DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

Rept. Bk. No. 89/52

THE FLINT REPORT

GEOLOGICAL SURVEY

by

D.J. FLINT
Senior Geologist
Mineral Resources Branch

R.B. FLINT
Senior Geologist
Regional Geology Branch

M.W. FLINTOFT
Technical Assistant
Mineral Resources Branch

May, 1989

DME 50/85

A00073

CONTENTS Page No:

TABLES

FIGURES

Fig No:	Title:	Plan No:
1.	Locality plan	S 20963
2.	Site and sample locality plan: Cape Banks to Nene Valley	89-267
3.	Site and sample locality plan: Douglas Point to French Point	89-268
4.	Site and sample locality plan: Racecourse Bay to Victorian border	89-269
5.	SiO_2 v (CaO + MgO)	S 20964
6.	Form types of European flint	S 20965

PLATES

Plate No:	Title:	Photo No:
1.	Flint bed and irregular concretion in Gambier Limestone.	38 133
2.	Flint bed with protuberances in Gambier limestone.	38 134
3.	Flint within joints in Gambier Limestone.	38 135
4.	Flint within joints in Gambier Limestone.	38 136
5.	Zoned flint within joints, Gambier Limestone.	38 137
6.	Conglomerate (Bridgewater Formation).	38 138
7.	Massive, boulder conglomerate (Bridgewater Formation).	38 139
8.	Bouldery conglomerate (Bridgewater Formation) overlying beds of flint within Gambier Limestone	38 140
9.	Coarse, bouldery conglomerate (Bridgewater Formation) overlying calcarenite (Bridgewater Formation)	38 141
10.	Flint boulders in soil at base of Bridgewater Formation	38 142
11.	Flint in calcarenite of Gambier Limestone reworked into beach deposits	38 143
12.	Middle Point deposit	38 144
13.	Typical grey pebbles, Blackfellows Caves.	38 145

APPENDICES

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

Rept. Bk. No. 89/52
D.M.E. No. 50/85
Disk A00073

THE FLINT REPORT

ABSTRACT

Flint occurs in four geological settings in the South East - beds and dykes in the early Miocene to late Oligocene Gambier Limestone, bouldery conglomerate of the Pleistocene Bridgewater Formation, Holocene surface lag deposits and Holocene beach deposits. Extensive beach deposits along the coast between Cape Banks and the Victorian border have been worked since 1909 with pebbles used mainly as grinding media and as a source of high-grade silica for ceramics. Additional applications are available for calcined silica, and greater use could be made of irregularly-shaped stones for ornamental purposes. The total resource along the coast is estimated at 330 000 tonnes.

Flint exhibits many local variations in size, colour, form and degree of rounding which often enables the provenance of boulders on the present beaches to be identified. Horizontal flint beds in Gambier Limestone formed from a calcareous-siliceous ooze, however, flint has also migrated into near-vertical NW-SE trending joints.

Mottled grey and black flint from Cape Hart, Kangaroo Island (formed during the late Oligocene), is found only as boulders on current beaches and can be distinguished from flint in the South East.

The flint is more appropriately classified as fossiliferous chert with a granular, cherty matrix of average grain size 0.05 mm or less. Fossil fragments consist of bryozoa, molluscs, echinoids, foraminifera and sponge spicules. All show variable overgrowths of and replacement by dolomite, fibrous chalcedony and granular chert.

High-grade samples from several localities, including Kangaroo Island, have chemical analyses approaching the flint produced from the Northfleet Plant, U.K. for ceramic use.

INTRODUCTION

The importance of flint has long been recognised and well-formed flint arrowheads, estimated at 40 000 - 50 000 years old, have been found in both the Sahara Desert and France (Beasley, 1984).

In Australia, Aboriginal flint artefacts have been found in coastal sites as far east as Wilsons Promontory but increase in abundance towards the South Australian border and date back at least to 5000 BP (Coutts, 1982). A few fragments of dark blue-grey flint have been excavated at Roonka in a site which dates from about 7000 BP (Pretty, 1977). Artefacts and a hand axe from near Kongorong have been dated by radiocarbon dating of charcoal in campfires at 6500 - 7000 BP (Beasley, 1984). In overseas archaeological investigations, detailed trace element geochemistry is available on English, Dutch and Belgian flints to trace the distribution patterns of Neolithic man. No such data appear available to trace the artefacts in South Australia and Victoria.

Modern interest in the South Australian deposits stems from around 1909, with peak activity during World War I & II. During World War I, peak production has been estimated at 2800 tonnes in one year with employment of at least 12 people. Since before 1910, flint pebbles for ball mills have been and continue to be imported into Australia. Therefore the local industry has considerable potential for expansion in the area of import-replacement in addition to other uses such as ornamental stone, sauna stones, aquarium stone, milling in the paint industry and high-grade silica for ceramics, glazing, porcelain and metallurgical applications.

Field work on flint deposits in the South East were conducted by D.J. Flint and M.W. Flintoft on 10-12 and 14 May 1984, accompanied on 10 May by J.G. Olliver (the then Chief Geologist, Mineral Resources Branch) and L.C. Barnes (the then Principal Geologist - Industrial Minerals, Mineral Resources Branch). Discussions were held with B.J. (Jack) Pascoe in Port MacDonnell on 10 May 1984 and 6 March 1985. Flint deposits in both Gambier Limestone and on the seaward side of Bridgewater Formation beach ridges were mapped in February and March 1985 during investigations of Gambier Limestone and production of ashlars (Flint, 1988). Details of occurrences in the Mount Gambier - Marte areas are not incorporated in this report. Representative samples from the mapping programs were submitted to the Australian Mineral Development Laboratories (AMDEL) for petrographic description (Appendix A) and chemical analysis (Appendix B) i.e. samples 6922 RS 52-62, 7021 RS 31-35 and A13/85 - A19/85.

Subsequent to the initial fieldwork in the South East, the authors were informed by Lyn Smith of Buckleboo in June 1984 of an additional flint occurrence on beaches of the south coast of Kangaroo Island; 6-8 boulders had been found. Samples were supplied by Lyn Smith and additional samples were collected from Point Hart (i.e. 6256 RS 21-24) by R.B. Flint and D.J. Flint in August/September 1984. Flint from Kangaroo Island had not previously been recorded in the geological literature though Aboriginal artefacts of flint had been found on Kangaroo Island.

BACKGROUND

The scientific literature on flint and chert is extensive and difficult to summarise. There have been four international symposia devoted to flint, the first of which was held in 1969 and the fourth in Brighton, England in 1983 (Sieveking and Hart, 1986). The majority of papers have a strong archaeological bias, concentrating on the use of flint by Palaeolithic and Neolithic man and with flint derived from the Cretaceous chalks of Europe.

In the U.K., flint has been used for centuries with well known examples of Grime's Graves in East Anglia (3200 BC) and Eastern Down in Dorset (2500 BC) (Clarke, 1963; Green, 1977; Anon., 1979).

The Bible also contains several references to flint.

a) 'Take heed lest you forget the LORD your God'.... 'who led you through the great and terrible wilderness, with its fiery serpents and scorpions and thirsty ground where there was no water, who brought you water out of the flinty rock'. (Deuteronomy, 8: 11 & 15).

b) 'Tremble, O earth, at the presence of the LORD,
at the presence of the God of Jacob,
who turns the rock into a pool of water,
the flint into a spring of water' (Psalms, 114: 7 & 8).

c) 'He will raise a signal for a nation afar off,'...
'their arrows are sharp,
all their bows bent,
their horses hoofs seem like flint,
and their wheels like the whirlwind' (Isaiah, 5: 26 & 28).

d) 'For the Lord God helps me;
therefore I have not been confounded;
therefore I have set my face like a flint,
and I know that I shall not be put to shame! (Isaiah, 50:7).

Although the early uses were for tools, weapons and striking sparks to light fires it was the Romans in about the mid 2nd Century A.D. that introduced the technique of constructing mortared walls with stone. Buildings with flint are extensive in Norfolk and are reviewed in Orna and Orna (1984). Other reviews (Anon. 1981 and Anon., 1983) discuss the various methods of flint stonewalling - randomly used cobbles, knapped cobbles, knapped but random shapes and laid so that pieces interlock and knapped blocks i.e. squared to dimensions in the range 60-150 mm with knapped faces. Flint for ornamental use was still available in 1981 from suppliers in Norfolk, Suffolk and Essex. Knapped flint displays facing colours of grey, grey-black, black, reddish and with milky patches and various inclusions.

A more extensive review of English flint discusses flint mining, knapping, flint glass, use in pottery, buildings, roads and flintlock guns (Mason, 1978). In Queen Victoria's reign, about 800 000 tons of flints were used annually in the potteries. Not only did the calcined flint act as a whitening

agent but the 'body' of the clay was stiffer and easier to work. In addition, flat articles such as tiles did not warp.

At Swanscombe in Kent, the Blue Circle Group operates a 80 000 tonne per annum flint plant which mainly supplies the U.K. ceramic industry and reduces dependence on imports from France (Anon., 1975). The flint plant is only viable as an adjunct to mining huge quantities of host chalk for cement plants at Northfleet and Swanscombe - consuming about 6mt of chalk per year. Chalk and flint are tumbled and milled together in washing drums - the flint nodules effectively contributing to the initial milling. Final stage of the separation involves dropping the pebbles past cameras which measure colour and reflectivity of each particle. Unwanted flints are deflected by a jet of air. Depending on particle size, particles can be inspected at the rate of 15-40 per second corresponding to 5-25 tonnes/hour.

Locally, flint is also sought by gem collectors for its variety of colours, including very rare blues and greens. Some samples contain pyrite and/or marcasite which polish attractively. Clear grey translucent veinlets of flint are found within pebbles of brown and grey flint on the north side of Bucks Bay i.e. at Carpenter Rocks whereas greenish flint is reported from the south side of Bucks Bay (M. Sheard, SADME, pers. comm., 1984). 'Swirling' multi-coloured flint is also reported to have been found on the south shores of Lake Bonney. Some of the flint from Northern England and ?other parts of Europe displays reddish tints but this has apparently not been recorded from South Australia.

Flint is Ohio's official gemstone.

PREVIOUS INVESTIGATIONS

Previous investigations are limited and the most comprehensive summary of the local industry is Willington (1956). Other uncompiled SADME summaries with production data, chemical analyses and calcining tests are Jackson (1954) and Hiern (1974) (Appendix C and D respectively).

Brief notes and comments on the flint industry and deposits were provided by Anon. (1911), Anon. (1923), Ward (1949) and Ludbrook (1980). Sprigg (1952) recorded flint debris as ejecta at the volcanic core of Mount Gambier.

During investigations for the Department of Marine and Harbours, Pain (1971) examined possible sources of materials for construction of the Port MacDonnell Breakwater, including flint. The current survey has shown that large boulders of flint, weighing in excess of 1 tonne, are found along the beaches but are most common at Douglas Point, 11km W-NW of Port MacDonnell.

Pebbles were produced as a by-product from the Longwood clay deposit which was reviewed by Olliver and Nichol (1978). Watkins (1978) assessed possible sources of sauna stones in South Australia, including flint pebbles.

Keeling (1982) reviewed South Australian sources of high-grade lump silica, including flint from the South East. However, chemical analyses of pebbles revealed an average silica content of only 90% with high iron of 1.23% Fe_2O_3 (total iron expressed as Fe_2O_3) hence pebbles failed to meet all specifications.

Burden (1987) prepared a bibliography of flint to aid this current study. A total of 173 references were obtained which are predominantly post-1973 and which concentrate on flint rather than chert but do exhibit the bias in the scientific literature towards archaeological studies on the use of flint by Palaeolithic and Neolithic man. The bibliography was compiled to identify other uses for the South Australian deposits, to review the genesis of flint deposits around the world and to collate additional physical and chemical data for comparative purposes.

MINERAL TENURE

Mineral tenure, (Table 1) is based on Departmental records and may be incomplete. Location, size and shape of the early tenements are based on information supplied by the tenement holder and may not be accurate.

A total of 122 tenements have been pegged for flint in the lower South East and all but six have been Mineral Claims (MCs). Five of the six Mineral Leases (MLs) are still in existence (i.e. MLs 2638 and 2862 - 2865) and have been current since 1945.

Only three claims remain unlocated after a search of available Departmental records. All other tenements have been grouped according to major place names along the coast. Table 1 lists tenements at those places starting in the northwest at Carpenter Rocks and progressing southeast and eastwards to Pelican Point, Blackfellows Caves, Douglas Point, Umpherstone Bay, Middle Point, Blanche Bay, Cape Northumberland, Orwell Rocks, French Point and Stony Point.

The first Mineral Claims (MCs 8770 - 8777) were registered by R. Broadbent on 23 June 1909 and covered flint deposits at Douglas Point, Middle Point, Cape Northumberland and Stony Point. Shortly afterwards on 2 July 1909, two further claims (MC 8778 and MC 8779) were registered at Orwell Rocks and French Point.

A series of claims (MCs 8786 - 8792) at Carpenter Rocks and Blackfellows Caves were registered by E.A. Gerloff on 29 July 1909. Further claims at Carpenter Rocks (MCs 8806, 8807) were registered by T. Haigh on 21 August 1909. All claims held by E.A. Gerloff were transferred on 21 January 1910 to Cape Banks Flint Company No Liability of which, E.A. Gerloff was one of the directors.

B.B. Pascoe first registered claims (MCs 8808 - 8810) at Douglas Point on 20 August 1909. In September, he lodged a plaint against R. Broadbent for MCs 8772 - 8774 at Middle Point alleging noncompliance with Regulations 117 and 123 of the Mining Act, 1893 as amended. The plaint was settled out of court and MC 8773 was later repegged and registered to S.A. Pascoe as MC 9142 on 14 August 1911.

All tenements have been pegged along the modern day coast except two pegged in 1918 by J.E. Feast in hundred Caroline, Block 609. Other inland flint occurrences are widespread and many have been worked for aggregate and road sub-base material but no tenements are recorded. Local government has access to the deposits under the Local Government Act and do not require a tenement under the Mining Act. Such occurrences include:

1. The Bluff - hundred Hindmarsh, section 455 (21 km NW of Mount Gambier.

2. Hundred Kongorong, section 465 (5 km NW of Kongorong).

Two-thirds of all tenements have been for a short duration and were cancelled for non-renewal of the related Miners' Right. Often the ground was immediately repegged and a new claim registered. Where known, this information is included in Table 1. Despite the large number of short-duration claims, nine tenements have a duration of 25 years or more. The largest continuous tenure, and which is still current, is MC 13715 converted to ML 2638 which was registered on 1 July 1932. All of the longstanding tenements have been held by W.H, C.B. & B.J. Pascoe and are summarised in Table 2 which includes all of the current tenements.

Other so-called flint workings are known in South Australia. The Oodlawirra flint workings (hundred Coglin) are poorly recorded with no apparent tenure and production data the only record being an un-dated photo (N.P. 102).

Pebbles and boulders of 'flint' were also obtained as a by-product at the Longwood clay deposit located in hundred Noarlunga, sections 326-328 and 331-333. The deposit was held by Bradbury Industries as MC 2754 (Olliver and Nichol, 1978).

Pebbles and boulders of 'flint' (actually quartzite) were also recovered from Sellicks Beach (hd. Willunga) especially during and after World War II. Apparently, the only recorded tenement was MC 9647, held by J.S. Heithersay, which was applied for on 1st October 1913. The claim was transferred on 4th April 1924 to ML 2470 which expired on 31st March 1945. Mining returns were provided until 1964.

TABLE 1

Tenement	Holder	Registered	Area (hectares)	Termination	Comments
CARPENTER ROCKS (from Cape Banks to Bungaloo Bay)					
MC 8896	E.A. Gerloff	29-7-09	8		Transferred to Cape Banks Flint Co. N/L.
"	Cape Banks Flint Company N/L	21-1-10	"	17-12-12	
MC 8787	E.A. Gerloff	29-7-09	5		Transferred to Cape Banks Flint Co. N/L.
"	Cape Banks Flint Co. N/L	21-1-10	"	17-12-12	
MC 8788	E.A. Gerloff	29-7-09	5		Transferred to Cape Banks Flint Co. N/L.
"	Cape Banks Flint Co. N/L	21-1-10	"	17-12-12	
MC 8789	E.A. Gerloff	29-7-09	5		Transferred to Cape Banks Flint Co. N/L.
"	Cape Banks Flint Co. N/L	21-1-10	"	17-12-12	
MC 8806	T. Haigh	21-8-09	6		
MC 8807	"	"			
MC 9716	Cape Banks Flint Co. N/L	16-12-13	5	4-12-15	Formerly MC 8787
MC 9717	"	"	"	"	" MC 8788
MC 9718	"	"	"	"	" MC 8789
MC 10485	"	17-1-17	"	7-11-23	" MC 9716
MC 10486	"	"	"	"	" MC 9717
MC 10487	"	"	"	"	" MC 9718
MC 14552	J.T. Bird	19-5-34		22-8-36	Same locality as current ML 2864.

A00073

TABLE 1 (cont)

Tenement	Holder	Registered	Area (hectares)	Termination	Comments
MC 15616	W.H. Pascoe	12-5-37	3		Converted to ML 2864.
ML 2864		6-7-45	"		Transferred to C.B. & B.J. Pascoe.
"	C.B.&B.J. Pascoe	9-5-52	"		Current
MC 567	B.J. Pascoe	25-11-43		24-1-47	Opposite sec. 500
MC 995	"	12-2-47		13-2-64	Previously MC 567
MC 573	B.J. Pascoe	14-12-43	3.2		Converted to ML 2865
ML 2865	"	1-7-45	"		Current
MC 594	W.H. Pascoe	14-2-44	16		Transferred to C.B. & B.J. Pascoe
"	C.B.&B.J. Pascoe	25-3-52	"	20-8-69	
PELICAN POINT					
MC 568	B.J. Pascoe	25-11-43		24-1-47	opposite sec. 499
MC 994	"	12-2-47		13-2-64	Previously MC 568
MC 1191	W.H. Pascoe	8-12-47	0.8		Transferred to C.B. & B.J. Pascoe
"	C.B.& B.J. Pascoe	25-3-52	"	20-8-69	
MC 1192	W.H. Pascoe	8-12-47	0.8		Transferred to C.B. & B.J. Pascoe
"	C.B.& B.J. Pascoe	25-3-52	"	20-8-69	
BLACKFELLOWS CAVES					
MC 8790	E.A. Gerloff	29-7-09	5		Transferred to Cape Banks Flint Co. N/L; opposite sec 616.
"	Cape Banks Flint Co. N/L.	21-1-10	"	17-12-12	
MC 8791	E.A. Gerloff	29-7-09	5		Transferred to Cape Banks Flint Co. N/L; opposite sec 392.

TABLE 1 (cont)

Tenement	Holder	Registered	Area (hectares)	Termination	Comments
"	Cape Banks Flint	21-1-10	"	17-12-12	
MC 8792	E.A. Gerloff	29-7-09	"		Transferred to Cape Banks Flint Co. N/L; opposite sec 391.
"	Cape Banks Flint Co. N/L	21-1-10	"	17-12-12	
MC 9719	"	16-12-13	16	4-12-15	Formerly MC 8790
MC 9720	"	"	"	"	"MC 8791
MC 9721	"	"	"	"	"MC 8792
MC 10488	"	17-1-17	"	7-11-23	Adjoins MC 10489
MC 10489	"		"	"	"MC 10488
MC 10951	H. Wilke	13-8-18	5		Opposite sections 391 & 392.
MC 13217	H.L.C. Cotton	27-2-31	4		Repegged as MC 13629
MC 13269	" "	16-3-32	"		Converted to ML 2633.
ML 2633	" "	1-10-32	"	4-10-35	Repegged as MC 15265.
MC 13719	W.H. Pascoe	8-7-32	1.2		Converted to ML 2862
ML 2862	"	6-7-45	"		Transferred to C.B. & B.J. Pascoe
"	C.B.& B.J. Pascoe	9-5-52	"		Current.
MC 13720	W.H. Pascoe	8-7-32			
MC 14443	P.A. Jackway	13-2-34	1.6	24-2-36	
MC 15265	W.H. Pascoe	20-11-35	2		Previously ML 2633; converted to ML 2863.
ML 2863	"	1-7-45	"		Transferred to C.B. & B.J. Pascoe.
"	C.B.& B.J. Pascoe	9-5-52	"		Current.
MC 997	W.H. Pascoe	17-2-47	16		Transferred to C.B. & B.J. Pascoe.

