lowered sea level and the exposure of broad expanses of continental shelf, extensive deposits of calcareous sand were built up and which now cover extensive tracts adjacent to the presnet coastline in the South East, Kangaroo Island, Yorke Peninsula and Eyre Peninsula and on many of the adjacent islands. The deposits (aeolianites) have become fixed by the development of kunkar at and near the surface. Unconsolidated sand dunes derived from the older system have in some areas encroached over the older dune system in the form of blowouts adjacent to the coast. While some of these have been fixed by the growth of vegetation others are still mobile.

Recent shell beds constitute useful deposits along parts of the eastern shores of Gulfs St. Vincent and Spencer. From these have been derived low dunes of unconsolidated shell sand. The occurrence of calcareous sand on the floor of Gulf. St. Vincent has been established.

(a) Lower South East (see Fig. 18)

In the South East of the State are preserved a series of successively younger Pleistocene beach deposits which occur as a subparallel system of dune ranges and have been described (Sprigg, 1952) as being stranded coastal dunes. They are typically well stratified with the cross laminations being of the "avalanched" type, steeply dipping and aeolian.

The various ranges are superficially similar but silica content increases to the north (Sprigg, 1959). Two of the dunes located nearest the seaboard have been scout sampled (Johns, 1961a); these are the Woakwine and Robe stranded aeolian ranges and their derived drift.

The Woakwine Dune extends southeasterly from near Cape Jaffa parallel to the coastline over a length of 20 miles. Mt. Benson at the northern extremity rises to 102 ft. but elsewhere the dune is generally less than 50 ft. in height.

The Robe Dune is largely composed of resorted aeolianite and extends along the coastline from Robe southeasterly to Cape Banks, being generally less than 30 ft. high throughout.

Partial analyses of the various samples taken (see fig. 18) are tabled below:

Locality	Hundred	Section	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5	SO_3	NaCl
8	Mt. Benson	44	77.4	4.0	16.3	0.27	0.70	0.07	0.35	0.05
9	Waterhouse	496	83.6	5.2	7.5	0.26	0.67	0.06	0.53	0.26
10	"	498	80.5	3.5	13.8	0.24	0.53	0.05	0.33	Tr.
11	Mt. Benson	53	38.3	0.85	59.5	0.41	1.00	0.03	0.05	nil
12	Waterhouse	137	81.5	3.4	12.2	0.49	0.63	0.07	0.31	0.13
13	"	213	73.8	3.3	19.2	0.27	0.42	0.07	0.30	nil
14	"	335	74.5	3.3	15.6	0.38	0.37	0.06	0.37	2.18
15	"	214	62.1	1.7	31.7	0.39	0.46	0.05	0.15	0.87
16	"	12	84.9	4.5	5.8	0.19	0.34	0.05	0.34	1.33
17	Rivoli Bay	136	84.6	4.1	9.0	0.37	0.30	0.09	0.33	0.02
18	"	4001	80.3	4.4	12.2	0.31	0.37	0.10	0.34	0.02

From these tables it is obvious that the $MgCO_3$ content is fairly constant while silica is the chief impurity and is in fact the dominant component of parts of some of the dunes.

(b) Kangaroo Island (See Fig. 3)

Pleistocene calcareous aeolianite dunes occur in a belt flanking the western and southern coasts and give rise to rugged cliffs between Cape Borda and Cape Willoughby. Recent mobile sands derived from these occur in a number of areas adjacent to the southern coast.

Kunkar developed on dune limestones which extend north west of Kingscote and in the Emu Bay - Pt. Marsen locality have been considered as a source of raw material for cement manufacture - it was proposed to utilize shell grit and kunkar in Hd. Menzies, secs.53, 54 and 55 with local basalt (Jack, 1926, pp. 1114-119) but the project was not pursued further,

The following analyses indicate the composition of some of the calcareous materials (locality 1, fig. 3).

Sample	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
1	82.68	3.21	7.78	0.68	0.94
2	83.07	5.58	6.42	0.44	0.46
3	84.48	2.71	7.38	0.58	0.70
4	81.70	3.90	9.26	0.84	1.64
5	82.70	1.91	12.01	0.28	0.62
6	90.00	1.00	3.48	0.50	0.64

A sample from Vivonne Bay (locality 2, fig. 3) analysed as below:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
82.53	4.64	1.28	0.34	0.40

(c) Yorke Peninsula (See Fig. 14)

Calcareous sand from Wardang Island is utilized as an ingredient in the fluxing charge for the lead smelters at Port Pirie. Leases are held by the Broken Hill Associated Smelters Pty. Ltd., and a jetty has been constructed by the Company on the north eastern end of the island. The deposits have been described by King (1952).

The island consists almost entirely of aeolianite with coastal cliffs attaining 80 ft. These older dunes have provided a source of supply since 1910 but coastal dunes derived from these are now being worked - the production (1910 to 1960) amounting to 1,086,400 tons. For the past ten years the average annual production approximates 23,000 tons. The reserves of unconsolidated sand were estimated by King to approximate 12½ million tons. Reserves of semi-consolidated Pleistocene aeolianite have not been assessed but are enormous.

Samples of lime sand (locality 26, fig. 14) showed on analysis the following:

Sample	$CaCO_3$	$MgCO_3$ (approx)	SiO_2	Fe_2O_3	NaCl	$CaSO_4.2H_2O$
1 (drift)	84.75	7.0	7.15	0.13	0.10	0.69
2 (drift)	72.13	6.0	20.88	0.31	0.03	0.39
3 (drift)	73.67	6.0	18.75	0.27	0.02	0.37
4 (aeolianite)	85.30	8.0	3.18	1.42	0.86	0.37
5 (aeolianite)	89.28	5.0	0.80	1.93	0.77	n.d.

Jackson (1952) reporting on laboratory tests on this sand to produce lime concluded that the product would require grinding before use.

Similar aeolianite occurs on the peninsula proper, south of Wardang Island; cliffs of this rock rising to 250 ft. at Cape Spencer. Recent drift sand from near the coast at Hardwicke Bay (localities 20 and 21, fig. 14) and aeolianite from the 30ft. high cliffs at Stenhouse Bay (locality 14, fig. 14) were sampled with results as follow:

Locality	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
20 Hardwicke Bay	71.3	3.40	20.8	0.19	3.05
21 " "	81.3	4.90	10.8	0.12	1.96
14 Stenhouse Bay	86.7	6.4	2.8	0.37	0.85
14 " "	85.0	2.4	8.88	0.48	1.52

A bulk sample from Stenhouse Bay was submitted for metallurgical beneficiation but preliminary work suggested that it could not be easily upgraded.

(d) Southern Eyre Peninsula (Fig. 21)

Surface sampling of Pleistocene and Recent deposits (Johns, 1961a, Whitehead and Owen, 1960) and more recently drilling (Johns, 1961c) has indicated the ready availability of high grade calcareous sand on Southern Eyre Peninsula.

Pleistocene aeolianites constitute enormous reserves of uniformly high grade limestone over large areas extending along the southern and western coast. Cliffs expose a thickness of over 600 ft. on Thistle Island and 400 ft. on Wedge Island while thicknesses of over 100 ft. are common on the mainland. Blowouts derived from Pleistocene materials are encroaching over the older system of fixed dunes in a number of localities adjacent to the mainland coast. These are constituted of unconsolidated calcareous sand but some have been stabilized by the growth of vegetation. The most conspicuous blowout developments occupy an area of some twenty square miles south of Coffin Bay. Similar but less extensive dunes are located on Coffin Bay Peninsula and others near Sleaford Bay.

Drilling at Coffin Bay has confirmed the existence of over 50 million cubic yards of uniformly high grade sand per square mile.

The weighted average analysis of 20 complete drill hole samples is as below:

$CaCO_3$	$MgCO_3$	SiO_2	SO_3	Total moisture
90.71	5.81	0.52	0.36	3.92

Surface samples of calcareous sand from other localities in this area have the following ranges of composition.

Locality	$CaCO_3$	$MgCO_3$	SiO_2
1. Sleaford Bay	81.9 - 89.5	4.7 - 5.8	2.1 - 6.2
2. Coffin Bay Peninsula	82.9 - 89.3	5.2 - 6.9	1.8 - 5.3
3. Point Avoid	91.3 - 91.7	6.1 - 7.3	0.30 - 0.54
4. The Fountain	95.2	2.3	1.05
5. Coffin Bay	90.0 - 91.9	5.4 - 6.3	0.5 - 0.6
6. Uley-Wanilla	93.0	2.7	0.60
7. Flinders	83.9	3.6	6.45

Sampling of the fixed Pleistocene aeolian deposits has shown that they have a like content of carbonate and silica.

A sample from Pt. Fanny at the south end ofBoston Island (locality 8) contained 76.6% $CaCO_3$.

Aeolianite and drift from near Port Le Hunte submitted by Dickinson and King (1949) showed the following:

	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
Port Le Hunte fixed dune	87.25	6.61	3.06	0.12	0.84
Blue Lake drift	85.91	5.67	4.40	0.18	0.86

(e) <u>Gulf St. Vincent - Spencer Gulf - Continental Shelf.</u>

Shell grit occurs as near shore deposits along the eastern coast of Gulf St. Vincent between Port Gawler and Port Wakefield (Mansfield, 1956) - see fig. 22 - Shell grit thrown up by wave action has been blown into low dunes which attain 20 ft. in height but are usually about 5 ft. These dunes have for many years offered a source of material for poultry shell grit, garden paths, cement manufacture, garden lime and lime for glass manufacture.

The material ranges in depth from 1 ft. to 6 ft. overlying grey clay and decomposed seaweed and extends inland for several hundred yards. Except for a covering of seaweed, there is no overburden.

Eighty bores were sunk by hand on a grid pattern in Secs. 696 and 699 Hd. Port Gawler (locality 1, fig. 22) to assess the quantity and quality of shell sand available and reserves have been established here at over 350,000 tons. It may reasonably be expected that large quantities similar in nature and quality are available beyond this area. Scout bores were drilled north of Port Gawler near Port Prime, Parham to beyond Lorne in Hds. Port Gawler, Dublin and Inkerman when indicated reserves were estimated at about 10 million tons (Mansfield, 1956).

