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TASMANIA

DEPARTMENT OF MINES

GEOLOGICAL SURVEY

MINERAL RESOURCES No. 10

LIMESTONES IN TASMANIA

by

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PREFACE

Limestone is widely distributed throughout the State of Tasmania and many of the deposits are in accessible places suitable for their development.

Limestone plays a vital part in the metallurgical and manufacturing industries in Tasmania and hence an important part in the economy of the State. During 1955 some 175,081 tons of limestone were used for the manufacture of cement and calcium carbide valued at £886,892; and a further 31,057 tons were used for metallurgical, building and other purposes. In addition a number of small quarries in various districts are mining and crushing limestone suitable for road metal and gravel. The use of finely ground limestone for pasture improvement is widespread throughout the State.

This Bulletin, prepared by T. D. Hughes, Senior Geologist, was written to satisfy the many enquiries received by the Department of Mines from various industries and individuals. The information available in various reports and plans, prepared by the Department of Mines, has been included and this resultant publication will assist those who have interests or enquiries relating to the limestone resources of this State. The chapter on the stratigraphy of the Limestones of Tasmania, prepared by M. R. Banks and A. Spry of the Geology Department of the University of Tasmania, is a most welcome and useful contribution to the Bulletin and their assistance is gratefully acknowledged. It is felt that the more specialised work of the University on stratigraphy allows of more complete and up-to-date descriptions, and greatly adds to the value of the publication.

J. G. SYMONS, Director of Mines.

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FIG. 1.—Goliath Portland Cement Co., Portion of Open-Cut and Works.

CHAPTER 1—INTRODUCTION

This volume is essentially a compilation. Limestone is a substance which comprises two important characteristics; it is a rock type of importance in the stratigraphic column, but it is also a material of great commercial significance. Consequently, it has figured largely in the records, reports and statistics of the Mines Department since these were first written. These records have been closely searched and the information contained in them is reproduced here. Some of the reports are quoted in their entirety, some have been rather completely edited, while others have been used to obtain information which has been rewritten into the general pattern.

While much of the material in this volume has been the work of Departmental geologists, past and present; in order to gain completeness, it has been necessary to include work of other geologists. First and foremost must be mentioned the work of M. R. Banks and A. Spry, of the Geology Department of the University of Tasmania in preparing the chapter on the stratigraphy of limestones. Information used in some other chapters has also been obtained from work done by students and staff members of the Geology Department of the University.

In 1954, several geologists from the Bureau of Mineral Resources worked for many weeks in the Flowery Gully Area to obtain information on reserves of high-grade limestone needed by the Australian Aluminium Commission for their works at Bell Bay. A full report of these investigations was prepared as Bureau of Mineral Resources Records 1954/65 and much of it is quoted here in the section dealing with the Flowery Gully Deposits.

The section of the Queenstown deposits was written by M. Solomon, of the geological staff of the Mt. Lyell Mining and Railway Company.

Of the present staff of the Mines Department, the following have contributed information on the areas after their names:—

H. G. W. Keid—Granton, Proctors Road and Bridport.

F. Blake—Gordon River, Smithton, South Coast, Avoca, Bronte, Little Denison River, St. Marys and most of the Dolomite Areas.

G. Everard—Maydena, Ida Bay, Cygnet, Gray, Maria Island and Flinders Island.

I. Jennings—Florentine River, Moina-Lorinna, Mole Creek-Liena, Railton.

K. Burns—Mole Creek-Chudleigh, Melrose.

Information was obtained from several unpublished typewritten reports by former members of the Geological Survey staff, as well as from the Bulletins, principally those dealing with West Coast Areas. Of the hundreds of analyses quoted in the text, practically all were carried out by the staff of the Chief Chemist and Metallurgist at the Department's Laboratories in Launceston.

In the main body of the work, comprising descriptions of individual limestone deposits, the arrangement of the material has been made firstly on a basis of age of the rock, and secondly on the locality of the deposit. Thus the primary chapters are descriptions of Ordovician, Permian, Tertiary and Recent Limestones and the Dolomites. Within these chapters are sub-headings of the individual localities arranged in alphabetical order.

CHAPTER 2—GENERAL ASPECTS OF THE LIMESTONES

DISTRIBUTION AND GRADE

The term limestone here may be used to cover a number of different forms of calcium carbonate compounds, varying from Pre-Cambrian dolomite to unconsolidated sands composed mainly of broken sea shells and other organic material. However, from an economic viewpoint the two most important limestones in Tasmania are those from the Ordovician and Permian. A glance at a map of Tasmania showing limestone occurrences will reveal that although deposits of both these limestones are widespread they each occupy very definite portions of the State. If a line were to be drawn from George Town in the north to Geeveston in the South, it would be found that all the Ordovician limestone deposits lie to the West of it and all but one or two insignificant deposits of the Permian to the East.

Many of the deposits of Ordovician limestone occur in quite inaccessible country in the Western part of the State, remote from roads, railways, power-lines, centres of population and coal supplies, and there is little likelihood of their exploitation in the foreseeable future. Other western deposits adjacent to mining fields are, or can be, used in metallurgical processes. However, there are many large deposits of good-grade stone in more accessible areas that are not exploited. Notably in the Mole Creek-Chudleigh and Gunns Plains Areas are large deposits of easily-quarried limestone which, apart from stone for road metal and some very small scale burning, have never been used.

The north-western part of the State is particularly well served with good-grade limestone deposits adjacent to centres of population; thus Gunns Plains to Ulverstone, Melrose to Devonport, Railton to Latrobe and Mole Creek to Deloraine. Some of these deposits are being utilised, some are not; but all are of good-grade and possess immense reserves which could be won from convenient quarry sites. All are connected by good roads, some by railways and are adjacent to power supply. The coal resources of the north-west are not extensive but seams of good-grade Permian coal do exist.

In the central north of Tasmania, the extensive high-grade deposits of Flowery Gully are within reasonable distance of Launceston as well as George Town and Beaconsfield. In the south, Hobart, the capital, has many deposits of Permian limestone adjacent. These, however, are not of high grade. It is only in the north-eastern part of the Island that there is any deficiency of lime deposits. Lime sands do occur near Bridport but these are of such low grade that it would appear that lime for agricultural purposes will have to be brought from other parts of the Island.

The central-eastern region is well supplied with Permian limestones, with deposits at Avoca, Fingal, St. Marys, down to Mt. Peter near Swansea. In the south-east are the highest grade of all the Permian limestones, outcropping on Maria Island. There are no deposits of any magnitude in the Huon District, although high-grade

Ordovician limestone is quarried at Ida Bay not far south of this rich orcharding district.

The Tertiary limestones mostly occur in the vicinity of Bass Strait; in the far north-west and on King and Flinders Islands. However, except, perhaps, for the latter locality, they are not extensive. Recent beach sands also have a higher lime content in the north of Tasmania.

The staff of the Mines Department Laboratory have undertaken the analyses of samples of Tasmanian limestones and many of these are quoted in the tables that follow. These tables are grouped according to the various ages of the samples and in each age the analyses are arranged alphabetically according to localities. It will be seen that the Ordovician beds have the highest calcium carbonate content, the better quality stone averaging about 90 per cent. MgO is very variable and careful sampling is necessary if the amount of this has to be controlled. The best limestone sampled so far seems to be from Flowery Gully and Ida Bay, though a single sample from Precipitous Bluff near the central south coast gave the highest individual $CaCO_3$ content of 98.85 per cent.

The Permian limestones are of lower grade and have not been utilised in Tasmania except for agricultural crushed stone, burnt lime and road metal. The better beds average about 80 per cent $CaCO_3$, though at Maria Island some beds reach the nineties. Some of the Tertiary limestones are of high quality, although a surprising feature of those near Marrawah and Redpa is the high magnesium content. The Recent lime sands are, of course, very variable and are usually low in $CaCO_3$ content; one sample, however, from large dunes on King Island showed a $CaCO_3$ content of over 90 per cent.

ANALYSES OF TASMANIAN LIMESTONES

RECENT:

Locality	Reg. No.	$CaCO_3$	CaO	MgO	Insol.	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	Ig. Loss
Bridport	851/50	29.8	16.7	0.6	65.6	1.0	—	0.2	—	15.5
	852/50	38.0	21.3	0.7	57.7	0.7	—	0.5	—	18.5
	853/50	41.8	23.4	0.7	53.6	0.8	—	0.6	—	20.2
	854/50	39.8	22.3	0.9	56.3	0.7	—	0.3	—	19.3
	855/50	30.0	16.8	0.3	66.3	0.6	—	0.4	—	14.6
	856/50	42.0	23.5	0.7	53.7	0.6	—	0.4	—	20.4
	857/50	37.5	21.0	0.3	59.2	0.8	—	0.2	—	18.1
	858/50	20.4	11.0	0.5	77.8	1.0	—	0.2	—	9.6
	860/50	37.7	21.1	0.8	57.7	0.8	—	0.4	—	18.8
	861/50	37.0	20.7	0.9	59.0	0.6	—	0.4	—	17.6
	862/50	38.5	21.5	0.9	58.0	0.5	—	0.3	—	18.8
	863/50	37.5	21.0	0.8	59.8	0.5	—	0.3	—	17.7
	866/50	38.2	21.4	0.5	58.4	0.7	—	0.8	—	18.2
	867/50	37.1	20.8	0.5	59.0	0.6	—	0.4	—	17.8
	868/50	32.1	18.0	0.5	64.0	0.5	—	0.3	—	15.4
	869/50	33.4	18.7	0.8	63.0	0.5	—	0.3	—	15.8
	871/50	34.1	19.1	0.7	61.0	1.0	—	1.0	—	17.3
	872/50	38.0	21.3	1.0	55.9	0.7	—	0.4	—	19.6
	873/50	40.0	22.4	1.0	55.4	0.6	—	0.5	—	19.9
	874/50	35.5	19.9	1.0	60.1	0.7	—	0.3	—	17.7
	875/50	35.2	19.7	0.9	60.2	0.7	—	0.4	—	17.6
	879/50	29.6	16.6	0.5	67.0	0.9	—	0.4	—	13.9
King Island										
Camp Creek ..	49/51	79.2	43.2	1.0	17.3	—	1.0	—	—	36.7
Porky Creek ..	50/51	80.3	44.3	0.6	10.4	—	2.2	—	—	41.9
Dripping Wells ..	51/51	96.4	53.4	0.5	0.4	—	0.5	—	—	45.2
Badger Box ..	52/51	53.0	28.4	1.2	44.0	—	1.3	—	—	24.7
	53/51	60.4	32.5	1.2	35.1	—	1.1	—	—	29.1
Buttons ..	54/51	89.8	47.7	2.4	4.7	—	0.5	—	—	42.8
	55/51	78.1	41.6	2.0	17.4	—	0.6	—	—	36.7

RECENT—*continued*:

Locality	Reg. No.	$CaCO_3$	CaO	MgO	Insol.	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	Ig. Loss
Surprise Bay . .	56/51	91.3	48.2	2.7	3.2	—	0.2	—	—	44.0
Loorana	57/51	69.4	37.1	1.6	26.7	—	0.8	—	—	32.6
	58/51	74.3	41.4	0.7	22.3	—	1.2	—	—	33.5
Grahams	—	66.8	—	1.5	26.7	—	1.6	—	—	—
	—	70.3	—	1.5	23.5	—	1.3	—	—	—
	—	68.7	—	1.5	25.2	—	1.2	—	—	—
Barnes	—	57.1	—	1.2	37.3	—	1.1	—	—	—
Low Head	40/50	77.32	43.3	0.6	17.2	1.0	—	1.0	—	—
	41/50	94.46	52.9	1.0	1.6	0.2	—	0.2	—	—
	42/50	55.71	31.2	0.8	37.4	1.7	—	1.4	—	—
Rekuna	547/49	66.25	37.1	1.7	23.5	1.7	—	2.1	0.04	—
	558/49	70.71	39.6	1.5	18.0	1.8	—	2.1	0.03	—
	559/49	22.32	12.5	3.7	53.7	2.9	—	6.1	0.01	—
	560/49	66.60	37.3	2.9	18.0	0.9	—	1.5	0.01	—
Smithton	—	—	53.76	1.72	0.48	0.56	—	0.24	—	43.70
	—	—	52.59	1.35	0.88	0.44	—	—	—	44.90
	—	—	52.39	1.51	0.84	0.52	—	—	—	44.72
Sorell	303/49	76.60	42.9	1.0	14.4	—	3.0	—	—	38.8
	304/49	24.28	13.6	1.6	44.5	—	16.9	—	—	24.9
	451/49	88.21	49.4	0.8	8.4	—	0.5	—	—	—
	452/49	63.92	35.8	1.3	28.2	—	3.0	—	—	—
	453/49	78.21	43.8	0.93	11.68	—	5.0	—	—	—
	455/49	82.75	46.34	0.64	10.30	—	3.12	—	—	—
	456/49	82.12	45.99	0.86	8.72	—	3.6	—	—	—
	457/49	51.78	29.0	1.9	28.1	—	9.5	—	—	—
	458/49	80.89	45.3	1.7	9.7	—	3.2	—	—	—
	459/49	46.07	25.8	1.3	34.8	—	9.3	—	—	—
	460/49	51.96	29.1	1.8	24.3	—	14.3	—	—	—

RECENT—*continued*:

Locality	Reg. No.	$CaCO_3$	CaO	MgO	Insol.	Fe_2O_3	$Fe_2O_3 + Al_2O_3$	Al_2O_3	P_2O_5	Ig. Loss
Sorell–continued	461/49	57.32	32.1	1.1	25.6	—	9.5	—	—	—
	462/49	64.82	36.3	1.8	19.5	—	6.4	—	—	—
	463/49	48.57	27.2	0.9	29.1	—	11.1	—	—	—
	464/49	57.32	32.1	1.1	26.2	—	8.2	—	—	—
	465/49	37.67	21.1	1.1	38.8	—	12.3	—	—	—
	466/49	83.55	46.79	0.97	7.88	—	3.76	—	—	—
	467/49	79.80	44.69	1.08	10.94	—	4.0	—	—	—
	468/49	69.94	39.17	1.19	18.16	—	5.6	—	—	—
	469/49	84.80	47.49	0.62	6.66	—	4.28	—	—	—
	470/49	82.03	45.94	0.68	10.5	—	3.0	—	—	—
	471/49	80.60	45.14	0.78	10.08	—	4.56	—	—	—
	472/49	67.53	37.82	0.80	19.32	—	6.0	—	—	—
	473/49	71.92	40.28	0.40	14.92	—	5.2	—	—	—
	474/49	72.82	40.78	0.69	15.64	—	4.76	—	—	—
	475/49	82.32	46.1	1.3	9.40	—	2.8	—	—	—
	476/49	87.67	49.1	0.7	5.40	—	2.5	—	—	—
	477/49	76.07	42.6	1.0	14.20	—	4.5	—	—	—
	478/49	83.03	46.5	1.3	8.90	—	3.1	—	—	—
	479/49	80.89	45.3	1.1	11.90	—	2.8	—	—	—
	480/49	85.07	48.0	1.1	7.0	—	2.8	—	—	—
	—	75.53	42.3	1.1	14.0	—	4.7	—	—	—
	—	83.39	46.7	0.65	8.5	—	3.6	—	—	—
	—	75.00	42.0	0.79	14.0	—	5.2	—	—	—
	—	74.46	41.7	0.70	13.9	—	4.6	—	—	—

2. TERTIARY:

Locality	Reg. No.	$CaCO_3$	CaO	MgO	Insol.	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	H_2O	Ig. Loss
Flinders Island											
Aerodrome ..	619/49	84.8	47.4	0.7	10.3	0.6	—	0.6	0.01	—	—
	620/49	58.8	32.9	0.7	36.4	0.9	—	0.7	0.02	—	—
nr. Aerodrome	634/49	58.6	32.8	0.6	31.9	1.4	—	3.3	0.01	—	—
	635/49	92.3	51.7	0.7	3.2	0.2	—	0.3	0.01	—	—
	636/49	52.0	29.1	0.6	38.0	1.3	—	2.5	0.01	—	—
	637/49	65.7	36.8	0.5	26.9	1.4	—	2.2	0.01	—	—
	638/49	74.0	41.4	0.6	19.0	1.3	—	1.0	0.02	—	—
	640/49	86.6	48.5	0.9	4.7	0.7	—	0.5	0.01	—	—
	642/49	58.2	32.6	0.7	34.7	1.3	—	0.4	0.03	—	—
	788/49	69.81	39.1	0.6	23.6	0.8	—	1.2	0.03	—	—
Blue Rocks ..	723/49	70.5	39.5	0.8	20.1	0.7	—	0.9	0.01	—	—
	724/49	66.07	37.0	0.8	26.0	1.3	—	1.8	0.02	—	—
Dutchman ..	193/50	80.89	45.3	0.6	14.8	0.8	—	0.7	0.12	—	—
Emita	617/49	75.17	42.1	1.2	19.2	0.4	—	0.5	0.03	—	—
	618/49	75.71	42.4	0.7	21.1	0.5	—	0.3	0.05	—	—
	641/49	92.85	52.0	0.8	0.2	0.1	—	0.3	0.03	—	—
	643/49	86.42	48.6	1.5	5.9	0.7	—	0.3	0.06	—	—
	670/49	89.82	50.3	0.8	0.4	0.1	—	0.1	0.02	—	—
	671/49	79.28	44.4	1.3	14.7	0.4	—	0.2	0.02	—	—
	672/49	94.10	52.7	0.7	4.0	0.6	—	0.6	0.06	—	—
	673/49	95.17	53.3	0.7	0.2	—	0.1	—	0.01	—	—
	674/49	77.50	43.4	1.9	16.0	0.9	—	1.2	0.05	—	—
	675/49	81.78	45.8	0.6	14.5	0.9	—	1.3	0.04	—	—
	789/49	86.96	48.7	2.4	3.7	0.4	—	0.5	0.05	—	—
	790/49	74.82	41.9	0.4	19.0	0.5	—	1.4	0.06	—	—
	797/49	61.42	34.4	1.1	32.6	0.4	—	0.4	0.04	—	—

2. TERTIARY—*continued*:

Locality	Reg. No.	$CaCO_3$	CaO	MgO	Insol.	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	H_2O	Ig. Loss.
Killiecrankie	240/50	76.25	42.7	0.6	15.8	0.7	—	0.3	0.04	—	—
Lady Barron	577/49	91.42	51.2	1.8	2.3	0.5	—	0.2	0.01	—	—
	578/49	84.46	47.3	1.7	9.7	0.7	—	0.6	0.02	—	—
	579/49	54.82	30.7	1.2	38.2	1.8	—	0.5	0.01	—	—
	580/49	69.28	38.8	1.6	24.7	0.9	—	0.2	0.02	—	—
	581/49	65.71	36.8	1.4	28.0	0.9	—	0.6	0.01	—	—
	582/49	90.35	50.6	1.6	3.2	0.6	—	0.2	0.02	—	—
Lughrata ..	550/49	66.96	37.5	0.7	2.64	1.5	—	1.5	0.06	—	—
	551/49	75.71	42.4	0.7	19.7	0.5	—	0.6	0.01	—	—
	552/49	85.71	48.0	0.7	9.4	0.3	—	0.2	Tr.	—	—
	553/49	89.46	50.1	0.8	7.0	0.8	—	0.5	0.06	—	—
	614/49	87.32	48.9	1.3	7.9	0.6	—	0.6	0.05	—	—
	615/49	94.82	53.1	0.8	0.5	0.1	—	0.4	0.01	—	—
	616/49	88.39	49.5	0.8	7.9	0.4	—	0.6	0.05	—	—
	666/49	70.5	39.5	0.8	24.4	1.2	—	1.1	0.04	—	—
	667/49	82.85	46.4	0.5	13.5	0.4	—	0.7	0.02	—	—
	668/49	83.92	47.0	0.8	13.2	0.7	—	1.0	0.02	—	—
	669/49	92.32	51.7	0.6	5.9	0.6	—	0.6	0.01	—	—
	791/49	67.14	37.6	0.5	27.5	0.8	—	1.2	0.05	—	—
	792/49	78.39	43.9	0.9	12.3	0.9	—	2.2	0.04	—	—
	793/49	77.32	43.3	1.0	13.3	1.2	—	2.1	0.05	—	—
	794/49	80.00	44.8	0.8	11.4	0.9	—	2.6	0.03	—	—
	795/49	86.78	48.6	1.2	5.9	0.6	—	1.0	0.05	—	—
	796/49	68.39	38.3	0.6	23.5	0.7	—	2.6	0.03	—	—
	238/50	76.96	43.1	0.6	15.6	0.9	—	1.2	0.02	—	—
	241/50	93.39	52.3	0.6	4.4	0.5	—	0.4	0.06	—	—
Palana	239/50	85.53	47.9	0.9	10.2	0.7	—	0.3	0.08	—	—

2. TERTIARY—*continued*:

Locality	Reg. No.	$CaCO_3$	CaO	MgO	Insol.	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	H_2O	Ig. Loss
Ranga	725/49	77.67	43.5	0.7	18.8	0.9	—	0.3	0.15	—	—
	726/49	77.32	43.3	0.6	19.3	0.6	—	0.4	0.08	—	—
	727/49	71.96	40.3	0.7	24.4	0.7	—	0.3	0.11	—	—
	812/49	89.10	49.9	0.4	7.6	0.7	—	0.3	0.02	—	—
	813/49	86.78	48.6	0.4	8.7	1.2	—	0.9	0.02	—	—
	814/49	93.03	52.1	0.6	3.0	0.2	—	0.1	0.1	—	—
	815/49	62.14	34.8	1.1	33.6	0.4	—	0.2	0.04	—	—
	816/49	58.92	33.0	1.1	36.8	0.3	—	0.2	0.03	—	—
Whitemark ..	548/49	92.13	51.6	0.5	4.5	0.4	—	0.4	0.02	—	—
	549/49	83.92	47.0	0.6	12.6	1.0	—	0.4	0.04	—	—
	621/49	84.46	47.3	0.6	12.6	1.1	—	0.9	0.06	—	—
Wingaroo ..	192/50	69.82	39.1	1.2	21.5	0.9	—	0.8	0.03	—	—
	194/50	69.28	38.8	1.1	22.1	1.0	—	1.6	0.04	—	—
	195/50	64.46	36.1	0.9	30.5	0.8	—	0.4	0.02	—	—
Hunter Island..	427/33	69.91	39.15	—	22.6	—	—	—	—	—	—
King Island ..	1099/48	93.92	52.6	0.8	1.4	—	1.6	—	—	—	43.2
	1100/48	61.78	34.6	1.5	16.0	—	12.0	—	—	—	32.8
	1101/48	97.67	54.7	0.4	0.7	—	0.8	—	—	—	43.4
	48/51	92.50	51.1	0.6	4.4	—	2.6	—	—	—	41.7
Marrawah ..	257/44	82.66	46.29	7.58	1.2	—	0.88	—	—	Nil	43.66
	258/44	84.71	47.44	7.24	0.4	—	0.60	—	—	Nil	43.7
Redpa	654/47	64.82	36.3	20.0	0.2	—	0.90	—	—	1.86	39.6
	655/47	62.32	34.9	16.8	0.4	—	0.80	—	—	0.2	46.3
	656/47	70.35	39.4	12.4	1.5	—	1.20	—	—	0.1	44.9

3. PERMIAN:

Locality	Reg. No.	$CaCO_3$	CaO	$MgCO_3$	MgO	SiO_2	Insol.	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	SO_3	H_2O	Ig. Loss	MnO_2
Beaconsfield	—	—	20.0	—	—	53.4	—	—	6.2	—	—	—	—	19.0	—
	—	—	37.6	—	0.9	23.0	—	1.8	—	5.8	—	—	—	30.4	—
Berriedale	740/22	76.19	—	—	0.68	21.2	—	0.2	—	1.36	—	—	—	—	—
	741/22	66.01	—	—	0.72	29.52	—	1.36	—	2.36	—	—	—	—	—
	742/22	77.40	—	—	0.72	18.20	—	2.15	—	1.27	—	—	—	—	—
	743/22	75.22	—	—	0.55	20.88	—	1.84	—	1.32	—	—	—	—	—
	744/22	70.36	—	—	0.80	24.2	—	2.36	—	1.64	—	—	—	—	—
	745/22	82.35	—	—	1.09	12.4	—	0.74	—	1.5	—	—	—	—	—
	746/22	80.73	—	—	1.09	13.8	—	0.54	—	1.56	—	—	—	—	—
	747/22	81.45	—	—	0.87	13.84	—	0.48	—	1.44	—	—	—	—	—
	748/22	54.30	—	—	0.87	38.8	—	1.02	—	2.98	—	—	—	—	—
	749/22	71.58	—	—	1.09	22.0	—	0.95	—	2.45	—	—	—	—	—
	791/22	78.49	—	—	1.00	17.4	—	1.48	—	2.0	—	—	—	—	—
	792/22	71.49	—	—	0.72	24.36	—	1.25	—	2.31	—	—	—	—	—
	793/22	88.18	—	—	0.58	10.0	—	0.94	—	0.86	—	—	—	—	—
	794/22	65.29	—	—	0.58	29.08	—	1.7	—	2.30	—	—	—	—	—
	795/22	75.50	—	—	1.01	19.8	—	1.56	—	2.52	—	—	—	—	—
	796/22	76.37	—	—	1.02	19.88	—	1.48	—	1.86	—	—	—	—	—
	797/22	80.08	—	—	0.36	16.84	—	1.4	—	1.79	—	—	—	—	—
	812/22	81.31	—	—	0.59	14.44	—	1.29	—	2.07	—	—	—	—	—
	813/22	68.54	—	—	0.94	26.52	—	0.72	—	2.96	—	—	—	—	—
	—	76.39	—	—	0.72	19.36	—	0.57	—	3.59	—	—	—	—	—
	—	65.87	—	—	0.72	28.36	—	2.93	—	2.27	—	—	—	—	—
	—	76.39	—	—	0.72	19.6	—	1.43	—	2.17	—	—	—	—	—
	—	77.37	—	—	0.72	18.6	—	1.43	—	2.53	—	—	—	—	—
	—	69.44	—	—	0.87	25.2	—	1.21	—	2.39	—	—	—	—	—
	—	62.76	—	—	0.79	29.72	—	1.72	—	5.0	—	—	—	—	—
	—	72.92	—	—	—	22.37	—	—	4.16	—	—	—	—	—	—
	—	24.47	—	—	—	54.08	—	—	14.19	—	—	—	—	—	—
	—	64.15	—	—	—	28.51	—	—	6.10	—	—	—	—	—	—
Bothwell	157/50	23.75	13.3	—	1.1	—	68.2	—	—	—	—	—	—	—	—
Bronte	172/47	59.06	33.08	—	0.84	31.92	—	—	—	—	—	—	—	—	—
	173/47	58.80	32.93	—	0.64	31.72	—	—	—	—	—	—	—	—	—
	174/47	45.44	25.45	—	0.91	41.36	—	—	—	—	—	—	—	—	—
	175/47	34.53	19.34	—	0.80	51.94	—	—	—	—	—	—	—	—	—
	176/47	32.19	18.03	—	0.78	52.0	—	—	—	—	—	—	—	—	—
	177/47	76.28	42.72	—	0.45	13.88	—	—	—	—	—	—	—	—	—
Brookstead	1013/22	92.14	—	—	—	—	—	—	—	—	0.1	—	—	—	—

3. PERMIAN—*continued*:

Locality	Reg. No.	$CaCO_3$	CaO	$MgCO_3$	MgO	SiO_2	Insol.	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	SO_3	H_2O	Ig. Loss	MnO_2
Campania	897/50	50.0 (Calc)	36.8	—	0.7	—	35.9	1.2	—	2.9	—	—	—	22.7	—
	898/50	41.1 (Calc)	31.1	—	0.4	—	43.6	2.0	—	4.8	—	—	—	18.5	—
	899/50	22.7 (Calc)	20.5	—	0.6	—	62.7	1.6	—	4.2	—	—	—	10.6	—
Cygnet	882/50	50.5	28.3	—	0.1	—	45.6	1.6	—	0.9	—	—	—	23.5	—
	883/50	48.75	27.3	—	0.5	—	44.4	1.9	—	1.8	—	—	—	23.8	—
	884/50	49.1	27.5	—	0.46	—	45.3	1.7	—	1.4	—	—	—	23.5	—
Dalmayne	209/23	57.83	—	—	0.72	37.0	—	1.14	—	2.86	—	—	—	—	—
	482/26	90.23	—	—	0.60	7.2	—	—	0.44	—	—	—	—	—	—
	486/26	79.25	—	—	0.75	17.4	—	—	1.0	—	—	—	—	—	—
	599/26	72.00	—	—	0.86	24.6	—	2.86	—	0.34	—	—	—	—	—
	624/26	77.60	—	—	0.29	20.16	—	2.29	—	1.54	—	—	—	—	—
	625/26	75.32	—	—	0.36	20.28	—	3.86	—	2.68	—	—	—	—	—
	626/26	71.69	—	—	0.50	23.52	—	2.00	—	0.34	—	—	—	—	—
Little Denison River ..	366/56	26.8	17.0	—	0.6	—	61.7	4.1	—	—	—	—	—	15.3	—
Dromedary	267/20	72.49	—	—	0.38	23.71	—	3.35	—	4.45	—	—	0.35	—	—
	743/52	55.2	29.9	—	—	—	41.4	—	—	—	—	—	—	25.3	—
	744/52	84.7	44.0	—	—	—	12.8	—	—	—	—	—	—	40.7	—
	745/52	66.9	37.0	—	—	—	28.9	—	—	—	—	—	—	29.9	—
	746/52	76.8	42.5	—	—	—	21.2	—	—	—	—	—	—	34.3	—
Fingal (Ransomes) ..	822/21	87.73	—	—	0.11	8.72	—	0.36	—	2.88	—	—	—	—	—
Fingal (Frodsley)	823/21	76.22	—	—	0.43	16.64	—	2.07	—	3.89	—	—	0.82	—	—
Fingal	72/22	71.67	—	—	1.45	22.52	—	1.14	—	3.06	—	—	—	—	—
Glenorchy	859/21	78.72	—	—	0.86	16.20	—	1.14	—	2.98	—	—	—	—	—
	860/21	76.30	—	—	1.09	17.92	—	0.86	—	3.34	—	—	—	—	—
	861/21	18.03	—	—	1.09	61.88	—	4.0	—	10.8	—	2.17	—	—	—
	—	79.25	—	—	0.86	13.12	—	2.0	—	3.5	—	—	—	—	—
	247/22	76.57	—	—	0.47	16.0	—	1.44	—	4.8	—	—	—	—	0.37
	248/22	83.89	—	—	0.43	9.88	—	0.85	—	3.42	—	—	—	—	0.26
	249/22	64.52	—	—	0.50	28.88	—	0.85	—	3.46	—	—	—	—	0.55
	250/22	65.86	—	—	0.89	26.52	—	1.14	—	3.74	—	—	—	—	0.44

3. PERMIAN—*continued*:

Locality	Reg. No.	$CaCO_3$	CaO	$MgCO_3$	MgO	SiO_2	Insol.	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	SO_3	H_2O	Ig. Loss	MnO_2
Glenorchy–continued	251/22	50.02	—	—	0.60	36.0	—	2.0	—	4.28	—	—	—	—	0.56
	252/22	73.0	—	—	0.72	19.64	—	1.26	—	5.06	—	—	—	—	—
	253/22	78.18	—	—	0.28	16.88	—	1.4	—	2.08	—	—	—	—	—
	254/22	44.17	—	—	0.79	44.6	—	2.1	—	6.06	—	—	—	—	—
	255/22	71.75	—	—	0.57	20.6	—	0.84	—	4.16	—	—	—	—	—
	256/22	54.26	—	—	0.57	34.36	—	1.36	—	6.34	—	—	—	—	—
	257/22	77.64	—	—	0.28	16.6	—	1.4	—	3.32	—	—	—	—	—
	258/22	68.54	—	—	0.57	26.6	—	0.7	—	3.5	—	—	—	—	—
	259/22	71.04	—	—	0.14	22.92	—	0.98	—	3.62	—	—	—	—	—
	260/22	25.53	—	—	0.72	60.16	—	3.52	—	8.56	—	—	—	—	—
	261/22	19.36	—	—	0.80	64.6	—	3.03	—	10.45	—	—	—	—	—
Granton	839/22	59.69	—	—	1.09	31.40	—	1.79	—	4.45	—	—	—	—	—
		86.40	—	—	0.72	10.32	—	0.91	—	2.27	—	—	—	—	—
		68.90	—	—	1.09	25.40	—	1.29	—	3.39	—	—	—	—	—
		68.93	—	—	0.36	26.64	—	1.86	—	2.54	—	—	—	—	—
	Doutbful	70.70	—	—	0.24	23.56	—	2.14	—	3.74	—	—	—	—	—
	Series	63.60	—	—	0.50	30.04	—	1.86	—	4.50	—	—	—	—	—
		84.34	—	—	0.20	12.88	—	0.70	—	1.78	—	—	—	—	—
		78.40	—	—	0.60	17.60	—	1.60	—	2.40	—	—	—	—	—
		63.26	—	—	1.01	29.72	—	1.56	—	2.64	—	—	—	—	—
		65.26	—	—	1.23	27.28	—	1.64	—	2.28	—	—	—	—	—

3. PERMIAN—*continued*:

Locality	Reg. No.	$CaCO_3$	CaO	$MgCO_3$	MgO	SiO_2	Insol.	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	SO_3	H_2O	Ig. Loss	S.
Granton-continued	137/48	75.00	42.0	—	0.7	19.9	—	0.9	—	1.8	—	—	—	33.5	—
	138/48	73.57	41.2	—	0.6	21.7	—	0.9	—	1.8	—	—	—	32.8	—
	139/48	76.42	42.8	—	0.4	19.1	—	0.2	—	2.1	—	—	—	34.2	—
	140/48	72.14	40.4	—	0.8	21.5	—	0.8	—	2.6	—	—	—	32.9	—
	141/48	58.92	33.0	—	0.6	34.4	—	0.9	—	3.1	—	—	—	26.7	—
	142/48	77.50	43.4	—	0.4	18.7	—	0.4	—	1.5	—	—	—	34.6	—
	143/48	60.89	34.1	—	0.5	33.1	—	1.3	—	2.5	—	—	—	27.6	—
	144/48	81.07	45.4	—	0.6	15.6	—	0.7	—	1.3	—	—	—	36.3	—
	145/48	72.67	40.7	—	0.6	21.4	—	0.9	—	2.5	—	—	—	33.0	—
	146/48	44.82	25.1	—	0.9	41.8	—	2.2	—	5.8	—	—	—	21.8	—
	147/48	70.17	39.3	—	0.7	23.4	—	1.1	—	2.8	—	—	—	32.0	—
	148/48	39.64	33.4	—	0.6	33.3	—	1.3	—	2.9	—	—	—	27.6	—
	149/48	53.39	34.9	—	0.5	29.3	—	1.2	—	3.7	—	—	—	28.8	—
	150/48	31.25	17.5	—	0.7	52.9	—	2.0	—	7.2	—	—	—	15.5	—
	151/48	43.92	24.6	—	0.6	44.6	—	1.9	—	4.7	—	—	—	20.8	—
	152/48	59.10	33.1	—	0.7	31.0	—	1.2	—	4.2	—	—	—	27.3	—
	153/48	64.82	36.3	—	0.6	27.0	—	1.1	—	3.5	—	—	—	29.8	—
	168/48	43.39	24.3	—	0.6	43.2	—	2.0	—	4.8	—	—	—	20.9	—
	169/48	19.10	10.7	—	1.2	53.8	—	3.1	—	11.7	—	—	—	12.5	—
	170/48	23.39	13.1	—	1.2	54.2	—	2.8	—	9.5	—	—	—	13.0	—
	171/48	15.00	8.9	—	1.2	59.5	—	3.6	—	10.3	—	—	—	10.4	—
	172/48	26.78	15.0	—	1.1	50.2	—	3.4	—	9.9	—	—	—	14.9	—
	173/48	69.10	38.7	—	0.7	25.3	—	1.0	—	1.8	—	—	—	31.3	—
	174/48	78.75	44.1	—	0.5	17.6	—	0.6	—	1.2	—	—	—	35.5	—
	175/48	58.92	33.0	—	0.8	30.4	—	0.9	—	4.1	—	—	—	27.1	—
	176/48	65.35	36.6	—	0.7	28.4	—	0.9	—	2.0	—	—	—	29.8	—
	177/48	71.42	40.0	—	0.7	22.6	—	1.0	—	1.8	—	—	—	32.5	—
	178/48	69.64	39.0	—	0.6	24.3	—	0.9	—	1.7	—	—	—	31.8	—
	179/48	63.39	35.5	—	0.6	30.0	—	1.0	—	1.2	—	—	—	28.9	—
	180/48	64.28	36.0	—	0.6	29.5	—	1.0	—	2.0	—	—	—	29.2	—
	181/48	43.75	25.5	—	1.0	41.2	—	1.7	—	5.0	—	—	—	22.2	—
	182/48	76.78	43.0	—	0.9	16.9	—	0.6	—	2.0	—	—	—	35.1	—
	183/48	58.29	33.0	—	0.9	30.0	—	1.3	—	4.2	—	—	—	27.9	—
	184/48	65.71	37.2	—	0.8	26.0	—	1.4	—	2.2	—	—	—	30.7	—
	185/48	44.28	24.8	—	1.0	42.6	—	1.6	—	5.8	—	—	—	21.3	—
	186/48	64.10	35.9	—	0.6	29.2	—	1.1	—	2.4	—	—	—	29.9	—
	187/48	61.07	34.2	—	0.7	31.3	—	1.1	—	3.1	—	—	—	28.5	—
	336/48	65.71	36.80	—	0.7	26.50	—	1.14	—	2.51	0.06	—	—	30.40	0.01