TABLE 1 (cont)

Tenement	Holder	Registered	Area (hectares)	Termination	Comments
"	C.B.& B.J. Pascoe	25-3-52	"	20-8-69	
MC 998	W.H. Pascoe	17-2-47	"		Transferred to C.B. & B.J. Pascoe.
"	C.B.& B.J. Pascoe	25-3-52	"	20-8-69	
DOUGLAS POINT					
MC 8770	R. Broadbent	23-6-09	2		
MC 8771	"	23-6-09	"		
MC 8808	B.B. Pascoe	20-8-09	4.9	19-8-16	
MC 8809		"		"	"19-8-16
MC 8810		"		"	"20-12-18
MC 9135	S.A. Pascoe	11-7-11	16	5-8-16	Formerly MC 8770
MC 9136	"	"	"	"	"MC 8771
MC 10665	"	27-8-17	8	9-2-27	Opposite sec 347
MC 10892	"	13-7-18	16	19-7-26	
MC 10893	"	"	"	"	
MC 11072	"	9-1-19	"	9-2-27	Formerly MC 8810
MC 13300	W.H. Pascoe	3-7-31	1		
MC 13815	"	31-10-32	2.4	14-11-35	
MC 15236	"	8-11-35	"	3-2-37	Previously MC 13815
MC 15520	"	16-1-37	"		Previously MC 15236; transferred to C.B. & B.J. Pascoe
"	C.B & B.J. Pascoe	25-3-52	"	20-8-69	
MC 821	W.H. Pascoe	12-2-46	16	11-1-52	Repegged as MC 1745
MC 822		"	"		"Repegged as MC 1744

A00073

TABLE 1 (cont)

Tenement	Holder	Registered	Area (hectares)	Termination	Comments
MC 1744	C.B.& B.J. Pascoe	14-2-52	"	20-8-69	Formerly MC 822
MC 1745		"		"	" "Formerly MC 821
UMPHERSTONE BAY					
MC 10880	W.H. Pascoe	6-6-18			On foreshore opposite sec. 343
MC 12037	"	4-4-24	1.2	28-3-25	
MIDDLE POINT					
MC 8772	R. Broadbent	23-6-9	16		
MC 8773		"		"	"
MC 8774		"		"	"
MC 9142	S.A. Pascoe	14-8-11	"		Formerly MC 8773; same locality as current ML 2638.
MC 10663	"	26-7-17	"		Opposite sec. 716 (previously Block A); Same locality as current ML 2638
MC 10837	"	7-5-18	"		Adjacent to MC 10663
MC 10925	G.A. Carrison	6-6-18	"		Repegged as MC 11647
MC 11635	S.A. Pascoe	15-6-22	2		Same ground as MC 8772
MC 11636	"	"	"		Adjacent to MC 11635.
MC 11647	G.A. Carrison	25-7-22	"		Formerly MC 10925
MC 12038	W.H. Pascoe	4-4-24	1.2	28-3-25	
MC 12573	"	23-4-25	16	8-8-29	
MC 12607	I. Southam	27-9-28	8	6-2-30	Same ground as MC 10663
MC 13227	I. Southam	25-3-31	8	13-7-32	Formerly MC 10837
MC 13228	"	"		"	Formerly MC 12607
MC 13714	W.H. Pascoe	1-7-32		15-8-33	

TABLE 1 (cont)

Tenement	Holder	Registered	Area (hectares)	Termination	Comments
MC 13715	"	"	2		Converted to ML 2638
ML 2638	"	1-1-33	"		Transferred to C.B. & B.J. Pascoe
"	C.B.& B.J. Pascoe	9-5-52	"		Current
MC 14337	W.H. Pascoe	31-10-33	16		Opposite sec 716 (previously Block A); transferred to C.B. & B.J. Pascoe)
"	C.B.& B.J. Pascoe	25-3-52	"	20-8-69	
BLANCHE BAY					
MC 10947	G.A. Carrison	16-8-18			
MC 10948	"	"			
CAPE NORTHUMBERLAND					
MC 8775	R. Broadbent	23-6-9	16		Opposite cemetery reserve.
MC 10886	A.C. Haig	15-6-18	"		
MC 10887	G.A. Carrison	"	"		
MC 12929	E.E. Williams	1-11-29	1.2	27-3-31	
MC 15926	"	31-3-38	3	2-4-40	
MC 15959	"	9-7-38	0.8	17-7-41	
ORWELL ROCKS					
MC 8779	R. Broadbent	2-7-9	16		
MC 10859	R. Wilke	13-6-18	2		Repegged as MC 11640
MC 11640	H. WILKE	27-6-22	2		Formerly MC 10859
MC 11804	E.E. Williams	13-3-23	0.1	29-4-24	Repegged as MC 12040
MC 12040	"	16-4-24	1.2	14-4-25	Formerly MC 11804
MC 12338	"	14-6-26	1.2	25-7-27	Formerly MC 12040
MC 15119	W.H. Pascoe	10-4-35	16	12-10-37	

TABLE 1 (cont)

Tenement	Holder	Registered	Area (hectares)	Termination	Comments
MC 207	E.E. Williams	1-1-41	0.8	11-4-45	
MC 208	"	"	"	"	
FRENCH POINT TO STONY POINT					
MC 8776	R. Broadbent	23-6-9	16		Repegged as MC 10664; Stony Point.
MC 8777	"	"	"		
MC 8778	"	2-7-9	"		French Point.
MC 10664	A.C. Haig	25-8-17	"		Formerly MC 8776
MC 10941	"	16-8-18			French Point
MC 10942	"	"			
MC 10943	"	"			French Point
MC 12034	W.H. Pascoe	4-4-24	1.2	5-6-25	"
MC 12035	"	"	"		"
MC 12036	"	"			2-4-25Stony Point
MC 12572	"	23-4-25	16	8-8-29	Stony Point
MC 14476	"	7-3-34	"	10-2-37	"
MC 14477	"		"		16-2-35"
MC 14624	"	17-6-34	14	14-7-39	French Point
MC 15017	"	11-2-35	16	10-2-37	"
MC 15018	"	"	"	11-8-38	"
HD CAROLINE					
MC 10874	J.E. Feast	6-7-18	16		Block 609; terminated during 1919
MC 10875	"	"	"		"

TABLE 1 (cont)

Tenement	Holder	Registered	Area (hectares)	Termination	Comments
UN-LOCATED TENEMENTS					
MC 10853	E.E. Williams	4-6-18			Hd. MacDonnell
MC 11628	G.A. Carrison	20-4-22	16		"
MC 15535	W.H. Pascoe	4-3-37		20-8-69	"

TABLE 2

CURRENT MINERAL LEASES AND
MINING TENEMENTS WITH MORE THAN 25 YEARS
CONTINUOUS TENURE

	Tenement	Locality	Registered	Cancelled	Duration (years)
1.	MC 15616 ML 2864	Carpenter Rocks	12-5-37 6-8-45	 Current	
2.	MC 573 ML 2865	Carpenter Rocks	14-12-43 1-7-45	 Current	 45
3.	MC 594	Carpenter Rocks	14-2-44	20-8-69	25
4.	MC 13719 ML 2862	Blackfellows Caves	8-7-32 6-7-45	 Current	 57
5.	MC 15265 ML 2863	Blackfellows Caves	20-11-35 1-7-45	 Current	 53
6.	MC 15520	Douglas Point	16-1-37	20-8-69	32
7.	MC 13715 ML 2638	Middle Point	1-7-32 1-1-33	 Current	 57
8.	MC 14337	Middle Point	31-10-33	20-8-69	36
9.	MC 15535	Un-located	4-3-37	20-8-69	32

PRODUCTION

A limited quantity of flint (quartzite) pebbles from Sellicks beach were shipped after World War II to Western Australia goldfields for ball-milling purposes (Willington, 1956). Mining returns were provided until 1964, revealing total production from 1946 to 1964 of 216 tonnes (Table 3).

Production of flint pebbles from the South East commenced in 1909 and total production from 1909 to 1988 is 12 939 t (Table 4). Although recorded production commenced in 1909 and coincides with the first mineral tenements, local companies were formed by the Pascoe family and date back to 1880 i.e.

- Australian True Flint Company
- Australian True Flint Pty
- W.H. Pascoe Flints Pty
- Port MacDonnell Silica Pebble Pty

Although the average production rate is 140 t/yr, peak production periods were during the two World Wars, after World War II and in the early 1970's (Table 4). Detailed production data for each area from 1909 to 1935 are shown in Table 5. After 1935, Pascoe's Mineral Leases were amalgamated and production from each site was not specified.

Higher production figures are quoted by Ward (1949) and Hiern (1974) (Appendix D) but the sources of the data are unknown. Total recorded production was apparently in excess of 17 000 t whereas this survey has estimated total production of about 13 000 t. Hiern (1974) may have included flint used for road material or aggregate from occurrences such as The Bluff, which are specifically not included in this report.

Peak production of about 2800 t/year (Hiern, 1974 and B.J. Pascoe, pers. comm., 1984) was reached during World War I when the normal supplies (i.e. Europe) of pebbles for ball mills at the South Mine and Zinc Corp. Mine at Broken Hill were cut off. At that time, about 12 people worked the deposits. Since 1951, output of pebbles declined as a result of substitution by porcelain balls in the paint industry; flint pebbles and mill liners are still imported today from England, Europe and Scandinavia.

Production data recorded by the Department does not distinguish the end product i.e. local road aggregate, mill liners, calcining (for pottery, porcelain and pure silica) and grinding balls - both in the paint and mineral milling industries.

After World War II, flint suitable for grinding pebbles and mill linings were shipped to Western Australia and New Zealand goldfields. Pebbles were also supplied to the mills at Broken Hill during both World Wars. Martha Gold Mining Co. was the main NZ market until mining operations ceased in 1951. Pebbles were also sent to the Bendigo and Ballarat goldfields in the period ?1910-1930.

Early production was hampered severely by lack of nearby port facilities and roads. Around 1910, no roads existed near some of the leases and all production had to be carted to the railway. Movement during winter was severely restricted due to widespread flooding and swampy conditions. In 1910, the Cape Banks Flint Co. N.L. had 200t stockpiled at Burrungull siding. In the period 1914-1920, pebbles were carted by horse-drawn carts through Kongorong to Mount Gambier railway siding. Most of the pebbles came from the Blackfellows Caves area, and carters stayed overnight in tents or a hut opposite the Kongorong store (Les Perkins, pers. comm., 1984). In later years, Tom Bird used his International solid-tyred truck to cart the flint pebbles although the first recorded use of a truck was by W.H. Pascoe in 1931.

In 1911 and 1912, Mineral Claims in the Douglas Point area had names such as Little Alice, Big Ben and Big Irene. At that time, flint pebbles were worth about 3-4 Pounds/ton (delivered). Realised net profits were small and losses were not uncommon. At times, even at 2 Pounds/ton imported flints were cheaper and it was difficult to sell local material; tariff protection was sought. The World Wars were the greatest boost to the local industry.

In 1911, B.B. Pascoe attempted to load bags of flint to the cutter IRENE from the beaches at Douglas Point but rough seas produced hazardous conditions and caused abandonment of the scheme. Instead, bags of flint were raised up the steep cliffs by a derrick and flying fox arrangement (SADME Photo 35527), remnants of which are still visible today. Initially, the setup involved a horse-drawn rope. Shipments of flint, presumably from Port MacDonnell, during the 1913-1915 period were made on the cutters CASINA, UMELLA and UMARILLA.

During the first World War, the extensive pebble deposits at Middle Point were more systematically worked. Previously, pebbles were handpicked - often in the zone between high and low tide. But around 1918-1919, the promontory was worked from one end with a working face about 3m high. Six men hand picked every pebble and boulder, and the face had advanced from east to west about halfway through the deposit by the end of the War. Remnants of the trench, now mostly backfilled, are evident today. The pebbles were bagged with 14 bags/ton i.e. each bag weighed about 72 kg.

Most of the production for use in pottery and porcelain was sold to Victorian companies. Consumers over the period 1942 -1973 include:

- Hoffman Brick and Potteries Ltd
- S.N. Rodda Pty Ltd
- Australian Porcelain Insulation Co Pty Ltd
- Clifton Potteries and
- H. & R. Johnson (Australia) Pty Ltd

Consumers requiring high-purity silica and low-iron pebbles for specialist milling and grinding include:

- Steetley Australia Pty Ltd
- Jarvis Industries
- Newbold General Refractories
- Proton Chemical Industries Pty Ltd
- Minerals Pty Ltd
- Foamrite Industries
- Sherwood Paint Industries Pty Ltd
- Parr Paint and Chemicals
- Cooper and Cook Pty Ltd and
- ACI Tennant Pty Ltd.

Markets have ranged from Adelaide, throughout Victoria to Alexandria, N.S.W.

The following comments are based on discussions with B.J. (Jack) Pascoe in 1984 and provide useful, additional details not available from SADME records.

Hotham Brick and Potteries Ltd bought pebbles for calcining as early as 1920 and also used flint pebbles for grinding all other silica purchased.

Mill liners sold to the Australian Porcelain and Insulation Co Pty Ltd came only from Cape Douglas as the pebbles and boulders were flatter i.e. more slab like. Flint from Cape Douglas was said to be more chert-like and not as hard or durable as flint from Middle Point. Flat slabs, about 25-30 cm square and 10cm thick, were preferred.

Middle Point pebbles were described as the hardest and preferred in dry grinding. These pebbles were supplied mainly to Broken Hill and to Hoffman Brick and Potteries Ltd. With their higher purity, pebbles from Middle Point were also ideal for calcining and glazing.

In general, pebbles from Tasmania were better for dry grinding but South Australian pebbles were preferred for wet grinding.

A 100-tonne parcel of pebbles supplied to Steetley Industries in the early 1980's was exported to Indonesia.

There is a small outcrop of pebbles on the beach north of Cape Banks which is observed only once every few years, being mostly covered by sand. No production is recorded. Similarly, pebbles are occasionally exposed on a reef off Cape Martin near Beachport (B.J. Pascoe, pers. comm., 1984 and Beasley, 1984) and on the shores of Lake Bonney. Flint from Carpenters Rocks tended to be in small pebbles but was brown in colour. Some were supplied to the paint trade but otherwise, the deposit has been little worked.

Flint sand, used as an abrasive, was once supplied to Metal Sprayers Pty Ltd, Adelaide.

Pelican Point contains abundant flint mostly as irregular-shaped boulders with few pebbles and quality was described as chert-like. Recorded production is limited.

Between Nene Valley and Blackfellows Caves, flint pebbles are occasionally exposed depending on storm activity.

In Blanche Bay (SE of Middle Point), flint crops out on the beach but because of irregular shapes is suitable only for calcining and B.J. Pascoe has not produced flint from this locality.

Storms continuously change beach conditions, both covering and uncovering deposits, hence all leases were deemed necessary to ensure continuity of supply. B.J. Pascoe believed that pebbles were washed out of the 'stockpiles' comprising the present beach and beach ridge, rather than washing ashore during storms. Note that the present beach and beach ridge results from a relatively steady sea level for the last 6000 years.

For calcining applications, pebbles of black flint were selected because of the observed relationship 'the blacker the flint the whiter is the calcined product'. Freshly broken surfaces of black flint rapidly lose their dark colour and develop a white rind. Waterworn pebbles out of the tide and storm-wash zone also re-develop this rind. Even museum specimens, including those of Aboriginal origins develop a weathering rind. Pebbles also stain permanently and readily when in contact with rusty steel.

Pebbles and boulders have been used for ornamental purposes. Examples include the construction in 1976 of a 1m high, 1m thick and several hundred metre long feature wall along the foreshore in Port MacDonell and the building of a Japenese Garden by the Corporation of the City of Adelaide in 1984.

In the early 1970's, the price of pebbles averaged about $45/tonne but increased to about $120/tonne by the early 1980's. Specially-selected small parcels have sold for up to $600/tonne. The pebbles have a bulk density of about 1.8 tonnes/m^3 (1.3 tons/yd^3).

TABLE 3

FLINT PRODUCTION - HUNDRED WILLUNGA

(Sellicks Beach)

Year	Production (tons)
1946	15
1947	15
1948	19
1949	16
1950	16
1951	35
1952	27
1953	11
1954	10
1955	12
1956	9
1957	4
1958	1
1959	-
1960	5
1961	4
1962	5
1963	5
1964	4
Total	213 tons
	216 tonnes

TABLE 4

TOTAL FLINT PRODUCTION, COUNTY GREY: 1909 - 1988

YEAR	TONNES	YEAR	TONNES	YEAR	TONNES	YEAR	TONNES	YEAR	TONNES
1909	151	1925	24	1941	75	1957	14	1973	503
1910	-	1926	50	1942	188	1958	104	1974	44
1911	130	1927	-	1943	321	1959	138	1975	13
1912	120	1928	-	1944	505	1960	67	1976	38
1913	-	1929	-	1945	343	1961	82	1977	101
1914	25	1930	11	1946	361	1962	71	1978	92
1915	72	1931	154	1947	310	1963	51	1979	53
1916	-	1932	204	1948	420	1964	-	1980	140
1917	856	1933	23	1949	283	1965	131	1981	1
1918	1095	1934	260	1950	311	1966	151	1982	6
1919	1157	1935	173	1951	402	1967	70	1983	8
1920	247	1936	101	1952	163	1968	109	1984	3
1921	246	1937	170	1953	60	1969	22	1985	12
1922	452	1938	108	1954	109	1970	19	1986	-
1923	286	1939	104	1955	73	1971	106	1987	-
1924	140	1940	77	1956	24	1972	356	1988	-
								TOTAL	12 939

A00073

TABLE 5

DETAILED PRODUCTION FOR EACH LOCALITY FROM 1909 TO 1935.

NB: After 1935 all of Pascoe's Mineral Leases were amalgamated and production from each site was not specified.

Year	Operator	Tonnes
	BLACKFELLOWS CAVES	
1931	H.L.C. Cotton	111
1932	W.H. Pascoe	6
	H.L.C. Cotton	47
1933	W.H. Pascoe	8
1934	P.A. Jackway	24
	H.L.C. Cotton	165
1935	W.H. Pascoe	33
	H.L.C. Cotton	132
	TOTAL	526
	CARPENTERS ROCKS	
1909	E.A. Gerloff	51
	T. Haig	-
1910	Cape Banks Flint Co.	-
1911	Cape Banks Flint Co.	102
1914	Cape Banks Flint Co.	25
1915	Cape Banks Flint Co.	72
1917	Cape Banks Flint Co.	206
1918	Cape Banks Flint Co.	531
1919	Cape Banks Flint Co.	857
1920	Cape Banks Flint Co.	47
1921	Cape Banks Flint Co.	104
1922	Cape Banks Flint Co.	73
1923	Cape Banks Flint Co.	46
1934	J.T. Bird	7
1935	J.T. Bird	7
	TOTAL	2128
	CAPE NORTHUMBERLAND	
1930	E. Williams	11
	TOTAL	11
	DOUGLAS POINT	

TABLE 5

DETAILED PRODUCTION FOR EACH LOCALITY FROM 1909 TO 1935.

1911	B.B. Pascoe	28
1912	S.A. Pascoe	50
1912	B.B. Pascoe	40
1917	B.B. Pascoe	15
1918	S.A. Pascoe	500
1922	S.A. Pascoe	36
1924	S.A. Pascoe	20
1925	S.A. Pascoe	12
1926	S.A. Pascoe	15
1931	W.H. Pascoe	43
1933	W.H. Pascoe	15
1934	W.H. Pascoe	29
	TOTAL	803

FRENCH POINT TO STONY POINT

1909	R. Broadbent	100
1918	A.C. Haig	14
1934	W.H. Pascoe	35
	TOTAL	149

MIDDLE POINT

1912	S.A. Pascoe	30
1917	S.A. Pascoe	635
1919	S.A. Pascoe	300
1920	S.A. Pascoe	200
1921	S.A. Pascoe	140
1922	S.A. Pascoe	343
1923	S.A. Pascoe	230
1924	S.A. Pascoe	120
1925	S.A. Pascoe	12
1926	S.A. Pascoe	15
1932	W.H. Pascoe	151
	TOTAL	2176

ORWELL ROCKS

1918	R. Wilke	50
1923	E. Williams	10
1926	E. Williams	20
	TOTAL	80

UNLOCATED TENEMENTS

1922	G.A. Garrison	10
	TOTAL	10

SITE GEOLOGY

CAPE BANKS

Bridgewater Formation aeolianite exposed on the point. Sandy beaches to the NW and SE without any flint pebbles evident.

BUCKS BAY

Tenement: ML 2865

Pebbles on the N side of Bucks Bay are found on six localities around the point (Fig. 2). The south side was not inspected but pebbles can be found. At all localities only Bridgewater Formation calcarenite/aeolianite is exposed in the low cliffs. Source of the pebbles is presumably Gambier Limestone in the numerous reefs just offshore and at water level along the point. Very local sources are suggested by the range of colours and shapes observed around the point. Brown pebbles are characteristic of Bucks Bay and reach an abundance of about 15% on the eastern side of the point (Plate 14). The abundance of brown pebbles decrease westwards and flint exposed on the south end of the beach, which extends NW to Cape Banks, is both grey and has a different flatter shape.

Deposit Localities

1. Small rounded pebbles of grey flint occur on the NW end of the main beach at high tide level. Average size is 5 cm with a thin white skin and concave surfaces.
   Dimensions: 45 x 2 x 0.3 m; about 50 tonnes.

2. First rocky beach west of the sandy main beach. Flint pebbly beach with average size 7 cm; up to 12 cm. Numerous brown flint pebbles with grey and grey-brown internal colours (Plate 14).

Dimensions: 2 semi-continuous beaches of 15 x 3 x 0.3 m; about 50 tonnes.

3. Beach nearest the point on NW tip of Bucks Bay. Pebbles are small and very well rounded; average size 4-5 cm. Larger boulders up to 14 cm occur on W end of beach. Mostly of grey flint but about 15% are brown.
Dimensions: 75 x 4 x 1.5 m, up to 2.5 m deep on E end; about 800 tonnes.
Samples : 6922 RS 52-54
A 13/85

4. West side of the point. Flint pebbly beach amongst outcrop of Bridgewater Formation. Raised beach, washed only in storms. Pebbles have a thick white rind and are mainly grey in colour with about 10% brown.
Dimensions: 40 x 3 x 0.25 m; about 40 tonnes.

5. West side of the point, N of Locality 4. Very short pebbly beach of rounded pebbles, average size 5 cm, maximum size 14 cm. Brown pebbles constitute about 5-8%.
Dimensions: 10 x 3 x 1.5 m; about 50 tonnes.

6. Located on the S end of the beach which extends NW to Cape Banks. Pebbles occur along storm high-tide level. Thick white rinds are common on grey flint. Average size is 4-5 cm but flint boulders up to 20 cm are mixed in with numerous large (>1m^3) boulders of Bridgewater Formation.
Dimensions: 50 x 4 x 0.5m; about 180 tonnes.

CARPENTER ROCKS

Tenement: ML 2864

SE of Carpenter Rocks township and opposite sec 500, hundred Kongorong.

Extensive deposits occur but no outcrop; presumably derived from the reefs 0.5-1 km offshore. Flint grey, grey-black and black with minor brown colours. White rind and limestone coatings occur often up to 5mm thick. Shapes are highly irregular and cavernous with numerous holes through the boulders (Plate 15). Baulders are poorly rounded and coarse, average size 15cm. Best rounding occurs along the present low-tide mark. Textures indicate variable replacement of bryozoal fragments and there are numerous carbonate inclusions as unaltered relicts.

Dimensions: 1 km x 20m x 1m, but up to 3m thick; about 35 000 tonnes.

Samples: 6922 RS 55-58.

BUNGALOO BAY

Tenement: -

No outcrop of Gambier Limestone or Bridgewater Formation. Flint pebbles and boulders extend across a large flat tidal platform and in a small storm-washed beach ridge. Boulders are large with a very low degree of rounding. Largest specimens are scattered across the tidal flat between high and low water mark. Irregular, cavernous shapes are common. Within the beach ridge, maximum boulder size is 35cm; average size is 15cm. Boulders exhibit thick white rinds and bryozoal calcarenite skins to greater than 10mm thickness, indicating minimal abrasion and attrition. Flint mostly grey to grey black in colour with obvious carbonate inclusions. Inclusions are rarer where flint is grey-black.