By selective mining it is possible to obtain material of 80-82% $CaCO_3$ content. Samples taken from the various deposits showed the following;

Locality	$CaCO_3$	$MgCO_3$	SiO_2	$Fe_2)$ $Al_2)O_3$
1 Hd. Pt. Gawler, secs. 698, 699	81.04	2.46	12.38	1.34
"	79.83	3.03	13.30	1.32
"	77.44	1.80	15.50	1.68
"	78.64	2.85	14.60	1.34
"	70.32	1.88	19.96	2.08
2 Hd. Pt. Gawler, sec. G	89.43	4.20	2.6	0.3
3 " sec. 2	90.0 - 91.2	3.0 - 4.1	2.3 - 2.5	0.2 - 0.3
4 " sec. A	89.1	4.4	3.3	0.1
5 " sec. A	80.0	3.7	12.7	0.4
6 Hd. Dublin, sec. 431	79.2 - 82.6	4.1 - 4.3	10.0 - 13.0	0.3
7 " sec. 400	79.1 - 85.6	3.2 - 3.4	7.8 - 14.2	0.4
8 " sec. 394	71.2 - 86.9	2.8 - 3.1	6.4 - 22.4	0.2 - 0.5
9 " sec. 166	69.3 - 82.5	3.2 - 4.2	9.6 - 24.7	0.3
10 " sec. 126	69.0 - 83.0	3.7 - 4.3	9.4 - 23.4	0.2 - 0.4
11 " sec. 72	56.3 - 76.9	2.1 - 3.8	16.2 - 37.7	0.3 - 0.9
12 " sec. 48	75.1 - 82.2	2.7 - 3.3	11.0 - 19.0	0.3 - 0.4
13 " sec. 47	85.8	2.1	8.7	0.4
14 Hd. Inkerman, sec. 1W	79.9	3.4	12.9	0.2
15 " sec. 2	75.1	2.2	19.7	0.3
16 " sec. 3	82.5	4.1	10.6	0.3
17 " sec. 5	72.9 - 85.3	3.9 - 4.4	7.2 - 20.0	0.2 - 0.4
" sec. 5	49.9	2.3	43.2	1.6
" sec. 5	76.2 - 92.3	2.5 - 5.5	2.8 - 16.9	0.3
" sec. 5	90.7 - 91.8	1.2 - 2.2	1.4 - 4.4	0.2
18 " sec. 7	87.2	5.0	5.1	0.3

Shell grit also occurs along parts of the Spencer Gulf coast where dunes attain a height of over 30 ft. in a belt extending along the coast north of Fisherman's Bay. (see fig. 23). Leases are held by the Broken Hill Associated Smelters Pty. Ltd. in Hd. Mundoora, secs. B and 531 and Hd. Wandearah, secs. D and E. This material has been used as a flux in the Port Pirie lead smelters when Wardang Island supplies have been disrupted. In the years 1951-52 production amounted to over 10,000 tons .

An analysis of the shell sand from Wandearah follows:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	MnO	S	P_2O_5	SO_4
81.3	6.5	8.4	0.57	1.2	0.14	0.21	0.20	0.06

At Port Paterson, about 8 miles south of Port Augusta (see Fig. 15, locality 18) consolidated shell beds and narrow low dunes of unconsolidated shell grit constitute small deposits of mostly impure limestone (Miles, 1956).

Samples collected yielded the following results:

Sample	$CaCO_3$	$MgCO_3$	SiO_2
Shell bed	56.97	3.79	37.88
Shell dune	85.24	1.30	11.52

Early in 1957 H.M.A.S. Warrego a hydrographic research vessel collected bottom samples utilising a Barcoo Sampler from St. Vincent Gulf and approaches to provide information on the nature of the bottom for anchorage purposes (see fig. 24). The samples have been investigated and a thesis submitted to the University of Adelaide by Cooper (1960, unpublished). The sediments in the Gulf and its approaches proved to be skeletal calcarenites which are being formed by the accumulation of predominantly molluscan remains. Cooper concluded that the high carbonate content of the sediments is partly due to the lack of terrestrial material entering the basin by rivers. A second factor is the mechanics of tidal and wave movement which are in a long shore direction, so that the products of coastal erosion are dispersed in a direction parallel to the basin margins.

Percentage estimates of the following components were made - calcirudite (calcareous material $>$ 2 mm.), calcarenite (calcareous material $<$ 2 mm.), sand (non-calcareous material $<$ 2, $>$ 1/16 mm.) and mud (non specified material $<$ 1/16 mm.), and the chemical character of the sediments studied. This study showed that $CaCO_3$ is the dominant constituent, $MgCO_3$ is a small but significant component, the mud is highly calcareous (up to 30% $CaCO_3$) and that quartz grains constitute less than 5% except between Cape Jervis and the Bay of Shoals and marginal to Troubridge Shoal.

Three partial analyses are as follow:

Sample	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2) Al_2) O_3
229 (algal debris calcarenite)	82.96	10.95	0.50	0.06
150 (mud free calcarenite)	91.34	5.73	1.00	0.72
200 (mud fraction)	67.52	6.87	8.80	3.76

Similar calcareous sands are expected to occur in Spencer Gulf and extend along the continental platform marginal to the South Australian coastline.

Diving equipment and sampling equipment have been prepared by the S.A. Department of Mines to further sample the floor of Gulf St. Vincent west of Outer Harbour.

(5) Whiting

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There are several deposits of natural whiting in this State which have been worked to varying degree.

The whiting in an extremely fine grained state and having the consistency of mud occurs in the beds of small lakes on Southern Yorke Peninsula and on Eyre Peninsula.

In Hd. Carribie, sec. L, two miles east of Daly Head (locality 16, fig. 14) there is a lake containing several feet of soft dolomitic whiting. There are also old workings at Marion Bay (locality 15).

Analyses of these materials follow:

Locality	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	$CaSO_4$	NaCL
16	49.8	36.8	n.d.	n.d.	n.d.	n.d.	n.d.
	43.5	45.4	6.00	0.39	0.43	0.28	0.10
15	68.25	19.35	4.10	1.00		n.d.	n.d.

A more recent sample from locality 16 (Weir, 1960) showed the following:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	$CaSO_4$	NaCl
46.23	44.75	4.34	0.05	0.05	0.20	0.20

On Eyre Peninsula near Wanna, ½ mile from Sleaford Bay, (see fig. 21, locality 9) whiting occurs in the bed of a now normally dry lagoon and has been exposed in a number of pits to a depth of 3 ft. There has been no production since 1919 when 70 tons were marketed. A sample yielded the following on partial analysis:

$CaCO_3$	$MgCO_3$	SiO_2
83.64	8.00	1.18

About 5 miles north of this area dolomitic whiting occurs in the bed of Lake Pillie (locality 10, Fig. 21). On partial analysis this material showed:

$CaCO_3$	$MgCO_3$	SiO_2
65.26	26.08	3.92

III DOLOMITE

1. PRODUCTION, USAGE AND SPECIFICATIONS

The mineral dolomite is composed of magnesium carbonate and calcium carbonate in the ratio of 1:1 and contains 21.7% MgO (45.65% $MgCO_3$) and 30.4% CaO (54.35% $CaCO_3$). However, most so-called dolomites are really dolomitic or magnesian limestones containing a smaller proportion of MgO than the theoretical 21.7%.

The uses of dolomite depend mainly upon its magnesia content and are in general similar to those of magnesite (see under IV). Being cheaper and more abundant it is used in preference to magnesite wherever its lower magnesia and its lime content permit the substitution.

Dead-burned dolomite, obtained by calcining dolomite at 1500°C, at which temperature practically all the carbon dioxide is driven off, leaving a sintered mixture of lime and magnesia, is used extensively for refractory purposes in basic open-hearth furnaces and Bessemer converters. For furnace linings it is applied either as a plaster by mixing with some binding material, or in the form of bricks. The most satisfactory dolomites for refractory uses contain not more than 1% SiO_2, 1.5% Al_2O_3 and Fe_2O_3, and at least 38-40% $MgCO_3$.

If the calcining temperature of dolomite is held at 725°-750°C, the calcium carbonate remains unchanged but the magnesium carbonate is converted to magnesia which can be separated and used for the same purposes as caustic burned magnesite.

Dolomite is the raw material used to produce basic magnesium carbonate (magnesia alba) which is widely used in the manufacture of pipe and boiler coverings and for general heat insulation.

The use of dolomite in the manufacture of magnesium has grown very rapidly in recent years. The precipitation of magnesia from sea water utilises lime or dolime (calcined dolomite).

Dolomite is used as an ingredient in glass manufacture and as a flux in blast furnace practice, particularly in the manufacture of ferro-silicon and ferro-manganese, as it carries very little of the manganese or silica into the slag. The crushed rock may be used as a fertilizer, also in paint, putty and in the curing and fabrication of rubber. It is used also in paper making. Roasted dolomite is used in the manufacture of certain magnesium salts, in the neutralization of acid water and as a buffer for various metals, pearl and celluloid (Vienna lime). It is a source of lime (dolime) and is used extensively as road metal and concrete aggregate.

It is a low priced mineral and large tonnages are consumed annually so that the location of deposits in relation to centres of consumption and their accessibility largely controls their exploitation.

Metallurgical dolomite is quarried by the Broken Hill Pty. Co. Ltd. for use as a fettling material in their own operations and those of associated companies from deposits located at Ardrossan on Yorke Peninsula. Refractory metallurgical grade dolomite should approach the following specifications:

MgO 20%

SiO_2 2% maximum

The annual production of dolomite during the years 1950-1960 is tabled below:

Year	Production (tons)
1950	21,128
1951	52,450
1952	83,873
1953	84,822
1954	118,612
1955	97,398
1956	101,496
1957	180,237
1958	129,315
1959	151,401
1960	182,290

2. GEOLOGICAL DISTRIBUTION

Dolomites may be primary deposits which originated by direct precipitation from sea water or by deposition of shells and tests of certain marine organisms which contain magnesium as well as calcium carbonate. Other deposits are obviously formed by the replacement of part of the calcium content of limestones by magnesium derived from sea water or groundwaters.

The physical and chemical conditions which lead to the precipitation of dolomite are not well known. In a study of aspects of carbonate sedimentation in the Coorong (SE, South Australia) Alderman (1959) concluded that dolomitic sediments being formed today "are formed inorganically, though seasonal effects and organisms may have played big parts in providing the right physico - chemical conditions for precipitation. There is no simple relationship between salinity and carbonate precipitation, but the carbonates have been observed forming in salinities ranging from less than 1.6% to more than 14%, with pH varying from 8.5 to 9.0, and with reducing conditions being suggested by associated sulphur-bearing muds. It is suggested, therefore, that the physical conditions of shallow waters favour the precipitation of dolomite."