3. PERMIAN—*continued*:

Locality	Reg. No.	$CaCO_3$	CaO	$MgCO_3$	MgO	SiO_2	Insol.	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	SO_3	H_2O	Ig. Loss	TiO_2	S.
Gray	375/51	58.4	32.7	—	0.6	—	36.2	—	1.9	—	0.1	—	—	28.1	—	—
	376/51	81.1	45.4	—	0.4	—	16.8	—	0.7	—	Trace	—	—	36.6	—	—
	377/51	85.7	48.0	—	0.5	—	12.8	—	0.5	—	0.1	—	—	38.0	—	—
	378/51	81.6	45.7	—	0.5	—	16.2	—	0.7	—	Trace	—	—	36.6	—	—
	379/51	69.7	39.0	—	0.5	—	26.7	—	1.3	—	Trace	—	—	31.9	—	—
	380/51	53.9	30.2	—	0.6	—	40.8	—	2.3	—	Trace	—	—	25.7	—	—
	381/51	70.7	40.6	—	0.5	—	23.6	—	2.0	—	Trace	—	—	33.4	—	—
	382/51	75.5	42.3	—	0.4	—	22.6	—	0.7	—	Trace	—	—	34.1	—	—
	383/51	57.3	32.2	—	0.6	—	37.3	—	2.3	—	0.2	—	—	27.4	—	—
	384/51	80.1	45.1	—	0.5	—	17.9	—	0.7	—	Trace	—	—	36.0	—	—
	385/51	76.8	43.0	—	0.5	—	20.8	—	0.7	—	0.2	—	—	34.7	—	—
	386/51	58.4	32.7	—	0.6	—	36.2	—	2.2	—	0.4	—	—	27.4	—	—
	387/51	75.0	42.0	—	0.4	—	22.4	—	0.9	—	Trace	—	—	33.8	—	—
Hobart	643/47	70.80	39.65	—	0.32	—	25.76	—	1.20	—	—	—	1.14	32.00	—	—
	644/47	14.01	7.85	—	1.00	—	76.52	—	4.68	—	—	—	0.56	8.32	—	—
	645/47	39.37	22.05	—	0.48	—	55.00	—	3.04	—	—	—	0.20	18.08	—	—
	127/50	38.9	40.5	—	0.4	—	40.0	0.8	—	0.5	0.08	—	—	17.1	0.3	—
	169/50	32.67	35.9	—	0.3	—	46.2	1.1	—	0.7	—	—	—	14.4	0.2	—
	170/50	35.89	31.0	—	0.3	—	49.3	1.2	—	1.7	—	—	—	15.8	0.2	—
	171/50	16.78	9.4	—	0.5	—	75.8	2.2	—	2.8	—	—	—	8.2	0.6	—
	172/50	45.89	42.2	—	0.1	—	34.6	0.7	—	1.2	—	—	—	20.2	0.1	—
Karoola	/30	85.30	—	—	0.5	—	10.2	—	2.0	—	—	—	—	—	—	—
	43/50	80.35	45.0	—	1.2	—	14.7	1.0	—	0.9	—	—	—	—	—	—
Margate	639/47	72.41	40.55	—	0.39	—	23.68	—	1.76	—	—	—	0.30	32.38	—	—
	640/47	81.69	45.75	—	0.40	—	15.44	—	0.92	—	—	—	1.08	36.72	—	—
	641/47	78.83	44.15	—	0.39	—	17.60	—	0.96	—	—	—	0.10	35.87	—	—
	642/47	79.73	44.65	—	0.43	—	13.44	—	0.84	—	—	—	0.04	37.80	—	—
Maria Island ..	974/51	85.0	47.6	—	0.8	—	12.4	0.7	—	0.5	Trace	—	—	—	—	Trace
	975/51	78.0	43.7	—	0.9	—	17.6	0.6	—	0.7	Trace	—	—	—	—	Trace
	976/51	83.5	46.8	—	0.8	—	13.8	0.5	—	0.5	Trace	—	—	—	—	Trace
	977/51	75.9	42.5	—	0.6	—	21.1	0.7	—	0.7	Trace	—	—	—	—	Trace

3. PERMIAN—*continued*:

Locality	Reg. No.	$CaCO_3$	CaO	$MgCO_3$	MgO	SiO_2	Insol.	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	H_2O	Ig. Loss	MnO_2	S.
Maria Island-continued	978/51	75.0	42.0	—	1.0	—	19.4	—	2.0	—	0.12	—	—	—	0.11
	979/51	69.8	39.1	—	0.8	—	25.7	—	2.7	—	0.1	—	—	—	0.24
	980/51	73.2	41.0	—	0.9	—	21.8	—	1.9	—	Trace	—	—	—	0.12
	981/51	74.6	41.8	—	1.0	—	22.4	—	1.9	—	0.14	—	—	—	Trace
	982/51	76.9	43.1	—	1.0	—	18.9	—	1.6	—	Trace	—	—	—	Trace
	37/54	88.9	—	1.3	—	—	8.0	—	1.2	—	.01	—	—	—	.04
	38/54	92.1	—	0.8	—	—	5.8	—	0.8	—	.01	—	—	—	.03
Mt. Nicholas	228/20	69.25	—	—	—	23.00	—	—	—	—	—	—	—	—	—
Mt. Peter	485/26	88.8	—	—	0.6	7.8	—	—	0.72	—	—	—	—	—	—
	621/26	82.4	—	—	0.29	15.4	—	2.15	—	0.45	—	—	—	—	—
	622/26	76.5	—	—	0.65	18.4	—	2.29	—	2.51	—	—	—	—	—
Picannini Creek	482/26	90.23	—	—	0.6	7.2	—	—	0.44	—	—	—	—	—	—
	486/26	79.25	—	—	0.75	17.4	—	—	1.0	—	—	—	—	—	—
	599/26	72.0	—	—	0.86	24.6	—	2.86	—	0.34	—	—	—	—	—
	624/26	77.6	—	—	0.29	20.16	—	2.29	—	0.43	—	—	—	—	—
	625/26	75.32	—	—	0.36	20.28	—	3.86	—	1.54	—	—	—	—	—
	626/26	71.69	—	—	0.50	23.52	—	2.00	—	2.68	—	—	—	—	—
St. Marys	914/56	—	32.1	—	0.3	—	37.6	—	1.30	—	—	1.10	26.8	—	—
Saltwater Lagoon	297/48	92.32	51.70	—	0.50	5.04	—	0.64	—	0.85	0.04	—	41.31	0.06	—
Silkstone	87/21	88.48	—	0.32	—	9.32	—	—	1.61	—	—	0.29	—	—	—
	88/21	71.96	—	0.80	—	23.26	—	—	3.10	—	—	0.27	—	—	—
	89/21	76.68	—	0.49	—	16.52	—	—	4.88	—	—	0.31	—	—	—
	90/21	82.87	—	0.36	—	10.20	—	—	4.60	—	—	0.24	—	—	—
	91/21	85.20	—	0.07	—	11.31	—	—	3.10	—	—	0.18	—	—	—
	93/21	70.10	—	0.14	—	26.11	—	—	2.60	—	—	0.30	—	—	—
	94/21	62.41	—	0.07	—	30.52	—	—	5.70	—	—	0.54	—	—	—
	711/21	86.75	—	—	—	—	—	—	—	—	—	—	—	—	—
	821/21	89.38	—	—	0.21	7.80	—	1.00	—	1.72	—	—	—	—	—
	830/21	78.32	—	—	0.32	18.08	—	1.08	—	1.20	—	—	—	—	—
	737/21	83.45	—	—	1.15	12.24	—	1.57	—	1.83	—	—	—	—	—
	738/21	83.90	—	—	1.15	11.52	—	1.43	—	2.27	—	—	—	—	—
	739/21	84.97	—	—	1.00	10.12	—	1.86	—	2.18	—	—	—	—	—
	740/21	87.38	—	—	1.00	8.60	—	1.72	—	1.52	—	—	—	—	—
Sorell	525/44	89.64	50.2	—	—	—	—	—	—	—	—	—	—	—	—
	454/49	—	46.7	—	0.3	—	25.2	—	1.4	—	—	—	—	—	—
	544/49	62.33	34.9	—	0.7	—	27.3	1.5	—	1.9	0.01	—	—	—	—

4. ORDOVICIAN:

Locality	Reg. No.	$CaCO_3$	CaO	$MgCO_3$	MgO	SiO_2	Insol.	FeO	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	SO_3	H_2O	Ig. Loss	TiO_2	MnO_2	S	Na_2O	K_2O
Dawson Road . .	498/43	90.35	50.60	—	1.02	4.52	—	—	0.50	—	1.66	Trace	—	0.12	44.30	—	—	0.06	—	—
	499/43	92.39	51.74	—	1.20	3.66	—	—	0.35	—	1.09	Trace	—	—	41.62	—	—	0.09	—	—
	500/43	92.94	52.05	—	1.12	2.96	—	—	0.40	—	1.28	Trace	—	0.06	41.88	—	—	0.12	—	—
	501/43	87.12	48.79	—	1.29	8.20	—	—	0.35	—	1.61	Trace	—	—	39.08	—	—	0.15	—	—
Darwin	3/51	88.90	49.8	—	2.2	—	5.2	—	0.4	—	0.2	Trace	—	—	41.7	—	Trace	—	—	—
Flowery Gully . .	274/24	93.44	—	—	2.17	2.48	—	—	0.58	—	0.62	—	—	—	—	—	—	—	—	—
	275/24	96.12	—	—	1.45	1.60	—	—	0.72	—	0.08	—	—	—	—	—	—	—	—	—
	276/24	91.75	—	—	3.62	2.52	—	—	1.14	—	0.14	—	—	—	—	—	—	—	—	—
	304/24	96.62	—	—	0.81	1.80	—	—	0.56	—	0.64	—	—	—	—	—	—	—	—	—
	—	93.72	—	—	—	—	5.35	—	—	0.55	—	—	—	0.20	—	—	—	—	—	—
	—	94.00	—	—	—	—	0.98	—	—	3.15	—	—	—	1.87	—	—	—	—	—	—
	—	95.45	—	—	—	—	1.85	—	—	1.65	—	—	—	1.05	—	—	—	—	—	—
	—	95.65	—	0.83	—	1.61	—	—	—	1.70	—	—	—	1.18	—	—	—	—	—	—
	—	95.40	—	1.22	—	1.44	—	—	—	1.79	—	—	—	0.13	—	—	—	—	—	—
	—	94.75	—	1.17	—	0.98	—	—	—	2.81	—	—	—	0.20	—	—	—	—	—	—
Flowery Gully . .	11/50	96.78	54.2	—	1.6	—	0.6	—	0.1	—	0.1	0.1	—	—	—	—	—	—	—	—
	12/50	91.78	51.4	—	3.7	—	0.7	—	0.4	—	0.1	0.1	—	—	—	—	—	—	—	—
	13/50	95.71	53.6	—	1.2	—	2.1	—	0.2	—	0.03	0.1	—	—	—	—	—	—	—	—
	14/50	84.64	47.4	—	3.5	—	7.9	—	0.3	—	0.1	Trace	—	—	—	—	—	—	—	—
	15/50	78.92	44.2	—	8.9	—	2.0	—	0.9	—	0.2	0.01	—	—	—	—	—	—	—	—
	16/50	91.6	51.3	—	2.0	—	4.1	—	0.6	—	0.2	0.01	—	—	—	—	—	—	—	—
	17/50	92.31	51.7	—	1.1	—	5.8	—	0.2	—	0.1	0.02	—	—	—	—	—	—	—	—
Flowery Gully	11/50	—	Trace	—	2.53	70.80	—	—	0.99	—	18.71	—	—	—	—	1.5	—	—	0.41	5.19
	12/50	—	Trace	—	2.66	67.28	—	—	1.42	—	20.0	—	—	—	—	1.94	—	—	0.34	6.25
(Analyses of Acid Insol. of above)	13/50	—	Trace	—	2.14	80.28	—	—	0.56	—	12.12	—	—	—	—	0.72	—	—	0.19	3.66
	14/50	—	Trace	—	0.85	91.64	—	—	0.28	—	5.18	—	—	—	—	0.34	—	—	0.23	1.20
	15/50	—	Trace	—	2.39	72.92	—	—	0.78	—	16.90	—	—	—	—	1.16	—	—	0.50	5.06
	16/50	—	Trace	—	2.20	74.96	—	—	0.50	—	16.23	—	—	—	—	0.87	—	—	0.40	4.76
	17/50	—	Trace	—	1.00	91.16	—	—	0.21	—	6.05	—	—	—	—	0.34	—	—	0.40	1.44
Golden Valley . .	/32	87.94	49.25	—	1.64	6.52	—	—	0.90	—	2.50	0.04	0.11	—	39.54	0.09	—	—	—	—
Gunns Plains . .	737/37	69.39	38.86	—	6.02	14.12	—	—	1.20	—	3.45	0.03	0.14	0.16	34.72	0.16	Trace	0.23	0.33	1.15

4. ORDOVICIAN—*continued:*

Locality	Reg. No.	$CaCO_3$	CaO	$MgCO_3$	MgO	Acid Insol.	Fe_2O_3 + Al_2O_3	S
Gunns Plains-continued	666/51	84.2	47.2	4.5	2.2	9.7	1.2	0.2
	667/51	87.6	49.1	3.1	1.5	7.8	0.6	Below 0.1
	668/51	94.2	52.8	1.6	0.8	3.3	0.3	Below 0.1
	669/51	88.5	49.6	1.8	0.9	8.1	0.7	Below 0.1
	670/51	93.9	52.6	1.6	0.8	3.9	0.5	Below 0.1
	671/51	89.9	50.4	2.1	1.0	7.2	0.6	Below 0.1
	672/51	92.4	51.8	1.4	0.7	5.4	0.4	Below 0.1
	673/51	93.1	52.2	2.0	0.9	4.4	0.5	Below 0,1
	674/51	84.4	47.3	2.8	1.3	11.7	0.8	Below 0.1
	675/51	69.8	39.1	8.7	4.1	19.4	1.4	Below 0.1
	680/51	92.6	51.9	1.8	0.9	4.9	0.6	Below 0.1
	681/51	85.0	47.6	4.9	2.4	8.5	0.8	0.1
	682/51	81.4	45.6	3.9	1.9	12.4	1.2	0.1
	683/51	88.7	49.7	2.2	1.0	7.7	0.6	Below 0.1
	684/51	91.4	51.5	1.9	0.9	5.4	0.4	Below 0.1
	685/51	88.7	49.7	1.4	0.7	8.3	0.8	Below 0.1
	686/51	93.0	52.1	1.2	0.6	4.4	0.6	Below 0.1
	687/51	92.6	51.9	1.2	0.6	4.7	0.6	Below 0.1
	688/51	84.1	47.1	1.5	0.7	12.8	1.1	Below 0.1
	689/51	88.0	49.3	1.2	0.6	8.9	0.9	Below 0.1
	690/51	86.6	48.5	1.2	0.6	10.8	0.9	Below 0.1
	691/51	93.0	52.1	1.3	0.6	4.6	0.7	Below 0.1
	692/51	90.0	50.4	1.4	0.7	7.2	0.7	Below 0.1
	693/51	86.6	48.5	1.8	0.9	10.2	1.0	Below 0.1
	694/51	85.1	47.7	1.7	0.8	11.8	1.0	Below 0.1
	695/51	90.9	50.9	1.8	0.9	6.0	0.7	Below 0.1
	696/51	88.7	49.7	2.6	1.2	7.3	0.8	0.1
	697/51	89.4	50.1	5.3	2.5	4.2	0.8	Below 0.1
	698/51	88.5	49.6	4.2	2.0	5.4	0.8	Below 0.1
	699/51	85.5	47.9	4.4	2.1	8.3	0.6	Below 0.1
	700/51	84.4	47.3	5.6	2.7	8.1	0.8	Below 0.1
	701/51	77.6	43.5	5.9	2.8	14.0	1.1	Below 0.1
	702/51	88.0	49.3	3.3	1.6	7.2	0.7	0.1
	703/51	82.5	46.2	3.6	1.7	12.0	0.9	Below 0.1
	704/51	86.4	48.4	4.5	2.2	8.6	0.7	Below 0.1
	705/51	80.0	44.8	9.2	4.4	9.8	0.8	Below 0.1
	706/51	88.0	49.3	5.0	2.4	6.5	0.8	Below 0.1

4. ORDOVICIAN—*continued:*

Locality	Reg. No.	$CaCO_3$	CaO	$MgCO_3$	MgO	SiO_2	Insol.	FeO	Fe_2O_3	$Fe_2O_3 + Al_2O_3$	Al_2O_3	P_2O_5	SO_3	H_2O	Ig. Loss	TiO_2	MnO_2	S	Na_2O	K_2O
Gunns Plains	817/51	85.3	47.8	7.3	3.5	—	6.4	—	—	0.8	—	—	—	—	—	—	—	0.1	—	—
	818/51	83.9	47.0	7.7	3.7	—	8.0	—	—	0.8	—	—	—	—	—	—	—	0.1	—	—
	819/51	90.5	50.7	4.2	2.0	—	4.7	—	—	0.6	—	—	—	—	—	—	—	0.1	—	—
	820/51	76.4	42.8	12.1	5.8	—	10.3	—	—	1.1	—	—	—	—	—	—	—	0.1	—	—
	821/51	79.6	44.6	7.7	3.7	—	11.6	—	—	0.9	—	—	—	—	—	—	—	0.16	—	—
	822/51	91.4	51.2	2.7	1.3	—	5.3	—	—	0.6	—	—	—	—	—	—	—	Below 0.1	—	—
	823/51	92.5	51.8	1.9	0.9	—	5.0	—	—	0.6	—	—	—	—	—	—	—	Below 0.1	—	—
	824/51	87.3	48.9	4.6	2.2	—	7.4	—	—	0.7	—	—	—	—	—	—	—	Below 0.1	—	—
	825/51	84.8	47.5	2.3	1.1	—	11.6	—	—	1.0	—	—	—	—	—	—	—	0.1	—	—
	826/51	94.8	53.1	2.1	1.0	—	2.6	—	—	0.4	—	—	—	—	—	—	—	nil	—	—
Hampshire	504/43	—	44.46	—	3.42	29.20	—	—	0.72	—	3.11	0.13	—	—	18.62	—	0.24	—	—	—
	/50	—	51.0	—	0.4	—	8.4	—	—	1.6	—	—	—	—	38.0	—	—	—	—	—
Ida Bay	—	92.85	52.00	—	1.50	3.70	—	—	—	—	1.00	—	—	—	41.80	—	—	—	—	—
	—	91.60	—	2.80	—	3.40	—	0.80	—	—	—	—	—	—	—	—	—	—	—	—
	—	92.67	—	1.83	—	4.02	—	—	—	0.91	—	—	—	—	—	—	—	—	—	—
	—	97.30	—	1.20	—	0.80	—	—	—	0.40	—	—	—	—	—	—	—	—	—	—
	827/21	97.88	—	—	0.28	1.28	—	—	0.42	—	0.38	—	—	—	—	—	—	—	—	—
	50/26	94.50	—	—	1.73	2.00	—	—	—	0.64	—	—	—	—	—	—	—	—	—	—
	51/26	94.70	—	—	1.00	2.48	—	—	—	1.16	—	—	—	—	—	—	—	—	—	—
	52/26	95.49	—	—	0.72	1.40	—	—	—	0.64	—	—	—	—	—	—	—	—	—	—
	53/26	93.70	—	—	0.89	4.20	—	—	—	0.84	—	—	—	—	—	—	—	—	—	—
	54/26	96.74	—	—	0.72	1.48	—	—	—	0.68	—	—	—	—	—	—	—	—	—	—
	55/26	93.40	—	—	1.70	3.00	—	—	—	0.40	—	—	—	—	—	—	—	—	—	—
	56/26	93.85	—	—	0.59	5.04	—	—	—	0.28	—	—	—	—	—	—	—	—	—	—
	57/26	91.66	—	—	1.00	5.08	—	—	—	0.56	—	—	—	—	—	—	—	—	—	—
	58/26	93.25	—	—	0.59	4.68	—	—	—	0.32	—	—	—	—	—	—	—	—	—	—
	59/26	96.21	—	—	0.59	1.68	—	—	—	0.16	—	—	—	—	—	—	—	—	—	—
	60/26	96.75	—	—	0.36	1.28	—	—	—	0.16	—	—	—	—	—	—	—	—	—	—
	61/26	96.38	—	—	1.00	2.00	—	—	—	0.16	—	—	—	—	—	—	—	—	—	—
	62/26	94.30	—	—	1.73	3.40	—	—	—	0.52	—	—	—	—	—	—	—	—	—	—
	63/26	91.93	—	—	1.73	5.48	—	—	—	0.68	—	—	—	—	—	—	—	—	—	—
	64/26	95.32	—	—	0.44	2.40	—	—	—	0.16	—	—	—	—	—	—	—	—	—	—
	65/26	94.60	—	—	0.44	3.88	—	—	—	0.60	—	—	—	—	—	—	—	—	—	—

4. ORDOVICIAN—*continued:*

Locality	Reg. No.	$CaCO_3$	CaO	$MgCO_3$	MgO	SiO_2	Insol.	FeO	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	SO_3	H_2O	Ig. Loss	TiO_2	MnO_2	S	Na_2O	FeS_2
Ida Bay ..	66/26	92.80	—	—	2.53	2.60	—	—	—	0.76	—	—	—	—	—	—	—	—	—	—
	5/48	92.76	51.95	—	1.59	3.44	—	—	0.29	—	0.48	0.01	—	0.28	42.02	0.02	—	—	—	—
	408/51	97.5	54.2	—	0.7	—	1.9	—	—	0.5	—	—	—	—	43.0	—	—	—	—	—
	409/51	94.8	53.1	—	1.0	—	3.7	—	—	0.2	—	—	—	—	42.1	—	—	—	—	—
	646/51	90.5	50.7	—	1.2	—	5.8	—	—	0.4	—	—	—	—	—	—	—	0.1	—	—
	647/51	92.2	51.6	—	0.8	—	5.7	—	—	0.4	—	—	—	—	—	—	—	Below 0.1	—	—
	648/51	97.5	54.6	—	0.6	—	1.0	—	—	0.3	—	—	—	—	—	—	—	Below 0.1	—	—
	649/51	94.8	53.1	—	0.9	—	3.1	—	—	0.3	—	—	—	—	—	—	—	Below 0.1	—	—
	650/51	94.5	52.9	—	0.7	—	3.5	—	—	0.5	—	—	—	—	—	—	—	Below 0.1	—	—
	651/51	93.0	52.0	—	1.6	—	3.2	—	—	0.5	—	—	—	—	—	—	—	Below 0.1	—	—
Loongana ..	869/51	90.1	50.5	2.5	1.2	—	7.0	—	—	0.8	—	—	—	—	—	—	—	—	—	—
	870/51	88.3	49.5	2.7	1.3	—	8,4	—	—	1.0	—	—	—	—	—	—	—	—	—	—
	871/51	84.2	47.2	4.2	2.0	—	11.6	—	—	0.8	—	—	—	—	—	—	—	—	—	—
	872/51	87.8	49.2	3.8	1.8	—	8.0	—	—	0.8	—	—	—	—	—	—	—	—	—	—
	873/51	94.4	52.9	2.5	1.2	—	3.2	—	—	0.4	—	—	—	—	—	—	—	—	—	—
	874/51	86.9	48.7	4.4	2.1	—	8.4	—	—	0.6	—	—	—	—	—	—	—	—	—	—
	875/51	86.2	48.3	5.2	2.5	—	7.7	—	—	1.0	—	—	—	—	—	—	—	—	—	—
Lorinna ..	852/56	—	47.7	—	1.7	—	10.6	—	—	1.4	—	—	—	—	39.3	—	—	—	—	—
	851/56	—	45.9	—	1.5	—	14.0	—	—	1.7	—	—	—	—	37.3	—	—	—	—	—
Maydena (A.N.M.)	606/51	83.9	46.4	—	0.7	—	13.7	—	—	1.2	—	—	—	—	—	—	—	—	—	—
	607/51	83.0	47.1	—	0.7	—	13.0	—	—	1.0	—	—	—	—	—	—	—	—	—	—
	608/51	70.3	39.7	—	0.9	—	24.6	—	—	1.6	—	—	—	—	—	—	—	—	—	—
	609/51	76.4	43.4	—	0.8	—	16.9	—	—	2.4	—	—	—	—	—	—	—	—	—	—
	610/51	83.7	47.1	—	0.5	—	13.2	—	—	1.0	—	—	—	—	—	—	—	—	—	—
	611/51	71.6	40.2	—	0.8	—	24.0	—	—	1.7	—	—	—	—	—	—	—	—	—	—
	941/52	96.0	53.8	—	0.4	—	2.4	—	0.2	—	0.6	—	—	—	—	—	—	Tr.	—	—
	942/52	91.2	51.1	—	1.4	—	5.4	—	0.3	—	0.7	—	—	—	—	—	—	Tr.	—	—
	943/52	86.2	48.3	—	2.4	—	7.6	—	0.5	—	0.7	—	—	—	—	—	—	Tr.	—	—
	944/52	90.5	50.7	—	0.6	—	6.8	—	0.3	—	0.7	—	—	—	—	—	—	Tr.	—	—
	945/52	78.9	44.2	—	0.8	—	18.2	—	0.4	—	0.8	—	—	—	—	—	—	0.22	—	—

4. ORDOVICIAN—*continued:*

Locality	Reg. No.	$CaCO_3$	CaO	$MgCO_3$	MgO	SiO_2	Insol.	FeO	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	SO_3	H_2O	Ig. Loss	TiO_2	MnO_2		Na_2O	FeS_2
Maydena (A.N.M.) ..	946/52	90.5	50.7	—	0.7	—	6.7	—	0.3	—	0.7	—	—	—	—	—	—	0.14	—	—
	947/52	93.3	52.3	—	0.6	—	5.0	—	0.2	—	0.4	—	—	—	—	—	—	Trace	—	—
	948/52	49.8	27.9	—	0.5	—	47.5	—	1.7	—	0.3	—	—		—	—	—	Trace	—	—
	949/52	56.7	31.8	—	0.6	—	40.3	—	1.2	—	0.7	—	—	—	—	—	—	0.1	—	—
	950/52	88.5	49.6	—	1.7	—	6.8	—	0.5	—	0.5	—	—	—	—	—	—	0.11	—	—
	951/52	91.0	51.0	—	0.9	—	6.1	—	0.4	—	0.5	—	—	—	—	—	—	Trace	—	—
Moina ..	855/56	—	47.0	—	2.9	—	9.2	—	—	2.2	—	—	—	—	38.6	—	—	—	—	—
Melrose ..	773/25	86.57	—	—	1.37	7.84	—	—	1.82	—	2.70	—	—	—	—	—	—	—	—	—
	—	90.84	—	—	—	3.68	—	—	1.79	—	2.17	—	—	—	—	—	—	—	—	—
	—	93.12	—	—	—	3.30	—	—	0.89	—	1.65	—	—	—	—	—	—	—	—	—
Melrose and Paloona	136/37	73.1	41.04	—	0.38	—	20.6	—	2.53	—	0.53	0.04	0.27	0.12	33.56	—	0.09	0.48	—	—
	137/37	89.75	50.14	—	0.59	—	8.84	—	0.84	—	0.16	0.01	—	0.06	39.66	—	0.03	0.07	—	—
	138/37	87.5	48.98	—	0.49	—	10.8	—	0.98	—	0.28	0.01	—	0.06	38.34	—	0.01	0.06	—	—
	139/37	90.0	50.24	—	0.62	—	8.52	—	0.77	—	0.17	0.01	—	0.06	39.6	—	0.01	0.04	—	—
	140/37	90.25	50.70	—	0.49	—	7.88	—	0.90	—	0.24	0.01	—	0.06	39.54	—	0.01	0.05	—	—
	141/37	91.75	51.34	—	0.78	—	6.56	—	0.49	—	0.17	0.01	—	0.06	40.44	—	0.01	0.03	—	—
	142/37	95.0	53.22	—	1.0	—	3.64	—	0.34	—	0.14	0.01	—	0.06	41.5	—	0.03	0.06	—	—
	143/37	90.0	50.50	—	1.84	—	5.28	—	0.70	—	0.34	0.01	—	0.06	41.76	—	0.03	0.06	—	—
	144/37	90.0	50.24	—	0.72	—	8.00	—	0.77	—	0.49	0.01	—	0.10	39.72	—	0.01	0.06	—	—
	145/37	90.15	50.64	—	0.76	—	7.36	—	0.62	—	0.40	0.01	—	0.10	39.84	—	0.01	0.04	—	—
	146/37	88.50	49.48	—	0.72	—	9.64	—	0.92	—	0.40	0.01	0.10	0.08	38.0	—	0.03	0.19	—	—
	147/37	90.25	50.7	—	1.12	—	6.00	—	0.56	—	0.70	0.01	—	0.08	40.8	—	0.01	0.03	—	—
	148/37	91.2	51.1	—	0.72	—	5.68	—	0.92	—	0.68	0.01	—	0.10	40.9	—	0.03	0.03	—	—
	149/37	90.1	50.5	—	0.44	—	7.28	—	0.70	—	0.85	0.01	—	0.08	40.22	—	0.04	0.03	—	—
Mole Creek ..	—	73.71	—	—	0.36	3.44	—	—	1.14	—	1.50	—	—	—	—	—	—	—	—	—
	340/21	81.78	—	—	1.82	13.42	—	—	1.18	—	1.56	—	—	—	—	—	—	—	—	—
	648/21	91.46	—	—	1.09	4.52	—	—	1.07	—	1.73	—	—	0.06	—	—	—	—	—	—
	542/56	—	48.5	—	2.2	—	5.6	—	—	0.8	—	—	—	—	40.8	—	—	—	—	—
	543/56	—	50.3	—	1.6	—	4.4	—	—	2.0	—	—	—	—	41.1	—	—	—	—	—
	544/56	—	52.5	—	1.2	—	3.2	—	—	0.6	—	—	—	—	41.6	—	—	—	—	—
	545/56	—	46.5	—	1.4	—	11.8	—	—	2.0	—	—	—	—	37.6	—	—	—	—	—
	546/56	—	50.2	—	1.0	—	6.0	—	—	1.6	—	—	—	—	40.9	—	—	—	—	—

4. ORDOVICIAN—*continued:*

Locality	Reg. No.	$CaCO_3$	CaO	$MgCO_3$	MgO	SiO_2	Insol.	FeO	Fe_2O_3	$Fe_2O_3 + Al_2O_3$	Al_2O_3	P_2O_5	SO_3	H_2O	Ig. Loss	TiO_2	MnO_2	S	Na_2O	FeS_2
Mole Creek .. (*continued*)	547/56	—	48.1	—	1.3	—	8.9	—	—	1.8	—	—	—	—	39.7	—	—	—	—	—
	548/56	—	47.2	—	2.5	—	9.5	—	—	1.0	—	—	—	—	39.5	—	—	—	—	—
	549/56	—	51.5	—	0.7	—	5.8	—	—	0.8	—	—	—	—	40.8	—	—	—	—	—
	550/56	—	50.5	—	1.2	—	6.2	—	—	1.2	—	—	—	—	40.5	—	—	—	—	—
	551/56	—	50.4	—	1.2	—	6.4	—	—	0.8	—	—	—	—	40.5	—	—	—	—	—
	552/56	—	50.8	—	2.2	—	4.2	—	—	0.6	—	—	—	—	41.5	—	—	—	—	—
	553/56	—	52.0	—	1.2	—	4.0	—	—	0.5	—	—	—	—	41.6	—	—	—	—	—
	554/56	—	50.0	—	1.8	—	6.0	—	—	0.7	—	—	—	—	41.5	—	—	—	—	—
	555/56	—	49.3	—	0.6	—	9.7	—	—	0.9	—	—	—	—	39.3	—	—	—	—	—
	556/56	—	53.0	—	1.4	—	2.1	—	—	0.4	—	—	—	—	43.1	—	—	—	—	—
	557/56	—	52.0	—	2.2	—	2.3	—	—	0.5	—	—	—	—	43.0	—	—	—	—	—
	558/56	—	52.8	—	1.1	—	2.9	—	—	0.4	—	—	—	—	42.6	—	—	—	—	—
	559/56	—	52.1	—	1.2	—	4.0	—	—	0.6	—	—	—	—	42.1	—	—	—	—	—
	560/56	—	51.0	—	0.4	—	7.0	—	—	0.6	—	—	—	—	40.9	—	—	—	—	—
	561/56	—	49.7	—	1.2	—	7.8	—	—	0.9	—	—	—	—	40.3	—	—	—	—	—
	562/56	—	50.3	—	1.0	—	7.5	—	—	0.8	—	—	—	—	40.2	—	—	—	—	—
	563/56	—	48.9	—	0.9	—	10.0	—	—	0.8	—	—	—	—	39.3	—	—	—	—	—
	564/56	—	49.0	—	1.7	—	8.0	—	—	0.8	—	—	—	—	40.3	—	—	—	—	—
	565/56	—	49.5	—	1.6	—	7.5	—	—	0.8	—	—	—	—	40.6	—	—	—	—	—
	566/56	—	48.9	—	1.0	—	9.8	—	—	0.8	—	—	—	—	39.5	—	—	—	—	—
	567/56	—	47.2	—	1.6	—	11.0	—	—	1.0	—	—	—	—	38.9	—	—	—	—	—
	568/56	—	45.4	—	3.6	—	10.4	—	—	0.7	—	—	—	—	39 6	—	—	—	—	—
	569/56	—	49.4	—	1.1	—	8.1	—	—	0.7	—	—	—	—	40.3	—	—	—	—	—
	570/56	—	49.6	—	1.6	—	7.5	—	—	0.6	—	—	—	—	40.6	—	—	—	—	—
	571/56	—	50.2	—	1.9	—	4.9	—	—	0.4	—	—	—	—	42.0	—	—	—	—	—
	572/56	—	51.2	—	1.1	—	5.0	—	—	0.6	—	—	—	—	41.8	—	—	—	—	—
	573/56	—	51.2	—	0.8	—	6.0	—	—	0.5	—	—	—	—	41.4	—	—	—	—	—
	574/56	—	50.2	—	1.4	—	6.4	—	—	0.5	—	—	—	—	41.4	—	—	—	—	—
	575/56	—	48.9	—	2.1	—	7.0	—	—	0.6	—	—	—	—	41.2	—	—	—	—	—
	576/56	—	49.5	—	1.0	—	8.3	—	—	0.6	—	—	—	—	40.4	—	—	—	—	—
Precipitous Bluff ..	264/38	98.85	55.36	—	0.39	0.06	—	—	0.09	—	0.59	Trace	—	0.08	43.02	—	Trace	0.19	—	—
Railton ..	856/22	21.6	—	—	0.94	57.72	—	—	3.15	—	12.21	—	—	—	—	—	—	—	—	—
	857/22	24.8	—	—	0.57	54.0	—	—	3.14	—	13.7	—	—	—	—	—	—	—	—	—

4. ORDOVICIAN—*continued:*

Locality	Reg. No.	$CaCO_3$	CaO	$MgCO_3$	MgO	SiO_2	Insol.	FeO	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	P_2O_5	SO_3	H_2O	Ig. Loss	TiO_2	MnO_2	S	NaO_2	FeS_2
Railton–*cont'd.*	858/22	62.76	—	—	0.79	29.72	—	—	1.72	—	5.0	—	—	—	—	—	—	—	—	—
	859/22	34.45	—	—	0.65	51.44	—	—	10.01	—	0.67	—	—	—	—	—	—	—	—	—
	860/22	83.98	—	—	1.16	9.32	—	—	1.56	—	2.02	—	—	—	—	—	—	—	—	—
	882/22	86.13	—	—	1.09	8.0	—	—	1.79	—	1.93	—	—	—	—	—	—	—	—	—
	891/22	91.33	—	—	0.57	4.68	—	—	1.00	—	1.96	—	—	—	—	—	—	—	—	—
	892/22	92.14	—	—	0.24	3.92	—	—	0.64	—	1.56	—	—	—	—	—	—	—	—	—
	986/22	85.39	—	—	1.45	7.40	—	—	1.72	—	4.20	—	—	—	—	—	—	—	—	—
	987/22	82.21	—	—	2.39	8.80	—	—	2.00	—	4.12	—	—	—	—	—	—	—	—	—
	988/22	87.91	—	—	1.16	7.0	—	—	1.5	—	3.10	—	—	—	—	—	—	—	—	—
	989/22	94.61	—	—	1.59	3.0	—	—	0.64	—	1.32	—	—	—	—	—	—	—	—	—
	990/22	93.44	—	—	1.45	3.0	—	—	0.57	—	1.63	—	—	—	—	—	—	—	—	—
	991/22	90.41	—	—	1.81	3.68	—	—	1.79	—	2.17	—	—	—	—	—	—	—	—	—
	992/22	94.61	—	—	1.30	3.0	—	—	0.43	—	1.17	—	—	—	—	—	—	—	—	—
	993/22	92.64	—	—	1.45	3.68	—	—	0.86	—	1.90	—	—	—	—	—	—	—	—	—
	994/22	93.06	—	—	1.23	3.52	—	—	1.07	—	1.73	—	—	—	—	—	—	—	—	—
	/23	60.87	—	—	1.81	25.72	—	—	2.37	—	4.56	—	—	—	—	—	—	—	—	—
Railton (Blenkhorns Quarry) ..		75.10	—	—	0.54	12.20	—	2.88	—	—	3.05	1.02	4.66	0.55	—	—	—	—	—	—
Round Hill ..	215/48	77.67	43.5	—	3.81	10.12	—	—	2.29	—	1.45	0.03	—	—	38.04	—	—	0.03	—	—
Smithton ..	1805/30	82.85	46.4	15.78	7.53	1.08	—	—	1.38	—	0.22	0.07	—	—	44.12	—	Trace	—	—	0.11
	1996/30	96.83	54.23	—	0.50	0.52	—	—	0.56	—	0.36	0.07	—	—	43.30	—	Trace	—	—	0.07
	1300/31	96.16	53.85	—	0.29	0.76	—	—	0 31	—	0.38	—	—	—	44.11	—	Trace	—	—	—
		96.05	53.79	—	1.72	0.48	—	—	0.56	—	0.24	Trace	—	—	43.70	—	—	—	—	—

UTILIZATION

The story of the utilization of limestone in Tasmania is almost as old as that of the colonization of the Island itself. Records show that almost from the days of the first settlement, limestone was burnt. Ruins of old kilns and abandoned quarry sites can be seen in many parts of the State, often situated in areas where, within living memory, no limestone has been quarried. The earliest use was, of course, to provide cementing material for masonry in buildings and bridges.