Dimensions: Beach ridge: 80 x 7 x 1.5; about 1000 tonnes.

BLACKFELLOWS CAVES

Deposits in the vicinity of Blackfellows Caves are extensive and extend along the beach semi-continuously for almost 2.5km. The following subdivisions are somewhat arbitrary as each zone merges with the next. Locations are shown in Figure 2. The pebbly beaches N of Blackfellows Caves have been major producers (ML 2862 and ML 2863) with abundant small and well rounded pebbles (Plate 13)

A stranded beach ridge has also been worked on the N part of ML 2862.

1. Tenement: ML 2862

   A stranded beach ridge occurs 50m inland from the present beach. Pebbles are coarse and poorly rounded with very irregular shapes. The ridge has been partly worked by front-end loader, presumably for ornamental stone (walling or paving), and a 2m high face has been developed. Overall, quality is low with some boulders poorly silicified and soft. Thick skins are developed and are often calcareous and covered with moss. Colour variations are in shades of grey; browns are present but few in number.

   Dimensions: 140 x 30 x 2m; about 14 000 tonnes.

2. Tenement: ML 2862

   Small beach to the N of outcropping Gambier Limestone containing flint beds. Boulders on beach are 60-70cm across and derived from the adjacent outcrop; shapes are very irregular and rounding is minimal.

Dimensions: to low water mark are 40 x 4 x 0.75m; about 200 tonnes.

3. Tenement: ML 2862

Small point opposite the middle of section 369, hundred Kongorong.

Point contains outcropping Gambier Limestone with flint beds, deposits of flint pebbles and boulders, and three in situ beds of flint below high water mark. These beds form reefs, the intervening bryozoal calcarenite having been removed by wave action.

In outcrops on the beach, above high water mark, several flint beds are exposed. The largest is about 40cm thick and contains pale grey to grey-brown flint with scattered pods and lenses up to 35cm long below the main layer. In outcrop, the flint beds are very irregular with many lobate forms - similar to flint from Nene Valley (Plate 2).

The three beds of flint below high water mark form prominent wavecut platforms. These are referred to by Hiern (1974) (Appendix D).

Adjacent to the reefs onshore there are extensive beach ridge deposits of pebbles and boulders. Shapes are very irregular and many boulders are more suited for ornamental purposes such as aquarium stones or object d'art.

Dimensions: 300 x 30 x 3m; about 45 000 tonnes.

4. Tenement: ML 2862

Semi-continuous pebble beaches with short low knolls of outcropping Gambier Limestone every 20 metres and containing flint pods and lenses. These are photographed in Willington (1956). Flint pebbles have grey exterior colours with specks of black. Internal colours are grey-black to black but with soft, carbonate inclusions as a result of incomplete replacement.

Sizes vary along the 250m long beach. Size decreases and rounding improves considerably from NW to SE. At the NW end, average size is about 15cm and pebbles have some concave surfaces still containing carbonate. Southeastwards, average size decreases and in places averages only 3cm and the degree of rounding and sphericity improves. Pebbles with the highest degree of sphericity were found in this section and through to Blackfellows Caves township.

Dimensions: 250 x 5 x 1.5m; about 2 500 tonnes.

Samples: 6922 RS 59

5. Tenement: ML 2863

Abundant outcrop of Gambier Limestone with a resistant capping bed of flint. One small bay contains abundant pebbles - average size 10cm up to a maximum of 40cm, mostly very well rounded, with no white rind.

Dimensions: 50 x 10 x 2m; about 1800 tonnes.

6. Tenement: ML 2863

Long steep beach with small, well rounded pebbles averaging 6-7cm. Maximum size is 25cm. Pebbles are grey to black with little or no rind but still containing some concave surfaces. Amongst the pebbles some flat slabs occur up to 18cm across and 2cm thick.

Dimensions: 200 x 7 x 1.5m; about 3700 tonnes.

7.

First small beach S of Blackfellows Caves. Outcrop of Gambier Limestone occurs in middle of beach with two wave-swept reefs consisting partially of flint. Abundant large boulders of flint occur up to 40cm long and averaging about 30cm. Flint grey to black in colour but with numerous white, soft carbonate inclusions. Thick white rind commonly occurs in excess of 10mm thick. The number of rounded pebbles is small.

Dimensions: (total resource) is 100 x 5 x 1m; about 900 tonnes.

8.

Second beach S of Blackfellows Caves. Steep, pebbly beach with abundant small, well-rounded pebbles, averaging 8-15cm in size, and grey in colour. Platy slabs of flint (2-3cm thick) do occur but contain white, soft carbonate lenses 2-3mm thick.

Dimensions: 250 x 4 x 1m; about 1800 tonnes.

NENE VALLEY

These outcrops provide the most useful geological information. The flint beds are exposed in Gambier Limestone as well as forming a conglomeratic band at the base of Bridgewater Formation. Pebbles and boulders from both units are reworked into present-day beach deposits. In addition, flint has apparently formed along and within NW-trending joints. No other area inspected shows a such wide variety of features affecting flint formation and reworking.

Location: Fig. 2 and opposite section 392, hundred Kongorong.

1. Located on N-NW side of low point and forms the SE end of the sandy beach which extends to Blackfellows Caves. The last 50-100m of the beach contains numerous large boulders of flint - frequently greater than 1m across with irregular shapes. Uses would be dominantly ornamental though many of the boulders would produce slabs. Flint is grey to black with thin 1-2mm white rind.

   Gambier limestone is exposed at water level and contains:

   a) horizontal to gently dipping beds of flint.
   b) flint infilling 3 subvertical joints.

Three or four, near horizontal beds of flint form disrupted sheets over an area of 20-30m square. Flint within these beds is grey and brown and shapes are highly irregular and knobby with many protruding and lobate forms (Plates 1 and 2). These beds are obviously the source of the boulders on the adjacent beach (see above).

At the NW end where the beach abuts 2-3m high cliffs of Bridgewater Formation, Gambier Limestone is present at water level. Flint is exposed as both a flat sheet and as infilling another NW-SE vein or joint.

The flat sheet dips SE at 1-2° and is laterally more continuous than exposures elsewhere, with an area of 35 x 7m and a thickness of 0.2m.

Flint infilling the joint exhibits similar features to the 3 joints 400m to the NW i.e.

- strikes 150°M
- is double sided with two flint bands only 10-15cm apart
- exhibits zoning with black cores and white soft rims which are either poorly silicified or are weathered rinds.
- combination of vertical joint and upright pods with zoning produces apparent 'pipes'.

Dimensions: Pebbly beach adjacent to the S, 50 x 4 x 0.8m; about 250 tonnes.

DOUGLAS POINT

Numerous outcrops with flint in Gambier Limestone and Bridgewater Formation conglomerate, as well as reworked into Holocene pebble and boulder beach deposits, extend for over 2km NW from Douglas Point. Localities for the following descriptions are shown in Figure 3. None of the Douglas Point deposits are within a current Mineral Lease.

occurs within a channel with a seaward slope of several degrees. However, blocks of cemented conglomerate up to 2m long are observed on some of the beaches in this region. The in situ conglomerate is a band 1-2m thick.

Flint on the beaches is grey to grey-brown while fragments are mostly brown and more analogous to the brown flint from Bucks Bay.

Flint within Gambier Limestone forms numerous thin irregular lenses and pods (Plate 8). Some pods appear like horizontal pipes and exhibit concentric zoning.

A beach on the E-SE end of this area contains pebbles and boulders of variable size but all are very well rounded, and are obviously derived from the reworking of Bridgewater Formation conglomerate.

Dimensions: Only the dimensions of the pebbly beaches were recorded in this instance.

Individual beaches are:

20 x 3 x 0.4m:	about	40 tonnes
20 x 15 x 0.3m:	about	120 tonnes
40 x 3 x 0.3m:	about	60 tonnes
30 x 5 x 0.3m:	about	270 tonnes
15 x 4 x 2.0m:	about	200 tonnes
Total		670 tonnes

Samples: A 14/85

3. NW end of long sandy beach (Fig. 2) which extends SE for several kilometres.

Flint also forms in three very distinctive NW-SE joints within Gambier Limestone, typical of widespread jointing in the South East (Sprigg, 1952; Flint, 1988). Outcrops are between high and low water mark and each can be traced about 5-8m along strike (Plates 3 - 5).

Two joints strike 125°M and vary from vertical to dipping steeply SW at about 80°. A third strikes 110°M and is vertical. Flint within the joint or vein forms discontinuous pods and lenses from 5cm to in excess of 1m long. The in-situ flint is grey to brown, whereas boulders on the beach which are mainly derived from the near-horizontal beds is dominantly grey to grey-black. Pods indicate that the lens may have undergone boudinaging. In addition, some of the pods or boudins exhibit internal, elliptical banding and colour zoning. One of the joints is a 'double' structure, with two veins of flint parallel and 10-15cm apart (Plates 3 - 5).
Samples: 6922 RS 60-62

2. The Point (Fig 2) contains excellent exposures of:
   a) flint beds and lenses within Gambier Limestone.
   b) overlying flint-boulder conglomerates at and near the base of Bridgewater Formation (Plates 6 - 10).

Both are strongly dissected producing short pebble and boulder beaches.

Boulders within the Bridgewater Formation are typically in the range 20-30cm and exhibit a high degree of rounding even though they still have the shape of hollow tubes (Plate 7). Many of the larger boulders on the beaches can thus not have been derived from the reworking of Bridgewater Formation conglomerates. The conglomerate of Plates 6 and 7 possibly

1. Douglas Point proper (section 365).

Extensive deposits of boulder flint. Boulders are characteristically large, often up to 1.5m long and 0.6m thick. Boulders of this size may be well rounded even though very irregular. Many boulders have slab-like forms. The number of carbonate inclusions is low. Flint is grey to grey brown.

The high degree of rounding of some large boulders is indicative of flint reworked from a conglomerate within Bridgewater Formation. Such a unit is exposed at low water off the point and forms a reef.

Dimensions: Boulders extend over 100 x 30 x 2.5m amounting to about 13 000 tonnes. Minor blocks of Bridgewater Formation aeolianite are also present.

Smaller quantities occur in a tidal zone eastwards towards the shacks and are either a dispersion trail from the Point or correspond to further outcrop of cemented conglomerate.

Samples: 7021 RS 32 and 33.

2. Short beach opposite the boundary of sections 365 and 366 (hundred MacDonnell).

Large to very large boulders occur on a short steep beach and are commonly over 1m across. Boulders have both rounded and slabby forms with few holes indicating low abundance of carbonate inclusions. Flint is typically pale grey, pale grey brown and dark grey to black.

Degree of rounding is variable. Some of the 0.6-0.7m boulders are very well rounded and are probably reworked from cemented conglomerate in Bridgewater Formation.

However, Bridgewater Formation is only exposed at each end of the beach.
Dimensions: 70 x 15 x 2m; about 37 000 tonnes.

3. Inaccessible beach at the base of high cliffs of Bridgewater Formation. Well-rounded and highly spherical boulders are distinctive and are perhaps the most spherical observed along the entire South East coast.
Dimensions: 35 x 6 x 1.5m; about 500 tonnes.

4. Similar to the above with well-rounded and moderate spherical boulders trapped in a short beach. Boulders have a fresh grey surface and no surface rind is evident. A possible outcrop of cemented conglomerate of Bridgewater Formation occurs just below low water mark.
Dimensions: 70 x 10 x 2m; about 2500 tonnes.

5. Same as above. Locality shows the relicts of a flying fox and derrick as photographed many decades ago in SADME Photograph 35527.
Dimensions: 40 x 10 x 2m; about 1400 tonnes.

6. Area contains outcrops of Gambier Limestone and Bridgewater Formation. Flint boulders are exposed at numerous localities in the cemented conglomerate (to 1m thick) and have been reworked in the present-day wash zone of the beaches. Degree of rounding and sphericity of pebbles and boulders are high. Boulders are grey to grey brown, but on the beach towards the NW end, brown boulders are common. A few black boulders with white rind are also present. Pebbles in the wash zone are often only 1-8cm in diameter. Pebbles and boulders are

apparently reworked exclusively, or nearly so, from Bridgewater Formation.

Dimensions:			
	20 x 5 x 1.2m:	about	200 tonnes
	10 x 4 x 1.0m:	about	70 tonnes
	30 x 8 x 1.0m:	about	400 tonnes
	15 x 5 x 0.4m:	about	50 tonnes
	35 x 10 x 1.5m:	about	900 tonnes
	45 x 10 x 1.5m:	about	1200 tonnes
	Total		2800 tonnes

7. First cove SE of the island exposes geological contacts and flint as boulders within cemented conglomerate (Bridgewater Formation) and as discontinuous lenses in calcarenite of Gambier Limestone (Plate 11). Boulders from both sources are reworked into the present-day beach.
Dimensions: 10 x 10 x 1.5m; about 250 tonnes.

8. Small island. Small causeway connecting the island to mainland contains a deposit of flint boulders. Flint also forms beaches and spits on the island.

Boulders in this area are very large up to 1.5m long and exhibit thick coatings. Shapes are irregular and degree of rounding is low. The boulders appear to be derived directly from Gambier Limestone, rather than Bridgewater Formation.

Dimensions:

60 x 40 x 1.2m:	about	4800 tonnes
80 x 10 x 1.2m:	about	1700 tonnes
100 x 20 x 0.8m:	about	2800 tonnes
Total	about	9300 tonnes

Samples: 7021 RS 31.

9. About six pebbly beaches amongst small outcrops of Bridgewater Formation. Not inspected.
Dimensions: 300 x 4 x 0.8m; about 1700 tonnes.

10. Flint pebbles form a long low deposit on a storm beach ridge rather than on the present sandy beach. Landward side of the ridge is partly vegetated and covered by Holocene sand. Pebbles have very irregular shapes and are similar to those found on the N extremity of the leases at Blackfellows Caves. Degree of rounding is low. This is the only deposit in the Douglas Point area to contain dominantly black flint. The black flint has a white rind, typically 4-7mm thick.

Gambier Limestone is exposed on the SE end of the beach at low water mark. A flint bed within the limestone is discontinuous, forming boulders up to about 0.5m long. Only minor flint was observed at the base of the overlying Bridgewater Formation where it forms a discontinuous bed of no more than 0.2m thick. Either or both occurrences may be the source of the black flint.
Dimensions: 200 x 7 x 1.5m; about 3700 tonnes.

UMPHERSTONE BAY

Opposite sec 343 hundred MacDonnell. Stranded beach ridge, 100m long, between the track and present-day sandy beach. Flint pebbles covered and partly obscured by Holocene sand.

MIDDLE POINT

Middle Point (Fig. 3) contains one of the most impressive accumulations of flint in South Australia with about 80 000 tonnes in a deposit averaging 2.5m in height (Plate 12). Half of this deposit was systematically worked during World War I, when peak production was about 2800 tonnes in one year.

Most of the flint pebbles and boulders on the beaches at Middle Point are derived from reworking the cemented conglomerate at the base of Bridgewater Formation. Even large boulders of 0.5-0.8m show a high degree of rounding (Plate 12). Flint is exposed both as beds in Gambier Limestone and as boulders in Bridgewater Formation.

Zones of highest attrition on the present beaches coincide with the greatest abundance of the more durable black flint.

All deposits at Middle Point are covered by ML 2638.

Middle Point 1.
Stranded ?Pleistocene dunes 60-80m behind present-day beach. Boulders occur up to 0.8m long with average size 15-20cm. Degree of rounding is highly variable and independent of size as some very large boulders are also well rounded. Flint is probably derived predominantly from the reworked conglomerate of Bridgewater Formation.
Dimensions: 100 x 3 x 1m; about 500 tonnes.

Middle Point 2

A triangular-shaped Point, composed entirely of flint boulders and pebbles, with a surface area of about 36 000m^2 and a depth of 2.5-3m, is one of the outstanding outcrops of flint in the South East (Plate 12). This deposit was worked by a team of 12 people, advancing a 3m-high face from E to W with production in one year alone of about 2800 tonnes. Relicts of the face are still visible. The point contains well-rounded blocks of flint up to 1m across. On both the NW and SE sides of the Point, there are probable outcrops of conglomerate (Bridgewater Formation) at and below low-water mark.

The small bay between this point of flint and Middle Point proper, is a zone of concentrated wave action and consequently high attrition rate. Pebbles and boulders within this zone are very well rounded and black flint predominates. Black flint usually shows a high silica content and is expected to be most durable. Boulders tend to be more iron-stained at this site than elsewhere. This may be organically derived and related to a nearby effluent discharge.

Extending NW from this Point, is a long beach composed entirely of flint pebbles and boulders. Flint is dominantly grey to brown with a thick white rind. Shapes are highly variable with numerous cavernous forms. Degree of rounding is variable from good to poor. Some shapes are indicative of flint derived from beds in Gambier Limestone with minimal reworking.

Dimensions:

Prominent point: Triangular surface area - base 300m, apex height 120m, depth 2.5m; about 80 000 tonnes.

Beach extending NW: 400 x 10 x 1.5m; about 10 000 tonnes.

Samples: 7021 RS 34 and 35
A 15/85 and A 16/85

Middle Point 3

On the NW side of Middle Point proper, flint is exposed both as a bed within Gambier Limestone and as a boulder conglomerate at the base of Bridgewater Formation. Boulders on the beach are to up 1m across.

Dimensions: Deposit merges NW into the one discussed previously:

a) 150 x 8 x 1.5m; abut 3200 tonnes.
b) small rocky beach near Point: 40 x 7 x 1.5m; about 700 tonnes.

Middle Point 4.

Between Middle Point proper and the shacks at Blanche Bay are several pebbly beaches composed entirely of flint pebbles characterised by a high degree of rounding. Even boulders of 0.5 - 0.8m are well rounded. The degree of rounding of large boulders is characteristic of those reworked from Bridgewater Formation. Cemented Bridgewater Formation conglomerate is exposed on two of the beaches, at and below low-water mark of the westernmost beach and at the eastern end of the middle beach. Large boulders in the vicinity of the conglomerate outcrop have a lesser degree of rounding which indicates that further rounding is the result of recent reworking.

The flint is grey, grey brown and black. As expected, rinds are thin.

Dimensions:			
	115 x 15 x 2m;	about	7 000 tonnes
	80 x 16 x 1.5m;	about	3 400 tonnes
	250 x 8 x 1.5m;	about	5 400 tonnes
	Total	about	15 800 tonnes

Middle Point 5.

At the W end of Blanche Bay is another triangular-shaped Point of flint boulders which is very similar to those at Middle Point and Pelican Point. The flint is also similar to the adjacent Middle Point deposits.

Dimensions: Triangular with base length 65m, apex height 25m and covered to an average depth of 2.5m; about 3500 tonnes.

ORWELL ROCKS

Pebbles and rare boulders of flint extend almost continuously for 500m along the beach with minor outcrop of Gambier Limestone. Several features are unusual:- the relatively uniform size of the pebbles and their tendency to have distinctly platy forms. Large boulders tend to be slabs only 2cm thick and 15-20cm across. Larger sized boulders are rare. Pebbles are slightly cavernous and contain abundant surface indentations. Flint is mostly grey and grey brown.

Dimensions: 500 x 5 x 2.5m; about 11 000 tonnes.

FRENCH POINT

Location: part section 465 and 886 (Recreation Reserve), hundred MacDonnell, (Fig. 3) Gambier Limestone crops out at water level. Flint pebbles along the beach are minor and form a narrow zone about 2m wide and 0.2m deep. Most of the flint occurs within the mass of French Point and is intermixed with Holocene sand which has been partly vegetated. At the W end of French Point the inland margin of the flint deposit has been quarried.

Dimensions:
French Point, total area - 400 x 150m (triangular) x 1m; about 45 000 tonnes.
French Point, in that portion quarried previously - 100 x 30 x 1.5m; about 8000 tonnes.

RACECOURSE BAY

Location: part section 886, hundred MacDonnell, (Fig. 4). Extensive flint deposits occur along the present beach. Flint pebbles and boulders are cavernous, with thick rinds and probably are suited more to ornamental purposes (?aquarium stone).

Flint is slabby, typically in slabs 3-7cm thick. These rarely exceed 0.40m across except on the E end of the beach where slabs are commonly 0.4-0.9m. Thick white powdery skins coat all boulders, particularly those along the back edge of the dune. Shapes are typical of flint derived directly from weathered Gambier Limestone.

Colours are grey, grey-brown and black. All flint has inclusions of soft white carbonate. Pebbles are restricted to the current wave wash zone.

The small island in the bay is a flat flint reef at water level with flint boulders heaped about 2m high.
Dimensions: 500 x 10 x 2m; about 18 000 tonnes.

STONY POINT

Location: part section 886 (Recreation Reserve), hundred MacDonnell (Fig. 4).

Flint colour, rind thickness and degree of rounding with cavernous shapes are all similar to deposits at Racecourse Bay. Flint was apparently derived directly from Gambier Limestone.

Dimensions: 400 x 30 x 1.7m; 3500 tonnes.

RIDDOCH BAY - DANGER POINT

Minor scattered flint deposits occur but largely covered by Holocene sand dunes.

GREEN POINT

Not inspected but presumably partly comprised of flint.

TABLE 6

SUMMARY OF COASTAL FLINT RESOURCES, CAPE BANKS TO GREEN POINT

Locality*		Resource (tonnes)	
Cape Banks		-	
Bucks Bay	- 1	50	
	- 2	50	
	- 3	800	
	- 4	40	
	- 5	50	
	- 6	180	
Carpenter Rocks		35 000	
Bungaloo Bay		1 000	
Blackfellows Caves	- 1	14 000	
	- 2	200	
	- 3	45 000	
	- 4	2 500	
	- 5	1 800	
	- 6	3 700	
	- 7	900	
	- 8	1 800	
Nene Valley	- 1	not determined	
	- 2	670	(4 deposits)
	- 3	250	
Douglas Point	- 1	13 000	
	- 2	37 000	
	- 3	500	
	- 4	2 500	
	- 5	1 400	
	- 6	2 800	(6 deposits)
	- 7	250	
	- 8	9300	(3 deposits)

A00073

TABLE 6 (cont)

SUMMARY OF COASTAL FLINT RESOURCES CAPE BANKS TO GREEN POINT

Locality*		Resource (tonnes)	
	- 9	1 700	
	- 10	3 700	
Umpherstone Bay		not determined	
Middle Point	- 1	500	
	- 2	90 000	
	- 3	700	
	- 4	15 800	(3 deposits)
	- 5	3 500	
Orwell Rocks		11 000	
French Point		8 000	
Racecourse Bay		18 000	
Stony Point		3 500	
Riddoch Bay/Danger Point		not determined	
Green Point		not determined	
TOTAL		330 000 Tonnes	

* For exact localities, see Figures 2-4.