In South Australia dolomites are present as minor members of the Archaean Hutchison Group on upper and lower Eyre Peninsula. They are widely distributed in the Proterozoic (Adelaide System) being most strongly developed in the upper part of the Torrensian series. The lower Cambrian limestones are generally dolomitic, the greatest development of relatively pure dolomite occurring on Yorke Peninsula (the Kulpara "limestone") at Ardrossan and Kulpara. Tertiary deposits in the South East appear to be of the replacement type generally in close proximity to faults. Late Tertiary or Pleistocene and modern deposits are known at Lake Torrens, Lake Eyre, on Yorke Peninsula and in the Coorong. At Lake Eyre massive dolomite, dolomitic muds and brecciolic varieties have been penetrated by boring in the lake bed while they also outcrop on the lake shore.

In general the weathered surfaces of the Pre Cambrian dolomites are brown or yellow, the fresh rock being of somewhat lighter hue - the colour being attributed to oxidation of contained ferrous carbonate. The Cambrian dolomitic limestones are generally buff, grey or blue in colour and commonly have a brecciated appearance. Twenhofel (1950) p. 333 observes that this feature "is due to the breaking up of algal crusts and recementation in those places where the fragments were washed together." Commenting on the general occurrence of mottled limestones (which are commonly developed locally) he considers these may be considered as small nests of dolomite in calcite limestone - "the mottling arises from the occurrence of patches of dolomite in the midst of calcite limestone ....They occasionally have a sandy appearance and due to their greater resistance stand a little in relief. With respect to origin their mottling may be of two types - inorganic in that the dolomitization appears to have spread outwards from centres in the limestone not related to organic matter, and organic, in which organic matter may have served as centres."

The various South Australian deposits are described in more detail below:

(1) <u>Pre-Proterozoic Dolomites</u>

<u>References</u>

JOHNS, R.K. 1957a. Cowell Geological Map (1 in. = 1 mile series)

JOHNS, R.K. 1957b. Arno Geological Map (1 in. = 1 mile series)

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MILES, K.R. and ELEY, J.R. 1952 McGregor Geological Map (1 in. = 1 mile series)

MILES, K.R., JOHNS, R.K. and SOLOMON, M. Roopena Geological Map (1 in. = 1 mile series)

(a) Middleback Ranges (Fig. 25)

Dolomites which outcrop on the flanks of the Middleback Range have been described in some detail by Miles (1955). The Middleback North Dolomite is in parts interbedded with cherts and may be white to grey in colour but weathers to dull brown. They outcrop on the south eastern extremity of the Katunga Hills and have been intersected in boreholes in this area, on the eastern flanks of Iron Prince, near Iron Baron and on the range about one mile north of Mt. Middleback North. The last named locality is reputed to show the best exposures where a bed of dolomite exceeds 200 ft. in thickness. There are also widely separated deposits of dolomite on the southern end of the Camel Hill line of ridges northwest of Kimba Gap, at Cook North, on the west flank of Iron Knight and on the Iron Duchess (Miles and Eley, 1952)

The extent of these deposits is not fully known though they all appear to be small.

Partial chemical analyses of a number of grab samples from the localities shown in fig. 25 are tabled below:

Locality	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	FeO	MnO
1	53.52	32.65	2.42		n.d.	n.d.
2	45.94	33.03	5.18	4.50	0.18	6.75
3	52.95	31.47	2.20	4.76	2.75	1.25
4	24.61	1.07	5.38	n.d.	n.d.	n.d.
5	52.94	34.83	0.18	0.21	7.10	0.70
6	53.01	38.33	0.44	0.70	3.23	1.76
7	52.61	34.83	0.48	0.17	7.35	0.70
8	24.61	1.06	51.78	5.38	0.11	5.71
9	55.13	31.83	0.90	0.81	6.48	0.93
10	50.59	35.68	2.07	5.61		4.16

(b) Cowell Region (Fig. 26)

Dolomites outcrop at a number of localities south of the Middleback Range, but only those located in the Cowell district (Johns, 1959, 1961) appear to have reserves sufficient to encourage exploitation.

The Carpa and Mangalo dolomite deposits were investigated in some detail by the Broken Hill Pty. Co. Ltd., prior to the development of deposits at Ardrossan. At the Mangalo locality (No. 6, Fig. 26) several deep trenches have been cut across the bed. The Carpa deposit (locality 4) has been tested by a number of shallow costeans and a shaft 50 feet deep, from the bottom of which have been driven crosscuts to the limit of the bed. Partial analyses available are tabled below:

Locality	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	MnO_2
1	67.57	29.29	7.76	0.33	0.02
2	56.12	39.81	3.02	0.41	n.d.
3	54.89	43.75	1.88	0.32	n.d.
4	50.35	58.99	3.2	1.1	Tr.
5	52.89	45.33	0.74	0.37	n.d.

(2) Proterozoic and Cambrian Dolomites

(a) Fleurieu Peninsula

(i) Normanville - Sellick Hill (See Fig. 27)

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Cambrian dolomites and dolomitic limestones outcrop almost continuously in a belt along and near the coast between Normanville and northerly to beyond Sellick Hill. Reserves are enormous and conditions for quarrying generally good. Proterozoic dolomitic limestone (the Brighton limestone equivalent) has been sampled in several localities west of Myponga. The various sampled sections of these deposits are listed hereunder.

Locality 1 (Hd. Myponga, secs. 621, 623).

A number of samples taken from the surface and from diamond drill holes at the Myponga dam site, 40 miles south of Adelaide generally have a high silica content (up to 50%) and showing the following ranges of composition:

$CaCO_3$ 13% - 83% and $MgCO_3$ 1.6% - 17.4%.

Locality 2 (Hd. Myponga, secs. 437, 458, 473 and 262, north of Carrickalinga Head).

Massive grey dolomitic members of the "upper" Archaeocyathinae horizon outcrop strongly along the coast between this point and Myponga Beach. Samples taken from east to west show the following ranges of composition, each sample representing a width of 200 ft.

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	66.3	24.0	5.2	0.93	1.95	0.06
2	74.2	18.5	4.5	0.57	1.82	0.07
3	53.6	37.2	5.6	0.91	1.83	0.10
4	57.1	39.3	2.4	0.64	1.24	0.08
5	57.4	35.1	4.4	0.87	1.88	0.11
6	60.6	35.8	1.7	0.56	1.04	0.06
7	56.2	40.0	2.1	0.60	0.96	0.06
8	57.7	37.4	2.80	0.58	1.31	0.09
9	52.4	40.5	4.30	0.75	1.56	0.09
10	55.2	33.8	3.15	1.20	1.24	0.09
11	57.4	37.3	3.30	1.03	0.88	0.09
12	70.0	24.8	3.90	0.45	1.10	0.05
13	71.5	23.7	3.35	0.50	1.44	0.06
14	84.5	12.1	2.05	0.42	1.27	0.05
15	83.4	12.3	2.60	0.36	1.28	0.04

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
16	89.5	6.70	2.20	0.30	1.22	0.04
17	90.8	6.25	2.25	0.19	0.75	0.06
18	85.8	8.85	2.70	0.60	1.62	0.06
19	78.2	17.5	2.10	0.42	1.16	0.08
20	79.2	16.9	2.20	0.36	0.98	0.08
21	83.0	13.1	2.60	0.32	0.89	0.07
22	66.1	30.9	1.50	0.38	0.99	0.11

<u>Localities 3, 4 and 5</u> (Hd. Myponga)

The three samples whose analyses are tabled below represent grab samples from coastal exposures:

Locality No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
3	53.4	41.8	2.26	1.00	1.15	0.04
4	53.5	41.9	2.14	0.95	0.90	0.03
5	55.2	37.0	2.72	2.25	1.29	0.07

<u>Locality 6</u> (Myponga Beach)

Rocks similar to those of locality 2 (above) sampled here are somewhat more siliceous and enclose more slatey bands. Analyses of the samples from east to west over 100 ft. intervals follow:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	69.4	25.5	2.70	1.07	1.24	0.07
2	66.4	27.5	2.60	1.48	1.44	0.06
3	59.2	36.7	2.60	1.08	1.08	0.08
4	61.7	26.4	8.70	0.69	2.45	0.14
5	-	-	20.4	-	-	-
6	55.9	40.6	1.40	0.74	0.82	0.16
7	55.7	38.3	3.35	0.70	1.19	0.09
8	54.3	39.4	3.60	0.61	1.47	0.06
9	64.2	23.5	7.25	1.34	2.65	0.11
10	74.4	3.35	14.1	1.60	5.30	0.19

<u>Locality 7</u> (secs. 608, and 611P, Hd. Myponga)

The dolomitic beds here sampled include members of the Sellick Hill limestone formation which are stratigraphically below the other dolomites outcropping in this region and here exposed in a domed anticlinal core.

Samples taken from east to west analysed as below:

Sample width (ft).	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
100	85.4	10.7	2.10	0.52	1.16	0.04
100	87.8	6.65	3.40	0.87	0.87	0.04
100	76.3	8.05	10.5	1.62	2.45	0.13
100	69.1	22.8	3.80	1.67	1.50	0.05
800 ft. of siliceous calcareous slates						
100	49.9	35.6	3.90	1.82	2.95	0.03
100	50.6	37.7	4.40	2.75	2.45	0.04
100	54.8	35.5	2.20	2.75	1.42	0.03
100	56.4	35.4	2.85	2.60	1.75	0.03
100	53.6	38.6	2.10	3.05	1.25	0.03
100	54.4	35.6	3.30	3.00	1.88	0.03
100	54.6	32.8	3.90	4.90	2.05	0.05
100	54.2	33.6	5.65	1.65	2.70	0.03
100	64.9	14.7	12.3	1.36	5.10	0.06
200	-	-	40.0	-	-	-
100	78.0	6.30	9.00	1.41	3.60	0.05
100	83.2	7.10	5.65	0.75	2.50	0.07
100	68.4	9.50	13.9	1.44	4.75	0.15

<u>Locality 8</u> (secs. 727, 733, 678, 679, 680 etc. Hd. Willunga, Sellick Hill

A series of dolomites and dolomitic limestones and shales which outcrop at Sellick Hill are well exposed along the old main road in the following order from the west - mottled 'limestone' (100 ft.), fine crystalline flaggy 'limestone' (400 ft.), <u>archaeocyathinae</u> 'limestone' (200 ft.), on which a quarry is based, impure banded ribbon 'limestone' (300 ft.), calcareous shales (600 ft.), and blue grey crystalline limestone (160 ft.) - all overturned and dipping south easterly at angles varying from 50^{o} to 80^{o}.