From these early beginnings, the limestone industry has expanded until today the stone is a raw material used in many important industries as well as for agriculture. In 1955, a production of over 206,000 tons of limestone was recorded in the Mines Department official statistics, but the actual amount obtained was higher than this as many quarries did not supply production figures.

The company using the greatest annual tonnage of limestone today is the Goliath Portland Cement Company, which annually quarries over 150,000 tons of limestone at their works at Railton in northern Tasmania. The annual production of limestone for the manufacture of cement by this company for the year 1955 was 157,135 tons.

The Australian Commonwealth Carbide Company quarry stone at Ida Bay in the far south of Tasmania for the manufacture of calcium carbide at their works at Electrona, near Hobart. In 1955, nearly 18,000 tons of limestone were produced for this purpose. A small portion of this material is eventually used for agricultural purposes and in the past some stone from their quarries was used by the Electrolytic Zinc Company at Risdon.

The Zinc Company now obtains most of its lime supplies from the powdery deposits at Pulbeena, near Smithton. This is used at the rate of about 1,000 tons per year in their purification plant. Subsidiary supplies are sometimes obtained from Maydena. In the past, the Zinc Company has used limestone from Ida Bay, Glenorchy, Sorell and Junee.

The two paper mills in Tasmania (the Associated Pulp and Paper Mills Ltd., at Burnie, and the Australian Newsprint Mills Ltd., at Boyer, near New Norfolk) use limestone for the manufacture of their bleach-liquor. The A.N.M. obtain their limestone from their own quarries near Maydena, at the end of the Derwent Valley Railway line and use about 2,500 tons per annum. They also dispose of small amounts of crushed limestone to the Zinc Company and burnt limestone to agricultural users and to a manufacturer of lime-sulphur spray. The A.P.P.M. at Burnie use about 8,800 tons of limestone per annum and obtain their supplies from a contractor at Flowery Gully. From 1941-47 they obtained a few thousand tons from their own quarry near Smithton.

Flowery Gully, too, is the source of limestone for other purposes. The Australian Aluminium Commission obtains large tonnages of high-grade stone for use in its works at Bell Bay, but the actual annual tonnage is not available. Agricultural limestone and burnt lime are also produced by other companies and individuals from this area.

The Mt. Lyell Mining and Railway Company, from their quarries at Queenstown, produce nearly 5,000 tons of limestone annually for their own use as a flux in smelting and also as burnt lime in their flotation plant.

An ever-growing use for limestone is for agricultural needs, and where once the principal form was burnt limestone, it is now more usual to use the crushed stone or natural fine-grained material as that from Pulbeena or King Island. The principal producer of agricultural lime is the Melrose Agricultural Lime Company, which in 1955 from its quarries at Melrose, produced 13,785 tons. Other important sources of agricultural lime are at Pulbeena, near Smithton, Flowery Gully, Railton, Maria Island and Granton. On King Island, the Closer Settlement Board uses lime-sand for the development of its farms. At Smithton the Duck River Dolomite Company crushes dolomite for agricultural use and in 1955 produced 2,266 tons.

Lime is still burnt in small kilns in Tasmania to produce CaO for various purposes. Kilns are at present operating at Railton, Flowery Gully, Granton and Boyer.

Limestone is an excellent material for road-making. Figures are not available for the amounts of limestone used from year to year on roads but two examples may be cited. The Australian Newsprint Mills have used a great deal of limestone in their network of roads between Maydena and the Florentine Valley. A huge quarry is operating at Glenorchy, a suburb of Hobart, and much of its output is used as road-making material.

The largest use ever made of the Tasmanian limestones was by the Broken Hill Pty. Ltd. from quarries at Melrose. In 1939, the year of greatest production, nearly 300,000 tons of limestone were obtained. This production gradually fell off until in 1946 the company ceased working its Melrose quarries and obtained all its stone from the mainland. This limestone was used as a flux in the steel plant at Newcastle.

Lime is used for many minor purposes in Tasmania, an example of which is in the manufacture of lime-sulphur spray in southern Tasmania. An enquiry has recently been received for limestone suitable for glass manufacture. However, the tolerance of Fe_2O_3 is about 0.1 per cent and few Tasmanian limestones could reach this low figure for iron.

During 1955, the recorded production of limestone in Tasmania was 206,138 tons, made up as follows:—

	Tons
Australian Commonwealth Carbide Company	17,946
Australian Newsprint Mills	2,678
Beaconsfield Lime Products	1,684
Beams, A. R. and A. H., Flowery Gully	620
Goliath Portland Cement Co.	157,135
Mt. Lyell Mining and Railway Company	4,477
Melrose Agricultural Lime	13,785
Pearson, A., Pulbeena	5,016
Railton Lime Works	2,797

and of dolomite, 2,266 tons produced by the Duck River Dolomite Company.

TOPOGRAPHIC EXPRESSION

The topographic expression of limestone (and this term includes dolomite) is influenced by one very important and unique characteristic of this rock. This is, that it is soluble in normal ground water, that is, water charged with CO_2, which may be obtained from the atmosphere and decaying vegetation. Consequently, surface and underground holes and caves readily form and the erosion rate is quicker than with other rocks. Limestone is therefore largely found underlying broad river valleys and wide plains and, except where it is protected by some cover rock, rarely forms hillsides or has bold outcrop. In Tasmania, particularly in the West Coast Regions where the landscape is approaching maturity, are large plains covered by black soil and often button grass overlying limestone areas; but seldom are any actual limestone outcrops visible.

Sometimes, however, cover rocks protect the limestone from erosion and outcrop is not only plentiful, it is sometimes bold. Fringing the Leven River to the south of Gunns Plains are cliffs of limestone rising to 200 feet in height and protected by a covering of basalt. North of Railton are several small limestone outcrops in the form of small steep-sided peaks. These remnants are always in the vicinity of dolerite outcrop showing that this hard cover rock has been a protection to the limestone remnants.

Normal surface drainage is disrupted in limestone areas. The rain water sinks through the crevasses and sink holes into underground streams and eventually to the water table. Consequently, a normal stream pattern is rare and only large rivers, like the Leven at Loongana and Gunns Plains and the Florentine are able to persist in open surface channels.

Sink holes are very common in limestone country and these crater-like depressions are very striking in aerial photographs, so that limestones can often be mapped from photographs on this evidence alone. Other characteristic features due to the solubility of the rock are underground caves and underground streams. The most spectacular caves are at Hastings, Mole Creek and Gunns Plains, and these are lighted and open for public inspection. An underground stream of quite large size, the Junee River, emerges from the hillside a few miles north of Maydena,

These characteristics all apply principally to the older rocks—the Precambrian dolomites and the Ordovician limestones. Permian limestones, because of their younger age and lack of folding, because of their lower $CaCO_3$ content, but mainly because they are interbedded with impervious shales and mudstones, show a much greater resistance to erosion. They often outcrop boldly in small cliff faces, although usually with an overburden of hard siliceous mudstone.

CHAPTER 3—STRATIGRAPHY

THE PRECAMBRIAN DOLOMITES OF TASMANIA

BY

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Dolomite is of outstanding stratigraphic significance in the problem of deciphering the stratigraphy of the Precambrian rocks of Tasmania because a very thick dolomite occurs in scattered localities throughout the State and this may eventually be proved to be a single horizon and the only marker bed in the Precambrian. Our knowledge of the complex structural and stratigraphic history of the Precambrian has not yet reached the stage where we know the relations between the thick dolomites at Smithton, Hastings, Jane River, Franklin River and Tim Shea. In fact, although sequences have been established in separate localities, it still needs a great deal of work before these can be related with confidence. There are a number of reasons for this, but the chief one lies in the extreme structural complexity of the Precambrian and particularly in the abundant faulting. Another contributing factor is the repetition of similar lithologies in different parts of the sequence and this is made worse by the presence of apparently unmetamorphosed sediments lying above, below and between schists, gneisses and amphibolites. Even within restricted areas it has been found that certain slates are not younger than adjacent schists and gneisses, and that they are not separated from them by an unconformity. Similarly, it cannot be certain that unmetamorphosed shales and sandstones with minor dolerite intrusions (as at Rocky Cape) are not the time equivalents of schists, quartzites and amphibolites (as at Frenchman's Cap). The distribution of Precambrian rocks is shown in text-figure 2.

For these reasons alternative interpretations are shown, but first lithological characteristics of each dolomite are given.

Smithton.

The widespread occurrences of dolomite in the Smithton area were first described by Nye, Finucane and Blake (1934), who referred to the main dolomite as the Dolomite Stage and as the "Duck River dolomite." Subsequently, other authors, e.g., Hills and Carey (1949), Carey and Scott (1952), and Hoskings and Hueber (1954), have referred to the Dolomite Stage as the "Smithton Dolomite."

As Nye **et al** (1934) used the term **Dolomite Stage** in their discussion and referred to the **Duck River dolomite** merely in passing, it seems best to retain the name **Smithton Dolomite** which is now established in the literature and to define it according to the Code of Stratigraphic Nomenclature, Raggatt (1952). Thus the Smithton Dolomite is defined as—

> the formation, chiefly dolomite, lying below the Dundas Group and above the Bryant Hill Quartzite of Carey and Scott (1952), being approximately 3000 feet in thickness with its type locality being immediately west of the Duck River just north of the Smithton-Marrawah Road.

The word "Pre-Cambrian" to be read as "Precambrian" throughout.

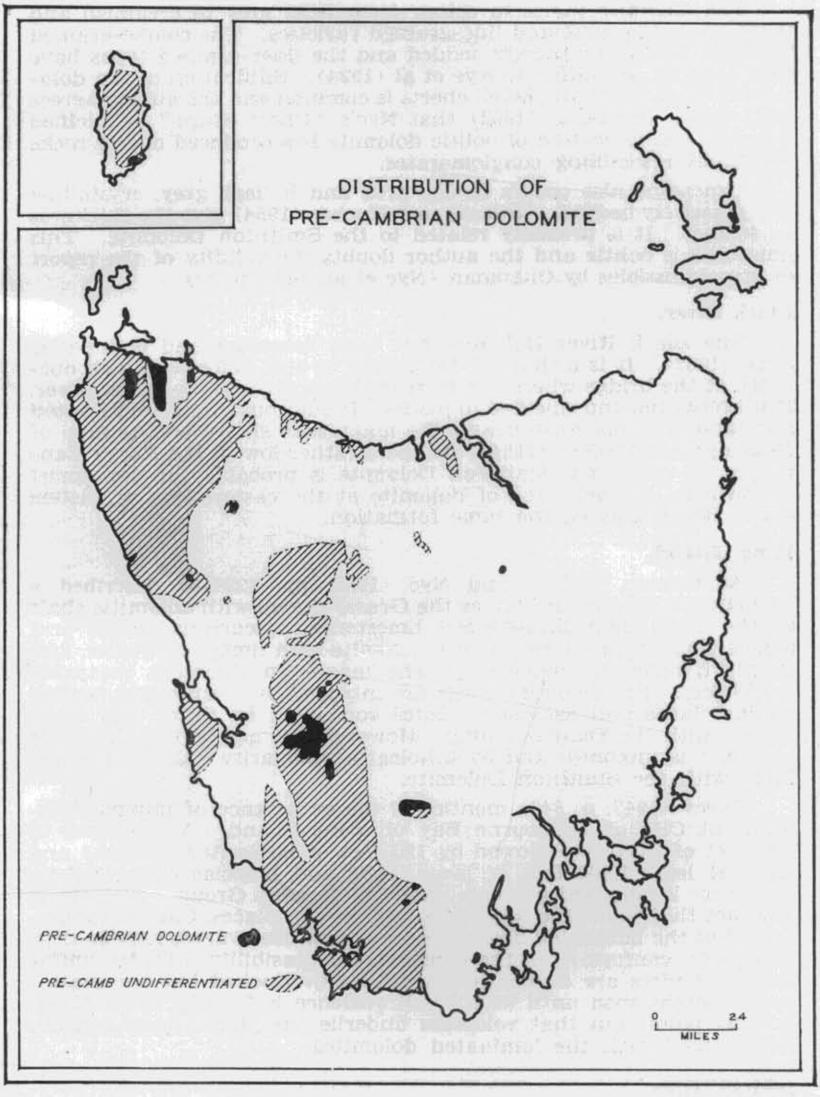

FIG. 2.—Precambrian Dolomite.

5 cm

The dolomite varies in colour from light grey to creamish and there are both coarse and fine-grained varieties. The coarse-grained varieties tend to be thickly bedded and the finer-grained types have thin bedding, according to Nye **et al** (1934). Silification of the dolomite to form white and black cherts is common and the author agrees with Carey and Scott (1952) that Nye's "Chert Stage" is silicified dolomite. Silicification of oolitic dolomite has produced cherty rocks somewhat resembling conglomerates.

Limestone also occurs in the area and is dark grey, crystalline and massively bedded. Hosking and Hueber (1954) give the thickness as 40 feet. It is probably related to the Smithton Dolomite. This limestone is oolitic and the author doubts the validity of the report of crinoid ossicles by Chapman (Nye **et al**, 1934, p. 39).

Black River.

The Black River Dolomite has been described and defined by Spry (1957). It is a thin (50 feet) grey to buff dolomite which outcrops at the bridge where the Bass Highway crosses the Black River. It is brecciated and silicified in places. It outcrops over a very limited area and does not have nearly the magnitude shown on the map of Hoskings and Hueber (1954). It ocurs rather low in the Rocky Cape Group, of which the Smithton Dolomite is probably the uppermost formation. A small area of dolomite at the eastern end of Sisters Creek Beach may be the same formation.

King Island.

At Grassy, Knight and Nye (1953, pp. 1224-5) described a sequence of calcareous beds as the Grassy Group with dolomitic shale at the base, then thin-bedded limestones, calcareous shales and shales, impure limestone, impure dolomite with limestone bodies, and finally a dolomitic mudstone. The maximum thickness measured is 477 feet. The dolomitic rocks are intruded by granite and faulted against lavas and associated slates correlated by Carey and Scott (1952) with the Dundas Group. However, the age of this dolomitic sequence is unknown and by lithological similarity only it is correlated with the Smithton Dolomite.

Carey (1947, p. 349) mentioned the occurrence of impure dolomites at City of Melbourne Bay on King Island. A thickness of 100 feet of tillite is followed by 150 feet of laminated dolomite and then at least 1,000 feet of lavas, tuffs and breccias correlated by Carey on lithological grounds with the Dundas Group. In view of the fact that the tillite itself is dolomitized in places, Carey's suggestion that the laminated dolomites are dolomitized varves may be true. Due to the conformity of the sequence, the possibility that the laminated dolomites are Cambrian cannot be overlooked but the matter must remain open until local fossil evidence is found. Scott (1951, p. 113) points out that volcanics underlie the glacial beds and are interbedded with the laminated dolomites.

McRae Hills.

Nicolls (1952) reported a small exposure of fine-grained, grey dolomite in a quarry on the bank of Western Rivulet, a tributary of the Lake River, six miles south-west of Cressy. This is overlain by the basal tillite of the Permian System, but nothing is known of its stratigraphic position, structure or extent. It has been burnt for lime and the old kilns remain near the quarry.

Hastings.

A considerable thickness of dolomite occurs at Hastings and was described by Carey and Banks (1954). It is light-coloured, thickly-bedded and steeply-dipping. The dolomite may be underlain by the saccharoidal quartzite of the Hogg's Back, two miles south of the Hastings Caves.

Mt. Picton.

In a later chapter, Blake reports dolomite in the Huon and Craycroft Rivers north-west of Mt. Picton. Fine-grained and crystalline dolomite, thickly-bedded, has been partly silicified to chert.

Tim Shea.

Carey and Banks (1952) have given the structural environment of a very thick dolomite which occurs on the south-eastern slopes of Tim Shea and the valley of Clark's Creek. It is approximately 4000 feet thick. It is buff, grey or pink in colour and is very fine-grained. It strikes east-west and dips at an average of 80° to the north. It is generally massive with poorly-developed bedding and has been silicified to chert in some places. Some layers show cross-bedding, but the most noticeable variation is a coarse dolomite-breccia which should not be confused with the overlying Ordovician Jukes Breccia which is rich in dolomite fragments. The dolomite is underlain by about a thousand feet of slates and slatey dolomites, then by the 1,500 feet thick Needles Quartzite, followed by laminated impure quartzites and dolomites.

Pieman Heads.

A thin dolomite just north of the Pieman Heads was first reported by Ward (1911) and more details were given by Spry and Ford (1956). It is quite thin (approximately 50 feet) and is dark grey in colour and occurs about 1½ miles south of Rupert Pt. It is interbedded with sheared conglomerates, phyllites and quartzites and is not Silurian as suggested by Ward (1911).

Savage River.

Smith (1897) reported a belt of magnesian limestone or dolomite close to the bridge on the old Specimen Reef track across the Savage River. No details are known.

Arthur River.

Waller (1901) reported a belt of white crystalline dolomite at the New Victory Copper Mine on the Arthur River about six miles south-west of Preolenna. It varies from about 50-60 feet in thickness at the river up to many hundreds of feet, a half-mile to the north. It lies between pyroxenite on the west and quartz-mica schists on the east. Nothing is definitely known about its age, but Nye and Blake (1938) regarded it as being due to the alteration of the adjacent ultrabasic rock and thus it would be Cambrian.

Mt. Bischoff.

Knight (1953) described dolomite and dolomitic shales with a thickness of at least 280 feet overlying quartzites and shales of the Mount Bischoff Group.

Stanley River.

Waterhouse (1914) noted the presence of dolomite at the Stanley River workings and regarded it is a sediment. It occurs among rocks which are overlain to the east by the Dundas Group and is thermally metamorphosed by a nearby granite.

Dundas.

Elliston (1954) described the Platt Dolomite as a formation in his Carbine Group, which is overlain by the Dundas Group. It is a white to dark-grey, thickly-bedded dolomite with a thickness of 80 feet. He suggests that the underlying Maestries Conglomerate which has quartzite pebbles with a dolomitic matrix may be the basal formation of the Carbine Group.

Albina

South of Macquarie Harbour, at Albina, are folded and metamorphosed dolomites and black slates which have been reported by Waller (1903) and Hills (1914). Dolomite also occurs from Albina south to Birthday Bay.

Franklin River Area.

A great deal of recent work now being published has confirmed and extended the report of Blake on the development of dolomite, particularly in the area around the Jane River. The major formation (2,000 feet thick) is the Jane Dolomite, but there are a number of thin (30 feet) dolomites interbedded with the schists of the Scotchfire Group. The Jane Dolomite is generally very fine-grained and poorly-bedded and varies in colour between white, light-grey, buff and pale-cream. Its thickness is not known, but there is probably about 2,000 feet exposed although its upper limit is not visible. It is underlain by the Lachlan Conglomerate and then the greenish, lustrous schists of the Scotchfire Group with its thin dolomites which resemble the Jane in their lithology. The dolomites are commonly silicified to chert. Masses of dolomite breccia occur at Christmas Rock and at other places on the Lightning Plains.

Thin dolomite and dolomitic schists occur along the Lyell Highway about 119 miles from Hobart as reported by Blake and these are associated with schists strongly resembling the Scotchfire Group. One striking lithological characteristic is that silicification has affected an oolitic variety and this resembles closely the silicified oolite from Smithton. A massive dolomite extends over a considerable area around the junction of Carbonate Creek and the Franklin River near the beginning of the Jane River Track. Outcrops are very poor, but this dolomite appears to be several thousand feet in thickness. Silicification has produced patches of dark chert, but one notable variety which outcrops in the bed of the Franklin River is a coarse dolomite breccia strongly resembling that in the Jane Dolomite and the thick dolomite at Tim Shea. From its associations it is likely that this is the Jane Dolomite although its structural relationships are obscure.

The place of the dolomites in the Precambrian sequence is at present not clear, but there is a very thick dolomite (Smithton, Hastings, Tim Shea) associated with unmetamorphosed quartzites and slates and another (Jane) associated with quite strongly deformed sediments showing regional metamorphism up to garnet grade. It is possible that all of these dolomites are equivalent and that the quartzites and slates of the Rocky Cape Group with their dolerite intrusions simply represent the unmetamorphosed equivalents of the quartzites and schists with amphibolites of the Franklin area, e.g.:—

Cambrian	Dundas Group	
	OROGENY	
	Without Regional Metamorphism	**With Regional Metamorphism**
Precambrian	Dolerite intrusion (Cooee)	=Amphibolites (Franklin River, Ulverstone, Interview River Dyke Swarm)
	Rocky Cape Group	Fincham, Franklin, Mary, Scotchfire, &c., Groups
	Sandstones, slates, dolomite	Quartzites, schists, dolomite
	Dolomite.	Smithton = Hastings = Tim Shea = Jane Dolomite.

On the other hand the distribution of the basic igneous rocks as given by Spry (1956) suggests that the Precambrian might be divided up into two major divisions separated by a major orogeny, as follows:—

Cambrian	Dundas Group	
	OROGENY	
Precambrian	Dolerites	(Cooee Dolerite)
	Rocky Cape Group	(Quartzites and slates with the **Smithton=Hastings =Tim Shea dolomites**).
	OROGENY WITH REGIONAL METAMORPHISM	
	Dolerites	(Amphibolites of the Interview River Dyke Swarm, Ulverstone, Whyte River, Port Davey, Franklin River area.)
	Fincham, Franklin, Mary, Scotchfire, &c. Group	(Quartzites and schists, &c. with the **Jane Dolomite.**)

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THE STRATIGRAPHY OF TASMANIAN LIMESTONES

BY

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INTRODUCTION.

Limestone occurs in Tasmania on numerous stratigraphic horizons. Precambrian or Lower Cambrian dolomites occur in the north-western, central and south-eastern parts of the State and are commonly thick, and are dealt with in the previous section.

Calcareous rocks are uncommon in the Middle and Upper Cambrian Dundas Group, but they do occur. The thick Gordon Limestone, of Lower Ordovician to probably Lower Silurian age, is very widespread except in the north-eastern part of Tasmania and contains some high-grade limestones as well as some dolomites. The Eldon Group, of Silurian and Lower Devonian age, is known to contain several thin, economically insignificant limestones. Of more importance are the Permian limestones which have a wide distribution in the eastern half of Tasmania, but no high-grade limestones are known from this system. Finally, Cainozoic limestones occur fringing the north-western part of the State, where they occur up to a couple of hundred feet above sea-level, and on the Bass Strait islands.

CAMBRIAN SYSTEM.

Limestones are uncommon in Tasmanian rocks of known Cambrian age, i.e., in the Dundas Group. Taylor (1955, p. 55) noted grey, impure limestones associated with purple slates and tuff bands south of the mouth of the Spero River and remarked on the resemblance of the slates to those in the Dundas district. Until the structure and stratigraphy of the area are better understood it would be better to leave the age of these limestones undecided.

Bradley (1956, p. 94) regarded a limestone east of Lake Dora on the West Coast Range in a quartzose sequence close to the Precambrian as Gordon Limestone in a thrust syncline lying between the thrust-mass of the Dundas Group and the under-thrust mass of Precambrian. The situation at this locality is that the Precambrian quartzites, folded and even overfolded to the south-east, are overlain by west-dipping crenulated chlorite schists and then, less than 100 feet stratigraphically above the contact, by lenses of calcareous material, less than 10 feet thick. The calcareous rocks are followed by quartz chlorite schist, 40 feet thick. The next formation in the sequence is cross-bedded, and a study of the cross-bedded sets indicates that the beds are dipping and facing west. The calcareous rock itself is a dolomitic breccia which has suffered silicification subsequent to brecciation. No fossils could be detected in it. While Bradley's hypothesis cannot be rejected on the available

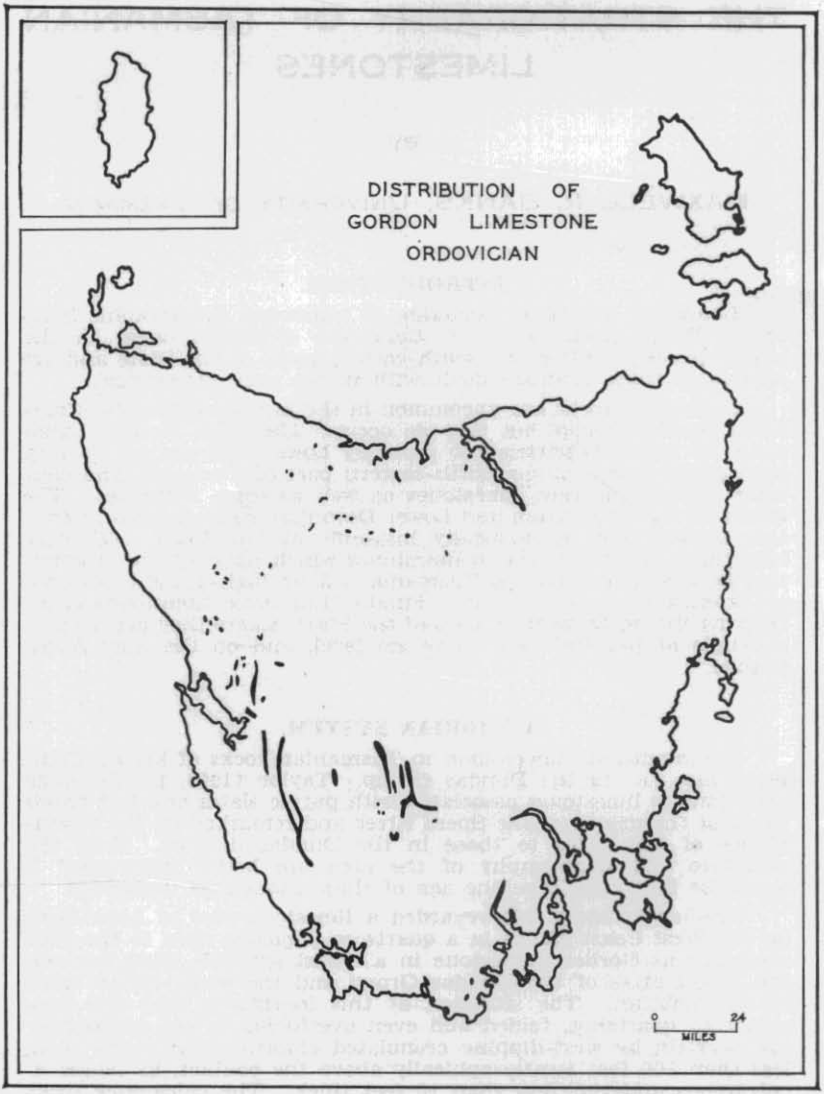


Fig. 3.—Ordovician Limestones.

evidence, there is no positive evidence for it, no fossils have been found in the dolomite and no independent evidence of thrusting was found in the field.

The schistosity in the beds above the unconformity and the brecciation of the dolomite may equally well be due to slight movement on the unconformity surface if the thin lenses of calcareous rock were originally low in the Dundas Group. The rocks associated with the lenses bear no lithological resemblance to rocks of the Junee Group associated with the Gordon Limestone. Thus, while Bradley's hypothesis is a possible one, the hypothesis that the calcareous lenses are in the lower part of the Dundas Group is as probable, perhaps more so, than Bradley's, and leads to a simpler, more probable structure.

Montgomery (1896) recorded limestone at Penguin but gave no locality. In 1899, Smith noted that the shaft of the old Penguin Mine cut through a hard silicified dolomite and Twelvetrees (1903 *b*, pp. 4-6) regarded it as a " 9-feet band of mineralised dolomite." If this is a sedimentary rock, and as no evidence on this point is presented, the possibility of its being gangue material cannot be overlooked, it is associated with lavas, tuffs and breccias lithologically like the Dundas Group correlates occurring just to the south along the strike in the Dial Range.

ORDOVICIAN SYSTEM.

Introduction.

Ordovician limestones are the most important actual and potential sources of lime within Tasmania. Their wide distribution is tions, as shown in text-figure 3.

The Ordovician System is represented in Tasmania by the Junee Group which consists, where fully developed, of at least five formations, as shown in text-figure 4.

As pointed out elsewhere (Carey and Banks, 1954), the Junee Group rests unconformably on older rocks in a number of places but the only place where fossils are known to occur in the basal beds of the Jukes Breccia is near Adamsfield, where trilobites, inarticulate brachiopods and gasteropods (including *Scaevogyra*) occur The age of this assemblage is not yet known with any accuracy, the *Scaevogyra* indicating an Upper Cambrian or Lower Ordovician age. The first abundant fossils of which the age is known occur in the Caroline Creek Sandstone which contains *Etheridgaspis*, *Tasmanocephalus*, *Asaphellus lewisi*, *Carolinites bulbosa*, *Prosopiscus subquadratus*, *&c.* (Kobayashi, 1940 *b*), at Caroline Creek, near Railton. These indicate a Lower Ordovician age. In the Florentine Valley area the Florentine Valley Mudstone contains *Asaphopsis*, *Tasmanaspis* (Kobayashi, 1940 *a*), with *Tasmanocephalus*, *Asaphellus* and *Carolinites* (Opik, 1951), as well as *Tritoechia lewisi* (Brown, 1948), which indicates an Upper Canadian age. At Adamsfield the basal beds of the Gordon Limestone contain *Manchuroceras*, *Suecoceras*, *Piloceras*, *Utoceras* and *Allocotoceras* (Teichert and Glenister, 1953), which also are Upper Canadian. The age of the top of the Gordon Limestone is not yet accurately established. In the Florentine Valley the top beds have *Catenipora* and *Eofletcheria* in them. Hill (1955) recorded the corals *Tetradium dendroides*, *T. tasmaniense*, *T. conjugatum*, *? Lichenaria*, *? ramosa*, *? Nyctopora*, and *? Protaraea* from the

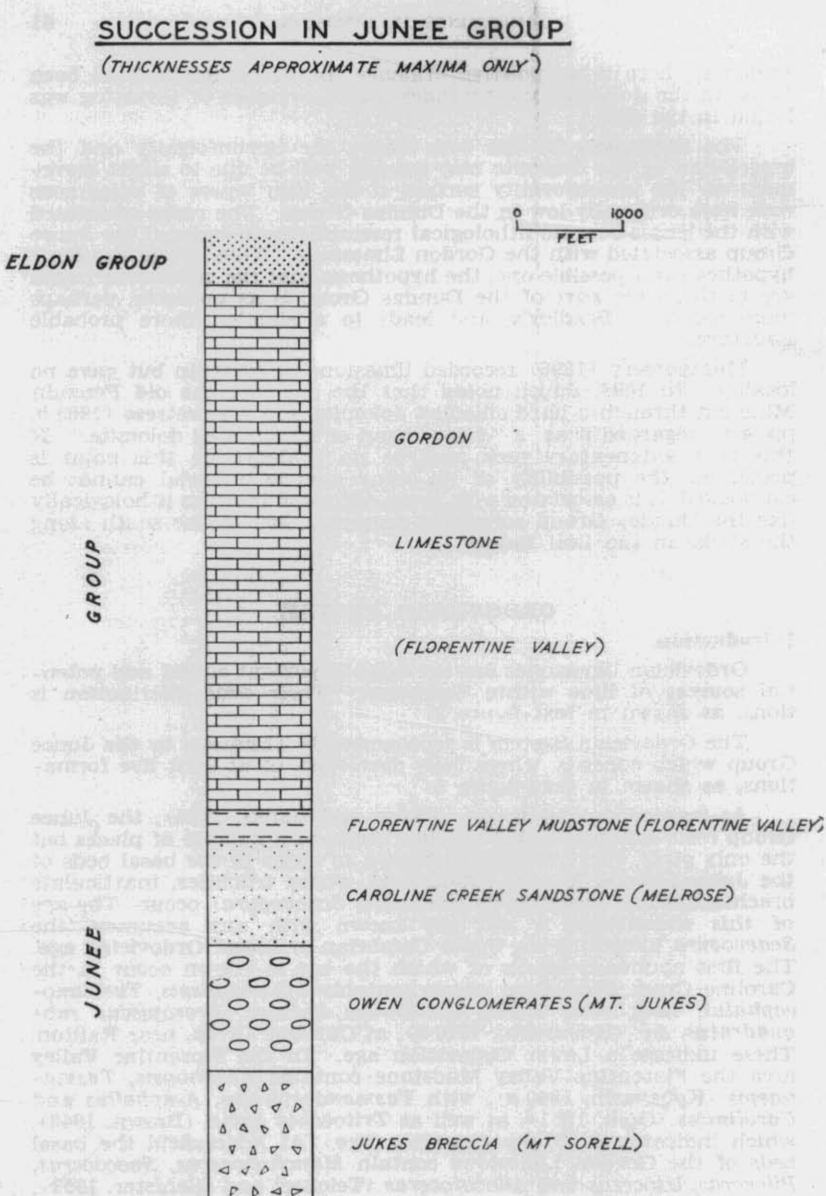


FIG. 4.—Junee Group Succession.

Smelters Quarry, Zeehan, and assigned a Trentonian age to them. These are not, however, the topmost beds as about 700 feet of fossiliferous limestone overlies these and underlies the Crotty Sandstone. The limestone in the Smelters Quarry at Queenstown with corals such as *Tetradium tasmaniense*, *T. conjugatum*, *T. dendroides*, *? T. syringoporoides*, *Alveolites* sp., *Protaraea richmondense* and *Acidolites* was dated by Hill (1955) as Trentonian or Richmondian, but these corals do not occur in the uppermost beds. At Bubbs Hill *Plasmoporella*, *Tetradium*, *Aulopora*, *Eofletcheria ida* and *Nyctopora* are present, and Hill (1955) regarded these also as Upper Ordovician. Thus, published evidence suggests that the Gordon Limestone probably ranges into the Richmondian and perhaps higher. At Zeehan and Bubbs Hill where the contact with the overlying Crotty Sandstone is well exposed the contact is seen to be gradational and no evidence of disconformity has yet been found.

Gordon Limestone.

A comprehensive study of the Junee Group and particularly of the Gordon Limestone is in progress and it is hoped the results will be available shortly. It seems undesirable to define the Gordon Limestone out of context so that this definition will be published with that of other formations.

This limestone is typically medium to dark-grey in colour but light-grey, pink, and almost white varieties occur without, as far as is known, any stratigraphic significance. They are compact rocks normally brittle, although some coarse-grained varieties tend to be tougher than others. The fine-grained limestones tend to develop conchoidal fracture, but coarser types usually have an even fracture. The rock is impervious in bulk, but, due to the common presence of solution cavities and passages, allows ready passage of water. Its solubility normally results in the limestone having a subdued topography, often close to local base-level. Where the limestone topography is still above local base-level a karst topography is developed, as at Gunns Plains, Mole Creek-Liena area, Maydena area and Ida Bay.