KANGAROO ISLAND

Flint pebbles and cobbles have been found on Kangaroo Island on a beach 2 km SW of Cape Hart. Specimens are rare because pebbly beaches are predominantly derived from Kanmantoo Group metasediments. Calcareous and fossiliferous flint or chert is poorly rounded which suggests that the source is local - either from coastal cliffs or limestone immediately offshore.

Samples (6256 RS 21 - 24) are of mottled flint in shades of grey to black. Mottled specimens are characteristic and can be distinguished from flint sourced from Gambier Limestone in the South East.

Sample 6256 RS 21 from near Cape Hart contains sponge spicules, bryozoa, echinoid fragments and foraminifera and is interpreted to be Late Oligocene (Guembelitria triseriata zone) (J.M. Lindsay pers, comm., 1989). Hence the Late Oligocene flint of Kangaroo Island represents a time equivalent of either the Ettrick Formation of the Murray Basin or the Ruwarung Member (Port Willunga Formation) of the Saint Vincent Basin. The flint at Cape Hart is younger than the currently known age range for the Kingscote Limestone (Eocene).

During recent geological mapping of KINGSCOTE 1:250 000 map sheet area, R. B. Flint and A. P. Belperio (Regional Geology Branch, SADME) have found additional flint pebbles at Cape Linois, Point Reynolds and Cape Ganthaume and investigations are continuing. Boulders of limestone with chert or flint have occasionally been found south of West Bay (A. Milnes, pers, comm., 1985). No outcrops have yet been found with silicification in situ.

PETROGRAPHY

Fifteen flint samples from the South East have been examined petrographically (Appendix A). Thin sections were prepared for three samples from Cape Hart, Kangaroo Island (6256 RS 22-24) but have not been examined. Flint from the South East was described as fossiliferous chert and comprises a predominantly fine-grained, granular chert matrix with scattered fossil fragments.

The matrix is predominantly granular chert of average grain size, 0.05 mm or less. Parts of the matrix consist of coarser-grained aggregates of granular chert and rare aggregates of radiating, fibrous chalcedony. Cherty replacement of former granular-carbonate matrix is incomplete producing relict, patchy areas of granular dolomite (e.g. 6922 RS 52). Granular calcite within the matrix is rare (7021 RS 31) as are dolomite rhombs within the matrix.
(7021 RS 32).

Amorphous to weakly anisotropic silica within the matrix is present only in a pebble of brown flint from Bucks Bay/Carpenter Rocks (6922 RS 54) but comprises 15% of the sample volume. Such amorphous zones could explain why brown pebbles from the area are considered to be less hard and not suited for use as grinding media, even though chemical data indicates high silica contents.

Trace amounts of glauconite were observed in only one sample from Bucks Bay/Carpenter Rock i.e. 6299 RS 52.

Opaques of up to 1-2%, are often present within the matrix and consist of anhedral grains to 0.1 mm and aggregates to 0.3 mm across. Disseminated pyrite in 6922 RS 59 from Blackfellows Caves forms subhedral crystals and crystal aggregates up to 0.5mm across. Common to all samples, but not positively identified, are finely-divided, opaque to translucent, dusty inclusions giving a translucent, brown colour in thin section. This phase is abundant in the weathered whiter rinds and petrographic descriptions suggest leucoxene; but TiO_2 is present only to a maximum of 0.02% and is often <0.01%. Oxidation of this fine-grained phase may give rise to the whitish rind on boulders away from the current tidal zone and on Aboriginal artefacts. However, the precise origin for the white rinds is unknown and other processes (e.g. hydration or dehydration) may also be relevant.

Fossil fragments of bryozoa, molluscs, echinoids and foraminifera were identified. Sponge spicules are present in 6922 RS 53, 54 and 58. Many fossil fragments of originally calcite have been extensively replaced by dolomite and have dolomite overgrowths e.g. 7021 RS 33 and 34. Sample 6922 RS 62 has the highest calcite content at 8%. Carbonate is usually restricted to fossil fragments which show either partial or complete replacement by a combination of fibrous chalcedony and granular chert. Complete replacement of fossil fragments occurs in 6922 RS 55. Fibrous chalcedony usually shows a slightly higher birefringence than granular chert in the matrix. Granular chert replacing fossil fragments is often coarser than granular chert in the matrix e.g. 6922 RS 54. The coarsest-grained chert is usually restricted to infilling chambered fossils. Some fragments exhibit both

dolomite/calcite zoning and cherty overgrowths e.g. 7021 RS 35.

CHEMISTRY

Full-silicate and trace-element analyses of flint from the South East and Cape Hart (Kangaroo Island) are presented as Appendix B. A plot of SiO_2 v (CaO + MgO) illustrates the expected relationship of silica replacing calcareous fossil fragments (bryozoa, echinoids and foraminifera) (Fig. 5).

Silica contents of samples from all localities exhibit a large variation, ranging from 78% to a maximum of 96.1%. Variation in analyses from each locality is within the same range as the variations for all areas combined. This is in keeping with field observations. Inclusions of fossiliferous limestone are common to all areas.

Silica content is not related to abundance of relict bryozoal fragments. Samples of black flint with very few or no bryozoal fragments contain no higher silica content than grey flint with abundant relict, bryozoal fragments. This suggests that most of the fossil fragments have been substantially replaced by flint and/or fibrous chalcedony. However, black flint does calcine to a whiter product than grey flint.

Well-rounded pebbles of dark grey flint (A14/85 - A 16/85, A18/85 and A19/85) average 93% SiO_2, the exception being A18/85 which is low at 85.5% SiO_2 and presumably contained an inclusion of limestone.

Brown flint pebbles from Carpenter Rocks and Bucks Bay have been regarded as inferior for industrial use because of assumed lower silica content, inferior hardness, and relatively abundant surface indentations. Typical analyses (6922 RS 52 and 53, A13/85 and A17/85) indicate a highly variable silica content ranging up to a maximum of 95.1%.

USES AND MATERIAL SPECIFICATIONS

The three main uses of flint are in the building, abrasive and pottery/ceramic industries. In Europe, all flint production is as a byproduct of mining chalk for cement manufacture. In South Australia, erosion and reworking of flint from Gambier Limestone and Bridgewater Formation to form pebbles and boulders as beach deposits provides a concentrated source which has been developed in its own right.

The following notes are mainly extracted from Anon (1979).

Flint in the Ceramics Industry

Traditional English earthenware is made from a blend comprising about 25% ball clay, 25% china clay, 15% flux and 35% flint. Silica sand is sometimes substituted for flint but does not convey the same range of properties. When added to the clay body, flint produces a whiter and stronger product, a desirable effect known in the U.K. ceramic industry since 1720. Consumption of flint in the U.K. ceramic industry totals about 70 000 tpa.

The Northfleet Plant in the U.K. produces three size grades of flint with typical analysis listed in Table 7. Where pebbles are dominantly hand selected, then only the blue-black variety is selected for use in the pottery industry. This would be equivalent to preferentially selecting black pebbles from the South East, based on observations that these calcine to a whiter product.

TABLE 7

CHEMICAL ANALYSES OF FLINT FOR CERAMIC USE

	Northfleet Plant %	Middle Point 7021 RS 35 %	Nene Valley A14/85 %	Bucks Bay 6922 RS 53 %	Cape Hart 6256 RS 23 %
SiO_2	97.4	95.8	96.1	95.1	95.1
Al_2O_3	0.35	0.15	0.24	0.25	0.27
CaO	0.46	1.38	0.52	1.05	0.84
MgO	0.18	0.19	0.08	0.10	0.61
Fe_2O_3	trace	0.08	0.14	0.26	0.28
Loss on ignition	1.3	2.48	2.02	2.54	2.54

Before being used in pottery blends, flint is calcined at 900-1000°C which drives off moisture and carbon. The flint becomes white, cracked and is more readily crushed. Calcining reduces the specific gravity of flint from 2.62 to 2.50. Calcined flint is crushed and wet ground to produce a product having 55-60% of particles with a diameter less than 10 microns.

Within the ceramic body, flint reduces shrinkage and distortion during firing, increases the whiteness and enhances the rigidity of the body. The main inversions of the three main polymorphs of silica are:

117°C	α tridymite	-	β_1 tridymite
163°C	β_1 tridymite	-	β_2 tridymite
220-280°C	α cristobalite	-	β cristobalite
573°C	α quartz	-	β quartz

The α - β quartz inversion at 573°C involves a 3% volume change whereas the α cristobalite inversion at about 250°C involves a 1% volume change. The α cristobalite inversion causes the solidified glaze to be under compression, thus preventing the glaze from cracking and increasing its strength, as ceramic glazes are stronger mechanically in compression than in tension. The α - β quartz inversion at 573°C and its 3% volume change is more likely to cause cracking, hence the rate of rise of temperature must be reduced as this inversion occurs.

Cristobalite inversions are also partly controlled by the exposed surface area of the silica particles. Hence the degree of cristobalite inversion, structure of the finished item, fit of the glaze and maturing temperature of the ceramic are all affected by the fineness to which the flint is ground.

Hand selected flint pebbles from SA approach the chemical analyses of crushed and optically sorted flint from the Northfleet Plant (Table 7), particularly the well-rounded pebbles of black flint from Middle Point (7021 RS 35) and well-rounded pebbles of dark grey flint from Nene Valley (A14/85). Even the rounded, brown to orange-brown pebbles from Bucks Bay/Carpenter Rocks (6922 RS 53) are comparable (Appendix B). A boulder of flint from Cape Hart, which

exhibits minimal rounding but contains about 75% black flint and 25% grey flint (6256 RS 23) also has a comparable chemical analysis (Appendix B).

The potential to use flint from SA in the pottery and porcelain industries was demonstrated by sales to Victorian potteries, particulary between 1942-1973, and is supported by available chemical data.

Flint as a Grinding Media

The combination of the hardness of flint, smooth rounded shape of water-worn pebbles and high purity has lead to the widespread use of flint pebbles as a grinding media in both general and specific applications such uses include the grinding of hard ores, chemicals, ceramic bodies, glazes and enamels. SA pebbles have been used as a grinding media since 1909 and have been exported to mills in New Zealand and Indonesia.

Ideally, these pebbles should have a high abrasive hardness, freedom from flaws likely to cause chipping or splitting, and free of metallic sulphide impurities. Flint from the South East occasionally contains pyrite and marcasite eg. sample 6922 RS 59 from Blackfellows Caves. Past experience has shown that black pebbles from Middle Point and dark grey pebbles from Blackfellows Caves have the highest abrasive hardness. Brown pebbles from Bucks Bay and Carpenter Rocks, however, are not as hard due possibly to the presence of amorphous or poorly crystalline silica as observed in

sample 6922 RS 54. Although SA pebbles are well-rounded (Plates 13-15), many also have surface indentations resulting from inclusions of calcarenite. These contribute to incomplete grinding and to contamination from batch to batch, especially when used in the paint industry.

Pebbles are usually graded and all sizing in SA is done by hand, including initial collecting from the beaches. A small front-end loader and screens would greatly aid the process, but final hand sorting would still be required.

Specific gravity of the flint pebbles is from 2.62-2.63. In general, for flint pebbles and then synthetic alternatives, heavier pebbles have greater grinding power and occupy less mill volume resulting in greater milling capacity. Small pebbles grind finer than large pebbles because they provide a greater surface area per unit weight of media.

Specific gravities of a range of grinding media are shown in Table 8.

TABLE 8

SPECIFIC GRAVITY OF FLINT AND ALTERNATIVE SYNTHETIC PEBBLES

Grinding media	S.G
Flint	2.62
Porcelain ball	2.4
Porcelain ball with alumina	2.7
Sintered alumina	3.6
Steatite ball (talc-clay ceramic)	2.75
Steel ball	7

Major advantages of synthetic grinding media are the controlled shape and specific gravity, combined with a low rate of wear. Flint pebbles from the South East tend to be disc shaped rather than spherical and while this increases their surface area have proved less efficient in fine grinding. In general, synthetic media because of their high price are used to process high priced raw materials, whereas flint pebbles are used for heavy duty grinding and the bulk processing of lower value commodities.

Other Industrial Uses for Flint

In the UK, about 7 000 tpa of flint is produced for other industrial uses such as filter media, poultry grit, a whitening agent and as an abrasive. Additional material is imported, particularly from France and Denmark.

Abrasive uses are either as a coated abrasive or as a loose 'shot blasting' abrasive. Coated abrasives consist of crushed flint, with sharp-edged grains from its conchoidal fracture, cemented to a paper or cloth backing. The sharp-edge grains form an efficient cutting edge, but have been largely substituted by synthetic abrasives. Use of flint as a loose, 'sand' abrasive has also declined enormously because of the hazard of silicosis. The common synthetic replacement is fused alumina.

Within the filtration industry, flint is an ideal medium because of its resistance to salts, bases and hydrocarbons combined with a constant composition. In addition, flint has a better resistance to abrasion than silica sand or crushed gravel, hence a longer life in the filtration bed. The size of the flint used depends on the type of system. A small

grain size is used in filtration systems for waters with few impurities, while coarser grades are used in layered filtration beds for the purification of crude, industrial water.

The presence of flint grains in poultry grit assists the grinding of food, promoting a healthy, fatter bird. Poultry grit requires cubical shapes rather than sharp-edged flakes or spikes which could injure the gizzard. This can be achieved by modifying the crushing and grinding technique, and flint poultry grit is marketed in the UK. The number of facets on each grain and the size of the grains are varied to suit poultry of different ages.

Flint in the Building Industry

An unusual building industry use of calcined flint is as a decorative finish to walls etc. Calcined flint is usually white to brilliantly white in colour and can be mixed with cement to produce white, pre-cast panels or cast in concrete, where it meets all normal strength specifications. Calcined flint is used also in the UK as a solar reflective roof covering, where its light colour helps to keep buildings cool in summer.

The most common use within the building industry is ornamental as rounded pebbles in exposed aggregate in walls and paths. Rounded pebbles are used also for landscaping and other decorative purposes, such as the Japanese Garden

prepared by the Adelaide City Council. Knapped flint cobbles and blocks have been used extensively in buildings in the UK and could be used in SA to produce an attractive finish. However, knapping is labour intensive and the required skills may not be available locally.

Flint is silica-rich, hard, impermeable and acid resistant hence is suitable for many types of industrial flooring. Flint can be crushed in such a way as to give an angular fracture, providing a non-skid floor surface.

Boulders of irregularly-shaped flint have also been used to construct feature walls such as the long low wall along the foreshore at Port MacDonnell.

Miscellaneous Use

Only a small proportion of the available flint resources in the South East consists of rounded pebbles and boulders. Most of the flint forms boulders with numerous caverns and holes (eg. Plate 16) and may only be suitable for decorative uses. A potential market for this material is as aquarium stone. If dissolution of the limestone, coating and infilling cavities, poses a problem in aquariums, this could be removed in an acid bath.

DISCUSSION

Inland flint deposits were too extensive to map during the course of these investigations. These mostly form as surface deposits either from gradual erosion of Gambier Limestone or from the erosion of basal pebble conglomerate in Bridgewater Formation e.g. (Steetley Quarry near Marte (Flint,

1988)). Flint lenses within Gambier Limestone have been intersected in numerous drillholes over a large area, especially within the hundred of Kongorong. Often several intersections were made in the one drill hole. Drill hole Douglas Point 1, intersected sporadic flint lenses over an interval of 200 m (Waterhouse, 1977).

This report has not attempted to examine the stratigraphic and age distribution of flint lenses within the Gambier Limestone and most of the coastal exposures occur within the 'upper grey cherty limestone' unit, as defined by Lindsay (1967).

Flint beds in Gambier Limestone are exposed along the coast at Blackfellows Caves, Nene Valley, Douglas Point and Middle Point. Other sites, such as Orwell Rocks and French Point, show minor outcrop of Gambier Limestone at low water level and flint on the adjacent beaches is most likely from this source. The forms of flint within the lenses varies from flat, slabby sheets to disrupted layers with lobate protuberances with overlying and underlying calcarenite (Plate 2). All outcrop sites exhibit rounded protuberances which appear more rounded than those of the flint horizons in Cretaceous chalk of the Netherlands, Belgium, France, England and Denmark (Fig 6). Possibly, the different forms reflect varying degrees of compaction and porosity in overlying and underlying sediments. Flat slabby flint is relatively rare and is best developed at Douglas Point but also occurs at Orwell Rocks and Nene Valley. The largest and most extensive flat sheets of flint are just to the north of Blackfellows Caves, with three prominent wave-cut platforms, the largest of which is 80 m long.

A second form of flint within Gambier Limestone is as an infilling of vertical and near-vertical NW-SE trending joints. These were observed only at Nene Valley and can be traced for 5-8 m along strike. The flint forms disrupted vertical sheets which appear as vertical pipes. The effect is enhanced by concentric colour and hardness banding within the "pipes". Flint within the joints tends to be grey or brown and softer than the grey to grey-black flint of adjacent near-horizontal flint beds. The age of jointing and hence earliest timing of silica mobility is difficult to establish. Regional forces producing faults and joints have probably been active since deposition of Gambier Limestone and have continued into the Holocene (Flint, 1988). Volcanics of the Mount Burr Range are aligned along NW-SE faults and have been variously dated at Pliocene-Pleistocene and 20 000 to 2 million years BP. (Dodson, 1974; Marker, 1975). However flint has been reworked into a basal boulder lag within the Bridgewater Formation inferring that silica mobility was pre-Pleistocene.

The origin of the flint is interpreted to be biogenic with flint beds forming from mixed calcareous-siliceous oozes. Relict sponge spicules were observed in brown, grey, and black flint from Bucks Bay and Carpenter Rocks (6922 RS 53, 54 & 58) as well as in grey-black flint from Cape Hart, Kangaroo Island (6256 RS 21). In all outcrops of Gambier Limestone containing flint beds, overlying and underlying lithologies are massive, bryozoal calcarenites. Flint beds occupy only a small fraction of the total volume of the carbonate host. Sponge spicules are regarded as an adequate source of silica. The model of Jones and Fitzgerald (1984, 1987) for silicified layers within the Late Eocene Blanche Point Formation interprets those sediments as originally a mixture of volcanic ash, sponge spicules and calcareous fossil remains.

Diagenetic alteration of volcanic ash produced smectite and clinoptilolite with release of silica and subsequent silicification (crystallisation of opal-CT in 'hard' layers). The diagnostic three-fold assemblage of smectite, silica minerals and zeolite has not been observed either in, or in close proximity to, flint beds within Gambier Limestone exposed along the coast. Hence derivation of silica by diagenetic alteration of volcanic ash is not favoured for the Miocene-Oligocene deposits in the Gambier Embayment. Although sponge spicules are regarded as the immediate source of the silica, this report presents no data on why there was apparently a higher concentration of silica in sea water and/or why the rate of preservation of spicules was increased.

Dissolution during burial is interpreted to have provided the silica required for diagenetic reprecipitation in the sediment. Silica mobility is indicated at Nene Valley where silica has migrated into near-vertical NW-SE joints. At the time of jointing at Nene Valley, the bryozoal calcarenite must have been at least semi-lithified while the silica was still mobile. In addition, flint within joints is zoned (suggesting several stages of emplacement) and may even infill pipe-like structures. The particularly lobate forms in flint beds with protuberances up to 20cm (Plates 2 and 16) and irregular, disseminated flint masses (Plate 1) are also highly suggestive of silica mobility during and shortly after sedimentation.

SUMMARY

Flint in the South East occurs in four geological settings:

- as beds and infilling joints within Gambier Limestone (Late Oligocene to Early Miocene)

- as a boulder conglomerate at the base of the Quaternary Bridgewater Formation,
- as Holocene beach deposits, and
- as a surface lag deposit from gradual lowering of the land surface (minor).

Holocene beach deposits contain flint reworked from both Gambier Limestone and Bridgewater Formation and all three major settings are exposed along the coast between Cape Banks and the Victorian Border. The size, shape and degree of rounding of boulders in these deposits are often diagnostic of the source, even where boulders are being derived from more than one source. The best localities for exhibiting the variety of settings are Nene Valley and the north end of the Douglas Point area. Flint boulders on Kangaroo Island have, to date, only been found in modern beach deposits.

Within Gambier Limestone, flint forms horizontal to gently dipping (1-5°) beds, the most prominent of which crop out as wave-cut platforms up to 80 m long just north of Blackfellows Caves. Beds are discontinuous and usually with highly lobate upper and lower surfaces. A second form of flint within Gambier Limestone occurs as near-vertical dykes which are only exposed at Nene Valley. Dykes are oriented NW-SE, the same as widespread jointing within Gambier Limestone in the South East.

The silica is interpreted to be entirely biogenic and derived from sponge spicules, with deposition of a mixed calcareous-siliceous ooze rather than the typical host rock of massive calcarenite. There is no evidence for silica being derived from volcanic sources. Silica was sufficiently mobile to produce lobate bed forms and to infill NW-SE joints.

Flint was reworked as boulders to form a conglomerate at the base of Bridgewater Formation now exposed at Nene Valley and north of Douglas Point. The conglomerate is cemented by carbonate, is up to several metres thick and comprises well-rounded boulders of moderate sphericity.

Holocene beach deposits along and near the present-day coastline contain an estimated 330 000 tonnes of flint. The largest single accumulation is about 80 000 t at Middle Point - an impressive beach deposit which was partly worked by hand during World War I. Pebbles and boulders on the beaches exhibit many local variations which reflect local sources. Slabby or platy grey flint is best developed at Douglas Point and Orwell Rocks. Rounded boulders of black flint are best developed at Middle Point, whereas brown flint is found mainly at Carpenter Rocks, Bucks Bay and to a lesser extent at Douglas Point. The most spherical pebbles, as distinct from the usual high degree of rounding, are found immediately north of Blackfellows Caves whereas the most spherical boulders are at Middle Point and at the base of cliffs at Douglas Point. All localities from Cape Banks to Stony Point contain a high proportion of irregularly-shaped cavernous boulders of flint, which may be suitable for use as ornamental or aquarium stone.