Jack (1926) sampled the beds at this locality to determine the nature and extent of these deposits. The following analyses were derived from samples recently taken (Thomson, B.P., 1961) from east to west across the two main dolomitic horizons:

Width Sample (ft.)	$CaCO_3$	$MgCO_3$	SiO_2	P_2O_5
eastern bed				
100	53.2	40.1	2.70	0.04
10	52.5	40.9	0.78	0.03
10	86.4	6.65	2.15	0.07
10	55.8	36.8	2.50	0.05
10	80.2	11.9	2.65	0.07
10	53.0	40.4	2.65	0.04
10	53.8	40.1	2.20	0.04
10	56.2	36.9	2.25	0.05
western beds				
70	66.6	3.40	19.4	0.53
70	61.2	2.60	22.9	0.45
100	67.2	2.35	17.2	0.18
150	81.7	1.55	9.8	0.21
120	81.0	7.00	6.65	0.17
100	53.7	40.2	2.60	0.12
100	58.2	34.6	2.85	0.08
100	51.4	39.8	4.05	0.25
120	57.8	20.3	13.1	0.25
120	73.7	22.4	1.75	0.04
180	63.8	28.9	3.60	0.15
100	73.0	16.7	6.30	0.28

(b) Central Region

(i) Beaumont (Fig. 28)

References

BARNES, T.A. and KLEEMAN, A.W. (1934) Trans. Roy. Soc. S. Aust. 58, pp. 80-85.

HOWCHIN, W. (1906) Proc. Roy. Soc. S. Aust. 30, pp. 227-262.

References (Contd.)

JOHNS, R.K. (1958) Unpublished report

SPRIGG, R.C. (1946) Trans. Roy. Soc. S. Aust. 70(2), pp. 313-347.

SPRIGG, R.C., WHITTLE, A.W.G. and CAMPANA, B. Adelaide Geological Map (1 in. = 1 mile series).

Dense fine grained siliceous blue dolomites (Beaumont Dolomite) outcrop near the scarp of the Mount Lofty Ranges south east of Adelaide at Beaumont, near the Devil's Elbow and at Brown Hill.

A number of thin dolomite beds are separable (Barnes and Kleeman, 1934). The thickest beds have provided quarry sites for the production of building stone and lesser for road building aggregate.

Analyses of samples taken from the various deposits as indicated on fig. 28 are as below:

Locality	$CaCO_3$	$MgCO_3$	SiO_2	$Fe_2)$ $Al_2)O_3$
1. Hd. Adelaide, sec. 1005	46.99	34.94	12.7	3.4
2.	42.68	32.21	24.7	2.7
3. Hd. Adelaide, secs. 266, 267	80.00	12.76	5.1	3.5
4. Near Devil's Elbow	38.75	30.76	27.5	3.4
5. " " "	43.75	33.89	22.0	3.4
6. " " "	40.89	31.59	27.6	3.0
7. Hd. Adelaide, sec. 1094	38.77	27.80	28.9	n.d.
8. Hd. Adelaide, sec. 1121	49.89	38.02	6.86	n.d.
9. Hd. Adelaide, sec. 911	37.72	28.70	29.0	n.d.

(ii) <u>Castambul - Montacute</u> (Fig. 29)

References

DENHOLM, L.S. (1958) Mining Review 105, pp. 89-93

HOWCHIN, W. (1906) Proc. Roy. Soc. S. Aust. 30, pp. 227-262.

JOHNS, R.K. (1950)a Unpublished report.

JOHNS, R.K. (1950)b " "

NIXON, L.G. (1959)a Mining Review 108, pp. 116-123.

NIXON, L.G. (1959)b Mining Review 108, pp. 124-125.

NIXON, L.G. (1962) Mining Review 114 (in press)

NIXON, L.G. (1961)a Unpublished report.

NIXON, L.G. (1961)b " "

References (Contd.)

SPRIGG, R.C. (1942) Trans. Roy. Soc. S. Aust. 66(2), pp. 185-214

SPRIGG, R.C. (1946) Trans. Roy. Soc. S. Aust. 70(2), pp. 313-347

SPRIGG, R.C., WHITTLE, A.W.G. and CAMPANA (1951) Adelaide Geological Map (1 in. = 1 mile series).

The dolomites of this region comprise dolomitic limestone, dolomite, siliceous dolomite and magnesite interbedded with calcareous slates, phyllites and quartzites. The dolomite members range from finely laminated to massive rocks and from white, cream and buff to grey or blue in colour. They have been quarried at a number of sites exclusively for the production of general aggregate.

Locality 1 (sec. 5494, Hd. Yatala, Castambul)

The Lower Torrens Dolomite is here 500 ft. thick and varies in texture and composition from a dense massive white dolomite through gritty dolomites to dolomitic sandstone (Johns, 1950). Large reserves of easily accessible stone extend northerly from the Torrens Gorge a distance of two miles. Two samples whose analyses follow were taken from a quarry face each over a length of 100 ft. (from west to east).

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	-	-	32.3	-	-	-
2	48.7	35.1	10.2	0.49	2.90	0.03

Locality 2 (sec. 333, Hd. Onkaparinga)

Buff to grey dense uniform textured dolomites are here exposed on the steep slopes immediately south of the Toreens Gorge road, in a bed 200 ft. thick and disturbed by faulting. Reserves here exceed ½ million cub. yds. (Johns, 1950). Two samples taken showed on analysis the following:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	41.5	40.0	5.85	0.66	1.44	0.02
2	50.2	33.1	12.6	0.66	2.30	0.02

Localities 3, 4 and 5 (Secs. 328, 329, 330, 332 and 833, Montacute)

Massive blue dolomite, sandy dolomites and dolomitic slates over 600 ft. in thickness which outcrop north of Montacute have been mapped in detail and have been tested by diamond drilling (Nixon, 1961 a and b). Samples taken over a length of 100 ft. at localities 3 and 4 contained over 20% silica. A sample from Sec. 330 (locality 5) analysed as below:

$CaCO_3$	$MgCO_3$	SiO_2
48.29	38.77	8.14

Locality 6 (secs. 5536, 5539, Hd. Onkaparinga)

Detailed mapping (Nixon, 1959a) has been undertaken and a full sequence which comprises blue dolomites and sandy dolomites with mica schists, quartzites and dolomitic slates has been defined. Magnesitic horizons, sedimentary breccias and cherts occur. The same strata have been mapped in detail north of the River Torrens towards Anstey Hill in Hd. Yatala, secs. 5394 and 5548 (Nixon, 1962). Quarries for the production of bitumen and general aggregate have been established in these deposits (Riverview quarries).

Samples taken over a length of 700 ft. in Torrens Gorge showed a silica content in excess of 30%, while selected material analysed as under:

$CaCO_3$	$MgCO_3$	SiO_2
44.48	36.68	17.04
42.68	41.00	13.2

Locality 7 (sec. 5634, Hd. Yatala, Tea Tree Gully)

Blue dolomite almost 150 ft. in thickness has been here mapped and tested by diamond drilling (Denholm, 1958). Fine grained and siliceous dolomites have been quarried for the production of bitumen aggregate. Samples taken over a width of 220 ft. contained over 33% silica.

Dolomites and dolomitic slates which outcrop sporadically adjacent to Dry Creek near Modbury (Hd. Yatala, secs. 721, 1567, 1568 etc.) have been drilled and reported on (Nixon, 1959b) but analytical data are lacking.

(iii) Williamstown - Rowland Flat (Fig. 30)

References

CAMPANA, B. (1953) Gawler Geological Map (1 in. = 1 mile series)

JACK, R.L. (1923) Geol. Surv. S. Aust. Bull. 10, p. 55)

In this region the dolomites sampled are thin, discontinuous and generally poorly exposed. They are of Proterozoic (Torrensian) age.

Locality 1 (sec. 1523, Hd. Para Wirra, 3 miles S. of Williamstown)

Serpentinized green and white marbles have been mapped in this vicinity. Steeply dipping white talcose dolomite was sampled here over a width of 100 ft. in a deep gully somewhat difficult of access near the South Para reservoir. Analysis of this stone is as below:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
48.6	38.6	1.42	0.52	5.40	0.03

Locality 2 (sec. 981, Hd. Barossa, 2 miles NE Williamstown)

White banded dolomite was here sampled over a width of 35 ft. where it is exposed in two small quarries. There appear to be large reserves available. A partial analysis follows:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
46.3	36.2	2.10	0.46	7.05	0.03

Locality 3 (sec. 764, Hd. Moorooroo, 3 miles E. of Rowland Flat)

Soft white powdery and talcose dolomite sampled over a width of 200 ft. showed a content of silica varying from 22 - 28%.

(c) Lower North

(i) Stonefield (see Fig. 31)

Reference

COATS, R.P. (1959) Truro Geological Map (1 in. = 1 mile series)

At this locality (sec. 23, Hd. Brownlow, 4 miles N. of Stonefield) cream to brown siliceous dolomites outcrop over a width of 30 ft., silica content of a sample taken was 40%.

(ii) Kapunda (see Figs. 12 and 13)

References

CAMPANA, B. (1953) Gawler Geological Map (1 in. = 1 mile series).

DICKINSON, S.B. and COATS, R.P. (1957) Kapunda Geological Map (1 in. = 1 mile series).

Locality 5 (sec. 1473, Hd. Kapunda)

Grey-white talcose marble possibly equivalent to the Brighton Limestone is here exposed in a shallow quarry. An analysis of this stone sampled over a width of 64 ft. is as below:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
73.1	14.7	7.45	0.61	1.70	0.01

Locality 6 (sec. 1413, Hd. Belvidere)

Siliceous dolomites which outcrop poorly in this area showed 20-40% silica over a sampled width of 300 ft.

Locality 12 (see fig. 13)-(sec. 200. Hd. Julia Creek)

A bed of cream-brown dolomite sampled over a width of 50 feet showed the following on analysis:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
45.4	33.4	11.0	1.55	1.53	0.04

Locality 9 (Fig. 12) (sec. 1665, Hd. Nuriootpa)

Locality 10 (sec. 1666, Hd. Nuriootpa)

A bed of Torrensian dolomite is traceable over a distance of about one mile from a point about two miles south of Daveyston. Samples taken from east of old copper workings were analysed as below:

Locality	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3
10	36.44	32.08	30.18	0.40
11	34.93	31.17	25.80	0.36

(iii) Hamley Bridge - Stockport (Fig. 32)

References

DICKINSON, S.B. and COATS, R.P. (1957) Kapunda Geological Map (1 in. = 1 mile series).