The limestone is normally of high purity, in many places containing over 90 per cent of calcium carbonate as will be seen in analyses quoted in later chapters. At the Iris Bridge, Florentine Valley, Queenstown and Zeehan, however, there are arenaceous and argillaceous beds in it, but volumetrically these do not seem to be very significant. More significant are beds of dolomitic limestone. It seems probable that the presence of magnesian limestone in this formation was recognised as early as 1886 by Thureau, but its widespread occurrence has been realized only recently. Noakes *et al* (1954) reported the ocurrence of dolomite on some horizons at Beaconsfield and it has been recognized since in the limestone with *Maclurites* and *Girvanella* in the Florentine Valley. Sandy-looking patches, typical of dolomitic limestones are widespread and it is probable that as more limestones are tested in the field and sectioned that dolomite will be found to have a wide occurrence in this formation. Silica is a common impurity and takes the form of chert nodules which, at Flowery Gully, are restricted enough stratigraphically for Noakes *et al* (1954) to refer to a "Chert Zone". The nodules often show a bedding and jointing control. Such chert nodules occur in most major areas of Gordon Limestone. The chert is medium to dark-grey and as such is readily distinguished from the light-grey, white or pink chert bodies in the Berriedale Limestone. These nodules are not the only source of silica impurity in the limestone as there are elongated siliceous rods which may be sponge spicules (Dallwitz in Noakes *et al.*, 1954), and other forms of dispersed silica remaining as a residue after acid treatment. Not infrequently fossils are silicified and beekitized but to a large extent this is a surficial effect only and silicification frequently does not extend more than an inch or two below the surface. In quite a few places spherical or sub-spherical bodies of radiating pyrite and chalcopyrite up to 1½ inches in diameter occur in the limestone well away from areas of mineralization, e.g., in the Florentine Valley, so that they seem to be syngenetic. The limestone usually emits a foetid odour when struck and in places bitúminous and carbonaceous (graphitic) streaks occur in it. In places it contains sufficient iron to produce reddish and purplish films on joint and cleavage surfaces as the limestone weathers and while this is particularly well-displayed at Melrose and Railton, it does occur elsewhere. *Terra rossa* is not the normal weathering product of the limestone under Tasmanian climatic conditions except where the limestone is above local base-level.

Fossils are common in the Gordon Limestone, but even early observers noticed that the fossils were frequently restricted to particular beds in which they are very common so that there are considerable thicknesses of limestone with few if any obvious fossils. In the fossiliferous beds there are frequently a large number of one species or one order and fewer specimens of other forms. The investigation of the detailed distribution has begun but it is too early yet for any attempt at generalisation.

The grainsize varies from very fine to coarse, some coralline fragments at Mole Creek and Ida Bay being over a foot across. Thus the limestone varies from a calcilutite to a calcirudite but fine and medium-grained limestone are commoner than the coarser types. In one case at the Smelters Quarry, Zeehan, it is possible to show large (6-8 inches long) colonies of *Tetradium* preserved in living position and enclosed in a calcilutite matrix. However, at Ida Bay, the southern end of the Tiger Range in the Florentine area and at Mole Creek, at least the large coral colonies are preserved as rolled fragments so that the rocks can adequately be described as coralline calcirudites.

The limestone is well-bedded with beds varing from laminae in some calcilutites to thick beds in the calcirudites. In a few places the bedding-planes are wavy, due to ripple-marking, but this seems to be rare. Cross-bedding has been recognized at Bubb's Hill and near Mole Creek. Stylolites are very common and there is hardly an outcrop of any extent which does not show them.

The thickness of the limestone varies considerably and as far as is known reaches a maximum of the order of 5,000 feet thick in the Florentine Valley area.

Florentine Valley Area.

The area of the thickest development of the Junee Group and the Gordon Limestone is in the Florentine Valley where the limestone is of the order of 5,000 feet thick. The base of the limestone is exposed at Adamsfield in Clarke's workings and in the road cutting on the Australian Newsprint Road just south of Frodsham's Gap. At Adamsfield, as far as the section is known, the limestone overlies white fossiliferous quartzites and the transitional beds contain the cephalopods listed above as well as an assemblage of sponges, trilobites, brachiopods and algae. Near Frodsham's Gap the limestone rests on calcareous siltstones, called the Florentine Valley Mudstone by Etheridge (1904), which contain brachiopods (Brown, 1948), trilobites (Kobayashi, 1940*b*) and graptolites. Fossils have not yet been found in the basal bed. In the Florentine Valley itself there are many fossiliferous horizons represented. On the main forestry road of the Australian Newsprint Mills about a quarter of a mile from the old Dawson Track an impure, nodular limestone occurs which contains *Tritoechia*, strophomenids and trilobites. This is presumably not far from the base. Along the Dawson Road a number of horizons have been recognised by Opik (1951) and the author, and are as follows:—

Limestone with ostracodes, brachiopods and trilobites.
Limestone with *Rhinidictya*, strophomenids and trilobites.
Limestone with cephalopods and ostracodes.
Limestone with *Maclurites*.
Limestone with *Spanadonta*.
Beds with *Phyllograptus*, ostracodes, trilobites and brachiopods.
Beds with *Tritoechia*.

The limestone with *Maclurites* also contains numerous *Girvanella* and provides a good marker horizon. The *Maclurites-Girvanella* rich limestone occurs on the Dawson Track, on and close to the main forestry road near Cashions Creek, on Karmbergs Track just north of Wherrets Lookout, on the Adamsfield Track about half a mile east of the bridge over the Florentine River, at Junee Caves with *Orthonybyoceras tasmaniense* and at Pillingers Creek Caves. This horizon is thought by Banks and Johnson (1957) to be Chazyan in age.

Just below the Eldon Group in the Tiger Range, where the Adamsfield Track rises over the southern limit of this range, the limestone is richly fossiliferous and contains *Eofletcheria* spp., *Catenipora*, *Palaeofavosites*, *Favosites*, stromatoporoids, and stauriid corals as well as brachiopods, cephalopods and trilobites in a coralline calcirudite. This is probably still only Upper Ordovician.

Ida Bay.

The quarries of the Australian Commonwealth Carbide Company at Ida Bay are in a limestone lithologically like the Gordon Limestone which is at least partly equivalent to it.

The lowest bed exposed is in a cutting of the old Lune River Timber Tram and as Opik (1951) pointed out they contain *Tetradium*. This *Tetradium* somewhat resembles *T. syringoporoides* which suggests that it may be as old as Blackriveran. Much higher up are the beds exposed in the cuttings along the Carbide Company Tram. In the quarry closest to the Lune River settlement, *Streptelasma* is common and in the second quarry *? Receptaculites* is extremely abundant and large trilobites, strophomenids, *Favosites* and *Streptelasma* occur as well as a cystoid. Along the road to the third quarry, now being worked, there are numerous exposures. The lowest limestone beds contain *Conularia*, *Tetradium* and a halysitid; higher there is a zone with *Girvanella*, and higher still limestone rich in *Tetradium*, a gasteropod-rich bed and then after a gap, a richly coralline calcirudite with rare *? Receptaculites*. This is followed by a calcarenite of crinoidal elements with some rhynchonellids and fragments of a large species of *Bumastus*, *Scutellum* and *Rhinidictya*. Cephalopods occur in the coral and trilobite beds but are not well-preserved or common. Higher in the section is an algal limestone then another coralline bed followed by a zone rich in *? Receptaculites* which may be equivalent to that in the second quarry. Higher still are the coralline beds in the saddle between the Sugarloaf and Cave Hill which contain corals such as *Heliolites* and *Favosites*, gasteropods and orthoconic cephalopods. On Cave Hill the highest fossiliferous beds below the Permian are rich in bryozoa and strophomenids and may be Lower Silurian (Opik, 1951). In the westernmost quarry some compound corals and *Hecatoceras longinquum* Teichert and Glenister (1953) occur, but fossils are uncommon. However, in the Mystery Creek Caves *Mysterioceras australe* and *Trocholitoceras idaense* are extremely common on one horizon (Teichert and Glenister, 1953). From Ida Bay, Hill (1955) has recorded *Streptelasma* cf. *aequisulcatum*, *Tryplasma cerioides*, *Lichenaria ramosa*, *Tetradium, ? compactum*, *Tetradium* sp., *Billingsaria banksi*, *Eofletcheria ida*, *Coccoseris ramosa* and *Acidolites*, and suggested that beds from oldest Blackriveran to Trentonian age at least were present. The thickness at Ida Bay is of the order of 500 feet. The directly underlying beds are not seen and the overlying beds are Permian. *Trocholitoceras idaense* may indicate the presence of Upper Canadian beds at Ida Bay (Teichert and Glenister, 1953, p. 13) in the westernmost quarry and it is possible that these beds are structurally below those with *Tetradium* on the Lune River Timber Tram.

Gordon River, Western Tasmania.

The Gordon River, below the Serpentine River, flows for much of its course through limestone and limestone extends some miles up the Franklin River from its mouth. At Pyramid Island the limestone overlies sandstone, probably the Caroline Creek Sandstone, and it is overlain elsewhere by a sandstone at the base of the Eldon Group (see Carey and Banks, 1954, p. 254, for map). Fossils are numerous but have not been zonally collected with the result that the age of the base of the limestone is unknown. Higher in the sequence a zone rich in *Maclurites* occurs which may be equivalent to that in the Florentine Valley. Johnston (1888) recorded numerous fossils from the limestone in this area, some of which have been determined by Teichert and Glenister (1953) as *Gordonoceras bondi*, *Stromatoceras eximium*, *Ephippiorthoceras decorum*, *Anaspyroceras* and *Gasconsoceras insperatum*. The presence of the *Gasconsoceras* may indicate that the top of the limestone here is as young as Lower or even Middle Silurian. Another suggestion that the limestone here includes Silurian beds is provided by the record of *Hercophyllum shearsbyi* and *Entelophyllum* (Hill, 1943, p. 58) which may indicate an age as young as Upper Wenlock or Lower Ludlow.

Bubbs Hill and Head of Nelson River.

At Bubbs Hill, 16 miles from Queenstown beside the Lyell Highway, there are more than 800 feet of limestone dipping gently southwest and capped by a quartzite, probably the Crotty Quartzite. Some of the beds here are somewhat sandy and show cross-bedding and slumping. Algae, corals, bryozoans, brachiopods, gasteropods and cephalopods are present. Hill (1942; 1955) has recorded the corals *Plasmoporella*, *Eofletcheria ida* and *Nyctopora* from this area and considered the limestone here as Upper Ordovician, at least in part. The limestone in the road cuts is variable in purity, some beds being markedly impure. The bedding is thick and in places the bedding-planes are wavy. Two species of *Tetradium*, *Aulopora* and rugose corals are present in the limestones in the road cuts.

Queenstown Area.

Limestone of this age is common along the valley of the King River but little is known of its characters there.

Bradley (1954, p. 202) gave the thickness of the limestone along the West Coast Range as 700 feet but gave no indication of how this figure was obtained and later indicated considerable variation from this figure. According to Bradley the limestone is transgressional from south to north, but no accurately measured sections or fossils are offered in support of this conclusion, Similarly, he suggested the possibility of the lateral equivalence of the top of the limestone south of Queenstown with the Crotty Quartzite at Queenstown, but again offered no evidence for this view. The occurence of limestone at Queenstown has been known for some time (Power, 1892; Hill and Edwards, 1941; and Hills, 1927). The beds are steeply-dipping, with fossiliferous blue-grey limestones passing upwards into brown and black shales with trilobites, bryozoa and brachiopods. The limestone contains the corals *Tetradium tasmaniense*, *T. conjugatum*, *T. dendroides*, *T. syringoporoides*, *Alveolites*, *Protaraea* cf. *richmondensis* and *Acidolites* and the cephalopods *Beloitoceras kirtoni* and *Anaspyroceras anzaas*. The corals indicate a Trentonian to Richmondian age for part of the limestone (Hill, 1955). The *Tetradium*-rich beds are only a few feet below the trilobite shales, but the possibility of strike faults cannot be overlooked. The trilobitic siltstone also occurs as a small ridge beside the railway line just north of the sports ground and contains *Ceraurus*, lichadids, harpids and other trilobites, as well as *Rhinidictya*-like bryozoa and rhynchonellids.

At Lake Margaret, Bradley (1954, p. 202) noted a sequence from Owen Conglomerate into the base of the Gordon Limestone which is locally fossiliferous.

Zeehan Area.

The limestone occurs from near Firewood Siding on the Zeehan-Strahan line, north to Zeehan and somewhat beyond. Over most of this area it overlies earlier Ordovician beds but overlaps these north of Zeehan to rest unconformably on Dundas Group or older rocks. At Greaves Siding, near Eden, on the Zeehan-Strahan Railway, the base of the limestone is somewhat argillaceous and arenaceous and contains *Favosites*, *Rhinidictya* and *Polypora* (Gill and Banks, 1950, p. 262) At this locality it is about 2,000 feet thick. In the Oceana Valley, near the Oceana Mine, a light-grey recrystallized limestone was exposed in Fox's Open Cut and contained simple rugose corals, heliolitids, favositids, *Aulopora*, rhynchonellids, gasteropods, and echinoderm fragments. A core from an exploratory drill at the Oceana Mine was sent to Dr. D. Hill, who recorded the following fossils (Hill, 1955): a band with *Tryplasma cerioides, ? Lichenaria, Tetradium, T. ? compactum, billingsaria ? banksi, Nyctopora zeehanensis, ? Nyctopora, Lyopora* cf. *favosa* and *Eofletcheria contigua*, from 47 feet to 102 feet; gasteropods from 130 feet to 170 feet; *Receptaculites* at 682 feet; gasteropods from 774 feet to 786 feet; brachiopods from 890 feet to 918 feet; and lower down still *Tetradium petaliforme, T. compactum, T. ? tasmaniense, T. dendroides, Lyopora ramosa*. Hill considers the higher coral band more likely to be Trentonian than otherwise, and possibly lower Trentonian. The succession in this core is summarised as text-figure 5.

Fossils have been known from the Smelters Quarry, just southwest of the Smelters Works at Zeehan, since Etheridge (1896) recorded *Eunema montgomerii, Raphistomina, Hormotoma*, &c., from this locality. Later, Chapman (1919) noted the presence of *Tetradium tasmaniense* and since then several workers have added considerably to the list of fossils. The lower part of the limestone is faulted against Amber Slate (Eldon Group) to the west, but the limestone passes gradationally up into the Crotty Sandstone on the southern end of the Smelters Hill. The total thickness of limestone revealed in this section is over 900 feet, but there is a distinct possibility of strike faulting producing inaccuracies in this thickness. The lowest bed exposed in the quarry contains numerous *Tetradium*, while somewhat higher are beds with *Rhinidictya, Strophomena*, rhynchonellids and asaphids; higher still are beds with numerous pelecypods, a bed with *Receptaculites*, another bed of *Tetradium*, and then beyond Austral Creek are impure limestones and brownish and blackish siltstones with numerous fossils, including halysitid, favositid and compound rugose corals, *Rhinidictya* and other bryozoans, strophomenids, rhynchonellids, nuculid pelecypods, bellerophontids and patelliform gastropods, cephalopods, including *Beloitoceras, kirtoni* and *Trocholitoceras* and cheirurid, asaphid, illaenid, harpid and phacopid trilobites. From this locality Hill (1955) has recorded *Tetradium dendroides, T. tasmaniense, T. conjugatum, ? Lichenaria ? ramosa, ? Nyctopora* and *? Protaraea*, and considered the most likely age to be Trentonian. Teichert and Glenister (1953) noted *Hecatoceras longinquum, H. obliquum, Tasmanoceras zeehanense, Anaspyroceras anzaas, Helicotoma, Raphistoma, Holopea, Hormotoma* and *Lophospira* from this locality and remarked on the resemblance of the fauna to that of the Trentonian of North America while considering that it is possibly as young as Richmondian.

Huskisson River Area.

Limestone occurs in the Huskisson River area (Waterhouse, 1914, pp. 51-2) and is known to be fossiliferous and to underlie the Eldon Group, but the age limits are as yet unknown. It apparently rests unconformably on the Dundas Group.

Heazlewood Area.

At Bells Reward Mine a blue-grey laminated and massive limestone occurs and is overlain by the Eldon Group (Nye, 1923). *Favosites grandipora* has been recorded from the limestone.

STRATIGRAPHIC COLUMN SHOWING FOSSIL BANDS IN CORE Nº 2 OCEANA MINE ZEEHAN

AS DESCRIBED BY DOROTHY HILL — ORDOVICIAN CORALS FROM IDA BAY, QUEENSTOWN & ZEEHAN TASMANIA. (PAP. & PROC. ROY. SOC. TAS 1955)

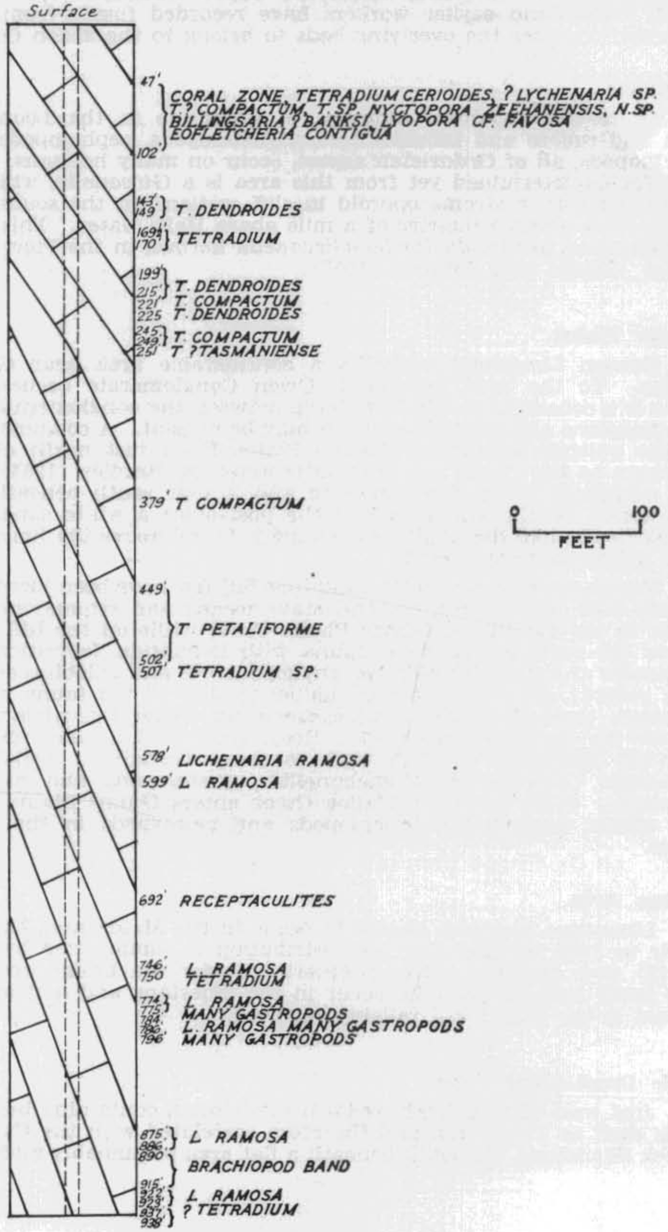


FIG. 5.—Core No. 2 Oceana Mine.

Mackintosh River Area.

At Sophia Flats fossiliferous limestone occurs between a sandstone below and a white sandstone above (Montgomery, 1895). Ward (1908) and earlier workers have recorded fossils from this area and consider the overlying beds to belong to the Eldon Group.

Loongana,

There are numerous outcrops of limestone in the Loongana area and rugose and tabulate corals, gasteropods, cephalopods and brachiopods, all of Ordovician aspect, occur on many horizons. The only fossils determined yet from this area is a *Girvanella,* which is associated with a stromatoporoid in cliff sections on the south side of the river about a quarter of a mile above Hells Gates. This may be equivalent to the *Maclurites-Girvanella* horizon in the Florentine Valley (Banks and Johnson, 1957).

Gunns Plains.

Gordon Limestone underlies a considerable area near Gunns Plains. To the west and south Owen Conglomerate occurs, but there is a considerable gap in outcrop between the conglomerate and the limestone and other formations may be present. A conglomerate in the cuttings beside the Gunns Plains Road just north of the entrance to the Gorge has been interpreted by Bradley (1954) and the author as Owen Conglomerate and it dips south beneath the limestone. In the valley east of the post-office a white sandstone lithologically like the Crotty Sandstone is found above the limestone and below Tertiary basalt.

Fossils are common in the limestone but few have been identified. Corals such as *Propora,* colonial stauriaceans and stromatoporoids occur in the vicinity of Gunns Plains Caves while on the hill slope above the caves a rich coral fauna with heliolitids, favositids and *Favistella* as well as *Rhinidictya,* rhynchonellids and trilobites occurs. The general aspect of these is similar to that of the fauna at the Smelters Quarry, Zeehan, and suggests an Upper Ordovician age. Beside the Gunns Plains-Preston Road about half a mile from the turn-off limestone outcrops and contains *Tetradium,* heliolitids, *Favistella, Rhinidictya,* rhynchonellids, gasteropods and asaphid trilobites. Close to where Walloa Creek enters Gunns Plains there are corals, gasteropods, brachiopods and pelecypods in the limestone.

Moina Area.

Limestone has been known to occur in the Moina area since as early as 1860 (Gunn) and the distribution is summarized by Reid (1919) and Jennings (later chapter). Under the bridge over the Iris River beds of quartzite occur in the limestone and a stromatoporoid is the only fossil reliably reported.

Mole Creek-Liena Area.

Just west of Chudleigh, reddish sandstones, containing brachiopods such as *Tritoechia,* and therefore correlated with the Caroline Creek Sandstone, dip south beneath a flat area presumably underlain by limestone. This flat area continues westward to Mole Creek where outcrops of Gordon Limestone occur. These outcrops are very extensive and are found from Caveside north to the Mersey and as far west as Liena where Hill (1942, 1943) recorded *Favistella cerioides, Favosites marginatus, Plasmoporella* cf. *convexotabulata* and *Halysites ? chillagoensis* which indicate possible ages between Upper Ordovician and Middle Silurian. Hill (1943) regarded the age as probably Upper Ordovician. Fossils are common in the limestones in the Mole Creek area, but again few have been even generically identified. *Tetradium*, cephalopods and a rich coralline fauna occur in limestones, including coralline calcirudites, in a paddock north of the Mole Creek-Liena Road just east of the turn-off to Mr. Lewis Lee's property. On the hill-slope west of Mr. Lee's house limestone is exposed, beginning with a cross-bedded calcarenite, then a lithoidal limestone containing *Tryplasma*, a richly coralline limestone and then a coralline, crinoidal limestone. Higher up the slope a sandstone lithologically like the Crotty Sandstone outcrops. In the cliffs above the Mersey River at The Den and close to the top of the limestone a richly coralline calcirudite with blocks of compound coral up to two feet in diameter occurs. This contains favositids, heliolitids, halysitids and *Favistella*.

Melrose and Railton.

At Melrose, rocks of the Junee Group outcrop extensively. The Gordon Limestone is underlain by slates lithologically very like the Florentine Valley Mudstone and containing brachiopods and trilobites similar to those in this formation at Frodsham's Gap. The limestone is several hundred feet thick and south of Melrose township contains sponges, *? Receptaculites,* corals and brachiopods, including rhynchonellids. South of Melrose it is overlain by a white sandstone which resembles the Crotty Sandstone. At the eastern end of the southern wall of the large western quarry at Eugenana, *Maclurites* is associated with *Girvanella* and stromatoporoids, an association suggesting correlation with the *Maclurites-Girvanella* horizon in the Florentine Valley. On other horizons nearby corals, bryozoans and brachiopods occur.

At Railton the Gordon Limestone overlies reddish slates a few yards east of Blenkhorn's Quarry. These slates contain *Tritoechia* and *Tasmanocephalus stephensi* (Twelvetrees, 1909) and are correlated with the Florentine Valley Mudstone. The lowest beds in Blenkhorn's Quarry contain strophomenids and higher beds cephalopods. These cephalopods, *Nybyoceras paucicubiculatum* and *N. multicubiculatum,* are considered by Teichert and Glenister (1953, pp. 10, 13) to be Chazyan or Mohawkian. They occur 300 feet stratigraphically above the base. Teichert and Glenister (1952, p. 734) also recorded *Ormoceras* and *Anaspyroceras* from Railton and considered that these indicate a post-Chazyan age. In the Goliath Cement Company's quarry *Maclurites* occurs as well as *? Receptaculites*, a sponge close to *Zittelella*, brachiopods, bellerophontids and cephalopods. These fossils may indicate a Chazyan or Blackriveran age.

Deloraine Area.

On Stocker's Plain, west of Quamby Bluff, Gordon Limestone overlies a quartzite with *Tritoechia,* which may be equivalent to the Caroline Creek Sandstone (Wells, 1954), but there is a big gap in the section. The limestone contains trilobites, but is not very fossiliferous. Limestone correlated with the Gordon Limestone occurs as an isolated fault-block on Cameron's property in Golden Valley. No fossils have yet been found in it.

Beaconsfield and Flowery Gully Area.

Limestone outcrops from just north of Winkleigh to Flowery Gully and again just north of the Flowery Gully Road about half a mile from the Tamar Highway near Beaconsfield. The occurrence at Flowery Gully has been mapped in some detail by Noakes, Burton and Randal (1954). Below the limestone is a sequence of sandstone, siltstone and shale, possibly the Caroline Creek Sandstone and the Florentine Valley Mudstone, and above it is a sequence of brown slate, black slate and sandstone, possibly the lowest beds in the Mathinna Group. Basing their hypothesis on a discontinuity in their " Chert Zone " and their " Lower " and " Upper " " Zones," they have deduced a fault affecting the Gordon Limestone, but not the overlying sediments. They postulated a normal fault followed by erosion before deposition of the Mathinna Group sediments. If this disconformity is substantiated it will be the first known case of such a structure between the Gordon Limestone and the Silurian and Devonian sediments. Noakes, *et al.* (1954) found the limestone here to be at least 1,700 feet thick. The limestone is divided by them into three zones as under:—

" Upper Silica Zone "	300 feet
" Chert Zone "	500 feet
" Lower Silica Zone "	900 feet.

Fossils are rare in the limestone here but a few do occur. An orthoconic nautiloid was found by the author in Sulzberger's Quarry in the " Lower Silica Zone," some algal fragments were found in the " Chert Zone " near Beams Bros. No. 2 Quarry, and echinoderm fragments in the " Upper Silica Zone " at the B.L.P. Quarry and Beams Bros. No. 1 Quarry. Dallwitz (in Noakes *et al.*, 1954) recorded the presence of very elongated siliceous rods which he considered must be sponge spicules. Dolomite is common on certain horizons and of especial interest is the association noted by Dallwitz of chert nodules and pyrite. The deduction of the presence of algal reefs in the limestone (Noakes *et al.*, 1954, p. 8) from the ocurrence of dolomitic masses seems suspect in the absence of actual evidence of reef-building algae or stromatoporoids as fossils in the limestone. The only algae observed by the author were spherical or sub-spherical bodies up to half an inch in diameter. In the absence of identified fossils this limestone is correlated with the Gordon Limestone on lithological grounds only.

Along the eastern side of Cabbage Tree Hill and Blue Tier, near Beaconsfield, there is an extensive development of the Junee Group which has been dealt with by a number of people, but perhaps the most comprehensive work is that of Twelvetrees (1903). In this area a formation of conglomerates and sandstones with at least three beds of conglomerate are overlain by sandstones with thin conglomerate bands. This sandstone contains brachiopods, trilobites, cystoid plates, tubular casts and algae (*Licrophycus tasmanicus*). The trilobites and brachiopods are forms typical of the Caroline Creek Sandstone. Over the sandstone formation is a formation of slates 32 feet thick in the Tasmania Mine. At the eastern end of

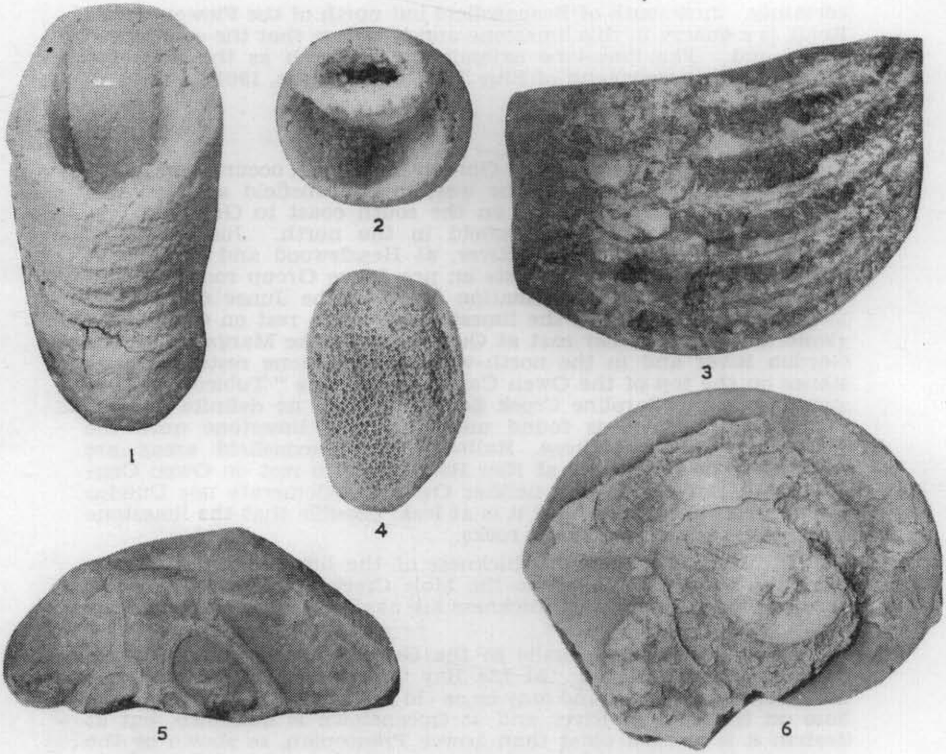
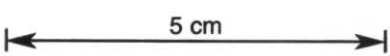


FIGURE 6.—Characteristic Fossils from the Gordon Limestone.

1, 2. *Manchuroceras steanei* Teichert, base of the Gordon Limestone, Adamsfield. 1. Dorsal view; 2. Anterior view. Both x 3/2.
3. *Nybyoceras paucicubiculatum* Teichert and Glenister, near base of Gordon Limestone, Blenkhorn's Quarry, Railton. Longitudinal section. x 1.
4. *Tetradium compactum* Hill, Gordon Limestone, Smelters Quarry, Zeehan. Surface view. x 1.
5, 6. *Maclurites* n. sp. Banks and Johnson, Gordon Limestone, Florentine Valley.
5. Section of specimen from near Cashions Creek. x 2/3.
6. Basal surface of specimen from Dawson Road, near Benjamin. x 4/7.

(*Photographs by T. S. McMahon, University of Tasmania.*)

the gorge of Blyths Creek this slate is overlain by a blue limestone containing fossils of which the only recognisable one is an orthoconic cephalopod. Corals have been recorded from this formation by Gould, but have not been seen by later workers. Twelvetrees (1903) gave the thickness of the limestone as 340 feet in the Tasmania Mine. There is a possibility that there is a second thinner limestone separated from the main limestone by sandstone and slate east (down-dip) of the Tasmania Mine. This may, however, be a structural repetition. The lithology and stratigraphic association of the main limestone indicates that it is the Gordon Limestone, overlying the Florentine Valley Mudstone. In view of structural difficulties the nature of the beds overlying the limestone is not known with



certainty. Just south of Beaconsfield but north of the Flowery Gully Road, is a quarry in this limestone and it is here that the cephalopod was found. The limestone extends as far south as the Salisbury Mine at the southern end of Blue Tier (Twelvetrees, 1903).

Summary.

A limestone formation, the Gordon Limestone, occurs from Eden, Zeehan and Heazlewood on the west to Beaconsfield and Ida Bay on the east, from New River on the south coast to Gunns Plains, Melrose, Railton and Beaconsfield in the north. Just north of Zeehan, near the Huskisson River, at Heazlewood and possibly in other places, the limestone rests on pre-Junee Group rocks without the intervention of any formation lower in the Junee Group. At Mount Zeehan and Eden the limestone seems to rest on Owen Conglomerate while further east at Queenstown, Lake Margaret, on the Gordon River and in the north-west the limestone rests on sandstones on the top of the Owen Conglomerate, the "Tubicolar Sandstone" and the Caroline Creek Sandstone, and no definite slate or mudstone formation is found underlying the limestone until the Florentine Valley, Melrose, Railton and Beaconsfield areas are reached. The limestones at New River seem to rest on Owen Conglomerate, but at Ida Bay neither Owen Conglomerate nor Dundas Group rocks are known, and it is at least possible that the limestone rests on pre-Dundas Group rocks.

The zone of maximum thickness of the limestone seems to be from the Florentine Valley to the Mole Creek area, but insufficient accurate measurements of thickness are available to attempt to draw an isopach map.

The oldest known fossils in the Gordon Limestone are Upper Canadian at Adamsfield. At Ida Bay the base is probably at least as old as Blackriveran and may be as old as Chazyan. The age of the base on the Gordon River and at Queenstown is unknown, but at Zeehan it is at least older than Lower Trentonian, as shown by the corals in the Oceana Core which does not reach the base of the limestone. In the north-west Caroline Creek Sandstone or Florentine Valley Mudstone underlies the limestone and us Upper Canadian in age. There is gradation from these formations into the limestone and 300 feet above the base at Railton Chazyan cephalopods have been reported. Thus, where information is available the base of the limestone is not younger than Lower Trentonian and not older than Upper Canadian.

Less information is available on the age of the top of the limestone. In the Gordon River in Western Tasmania the presence of *Hercophyllum shearsbyi, Entelophyllum, Stromatoceras eximium* and *Gasconsoceras insperatum* indicate the possibility of the top of the limestone reaching into the Silurian. In the Florentine Valley area no definitely Silurian fossils have been found in the top beds of the limestone which are probably Upper Ordovician. The top beds at Ida Bay may be Lower Silurian, the topmost dated beds being probably Richmondian. At Zeehan beds perhaps as young as Richmondian are about 500 feet below the top of the limestone but as yet no definitely Silurian forms have been found. Beds at Bubbs Hill and Liena contain corals which may be Upper Ordovician or Silurian, but no definitely Silurian forms have yet been found. Thus the established evidence suggests a maximum age range from

Upper Canadian to Lower Silurian. There is some possibility, in view of the differences in age of the youngest known fossils in the limestone and of the evidence advanced by Noakes *et al.* (1954) from Flowery Gully that there is an erosional break between the Gordon Limestone and the Eldon Group. An alternative possibility is that of equivalence of the Crotty Quartzite with parts of the top of the Gordon Limestone, but insufficient fossil evidence is available from either formation to regard this as anything more than speculation to be tested.

SILURIAN AND DEVONIAN SYSTEMS.

Although limestones are uncommon in the Eldon Group and its probable correlate, the Mathinna Group, they do occur. Probably the best known one is that a quarter of a mile above the Mines General Office at Queenstown. Here a light-grey, stylolitic limestone is found in black slates. The limestone is apparently lenticular, being less than 100 feet thick and probably not much more than a quarter of a mile along the strike. Fossils are quite abundant and include articulated and disarticulated crinoid columns of large diameter, numerous large and small fragments of colonial corals, including favositids, syringoporids and stauriaceans, brachiopods, including rhynchonellids, and numerous *Tentaculites* in some places. The enclosing slates are also rich in *Tentaculites* and richness in this fossil suggests that the limestone and slates are part of the Amber Slate, one of the diagnostic features of which is richness in *Tentaculites*. However, *Tentaculites* has a distinctly longer stratigraphic range and more palaeontological work is necessary before the age of the limestone can be regarded as known.

In 1914 Hills reported on some of the country south of Macquarie Harbour and noted the presence of limestone from the Hibbs River to the southern side of Point Hibbs. The limestones were recorded (*ibid.*, p. 9) as being highly fossiliferous and as being associated with " quartzites, claystones, calcareous claystones, sandstones and quartz conglomerates ". Hill (1942) has recorded *Heliophyllum chillagoense* and *Favosites ? bryani* from limestone at Point Hibbs and suggested a Lower Devonian age for at least part of it. It is possible that it is a lense or bed in the Bell Shale, but detailed field work needs to be done before this is definitely established.

Beds of white, fine-grained limestone occur in the Mathinna Group in road cuttings just west of Fingal. They are only an inch or so thick and it is uncertain whether they are original sedimentary limestones or later deposits from ground-water.

PERMIAN SYSTEM.

Introduction.