Total production is estimated to have been between 13 000 and 17 000 tonnes, mainly as flint pebbles used for grinding media, ornamental purposes and as a source of high-grade silica for ceramics. Potential exists for greater use of calcined silica in applications such as ceramics and white cement.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the data and comments provided by Jack Pascoe which added considerably to our knowledge of flint and the flint industry in the South East and was of much benefit in the preparation of this report. Additional historical research by Fred Aslin (SADME- Mount Gambier) was also appreciated.

REFERENCES

Anonymous, 1911. Flint pebbles near Cape Banks. Review of Mining Operations, 14: p9.

Anonymous, 1923. Flint pebbles. Mining Review, Adelaide, 39: p13.

Anonymous, 1975. New flint plant in the Swanscombe chalk Industrial Minerals, June 1975: 44-45.

Anonymous, 1979. Flint - an age old product going steady. Industrial Minerals, January 1979: 21-29.

Anonymous, 1981. The familiar faces of flint. Stone Industries, 16(3): 21-26.

Anonymous, 1983. Matching flint faces. Stone Industries, 18: p17.

Beasley, A.W., 1984. The importance of flint. Australian Gem and Treasure Hunter, March 1984 issue: 34-36.

Burden, A., 1987. Bibliography of flint. South Australian Department of Mines and Energy report 87/46 (unpublished).

Clarke, R.R., 1963. Grime's Graves. Her Majesty's Stationery Office, London.

Coutts, P.J.F., 1982. Coastal archaeology in Victoria. Part 2: Adaption technology and volcanism. Proceedings of the Royal Society of Victoria, 93: 15-22.

Dodson, J.R., 1974. Vegetation history and water fluctuations at Lake Leake, southeastern South Australia. 10 000 BP to Present. Journal of the Geological Society of Australia, 22:719-741.

Felder, W.M., 1971. Bijdrage tot de kennis dergenese van de vuursteenhorizonten. Eerste International Symposium over vuursteen, 26-29 April 1969. Nederlandse Geologische Vereniging, 78-101.

Flint, D.J., 1988. A review of Gambier Limestone - geology, uses, specifications and production. South Australian Department of Mines and Energy report 88/2 (unpublished).

Green, B., 1977. Young people's guide to Grime's Graves. Her Majesty's Stationery Office, London.

Jones, J.B. and Fitzgerald, M.J., 1984. Extensive volcanism associated with the separation of Australia and Antarctica. Science, 226:346-348.

Jones, J.B. and Fitzgerald, M.J., 1987. An unusual and characteristic sedimentary mineral suite associated with the evolution of passive margins. Sedimentary Geology, 52:45-63.

Keeling, J.L., 1982. Review of high grade lump silica sources in South Australia - A review. Mineral Resources Review, South Australia, 154: 54-59.

Lindsay, J.M., 1967. E&WS Dept. Millicent bores 2 and 5. Micropalaeontological examination of Gambier Limestone sections. South Australian Department of Mines Report 64/116 (unpublished).

Ludbrook, N.H., 1980. A guide to the geology and mineral resources of South Australia. Government Printer of South Australia, Adelaide.

Marker, M.E., 1975. The lower southeast of South Australia: a karst province. Department of Geography and Environmental Studies, University of Witwatersrand, Johannesburg, Occasional Paper, 13:1-68.

Mason, H.J., 1978. Flint - The versatile stone. Providence Press, Cambridgeshire.

Olliver, J.G. and Nichol, D., 1978. Longwood clay deposits, County Adelaide hundred Noarlunga, sections 326, 327, 328, 331, 332, 333 (ML 2754 - Bradbury Industries). Mineral Resources Review, South Australia, 142: 119-132.

Orna, B. and Orna, E., 1984. Flint in Norfolk Building. Running Angel Press, Norwich.

Pain, A.M., 1971. Preliminary report breakwater construction materials Port MacDonnell - Department of Marine and Harbours. South Australian Department of Mines and Energy report 69/117 (unpublished).

Pretty, G.L., 1977. The cultural chronology of the Roonka Flat: a preliminary consideration. In: Stone tools as cultural markers, R.V.S. Wright (editor), Prehistory and material culture series, 12: 288-331. (AIAS, Canberra).

Sieveking, G. de C. and Hart, M.B., 1986. The scientific study of flint and chert. Proceedings of the 4th International Flint Symposium held at Brighton Polytechnic, 10-15 April, 1983. Cambridge University Press, Cambridge.

Sprigg, R.C., 1952. The Geology of the South-east province, South Australia, with special reference to Quaternary coast-line migrations and modern beach developments. Bulletin, Geological Survey of South Australia, 29: pp 27, 33.

Tate, R., 1879. Transactions of the Philosophical Society of South Australia, 2: p109.

Ward, L.K., 1949. Flint pebbles. Mining Review, Adelaide, 87: p155.

Waterhouse, J.D., 1977. The hydrogeology of the Mount Gambier area. Report of Investigations, Geological Survey of South Australia, 48.

Watkins, D.C., 1978. Sauna stove stones. South Australian Department of Mines and Energy report 78/21 (unpublished).

Willington, C.M., 1956. Flint deposits - County Grey. Mining Review, Adelaide, 100: 100-102.

PLATES 1-8, CAPTIONS

1. Flint bed and irregular concretion. Flat, sheet-like bed of grey flint with thin white rind and irregular-shaped mass of flint (below) set in cream-coloured calcarenite of Gambier Limestone. 1.5 km SE of Blackfellows Caves at Locality Nene Valley-1. Slide No. 38133

2. Flint bed with protuberances. Semi-continuous bed of flint but with pronounced protuberances, apparently by silica mobility, into adjacent calcarenite of Gambier Limestone. 1.5 km SE of Blackfellows Caves at Locality Nene Valley-1. Slide No. 38134

3. Flint within joints. Double row of flint pods and lenses along steep joint trending 125°M within Gambier Limestone. Present beach comprised of sand and small flint pebbles as well as flint boulders (background). 1.5 km SE of Blackfellows Caves at Locality Nene Valley-1. 12/05/84. Slide No. 38135

4. Flint within joints. Prominent, double row of flint lenses along steep SE-NW trending joint within poorly-outcropping Gambier Limestone. 1.5 km SE of Blackfellows Caves at Locality Nene Valley-1. 7/03/85. Slide No. 38136

5. Zoned flint within joints. Colour zoning along the margins of flint lenses infilling steep joints trending 150°M. Unaltered calcarenite between the lenses. Grey-black flint within each lens rapidly develops the milky rind upon exposure. 1.8 km SE of Blackfellows Caves at locality Nene Valley-1. View vertical. Slide No. 38137.

6. Flint conglomerate. Prominent basal conglomerate (Bridgewater Formation) of flint boulders overlying Gambier Limestone. View SE. Locality is Nene Valley-2, Grid 544987.
March 1985. Slide No. 38138

7. Cemented conglomerate. Prominent outcrop of cemented boulders of flint, Bridgewater Formation. Boulder shapes are irregular, including cavernous but tend to be well rounded. MW Flintoft, 12/05/84. Locality is Nene Valley-2. Slide No. 38139

8. Contact. Cemented conglomerate of flint boulders (Bridgewater Formation) overlying two layers of flint slabs within calcarenite of Gambier Limestone. Locality is Nene Valley-2, Grid 544987.
7/03/85. Slide No. 38140

1

2

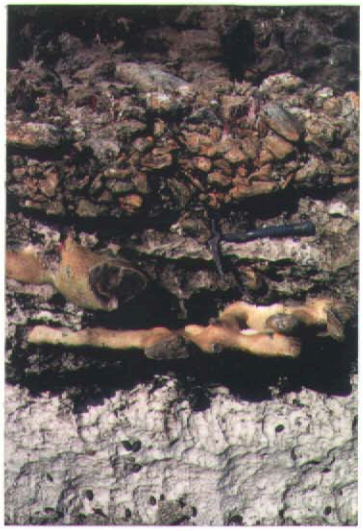
3

4

5

6

7



8

PLATES 9-16, CAPTIONS

9. Contact. Cemented conglomerate of poorly-rounded flint boulders (Bridgewater Formation) overlying calcarenite of Gambier Limestone. Locality as above. Slide No. 38141

10. Contact. Boulders of black flint with white rinds in red-brown soil at the base of the Bridgewater Formation overlying cream coloured calcarenite of Gambier Limestone. Locality as above. 12/05/84. Slide No. 38142

11. Reworked flint. Bridgewater Formation aeolianite and soil overlies outcrop of Gambier Limestone calcarenite containing a gently-dipping bed of flint. Flint is reworked into present-day beach deposit (dark grey boulders and pebbles) and storm-ridge deposit (light grey boulders). View SE, 12/05/84. Locality is Douglas Point -7. Slide No. 38143

12. Middle Point deposit. Extensive deposit with 4-5 m bank of large flint boulders with a very high degree of rounding. Half of this deposit was reworked by hand during World War I. Locality Middle Point-2, view E, 12/05/84. Slide No. 38144

13. Grey pebbles, Blackfellows Caves. Typical very well rounded, grey to dark grey flint pebbles just N of Blackfellows Caves. Minimal weathering skin but with minor relict limestone within surface indentations. Present-day beach zone

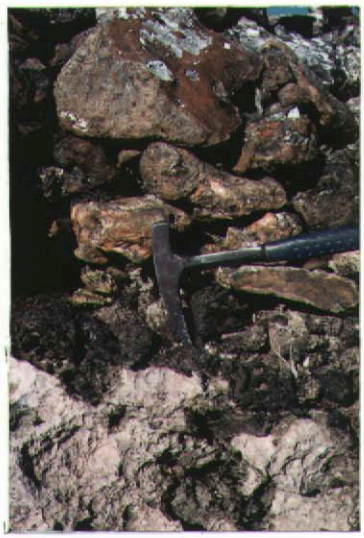
Slide No. 38145

14. Grey and brown pebbles, Bucks Bay. Typical mixture of well-rounded grey and brown flint pebbles from present-day beach zone. Thicker white rinds than pebbles from Blackfellows Caves and with more relict calcarenite in deeper surface indentations.

Slide No. 38146

15. Mixed grey and black flint, Carpenter Rock. Rounded boulders include deeply cavernous shapes. Note thin weathering rind on grey flint contrasts with thicker, whiter rind on black flint. Relict white calcarenite on larger surface indentations. ML 2864. Slide No. 38147

16. Cavernous grey flint. Cavernous boulder of grey flint with numerous calcarenite inclusions. White surface is dominantly weathering rind. Ornamental stone. Douglas Point. Slide No. 38148



9

10

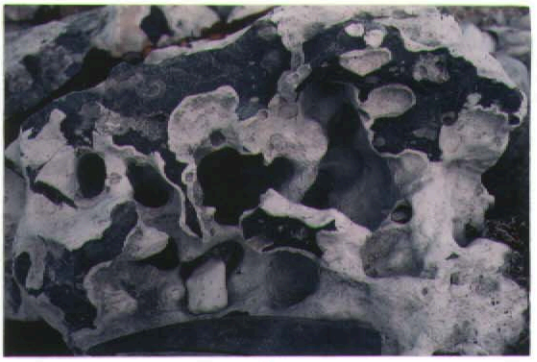
11

12

13

14

15



16

APPENDIX A

PETROGRAPHY, MINERAGRAPHY AND SAMPLE DESCRIPTIONS OF FLINT FROM THE SOUTH EAST

7021	RS 31	Point Douglas	Light grey, slabby flint
	RS 32	" "	" " " "
	RS 33	" "	Boulder with diffuse colour banding; grey to medium dark grey flint
	RS 34	Middle Point	Black to grey black, slabby flint
	RS 35	" "	Very well-rounded pebble of black flint; strong conchoida fracture. Approaching highest grade available.
6256	-	Cape Hart (Kangaroo Island)	
	RS 22	"	Boulder of distinctly mottled flint with only 10% black; minimal rounding.
	RS 23	"	As above - but with 75% black flint.
	RS 24	"	Even-coloured flint with a dark grey colour and thin (< 1m white rind.
6922	RS 52	Carpenters Rocks, ML 2865	Very well-rounded pebble but of pale grey brown flint. Low quality.
	RS 53	" " "	As above - but brown to slightly orange-brown colour.
	RS 54	" " "	Very well-rounded pebble, 80mm across, of grey to dark grey flint but with cavernous limestone.
	RS 56	" " ML 2864	Dark grey to grey black, slabby flint.
	RS 57	" " "	Rounded boulder of grey-black flint with distinct conchoid fracture and rare bryozoal fragments. High quality.
	RS 58	" " "	Black high-grade flint in core of limestone boulder.
	RS 59	Blackfellows Caves	Typical medium grey, very well-rounded pebble from beach on N side of Blackfellows Caves. Hand specimen contains pyrite.
	RS 62	Hd. Kongorong, sec. 392	Pale to medium brown-grey flint from NW - trending joint, minor bryozoal fragments, thick white rind.

A 13/85	Carpenters Rocks, ML 2865	Very well-rounded pebbles of brown flint. Regarded as identical with 6922 RS 52 and 53.
A 14/85	Hd. Kongorong, Sec. 392	8 X 5 X 3 cm very well rounded pebble of dark grey flint
A 15/85	Middle Point, ML 2638	Well rounded, highly-spherical pebble of dark grey flint, abundant bryozoal fragments.
A 16/85	" " "	Large pebble of black flint with carbonate inclusions.
A 17/85	Carpenters Rocks, ML 2865	Rounded to well rounded large pebble (10 X 7 X 2.5 cm) of brown, cavernous flint. Apparently low grade.
A 18/85	" " "	Very well-rounded pebble (8 X 6.5 X 2 cm) of dark grey flint; thin milky rind.
A 19/85	" " "	Dark grey to grey-black flint pebbles to 7 X 6 X 1.5 cm. Thin to minimal rind and no cavities.

To D. Flint - Mineral Resources

The Australian Mineral Development Laboratories

Flemington Street, Frewville,
South Australia 5063
Phone Adelaide (08) 79 1662
Telex AA82520

Please address all correspondence to
P.O. Box 114 Eastwood
SA 5063
In reply quote:

amdel

13 November 1984

GS 1/16/0

Your Ref: 12.03.121 EX-246

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

Attention: Mr D.J. Flint

REPORT G 6112/85

YOUR REFERENCE:	Application dated 4 October 1984
IDENTIFICATION:	6922 RS 52-62, 7021 RS 31-35
MATERIAL:	16 rock samples
LOCALITY:	Gambier Embayment, Otway Basin
DATE RECEIVED:	5 October 1984
WORK REQUIRED:	Petrography (16 MA1.3) and mineragraphy (1 MA2.2)

Investigation and Report by: Frank Radke

Chief, Geological Services Section: Dr Keith J. Henley

Keith Henley

for Dr William G. Spencer
Manager, Mineral and Materials Sciences Division

jd/17

Head Office:
Flemington Street, Frewville
South Australia 5063,
Telephone (08) 79 1662
Telex: Amdel AA82520
Pilot Plant:
Osman Place
Thebarton, S.A.
Telephone (08) 43 8053
Branch Laboratories:
Melbourne, Vic.
Telephone (03) 645 3093
Perth, W.A.
Telephone (09) 325 7311
Townsville
Queensland 4814
Telephone (077) 75 1377

PETROGRAPHY OF FIFTEEN FOSSILIFEROUS CHERTS AND ONE CALCRETE

1. SUMMARY

All except one of these samples have been termed 'fossiliferous cherts' and consist of very finely granular chert which forms a matrix through which fossil fragments are disseminated. These fossil fragments consist of unstained carbonate (probably dolomite) and smaller amounts of calcite and also shows some replacement by chert and chalcedony. The degree of replacement of the fossil fragments varies greatly with some samples having highly silicified fragments and other samples having fragments showing little silificiation. Many of the larger fossil fragments tend to have a zoned character with calcite cores and dolomitic outer margins suggesting that the dolomitic fossil fragments could be a product of dolomitization of original calcite fragments. A few of the silicified fossil fragments also have zoned characters with carbonate and calcite cores and siliceous outer margins. One fossiliferous chert sample (6922 RS 59) also contains disseminated pyrite within localized areas.

Sample 6922 RS 60 is totally different from the other samples and is considered to be a calcrete comprised mainly of micritic calcite.

2. PETROGRAPHY AND MINERAGRAPHY

All of the thin sections described in this report have been stained with an alizarin red-S solution to distinguish calcite from other carbonates by staining it pink and in the petrographic descriptions calcite is used only for stained carbonate. The unstained carbonate is thought to be dolomite in all cases.

Sample: 6922 RS 52; TSC43560

Rock Name:
Fossiliferous dolomite/chert

Hand Specimen:
This is a mottled rock with a variable pale tan to grey colour.

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

	%
Dolomitic matrix	40
Cherty matrix	35
Fossil fragments	25
Glauconite	trace
Opaques	trace-1

This sample consists mainly of fossil fragments disseminated through a very fine-grained matrix with a variable mineralogy locally consisting mainly of chert or dolomite. The dolomitic matrix has a very finely granular texture and is intergrown with minor amounts of finely granular cherty silica. The cherty matrix consists of very finely granular chert and locally contains irregular patches of dolomite believed to be remnant patches of an original dolomitic matrix.

The fossil fragments consist mainly of finely granular chert and fibrous chalcedony as well as smaller amounts of carbonate including some calcite. A significant proportion of the fossil fragments have elongate shapes typical of sponge spicules but others are obviously shell fragments. Some of the shell fragments have been replaced by finely granular chert but others consist of calcite or an unstained carbonate.

Traces of glauconite were noted as small pellets below 0.1 mm wide which have a pale green to brownish-green colour. Minor opaques are disseminated through the rock as anhedral grains up to 0.1 mm wide.

This rock is considered to represent a fossiliferous dolomite which has been locally replaced by finely granular chert.

Sample: 6922 TS 53; TSC43561

Rock Name:
Fossiliferous chert

Hand Specimen:
A massive, brown coloured rock containing some irregular voids lined with a dull white to pale tan material which reacts strongly to dilute hydrochloric acid indicating it consists largely of calcite. The rock also contains some finely disseminated dull white areas which also consist mainly of calcite.

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

	%
Cherty matrix	65
Fossil fragments	25
Carbonate	10
Opaques and semi-opaques	trace-1

This sample consists mainly of fossil fragments disseminated through a very finely granular, cherty matrix. Most of the matrix consists of very fine-grained chert and weakly anisotropic silica intergrown with small amounts of finely granular carbonate. Locally the matrix consists of fibrous, chalcedonic silica which forms well developed radiating aggregates or slightly more coarsely granular chert patches.

The fossil fragments now consist mainly of very finely granular chert or carbonate including minor calcite. Many of the siliceous fossil fragments have shapes typical of sponge spicules and are considered to be original siliceous deposits but others have shapes indicating they were originally shells and are believed to represent carbonate fossils which have been silicified. Some of these carbonate fossils contain remnants of finely granular carbonate and calcite but have been largely replaced by a fibrous, slightly more birefringent chalcedony.

Opaques are disseminated through the rock as anhedral grains and aggregates up to 0.1 mm wide.

This rock is most likely a fossiliferous limestone or dolomite which has been pervasively silicified producing a cherty matrix with minor remnant carbonate. The fossil fragments consist of both siliceous sponge spicules and shell fragments which have been partially silicified.

Sample: 6922 RS 54; TSC43562

Rock Name:
Fossiliferous chert

Hand Specimen:
This is a massive, dark grey rock containing some irregular dull white patches up to about 1 cm wide.

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

	%
Cherty matrix	55
Fossil fragments	20
Amorphous silica	15
Carbonate	10
Opaques and semi-opaques	1

This sample consists mainly of fossil fragments disseminated through a very finely granular, cherty matrix. Most of the matrix consists of finely granular chert with a typical grain size below 0.05 mm but locally the matrix consists of a turbid brown amorphous silica with an isotropic character. The amorphous silica would represent the dull white patches noted in hand specimen and the brown turbidity is believed to be due to very finely disseminated leucoxene which accounts for its white character.

The fossil fragments have been largely replaced by finely granular cherty silica which has a slightly coarser grain size than the bulk of the matrix. Some of the fossil fragments have also been replaced by a fibrous, slightly more birefringent chalcedony. Remnants of carbonate including granular unstained carbonate and small amounts of calcite also occur in the fossil fragments. Most of the fossil fragments are thought to be calcareous shells which have been replaced by siliceous material but a few elongate fossil fragments which are thought to be siliceous sponge spicules are also present.

Very finely disseminated carbonate occurs in the cherty matrix as small rhomb-shaped crystals up to 0.1 mm wide. Opaque to translucent iron and titanium oxides form fine disseminated grains and aggregates up to 0.3 mm wide.

This is considered to be a fossiliferous limestone or dolomite which has been subjected to silicification comprised mainly of finely granular chert with smaller amounts of amorphous silica.

Sample: 6922 RS 55; TSC43563

Rock Name:
Fossiliferous chert

Hand Specimen:
A massive rock containing angular pale grey to tan fragments up to a few millimetres wide disseminated through a darker grey matrix.

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

	%
Cherty matrix	60
Fossil fragments	40
Opaques and semi-opaques	1

This sample consists mainly of fossil fragments up to several millimetres wide disseminated through a very finely granular, cherty matrix. The matrix has an equigranular texture with a grain size below 0.05 mm and locally contains irregular patches of slightly coarser-grained quartz/chert. Many of the coarser-grained patches have round shapes and could represent silicified fossils.

The fossils which are disseminated through the rock consist mainly of fibrous chalcedonic silica with a slightly higher birefringence than the chert intergrown with granular carbonate and calcite. These fragments have angular, broken shapes and would represent the disseminated material noted in hand specimen. Virtually all of the fossil fragments have been replaced by fibrous chalcedony leaving only minor remnants of carbonate or more rarely calcite. A few fossil fragments consist mainly of calcite or carbonate.

Minor opaques are disseminated through the rock as small grains and aggregates up to 0.1 mm wide.

This is a silicified fossiliferous limestone or dolomite now comprised of a cherty matrix with fossil fragments which have also been largely replaced by chalcedony and chert.

Sample: 6922 RS 56; TSC43564

Rock Name:
Fossiliferous chert

Hand Specimen:
A dark grey to black coloured rock with a dull white weathering rind which penetrates up to several millimetres into the rock.