Thin lenticular and highly siliceous dolomites in this region are insubordinate members of the Torrensian Series. The various localities sampled with relevant analytical data follow:

Locality	Hundred	Section	Width Sampled(ft)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	Alma	438	100	46.5	40.2	11.8	0.21	0.78	0.01
2	Alma	260	35	-	-	95.9	-	-	-
3	Alma	610	100	-	-	60-80	-	-	-
4	Alma	128	96	31.4	49.3	15.5	0.60	2.10	0.02
5	Light	292	95	-	-	35.4	-	-	-
6	Light	492	60	-	-	41.6	-	-	-

(iv) Riverton - Auburn (Fig. 33)

Reference

WILSON, A.F. (1952) Trans. Roy. Soc. S. Aust. 75, pp. 131-149.

Dolomites are prominent members of the Adelaide System developed in the region extending from Riverton northwards beyond Auburn. They comprise lenticular members in the Willouran Series (River Wakefield Group) while the Torrensian Montacute Dolomite equivalent (Skillogalee Dolomites) are major units (Wilson, 1952).

Locality 1 (sec. 75, Hd. Upper Wakefield, 5 miles NW. of Rhynie)

White arenaceous oolitic limestone sampled here showed the following on analysis:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3) Al_2O_3)
46.72	5.70	46.98	0.60

More commonly the carbonate members are reported to be pale cream coloured massive very fine grained dolomites.

Localities 2 and 3 (sec. 68, Hd. Upper Wakefield)

Very pale dull-blue fine grained dense dolomite occurs here as a narrow bed, 5 ft. in thickness, and as a near basal bed in a magnesite sequence. An analysis follows:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3) Al_2O_3)
47.22	38.20	12.42	1.66

Locality 4 (sec. 508, 506, Hd. Alma)

Cream coloured dense fine grained dolomite from this locality contained the following:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3) Al_2O_3)
53.76	44.40	1.14	0.98

Locality 5 (sec. 65, Hd. Upper Wakefield)

A specimen considered typical of the Skillogalee Dolomites and comparable with the dolomites of the Torrens Gorge showed the following on analysis:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3) Al_2O_3)
50.86	41.46	6.20	1.22

Locality 6 (secs. 210, 557, Hd. Alma)

Thin bedded and contorted cherty blue grey dolomite 30ft. in thickness sampled here analysed as below:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3) Al_2O_3)
37.26	31.48	31.16	0.40

Localities 7, 8 and 9

Numerous dark grey very fine grained dense dolomites occur as thin bands within dolomitic shales - these Auburn dolomites are generally siliceous. Analyses are tabled below:

Locality	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3 Al_2O_3
7, sec. 547, Hd. Upper Wakefield	37.42	27.48	30.12	4.64
8, sec. 275, Hd. Upper Wakefield	46.16	39.90	12.36	1.78
9, sec. 396, 397, Hd. Saddleworth	37.46	29.74	29.90	2.40

(d) Yorke Peninsula

(i) Kulpara

References

BARNES, T.A. and KLEEMAN, A.W. (1934) Trans. Roy. Soc. S. Aust. 58, pp. 7-9

CRAWFORD, A.R. (1961) Maitland Geological Map (1 in. = 4 miles series)

HORWITZ, R.C. (1959) Wakefield Geological Map (1 in. = 1 mile series)

JOHNS, R.K. (1961) Unpublished report.

WADE, M.L. (1952) Unpublished report.

Dolomites and limestones are conspicuous members of the Cambrian group of sediments exposed along the eastern flanks of a prominent fault scarp to the north and west of Gulf St. Vincent at and south of Kulpara, 70 miles from Adelaide (Horwitz, 1959). They comprise two members, the lower one (Kulpara limestone) is generally buff coloured and is a dolomite, being succeeded by the Parara Limestone which is blue grey in colour and having a much lower magnesia content.

Reserves of uniformly high grade dolomite are considerable and quarry sites are readily available. Sturtian dolomitic limestones in this region appear to be very siliceous.

Locality 1 (secs. 229, 230 and 233, Hd. Kulpara, 2 miles E. of Kulpara)

The Kulpara limestone sampled here is uniform in chemical composition as demonstrated by the following analyses; the samples were taken over lengths of 100 ft. from east to west.

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	70.6	26.3	2.70	0.70	0.32	0.01
2	53.6	44.1	1.76	0.51	0.32	0.01
3	53.7	43.9	1.56	0.44	0.29	0.01
4	53.4	43.5	2.55	0.46	0.26	0.01
5	54.0	44.6	1.04	0.38	0.23	0.01
6	53.5	44.6	1.71	0.39	0.37	0.01
7	53.1	44.2	2.30	0.38	0.30	0.01
8	53.5	44.0	1.61	0.57	0.25	0.01
9	51.7	43.0	4.00	1.00	0.39	0.02

<u>Locality 2</u> (sec. 230, Hd. Kulpara)

The three first samples listed below were taken from outcropping Parara Limestone, the others represent the Kulpara Limestone.

Quarries situated adjacent to the main road have provided a source of aggregate for road building (Wade, 1952).

Analyses below are of samples taken from east to west, each representing an interval of 100 ft.

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	89.0	5.80	2.35	1.94	0.39	0.04
2	81.3	16.2	1.14	1.19	0.38	0.03
3	80.1	16.5	0.89	1.80	0.31	0.03
4	54.7	42.3	1.19	0.82	0.38	0.03
5	53.9	43.0	1.43	0.77	0.57	0.01
6	54.0	43.6	1.19	0.71	0.39	0.01
7	53.5	44.5	1.21	0.61	0.40	0.01
8	53.6	43.1	2.10	0.69	0.56	0.01

<u>Locality 3</u> (sec. 206-207, Hd. Kulpara)

A diamond drill hole completed at this site penetrated over 300 ft. of grey and buff dense, but in places brecciated, dolomite (the Kulpara Limestone) before encountering the underlying quartzites. The split core was analysed over the intervals indicated below.

Sample Interval (ft.)	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
15 - 50	51.78	43.19	3.05	0.75	0.88	0.01
50 - 100	51.78	43.30	2.40	0.84	0.98	0.02
100 - 150	52.50	43.93	2.10	0.56	0.68	0.02
150 - 200	52.68	43.93	2.40	0.67	0.36	0.02
200 - 250	52.14	43.39	2.70	0.76	0.44	0.02
250 - 331½	49.47	40.37	7.00	1.39	1.26	0.04

Locality 4 (secs. 204, 206, 208, Hd. Kulpara, Canowie)

Kulpara Limestone here sampled is the outcropping equivalent of the section intersected in the bore (locality 3) above and it maintains the same high uniform grade in an area where there are considerable reserves of quarryable stone.

Samples taken over 100 ft. lengths showed the following on analysis:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	82.65	1.82	6.52	4.61	1.29	2.81
2	87.39	4.90	2.81	3.66	0.64	0.21
3	69.61	25.34	1.61	2.45	0.36	0.05
4	52.26	42.68	0.93	2.08	0.27	0.05
5	53.45	42.68	1.51	1.85	0.31	0.03
6	53.23	43.32	1.76	0.68	0.31	0.01
7	53.77	44.05	0.88	0.44	0.34	0.01
8	53.88	43.95	0.85	0.78	0.20	0.01
9	53.99	43.68	0.78	0.83	0.22	0.02
10	53.77	43.86	0.92	0.65	0.30	0.01
11	52.69	42.86	3.27	0.51	0.36	0.01
12	53.13	43.86	1.00	0.37	0.93	<0.01
13	53.45	41.68	1.10	0.99	1.03	0.03
14	54.63	43.32	1.39	0.67	0.31	0.01
15	53.66	42.59	1.59	1.04	0.55	0.02
16	53.88	43.59	1.61	0.85	0.25	<0.01
17	53.10	41.80	3.65	0.91	0.41	0.03
18	53.70	41.60	4.85	0.89	0.57	0.03

Locality 5 (secs. 356, 357, Hd. Clinton)

Grey and brown mottled, rubbly limestones sampled in this area are siliceous along the eastern part of the outcrop (20 - 40% SiO_2) - these are underlain by purer limestones and dolomites near the base. Samples taken over 100 ft. intervals across the Kulpara Limestone showed the following contents:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
1	80.2	1.91	13.4	1.12	2.35	0.04
2	87.1	3.00	7.25	0.96	1.29	0.63
3	85.4	3.35	8.25	0.99	1.56	0.46
4	55.4	43.8	0.41	0.69	0.19	0.03

Locality 6 (sec. 46, Hd. Clinton)

In Clinton stratigraphic bore no. 1 grey Kulpara Limestone was penetrated below 310 ft. of Tertiary and Quaternary sediments. The bore passed into the underlying quartzites at 336 ft. Samples taken at 5 ft. intervals within the limestone sequence were analysed as below:

Depth	$CaCO_3$	$MgCO_3$
311 ft. 5 ins.	22.6	15.9
316 ft. 2 ins.	24.7	16.9
321 ft.	22.5	16.1
326 ft.	23.3	16.5
331 ft.	19.4	13.8
336 ft.	20.4	14.1

Locality 7 (Sec. 321, Hd. Clinton)

Dolomitic limestones, with siltstones and quartzite lenses of the Sturtian Series extend over a distance of some six miles near the scarp west of Gulf St. Vincent. Though the contents of insolubles in the following partial analyses were not determined it is obvious that they are high:

$CaCO_3$	$MgCO_3$
63.57	1.99
78.93	8.99

Locality 24, (fig. 14)(near Wallaroo jetty, Wallaroo, Hd. Tiparra)

A sample of Kulpara Limestone exposed along the foreshore at Wallaroo was taken for partial analysis - results are as below:

$CaCO_3$	$MgCO_3$
49.3	40.8

Locality 25, (fig. 14)(near Wandilta Mine, Kadina)

An analysis of dolomitic limestone from this locality is as below:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3) Al_2O_3)
57.85	34.65	0.10	0.73

(ii) Ardrossan (Locality 12, fig. 14) (secs. 31E, 33 and 31W, Hd. Cunningham and secs. 59, 60, 61, Hd. Muloowurtie, 1 to 4 miles south of Ardrossan, 95 miles by road from Adelaide).

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A programme of diamond and auger drilling was initiated during 1945 on a deposit of dolomite (The Kulpara Limestone) which outcrops in a low scarp to the west and south of Ardrossan township. The construction of a crushing plant and loading installations were authorised in 1948 and full production commenced by the Broken Hill Proprietary Co. Ltd. in 1950.

Plant has been designed to meet the requirements of B.H.P. Co. Ltd. steel plants, the dolomite being used as a refractory fettling material and for lining open hearth furnaces at the Newcastle, Pt. Kembla and Whyalla steelworks, and incorporates a jetty 3,055 ft. long with an 800 ft. T-head carrying a conveyor belt, crushing plant and bins.

Present output exceeds 180,000 tons per year and production to date totals 1¼ million tons.