Limestone occurs in the Permian System on three main horizons, the lowest one being the Darlington Limestone and its correlates, the next and most important one being the Berriedale Limestone and its correlates, and the highest being lenticular limestones in the " Woodbridge Glacial Formation." The distribution of these limestones is shown in text-figure 7.

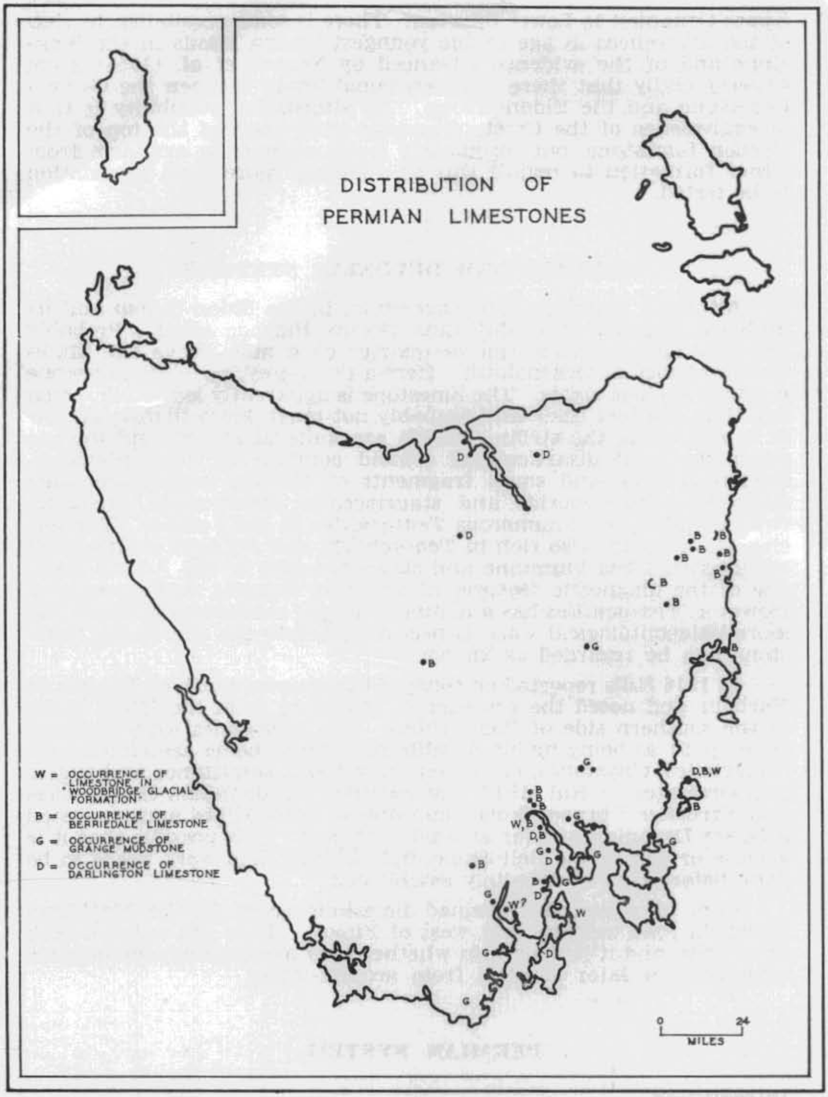


FIG. 7.—Permian Limestones.

THE DARLINGTON LIMESTONE AND ITS CORRELATES

The Darlington Limestone is here defined as that limestone formation 50 feet thick overlying a sandstone and siltstone formation. called by Johnston (1900) the "Erratic Zone," and overlain by erratic-rich sandstone, and is exposed in quarry and cliff sections at the north end of Maria Island one mile north of the village of Darlington, from which it is named. It contains *Eurydesma cordatum*, *Stenopora johnstoni*, *Keeneia* and *Calcitornella*. It is Permian, probably basal Artinskian in age.

Details of the section are given below and are summarised as text-figure 8:—

TOP:

Units 14-24. An alternation of *Eurydesma*-rich limestones and spiriferid calcirudite similar to units 12 and 13 respectively; the *Eurydesma*-rich limestone units are thicker than the succeeding spiriferid calcirudites. In unit 17, *Eurydesma cordatum* var. *sacculum* was noted and this is the lowest unit in the section in which this variety was seen by the author. In unit 24, the 12 feet thick *Eurydesma*-rich limestone contains the calyx of a *Camptocrinus* sp. with the plates separated but still associated, and some specimens of *Dielasma*.

Unit 13. Medium to coarse-grained, poorly-sorted, spiriferid calcirudite; light-grey, thickly-bedded; composed mainly of broken shell fragments with some rounded and facetted rock fragments up to 15 inches long near the top of the bed; dominantly calcite but some quartz and feldspar; it is foetid when struck with a hammer; fauna includes *Stenopora*, *Grantonia* sp., *Martiniopsis* sp., *Eurydesma cordatum*, aviculopectinids and crinoid basals and columnals. The fossils are all fragmentary except for some of the smaller spiriferids; this unit has a markedly irregular lower surface, indicating pene-contemporaneous erosion, probably sub-marine, but the upper surface is fairly flat; the unit is a good local marker because of its light colour and irregular base.

Unit 12. A *Eurydesma*-rich limestone, generally well-sorted, dark-grey, foetid; the fossils are in a matrix of silty limestone, in many places the shells of *Eurydesma* are convex upwards; colonies of *Stenopora tasmaniensis* show imbrication in one part of quarry which is mostly in this unit, the currents producing the imbrication having come from the south-west; although generally fairly well-sorted, the limestone contains a number of erratics which have been rejected by the quarrymen; in addition to large facetted ones there are rounded pebbles up to eight inches long. The fauna includes *Stenopora johnstoni* (up to two feet long), *Stenopora* spp., a monticulate, encrusting, laminated form and a medium ramose form, *Fenestella* spp. and *Polypora* spp., broken bases and fronds, *Grantonia* sp., disarticulated or fragmentary or articulated, *Martiniopsis* (?) *subradiata*, *Eurydesma cordatum*, both small and large individuals, some broken, aviculopectinids, *Merismopteria*, *Mourlonia morrisiana*, *Calceolispongia*, some not completely disaggregated, some disaggregated but with the plates still associated and others just isolated columnals and calical plates, *Camptocrinus*, articulated columnals.

Unit 11. A spiriferid calcirudite with a coarse to medium-grained calcareous siltstone matrix; light-grey; few rounded to sub-angular erratics; thin bedding; fauna includes *Stenopora tasmaniensis*, stenoporids, fine ramose, medium ramose, and a monticulate, laminate form, *Fenestella* spp., bases common, *Polypora* spp., *Grantonia* sp., articulated, disarticulated and fragmentary, *Martiniopsis* sp., *M. subradiata*, aviculopectinids, fragmentary, *Eurydesma cordatum*, *Merismopteria*, broken, *Keeneia* sp., very small, almost smooth, *Calceolispongia* sp., basals up to 2 cms. across, radials, *Camptocrinus* sp., articulated and disarticulated columnals.

Unit 10. A *Eurydesma*-rich limestone, light-grey in colour, and with few rounded and facetted erratics; some mica in matrix; fauna includes *Stenopora johnstoni*, up to one foot long, fine and medium ramose stenoporids, very common, *Fenestella* sp., many bases, *Polypora* sp., *Grantonia* sp., very fragmentary, *Eurydesma cordatum*, complete and fragmentary, both convex and concave upwards, aviculopectinids, fragmentary, *Keeneia*, *Camptocrinus* articulated columnals, *Calceolispongia*, disarticulated columnals, basals, anals.

Unit 9. A spiriferid limestone which varies a little in thickness; erratics up to 10 inches long are common near the top of the bed, they are both facetted and rounded and include quartzite and greywacke breccias; fauna includes *Stenopora johnstoni*, four to five inches long, *S. tasmaniensis*, a stenoporid, a bilaminar form with a coarse ramose form arising from the monticules, fenestellids, *Grantonia* sp., *Trigonotreta*

TYPE SECTION OF DARLINGTON LIMESTONE
MARIA IS.

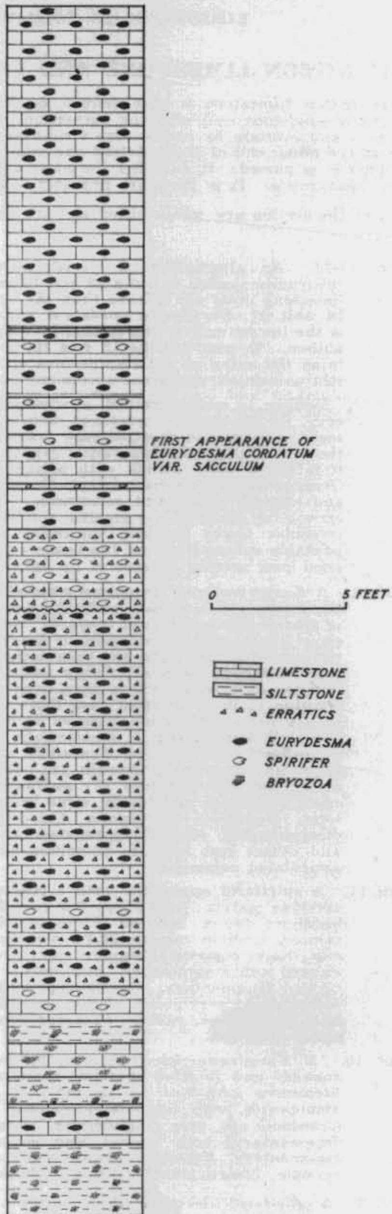


FIG. 8.—Darlington Limestone, Maria Island.

(?), *Martinopsis*, aviculopectinids, *Eurydesma cordatum*, *Calceolispongia*, columnals, radials and basals, a crinoid with pentagonal columnals.

Unit 8. Medium-grained, well-sorted, light-grey bryozoal silty limestone with very rare erratics; laminations due to numerous bryozoa; top surface irregular; fauna includes *Calcitornella* (?), fenestellids, *Stenopora*, fine ramose; spiriferids, *Grantonia Dielasma*, aviculopectinids, *Eurydesma*, very small.

Unit 7. Medium-grained, well-sorted, medium-grey bryozoal limestone; thickness variable; some erratics present and most of them rounded; fossils include *Stenopora johnstoni*, up to six inches long; *Stenopora*, fine and medium ramose forms, badly smashed, fenestellids, *Fenestella*, *Polypora*, *Grantonia*, fragmental, smoothed, *Dielasma*, *Eurydesma cordatum*, aviculopectinids, *Calceolispongia*, basals.

Unit 6. Medium-grained, well-sorted, medium-grey, laminated bryozoal siltstone with some mica parallel to bedding; boundaries irregular; fauna includes *Stenopora* spp., fine ramose, fenestellids, *Grantonia* and *Trigonotreta* very common at top and bottom of bed but only few in centre; *Eurydesma cordatum*, aviculopectinids, crinoids, few small columnals and common large flat pentagonal basals, *Calceolispongia* basals common.

Unit 5. Poorly-sorted, *Eurydesma*-rich limestone with numerous angular to sub-rounded erratics up to eight inches in length; medium-grey in colour; many shells convex upwards; fauna includes *Stenopora*, fine and medium ramose, *Fenestella* spp., bases overturned, *Grantonia* spp., *Martiniopsis*, *Schuchertella*, *Eurydesma cordatum*, aviculopectinids, *Calceolispongia*.

Unit 4. Coarse-grained, well-sorted, medium-grey, laminated bryozoal siltstone with limestone lenses at two feet and two feet eight inches above the base; rare small erratics of quartz in groundmass of quartz, feldspar and golden mica; fauna includes *Stenopora*, *Fenestella*, *Polupora*, *Grantonia*, *Martiniopsis*, *Dielasma*, very small; *Eurydesma cordatum*, crinoid columnals.

Unit 3. Medium- to fine-grained, fairly well-sorted, medium-grey *Eurydesma*-rich limestone; shells convex upwards; erratics common, dominantly rounded, some angular, up to eight inches long; fauna includes *Stenopora*, *Polypora* spp., *Grantonia*, *Martiniopsis*, *Eurydesma cordatum*, aviculopectinids, *Conularia*.

Unit 2. Coarse-grained, well-sorted, light-grey, laminated bryozoal siltstone with rare small erratics of quartz and quartzite in a matrix of quartz, feldspar and golden mica; fauna includes *Stenopora*, *Fenestella*, *Polypora*, *neospirifer*, *Grantonia*, *Eurydesma cordatum*, aviculopectinids, *Merismopteria*, *Camptocrinus*, columnals, *Calceolispongia*, crinoid columns with columnals alternating in size, pentagonal columnals.

Unit 1. Poorly-sorted- medium-grey *Eurydesma* calcirudite with shells convex upwards and a few rounded erratics up to six inches long; quartz, feldspar and golden mica in the groundmass; fauna includes *Stenopora*, *Fenestella*, *Polypora*, spiriferids, *Grantonia*, *Trigonotreta*, *Martiniopsis*, *Schuchertella*. *Dielasma*, *Eurydesma cordatum*, aviculopectinids, *Merismopteria*, *Keeneia*, *Mourlonia morrisiana*, *Calceolispongia*, recognized by one horn on the basal, calices disarticulated but still associated, pentagonal columnals, few brachials.

From the section (figure 8) and the detailed notes on this, it will be seen that the Darlington Limestone as exposed in the northern shore of Maria Island in shore platform, cliff and quarry section, consists of an alteration of *Eurydesma* calcirudites and bryozoal siltstones near the base and of *Eurydesma* calcirudite and spiriferid calcirudite higher up. The bryozoal siltstone units in the lower part of the formation become more calcareous higher in the formation and more spiriferids are found in them, so that units 6, 7, 8 and 9 take the place of a bryozoal siltstone in the alternation. These are a bryozoal siltstone with numerous spiriferids near the base and top of the unit, a spiriferid bryozoal limestone, then a bryozoal silty limestone, and finally a spiriferid limestone (unit 9). In the next alternation the bryozoal siltstone unit is represented by a spiriferid calcirudite (unit 11), and in subsequent cycles the succession is *Eury-*

desma and spiriferid calcirudite. Under this interpretation of units 6, 7, 8 and 9 there are eleven cycles involving a *Eurydesma* calcirudite and with the *Eurydesma* calcirudite member of the cycles generally the thicker of the two.

The Darlington Limestone is correlated with the Callytharra Limestone of Western Australia, the limestone in the Rutherford Formation of the Dalwood Group of New South Wales, and the Dilly Stage of the Bowen Basin in Queensland. Reasons for this correlation are given by the author in another paper (Banks, 1957, in press) where this limestone is referred to as the " *Eurydesma* Limestone."

Richly-fossiliferous mudstones and limestones occur on this horizon as far south at least as Woody Island and as far north-west as Wynyard. On Woody Island the Darlington Limestone is only five feet thick, is underlain by an erratic-rich sandstone, and overlain by a very fossiliferous siltstone. As shown by Banks, Hale and Yaxley (1955), it contains *Eurydesma cordatum, Calcitornella stephensi, Stenopora johnstoni* and *S. tasmaniensis*, and the overlying siltstone contains *Keeneia platyschismoides*.

In road cuttings just north of the bridge where the Channel Highway crosses the Snug Falls River near Snug, 25 feet of grey siltstone with some sandstone and limestones bands are exposed. The presence of numerous specimens of *Eurydesma cordatum* suggests correlation with the Darlington Limestone, but this needs checking.

A limestone occurs near water-level on the shore-line below Porter Hill, about a mile south of Long Beach, Sandy Bay. As the base is below low-tide mark the thickness is unknown, but several feet are exposed. It is a medium-grey, massive, foetid limestone which contains numerous fossils, including *Stenopora tasmaniensis, S. johntoni, Eurydesma cordatum* and *Calcitornella*. Above the limestone are blue-grey fossiliferous mudstones with a few specimens of *Keeneia platyschismoides*. The fossils in the limestone and the overlying mudstones indicate correlation with the Darlington Limestone.

Voisey (1938, p. 316) mentioned a *Eurydesma*-rich limestone on the Glenlusk Road about a mile and a half west of the Berriedale Railway Station. The association of sediments supports Voisey's correlation with the Darlington Limestone. On the eastern slope of Mount Faulkner south of the Collinsvale Road, Carey recently measured a section, including about 10 feet of highly-fossiliferous, medium-grey foetid limestone with numerous specimens of *Eurydesma cordatum*. More recently still, the author identified *Calcitornella* in this limestone, thus supporting correlation with Darlington Limestone.

In northern Tasmania, the presence of a limestone, now correlated with the Darlington Limestone, has been known since 1890 when Stephens recorded the first Permian foraminifera from Australia in a limestone near Karoola. This limestone is only three feet thick, but is richly fossiliferous and contains *Calcitornella stephensi* and *Geinitzina triangularis* (Crespin, 1947), as well as fenestellids, brachiopods and crinoid fragments.

Even earlier, Strzelecki (1845) and McCormick (1847) had remarked on the Permian limestones at Beaconsfield. Voisey (1938) noted that they contained abundant *Eurydesma cordatum* and correlated them with the Darlington Limestone. Recently the author identified *Calcitornella* in a specimen (P.L. 725) in the British Museum of Natural History from the Beaconsfield area (marked "Near George Town, Port Dalrymple") and later saw numerous specimens of this foraminifer in samples collected by D. H. Green at Beaconsfield. The thickness of this limestone is 10 feet.

Wells (1957) found a limestone in the Permian sequence in Golden Valley just south of Deloraine. This limestone is rich in *Eurydesma cordatum* and contains *Stenopora tasmaniensis* and *Calcitornella*, again indicating correlation with the Darlington Limestone. At Golden Valley this limestone is about 10 feet thick and it extends southwards under the Western Tiers. Much earlier Johnston (1888) had recorded very fossiliferous mudstones from Cheshunt on the Meander River a few miles west of Golden Valley. A specimen from this locality, now in the British Museum (98222), contains *Eurydesma cordatum* and *Calcitornella stephensi*, the latter being abundant.

Beds definitely of this age occur further north-west in the Latrobe area. In a limestone from Port Sorell in the British Museum (specimen 90284, marked "Port Lowell") *Calcitornella stephensi* occurs with *Stenopora tasmaniensis* and indicates extension of the Darlington Limestone correlates at least this far. The author (Banks, 1957) has advanced reasons for correlating richly fossiliferous beds above the tasmanite and below the coal in the Mersey area with the Darlington Limestone and suggested that the fossiliferous siltstones below the Preolenna Coal Measures (Hills, 1913) are also roughly on this horizon. Correlation of richly fossiliferous beds in the Central Plateau and western Tasmania with the Darlington Limestone is not yet based on adequate fossil evidence.

Although the Darlington Limestone and its correlates are quite widespread, they are rarely thick enough or pure enough to provide economic sources of lime. Erratics are common in them and grains of quartz, feldspar and other rock material are abundant. Despite lack of economic significance this limestone is of prime stratigraphic importance for correlation within the Permian of Tasmania and for interstate correlation.

The Berriedale Limestone and Its Correlates.

This limestone has been known since Jukes (1847) noted its occurrence on Mount Wellington, at Glenorchy and on Maria Island. Many people have contributed to knowledge of it, especially faunally, but no one published adequate or detailed stratigraphic sections until Brill (1956) dealt with the cycles of sedimentation in it and variations in thickness and clastic content.

Although the type area should be Berriedale Quarry the Permian section is not so well exposed there as at Mount Nassau and has structural complications so that the Mount Nassau section is being chosen as the type section for defining most of the Permian formations. However, the longest and best exposure of the Berriedale Limestone known in the Hobart district is at Weily's Quarry, Glenorchy, and the section in this quarry as well as in other quarries in the Hobart area, were described by Brill (1956). In Weily's Quarry the section begins with a sandstone at least four feet thick, then follows 16 feet 11 inches of mudstone with one limestone bed only eight inches thick. The Berriedale Limestone itself which may be taken as starting with Brill's Unit 11 (Brill, 1956, p. 140) is 93 feet

5 inches thick, accepting the top of the Berriedale Limestone as the top of Brill's Unit 64 (*ibid.*, p. 138). Of this thickness 68 feet 2 inches are limestone and 18 feet 10 inches are mudstone or meta-bentonite. The thickest limestone unit is number 12, which is six feet, for although unit 19 is thicker, 7 feet 4 inches, it contains seven thin shale breaks. The thickest mudstone bed (Unit 49) is 5 feet 7 inches thick but most of them are less than a foot thick. Of considerable interest is the occurrence of 13 beds of montmorillonite-rich shale, considered by Hale and Brill (1955) to be meta-bentonite. Another point of interest is the presence of a bed of dolomite (Unit 40).

The limestone in this quarry is richly fossiliferous and the fauna includes *Taeniothaerus subquadratus, Trigonotreta stokesii, Aviculopecten squamuliferus*, and *Stenopora pustulosa.*

Beds of limestone, lithologically very similar to the Berriedale occur on the western bank of the Derwent as far south as Porter Hill where they occur interbedded with the Grange Mudstone, especially close to the base of that formation. Further north limestone occurs on the north bank of Sandy Bay Rivulet near the Turnip Fields Road and from mudstone beds from this formation on the Huon Road numerous fossils have been recorded. These include *Aviculopecten squamuliferus, Stenopora pustulosa, Fenestella granulifera* and *Polypora woodsi.*

Berriedale Limestone is exposed in the quarries on the Berriedale-Collinsvale Road near Collinsvale and the section is recorded by Brill (1956, p. 133) who showed detailed correlations with the Weily's Quarry section, The limestone in this quarry contains *Pterotoblastus, Taeniothaerus subquadratus, Lyroporella* and *Eurydesma cordatum* var. *sacculum*. Thirty feet of limestone with some mudstone beds are exposed in the quarry but the total thickness of limestone is probably about 150 feet. Here the limestone and calcareous shale sequence is also underlain by a fossiliferous sandstone with erratics. The basal part of the limestone sequence is dominantly mudstone as at Weily's Quarry and the main limestone sequence is followed by Grange-type creamy fossiliferous mudstone as at Weily's Quarry. Above the fossiliferous mudstone is a fossiliferous sandstone, the basal unit of the " Woodbridge Glacial Formation."

The Black Snake Gully Quarries behind Granton contain at least 50 feet of limestone with minor beds of mudstone and meta-bentonite as shown by Brill (1956, p. 133). This limestone is virtually continuous with that at Rathbone's Quarries on the northern slope of Mount Nassau. The total thickness of the calcareous units at Mount Nassau is 300 feet and they overly eight feet of fossiliferous sandstone with numerous erratics and are overlain by the basal sandstone unit of the " Woodbridge Glacial Formation ". The basal part, as at Weily's Quarry, is dominantly mudstone which is between 50 and 100 feet thick, then follows limestone with meta-bentonite, and finally the Grange-type mudstone with numerous *Strophalosia*. The limestone here also contains *Lyroporella, Taeniothaerus subquadratus* and *Eurydesma cordatum* var. *sacculum.*

At several places in the foothills of Mount Dromedary the Berriedale Limestone is exposed. In one section above Bundella Station, 11 feet of fossiliferous sandstone are followed by 90 feet of bryozoal mudstone and then 255 feet of Berriedale Limestone which is overlain by the "Woodbridge Glacial Formation." The limestone is richly fossiliferous and contains several beds of meta-bentonite.

In the valley of the Little Denison River, Ford (1956, p. 149) has recorded the presence of 90 feet of Berriedale Limestone. The limestone overlies shales, conglomerates and well-laminated feldspathic sandstone containing muscovite. These are probably equivalent to all the beds from the Bundella Mudstone to the sandstone just beneath the fossiliferous siltstones which grade up into the the limestone at Mount Nassau. The limestone itself is a dense, grey, massive limestone with numerous brachiopods, bryozoa, corals and aviculopectinids and *Conularia ? derwentensis*. The limestone is impure and foetid and contains erratics of several rock types. Between the limestone and the base of the "Woodbridge Glacial Formation" are calcareous shales.

At Bronte Prider (1948, p. 133) noted the presence of richly-fossiliferous, blue-grey calcareous mudstone which he called "Granton Facies" of his Marlborough Group. Correlation of this facies with the Berriedale Limestone is as yet uncertain.

Minor bands or lenses of limestone occur in the Grange Mudstone near Waddamana and Ross and will be considered later. The next area where there is a definite limestone formation is at Avoca, In this area limestone occurs beneath Ben Lomond, on St. Pauls Dome and in other places. On the north-western slopes of St. Pauls Dome a coarse sub-greywacke sandstone is followed by 80 feet of fossiliferous siltstone with *Cladochonus* and *Terrakea*, and over this are 14 feet of limestone, the lower part of which is silicified. The upper, unsilicified part of the limestone contains *Lyroporella*, *Thamnopora* and *Pterotoblastus*. *Anidanthus springsurensis* occurs in this limestone below Ben Lomond (Hill, 1950, p. 12; Banks, 1957).

Limestone with *Lyroporella*, *Streblotrypa* and many other fossils occurs near Fingal and has been mentioned by Strzelecki (1845) from this area. Limestone was cut by the Killymoon Bore west of St. Marys and is probably the same limestone. At Rays Hill, just north of St. Marys, a conglomeratic arkose is followed by a fossiliferous mudstone and then by 45 feet of creamy limestone, silicified in part, containing *Lyroporella*, *Streblotrypa* and *Eurydesma cordatum* var. *sacculum*. Over this is a calcareous mudstone. At Enstone Park, west of Falmouth, this limestone is again exposed (Walker, 1957). The bore at Harefield passed through this limestone which is well-exposed in road cuttings and cliff sections in the Elephant Pass area. This is the Gray Limestone of Voisey (1938, p. 323). The limestone section has recently been measured in detail by K. G. Brill who kindly made his section available for publication (text-figure 9). The limestone sequence is 144 feet thick and contains mudstone intercalations. The thickest individual limestone bed is about six feet thick and the thickest mudstone bed is five feet thick. The limestone, which is creamy to grey in colour, is richly fossiliferous and contains *Lyroporella* and *Eurydesma cordatum* var. *sacculum*, and in the lower part of it *Calcitornella* occurs.

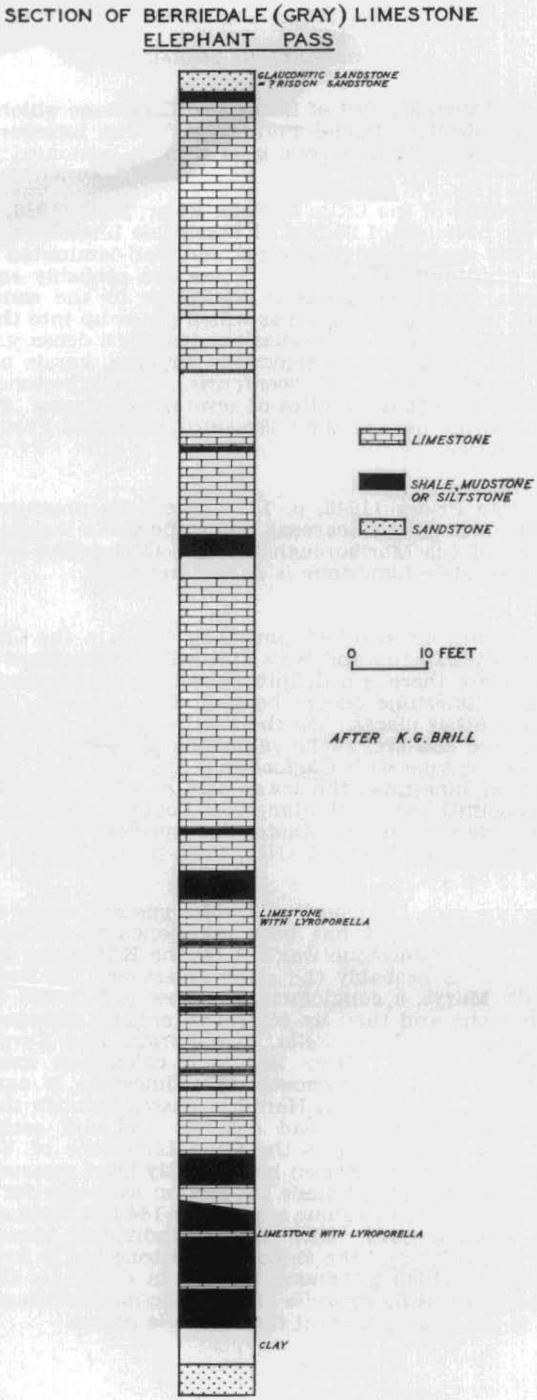


FIG. 9.—Berriedale (Gray) Limestone, Elephant Pass.

At Seymour a bore cut 220 feet of limestone which can probably be correlated with the Berriedale Limestone (Banks, 1957). At the southern end of Friendly Beaches a conglomeratic formation is followed by about 340 feet of limestone and fossiliferous calcareous mudstone over which is a fossiliferous siltstone. The limestone contains corals, *Lyroporella, Taeniothaerus subquadratus, Eurydesma cordatum* var. *sacculum* and many other fossils.

On the northern end of Maria Island above the Darlington limestone are a number of formations before another limestone formation occurs. Overlying a bed of sub-greywacke two feet thick, Montgomery's " tuff " (1891), is a succession of mudstones and limestones with a total thickness of 300 feet. The lowest part of this, 115 feet thick, is an alternation of siltstone and limestone (= Montgomery's "*Productus Zone*") and contains *Pterotoblastus* as well as numerous other fossils. The next part of this, also 115 feet thick is dominantly limestone, with some siltstone and meta-bentonite (Hale and Brill, 1955) and was referred to by Montgomery (1891) as the " Crinoidal Zone " in recognition of the fact that the limestone is dominantly a crinoidal calcirudite. It is dominantly creamy coloured or light-grey, although there are some dark-grey beds. There are some erratics but the main impurities are chert bands and nodules which are quite common. Limestone beds are from less than a foot to 10 feet thick and the shale beds may reach a foot thick. Current scour structures are present in several places. The limestone is richly fossiliferous and contains *Cladochonus, Lyroporella, Taeniothaerus subquadratus, Eurydesma cordatum* var. *sacculum* and *Pterotoblastus*. The " Crinoidal Zone " is overlain by fossiliferous calcareous siltstone which will be considered later. At the northern end of the southern half of Maria Island a crinoidal limestone occurs and contains *Lyroporella, Pterotoblastus* and *Eurydesma cordatum* var. *sacculum*. Its thickness is unknown.

Thus the Berriedale Limestone and its correlates occur in the Hobart district, in the valley of the Little Denison River, in the Avoca area, at Fingal, St. Marys, Seymour, Coles Bay and Maria Island. This distribution is expressed in the isopach map of this formation published by Brill (1956, p. 133) and this map also summarizes the known information on the thickness of the formation. The " O " feet isopach should be moved outwards to include the outcrops at Avoca and the Little Denison River, and the isopachs near Maria Island should also be moved outwards to allow for the 115 feet of limestone at Darlington (shown as 73 feet). However, the north-easterly trend of the zone of maximum thickness seems correct and limestone distribution at the time of formation of the Berriedale is not much more extensive than shown. Voisey (1938), Lewis (1945), Banks (1952) and Hosking and Hueber (1954) have all described the general lithological characters and these need be repeated here only very briefly, The limestone is a light-grey to medium-grey or creamy colour, varying in grain-size from calcilutites to crinoidal calcirudites, and usually containing erratics of variable composition up to a foot across. Smaller particles of clastic origin are also common and lead to a calcium carbonate content which may be as low as 18 per cent (Hosking and Hueber, 1954, p. 11). Brill (1956, p. 134) has shown that the amount of insoluble material decreased gradually from the lower part of a limestone bed up to a point just above the middle of the bed and then increases again, thus suggesting relatively deep water and fluctuation in sea-level or supply of clastic material. Pyritic nodules occur in several places and the limestone consistently has a foetid odour. In addition to the clastic limestones, biohermal and coquinal limestones occur but no detailed work has been done on the limestone types. The fossils important for intra-state correlation have been listed for each locality so that a general correlation of the limestones mentioned seems likely. Detailed correlations are not yet possible so that exact equivalence of the top and bottom of the limestone in its various outcrops cannot be established. In fact there is some evidence suggesting that the bottom and top of the formation vary in age from place to place.

The Berriedale Limestone is considered to be partly equivalent to the Maitland Group of New South Wales and to the Cattle Creek and/or Ingelara Stages of Queensland. Reasons for these correlations are detailed elsewhere (Banks, 1957).

The Grange Mudstone and its Correlates.

This formation was named from the outcrops in the Grange Quarry where the sediments are mainly highly fossiliferous, creamy, siliceous mudstones. K. G. Brill, who measured the section in the quarry, found siliceous clays, limestone and dolomite in addition to the predominant siliceous mudstone. In addition, a bed of nontronite occurs in the quarry (Hale and Brill, 1955). The thickness of the section at Grange Quarry is 113 feet but this is incomplete as it is cut off to the east by a fault and to the west is overlain by a discordant dolerite intrusion. The siliceous mudstone can be traced around the hill to Porters Hill where the full thickness of about 290 feet is exposed. At Porters Hill 10 feet of dense, fossiliferous sandy mudstone is followed by richly fossiliferous, foetid, thickly-bedded, medium-grey limestone, lithologically like the Berriedale Limestone, and the limestone is succeeded by the richly-fossiliferous siliceous mudstones like those exposed in the Grange Quarry. Higher up there are several beds of Berriedale-type limestone in the mudstones and the Grange Mudstone is seen to be succeeded by the basal sandstone unit of the "Woodbridge Glacial Formation." The fossils in the Grange Mudstone in its type area include *Polypora woodsi, Schuchertella* and *Strophalosia*. The Grange Mudstone is considered to be a facies variant of the Berriedale Limestone and the beds above and below it at Mount Nassau and evidence for this will be presented elsewhere.

The Grange Mudstone occurs in the La Perouse area where it has been studied by B. F. Glenister. At Dover, Hale (1953, p. 107) reported highly fossiliferous silicified mudstone which he correlated with the Grange mudstone. A piece of blue-grey limestone resembling the Berriedale Limestone was also found but not *in situ*. Ford (1954) recorded Grange Mudstone from the hills to the north of Castle Forbes Bay where about 400 feet of hard, creamy-white, fine-grained, siliceous mudstone occurs, and contains some coarser bands. No limestone was recorded from this area. The limestone band at Glaziers Bay referred to by Ford (1954, p. 153) will be considered later. Isolated outcrops of Grange Mudstone occur in the Huonville area (Mather, 1955) but lack limestone.

Along the eastern shore of Pierson's Peninsula, Grange Mudstone outcrops in cliff sections south of Blackmans Bay where it is intruded by dolerite. Several thin beds of limestone occur but their stratigraphic position is unknown and they are somewhat metamorphosed by the dolerite. Over 300 feet of Grange Mudstone occur on the northern wall of the valley of the Snug River about a mile above its mouth. Limestone beds occur but are few and thin. On the flats around Nieka and in cuttings along the Huon Road the Grange Mudstone occurs, forming the roof of a dolerite sill. Again a few limestone beds are present but they are not thick. At Mount Nelson several quarries have been opened in the Grange Mudstone where it is intimately intruded by dolerite sills which have produced contact metamorphic effects. Although several relatively pure beds of limestone were originally present these are now metamorphosed. The maximum calcium carbonate content is just over 50 per cent and most beds contain little more than 30 per cent.

The Grange Mudstone outcrops in Myrtle Gully and Macrobies Gully behind the Cascade Brewery and continues north to beyond Glenorchy, although broken somewhat by faulting and topography. Some limestone is exposed in the creek bed just above the Cascade Brewery and bores put down somewhere nearby pass through 500 feet (?) of limestone before reaching dolerite. In this area from South Hobart to and beyond Glenorchy the Grange Mudstone overlies the Berriedale Limestone. This relationship continues at least as far north as the foothills of Mount Dromedary with the Grange Mudstone tending to become thinner in that direction although there seem to be some anomalies.

At Grass Tree Hill, near Richmond, Grange Mudstone has been recorded (Nye, 1921) and it occurs at several places in the Sandford and South Arm Peninsula as in Pipe Clay Lagoon. The best exposure is probably that at Cape Deslacs, where K. G. Brill measured 103 feet of dolomite, limestone and mudstone correlated with this formation.

At Pawleena, near Sorell, and at Carlton and several other places in the area between Richmond, Dunalley and Swansea, the Grange Mudstone is exposed but outcrops are not good and the amount of limestone small. An exception to this is at Cape Paul Lamanon, where good sections are exposed of Grange Mudstone. Here the mudstone contains *Strophalosia clarkei, S. typica, Stenopora crinita.*

At Darlington, on the northern end of Maria Island, the "Crinoidal Zone" is overlain by 68 feet of mudstone, lithologically very like the Grange, calcareous and highly fossiliferous. At least one bed of limestone, two feet thick, occurs and this contains numerous *Cladochonus* and *Thamnopora.* It is followed by a sandstone formation lithologically like the "Woodbridge Glacial Formation."