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

	%
Cherty matrix	60
Fossil fragments	40
Opaques and semi-opaques	1

This sample consists mainly of fossil fragments disseminated through a finely granular cherty matrix. The matrix has a typical grain size of about 0.05 mm and consists mainly of granular-textured chert. Locally the matrix contains radiating aggregates of chalcedony and this is particularly well developed within the chambers of some shell fragments. The matrix also contains small amounts of very finely disseminated carbonate which could represent remnant shell fragments.

The fossil fragments now consist mainly of granular carbonate and fibrous chalcedony which has a slightly higher birefringence than most of the chert. Very minor amounts of calcite also occur within some shell fragments. The shell fragments generally have a slightly turbid character produced by concentrations of opaque to translucent material within the chalcedony.

The weathering rind noted in hand specimen is similar in character to the rest of the rock except that it contains a concentration of a translucent brown material believed to represent leucoxene. This leucoxene would account for the white colour of the weathering rind. Minor opaques are also disseminated through the rock as small grains and aggregates below 0.05 mm wide.

This is considered to be a fossiliferous limestone or dolomite which has been silicified producing a cherty matrix along with partially silicified fossil fragments.

Sample: 6922 RS 57; TSC43565

Rock Name:
Fossiliferous chert

Hand Specimen:
A massive dark grey to black rock with a dull white weathering rind which penetrates approximately 3 mm into the sample.

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

	%
Chert/chalcedony	65
Carbonate	30
Calcite	2
Opaques and semi-opaques	2

This sample consists mainly of very finely granular chert intergrown with granular carbonate. The chert consists mainly of a very finely granular mosaic but locally forms slightly coarser-grained mosaics or fibrous, chalcedonic aggregates. The carbonate is finely intergrown with the chert as small granular aggregates. Remnant fossiliferous textures are evident and are comprised of both granular carbonate and fibrous, chalcedonic silica. These fossils comprise approximately 35% of the sample. Much of the carbonate occurs as remnant fossil fragments but some carbonate forms small granular aggregates which could also represent fossil fragments or possibly finely disseminated remnant carbonate with another origin.

Traces of calcite are disseminated through the rock as very small grains up to 0.1 mm wide. Some of the calcite also occurs in fossil fragments. Opaque to translucent iron and titanium oxides form small disseminated grains and aggregates producing a localized turbidity. Some areas of the matrix have a turbid brown colour due to very finely intergrown leucoxene.

This is believed to be a fossiliferous limestone or dolomite which has been largely replaced by chert and chalcedony leaving minor remnant carbonate and traces of calcite.

Sample: 6922 RS 58; TSC43566

Rock Name:
Fossiliferous chert

Hand Specimen:
A dark grey to black rock containing some irregular dull white patches as well as a weathering rind up to 1 cm thick with a dull white colour.

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

	%
Chert/chalcedony	70
Carbonate	25
Calcite	1
Opaques and semi-opaques	2

This sample consists mainly of very fine-grained chert intergrown with smaller amounts of finely granular carbonate. The chert forms a finely granular matrix with a typical grain size below 0.05 mm and is generally intergrown with granular carbonate with a similar grain size which forms small patches up to 0.2 mm wide. A fossiliferous texture is evident with about 25% of the sample being comprised of fossils. These fossils have been replaced by fibrous chalcedonic silica but still retain moderate amounts of remnant carbonate and minor calcite. Some elongate, rod-like siliceous fossils are also present and most likely represent sponge spicules.

Opaque to translucent iron and titanium oxides are disseminated through the rock as small grains and aggregates up to 0.1 mm wide. Locally the rock has a translucent brown colour produced by very finely divided material which is believed to be leucoxene. The leucoxene is concentrated along one margin which would represent the dull white weathering rind noted in hand specimen. Leucoxene also tends to be concentrated as finely granular turbid intergrowths with some chalcedonic silica.

This is a fossiliferous limestone which has been largely replaced by finely granular chert and fibrous chalcedony but still retains a remnant fossiliferous texture.

Sample: 6922 RS 59; TSC43567

Rock Name:
Pyritic chert

Hand Specimen:
A dark grey to black rock containing areas with disseminated pyrite. The rock also has localized reddish-brown iron staining on its surface.

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

	%
Chert/chalcedony	85
Carbonate	10
Pyrite	5
Leucoxene	trace-1

This rock consists mainly of very finely granular chert intergrown with smaller amounts of carbonate. The chert retains a remnant fossiliferous texture containing partially silicified shell fragments with irregular carbonate remnants. Most of the carbonate is present as remnant shell fragments. Within some areas the shell fragments have been partially replaced by a fibrous, chalcedonic silica.

Pyrite is disseminated through one portion of the thin section as subhedral crystals and polycrystalline aggregates up to 0.5 mm wide. The pyrite is unevenly distributed through the rock being present within localized bands and patches. The rock also contains very finely disseminated leucoxene which locally forms very fine intergrowths with the chert.

This is believed to be a fossiliferous limestone or dolomite which has been largely silicified leaving minor remnant carbonate. The rock also locally contains disseminated pyrite.

Sample: 6922 RS 60; TSC43568

Rock Name:
Calcrete

Hand Specimen:
A medium grey coloured rock with some irregular dull white or darker grey patches.

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

	%
Calcite	98
Quartz	trace
Opaques and semi-opaques	2

This is essentially a monomineralic rock comprised of micritic calcite intergrown with irregular patches of more coarsely granular, sparry calcite. The micritic calcite at least locally exhibits a weakly developed fragmental character containing irregular patches up to a few millimetres wide with slightly varying textures and turbidity. The sparry calcite patches rarely exceed 0.5 mm wide and at least locally tend to have elongate, vein-like shapes.

Traces of quartz form small, disseminated grains up to 0.15 mm wide which tend to have angular shapes. Opaque to translucent iron and titanium oxides form very finely divided intergrowths with the micritic calcite.

This is a calcite-rich rock with a fragmental texture typical of calcretes.

Sample: 6922 RS 61; TSC43569

Rock Name:
Fossiliferous chert

Hand Specimen:
This is a dark grey to black rock containing a weathering rind up to 1 cm wide with a dull white to pale grey colour.

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

	%
Cherty matrix	65
Carbonate	30
Calcite	1
Opaques and semi-opaques	3

This sample consists mainly of very finely granular chert intergrown with finely disseminated carbonate. The chert forms a finely granular matrix through which shell fragments are disseminated. The shell fragments consist largely of finely granular carbonate but have also been largely replaced by chert and fibrous chalcedony. Most of the carbonate consists of remnant fossil fragments but some dolomite rhombs are present and appear to represent recrystallized carbonate. The carbonate consists mainly of unstained material although small amounts of calcite are present within some remnant fossil fragments.

Opaque to translucent iron and titanium oxides form very finely disseminated grains and aggregates. The dull white rinds noted in hand specimen contain a concentration of finely divided leucoxene which imparts a translucent brown colour to the rock and also accounts for its white character in hand specimen.

This sample is considered to represent a fossiliferous limestone or dolomite which has been replaced by finely granular chert leaving minor amounts of remnant dolomite.

Sample: 6922 RS 62; TSC43570

Rock Name:
Fossiliferous chert

Hand Specimen:
A massive, pale grey coloured rock with a dull white weathering rind which penetrates up to several millimetres into the rock.

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

	%
Chert	55
Carbonate	35
Calcite	8
Opaques and semi-opaques	2

This sample consists mainly of very finely granular chert which forms a matrix through which carbonate-rich fossil fragments are disseminated. Most of the carbonate forms very finely granular-textured fossil fragments up to 0.8 mm wide which consist mainly of unstained carbonate although smaller amounts of calcite are also present. Virtually all of the carbonate and calcite occur as remnant fossil fragments although a minor proportion of carbonate forms finely granular intergrowths with the chert which lack any remnant fossil textures. Most of the chert has a very finely granular texture although small amounts of fibrous, chalcedonic material are also present.

The rock contains very finely disseminated opaque to translucent iron and titanium oxides which impart a slightly turbid character. One margin of the thin section contains a concentration of very finely granular, translucent brown leucoxene and would represent the white rind noted in hand specimen.

This is considered to be a limestone or dolomite which has been partially silicified producing abundant finely granular chert with remnant calcareous fossil fragments.

Sample: 7021 RS 31; TSC43571

Rock Name:
Fossiliferous chert

Hand Specimen:
A medium grey coloured rock with some paler dull white to grey mottling as well as a dull white rind up to a few millimetres wide.

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

	%
Chert	50
Carbonate	35
Calcite	12
Opaques and semi-opaques	3

This sample consists mainly of very finely granular chert intergrown with granular carbonate which generally consists of remnant fossil fragments. Most of the carbonate forms irregular shell fragments and consists of unstained carbonate although moderate amounts of calcite occurs in the cores of some shell fragments. Some calcite forms finely granular intergrowths with the cherty matrix with no textural evidence indicating that they represent remnant fossils.

Most of the chert forms a very finely granular, cherty-textured matrix but a small proportion of fibrous chalcedonic to more coarsely granular quartz is locally present. This material generally fills rounded voids within chambered shell fragments.

Minor amounts of opaque to translucent iron and titanium oxides form small disseminated grains and aggregates. Locally the rock has a slightly turbid brown colour produced by concentrations of finely divided leucoxene. These areas would most likely represent the paler coloured patches noted in hand specimen.

This is considered to be a fossiliferous limestone or dolomite which has been largely replaced by finely granular chert.

Sample: 7021 RS 32; TSC43572

Rock Name:
Fossiliferous chert

Hand Specimen:
A dark grey coloured rock containing some irregular dull white patches as well as a white weathering rind which penetrates up to 3 mm into the sample.

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

	%
Chert	70
Carbonate	23
Calcite	5
Opaques and semi-opaques	2

This sample consists mainly of finely granular chert intergrown with carbonate which generally forms fossil fragments. Most of the carbonate also has a finely granular texture and consists of broken shell fragments. A small proportion of the carbonate forms rhomb-shaped crystals or finely granular intergrowths with the cherty matrix. Most of the carbonate is unaffected by the alizarin red-S stain but a small proportion of stained calcite is also present.

Most of the chert forms very finely granular aggregates although locally fibrous-textured chalcedony with a slightly higher birefringence is present. Some of this chalcedony occurs as a replacement product of fossil fragments. Minor fibrous chalcedony and slightly more coarsely granular chert also form fillings of chambered fossil fragments.

Opaque to translucent iron and titanium oxides form finely disseminated grains and aggregates below 0.1 mm wide. Locally a turbid brown leucoxene is slightly more abundant and would represent the white areas noted in hand specimen.

This is considered to be a fossiliferous limestone or dolomite which has been largely replaced by chert and minor chalcedony.

Sample: 7021 RS 33; TSC43573

Rock Name:
Fossiliferous chert

Hand Specimen:
A medium grey coloured rock with some paler coloured patches up to a few millimetres wide. The rock also has a dull white weathering rind approximately 1 mm wide.

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

	%
Chert	45
Carbonate	40
Calcite	13
Opaques and semi-opaques	2

This sample consists mainly of finely granular chert intergrown with carbonate most of which represents fossil fragments. The carbonate consists mainly of an unstained carbonate believed to be dolomite although most of the larger fossil fragments contain moderate amounts of calcite. Some of the larger fossil fragments have calcite cores and dolomite around their outer margins. These fossil fragments are up to several millimetres wide and show a variety of shapes and textures.

The cherty matrix consists mainly of very finely granular, cherty-textured quartz although locally minor amounts of slightly more coarsely granular quartz or fibrous chalcedony are present. The more coarsely granular quartz generally occurs in the chambers of some fossil fragments. Some of the fossil fragments have also been partially replaced by chert and chalcedonic silica.

Opaques to translucent iron and titanium oxides form finely disseminated grains and aggregates which locally impart a translucent, brown colour to the rock.

This is considered to be a fossiliferous limestone or dolomite which has been largely replaced by finely granular chert.

Sample: 7021 RS 34; TSC43574

Rock Name:
Fossiliferous chert

Hand Specimen:
A dark grey to black rock with some paler grey to dull white mottling as well as a white alteration rind up to 3 mm thick.

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

	%
Chert	75
Carbonate	17
Calcite	5
Opaques and semi-opaques	3

This sample consists mainly of very finely granular chert intergrown with smaller amounts of carbonate including some calcite. The carbonate generally occurs as small fossil and shell fragments up to 0.5 mm wide. A small proportion of carbonate is also disseminated through the rock as small grains or rarely small, rhomb-shaped crystals. The calcite in particular occurs only as fossil fragments and some of these have calcite cores with dolomitic outer margins.

Most of the finely granular chert forms a matrix although some chert as well as fibrous chalcedony occurs as a replacement product of fossils. Minor amounts of slightly more coarsely granular quartz and fibrous chalcedony also forms fillings of chambered fossils.

Opaque to translucent iron and titanium oxides form small grains and aggregates up to 0.1 mm wide. The dull white patches and rind noted in hand specimen contain a concentration of translucent brown leucoxene.

This is believed to be a fossiliferous limestone or dolomite which has been largely replaced by finely granular, cherty silica.

Sample: 7021 RS 35; TSC43575

Rock Name:
Fossiliferous chert

Hand Specimen:
A dark grey to black rock with a dull white rind up to 1 mm thick.

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

	%
Chert	80
Carbonate	15
Calcite	3
Opaques and semi-opaques	2

This sample consists of a very finely granular, cherty matrix through which fossil fragments are disseminated. The fossil fragments consist largely of finely granular carbonate and small amounts of calcite and include shell fragments up to 1 mm long. Most of the carbonate and calcite occurs in fossil fragments but many of them have been partially replaced by finely granular chert and fibrous chalcedony. A few fragments contain carbonate and calcite cores with cherty outer margins. A small proportion of the carbonate forms well developed rhomb-shaped crystals which are intergrown with the cherty matrix.

Most of the chert has a very fine grain size below 0.05 mm but locally slightly coarser-grained chert is present. The coarser-grained chert generally occurs within chambered fossils.

Opaque to translucent iron and titanium oxides form small disseminated grains and aggregates up to 0.1 mm wide.

This is a fossiliferous limestone or dolomite which has been subjected to silicification producing abundant finely granular chert and some fibrous chalcedony.

APPENDIX B

CHEMICAL ANALYSES OF FLINT FROM THE SOUTH EAST AND KANGAROO ISLAND

To D. Flint – Mineral Resources

The Australian
Mineral Development
Laboratories

Flemington Street, Frewville,
South Australia 5063
Phone Adelaide 79 1662
Telex AA 82520

Please address all
correspondence to
P.O. Box 114 Eastwood
SA 5063
In reply quote:

amdel

1/16/0 - AC 2776/85

8 February 1985

NATA CERTIFICATE

The Director General
S.A. Department of Mines & Energy
P.O. Box 151
EASTWOOD S.A. 5063

REPORT AC 2776/85

YOUR REFERENCE: EX-301 12/03/141

REPORT COMPRISING: Cover sheet
Pages I1 - I9
Page X1

DATE RECEIVED: 3 January 1985

D. Patterson

D. Patterson
Chief Chemist
Analytical Chemistry Division

mo

Head Office:
Flemington Street, Frewville
South Australia 5063,
Telephone (08) 79 1662
Telex: Amdel AA82520
Pilot Plant:
Osman Place
Thebarton, S.A.
Telephone (08) 43 8053
Branch Laboratories:
Melbourne, Vic.
Telephone (03) 645 3093
Perth, W.A.
Telephone (09) 325 7311
Townsville
Queensland 4814
Telephone (077) 75 1377

amdel

Analysis code H1 Report AC 2776/85 Page I5

NATA Certificate Results in percentages

	7021 RS31	7021 RS32	7021 RS33	7021 RS34	7021 RS35
SiO2	81.5	86.1	78.2	90.0	95.8
TiO2	0.02	<0.010	0.03	<0.010	<0.010
Al2O3	0.35	0.15	0.29	0.13	0.15
Fe2O3	0.13	0.07	0.14	0.08	0.08
MnO	<0.010	<0.010	<0.010	<0.010	<0.010
MgO	0.52	0.35	0.39	0.23	0.19
CaO	9.05	6.15	10.5	4.52	1.38
Na2O	0.14	0.09	0.21	0.11	0.06
K2O	0.10	0.06	0.09	0.08	0.08
P2O5	0.04	<0.010	0.05	0.02	0.02
LOI	8.20	6.00	9.20	4.60	2.48
Totals	100.0	98.9	99.1	99.7	100.2
BA	<0.002	<0.002	<0.002	<0.002	<0.002
SR	0.003	<0.001	0.005	<0.001	<0.001
CU	0.009	0.011	0.007	0.004	0.005
NI	0.003	0.003	0.004	0.003	0.002
ZN	0.002	<0.001	0.002	0.001	0.001
PB	0.015	0.006	0.012	0.011	0.008
CR	0.005	0.005	0.007	0.006	0.007
V	0.002	0.002	0.003	0.003	0.001
CO	0.005	0.007	0.005	0.006	0.008
ZR	0.009	0.007	0.008	0.008	0.007
LA	0.006	0.003	0.006	0.005	0.004
Y	0.001	<0.001	0.002	<0.001	<0.001
MO	<0.002	<0.002	0.002	<0.002	<0.002

Total FE as Fe2O3

amdel

Analysis code H1 Report AC 2776/85 Page I6

NATA Certificate Results in percentages

	6256 RS22	6256 RS23	6256 RS24	6922 RS52	6922 RS53
SiO2	94.1	95.1	87.4	82.1	95.1
TiO2	0.02	0.01	<0.010	0.02	0.01
Al2O3	0.25	0.27	0.16	0.38	0.25
Fe2O3	0.11	0.28	0.08	0.16	0.26
MnO	<0.010	<0.010	<0.010	<0.010	<0.010
MgO	0.23	0.61	1.77	0.27	0.10
CaO	1.25	0.84	4.24	8.45	1.05
Na2O	0.13	0.13	0.08	0.18	0.11
K2O	0.14	0.11	0.09	0.13	0.12
P2O5	<0.010	0.01	0.05	0.03	<0.010
LOI	2.46	2.54	5.85	8.95	2.54
Totals	98.7	99.9	99.7	100.7	99.5
BA	<0.002	<0.002	<0.002	<0.002	<0.002
SR	<0.001	<0.001	0.002	0.005	<0.001
CU	0.006	0.014	0.005	0.005	0.004
NI	0.004	0.005	0.004	0.004	0.003
ZN	0.003	<0.001	0.002	0.001	<0.001
PB	0.011	0.010	0.011	0.007	0.007
CR	0.005	0.006	0.006	0.006	0.004
V	0.003	0.002	0.002	0.002	0.002
CO	0.010	0.010	0.009	0.006	0.007
ZR	0.010	0.008	0.009	0.008	0.007
LA	0.006	0.004	0.006	0.005	0.003
Y	0.002	<0.001	<0.001	<0.001	0.001
MO	<0.002	<0.002	<0.002	0.002	<0.002

Total FE as Fe2O3

amdel

Analysis code H1 Report AC 2776/85 Page I7

NATA Certificate Results in percentages

	6922 RS54	6922 RS56	6922 RS57	6922 RS58	6922 RS59
SiO2	95.6	94.4	95.7	93.4	94.0
TiO2	0.01	0.01	<0.010	0.02	0.01
Al2O3	0.22	0.17	0.18	0.28	0.13
Fe2O3	0.08	0.08	0.10	0.13	1.07
MnO	<0.010	<0.010	<0.010	<0.010	<0.010
MgO	0.15	0.13	0.09	0.17	0.06
CaO	0.48	1.96	0.99	1.23	0.77
Na2O	0.12	0.12	0.14	0.40	0.06
K2O	0.11	0.10	0.12	0.21	0.12
P2O5	<0.010	<0.010	0.04	0.01	0.02
LOI	1.79	2.92	2.38	2.94	2.08
Totals	98.5	99.9	99.7	98.8	98.3
BA	<0.002	<0.002	<0.002	0.002	<0.002
SR	<0.001	<0.001	<0.001	<0.001	<0.001
CU	0.006	0.035	0.007	0.017	0.023
NI	0.004	0.004	0.004	0.006	0.005
ZN	0.002	0.001	0.001	0.001	0.002
PB	0.009	0.009	0.010	0.018	0.014
CR	0.006	0.005	0.006	0.006	0.007
V	0.002	0.002	0.002	0.003	0.003
CO	0.011	0.010	0.010	0.012	0.013
ZR	0.009	0.008	0.009	0.011	0.010
LA	0.005	0.005	0.005	0.008	0.007
Y	<0.001	0.001	0.001	0.002	0.001
MO	<0.002	<0.002	0.002	0.002	0.002

Total FE as Fe2O3

amdel

Analysis code H1 Report AC 2776/85 Page I8

NATA Certificate Results in percentages

	6922 RS62	A 13/85	A 14/85	A 15/85	A 16/85
SiO2	82.2	95.0	96.1	93.1	92.7
TiO2	0.01	0.01	0.02	0.01	<0.010
Al2O3	0.13	0.26	0.24	0.17	0.15
Fe2O3	0.13	0.30	0.14	0.11	0.10
MnO	<0.010	<0.010	<0.010	<0.010	<0.010
MgO	0.25	0.09	0.08	0.11	0.14
CaO	8.95	1.37	0.52	2.08	2.56
Na2O	0.15	0.11	0.11	0.11	0.09
K2O	0.13	0.12	0.14	0.16	0.14
P2O5	0.01	<0.010	0.02	0.01	<0.010
LOI	7.75	2.74	2.02	2.88	3.22
Totals	99.7	100.0	99.4	98.7	99.1
BA	<0.002	<0.002	<0.002	0.002	<0.002
SR	<0.001	<0.001	<0.001	<0.001	<0.001
CU	0.019	0.010	0.008	0.015	0.008
NI	0.006	0.003	0.004	0.005	0.005
ZN	0.002	0.002	0.002	0.002	<0.001
PB	0.013	<0.005	0.014	0.016	0.011
CR	0.008	0.006	0.007	0.006	0.008
V	0.004	0.001	0.003	0.004	0.003
CO	0.009	0.012	0.012	0.012	0.009
ZR	0.011	0.006	0.009	0.011	0.010
LA	0.008	<0.002	0.005	0.008	0.006
Y	0.002	<0.001	0.002	0.002	0.002
MO	<0.002	<0.002	<0.002	<0.002	0.002