The dolomite is fine grained dense and buff in colour and is gently folded. Drilling has confirmed metallurgical grade material over a large area.

Karst topography developed over the upper surface of the dolomite is a feature of the deposit in the upper levels of the main quarry where clay infillings and Tertiary grits constitute overburden (Johns, 1961).

A typical analysis is as below:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	MnO
55.05	43.05	0.50	1.00	0.42	0.26

(e) Flinders Ranges

See under II Limestones

(3) Tertiary Dolomites

(a) Lower South East (see fig. 18)

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Dolomites have been developed in several areas in the Lower South East by metasomatic replacement of bryozoal limestones generally in proximity to faults and a relation is inferred between dolomitization and volcanic activity (Cochrane, 1952). It is doubtful whether the dolomitization is of stratigraphic significance and where dips exceed 40° faulting is known or suspected. The dolomites are usually pink in colour, but may be white or yellow; they are of variable hardness and texture. There is a comparative absence of rock types intermediate in composition between limestone and dolomite.

Locality 4 (fig. 18) (secs. 200, 205, 213, 204, Hd. Hindmarsh, Up and Down Rocks)

Large deposits of good quality hard pink and yellow brown dolomites are exposed in a fossil sea cliff, 3 miles E.S.E. from Tantanoola. Dolomitization is irregular and unpredictable and gives way to normal bryozoal limestones both laterally and vertically over short distances (Cochrane, 1952).

A diamond drill programme undertaken in 1949 outlined reserves sufficient for the provision of ballast for the S.A. Railways Department and new quarries were established on the deposit.

Samples of the various dolomites showed the following ranges of composition:

$CaCO_3$	$MgCO_3$	SiO_2	$\left.\begin{matrix}Fe\\Al\end{matrix}\right)_2O_3$
57.59 to 63.98%	35.24 to 39.89%	0.22 to 0.66%	0.44 to 1.54%

Locality 19 (secs. 385, 724, 717, 721 etc. Hd. Blanche, near Burnda railway siding.)

Over an area of some 18 sq. miles, north and south of the railway line pink and white dolomites occur as bedded replacements within bryozoal limestone adjacent to a major zone of faulting (Cochrane, 1952). Stone of variable hardness has been worked from a number of shallow openings (Jack, 1923).

Three analyses available follow:

Hd. Blanche	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5
sec. 724	58.66	40.79	0.28	0.27	0.12	0.07
sec. 717	59.46	40.00	0.22	0.03	0.24	0.06
sec. 721	65.86	32.62	0.66	0.10	Tr.	-

Locality 20 (Blue Lake, Mt. Gambier)

On the northern side of the lake pink dolomite which grades laterally into bryozoal limestone underlies the basalt and volcanic ash accumulations. Typical analyses approximate the following:

$CaCO_3$	$MgCO_3$
60.19	39.47

Locality 21 (Hd. Caroline, adjacent Mt. Gambier - Nelson road)

A narrow dolomitized zone is traceable for a distance of more than one mile along the Nelson Fault - the zone of replacement being sharply defined and very narrow.

(4) Late Tertiary - Quaternary - Modern dolomites

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See also under II Limestone, (5) Whiting, page 61.

Aspects of present day carbonate sedimentation in shallow water lagoons and at the closed shallow end of the Coorong have been discussed by Forbes (1955), Alderman and Skinner (1957) and Alderman (1959). Calcite and dolomite are both present in most localities, elsewhere dolomite is the dominant carbonate mineral.

Older, but as yet of undefined age, dolomites have been described at Lake Eyre (Madigan (1930); King (1956) and Johns (1962)), and in the bed of Lake Torrens (Johns (1962). The dolomites outcropping on the southern shore of Madigan Gulf, Lake Eyre are hard and massive and display intraformational pellet structures. Boreholes in the bed of the lake showed a thickness of almost 150 ft. of dolomitic sediments - hard and soft dolomite (displaying brecciolic structures in part) and dolomitic muds.

At Maralinga (fig. 20, locality 5) outliers of dolomite occur as cappings 30 ft. thick to dissected tablelands. Oolitic and brecciolic varieties similar to those of the Lake Eyre region have been tested by diamond drilling at Roadside (Johns, 1962)a. Equivalence in age has not been verified but is suspected.

Partial analyses of these various deposits are tabled below:

Locality	$CaCO_3$	$MgCO_3$	SiO_2
Coorong	47.52	22.27	8.24
Lake Hawdon North	62.09	23.47	6.86
Kingston Lake	51.09	19.71	19.42
Lake Eyre - South shore	48.93	36.40	2.50
" "	53.58	38.29	4.68
- Bore 20 21-48 ft.	27.50	22.38	n.d.
48-79 ft.	51.09	37.65	n.d.
79-87 ft.	37.50	28.04	n.d.
Maralinga	53.8	42.8	0.82

IV MAGNESITE

1. PRODUCTION, USAGE AND SPECIFICATIONS

When pure, magnesite ($MgCO_3$) is composed of 47.6% MgO and 52.4% CO_2. The main impurities in local materials are silica (chert), and lime.

Magnesite as such has little commercial use, but it is valuable for its magnesia (MgO) content. Magnesia has a high melting point, is chemically inert and is therefore suitable for many refractory purposes.

By heating magnesite to about 650°C most of its contained carbon dioxide is expelled and the resultant product is known as caustic magnesite. Heating to 1500°C-1800°C removes all the carbon dioxide, leaving "dead-burned" magnesite, which is the material generally used for refractory purposes.

Dead burned magnesite is used primarily for lining furnaces, particularly in the steel industry, for which purpose the burned magnesite is often preformed as bricks of various shapes. These bricks have a low mechanical strength and therefore are limited in use to places where they can be supported. Brick grade specifications are MgO, 80-90%; CaO, 2-5%, SiO_2, 1-6%; Al_2O_3, 0.5-1.5% and Fe_2O_3, 1-7%.

For refractory purposes the calcined magnesite should contain a minimum of 87% MgO and should be free as possible from volatile metallic impurities. For metallic magnesium production a maximum total of silica and lime of 1.5%is specified.

Caustic-burned-magnesite is used chiefly in the manufacture of oxychloride (Sorrell or Sorel) cement; specifications include MgO at least 87%, lime less than 2.5%. The principal use of this cement is in the preparation of composition flooring, in which the calcined magnesite, mixed with magnesium chloride and fillers, forms a resistant, non-slip, fire-proof and durable floor. Special tiles, imitation marble, drain pipes etc., fireproof partitions etc, heat insulator coverings for boilers, pipes etc. are also manufactured from magnesite cement. A high lime content in the original magnesite is deleterious for the quick-lime formed during calcination becomes hydrated and forms bulges in the setting cement. Caustic calcined magnesite finds various uses in the rayon, fertilizer, paper, rubber, glass, enamel, and porcelain industries. Other uses are for medicinal purposes in the preparation of magnesia, epsom salts etc., as a base for fire resisting paints and as a whiting substitute. Both crude and calcined magnesite have been used to protect stored wheat, potatoes etc. against pests. Magnesia is also used in the production of magnesium metal.

Most of the Australian magnesite production (approximately 85,000 tons in 1960) is used for refractory purposes by the Broken Hill Pty. Co. Ltd. at their steel works. They have mined small tonnages from leases held at Mundallio, Port Germein Gorge and Balcanoona.

F. H. Faulding and Co. Ltd. of Adelaide are the principal manufacturers of magnesium chemicals deriving supplies from Copley and in part from Mundallio. Magnesium sulphate is produced principally for use in the leather manufacturing industry the raw material being principally obtained from the Copley district.

Industrial utilization of South Australian magnesite has been discussed in some detail by Willington (1956).

Tabled below is the recorded annual production of magnesite in South Australia for the years 1950-1960:

Year	Production (tons)
1950	1,177
1951	998
1952	572
1953	36
1954	235
1955	315

Year	Production (tons)
1956	831
1957	202
1958	341
1959	790
1960	498

2. GEOLOGICAL DISTRIBUTION

Magnesite occurs on Eyre Peninsula within Archaean metasediments at a number of localities usually in close association with graphitic schists.

Within the Adelaide System a dolomite-magnesite sequence (the Montacute Dolomite) contains significant developments of magnesite at a number of localities. The individual beds vary in thickness up to nearly 15 ft. and are often traceable with little change in thickness or facies over many miles. The magnesite is white to pale grey in colour, hard and dense, and typically displays a brecciola structure which is in reality a magnesite conglomerate. The beds are enclosed by cherts, dolomites, dolomitic shales and arkoses and are best developed in the Copley - Witchelina locality though they occur at intervals as far south as near Adelaide.

The origin of magnesite in the Adelaide System has been most recently discussed by Forbes (1961) who infers that it formed in areas of shallow water marginal to the sea and the Montacute Dolomite as a whole to have been deposited under paralic conditions - the magnesium carbonate being deposited by alkaline waters of continental origin reacting with sea water. He suggests that these sediments were then subject to periods of subaerial exposure, erosion and redeposition in deeper water, thus accounting for their conglomerate structure and associated polygonal cracking. Natural precipitation of magnesium carbonate from present day saline waters is established but they are at present of non-commercial interest.

Sea water and natural brines are important sources of magnesia overseas - normal sea water contains the equivalent of 0.2% MgO. In the recovery processes, magnesium hydroxide is precipitated by lime or calcined dolomite. The hydroxide is then calcined for the market.

In order of antiquity South Australian deposits are discussed in more detail below:

(1) Pre-Proterozoic Magnesites

(a) Eyre Peninsula

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Magnesite occurs at a number of separate localities in association with graphite within the Hutchison Series near Tumby Bay and in the Cleve Uplands, the main deposits being situated in secs. 33 and 42, Hd. of Stokes and sec. 178, Hd. of Koppio.

High grade snow-white dense cryptocrystalline magnesite containing up to 99.50% $MgCO_3$ occurs in narrow elongate lenses up to 5 ft. in width in association with quartz, haematite and graphite. Small tonnages have been mined by means of shallow shafts and trenches but they are all of limited size and quite unimportant.