The thickness of 340 feet of limestone at Friendly Beaches mentioned previously under the heading of the Berriedale Limestone, includes less than 100 feet of cream-coloured mudstones and limestones at the top which are like the Grange Mudstone. The limestones are present but not common.

Overlying the limestone near Avoca is a thickness (on St. Pauls Dome) of 54 feet of fenestellid siltstones with some limestone lenses. These siltstones may be equivalent to the Grange Mudstone or to the "Woodbridge Glacial Formation" and are followed by a glauconitic sandstone correlated with the Risdon Sandstone.

Fairbridge (1949) noted the presence of Grange Mudstone in an inlier at Waddamana. The rock types present include creamy fossiliferous mudstones, mudstones with erratics, and sandy mudstones. Of the fossils recorded, *Polypora woodsi*, *Strophalosia clarkei*, *S. gerardi*, *S. jukesi*, *Terrakea fragile*, *T. brachythaera* and *Cancrinella farleyensis* are of particular interest in correlation. A little further south at Marlborough Prider (1948, p. 133) recorded the Grange Facies composed of richly-fossiliferous yellow mudstone with moulds of fenestellids, stenoporids, *Strophalosia*, spiriferids and other fossils.

In the Midlands Nye (1924) and others have reported Grange-type mudstones but no long sections are exposed.

Finally, Jennings (1955), p. 174) reported impure, fossiliferous marls in the bed of the Florentine River, 2½ miles north of the Dawson Settlement and these may be equivalent to the Grange Mudstone.

It will be seen that the Grange Mudstone and rocks correlated with it or similar to it occur from La Perouse in the south to Waddamana and Friendly Beaches in the north, and perhaps as far north as Avoca, and from Maria Island in the east to Bronte in the west. While the formation contains some limestone bands in most places, the limestone bands are neither numerous nor thick, and the lime content of the formation as a whole is low. There is some evidence that the Grange Mudstone is equivalent as a whole to the Berriedale Limestone and the formations immediately above and below it, although in places the Grange Mudstone, or, more precisely, the upper part of it, overlies the Berriedale Limestone. Fossils in the Grange Mudstone indicate correlation with some part of the Maitland Group, more especially the Branxton Sub-group, of New South Wales and the Cattle Creek and/or Ingelara Stages of Queensland (Banks, 1957, for fuller discussion).

The " Woodbridge Glacial Formation " and Its Correlates.

Although the limestones of the " Woodbridge Glacial Formation " are not economically important, they are mentioned here for the sake of completeness.

In the Mount Nassau section lenses of olive-grey, foetid, fossiliferous limestone up to 18 inches thick occur about 13 feet below the top of the formation. Many years ago Johnston (1888) recorded limestones composed dominantly of *Stenopora crinita* in this formation at One Tree Point, on Bruny Island.

A bed of limestone about six feet thick occurs on Silver Hill, near Glaziers Bay, on the Cygnet Peninsula. It is a medium-grey, foetid, fossiliferous limestone with erratics up to six inches in length of quartzites, slate, hornfels, and grains of quartz and feldspar visible. Fossils include *Stenopora* prob. *crinita*, *Protoretepora*, *Fenestella*, *Polypora*, *Neospirifer*, dielasmids, *Strophalosia*, *Schuchertella*, aviculopectinids, *Mourlonia*, *Platyschisma* and ostracodes, *Martiniopsis* and *Eurydesma cordatum*. The stratigraphic position of this limestone is not yet clear. It is underlain by a considerable thickness of sandstone and siltstone with a fauna including very alate spiriferids which in Tasmania occur mainly in the Berriedale Limestone and the " Woodbridge Glacial Formation ". Above the limestone is a siltstone with a few erratics and common fossils, including *Strophalosia*, *Fenestella*, alate spiriferids, and a few *Eurydesma cordatum* var. *sacculum*. Its thickness suggests either the Darlington Limestone or a limestone in the " Woodbridge Glacial Formation." This criterion does not, however, exclude the possibility that it is the Berriedale Limestone, as evidence from other areas suggests that the Berriedale Limestone is thinning to the south-east (Brill, 1956). The associated rocks allow no sound correlation to be made. The fossils in it and the associated sediments suggest that it is not the Darlington Limestone and make correlation with the Berriedale Limestone, or more especially, with part of the "Woodbridge Glacial Formation" seems more likely.

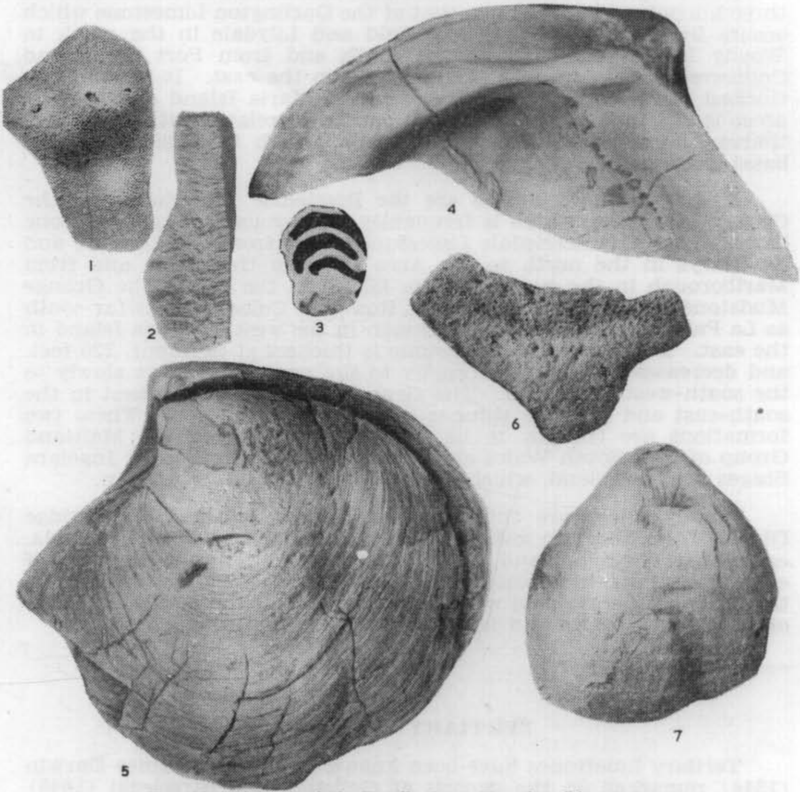


FIG. 10.—Characteristic Fossils from Permian Limestones.

FIGS. 1, 2.—*Stenopora johnstoni* Etheridge, Darlington Limestone, Darlington, Maria Island: (1) surface view showing monticules; (2) side view showing colaminar form. Both. $\times 1$.

FIG. 3.—*Calcitornella stephensi* (Howchin), Darlington Limestone, Beaconsfield; section near base. $\times 15$.

FIGS. 4, 5.—*Eurydesma cordatum* Morris, Darlington Limestone, Darlington, Maria Island; (4) internal view of left valve $\times \frac{1}{2}$; (5) external view of left valve. $\times \frac{1}{2}$.

FIG. 6.—*Lyroporella*, Berriedale Limestone, Darlington, Maria Island, showing calcareous support and part of frond. $\times \frac{2}{3}$.

FIG. 7.—*Taeniothaerus subquadratus* (Morris), Berriedale Limestone, Rathbones Quarry, Mt. Nassau; pedicle valve showing sulcus and position of muscle scar. $\times \frac{1}{2}$.

(Photographs by T. S. McMahon, University of Tasmania.)

5 cm

On Maria Island the " Woodbridge Glacial Formation " contains thin limestone beds on two horizons. A bed two feet thick occurs 68 feet above the base and another, also about two feet thick, 95 feet above the base.

Summary.

The Permian System contains limestone and calcareous beds on three horizons. The lowest is that of the Darlington Limestone which occurs from Port Sorell, Beaconsfield and Lilydale in the north to Woody Island and Snug in the south and from Port Sorell and Collinsvale in the west to Maria Island in the east. It seems to be thickest (50 feet) on the northern end of Maria Island and in most areas is less than 10 feet thick. It can be correlated with the Callytharra Limestone in Western Australia, which is considered to be basal Artinskian.

Higher in the sequence are the Berriedale Limestone and the Grange Mudstone, which is frequently calcareous and has limestone bands in it. The Berriedale Limestone occurs from Ben Lomond and St. Marys in the north to the Arve River in the south, and from Marlborough in the west to Maria Island in the east. The Grange Mudstone is found as far north as Ross and Coles Bay; as far south as La Perouse; and from Marlborough in the west to Maria Island in the east. The Berriedale Limestone is thickest at Seymour, 220 feet, and decreases in thickness rapidly to the north and more slowly to the south-west and south. The Grange Mudstone is thickest in the south-east and becomes thinner to the north and west. These two formations are thought to be equivalent to part of the Maitland Group of New South Wales and to the Cattle Creek and/or Ingelara Stages of Queensland, which are considered to be Artinskian.

Finally, there are thin limestone lenses in the " Woodbridge Glacial Formation " in several places in the eastern half of Tasmania, eg., Hobart, Maria Island, and Bruny Island. They are seldom, if ever, more than three feet thick. The " Woodbridge Glacial Formation" has been correlated with the upper part of the Maitland Group of New South Wales and is probably Upper Artinskian.

TERTIARY SYSTEM.

Tertiary limestones have been known in Tasmania since Darwin (1844) remarked on the deposit at Geilston, and Strzelecki (1845) described limestones from Wynyard and Cape Grim. These limestones are friable rocks at most places and are composed of fragments of shell material or of small fossils and most of them are calcarenites. Marine limestones occupy a fringe around the North-West Coast from Temma to Irishtown, cover much of King Island, occur in the Wynyard district and outcrop over much of Flinders Island. In the north-western part of the State they are apparently nowhere thicker than 100 feet, although they reach heights of 250 feet above sea-level. On Flinders Island the limestones are apparently thicker and occur up to 600 feet above sea-level (see later chapter). The distribution is shown in text-figure 11.

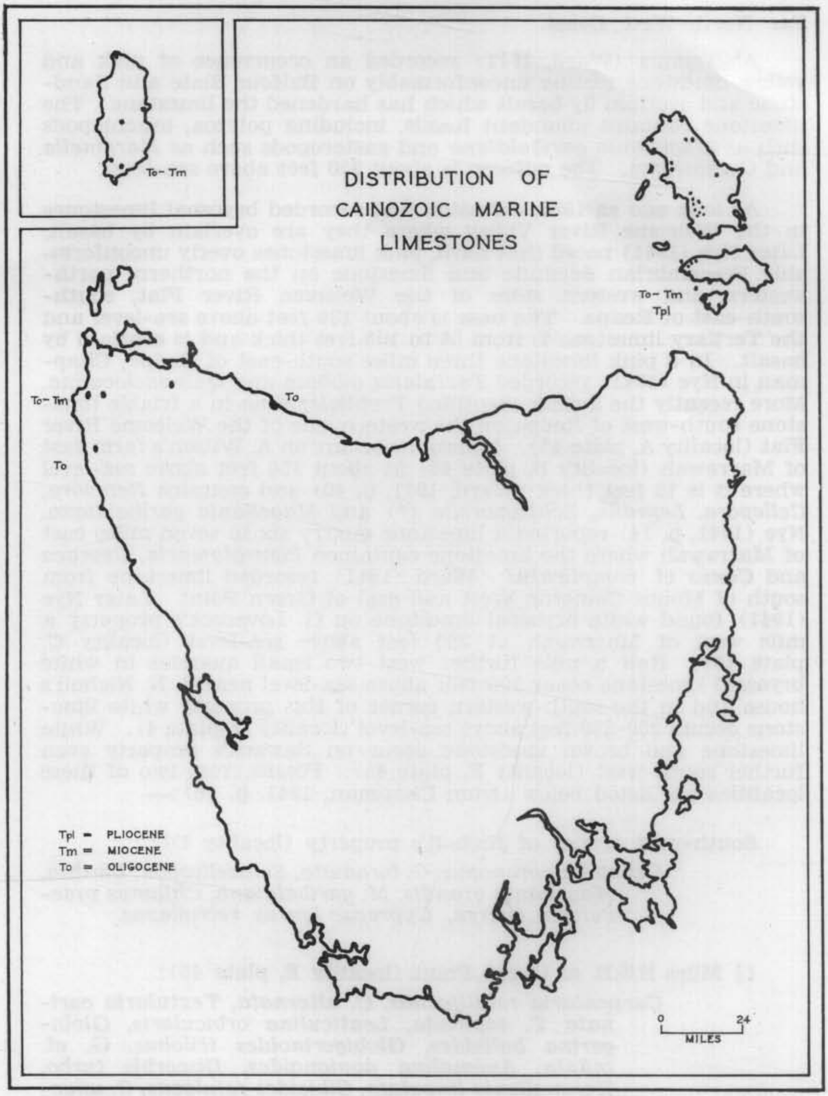


FIG. 11.—Cainozoic Limestone.

Far North-West Coast.

At Temma (Ward, 1911) recorded an occurrence of pink and yellow limestone resting unconformably on Balfour Slate and Sandstone and overlain by basalt which has hardened the limestone. The limestone contains abundant fossils, including polyzoa, brachiopods such as *Magellania garibaldiana* and gasteropods such as *Marginella* and *Calliostoma*. The outcrop is about 250 feet above sea-level.

As long ago as 1888, Johnston had recorded bryozoal limestones in the Welcome River Valley where they are overlain by basalt. Later Nye (1941) noted that hard, pink limestones overly unconformably Precambrian dolomite and limestone on the northern, north-western and western sides of the Welcome River Flat, south-south-east of Redpa. The base is about 135 feet above sea-level and the Tertiary limestone is from 50 to 100 feet thick and is overlain by basalt. In a pink limestone three miles south-east of Redpa, Chapman in Nye (1941) recorded *Textularia gibbosa* and *Quinqueloculina*. More recently the author identified *Trybliolepidina* in a friable limestone south-west of Redpa on the western side of the Welcome River Flat (locality A, plate 45). Limestone occurs on A. Wilson's farm east of Marrawah (locality B, plate 45) at about 150 feet above sea-level where it is 12 feet thick (Ward, 1911, p. 40) and contains *Retepora, Cellepora, Lepralia, Schizoporella* (?) and *Magellania garibaldiana*. Nye (1941, p. 14) reported a limestone quarry six to seven miles east of Marrawah where the limestone contained *Pleurotomaria, Cypraea* and *Conus* cf. *complicatus*. Ward (1911) recorded limestone from south of Mount Cameron West and east of Green Point. Later Nye (1941) found white bryozoal limestone on G. Loverock's property a mile west of Marrawah at 250 feet above sea-level (locality C, plate 45). Half a mile further west two small quarries in white bryozoal limestone occur 190 feet above sea-level near J. N. Nicholl's house and in the south-western corner of this property white limestone occurs 200-250 feet above sea-level (locality D, plate 4). White limestone and brown mudstone occur on Saward's property even further south-west (locality E, plate 45). Fossils from two of these localities are listed below (from Chapman, 1941, p. 16):—

South-west corner of Nicholl's property (locality D):

Cellepora coronopus, C. biradiata, Schizellozoon, Linthia, Magellania grandis, M. garibaldiana, Chlamys praecursor, Ostrea, Cypraea, Isurus retroflexus.

1½ Miles S.S.E. of Green Point (locality E, plate 45):

Carpentaria rotaliformis, C. alternata, Textularia carinata T. sagittula, Lenticulina orbicularis, Globigerina bulloides, Globigerinoides trilobus, G. cf. *inflata, Anomalina nonionoides, Discorbis turbo, Heronallenia lingulata, Cibicides refulgens, C. ungerianus, C. culter, Siphonina australis, ? Spirillina decorata, Eponides scabiculus, E. karsteni, Elphidium antonina, Planorbulinella larvata* var. *plana, Mopsea, tenisoni, Cellaria australis, Schizolavella phymatophora, Acropora gracilis, Hornera striata, Idmonea trigona, I. incurva, Lichenopora, Murravia triangularis.*

Immediately below the basalt at Mount Cameron West, a yellow, white and red, friable calcarenite occurs (Gill and Banks, 1956, p. 4) which contains *Carpentaria rotaliformis, Cassidulina subglobosa, Cibicides, Notorotalia, Spondylus, Pecten* and *Magellania*.

Strzelecki (1845) was the first person to record the presence of bryozoal limestone at Cape Grim, but regarded it as an emerged shell-bed. Johnston (1888), pp. 244, 268) recorded bryozoal limestone capped with basalt in the cliffs south of Cape Grim and reported the following fossils from Cape Grim and the Welcome River flats:—

> *Cellepora gambierense, C. spongiosa, C. nummularia, C. hemisphaerica, Lepralia, Eschara, Placotrochus deltoideus, Lovenia forbesi* and *Magellania grandis*.

At the mouth of the Harcus River and on the Montagu River, limestones are recorded close to sea-level. At the northern end of Britton's Swamp, basalt contains fragments of baked limestone with *Carpentaria, Triloculina, Sigmoilina* and *Pecten* cf. *antiaustralis* (Gill and Banks, 1956, p. 6), indicating a Tertiary limestone somewhere in the vicinity. Similarly, a limestone boulder in basalt at Irishtown (see later chapter) indicates the presence of limestone nearby.

King Island.

Tertiary limestones are widespread on King Island and have been reported from Cape Wickham, half-way from Wickham to Yellow rock, a little south of Lavinia Point, at Blow-hole Creek (about four miles north of Naracoopa), along the Seal River, between the Pass and Ettrick Rivers, near Porky Lagoon and inland from Fitzmaurice Bay and at "Avondale" in the centre of the island (Baldwin Spencer, 1888; *et al.*).

At Cape Wickham the limestone apparently rests on granite (Chapman, 1912, p. 39). A bryozoal limestone occurs at Blow-hole Creek, and for three-quarters of a mile to the north below high-water mark and just south of the creek above high-water mark (see later chapter). This is possibly that referred to by Waterhouse (1916, p. 90) as near the northern end of Sea Elephant Bay which is composed of marine shells and shell fragments.

At Seal River, Debenham (1910, p. 567) noted the presence of 20 feet of limestone dipping slightly west. At the base is coarse fragmental material with complete shells and pebbles of schist and quartzite, and this is followed by a very hard, firmly cemented, fine-grained calcarenite containing *Pecten* cf. *antiaustralis, Lima* cf. *bassi, Hipponyx* cf. *australis, Turritella, Hemithyris* and *Retepora*. Later Chapman (1912, p. 40) described two types of limestone from this area. One of these is a pale ochre colour, fragmental, friable and is apparently a polyzoal calcarenite with some larger fossils. The other is a harder yellow to pink limestone, close-textured and containing polyzoa and echinoid spines. It is apparently cemented by calcareous mud. Fossils are numerous in both types and are listed hereunder:

Hard Pink Limestone:—

> *Palaeachlya tuberosa, Lithothamnium, Globigerina* cf. *bulloides, Cibicidella variabilis, Selenaria marginata, S. concinna, Magellania* cf. *divaricata, Lima bassi.*

Polyzoal Calcarenite:—

> *Lithothamnium, Cibicides lobatulus, C. ungerianus, Mopsea hamiltoni, Leiocidaris* cf. *australiae, Spirorbis, Heteropora pisiformis, Amphiblestrum ? bursarium, ? Lepralia* cf. *crassatina, Adeona, Pinna reticosa, Vulsella laevigata, Pecten aldingensis, Chlamys praecursor* and *Placunanomia sella.*

At "Avondale," in the centre of the island, a cream-coloured bryozoal, shelly, marly limestone overlies a blue-grey, partly recrystallised limestone (Crespin, 1945*a*). The fauna includes *Gaudyrina crespinae, Frondicularia lorifera, Elphidium parri, Fibularia gregata, Aspidostoma airensis, Chlamys praecursor,* and club-shaped cidaroid spines.

Wynyard Area.

Tertiary beds were first noted in this area by Strzelecki (1845) who referred to them as raised shell-beds. These beds have since received much attention by Australian geologists because of their richly fossiliferous nature, accessibility and striking-looking outcrop. Most of the work on them was done in the last half of the last century and the early years of this one, but there have been isolated papers on them during the last 40 years. The beds have been referred to in many formal and informal ways and in order to clarify the nomenclature the units are here formally defined in accordance with the Australian Code of Stratigraphic Nomenclature (Raggatt *et al.*, 1952).

TABLE CAPE GROUP.

The Table Cape Group is here defined as consisting of the Freestone Cove Sandstone below and the Fossil Bluff Calcareous Sandstone above as exposed at Fossil Bluff, near Wynyard. The name is derived from a prominent coastal feature several miles from Fossil Bluff. It is Tertiary in age.

The name was first applied to this unit by Stephens (1870, p. 20), who called it the "Table Cape Beds." The history of the nomencl-ture is summarised below:—

> Table Cape Beds: Stephens, 1870; Johnston, 1875; Woods, 1875; Johnston, 1880*a*, 1880*b*; Johnston, 1885*a*, 1885*b*; Johnston, 1888; Montgomery, 1896; Singleton, 1941; David, 1950; and others.
>
> Wynyard Stage: Nye and Lewis, 1928, p. 31, not applicable, due to use by Montgomery, 1896 of the name Wynyard formation for the Permian tillite underlying these beds.
>
> *non*-Table Cape Conglomerate of Etheridge, 1883, pp. 158-159, 161; Johnston, 1888, pp. 66, 263-4; used for the Permian Wynyard Tillite of Montgomery, 1896.

Stephens (1870) pointed out that this group occurs within a radius of five or six miles from the mouth of the Inglis River and later work by Loftus Hills (1913) showed that it extends well up the Inglis River. It extends as far as the south side of Table Cape where it is hidden by talus. Lately J. Loveday, C.S.I.R.O. Soils Division, has found the Fossil Bluff Sandstone about one mile east of Doctors Rocks. It overlies the basal Permian formation, the Wynyard Tillite, at Fossil Bluff with some unconformity and is overlain at Fossil Bluff and on the hills to the north by basalt. The character of this contact is not known.

South of Doctors Rocks the lower formation of the group is missing and the Fossil Bluff Sandstone rests on basalt. The group is of the order of 80 feet thick at Fossil Bluff. The most probable age limits are Upper Oligocene to Lower Miocene, as will be shown later.

FREESTONE COVE SANDSTONE.

The Freestone Cove Sandstone is that formation of sandstone up to four feet thick, overlying unconformably the Permian Wynyard Tillite and overlain by the Fossil Bluff Sandstone at Fossil Bluff, near Wynyard. It contains *Sherbornina atkinsoni*, *Planorbulinella*, *Crassatellites oblonga* and many other fossils.

The age is probably Upper Oligocene to Lower Miocene. The name is derived from Freestone Cove, near Wynyard.

This sandstone has in the past been referred to as the "*Crassatella* Bed," a name applied to it first by Johnston (1877, pp. 84-86) and later by numerous other authors such as Noetling (1910) and David (1950). It seems that it has not been referred to by any other name. Stephens (1870, p. 19) described it as a breccia of coarse sand and broken shells, while Johnston described it as consisting of shells in a matrix composed of ferruginous mud containing rounded pebbles of yellowish quartz and many foraminifera. The presence of the yellowish quartz pebbles is characteristic. Johnston described it as from three to four inches thick to three to four feet thick at Fossil Bluff and it is shown as such on the figure, although in the text describing the figure he gives the thickness as 80 feet. His figure of four feet is the correct one. Noetling (1910, p. 162, and pl. XII.) described the contact of the Freestone Cove Sandstone with the Wynyard Tillite in some detail and showed how the sandstone occurs under ledges of the tillite. He pointed out that some of the fossils in the sandstone are broken and rolled.

Fossils are very abundant in the Freestone Cove Sandstone and over 300 species have been identified. Foraminifera are common and include *Sherbornina atkinsoni*, *Planorbulinella* and numerous miliolids. Both solitary and colonial corals occur and include *Placotrochus deltoideus*, *P. elongatus* and *Thamnastraea sera*. Polyzoa are represented by *Cellepora gambierense*, *C. nummulina*, *C. hemisphaerica*, *C. spongiosa* and *Salicornaria sinuosa*. Brachiopods occur but are uncommon. There are numerous pelecypods but the commonest forms are *Crassatellites oblonga*, *Cucullaea corioensis*, *Eotrigonia semiundulata*, *Glycimeris maccoyi* and *Cucullaea cainozoicus*. Gasteropods are also very numerous and include *Voluta anticingulata* and *V. weldi*, *Cypraea platypyga*, *C. platyrhyncha*, *Typhis maccoyi* and *Murex eyrei*. Barnacles occur but are rare. Echinoids are rare but *Arachnoides australis* does occur. Sharks teeth such as *Lamna elegans*, *Oxyrhina trigonodon* and *Carcharodon augustidens* have been reported from this formation and there is also some decomposed wood.

The lithology and fossils both indicate very shallow water as suggested by Tate and Dennant (1896). The presence of *Sherbornina atkinsoni*, *Planorbulinella*, many of the pelecypods and gasteropods and *Arachnoides australis* indicates correlation with the Torquay Group (Raggat and Crespin, 1955), more especially with the Jan Juc Formation, and with the Longfordian.

FOSSIL BLUFF SANDSTONE.

The Fossil Bluff Sandstone is that formation about 80 feet thick composed of calcareous sandstone and limestone exposed in the cliffs at Fossil Bluff where it overlies the Freestone Cove Sandstone and underlies a basalt. It is named after Fossil Bluff, the headland immediately north of Wynyard and south of Freestone Cove.

The formation contains *Aturia australis, Prosqualodon davidi* and *Wynyardia bassiana* and its age is probably Upper Oligocene or Lower Miocene.

Stephens (1870, p. 19) described this formation as composed of fine-grained whitish sandstone but gave it no name. In 1877 Johnston called this formation the "*Turritella* Group" and described it as 80 feet thick and showed its relationship to the underlying "*Crassatella* Bed" and the overlying basalt in plate XII. The contact between the Freestone Cove Sandstone below and the Fossil Bluff Sandstone is gradational. The Fossil Bluff Sandstone consists of white or grey calcareous sandstone with some hard bands which are really impure limestones. Included in the formation are several beds very rich in *Cellepora gambierense*. This formation extends at least as far as the south side of Table Cape to the north and at least one mile beyond Doctors Rocks to the east. Its southward extension is unknown. The history of the nomenclature of this formation is as under:—

Turritella Group: Johnston, 1877, pp. 82-84; Johnston, 1888, pp. 244, 260-1.
Turritella Sandstone: Noetling, 1910.
Turritella Beds: David, 1950, p. 537.
Turritella Limestone: Gill and Banks, 1956, p. 11.

It does not seem to have been given any other names.

At Fossil Bluff the Fossil Bluff Sandstone overlies the Freestone Cove Sandstone and is overlain by basalt. However, just south of Doctors Rocks it overlies basalt and is overlain by basalt.

Tate and Dennant (1896) remarked on the poverty of species in the "*Turritella* Bed" as compared with the "*Crassatella* Bed" and stated that all species in the higher formation also occurred in the lower except the echinoderms. They pointed out that there is a reduction in the number of species upwards through the formation and that close to the top it becomes unfossiliferous. Stephens (1870, p. 21) had noted the occurrence of leaf impressions and fragments of lignite in the sandstone some years before Johnston (1888, p. 251) reported the occurrence therein of *Sapotacites oligoneuris* and *Pteris belli*. The formation has been characterised by the abundance of *Turritella warburtoni* and other species of *Turritella*. Corals are common in some bands especially with *Cellepora gambierense* and other species of *Cellopora;* brachiopods occur but are rare. Both gasteropods and pelecypods are abundant but cephalopods are rare. *Aturia australis* has been recorded from this formation by Glaessner (1955). *Lovenia forbesii* var. *woodsi* occurs, especially in the *Cellepora*-rich bands, and several other echinoids have been reported. The mammals are represented by *Prosqualodon davidi* and *Wynyardia bassiana*. Glaessner (1955, p. 359) considered the formation to be at least partly Upper Oligocene on the evidence of *Aturia* and *Prosqualodon*.

Flinders Island.

Tertiary limestones are widespread on Flinders Island and some other islands of the Furneaux Group on the lower parts of the islands.

Strzelecki (1854) apparently collected fossils from the group as *Cypraea eximia* is recorded by him from a well at Franklin Village, now called The Corners, or Cape Barren Island, at the north-west end of Cape Barren Island. Later Johnston (1879) recorded a shelly limestone which he called the "*Turritella* Limestone" from Heathy Valley, near the Three Patriachs on Flinders Island and noted the presence of *Glycimeris cainozoicus* and *Nucula tenisoni.* This limestone rests on slates and granite.

At Franklin Village, Sandford Bay, on Cape Barren Island, hard and friable, cream-coloured bryozoal limestones occur with a rich fauna (Crespin, 1945, p. 13). The fauna includes the foraminifera *Calcarina verriculata, Planorbulinella plana, Operculina victoriensis, Amphistegina lessonii* and *Gypsina globulus,* corals such as *Mopsea tenisoni,* the bryozoa *Cellaria contigua* and *C. depressa* and the ostracode *Bythocypris tumefacta.*

At Wingaroo a bore passed through limestone from which Singleton and Woods (1934) reported *Milthia (Milthoidea) grandis flindersiana* between 55 and 80 feet.

In a later chapter the distribution of limestone on Flinders Island is detailed. In many places on the west coast the limestone rests directly on granite as at Trousers Point and Emita, but at others rests on sand. The limestones apparently rise to 600 feet above sea-level at Emita, to 400 feet on the Pratts River and up to 340 feet at Ranga. On the east side of the island the limestone overlies beds of sand, gravel and clay with one or more beds of dense tough limestone which pass laterally into clays with calcareous nodules. Foraminifera from these limestones indicate, according to Crespin, an Upper Pliocene to Pleistocene age.

Geilston.

The presence of travertine at the head of Geilston Bay became known soon after colonisation of the State and this deposit was used as a source of lime in the young colony for many years. The earliest scientific record of it appears to be that by Darwin (1844).

It was described in some detail by Johnston (1888). At the base is a stiff brown clay with plant fossils. This is followed by 10 to 12 feet of travertine with numerous plant fossils, leaves, stems and fruit and then there is six to eight feet of yellow to brown calcareous clay with ferruginous bands and veins and stringers of limestone containing bones and teeth of *Hysiprimnus.* There are then four feet of cherty rock with numerous *Cypris alburyana.* This is overlain by five feet of basalt and then a soil cover. Johnston (1888, p. 285) recorded several species of *Helix,* a *Vitrina* and *Bulimus gunii* from this deposit.

Johnston (1888) remarked on similar travertine deposits at the top of Burnett Street, Hobart, Risdon Railway Station and in the vicinity of Trinity Hill, but gave no details of these occurrences. Milligan (1847) noted calcareous beds with fossil plants between Elizabeth Street and Knocklofty.

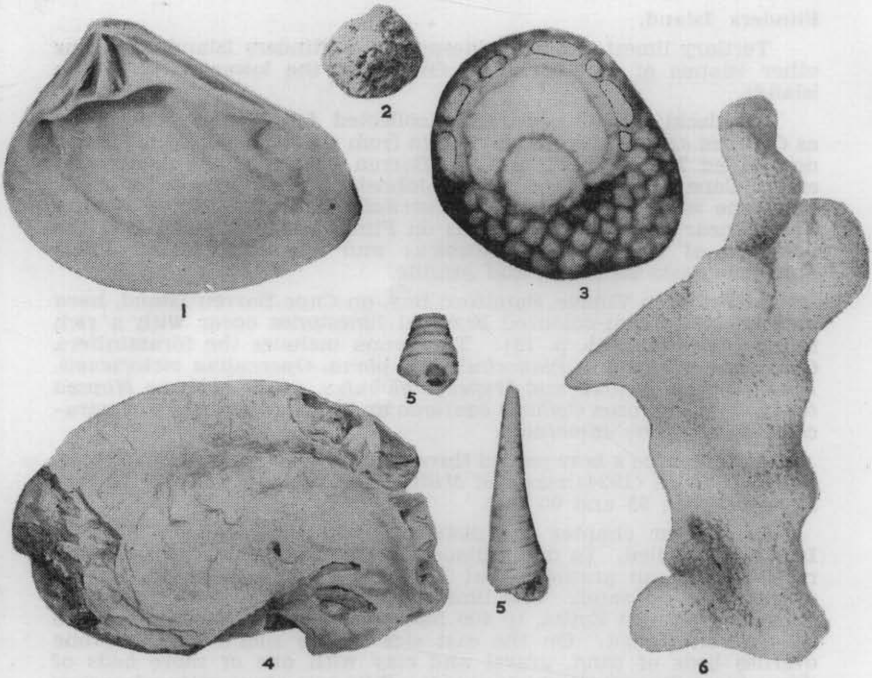


FIG. 12.—Characteristic Fossils from Tertiary Limestones.

FIG. 1.—*Crassatellites oblonga* (Ten.-Woods), Freestone Cove Sandstone, Fossil Bluff, Wynyard; internal view, right valve. $\times \frac{1}{2}$.
FIGS. 2, 3.—*Trybliolepidina*, Redpa; (2) external view. $\times 4$; (3) section of juvenarium, $\times 8$.
FIG. 4.—*Aturia australis* (McCoy), Fossil Bluff Sandstone, Fossil Bluff, Wynyard; partly decorticated specimen. $\times \frac{1}{3}$.
FIG. 5.—*Turritella warburtonii* Ten.-Woods, Fossil Bluff Sandstone, Fossil Bluff, Wynyard. $\times 1\frac{1}{2}$.
FIG. 6.—*Cellepora gambierense* Ten.-Woods, Fossil Bluff Sandstone, Fossil Bluff, Wynyard. $\times 2$.

(*Photographs by T. S. McMahon, University of Tasmania.*

Summary.

In view of the present discussion on the age of the Victorian Tertiary formations it is difficult to arrive at accurate dates for the Tasmanian Tertiary sequences.

The presence of *Magellania garibaldiana* at Temma seems to indicate a Balcombian (in the sense of Crespin, 1943) age for that limestone. The oldest beds at Marrawah are those at Mount Cameron West which are regarded by Glaessner as most probably Upper Oligocene or Longfordian (Gill and Banks, 1956). The fauna from A. Wilson's property also contains *M. garibaldiana* and is presumably Balcombian. Chapman (in Nye, 1941) regarded the faunas on Nicholl's property and $1\frac{1}{2}$ miles south-south-east of Green Point as

5 cm

Lower Miocene. The fauna at the latter locality shows relationships to that of the Jan Juc Formation and the Balcombian of Gippsland. That from Nicholl's property shows a relationship to the Balcombian and may extend upwards to the Mitchellian as indicated by *Isurus retroflexus*. The *Lepidocyclina* limestone south of Redpa can be correlated with the Batesfordian and the presence of a Batesfordian fauna at Franklin Village on Cape Barren Island (Crespin, 1945) indicates approximate correlation with the Redpa occurrence. The *Lepidocyclina* limestone is probably lower in the sequence than that at Nicholl's property on faunal and topographic grounds but its relationship to the locality 1½ miles from Green Point is uncertain. The limestones from Cape Grim with *Magellania grandis* and *Lovenia forbesi* appear to be Balcombian. Chapman (1912) regarded the limestones at Seal River on King Island as Janjukian and their fauna shows relationship also to the Balcombian of Gippsland with forms such as *Lima bassi* indicating an age as young as Mitchellian. The fauna from "Avondale" was regarded by Crespin (1945*a*) as Longfordian. The fauna of the Freestone Cove Sandstone ("*Crassatella* Bed") at Table Cape has long been regarded as similar to that of the Jan Juc Formation, while the presence of *Sherbornina atkinsoni*, *Eotrigonia semiundulata* and *Arachnoides australis* indicates relationship to the Longfordian of Gippsland (Crespin, 1943). Glaessner (1955) regarded the Fossil Bluff Sandstone ("*Turritella* Bed") as Upper Oligocene on the evidence of *Prosqualodon davidi* and *Aturia australis*. At Franklin Village, on Cape Barren Island, Crespin (1945) reported a Batesfordian fauna with *Calcarina verriculata* and *Planorbulinella plana* while *Milthia (Milthoidea) grandis flindersiana* from the Wingaroo No. 1 bore indicates a Pliocene-Pleistocene age (Singleton and Woods, 1934).

Marine transgression began at Table Cape and Marrawah and probably at other points along the North-West Coast in Upper Oligocene time (this assumes an Upper Oligocene age for the Jan Juc Formation and the Longfordian, assumptions now under discussion by several groups of workers: Raggat and Crespin (1955) regarded the Jan Juc Formation as Upper Eocene). The transgression reached heights of about 250 feet above present sea-level on the North-West Coast and perhaps up to 600 feet on Flinders Island. The sea withdrew after the Lower Miocene, perhaps as late as the Mitchellian at Marrawah and King Island, and no further marine sediments are known before those deposited at Wingaroo during the Upper Pliocene or Pleistocene. This sequence of events, uncertain as the actual dates may be, agrees with that proposed by Glaessner (1953) of Upper Oligocene and Lower Miocene transgression followed by Upper Miocene regression and then a re-advance of the sea in the Pliocene Epoch, the Pliocene transgression affecting only the Furneaux Group of islands. The presence of Plio-Pleistocene marine beds at considerable heights above sea-level on Flinders Island may indicate late Cainozoic tectonic activity, an activity also suggested by earth tremors with epicentres in the eastern part of Bass Strait and the north-eastern part of Tasmania (Burke-Gaffney, 1952).