Total FE as Fe2O3

amdel

Analysis code H1 Report AC 2776/85 Page I9

NATA Certificate Results in percentages

	A 17/85	A 18/85	A 19/85
SiO2	94.9	85.5	92.7
TiO2	0.02	<0.010	<0.010
Al2O3	0.30	0.14	0.17
Fe2O3	0.24	0.10	0.06
MnO	<0.010	<0.010	<0.010
MgO	0.11	0.15	0.12
CaO	1.48	6.95	3.20
Na2O	0.16	0.10	0.11
K2O	0.19	0.08	0.10
P2O5	<0.010	0.02	<0.010
LOI	2.74	5.65	3.46
Totals	100.1	98.7	99.9
BA	<0.002	<0.002	<0.002
SR	<0.001	0.003	<0.001
CU	0.022	0.036	0.015
NI	0.004	0.004	0.004
ZN	0.002	0.001	0.001
PB	0.014	0.011	0.012
CR	0.005	0.005	0.006
V	0.003	0.002	0.002
CO	0.011	0.007	0.010
ZR	0.010	0.009	0.009
LA	0.007	0.006	0.006
Y	0.002	0.001	<0.001
MO	0.002	<0.002	<0.002

Total FE as Fe2O3

amdel

Analysis code X1 | Report AC 2776/85 | Page X1

NATA Certificate | Order No. 12/03/141 | Results in ppm

Sample	Rb	Cs	Nb	Ce	Th	U
6230 RS 364	31	<20	8	85	155	56
6230 RS 365	<2	<20	20	550	115	20
6230 RS 366	2	<20	<4	25	84	8
6230 RS 367	<2	<20	<4	20	28	<4
6230 RS 368	3	<20	26	130	50	10
6230 RS 369	<2	<20	18	130	42	4
6230 RS 370	<2	<20	<4	<20	4	<4
6230 RS 371	10	<20	16	150	50	10
6230 RS 372	80	<20	<4	<20	<4	<4
6230 RS 373	15	<20	<4	40	6	<4
6230 RS 374	14	<20	<4	45	8	4
6230 RS 375	30	<20	<4	20	<4	<4
6230 RS 376	<2	<20	<4	<20	<4	<4
6230 RS 377	72	<20	18	190	38	<4
6230 RS 378	88	<20	<4	20	4	<4
6230 RS 379	46	<20	10	45	16	4
7021 RS 31	<2	<20	<4	20	4	<4
7021 RS 32	<2	<20	<4	<20	<4	<4
7021 RS 33	<2	<20	<4	<20	4	<4
7021 RS 34	<2	<20	<4	<20	4	4
7021 RS 35	<2	<20	<4	<20	<4	<4
6256 RS 22	<2	<20	<4	<20	6	<4
6256 RS 23	<2	<20	<4	20	<4	<4
6256 RS 24	<2	<20	<4	<20	<4	<4
6922 RS 52	<2	<20	<4	<20	<4	<4
6922 RS 53	<2	<20	<4	<20	<4	<4
6922 RS 54	<2	<20	<4	20	<4	<4
6922 RS 56	<2	<20	<4	20	<4	<4
6922 RS 57	<2	<20	<4	25	<4	<4
6922 RS 58	<2	<20	<4	25	<4	<4
6922 RS 59	<2	<20	<4	25	4	<4
6922 RS 62	<2	<20	<4	20	4	<4
A13/85	<2	<20	<4	20	<4	6
A14/85	<2	<20	<4	25	<4	<4
A15/85	<2	<20	<4	<20	<4	<4
A16/85	<2	<20	<4	20	<4	<4
A17/85	<2	<20	<4	20	<4	<4
A18/85	<2	<20	<4	<20	<4	<4
A19/85	<2	<20	<4	20	<4	<4
Detn limit	(2)	(20)	(4)	(20)	(4)	(4)

APPENDIX C

JACKSON (1954) - NOTES ON FLINT SAMPLES FROM THE PRINCIPAL SOUTH EAST DEPOSITS

TO MINING ENGINEER: (Mr. C.M. Willington).

Flint Samples from Principal South East Deposits.

Tests have been carried out on flint samples submitted by you as suggested by the Director to obtain results for incorporation in your report on this subject. The six samples are described below.

(1) Flint cobbles and pebbles.

Locality - "The Bluff", Section 450, Hd. Hindmarsh.

Description - Irregularly shaped flat rounded pebbles, ¾" thick, ranging from 1" - 2½" diameter. Surfaces very pitted, grey to black in colour on cracking open, no cavities and an irregular calcareous shell on some pebbles. Numerous white calcareous inclusions.

Uses - Local road material.

(2) Selected pebbles.

Locality - "Blackfellow's Caves", Section 369, Hd. Kongorong.

Description - Flat rounded pebbles, ¾"— 2" diameter, very irregular surfaces with pits up to ½" deep. Grey to black in colour, a few cavities, numerous calcareous inclusions and a thin calcareous shell in places.

Uses - Grinding pebbles.

(3) Unselected pebbles.

Locality - As for (2).

Description - Irregular shapes, average 1½" diameter. Light to dark grey colour, relatively free of cavities, a thin calcareous shell in places.

Uses - ----

(4) Massive flint blocks.

Locality - Port Douglas, Section 365-366, Hd. Kongorong.

Description - Blocks about ½ ft.^{2} on flats, 3 - 4" thick. Light to dark grey colour, no internal cavities, extremely thin calcareous shell and large calcareous inclusions.

Uses - Mill liners; calcined for silica.

(5) Massive flint cobbles.

Locality - Middle Point. Section A, Hd McDonnell.

Description - Irregular blocks weighing 6 - 7 lb. Dark grey to black colour. few cavities, very few calcareous inclusions and a calcareous shell up to ¼" thick in places.

Uses - Calcined for pottery, porcelain and pure silica.

(6) Flint balls and pebbles.

Locality - As for (2).

Description - Range from 1" well rounded pebbles, free of calcareous shell, with a few surface pits, to 3" pebbles generally with a thin shell. Dark grey in colour.

Uses - Paint industry and grinding balls.

Tables are given for analyses of raw and calcined flint, with colour determinations.

A total analysis was done on a representative fraction of each sample and a second fraction calcined and assayed for iron. The second determination gave the actual iron present, avoiding contamination from the pulveriser.

Sample	(1)	(2)	(3)	(4)	(5)	(6)
SiO_2	90.30	92.76	91.92	84.48	91.08	91.20
Al_2O_3	0.81	0.69	0.61	0.40	0.77	0.21
Fe_2O_3	0.11	0.15	0.10	0.06	0.09	0.12
MgO	0.06	0.12	0.10	0.14	Nil	Nil
CaO	2.90	1.58	1.92	6.32	2.44	2.34
Na_2O	0.12	0.16	0.14	0.14	0.72	0.48
K_2O	0.16	0.16	0.18	0.16	0.18	0.16
H_2O at 100°C	0.45	0.37	0.56	0.55	0.33	0.55
H_2O above 100°C	1.15	1.21	1.22	1.11	1.13	1.27
CO_2	2.06	1.07	1.29	4.72	1.69	1.56
TiO_2	0.13	0.05	0.11	0.08	0.09	0.07
SO_3	0.02	0.02	0.05	0.03	0.02	0.03
Cl	0.05	0.03	0.06	0.03	0.02	0.07

APPENDIX D

HIERN (1974) - NOTES ON FLINT PEBBLES, COUNTY GREY

DM.301/45
DEC.3267/73

TO THE ACTING CHIEF GEOLOGIST:

FLINT PEBBLES - COUNTY GREY

Harvesting of flint pebbles from the coast between Cape Banks and Pt. MacDonnell commenced in 1908 and recorded production to date exceeds 17 000 tons. Early production was used as a grinding medium in ball mills and reached a peak of 2800 tons in 1918 as a consequence of normal supplies being cut off by World War I.

Production declined but was revived during World War II due to overseas shortages and maintained a rate of about 300 t.p.a. until 1951. Since 1951 porcelain balls have replaced natural flint pebbles and current production is used as calcined silica for ceramic ware.

Willington (Mining Review 100, pp.100-102) refers to deposits on the modern beaches and in associated back shore banks and also to older inland buried deposits, notably at The Bluff in Section 455, Hd. Hindmarsh. Pebbles in inland deposits are coated with calcrete and are considered suitable only for road metal.

The Gambier Limestone, which outcrops along the coast, contains bands of flint, and the pebble deposits result from erosion of this unit. They are no doubt replenished during winter storms. The coastal deposits are extensive, the largest observed being at Blackfellows Caves (Sections 393W, 394, Hd. Kongorong) where a bank estimated to contain 1000 tons per chain is exposed continuously for a distance of 20 chains.

Calcareous inclusions are common and painstaking hand sorting is necessary to obtain pebbles of the required grade.

Mr B.J. Pascae of Pt. MacDonnell holds five mineral leases which have been current since 1945. These are located on the accompanying plan Fig. 1 and production since 1952 shown on figure 2. A marked increase in production since 1971 is evident.

The nature of the beaches is not known to the author but reference is made by others to wave cut platforms suggesting that the Gambier Limestone is actually exposed to the sea. Despite production of over 17 000 tons over a period of 60 years there are not reports of major change to the coast

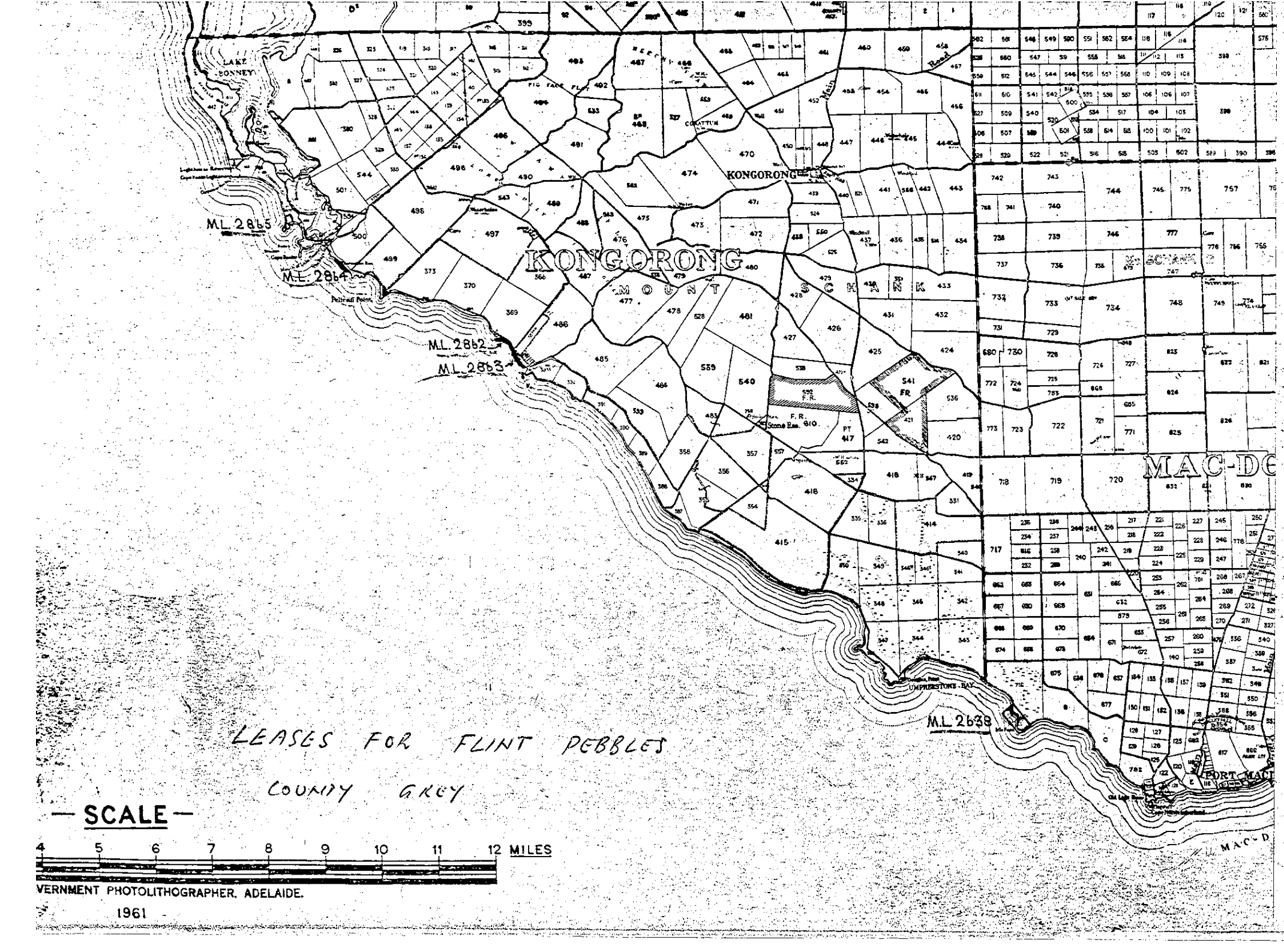
suggesting that harvesting operations to date are having no deleterious effect.

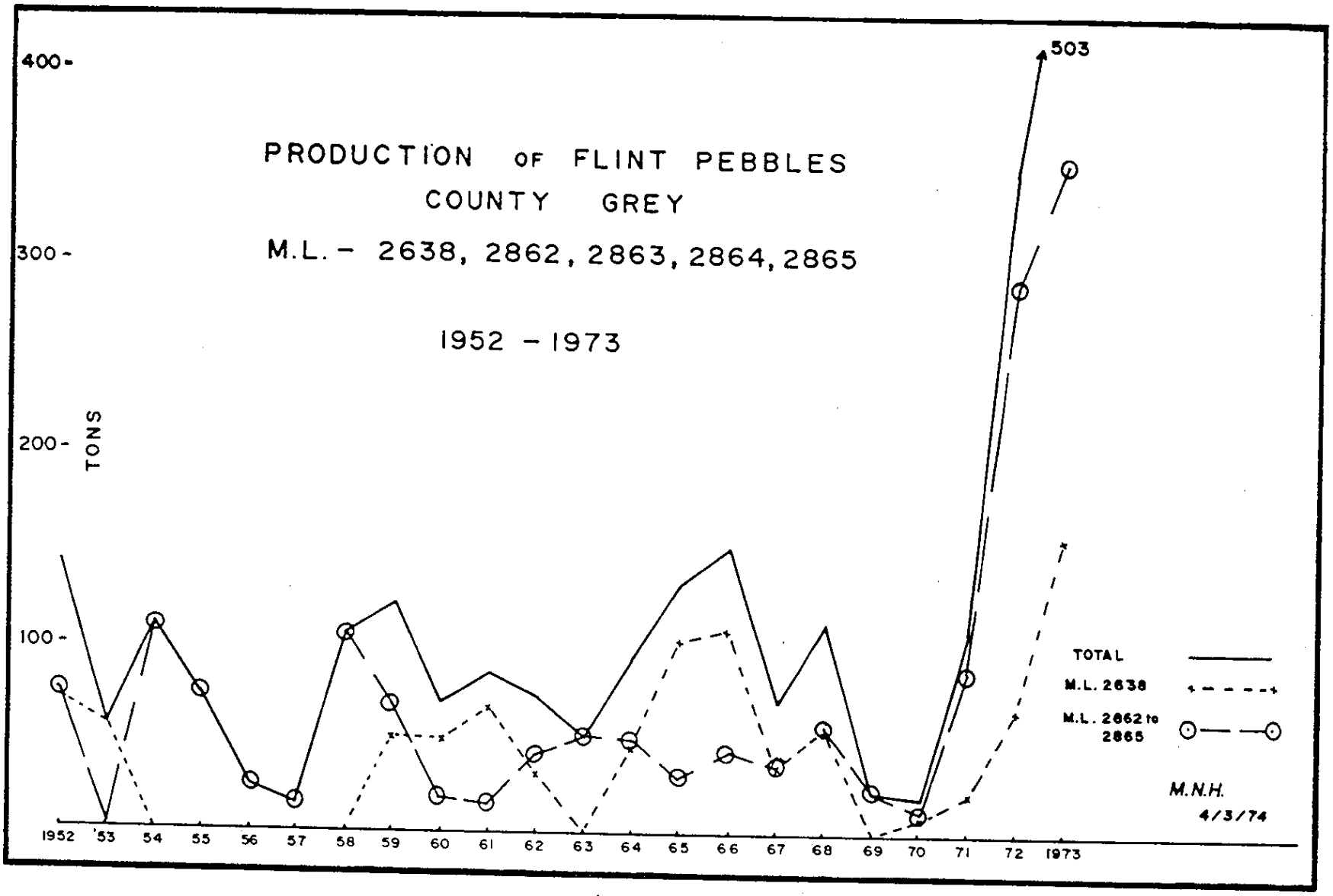
It is considered that this is a matter for controlled harvesting rather than termination of the leases. Further investigation is required to determine:- the nature of the beach; the rate of natural replenishment; and the type of harvesting operation used, particularly in respect to disposal of reject material.

It is recommended that personnel from the Mt. Gambier office inspect and photograph the deposits from a fixed point regularly and that a detailed report on the deposits, including the nature of the beach, be prepared.

MNH:PAL
1/4/74

M.N. HIERN
Supervising Geologist
Environment & Resource
Division


LAKE BONNEY
M.L. 2865
M.L. 2864
KONGORONG
MOUNT SCHANK
M.L. 2862
M.L. 2863
M.L. 2638
MAC-DE
PORT MACD
LEASES FOR FLINT PEBBLES
COUNTY GREY
— SCALE —
4 5 6 7 8 9 10 11 12 MILES
VERNMENT PHOTOLITHOGRAPHER, ADELAIDE.
1961


PRODUCTION OF FLINT PEBBLES
COUNTY GREY
M.L. - 2638, 2862, 2863, 2864, 2865
1952 - 1973
TONS
400-
300-
200-
100-
503
1952
'53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
1973
TOTAL
M.L. 2638
M.L. 2862 to 2865
M.N.H.
4/3/74

APPENDIX E

SADME DOCKETS REGARDING FLINT PRODUCTION, TENEMENT HISTORY, GEOLOGICAL INVESTIGATIONS AND USES

YEAR	DOCKET No.
1909	628, 674, 761, 842, 853, 857, 900
1910	76, 292, 377, 616
1911	612, 622, 773
1913	588, 943, 1185
1916	743, 790
1917	42, 704, 789, 793
1918	381, 458, 459, 463, 493, 494, 572, 600, 703, 727, 728, 1073
1919	20, 489
1920	51
1921	447
1922	256, 382, 407, 482, 731
1923	202, 436, 736
1924	22, 280, 297, 341, 398, 566
1925	398
1926	300, 367
1927	61, 347
1928	156, 519
1929	591, 774
1930	75
1931	279, 327, 418, 689
1932	244, 275, 787, 996, 1042
1933	14, 980, 1277
1934	109, 253, 254, 273, 475
1935	227, 283, 559, 1220, 1384, 1420
1936	152, 337, 681
1937	79, 100, 150, 235, 767, 770
1938	190, 379, 467
1939	105, 438
1941	65

YEAR	DOCKET No.
1943	91, 258
1944	57, 488
1945	301
1947	189, 270, 361, 1004
1948	97, 793
1949	417
1950	13
1951	523
1952	96
1955	1090, 1446
1956	585
1960	297
1962	71, 1329
1973	DEC 3267/73
1974	631
1985	50

½" fragments in covered crucibles for ½ hour in the laboratory electric furnace. Temperatures used ranged from 500-1300°C, loss in weight, S.G., and reflectivity being determined at each stage.

The samples showed no visual change until a temperature of 700°C was reached when they appeared a slightly lighter colour, but were still as hard to grind as originally. The most noticeable change occurred at 900°C, the flint becoming off-white in colour, cracked, and more easily powdered. Beyond 1100°C, little visual change occurred except for sample (4) which became very much whiter at the higher temperatures. A listed reflectivity of 93 would be a good cosmetic grade of whiteness. Higher figures than this denote exceedingly good white reflectance. This was due to calcination of $CaCO_3$ (approx. 10%) also resulting in a higher loss in weight.

With the possible exception of sample (4), tests indicate that production of fairly high grade silica for ceramic work could be expected from these deposits.

Sample		(1)	(2)	(3)	(4)	(5)	(6)
Original	S.G.	2.50	2.49	2.48	2.50	2.50	2.50
500°C-% loss wt.		0.65	0.67	0.80	1.67	0.93	1.00
	S.G.	2.50	2.50	2.46	2.50	2.50	2.47
	reflectivity		Not determined.				
700°C-% loss wt.		1.45	1.02	1.88	1.95	1.72	2.32
	S.G.	2.44	2.46	2.39	2.50	2.44	2.40
	reflectivity		Not determined				
900°C-% loss wt.		3.75	3.05	3.22	6.33	3.50	3.85
	S.G.	2.37	2.39	2.36	2.40	2.38	2.37
	reflectivity	86	89	89	91	89	90
1100°C-% loss wt.		3.83	3.07	3.38	7.48	3.67	3.92
	S.G.	2.36	2.27	2.19	2.29	2.27	2.25
	reflectivity	90	90	90	97	89	90
1300°C-% loss wt.		4.25	3.25	3.43	8.16	3.83	4.23
	S.G.	2.14	2.15	2.12	2.23	2.17	2.17
	reflectivity	92	91	91	97	93	92

NJ:MPC.
12/11/54.

Nort Jackson
NORTON JACKSON
CHIEF METALLURGIST.