Typical analyses are as follow:

Locality	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
Hd. Stokes, sec. 6B	0.43-1.93	87.30-96.72	1.00-5.56	0.20-0.96	0.57-2.13
Hd. Hutchison, sec. 27	0.23-4.46	89.91-97.35	1.30-2.50	0.31-0.80	0.72-0.97
Hd. Yaranyacka, sec. 42	0.23	97.25	1.90	0.11	0.62

(2) Proterozoic Magnesites

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(a) Central Region

The presence of thin but distinct and highly siliceous magnesite horizons within the Montacute Dolomite in the Torrens Gorge area was first noted by Sprigg (1946) who pointed out the gradation to obvious intraformational breccias and conglomerates. A sample from this locality (locality 6, fig. 29) showed the following on analysis:

$CaCO_3$%	$MgCO_3$%	SiO_2%
6.5	72.0	21.6

The equivalent member in the Riverton-Auburn locality carries little or no magnesite (Wilson, 1952). A sample taken by him from Hd. Upper Wakefield, sec. 68, 5 miles north west of Rhynie showed:

$CaCO_3$	$MgCO_3$	SiO_2
14.66	71.54	11.58

At the Emu Flat copper mine (Hd. Clare, secs. 1995 and 1976) magnesite occurs in dolomite and in 1929 production amounted to 95 tons.

Near Saddleworth (sec. 420, Hd. Saddleworth) magnesite occurs within Torrensian dolomites. Winton (1929) reported that the magnesite exposed in a road metal quarry was white but occasionally iron stained and was mainly earthy in texture. Both hard and soft ore occurs, the thickest seam exposed being 18 inches in width. Production at that time amounted to 80 tons with reserves apparently small. Representative samples showed the following:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
1	19.14	72.63	9.74	0.44	0.18
2	27.80	65.36	6.30	0.30	0.04

Magnesite deposits near Robertstown, 74 miles north east of Adelaide are confined to Torrensian dolomites and extend from two miles north of Robertstown a distance of 10 miles to the northwest in Hd. Bright, secs. 20, 21W etc. The magnesite, first worked in 1916, occurs in more or less isolated, shallow and lenticular lenses, the maximum recorded size being 30 ft. x 800 ft. The mineral ranges from masses of hard, dense, pure white magnesite with conchoidal fracture to soft powdery material (Winton, 1929). Although some of the magnesite is of good grade, much of it has a high lime and iron content. Production from this district amounts to 5,250 tons; there has been no mining activity since 1953. Samples from these deposits show the following:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3, Al_2O_3
1	1.89	95.15	1.52	1.22
2	7.18	46.64	40.52	4.58
3	0.91	92.08	1.50	0.48
4	15.89	81.51	2.04	1.10

On Bundaleer Creek (4 miles north of Bundaleer Reservoir) weathered conglomeratic magnesite has been noted as occurring in massive dark blue and grey dolomite (Forbes, 1955).

(b) <u>Flinders Ranges</u>

(i) <u>Port Germein Gorge</u> -(locality 14, fig. 15)

Geological features, partial analyses and workings have been described in detail by King (1956). The exposures in and near Port Germein Gorge are leased by the Broken Hill Pty. Co. Ltd. and small tonnages of ore have been produced during the years 1946-1956 for refractory usage. The main workings are on sec. 216, Hd. Wongyana while some surface material has been produced from open workings in secs. 221 and 264; the leases extend beyond the boundaries of this hundred into Hds. Baroota and Telowie.

Magnesite beds are enclosed by dolomitic slates, cherts, quartzites and dolomites of the Torrensian Series, the main magnesite horizon being 1,200 ft. stratigraphically above the Thick Quartzite and traceable round the nose of a northerly pitching anticlinal structure north of the gorge.

The western limb of this structure is truncated by faulting which determines the Pirie-Torrens Sunklands. However the magnesite bearing rocks occupying the eastern limb of this structure are traceable southwards. The magnesite horizon is not easily traceable because of poor outcrop conditions but these beds are repeated along the axis of a tight synclinal fold along Beetaloo Valley to near Crystal Brook.

King (op. cit.) has described the magnesite beds as being only a few feet wide - the best grade material being confined to a bed of massive pale grey magnesite varying in thickness from 3 to 4 ft. and separated from a similar bed of 1-2 ft. thickness by about 1 ft. of impure magnesite and chert.

The leases were first pegged by the B.H.P. Co. Ltd. in 1944. Costeans were sunk to procure samples for analysis, three diamond drillholes intersected the beds in the most favourably situated locality and in the years 1947-1950 ore (totalling 1256 tons) was shipped to Newcastle for trial as a refractory in their steel furnaces. The ore was produced from shallow open cut workings and from shallow underground workings comprising an adit which connected with an inclined shaft, and stoping.

Sampling indicated that the beds are of a consistently high grade with a tendency for the superficially weathered material to be slightly purer due to preferential leaching of calcium.

A shipment of 793 tons taken from the open workings south of the gorge showed the following:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	MnO
1.95	91.38	4.65	0.79	0.93	0.06

Samples cut from the main magnesite beds exposed in underground workings showed the following ranges of content:

$CaCO_3$%	$MgCO_3$%	SiO_2%
0.9 to 10.35	64.8 to 96.2	1.6 to 8.2

The calculated average composition of the main bed intersected in boreholes 1 and 2 is:

Drillhole No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3
1	0.87	97.44	2.28	0.44
2	1.13	97.53	2.12	0.43

Part of the southward extension of the Port Germein gorge beds were leased by the B.H.P. Co. Ltd. during the years 1915-1919 when 37 tons of magnesite were produced from a deposit situated in sec. 184, Hd. Howe, ¾mile north east Beetaloo H.S. and 14 miles east of Port Pirie (General Notes, 1915) - (locality 16, fig. 15).

East of Crystal Brook (locality 17, fig. 15) a soft friable bed of magnesite (15 inches thick) occurs in dolomite breccias, shales, cherts, and quartzites (Shepherd, 1954). Four samples taken from shallow excavations in secs. 735 and 736, Hd. Crystal Brook showed the following on analysis:

Sample No.	Width (inches)	$CaCO_3$	$MgCO_3$	SiO_2
1, sec. 735	15	1.9	95.3	2.4
2, sec. 736	12	7.7	83.8	6.9
3, sec. "	12	11.7	83.7	4.3
4, sec. "	18	25.1	62.6	10.5

(ii) Mundallio (locality 12, fig. 15)

Sedimentary magnesite beds similar to the above have been mined on Mundallio station, 12 to 18 miles east and north east of Port Augusta where they extend from near Saltia northwards some ten miles. The larger proportion of the outcrops (in Hds. Davenport and Crozier) are leased by the B.H.P. Co. Ltd. but remain undeveloped. Additional claims to the south of these (in Hd. Davenport) are held; from these small tonnages of magnesite have been mined for manufacturing chemists in Adelaide.

The magnesite succession was recorded in some detail by Mawson (1947). Attention to the magnesite deposits was given by Armstrong (1940) and in more detail by King (1956). Results of metallurgical investigation into the manufacture of sorel cement from this material were reported by Jackson (1956).

The magnesites occur interbedded with dolomite shale, dolomite, chert and thin quartzites and are clearly a continuation of the same beds that are worked near Port Germein - they strike regularly in a north-south direction and dip steeply to the east (50^o - 60^o). Magnesite has been prospected in several different seams, but the main workings are located along a bed measuring 2 to 3ft. 6 ins. thick (the main bed) which can be traced in suboutcrop over the whole length of the leases.

Production, dating from 1940 to 1953 totals 2423 tons, and is almost wholly from claims in Hd. Davenport. The ore has been raised from the main bed of hard and massive grey-white magnesite from shallow open trenches along the outcrops and adits. At the southern most workings stoping above the back of the adit has broken through to the surface.

Samples taken show the following contents:

$CaCO_3$%	$MgCO_3$%	SiO_2%	Fe_2O_3%	Al_2O_3%
0.11 - 4.08	85.8 - 98.3	1.00 - 6.00	0.12 - 0.60	0.01 - 0.20

(iii) Johnburgh Region - (Locality 19, fig. 15)

Magnesite deposits situated in sec. 119, Hd. Oladdie, 2½ miles northwest of Johnburgh were first recorded by Winton (1925) and later by Segnit (1940). A number of beds of magnesite ranging from 6 to 48 inches in width have been exposed in shallow trenches where they occur in a series of alternating quartzites, slates and dolomites near the axis of a north-pitching anticline. The beds, though disturbed by faulting, dip in a north easterly direction at 40^o-70^o. The ore has been exposed to a depth of only 10 ft. where it is soft, siliceous and contains a high proportion of alumina and lime. Production amounts to 200 tons.

Samples taken from the various beds show the following ranges of composition:

$CaCO_3$%	$MgCO_3$%	SiO_2%	Fe_2O_3%	Al_2O_3%
1.9 - 10.7	66.9 - 91.0	6.1 - 13.8	0.4 - 0.6	1.4 - 6.2

Further west in sec. 86, Hd. Eurelia (4½ miles south of Carrieton) (locality 20, fig. 15), a thin irregularly distributed occurrence of magnesite has been recorded (Segnit, op. cit.). There has been no development. Available analyses show:

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	$Fe_2O_3.Al_2O_3$
1	21.67	70.50	n.d.	1.82
2	4.86	78.55	n.d.	0.56

At a distance of 3½ miles north west from Paratoo R.S. in secs. 100, 134, 135, 99 and 139, Hd. Paratoo magnesite has been mined from a series of shallow pits (Cornelius, 1934). Analyses of the material showed the following:

Sample No.	$CaCO_3$%	$MgCO_3$%	SiO_2%	Fe_2O_3%	Al_2O_3%
1	1.97	96.65	0.52	0.14	0.78
2	3.00	93.38	0.12	n.d.	0.12
3	6.52	91.29	0.24	n.d.	1.12
4	22.72	65.21	0.32	n.d.	1.44

Recorded production in the period 1921-1945 amounted to 692 tons.

East of Hawker, in the Mount Plantagenet area near Yednalue H.S. (near Locality 11, fig. 15) Spry (1952) has described the Adelaide System succession which includes the magnesitic horizons. The magnesite is distributed through the lower 1,400 ft. of the Montacute Dolomite formation as beds of a foot or two in thickness, although a bed of impure pellet magnesite 12 ft. thick was observed. The sequence shows a poorly developed cyclic form with a large number of thin dolomite, shale, magnesite and grit beds. The magnesite occurs in beds entirely composed of white cryptocrystalline material or as pellet conglomerates; a sample of the latter analysed:

$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3, Al_2O_3
3.5	83.2	6.1	3.5

(iv) <u>Copley Region</u> (Locality 5, fig. 15)

Magnesite beds are particularly well exposed in this area extending from a point about 3 miles south west of Copley in a north westerly direction continuously with little change in thickness or facies a distance of some 17 miles. The deposits were first reported in 1918 but were little worked until 1947 when two diamond drill holes were completed. F. H. Faulding & Co. Ltd. pegged claims in 1941 and they have been consistent producers since that time. The crude magnesite is calcined and processed in Adelaide to magnesium sulphate - the bulk of the Australian chemical requirements being supplied from this source.