The Table Cape Group represents only the initial transgression and seems to merge upwards into a lacustrine deposit (Tate and Dennant, 1896) or at least estuarine deposits representing the infilling of the original bay by sediments brought down by the ancestral Inglis River. The stratigraphic conclusions are summarised in the form of a correlation table (Table 1).

TABLE 1
CORRELATION OF CAINOZOIC STRATA

System	Series	Marrawah	King Island	Wynyard	Launceston	Furneaux Group
QUATERNARY	Holocene	Middens Aeolianite				Helicidae Sandstone Raised Oyster Beds
	Pleistocene					Faulting ?
	Pliocene	Basalt Erosion		Basalt		Limestone at Wingaroo with *Milthia grandis*
	Miocene	Limestone with *Chlamys praecursor*, *Isurus retroflexus* Limestone with *Trybliolepidina*	Limestone with *Chlamys praecursor*, *Lima bassi* Limestone with *Chlamys praecursor*, *Fibularia gregata*, &c.			Limestone with *Calcarina verriculata*, *Amphistegina lessonii*, &c. at Franklin Village
TERTIARY	Oligocene	Limestone with *Carpentaria rotaliformis*, *Cassidulina subglobsa*		Fossil Bluff Sandstone with *Aturia australis Prosqualodon davidi*, *Wynyardia bassiana* Freestone Cove Sandstone with *Sherbornina atkinsoni*, *Arachnoides australis* Erosion. Basalt	Basalt Erosion	
	Eocene				Launceston (Tertiary) Beds with *Trisacciles micropterus* Faulting	
	Palaeocene					

QUATERNARY SYSTEM.

West and North-West Coast.

Calcareous sand dunes and emerged shell-beds have been recorded just north of Macquarie Harbour (Stephens, 1941), just south of Mount Cameron West (Edwards, 1941), just north of Mount Cameron West (Gill and Banks, 1956), on King Island (Debenham, 1910; Chapman, 1912; Waterhouse, 1916; Stephens and Hosking, 1932). Pleistocene and recent fossils have been recorded from an emerged shell-bed recorded by Edwards from south of Mount Cameron West, from the aeolianite just north of Mount Cameron West, and from a dune sand at Surprise Bay, King Island (Chapman, 1912, p. 51).

Pleistocene limestones have been known from the Smithton area for many years but the latest work is that of Gill and Banks (1956) which lists earlier references. Patches of marl occur inter-bedded with peat in the Mowbray Swamp Peat and are only a couple of feet thick. They contain fresh-water gasteropods and have been dated by the radiocarbon method as older than 37,600 years. The spring mounds of Mowbray Swamp contain alternations of peat and marl, the latter containing fresh-water snails, calcareous algae and marsupial remains. Radiocarbon analysis shows these to be Upper Pleistocene. At Fentons Quarry, Pulbeena, there are alternations of peat and marl containing gasteropods, algae and ostracodes. The highest peat is 13,520 $\pm$ 40 years and a marl lower in the sequence is 28,190 $\pm$ 1,520 years old. The radiocarbon dates indicate an Upper Pleistocene (early Cary) age.

Similar deposits occur in the northern part of King Island (Stephens and Hosking, 1932).

North-East Coast and Furneaux Group.

Calcareous dune-sands and emerged shell-beds occur on the North-East Coast from Low Head to Eddystone Point (Stephens, 1941; Hosking and Hueber, 1954; and later chapter).

On Flinders Island Johnston (1879) noted elevated shell-beds composed largely of oyster shells at a height of about 30 feet above high-water mark about two miles above the mouth of the Arthur River. He showed this and other shell-beds covered by a rock he called the "Helicidae Sandstone" which is 60 to 70 feet thick and occurs up to 100 feet above sea-level. It varies from a coarse gritty sandstone (calcarenite) to a cherty or arenaceous limestone and occurs on Cape Barren, Badger, Chappell, Green and Kangaroo Islands and in the Kent Group. He considered it to be of dune origin, In addition to fragmental marine shells it contains fresh-water snails.

South, East and South-East Coastal Areas.

Spring deposits occur at Richmond (Hosking and Heuber, 1954; Gould, 1869) and emerged shell-beds are found at the Little Swanport River, Pipeclay Lagoon and Ralphs Bay (Lewis, 1946; Hosking and Hueber, 1954).

SUMMARY.

Several minor occurrences of limestone and dolomite at Point Hibbs and at the south end of the Sticht Range possibly belong to the Middle and Upper Cambrian Dundas Group. The most extensive and valuable limestone deposits belong to the Gordon Limestone which reaches a thickness of at least 5,000 feet in places and in many areas has a purity greater than 90 per cent. This formation covers a time range from the upper part of the Lower Ordovician to the Upper Ordovician and perhaps even into the Lower Silurian. Limestones of Silurian and Devonian age occur in the Eldon Group at Queenstown and Point Hibbs on several horizons but are apparently not extensive. The Darlington Limestone of Lower Permian age occurs in the eastern and north-eastern part of the State but except on Maria Island where it is 50 feet thick it not thick enough to work. Higher in the Permian a formation of limestone up to 300 feet thick, the Berriedale Limestone and its equivalents, has been worked in a number of places in eastern Tasmania, but is not as pure as the Gordon Limestone. Thin limestone beds are present in the "Woodbridge Glacial Formation" higher in the Permian but are not of economic significance. Probably late in the Oligocene Epoch a marine transgression commences in north-western Tasmania and at its maximum extended from Temma to Irishtown, covered King Island and much of Flinders Island. In this sea limestones were deposited of Upper Oligocene to Lower (or perhaps Middle) Miocene age. A later transgression in the Upper Pliocene covered part of Flinders Island and limestone was again deposited. Quaternary limestones are mainly aeolianites but swamp deposits, spring deposits and emerged shell-beds also occur.

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CHAPTER 4—THE ORDOVICIAN LIMESTONES

BEACONSFIELD AND FLOWERY GULLY

FLOWERY GULLY.

Although these deposits are classified under the joint heading and the Beaconsfield limestone has been worked to a small degree, it is the Flowery Gully beds that are the more important and that are being utilised at the present time.

Introduction.

The first comprehensive report on these deposits is in Mineral Resources No. 2 "Cement Materials at Flowery Gully" by W. H. Twelvetrees, in 1917. Already the stone had been quarried for lime-burning, a kiln had operated, and by this time had been abandoned. Prior to this the limestone had also been used as a flux in connection with iron smelting. By 1924 consideration was again being given to the utilisation of limestone in the cement industry but again nothing came of it. The establishment of the Aluminium Industry at Bell Bay and the increasing need for agricultural lime led to further investigation of the deposits in 1950. At that time three operators were working various limestone beds to supply crushed and burnt lime. Finally, in 1954, the Bureau of Mineral Resources sent a team of geologists to examine and report on the Flowery Gully Deposits for utilisation by the Aluminium Commission. The beds were closely mapped and sampled and a comprehensive report by Noakes, Burton and Randal was prepared and issued as Bureau of Mineral Resources, Geology and Geophysics Records 1954-65. This chapter consists mainly of this report.

Situation and Access.

Beaconsfield is a town near the Central North Coast of Tasmania and lies on the east side of the Tamar River, near its mouth. It has a population of almost two thousand and is the seat of the local Council. A good motor road connects with Launceston (26 miles), the rail-head, and Beauty Point (3 miles), a good deep-water port. Flowery Gully is situated almost five miles by road south of Beaconsfield and may be reached by branching off the main Launceston-Beaconsfield road either two miles south of Beaconsfield or at Exeter and proceeding via Winkleigh.

Topography.

The limestones in Flowery Gully have been dissected to a maximum depth of 250 feet by the creek which, in most places, follows the meridional strikes of the rocks. In its lower course, the stream channel disappears underground into the Flowery Gully Caves and emerges approximately 1,200 feet to the north below and sometimes into the present Sulzberger's Quarry. Underground drainage is effective along the entire length of the watercourse, which only functions as a surface stream in floods.

Limestone is found in scattered outcrops which total less than half the area underlain by limestone; thin to deep soil cover occupies the remainder. Most of the area underlain by limestone is improved pastoral land but at present none is used for agricultural purposes.

General Geology.

The limestone at Flowery Gully forms part of a broad folded sequence of Lower Palaeozoic rocks which were subsequently covered by sub-horizontal Permian sediments, which blanket the older rocks south and west of Flowery Gully. The folded sequence exposed begins with sandstone, siltstone and shaly beds—all of which are prominently gossanized in the only locality in which outcrops were found. These are overlain by the limestones of Flowery Gully, which are at least 1,700 feet thick, and these in turn are overlain by slate and sandstone to complete the local sequence. These beds have been folded together along a sub-meridional axis and dip fairly uniformly in an easterly direction at about 45° as part of a broad fold. The limestone seems to be structurally conformable with the underlying sandy beds, a few hundred feet west of Quigley's Quarry, but the contact is not exposed. However, there is an erosional unconformity between the limestones and the overlying slate and sandstone. Some of the limestone beds have been truncated in period of erosion which intervened before the deposition of the overlying beds. The folding of the sequence took place later still.

The grade of metamorphism within the sequence is generally low. Shale has been cleaved and converted to slate. Particularly in beds above the limestone. Shearing is prominent in the limestone in places; dolomitic patches have, in most places, suffered recrystallisation although the degree to which the limestone itself has been recrystallised is difficult to establish.

Previous workers (Nye, 1924; Hughes, 1950) noted that the limestone beds are not found north of the stream alluvium which forms the present northern limit of the belt, and an easterly trending transcurrent fault, which could displace the limestone, seemed a possibility. The occurrence of mineralized veins in the beds underlying the limestone, and the pronounced swing of bedding in the limestone toward the north-east at the northern end of the limestone belt, are consonant with the fault hypothesis. On the other hand, the erosional unconformity at the top of the limestone, with the truncation of beds, provides a possible explanation of the absence of limestone north of the alluvium without recourse to faulting.

The folded sequence is Lower Palaeozoic in age. The limestone beds, in which a few fossils have been found, are regarded as part of the Gordon Limestone of Upper Ordovician age so that the sequence to the top of the limestone is probably Ordovician and the overlying slates possibly Silurian in age.

The Lower Palaeozoic rocks are covered west and south of Flowery Gully by unfolded sandstone, siltstone, claystone and conglomerite. These were deposited on an uneven surface of the Lower Palaeozoic rocks; this unevenness explains the low elevation of the cover of conglomerate in the Winkleigh Valley, adjoining the southern end of Flowery Gully, at about the same elevation where limestone would outcrop had the surface of the unconformity beneath the younger sediments been approximately horizontal.

The thickness of these sediments was not measured, but the sequence within a mile west of Flowery Gully probably totals 180 feet. Fossils found in sandstone 400 feet south of Quigley's Quarry indicate a Permian age for these sediments.

The Limestones.

Structure and Lithology.

Most of the limestone exposed conforms closely to an average strike of 150-160°* and an average dip of 45° to the east; but, toward the northern end of the belt the strike swings to 170-180° although the average dip remains unchanged. Some cross-faulting may be involved in this change of strike, but no evidence was found in the outcrops.

The only fault of any consequence noted was a shear in the most westerly of Sulzberger's Quarries. The strike of this is close to that of the bedding and it dips east at 55°, and lineations indicate that the major or last movement plunged gently northward. Some gossanous ironstone occurs in the fault zone.

The evidence for a possible fault with major displacement toward the southern end of the limestone belt is discussed later.

In many places, the limestone shows the effect of shear in thin section and some outcrops show platy, light-coloured partings whose origin is not clear but is probably due to shearing.

The lithology remains remarkably constant throughout the crystalline limestone sequence which is at least 1,600 feet thick. The limestones are fine-grained and show no evidence of clastic origin either in hand specimen or in microslide, Sparse sand grains appear in thin sections but the evidence for chemical deposition appears very strong. As noted above, it is difficult to determine the degree to which recrystallisation has taken place within the limestone. The only clastic sediment found within the limestone sequence was a 15-inch bed of dark shale found in the upper portion of Quigley's Quarry, about 200 feet stratigraphically above the base of the sequence.

In general, the limestone is massive or very coarsely bedded, and, in most places, the dip is readily determined. Bedded limestone, some very finely bedded, is prominent in Quigley's Quarries, toward the base of the sequence, and laminated beds appear at the upstream entrance to the Flowery Gully Caves.

Black chert nodules are found in the limestone in a number of places, but are apparently restricted to the middle portion of the sequence. Commonly they form slightly irregular lenses, 3-10 inches long and up to six inches in thickness, but they also appear as small, irregularly-shaped masses, doubtless formed by slump and roll of the plastic silica gel in deposition. In most occurrences, the cherts are elongated along bedding planes and serve as a guide to bedding.

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* All bearings magnetic.

Veins and lenses of calcite are common throughout the limestone, and range in width from mere stringers to veins and masses up to two feet across. In places, a minute ribbon of quartz occupies the central portion of a calcite vein.

The colour of the limestone, in most places, ranges from black to grey; only the uppermost beds are very light-grey to off-white in colour. This variation in colour has some significance because the lightest-coloured limestone has, invariably, a very low silica content (less than one per cent), and, with one notable exception, dark limestone contains considerably more than one per cent. W. B. Dallwitz, Senior Petrologist, Bureau of Mineral Resources, has confirmed that the dark colour is due to the presence of organic matter. The relationship between organic matter and silica content is discussed in the next section.

The presence of significant quantities of organic matter in the darker-coloured limestone offers a simple explanation of the local lime-burners' preference for the darker stone and of their assertion that calcite from veins is not good material for lime burning. Even small quantities of organic matter help in the calcining of the stone because the ignition of the well-distributed combustible organic matter assists the disintegration of the rock which produces more widespread heating of the limestone. The darker limestone also appears to be easier to mine and to split, again probably because of the organic content. On the other hand limestone which is very light in colour and calcite itself provides little or no dispersed combustible material to assist disintegration during heating and consequently the proportion of partially burned stone remaining in the kiln after firing is noticeably increased.

Chemical Constitution.

The limestones are high-grade, in that the $CaCO_3$ content normally exceeds 94 per cent, and content of iron and other impurities is very low, so that only silica and dolomite content and the possible role of organic matter need special comment.

Silica.

Silica is present throughout the limestone sequence, and ranges in amount from 0.1 to about 10 per cent of the rock. It was important to determine the form of this silica. Early megascopic and microscopic examinations showed that the only obvious sources of silica were sporadic sand grains and rare ribbons of quartz noted in calcite veins, but these sources were totally inadequate to account for the amount of silica in the limestones. Furthermore, the very small clay content of the limestones, as indicated by low R_2O_3 showed that little of the silica present was in a combined form. The cherts are, of course, masses of silica within the limestone, but in most samples, cherts were carefully excluded. However, it was noted early in the investigation that limestone near a chert horizon, but with no trace of macroscopic chert, was invariably relatively high in silica.

Finally, W. B. Dallwitz examined the insoluble residues from a number of specimens and discovered minute elongated rods and lenticules of quartz which appear to be the main source of the silica in the limestone.

The origin of these lenticular or rod-like masses is in doubt. Certainly, there are rare, very elongated rods which must be sponge spicules, and at least some of the shorter ones are probably broken spicules, although no distinctive cross-sections were found to confirm diagnosis.

All this material is now in the form of quartz, and not chalcedony. The presence of less regular, though elongated, particles suggests that some may be minute cherts, rolled and elongated after deposition and later crystallised to quartz.

The silica in the limestone, apart from the visible cherts, is in the form of very finely divided quartz. For the most part, silica was deposited with the limestone (syngenetic), and there is little evidence of silica which has been re-distributed or introduced into the limestone from external sources.

Dolomite.

The mineral dolomite, which consists of 54 per cent calcium carbonate and 46 per cent magnesium carbonate, is found in most limestones, although generally in small amounts. Dolomite may be deposited direct from sea water but magnesium is generally introduced by solutions which replace calcite by dolomite soon after the limestone is deposited. Sea water provides the source of the magnesium. Limestones with a high content of dolomite are termed "dolomitic" or magnesium limestones, and those with 45 per cent magnesium carbonate or more are called "dolomites." However, for reasons of expediency, the term "dolomite" in this report has been broadened to include all rock with a magnesium carbonate content higher than about 10 per cent—rock which must obviously be rejected in mining.

The magnesium carbonate content of the limestones at Flowery Gully ranges from less than one per cent to more than 30 per cent. Magnesium carbonate occurs in minor quantities—up to 10 per cent throughout the limestone, but also occurs in much greater concentrations in restricted masses of dolomite which are found at many places within the limestone belt.

Unfortunately, it is not possible to discern small quantities of dolomite in limestone by megascopic examination or by acid treatment, so that the economic limits of deposits in which the magnesium carbonate content is below 10 per cent can only be established by chemical analysis.

However, with a little experience, most of the high concentrations of "dolomite" can readily be recognised. Most of these masses of "dolomite" which may be 25 feet in width, and are commonly elongated in the direction of bedding, have a distinctive mottled brown appearance in outcrop. On closer inspection, tiny crystals of dolomite can be recognised, standing out in relief, whereas the more calcareous material has been etched by weathering. Dilute hydrochloric acid, applied to a surface cleaned and smoothed with a file, dissolves the limestone and clearly outlines the less soluble grey or white rhombs of dolomite. The "dolomite" is not so easy to recognise on fresh surfaces, such as clean quarry faces, where the distinctive brown mottling is missing, but in many places the fresh "dolomite" has a dull grey colour, distinctive from that of the limestone, and close inspection and acid tests leave no doubt of its identity.

Many of these masses of "dolomite" characteristically include an irregular network of small and large calcite veins and fragments of "dolomite" surrounded by calcite; this commonly simulates a tectonic breccia but is in fact a reef breccia.

However, some "dolomites," notably those in the main portion of Quigley's Quarry, look like fine-grained dark limestones and can only be recognised by their failure to react with acid.

Most of the "dolomites," particularly in the middle and upper beds of the sequence, probably represented algal reefs—stromatoporoid bioherms—which built up from the sea floor. Those noted in the middle beds rarely extend along the strike for more than one to two hundred feet but the occurrence of a "dolomite" bed extending for at least 1,600 feet in the upper beds of the sequence seems to provide convincing proof of the origin of these masses. In this major reef, the bioherms have grown to a fairly uniform height of about 20 feet and now appear as a fairly regular "bed," quite conformable with limestone above and below.

These reefs were originally built of calcium carbonate, but, in early stages of burial, the reefs, because of their high porosity compared to ordinary limestone, became traps for dolomitic solutions, and hence centres of high dolomite concentration.

In the upper beds, magnesium solutions have penetrated the limestone underlying the original reef to raise the average content of $MgCO_3$ to 4-5 per cent, in contrast to an average content of only two per cent in the limestone overlying the reef.

Environment.

The environment of deposition of the limestones can be fairly clearly deduced; it is marine. The occurrence of algal reefs, at least in the middle and upper portions of the sequence, indicates very shallow water, less than 50 fathoms, because algal bioherms need light. Most of the sequence is, therefore, a shallow water deposit, probably laid down on a shelf whose gradual subsidence allowed the accumulation of more than 2000 feet of limestone.

Despite the shallow water, which normally presages that land is not far distant, there are no structures such as cross-bedding to provide evidence of strong currents. The almost complete lack of silt and sand and other clastic material within the sequence indicates that either adjacent land was of such low relief that only chemical weathering was active or that deposition of these limestones took place on a very extensive shelf or platform, portions of which were far removed from the influence of rivers and littoral conditions.

Further study of the environment would require regional data but sufficient is known to indicate that the quiet, shallow-water conditions under which the limestones at Flowery Gully were deposited would provide a fairly consistent environment and an orderly sequence of sediments in which any significant changes should be readily followed along the strike. This is an important point in dealing with the sequence at Flowery Gully.

Sequence.

The only clue to structure in most places is the sequence within the limestone, and as there are no marked lithological changes to act as markers, the sequence may only be established on chemical grounds.

The subdivisions which the writers consider justified, on the work done, are based mainly on silica content, and are termed " silica zones." They are not mappable rock units, although the indefinite boundaries of the zones do appear roughly to follow bedding, and, indeed, the zones themselves are believed to be the reflection of slight changes in environment, and are thus of stratigraphical value.

The complete sequence, toward the northern end of the limestone belt, is divided as follows:—

Lower Silica Zone.—Approximately 900 feet of limestone—well bedded grey to black toward the base, with some shale, and slightly more massive grey limestone toward the top. The central portion of the zone does not crop out. Two to three per cent silica toward base, with beds one to two per cent silica in upper section. Magnesium content high in basal beds.

Chert Zone.—Approximately 500 feet of limestone, mainly dark-grey to black with lenses and patches of chert. Rock ranges from massive to well-bedded. Silica content of limestone variable, but relatively high—normally above two per cent and between five and ten per cent in vicinity of cherts.

Upper Silica Zone.—Approximately 300 feet in most exposures, and consisting of (in ascending stratigraphical order)—

130 feet dark, massive but low silica limestone (less than one per cent, with magnesium carbonate content average about five per cent.

25 feet " dolomite " bed (30 per cent $MgCO_3$).

140 $\pm$ feet very light coloured low silica limestone—mainly massive.

In the thickest section preserved (on the northern side of the cross-fault) an additional 300 feet of light-coloured limestone seems likely, increasing the complete section to almost 600 feet.

However, outcrops are very few in the area immediately north of the fault.

The total observed thickness of the limestone is approximately 1,700 feet, with a probable extension to 2,000 feet.

Faulting.

The interpretation of the sequence at the southern end of the limestone belt has important economic implications which fully justify the attempt to establish sequence and structure,

The sequence of chert zone and upper zone in the central and northern portion of the limestone belt cannot be followed into the outcrops in the southern end of the belt; hence either fault-displacement is involved or chemical changes in the limestone sequence are irregular, random features of no stratigraphical significance. The writers believe that the evidence is strongly in favour of the former alternative, and therefore have delineated the silica zones and the cross-fault which is implied by the offset zones. The fault is concealed by soil cover; it has not been proved in the field, and future workers can weigh the available evidence for themselves.

The probable fault has some topographic expression in the marked cleft or narrow valley at its south-western end, and in the apparent displacement of outcrops of limestone at its north-eastern extremity, but the main evidence of the displacement is as follows:—

1. The beds of the Upper Silica Zone, north of the fault—the dark limestone with low silica but appreciable magnesium content below the "dolomite" bed and the light-coloured low-silica limestone above—cannot be traced along the strike north of the fault, where outcrops contain chert and are similar to those in the Chert Zone north of the fault.
2. The pocket of grey, low-silica limestone in Deposit 2 south of the fault, merges into high-silica limestone with chert along the strike to the south, and is the counterpart of the main Sulzberger's Quarry in the Chert Zone north of the fault, where, in similar fashion, low to medium silica limestone grades into the chert-bearing rock north of R. Beam's house.
3. A stratigraphical section through the limestone sequence south of the fault, with particular reference to the distribution of chert and silica values, gives the same sequence as that measured north of the fault with a "chert zone" of approximately 500 feet in thickness.
4. The light-coloured limestone above the "dolomite" bed in the Upper Zone is the most distinctive lithological type in the limestone sequence and the only exposures of limestone of this type south of the fault are found near Beams Bros.' No. 1 Quarry.
5. Rock type and silica content change markedly across the narrow valley at the south-western end of the fault (in samples 30, 31 and 50).

This evidence not only indicates that displacement has taken place but also implies considerable information on the fault itself. In the first place, displacement must have taken place before the sediments overlying the limestone were deposited because most of the beds of the Upper Zone on the up-throw (southern) side of the fault were removed before sedimentation was resumed. The faulting took place when the limestones were near-horizontal; the fault was normal, but transcurrent as appears now after subsequent folding of the limestone, with a throw of about 800 feet on the northern side, by which the beds of the Upper Zone were faulted down and effectively preserved from erosion. The swing in the north-eastern boundary of the limestone north of the fault, between Sample 22 and 23 is the trace of an original fault scarp, some 200 feet high, which has been tilted by the subsequent folding of the complete local sequence.

Deposits of Low-Silica Limestone.

General.

The geological investigation of the limestone belt clearly indicated that the search for deposits of low-silica limestone should be concentrated on—

(1) the Upper Zone:

(2) possible pockets of low-silica stone toward the base of the Chert Zone.

Additional guiding factors in the search were—

(1) relief—to provide sufficient "backs" for economic quarrying:

(2) outcrop—to indicate that the ratio of clay to solid rock would be reasonably low.

Ridges or hillocks, which have no outcrops, within a limestone belt should be avoided, if possible, because almost invariably zones or pockets of deep weathering will be found which increase the clay/rock ratio in quarrying and may make it difficult or impossible to adhere to a consistent production schedule.

As an example, the grassy hillside, 300 feet north-east of Deposit 3, was "probed" at a number of points by pit and auger to a maximum depth of 11 feet to obtain geological information, but at no point was rock found.

Most of the area underlain by beds of the Upper Zone was mapped in detail by plane table, and mapping was extended to cover portion of the Chert Zone south of the cross-fault, where a pocket of low-silica limestone had been indicated by reconnaissance sampling. This detailed work indicated the limits of a major and a minor deposit within the Upper Zone, and a minor one within the Chert Zone.

None of the deposits was exhaustively sampled, because the samples taken, particularly in Deposits 1 and 3, showed remarkable consistency. For this reason, the grade of the deposits, as shown in the table of reserves, should be reliable, particularly as regards silica content. Possible variations in grade in Deposit 2 are noted below:—(see table).

Content of magnesium carbonate is less consistent and shows some irregularities in most places because it is the result of somewhat irregular replacement of calcite by dolomite.

The estimation of the tonnage of rock available is more difficult, and indeed can never be precise where limestone deposits are concerned.

The vulnerability of the rock to chemical attack by slightly acid ground water commonly leads to a very irregular surface of weathering beneath soil cover, and, at greater depth, produces solution cavities and caves which cannot be detected from the surface. The factor used in reducing the volume of any deposit to available rock material to allow for these contingencies must, to some extent, be an arbitrary one which is based on experience and the characteristics of the deposit concerned. In all deposits, the reserves estimated are *not* total reserves, but the quantity of stone which in our judgment could be economically quarried.

RESERVES OF LOW-SILICA LIMESTONE — FLOWERY GULLY, TASMANIA — DEPOSITS 1, 2 and 3

Deposit	Portion	Reserves of Limestone (long tons*)			Indicated Grade				Remarks
		Indicated	Inferred	Reduction Factor Used†	SiO_2	R_2O_3‡	$CaCO_3$	$MgCO_3$	
					%	%	%	%	
1.	1 (*a*)	330,000	—	35%	0.2	0.5	97.0	2.0	Upper limestone beds (above the dolomite bed)
					(Range) 0.1–0.2	0.3–0.8	94–98	1.3–3.9	
	1 (*b*)	86,000	—	30%	0.4	0.6	93.1	5.7	Lower limestone beds
					(Range) 0.3–0.4	0.4–1.4	79–96	3.5–18.7	
	1 (*c*)	—	46,000	40%	Grade probably similar to that of (*a*)				Upper limestone beds
			14,000	40%	Grade probably similar to that of (*b*)				Lower limestone beds
	1 (*d*)	262,000	—	35%	0.4	0.4	95.0	4.0**	Both upper and lower beds
					(Range) 0.1–1.0	0.3–0.7	83–99	0.4–16.1	Dolomite bed and many dolomitic patches to be hand-sorted
	1 (*e*)	98,000 ††	—	35%	0.4	0.4	95.0	4.0	Lower limestone beds—many dolomitic patches to be hand-sorted
					(Range) 0.1–1.0	0.3–0.7	83–99	0.4–16.1	
2.	—	120,000	—	30%	Inferred Grade				
					0.4	0.5	97.1	1.7	
					(Range) 0.2–1.0	0.3–0.7	94–98	0.8–4.7	
3.	—	—	140,000	35%	0.5	0.5	96.7	1.8	Only three analyses
					(Range) 0.2–0.7	0.4–0.7	96–98	1.1–2.3	

* 14 cubic feet Limestone to the ton.

†Reduction of volume of limestone to allow for soil, solution cavities, and hand-picked dolomite.

‡ Al_2O_3, Fe_2O_3, &c.

** $MgCO_3$ content probably lower where limestone above dolomite bed included in run-of-quarry stone.

†† Included in 1 (*d*).

Deposit 1.

This is the major deposit, which should be capable of supplying Bell Bay for at least 20 years, even if only the most suitable stone is quarried. The deposit has been sub-divided into five sections, mainly to indicate changes in the grade of the limestone. The main subdivision is provided by the central "dolomite" bed and, for convenience, the limestones above are termed the "upper limestone beds" and those below the "lower limestone beds." In the southern portion of the deposit, where most of the reserves lie, limestone from both upper and lower beds could be quarried without removing the "dolomite" bed, and reserves have been calculated accordingly. The quarry limits, used in calculating reserves, are shown in the series of cross-sections on Plate 2, and all reduction factors used appear in the table of reserves.

The main difficulty in calculating reserves in portions of Deposit 1 was the indefinite location of the upper boundary of the limestone. As noted before, the contact between limestone and overlying slate is not conformable and is nowhere actually exposed. The top of the limestone approximates, therefore, to a land surface which existed before the slates were deposited; and this implies that the limestone boundary may be quite irregular in detail, and furthermore, that there could be caves or solution cavities developed in Lower Palaeozoic time and subsequently filled with shale. It is impossible to map this boundary without considerable costeaning, but the indefinite boundary shown seems a reasonable approximation.

It will be noted that an outcrop of limestone occurs outside the mapped boundary in the limits of section line J-K, indicating that the upper limestone beds in this area will probably be considerably thicker than allowed for, but the boundary was purposely restricted to the eastern edge of the main outcrops to provide conservative reserves in this area which may offset errors in the boundary to the immediate south. Deposit 1 is situated on a well-timbered hillside. Fern and shrub cover can be removed by burning, but 200-250 trees would need to be cleared if the entire deposit were worked.

Deposit 1*a*.

This deposit includes over 300,000 tons of quarryable stone with very low silica content, and recommended as the deposit in which quarrying should start. There are relatively few sizeable outcrops along the line of the deposit, but the consistency of both lithological type and chemical constitution in the available outcrops leaves little doubt that the grade will be consistent. No massive "dolomite" was found above the main "dolomite" bed, and as massive "dolomite" tends to crop out more strongly than limestone, the absence of outcrop probably means that little massive "dolomite" may be expected.

The "dolomite" bed will be the footwall of the quarry. The top of this bed is likely to be somewhat irregular, but detailed mapping on the surface indicates that in general it behaves as a bed within the limestone. Difficulties arising from the indefinitely mapped eastern boundary of the limestone have already been noted. This contact will not dip regularly to the east at 45°, as does bedding within the limestone, but errors from this irregularity are unlikely to affect estimation of reserves because it will not be practicable to quarry the limestone where it dips underneath the slate on the eastern side.

Quarrying of Deposit 1 *a* should begin at either end. The northern end offers a slightly lower base level for a quarry floor, but the southern end offers the obvious advantage of a solid outcrop and promise of immediate production with a minimum of clay and overburden to be removed. Furthermore, outcrops at the southern end have been partly cleared of trees, of which there are about 100 on the deposit.

The level of the floor of the quarry at the southern end will be critical, and should be at 450 feet on the datum used for the planetabling.

If the floor is higher than this level, reserves will be lost, and if below, dolomite may have to be removed to provide sufficient working width in the quarry.

The 450 feet contour has been marked by two white pegs where the quarry should commence, and datum has been established at the gate on the western side of the road, 70 feet south of section line N-O. The level at the highest point of the southern gate post is 441.1 feet.

As quarrying progresses it is suggested that the actual limestone-slate contact be located by costeaning ahead of work, and a batter established in the soil and weathered slate east of the contact to enable the eastern wall of the quarry to be advanced as far as possible.

Deposit 1b.

Reserves in this deposit could readily be quarried leaving the "dolomite" bed standing on the hanging-wall side, but the average $MgCO_3$ content (five to six per cent) is unattractive. Samples indicate that the $MgCO_3$ content is less regular than in Deposit 1*a*.

If Deposit 1*a* and other deposits with lower $MgCO_3$ content are worked out, the reserves in 1*b* would, of course, be effectively lost unless tolerance for $MgCO_3$ were increased. If emphasis is put on the conservation of reserves, the only way to use Deposit 1*b* would be by mixing with other low-magnesium limestone. For instance, a mix of two parts of Deposit 1*a* and one part of Deposit 1*b* should provide an average of about 3 to 3·5 per cent MgCO content. A simple mix could be done by regulated truck loads to the hulk, but it is very doubtful whether the additional five years' reserves so obtained would be worth the trouble involved.

Deposit 1c.

Reserves are quoted as "inferred" in this section because no outcrops are visible and soil cover seems very thick.

It is possible that 40,000-50,000 tons of limestone from the upper limestone beds can be quarried here as a continuation of Deposit 1*a*, and some additional reserves, perhaps 20,000-30,000 tons, would be available by reversing the direction of work in Deposit 1*a* and quarrying south at the lower level provided by the topographical embayment in the area of 1*c*.

Deposits 1*d* *and* 1*e*.

In this area, toward the northern limit of Deposit 1, the upper limestone beds are probably too thin to be quarried by themselves. Furthermore, caves are known to exist toward the southern limit of these beds in Deposit 1*d*. Hence, there are two alternatives—either the whole upper zone, east of the road, is quarried and the dolomite bed rejected by hand picking (1*d*), or the lower limestone beds are quarried alone (1*e*).

$MgCO_3$ content is likely to be more variable than in deposit 1*a* and a probable average is about four per cent. The overall reserves and tolerance for $MgCO_3$ will dictate whether any portion of Deposit 1*d* is quarried, but the hand-sorting of the whole dolomite bed should be avoided if possible. The quarrying of Deposit 1*e*, nearly 100,000 tons, is a better proposition and the grade is quite attractive, particularly toward the southern end; but reserves have been calculated on a basis of a quarry extending to the present road (which could be fenced) and working below road level. Any local government regulations against these practices will greatly reduce reserves or involve considerable expense in re-locating the road.

It is unlikely that Deposit 1*e* could be extended much to the north where it would impinge on the chert zone.

Deposit 2.

The No. 2 Deposit is a small pocket of low-silica limestone lying in the Chert Zone about 1,200 feet south of the southern limit of the No. 1 Deposit, It is 200 feet west of the road and access is gained by a short bush track. The deposit bears a medium to heavy cover of timber.

The reduced level of the quarry floor would be 560 feet and excavation would begin in the quarry at the north-eastern corner; the existing floor of this quarry is slightly above 560 feet. The reserves of No. 2 Deposit quarry will be 120,000 tons.

The inferred grade of limestone is 0.4 per cent silica, 1.7 per cent $MgCO_3$ and 97.1 per cent $CaCO_3$. In view of the abrupt variations which occur in the silica content in this zone, as exemplified by analyses of nearby limestone, the silica figure of this grade should be taken as a guide to expected quality rather than a guarantee, for it is just possible that patches higher in silica may be encountered at depth. The same remark applies to the percentage of $MgCO_3$: in this particular area dolomization has taken place in irregular patches rather than along a distinct bed and although the main surface areas of " dolomite " have been excluded from the quarry zone some patches may be encountered at depth.

Although this area is not as attractive as No. 1 Deposit and does not offer the same guarantee of continued quality, it provides a valuable quantity of good limestone, and no difficulty should be experienced if quarrying is begun near the existing north-eastern quarry, where both the quarry face and nearby outcrop samples have shown low-silica limestone and where there is little clay overburden. Regular sampling and analyses should be carried out, particularly if the presence of black chert nodules or large dolomite patches is detected. This will permit the early determination of poor limestone at depth and permit a revision of quarrying plans and a reassessment of reserves.

Deposit 3.

The third deposit immediately adjoins Beams Bros.' No. 1 Quarry and lies at the extreme southern end of the area surveyed. The existing quarry track provides access to the Beaconsfield road.

This pocket of Upper Zone limestone, fortuitously preserved from erosion, becomes unworkable to the north owing to thinning and alluvial cover. Its eastern boundary is defined by its junction with the overlying disconformable slate and quartzites and its western boundary is the passage into the Chertz Zone, with a consequent rise in silica content of the limestone. To the south, the present limit is marked by its disappearance beneath the overlying Permian sediments and the branch road.