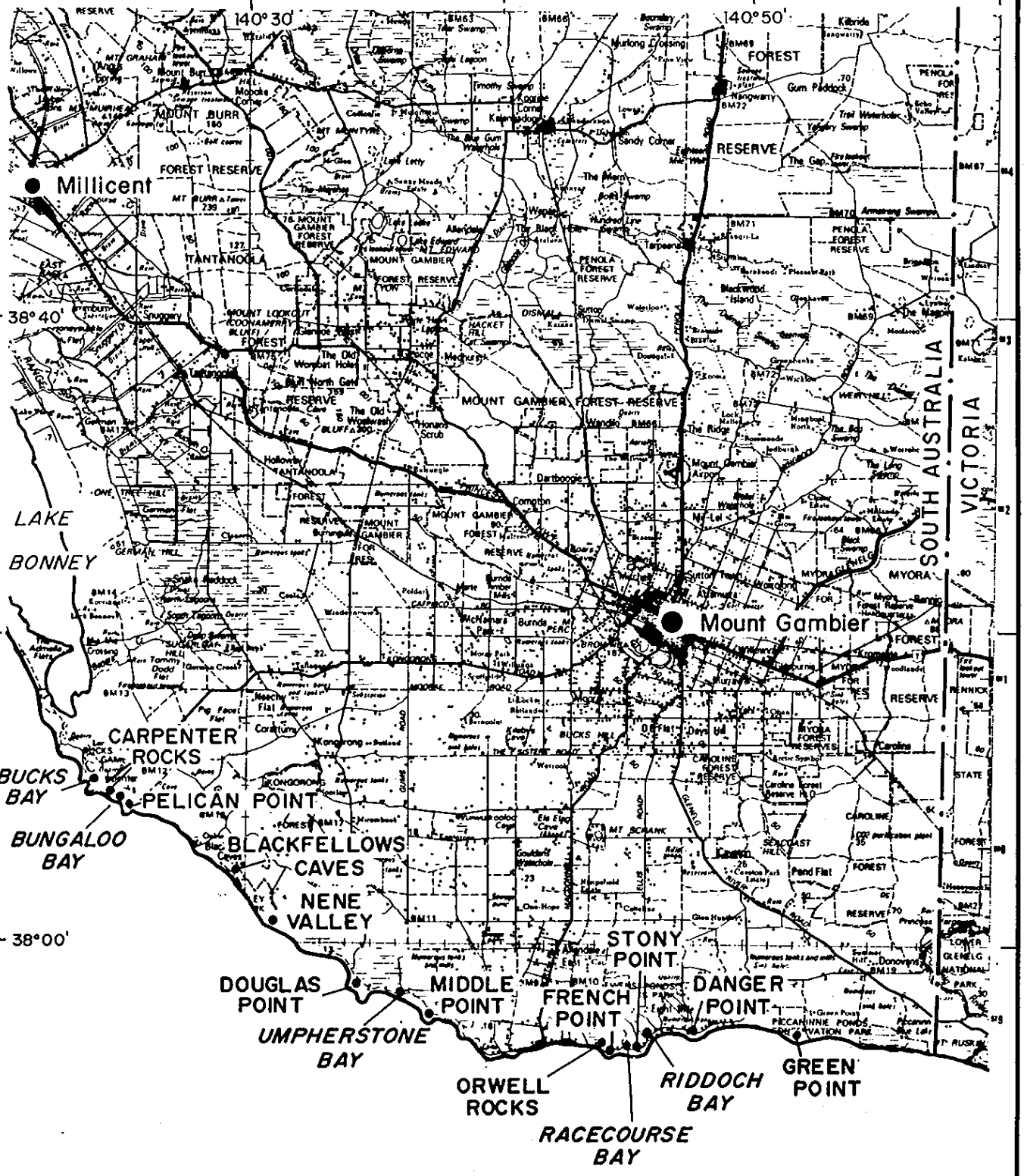


Figure 1

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED D. Flint	C.D.O. 8.2.90 DATE
FLINT IN SOUTH AUSTRALIA LOCALITY PLAN	DRAWN L. W.	SCALE As shown
	DATE 19-7-89	PLAN NUMBER S20963
	CHECKED	

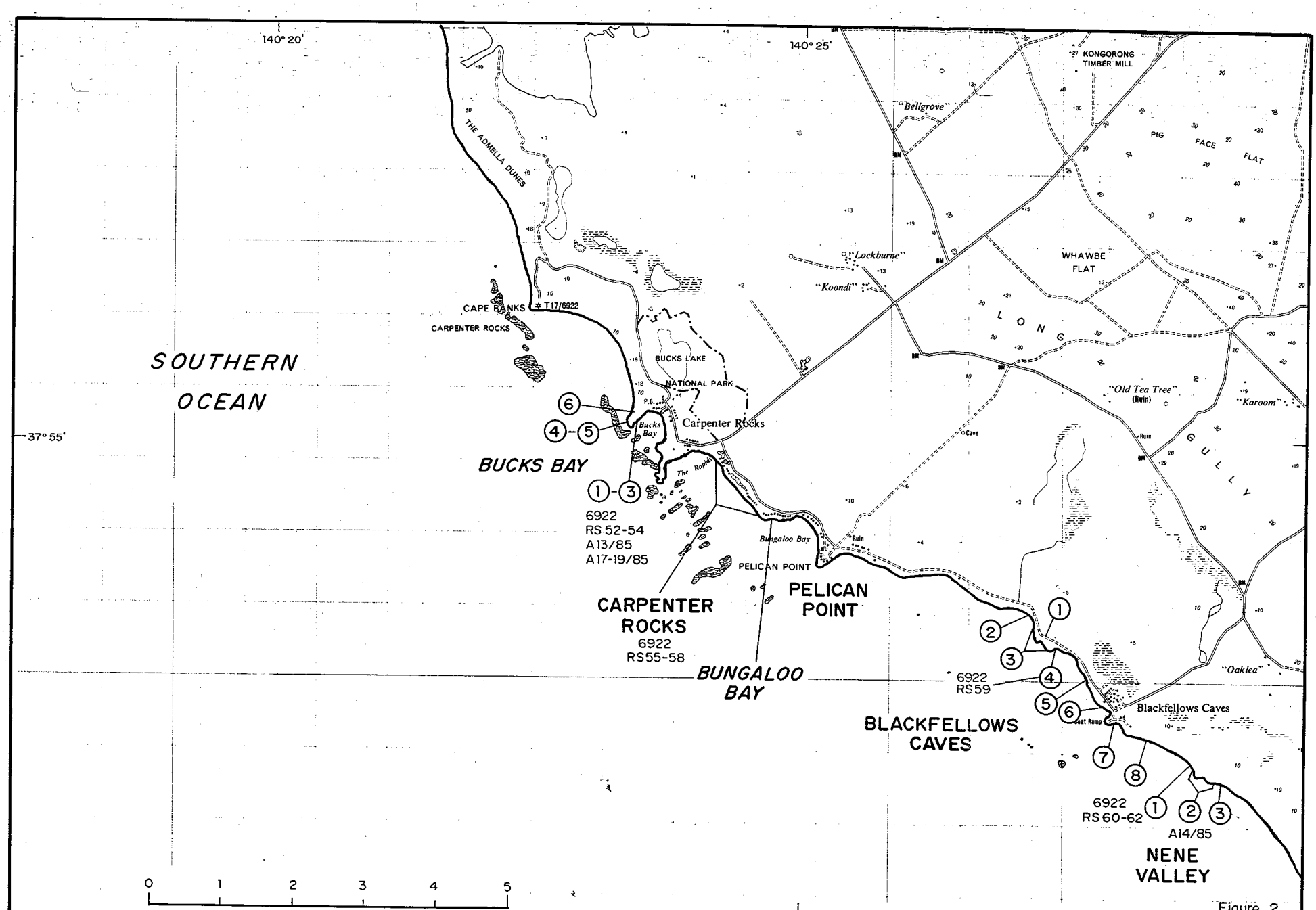


Figure. 2

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

FLINT IN SOUTH AUSTRALIA
LOCALITY PLAN
CAPE BANKS - NENE VALLEY

COMPILED D. Flint	C.D.O. 8. 2. 90 DATE
DRAWN L.W.	SCALE As shown
DATE 19-7-89	PLAN NUMBER 89-267
CHECKED	

4864

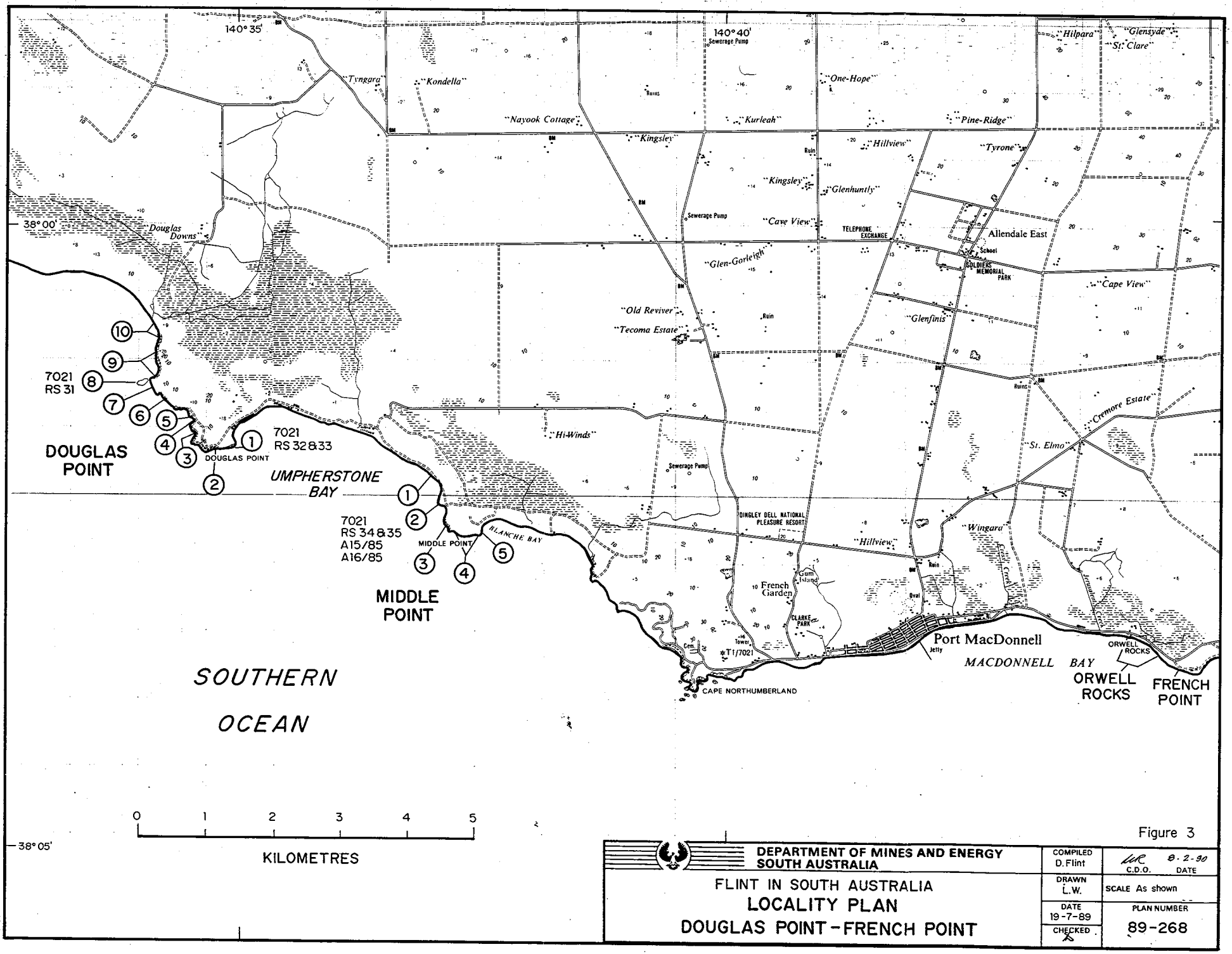


Figure 3

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

FLINT IN SOUTH AUSTRALIA
LOCALITY PLAN
DOUGLAS POINT – FRENCH POINT

COMPILED D. Flint	C.D.O. 8-2-90 DATE
DRAWN L.W.	SCALE As shown
DATE 19-7-89	PLAN NUMBER 89-268
CHECKED	

A664

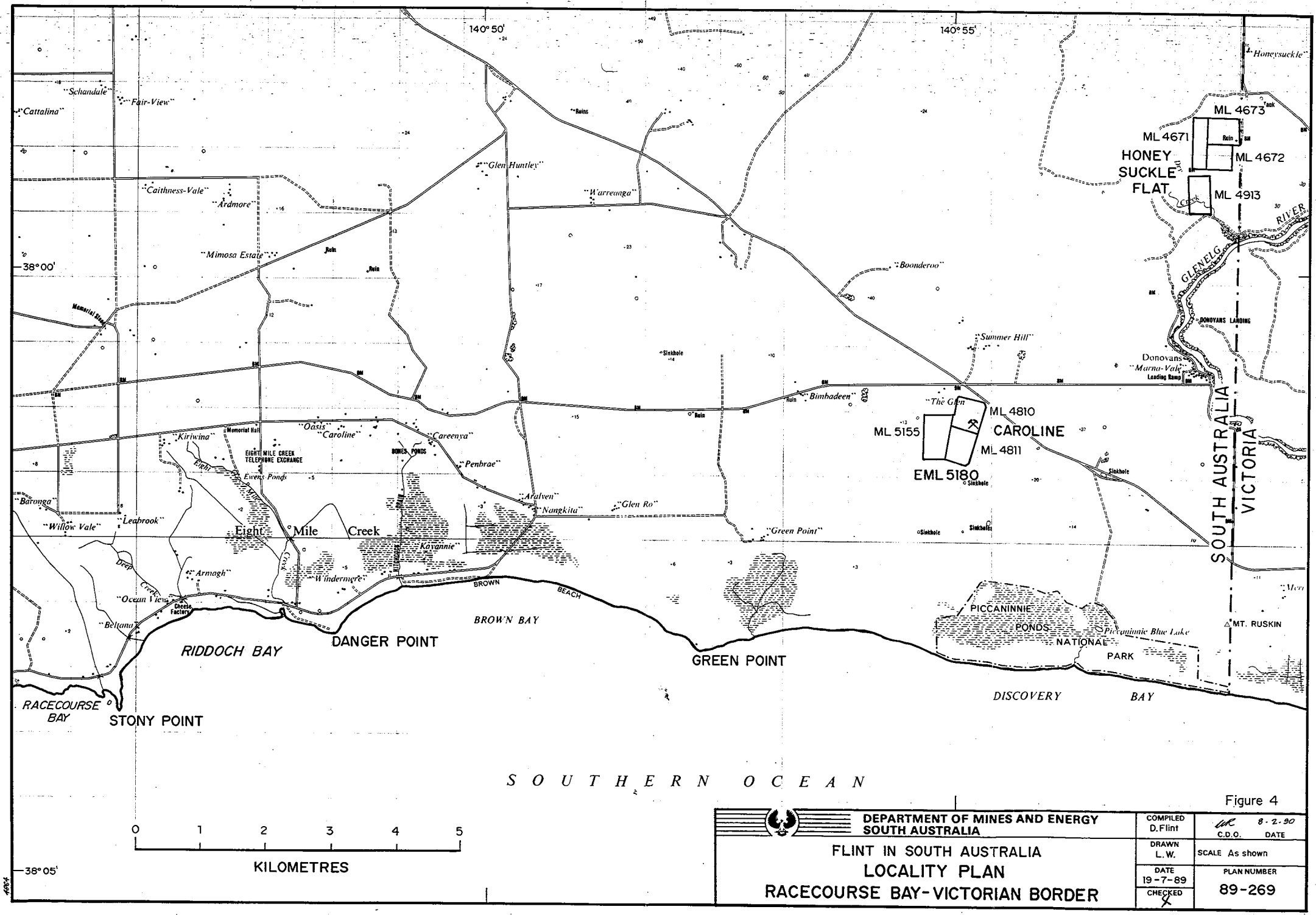


Figure 4

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED D.Flint	C.D.O. 8-2-90 DATE
FLINT IN SOUTH AUSTRALIA LOCALITY PLAN RACECOURSE BAY-VICTORIAN BORDER	DRAWN L.W.	SCALE As shown
	DATE 19-7-89	PLAN NUMBER 89-269
	CHECKED	

FLINT
SiO_2 v CaO+MgO

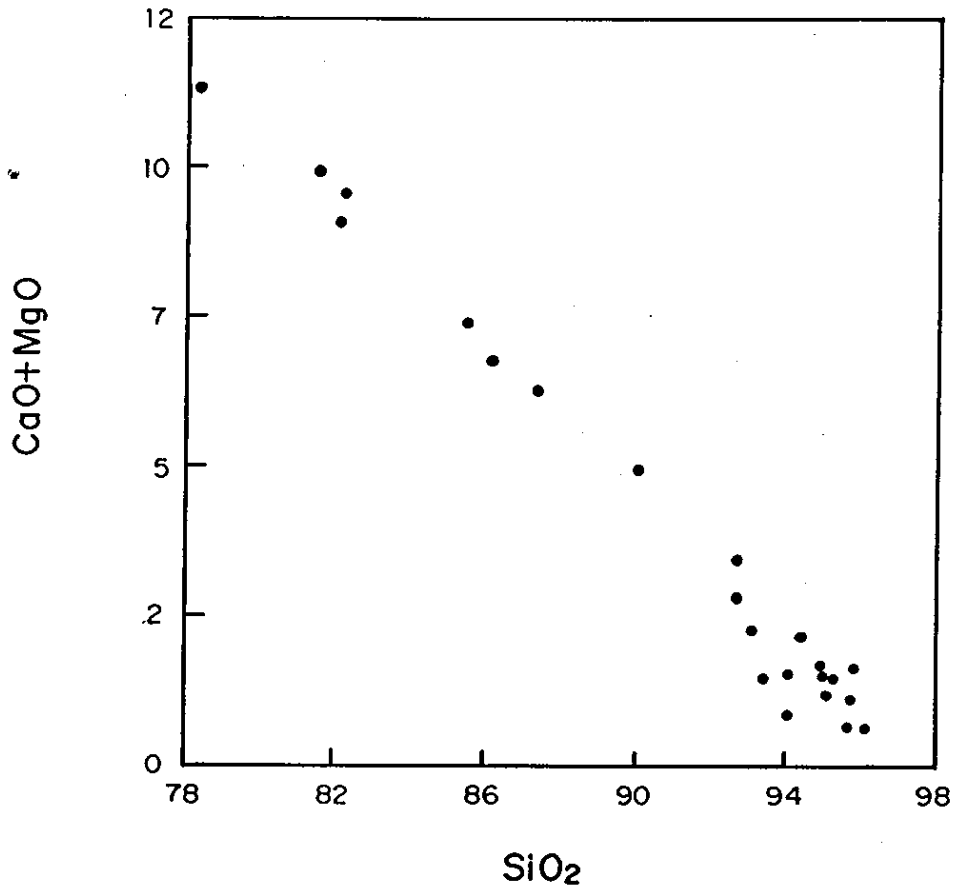
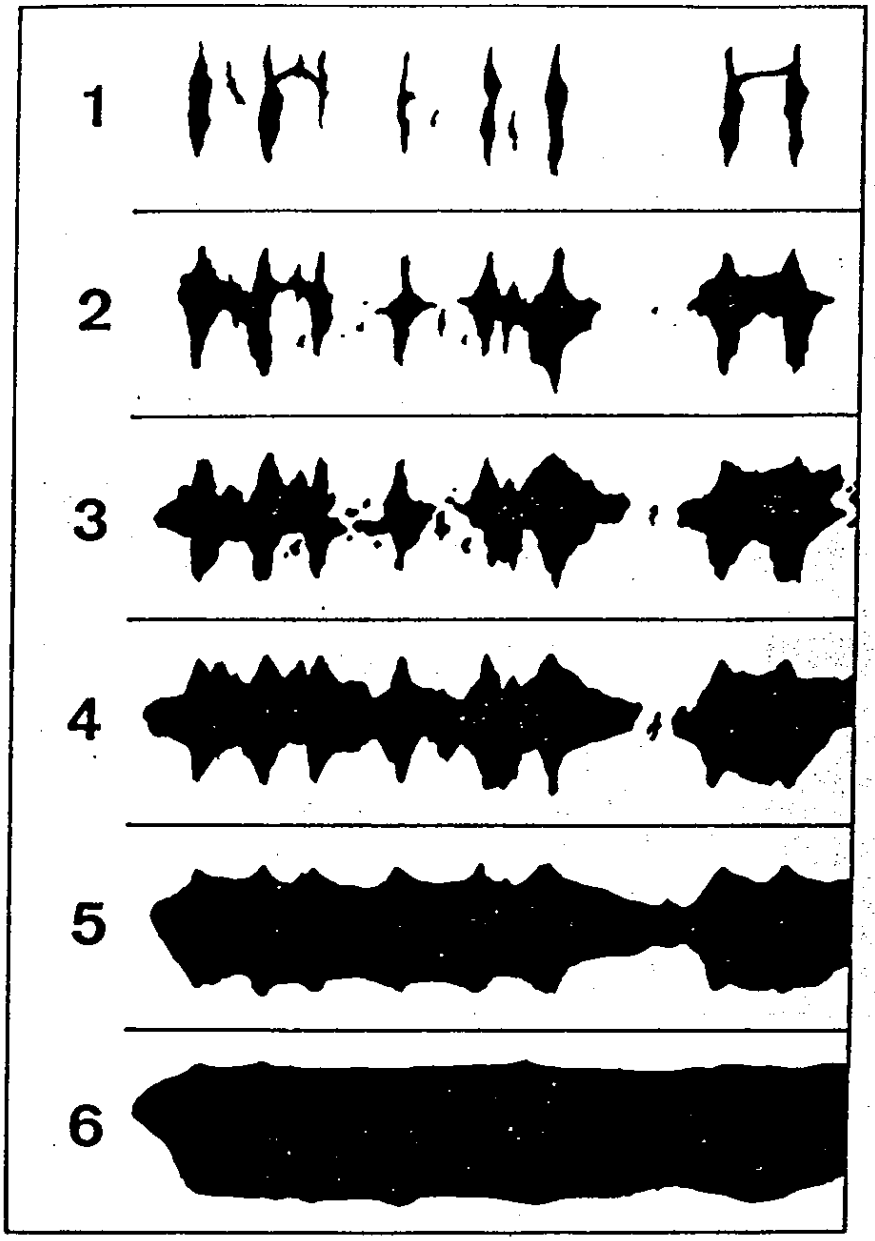


Figure 5

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED D. Flint	C.D.O. 8:2:90 DATE
	DRAWN L. W.	SCALE
FLINT – SiO_2 v CaO + MgO	DATE 19-7-89	PLAN NUMBER S 20964
	CHECKED	



from Welder (1971)

Figure 6

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED D. Flint	C.D.O. 8·2·90 DATE
	DRAWN L. W.	SCALE
FORM TYPES OF EUROPEAN FLINT	DATE 19-7-89	PLAN NUMBER S 20965
	CHECKED X	