Production from 1926 - 1960 amounts to 7,688 tons. For the past ten years the annual production has ranged from 200 - 800 tons.

The stratigraphic succession was first recognised by Mawson (1941) and mapped by Parkin and King (1952 a and b). Extensions of the magnesite deposits near Witchelina have been recorded by Johns (1956, 1958, 1960) and at Mt. NorWest by Forbes (1955). The main working area near Copley has been reported by Segnit (1940) and more recently by Parkin (1947, 1949).

A costean cut across the deposits exposed 30 seams of magnesite varying in thickness from a few inches to 4 ft. and variable from white pulveralent powder to dense hard blue grey rock, nodular in parts. The beds dip north easterly at 60^{o}-80^{o}.

Much of the ore marketed has been collected by hand from the surface of the ground adjacent to the outcrops. Shallow trenches along the outcrop and quarries have provided a considerable quantity from the main workings near Copley. Some production has been recorded from the Myrtle Springs locality, east of Leigh Creek Coalfield. Three prominent beds south of Witchelina, one of which attains a thickness of over 10 ft. have not been exploited because of the long haulage involved to rail at Farina.

The surface material in general has been found to contain about 90% $MgCO_3$ but diamond drilling showed an increase in lime content with depth. Analyses of samples taken from costeans and drill holes showed the following ranges of composition with averages of 38 samples below:

$CaCO_3$%	$MgCO_3$%	SiO_2%
1.8 - 1.34	62.8 - 94.1	5.0 - 20.0
average 5.5	81.1	13.1

A parcel of 861 tons showed on analysis the following:

$CaCO_3$	$MgCO_3$	SiO_2, Al_2O_3, Fe_2O_3
4.7	92.1	5.9

The Copley area provides the greatest reserve of magnesite in the State because of number of beds present, their width and their extent. As with the Mundallio and Port Germein localities which are of the same type no specific ore reserve appraisement has been made though it is obvious from surface indications and the limited amount of mining and drilling that has been undertaken that reserves of +90% $MgCO_3$ ore are considerable. The comparative thinness of the magnesite beds and the need for some degree of selectivity in mining to obtain the highest grade material are factors not conducive to cheap mining.

(v) Balcanoona (Locality 4, fig. 15)

A deposit of magnesite situated 8 miles west of Balcanoona H.S. and 70 miles by road easterly from Copley was first recorded by Johns (1957) and later by Nixon (1959). A claim is now held by the Broken Hill Pty. Co. Ltd. who quarried a 650 ton shipment for trial at the Newcastle steelworks.

The deposit is unlike those previously described belonging to the Torrensian Montacute Dolomite formation. Here, a large irregular body of crystalline magnesite occurs as a replacement in dolomite adjacent to a zone of faulting - the dolomite lies above the Sturtian Series and is probably the Brighton Limestone equivalent.

Analyses 1 to 4 below are grab samples of magnesite while No. 5 refers to a 650 ton sample taken by the B.H.P. Co. Ltd.

Sample No.	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
1	0.6	97.9	n.d.	n.d.	n.d.
2	0.9	98.1	n.d.	n.d.	n.d.
3	1.8	93.3	2.64	1.18	n.d.
4	2.5	94.3	1.66	1.31	1.43
5	0.75	95.68	0.76	1.80	0.54

(3) Cambrian Magnesites

(a) Yorke Peninsula

Old workings in sections 375 and 383, Hd. Clinton, 3 miles north west of Clinton township have exposed pockets of magnesite within Cambrian dolomitic limestones (locality 5, fig. 34). Analyses of four samples taken from here showed the following:

Sample	$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3) Al_2O_3)
1	1.46	97.66	0.66	0.30
2	0.96	97.02	0.98	1.26
3	2.82	96.00	0.76	0.22
4	5.07	89.80	4.20	1.02

(4) Modern Magnesites

The precipitation of magnesite in the Upper South East in at least one lagoon near the Corrong is currently under investigation (Von der Borch, C. - personal communication) but these deposits are of no present economic worth.

R. K. Johns,
Senior Geologist
Non Metallic Section

RKJ:CERF
16/1/62

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N. 11787
Hd. Yankalilla

Slide 984

I. Aerial view looking north over Rapid Bay quarry, loading installations and township.

N. 8580
Hd. Yankalilla

II. Rapid Bay quarry.

Slide 1818

N 11788 Hd. Willunga

III. Diamond drilling operations south of River Onkaparinga near Noarlunga.

N.11789

Slide 1831

IV. Quarry in pink marble for production of dimension stone, Hd. Moorooroo, Sec. ~~422~~ 113.

N.4387
Hd. Moorooroo

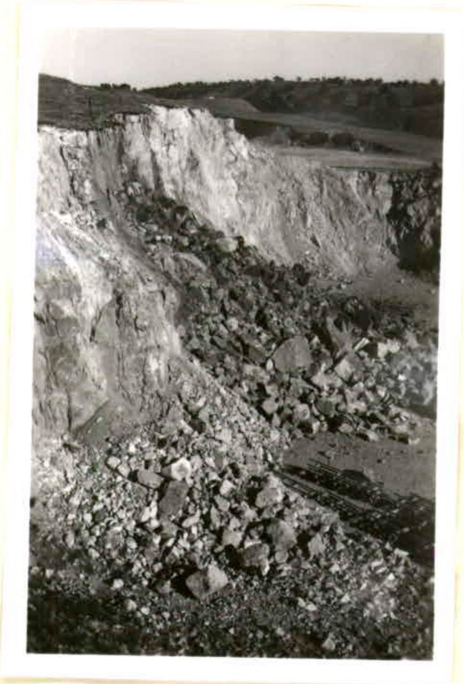
V. Stockwell marble quarry.

N.11790

Slide
1357

HD MOOROOROO

VI. Quarry operations, I.C.I., Penrice.



N. 6452
Hd. Moorooroo

VII. Quarry operations, S.A.P.C.Co., Angaston

VIII. Production of dimension stone, Sec. 339, Hd. Moorooroo.

N. 186 Hd. Moorooroo

N.11792
HD.CURRAMULKA
SLIDE 1954

IX. Curramulka limestone quarry.

N.1179
Grid J.5
Slide 2070

X. Cambrian limestone deposits, Aroona Valley. Limestones outcrop in foreground. Mt. Scott is high ridge in background.

HD. NILPENA
N. 11793
SLIDE 1244

XI. Flinders Ranges, east of Parachilna. Cambrian limestones outcrop in the foothills of the main range.

N. 11502
Hd. Blanche

N. 11494
Hd. Blanche

XII & XIII. Mt. Gambier limestone quarry. Dimension stone being cut directly from the face and floor of the quarry.

N.11796 HD. NARACOORTE

XIV. James quarry, Naracoorte.

N.10611
Hd. Waikerie

XV. Blakes quarry, Waikerie.

HD. MOBILONG
N. 11797
SLIDE 2078

XVI. Murray Bridge limestone quarry, east side of River Murray.

HD. DALRYMPLE
N. 11798
SLIDE 2062

XVII. Adelaide Cement Co. quarry at Klein Point, looking north.

HD. DALRYMPLE
N. 11799

XVIII. Adelaide Cement Co. quarry at Klein Point, looking south.

N. 272 Grid A.6

XIX. Wilson Bluff, looking east along coastal cliffs of the Nullarbor Plain.

XX. Koonalda Cave, Nullarbor Plain.

XXI. Kulpara lime kilns. SLIDE 1356

N. 11800 H.D. KULPARA

Hd. Kilkerran

XXII. Loading calcareous sand, Wardang Island.

N. 11801

HD. LAKE WANGARY

XXIII. Coffin Bay calcareous sand deposits.

HD. CUNNINGHAM. N.11802 SLIDE 1944

XXIV. Dolomite quarry, B.H.P. Co., Ardrossan.

N. 11534

Hd. Hindmarsh

XXV. Up and Down Rocks, quarry, Tantanoola.

HD. TELOWIE

N. 11803

XXVI. Exploratory adit, Port Germein gorge magnesite deposits.

N. 11804

HD. DAVENPORT

XXVII. Open workings on outcrop of main magnesite bed, Mundallio.

N. 11805

HD. DAVENPORT

XXVIII. Adit, Mundallio magnesite deposits.

GRID J.5

N. 11806

SLIDE 1003

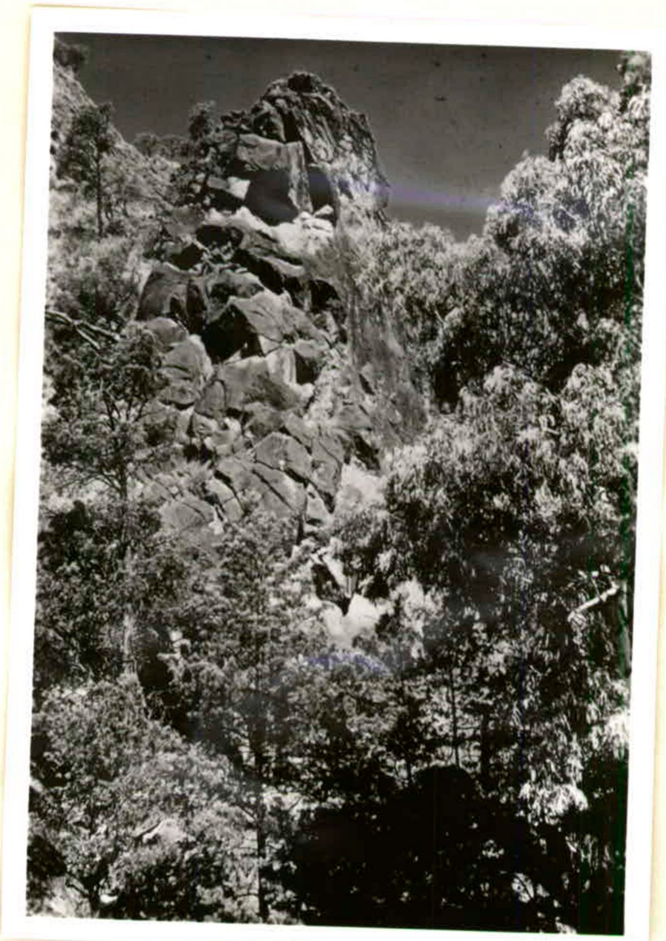
XXIX. Myrtle Springs magnesite deposits.

J. 5

N. 11794

Slide 1000

XXX. Magnesite conglomerate.



K. 5

N. 11425

Slide 1180

XXXI. Massive magnesite, Balcanoona.