The existing quarry has worked limestone from the Chertz Zone, and it would have to be extended to the east and south-east to yield low silica stone. To obtain the full benefit of the reserves available it would be necessary to work from the 520-foot level, which corresponds to the level of the entrance of the present quarry. The present easterly quarry face provides a suitable entry to the high quality limestone. Part of the eastern face exposed in April, 1954, was made up of the high silica zone of the Chert Zone and it would be necessary to break through this before reaching the low-silica beds above and to the east.

Total inferred reserves have been estimated at 140,000 tons and the inferred quality based on three samples, which were reasonably consistent, was very good: the average yielded a content of 0.5 per cent silica, 1.8 per cent $MgCO_3$, and 96.7 per cent $CaCO_3$.

Additional Deposits of Low-Silica Limestone.

The search for additional reserves should be concentrated on the Upper Zone. There are two areas in which investigation is warranted. The most attractive one is the southern continuation of Deposit 3, where the beds of the Upper Zone appear to be thickening in a southerly direction. The limestones pass under a cover of Permian sandstone and conglomerate immediately north of the eastern branch road, south of Deposit 3, but the sink holes in the conglomerate immediately south of this road and to the east of the Winkleigh Road indicate that limestone is underfoot, and preliminary evidence suggests a thin conglomerate cover.

Provided the beds of the Upper Zone, preserved below the unconformable contact of limestone with slate, do not decrease in thickness, this area offers a promise of great reserves, although conglomerate cover would have to be removed.

The second area lies between Deposit 1 and the cross-fault Some low-silica stone will be available east of the road but present indications are that ratio of clay and soil to rock would be high.

Better conditions exist west of the road, in the triangle between road, fault, and boundary of the Chertz Zone. Even allowing 50 per cent wastage, reserves of the order of 200,000 tons might be quarried here. There are, however, foreseable difficulties. The area has no outcrop and much clay overburden will probably have to be removed. If the dolomite bed continues along the strike, it would have to be hand-sorted, and most of the reserves would be provided by the lower limestone beds, and may well be relatively high in magnesium carbonate. However, the " dolomite " reef might lens out, and lead to a decrease in $MgCO_3$ content of the lower limestone beds. For this reason, a shaft to test the lower beds in this area would be warranted as part of any programme to establish additional reserves, although the southern extension of Deposit 3 offers by far the better promise.

Detection of Dolomite, and Quarry Sampling.

Attempts have been made to provide a chemical solution which could be used by a quarry foreman in the detection of " dolomite," but so far, no real improvement on weak hydrochloric acid (N.HCl) has been found. Lemberg's solution, which often acts as suitable dye test, proved unsatisfactory when tested on the Flowery Gully samples in the laboratory but this may be partly due to the fact that extract of logwood, used in this preparation, was not available, and an extract of dubious properties was prepared after much difficulty in the laboratory.

Patches of dolomite can be clearly discerned in outcrop because of brown mottling, and it is likely that most patches in fresh rock will be apparent from the grey metallic hue and the presence of etched rhombs of dolomite.

Further indication is provided by treating the rock with weak hydrochloric acid, applied on a surface smoothed by a file. In this treatment, limestone shows uniform effervescence and dolomite shows markedly less effervescence; a pitted surface is produced on which crystals of the less soluble dolomite stand out in relief.

In establishing the quarry at the southern end of Deposit 1*a*, the delineation of the " dolomite " footwall will provide some experience for quarrymen which should enable them to reject any pocket of " dolomite " found in the limestone above the footwall. The boundary of the " dolomite " bed will probably be slightly irregular, and some streaks in lenses of brown or grey " dolomite " may appear in the limestone near the contact. These may produce a zone of limestone of higher $MgCO_3$ content near the contact, but the width is not likely to be sufficient to affect significantly the overall grade of run-of-quarry stone.

Sampling should provide no difficulties in Deposit 1 *a*, where outcrop samples indicate a fairly uniform grade. Chip samples across the strike should be taken regularly while the quarry is being established as a check on grade, and limestone near the contact with the " dolomite " should be given special attention. Once the quarry is established, routine face-sampling, possibly after each major blasting, should be sufficient, although any apparent change in lithological type should be checked by analysis.

Conclusions.

The investigations showed that there are reserves of low silica limestone at Flowery Gully sufficient to supply Bell Bay plant, at present capacity, for 50 years.

However, some of these reserves are relatively high in $MgCO_3$ and others would involve some difficulty in quarrying. If the Commission restricts itself to the most suitable deposits (1*a*, 2 and 3), it has reserves totalling 620,000 tons, of which 330,000 tons are provided by the major deposit—1 *a*.

Limestone for Other Industrial Uses.

The suitability of these limestones for use in the manufacture of cement has already been noted by Nye (1924) and others; but the information on grade, shown above, provides some more detailed information.

Considerations indicate that limestones suitable for use in manufacturing Portland Cement are mainly found in the Upper Zone (excluding the " dolomite " bed), in the upper portion of the Lower Zone, and in places in the Chert Zone. The most suitable areas of outcrop may clearly be seen by reference to the table, taking most suitable areas as those without cherts and with less than six per cent magnesium carbonate.

Besides the two uses already discussed, limestone is used widely in road building and as aggregate in concrete construction; it is used also in the manufacture of paper, wool rock, and of cements other than Portland; and it is calcined for the production of quicklime, which is used extensively in mortar, in tanning, and as a soil conditioner in agriculture.

For road construction the Flowery Gully limestone offers an excellent source of metal. All zones of the deposit are suitable. The heavily dolomitised areas within the zones are likely to be slightly inferior to the purer limestones because of lower solubility and consequent binding power, and because the increased hardness may make crushing more difficult.

No information has been obtained on the bonding ability of Flowery Gully limestone and bitumen and the limestone should not be used for bitumen surfacing until this has been tested; normally limestones combine well with bitumen and resist water but abnormal stripping limestones have been recorded in other places and testing safeguards must be taken.

The lighter-coloured but non-dolomitic limestones are likely to be most suitable for use as aggregate in cement construction because it is known that where the lightness of colour is not due to dolomitisation it is an indicator of the quantity of carbonaceous material present. This carbonaceous matter can produce acids which are known to attack and weaken the aggregate. Chert nodules, because of their chalcedony, should not be used with high-alkali cements; also the durability of cherts is always questionable in cement aggregates.

All zones of the limestone appear to contain limestone suitable for the manufacture of wool rock. It would be necessary, however, to add sufficient siliceous or argillaceous rock to reduce the content of calcium and magnesium carbonate to between 40 per cent and 65 per cent. Uniformity of the source materials is a desirable feature for such composite wool rock, but little difficulty should be encountered in finding uniform limestone in all zones of the Flowery Gully limestones. Data are not available on the effect of variation in the ratio of magnesium to calcium, but if the variation is undesirable the difficulty could be overcome by avoiding the strongly-dolomitised zones.

Limestone is used widely in the several paper manufacturing processes. It is known that in some of the processes the presence of large quantities of magnesium carbonate is undesirable whereas in others it is quite permissible. Hence the suitability of the various zones will be governed by the particular requirements of the manufacturer and can be selected readily after reference to the plans and text of this record. It should be noted, however, that the black cherts of the Chert Zone may cause excess wear in the crushers and yield a product of inferior consistency. The presence of large quantities of silica in the zone may also be undesirable.

As has been mentioned earlier in the text the limestone has been used extensively already in the preparation of quicklime for mortar and agricultural purposes. Preference is shown for the darker stone by some users and a possible explanation of this has also been given earlier. The quicklime prepared for these purposes would also be useful as a depilatory in tanning."

BEACONSFIELD.

The deposits at Beaconsfield occur near the junction of the Flowery Gully Road and the West Tamar Highway, a few miles south of the town. This stone has been won in the past by subsurface pits which are at present full of water. However, Nye reports that the stone is very similar to that at Flowery Gully. Although this deposit is closer to main highways and ports, economically it cannot be compared with the Flowery Gully limestone as not only could it not be quarried but would have to be extracted from pits from which water would have to be pumped, but also it is covered by an overburden up to 30 feet in thickness in the area investigated.

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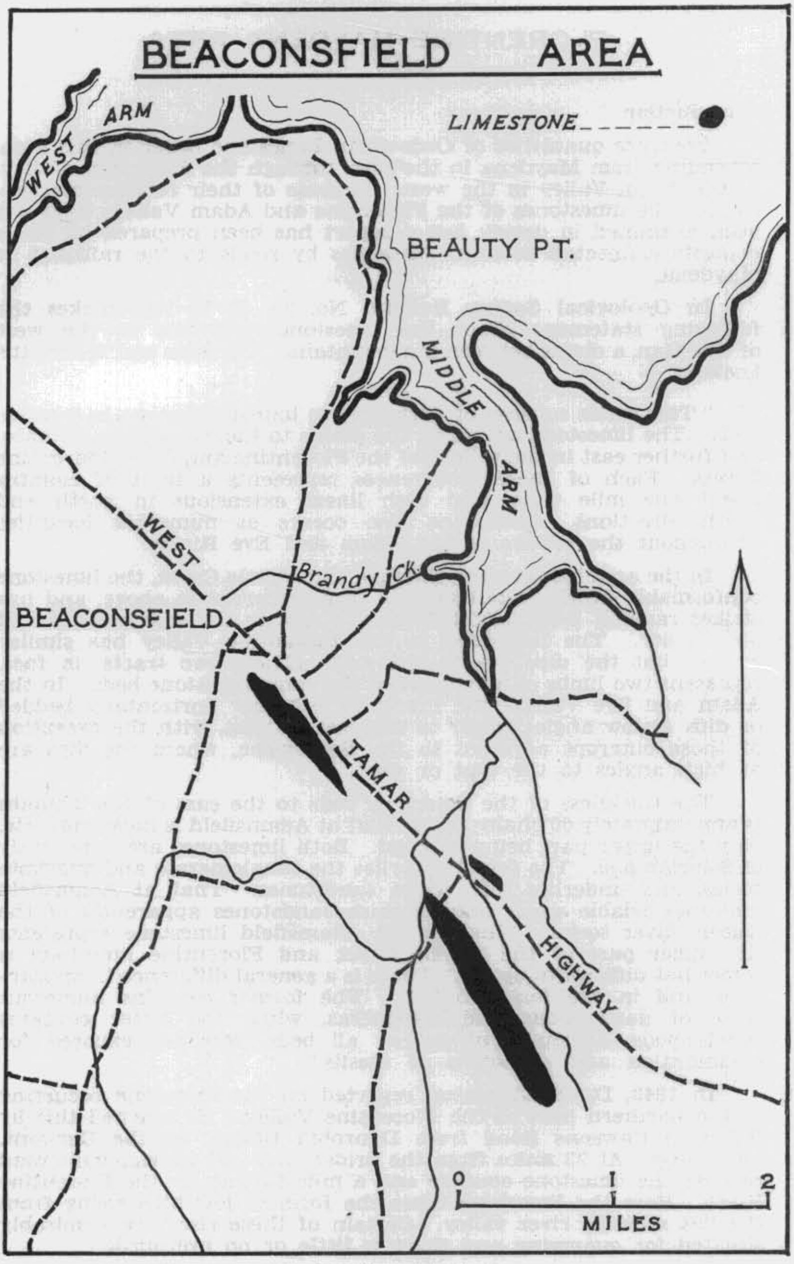

FIG. 13.—Beaconsfield Area.

5 cm

FLORENTINE–MAYDENA AREA

Introduction.

Immense quantities of Ordovician Limestone occur in this area, extending from Maydena in the east, through the Florentine Valley, to the Adam Valley in the west. Because of their relative inaccessibility, the limestones of the Florentine and Adam Valleys have not been examined in detail; but a report has been prepared on those deposits connected in short distances by roads to the railhead at Maydena.

In Geological Survey Bulletin No. 39, P. B. Nye makes the following statement about the limestone occurring to the west of The Gap, a divide between the mountains, Tim Shea and Wherritt's Lookout:—

" This series consists of dark-grey to bluish limestone in massive beds. The limestone occurs on the plains to the east of the Thumbs, and further east in the valleys of the Florentine and Little Florentine Rivers. Each of these occurrences represents a tract of country about one mile wide, and with lineal extensions in north and south directions. Limestone also occurs at numerous localities throughout the valleys of the Adam and Eve Rivers.

In the area between the Thumbs and Myrtle Creek, the limestone conformably overlies the quartzite series referred to above, and has strikes ranging from 350° to 15°, and dips to the east at angles of 60° to 80°. The limestone in the Florentine Valley has similar strikes, but the dips are to the west. These two tracts, in fact, represent two limbs of a syncline of the same limestone beds. In the Adam and Eve Valleys the limestone is either horizontally bedded or dips at low angles either to the east or west, with the exception of those outcrops adjacent to the Serpentine, where the dips are at high angles to the east or west.

The thickness of the limestone beds to the east of the Thumbs is approximately 60 chains, while that at Adamsfield is indeterminate, only the upper part being exposed. Both limestones are apparently of Silurian age. The former overlies the conglomerate and quartzite series, and underlies soft, white sandstones. That at Adamsfield underlies friable white and greenish sandstones apparently of the Queen River series. Whether the Adamsfield limestone represents the upper part of the Myrtle Creek and Florentine limestone is somewhat difficult to decide. There is a general difference in appearance and in the fossil content. The former contains numerous casts of gasteropods and orthoceras, while the latter contains brachiopods, although, of course, all beds were not exposed for examination and collection of fossils."

In 1943, D. R. Dickenson reported on the limestone occurring in the northern part of the Florentine Valley. He reached this by following Dawsons Road from Dunrobin Bridge, on the Derwent, near Ouse. At 23 miles from the bridge, this old convict-built road reaches the limestone country and a mile further on the Florentine River. Here the limestone takes the form of low hills rising from the flat swampy river valley. Certain of these rises are admirably situated for quarrying and there is little or no overburden.

The rock is hard, dense and fine-grained. The colour is usually blue-grey or greyish-black, sparing seamed, with white calcite veins. The formation varies from a massive blocky type to a reasonably close-jointed phase.

Four samples were broken on allotments 29341 and 29344, Parish of Bethune, County of Buckingham. In obtaining these, an effort was made to avoid stone showing secondary surface silicification, but otherwise they do not represent selected material and are quite probably inferior in grade to some of the less weathered rock.

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	P_2O_5	CaO	MgO	Ig. Loss	Sulphur
	%	%	%	%	%	%	%	%
1	4.52	1.66	0.50	Tr.	50.60	1.02	41.30	0.06
2	3.66	1.09	0.35	Tr.	51.74	1.20	41.62	0.09
3	2.96	1.28	0.40	Tr.	52.05	1.12	41.88	0.12
4	8.20	1.61	0.35	Tr.	48.79	1.29	39.08	0.15

In 1955, I. B. Jennings published in the Royal Society Papers and Proceedings an account of the Geology of Portion of the Middle Derwent Area. In his mapping he includes the northern areas of limestone in the Florentine and Gordon River Valleys. In his text he describes the lithology and structure of the limestones as follows:—

" The lithology of the formation varies considerably from pure limestones through arenaceous and agrillaceous varieties, to slates and sandstones. The exact proportions of the impure types is difficult to determine because of the poor outcrops, but certainly, in this area, slates and sandstones form minor proportions. The limestone is a dense, blue-grey rock containing occasional nodules of pyrite; it has a distinctive, foetid odour when freshly broken. The impure varieties have a banded or foliated appearance in outcrop, and split with difficulty along the impure bands. Fossils are frequently found on the weathered faces, in a good state of preservation, apparently being less soluble than the limestone. The formation is fossiliferous throughout, but certain horizons are more fossiliferous than others.

In outcrop, the rock exhibits solution flutings. It is closely jointed in general, and intensely sheared in the vicinity of the faults. The deposition of calcite as veins along joints is common. The rock weathers to a black to reddish, ferruginous loam which is highly fertile where adequately drained. Deep weathering is a feature of this limestone throughout the west and south-west of Tasmania. For this reason, there is always a marked lack of outcrop in limestone areas, and this is particularly so in the Rasselas Valley where the residual soils form a grey-black pug overlain by extensive alluvial deposits. Underground drainage is common in both valleys, and many caverns and sink holes occur in the Florentine Valley. The caverns consist of solution openings along both joints

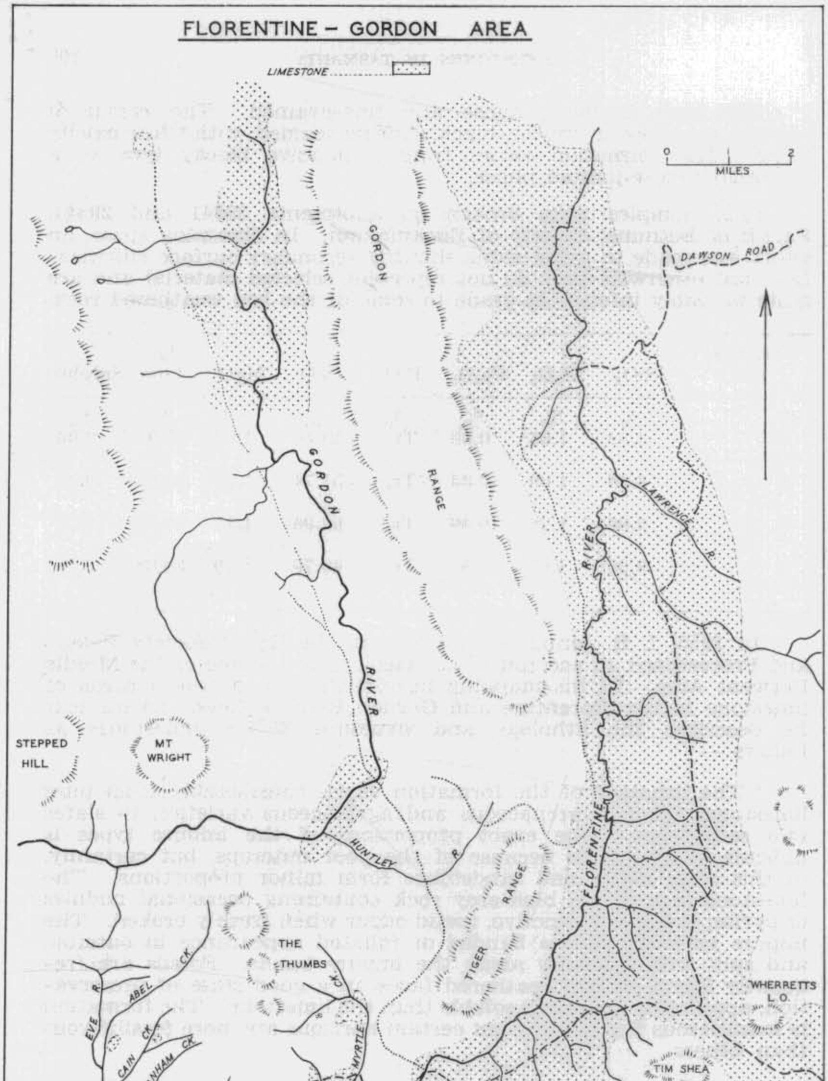

FIG. 14.—Florentine Area.

5 cm

and bedding planes, but with a preference for the joints. They cannot be traced for any distance on account of the low relief and high water table.

The width of the limestone outcrop in the Florentine Valley is about 11,000 feet and the average dip is about 30°. This gives a very approximate thickness of about 5,000 feet.

The limestone is overlain by the Eldon Group rocks, apparently conformably, but the outcrops are too poor to discount the possibility of a disconformity between the two groups. However, there appears to be no great change in strike between them. The formation is overlain unconformably by the Permian rocks, which form the base of the Misery Range.

In Map Square 4376, the Eldon Group rocks and the Gordon Limestone are folded into a broad syncline pitching gently to the north. The eastern limb of the syncline is cut by several faults, the major one being the Gordon Range fault. This fault is clearly shown on the air photos where it cuts the Eldon Group rocks north-west of the Settlement. The syncline opens up considerably north of the fault and the rocks show clear signs of warping. The fault is not exposed in the Florentine Valley because of the poor outcrops in the limestone but there is a distinct change in strike and a flattening of the dip in its vicinity.

In contrast to the clearly defined rupture where the fault cuts the eastern limb of the syncline, there is no sign of a corresponding break in the western limb, and the fault has been indicated as turning slightly north and running along the axis of the syncline.

The age of the fault is open to doubt. It has a similar trend and throw to the Tertiary faults but unlike these faults has warped and folded the rocks. This seems to indicate that the rocks were deeply buried at the time of faulting and would place the fault as older than Tertiary. Also, the associated fractures can be clearly seen cutting the Eldon Group rocks and striking straight into the Permian, but no corresponding faults have been found in those rocks. If this is correct, the Gordon Range fault is Pre-Permian and probably dates from the time of the folding, that is, presumably Devonian. The associated fractures are difficult to locate in the limestone; they may not actually extend as far as the Permian rocks. Until further evidence is available the age of this fault is best left in abeyance."

Towards the end of 1952, the Australian Newsprint Mills became interested in the Maydena Deposits as a source of high-grade limestone for the manufacture of the bleach-liquor used in their treatment plant. Before this the company had utilised the limestone on roads in their concession area, and two quarries had been opened to provide the stone. In 1953 a report on the limestones near Maydena was prepared by Hughes and Everard and is quoted below.

"This report deals with the examination of the limestones and their associated beds in an area extending from the vicinity of the Maydena Station to the Gap, between Tim Shea and Wherritt's Lookout, traversed by the new Florentine Road.

Location and Access.

Maydena is the logging centre for the Australian Newsprint Mills and in recent years a new town has sprung up, just beyond the old township of Fitzgerald, distant 55 miles from Hobart. The railway line now terminates at the Depot Site of the company, $1\frac{3}{4}$ miles beyond Maydena. A new road with several spur roads has been constructed by the company from the depot to the Florentine Valley. South of the depot, the company's new roads include the Burma, Risby's Basin and Roberts. A new Forestry Commission road runs south and west from Maydena to connect with the end of Risby's Basin Road. Numerous walking tracks shown on the attached plan have also been constructed and recently re-cleared by the Forestry Commission. The Junee Road runs for three miles north-east from Maydena past the Junee Caves. From the end of this, the old Adamsfield pack track more or less parallels the Florentine Road in the area investigated.

Geomorphology.

The Maydena area includes the upper part of the Tyenna Valley. This valley is enclosed on its northern side by the Mount Field Plateau rising to over 4,000 feet and on its southern side by the divide between the Styx and Tyenna Rivers, which rises to over 3,000 feet. At its mouth the valley is a narrow gorge debouching somewhat abruptly at Westerway into the more open country drained by the Derwent, but it widens out progressively towards its head.

Just before reaching Westerway, the Tyenna River is a swift flowing stream with rapids, in a juvenile V-shaped valley with overlapping spurs. A little further up the valley it displays a narrow flood plain, which broadens out in the Maydena area, where the stream meanders smoothly across it with the characteristics of late maturity. The Tyenna and other streams in the area do not, as a rule, have their sources in the most elevated places such as the Mount Field Plateau, but at much lower altitudes in relatively open country, and apparently constitute a drainage system imposed from an earlier erosional epoch. The evidence suggests that the Tyenna dates from a period prior to the great Tertiary faulting and epeirogenic movements. Since these tectonic disturbances resulted in the formation of the Derwent, the Tyenna may have been beheaded and finally reversed in flow, by a subsequent tributary of the Derwent cutting back through the dolerite at the present mouth, formerly the head, of the Tyenna Valley.

The Maydena area, including the present headwaters and tributaries of the Tyenna River is open country with button grass plains, and the remains of previous belts of heavy timber. Foothills, chiefly of quartzite and limestone, the elevation of which is due to the effects of great hardness and underground drainage, respectively, lead up to higher country consisting of mudstone capped by great thicknesses of dolerite. Various thicknesses of detritus from the igneous rock may cover the sedimentary formations.

Geology.

The Maydena area is an irregular basin in which the youngest deposits are the Recent alluvium brought down by the present streams. The north-eastern and south-eastern portions of the rim consist of dolerite overlying Permian strata through which it has been intruded. The Permian beds consist partly of fossiliferous yellow mudstones of a common type, and partly of coarse yellow-brown sandstones and grits, sometimes with dark bands of especially well-consolidated material.

In the lower part of the basin and along its western rim, Ordovician rocks belonging to the Junee Group are exposed. Quartzites are exposed west of Frodsham's Gap, at Pine Hill and on Nichols Spur. These quartzites are white in colour in exposure, and contain beds of intraformaticnal conglomerate. They may be an off-shore facies of the Owen conglomerate.

Shales, sheared and metamorphosed, in places to phyllite stage, overlie the quartzites. Minor quartzite bands occur in the shales which are usually chocolate in colour and weather to a light green. Some of these shales, however, may be relatively unsheared and incline to a mudstone type, yellow in colour. Fossils are often plentiful and consist of trilobites, gastropods and brachiopods.

The shales become calcareous and grade up into limestones in a short distance. Bands of intraformational calcareous breccia indicate minor time breaks and oscillations. Siliceous bands are common. The limestone becomes more massive, although often siliceous, but finally a well-bedded, high-grade, fossiliferous limestone appears towards the top of the series, containing numerous trilobites, brachiopods and gastropods.

At this point a major unconformity occurs and the fossiliferous mudstones, sandstones and grits previously referred to are superimposed on the old erosional surface. Conglomerates with quartzite boulders up to two feet across occur near the base of the Permian.

Structural Features.

Folding.

Striking evidence of folding is afforded by the formation in this area of small ridges due to the differential rate of erosion of the quartzite compared with the softer mudstones and limestones. Small quartzite ridges such as Pine Ridge, Sunshine Ridge and Junee Ridge are expressions of anticlines. These anticlines, which have axes of 300° to 340° are not parallel but arranged rather like out-stretched fingers from a hand, so that they diverge to the north-west. Moreover, they plunge to the north-west so that in that direction they become cut off due to the greater effect of erosion on the mudstones which overlie the quartzites. Sunshine Spur is a good example of this and around its north-western limits strikes may be observed nearly at right angles to the general direction. The major fold axes are about 60 chains apart, but minor folding does occur between them and a splendid example of an anticlinal fold may be observed in a railway cutting between Maydena Station and the Depot.

Faulting.

Nowhere in this area was it possible to observe the Upper and Lower Palaeozoic beds in actual contact so that it is not possible to decide whether the Permian beds are in faulted relationship to the Ordovician or whether they have been laid down on an erosion surface of the limestone. Certainly the tremendous Tertiary block faulting has probably shown some activity in this area but no definite fault line around the edges of the Ordovician can be detected. However, faults are probably present within the area. Near the newsprint Depot a triangular wedge of Permian strata juts into the Ordovician strata as the possible result of two faults intersecting at this locality. One follows generally the course of the Tyenna River and the other the ridge of Roberts Hill. The lower limestone beds, exposed on the quarry near the Maydena Station appear to have been displaced a few hundred feet to the west by faulting.

The Limestones.

Quantity.

Such vast deposits of limestones exist in this area that no attempt has been made to estimate in tons quantities available. On the geological map areas of limestone are shown in blue. Where limestones actually outcrop the areas have been coloured dark-blue, and where these rocks are covered by dolerite boulders, soils, &c., they are coloured light-blue.

Quality.

The grade of limestone here differs enormously according to the position of the beds within the series. At the base of the limestones there is a transitional breccia bed containing some calcareous material. Above this are dark-blue massive limestones showing little bedding. These beds are exposed in the big road quarry north of Sunshine Spur and towards the Gap on the Florentine Road. These limestones are not high grade and a grab sample taken from the quarry showed 79 per cent $CaCO_3$ and 18 per cent acid insoluble, while a sample from similar beds along the road showed 57 per cent $CaCO_3$ and 40 per cent acid insoluble. Succeeding these massive beds on the outcrop, chert can be seen as well-developed angular pieces in the limestones and often constituting fifty per cent of the rock. When the rock weathers the chert remains after the limestone becomes dissolved and forms gravel beds. In places this residue has been quarried and such pits may be seen above the Junee Road near the caves and again near the six-mile peg on the Florentine Road. A sample taken across a few feet of these beds showed 50 per cent $CaCO_3$ and 47.5 per cent acid insoluble.

The upper beds of the limestone series, which are the greatest in extent and possibly are nearly a thousand feet in thickness, consist of high-grade grey limestones, sometimes of remarkably fine grain, containing in places abundant calcite. They are well bedded and sometimes individual beds are only a few inches in thickness and are in places rich in fossil fragments. Samples of these beds were taken at various localities and showed an average $CaCO_3$ content of 91 per cent, while the acid insoluble was under six per cent. The MgO content varies between 2.4 per cent and 0.4 per cent and averages one per cent. Iron and alumina together are less than one per cent and there are traces of sulphur and phosphorus present.

Access and Quarry Sites.

With such large deposits of high-grade limestone as are contained in the upper beds of this series, the choice of a quarry site depends largely on topographical features and closeness to existing roads. Two areas immediately suggest themselves, namely north-west of the Caves Reserve and south-east of the Maydena Depot. In the northern area, steep-sided hill slopes and large sink holes on either side of a synclinal axis make for ease of quarrying in practically any direction. This area lies within a mile of the Junee Road. Chip samples were taken across several hundred feet of these beds on both sides of the synclinal axis and showed a $CaCO_3$ content of just on 90 per cent, a MgO content of three per cent, and an acid insoluble amount of six per cent. In this area limestone outcrops generally right to the surface and apart from a little soil and clay, overburden should be negligible.

Even more accessible are the limestone beds to the south of the depot. A sample taken from the hill which abuts the main road showed a calcium carbonate content of 91 per cent, while on the same hillside near the end of Roberts Road a sample taken over about 30 feet averaged over 93 per cent $CaCO_3$. However, the limestone is not outcropping so freely in these localities and there may be a lot of rubbish mixed with the limestone. Just beyond the end of Risby's Basin Road is a splendid face of high-grade limestone rising 70 feet from a large sink hole. In this rock calcite is very abundant and an analysis showed the beds contain 91 per cent of $CaCO_3$. No attempt was made to channel sample this face but samples were

FIG. 15.—Limestone Quarry, Maydena.

The results of sampling are shown as follows—

Locality	Reg. No.	Insol.	CaO	MgO	Ig. Loss	Fe_2O_3	Al_2O_3	S.	P_2O_5	CaO calculated to $CaCO_3$
		%	%	%	%	%	%	%	%	%
On Forestry Track F.D.9..	941/52	2.4	53.8	0.4	42.3	0.2	0.6	Tr.	Tr.	96.0
Up hillside on N. dipping Beds, N.W. of Junee Caves ..	942	5.4	51.1	1.4	41.2	0.3	0.7	Tr.	Tr.	91.2
Up hillside on N. dipping Beds, N.W. of Junee Caves ..	951	6.1	51.0	0.9	40.8	0.4	0.5	Tr.	Tr.	91.0
Same beds on opposite side of Syncline (nr. Newsprint Co. sampling)	943	7.6	48.3	2.4	40.6	0.5	0.7	Tr.	Tr.	86.2
Rock Face near end of Risby's Basin Road	944	6.8	50.7	0.6	40.8	0.3	0.7	Tr.	Tr.	90.5
Big Quarry	945	18.2	44.2	0.8	35.1	0.4	0.8	0.22	Tr.	78.9
Hill near Depot ..	946	6.7	50.7	0.7	40.8	0.3	0.7	0.14	Tr.	90.5
End of Roberts Road	947	5.0	52.3	0.6	41.5	0.2	0.4	Tr.	Tr.	93.3
Above Gravel Quarry Junee Road ..	948	47.5	27.9	0.5	22.0	1.7	0.3	Tr.	Tr.	49.8
Lower Beds, Florentine Road	949	40.3	31.8	0.6	25.6	1.2	0.7	0.1	Tr.	56.7
Quarry near Maydena Station	950	6.8	49.6	1.7	40.9	0.5	0.5	0.11	Tr.	88.5

taken across several beds and the result should be fairly representative. In only one place a few feet of poorer material was noticed.

In this area the cherty limestones outcrop along Pillingers Creek where it bends to the north, but after a hundred feet or so they are succeeded to the east by the better grade beds. The lowest members of the series, the dark-blue massive limestones, are not visible in this area nor is the eastern leg of the syncline.

Near the Maydena Railway Station a small quarry has been opened on land owned by the Commonwealth Carbide Company. A grab sample taken from here showed the limestone to have a 91 per cent $CaCO_3$ content. However, there is a lot of soil and clay associated with these beds and just west of the quarry cherty beds occur so that it is not expected that any large quantities of high-grade stone could be obtained from this spot."

Since the writing of this report, the Australian Newsprint Mills have opened a quarry in the area to the north-west of the Junee Caves Reservation and have connected it to the depot at Maydena with a good road. The company first began using its own limestone in 1953 and, during that year and the next, some crushed limestone was sold to the Electrolytic Zinc Company for use at the Risdon Works. To crush the limestone the A.N.M. installed jaw-crushers and rolls at Maydena. For its own use the company brings lumps of limestone to Boyer where it is burnt in a kiln, slaked, and treated with chlorine to form calcium-hypochlorite which is used as a bleach. The company uses approximately 2,500 tons of limestone each year and the calcium carbonate content averages about 95 per cent. Part of the fines from the kiln are sold locally for agricultural lime and the company supplies burnt lime to a manufacturer of lime-sulphur spray.

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GOLDEN VALLEY

The Golden Valley area lies south of Deloraine on the Lake Highway. This area has been mapped by A. T. Wells, for a thesis for the University of Tasmania and he records two outcrops of Ordovician limestone here. An outcrop on Cameron's property at Quamby Brook has been quarried in the past, but is now under water. According to Wells's map, this is an isolated occurrence in a fault zone.

Another outcrop occurs at the eastern end of Stockers Plain, and represents the eastern end of the large syncline trending S.E. from Chudleigh. This syncline everywhere has a limestone basement, but is covered by alluvials and basalt, and by Permian rocks in the south. The following description of the limestone is taken from Wells's thesis:—

"No contacts of the Gordon River Limestone with the underlying West Coast Range Conglomerate are known, the limestone forming two isolated inliers being faulted against the Davey Group rocks on Stockers Plain. At Quamby Brook the structure of the formation is obscured. The limestone may actually overlap the West Coast Range Conglomerate, and rest directly on the Dundas rocks.

Only two exposures of rock correlated with the Gordon River Limestone are present, one on Stockers Plain, and on Cameron's property at Quamby Brook. In the latter locality no rock could be observed *in situ* since the quarry from which the rock was taken is under water. The outcrop on Stockers Plain is about 300 yards long and not more than 50 yards wide, and the limestone has a minimum thickness in the vicinity of 1,000 feet. The rock in the quarry strikes 318° and dips at 66° to the north-east, that is, into the ridge of Precambrian rocks. The limestone occurs in low flat plains due to its inferior resistance to weathering. The deposit on Stockers Plain is partly protected by a covering of Permian sediments. The presence of sink holes about 100 yards to the north-west of the limestone quarry indicates the presence of the limestone under Stockers Plain. This first sink hole is 12 feet in diameter and 15 feet deep. No bed rock is visible. A small creek is present about 20 yards to the east. Coarse gravels are present on the sides of the sink hole with about five feet of alluvium above it. About 50 yards north-west again two smaller sink holes are visible, being about seven feet in diameter and five feet deep. In this locality the top soil has a dense black colour, due to the high lime content.

The limestone in the quarry is crenulated and foliated with laminae about 4 mm. apart. Minor faults were visible. The rock is rather schistose and appears to be slightly sheared. This is probably due to the proximity of a fault zone. Calcite veins up to four inches across occur as sheets parallel to the bedding and often lens out laterally. A slide of the rock shows evidence for the presence of fossils but no definite forms could be recognised.

The weathered surface of the rock shows irregular distorted forms which may represent fossil remains.

There has been some solution weathering of the limestone and surfaces with secondary calcite and small stalagmites were observed.

A reddish-brown residual clay overlies the limestone. The fresh rock is a light blue-grey with paler sheared linear patches. An erratic of the limestone was treated with acid. Several outlines were etched, apparently representing fossil structures. It was noticed that one section of the limestone was more resistant to attack and was left as an extremely irregular globular pale grey mass. The more soluble limestone was a coarser-grained variety, containing distinct rhombs of calcite in section. The harder portion is exceedingly fine-grained and is probably partly silicified. It appears from the nature of the boundaries of the two types that the latter is being replaced by the coarser limestone. The residue left after acid extraction is ash coloured and very similar to that obtained from a sample from the Melrose Quarry. It appears to contain a good deal of graphite.

The odd boulders collected from the black soil at Cameron's property are a much darker colour, almost black, and most are ramified with calcite veins of varying thickness. The rock is somewhat altered by dynamic metamorphism. No signs of fossils were visible, which makes any attempt at correlation difficult. Stylolites are present which stand out on the weathered surface as very irregular thin lines. The deposit here may represent an isolated pinnacle of limestone, the rest of the formation being concealed beneath the Recent river alluvium.

The limestone appears to have been deposited in shallow seas bordered by low-lying land surfaces from which very little clastic material was derived. In other areas the fauna present, particularly the abundant corals, suggest warm water conditions.

The limestone has been quarried locally for agricultural purposes, but at present is unexploited."

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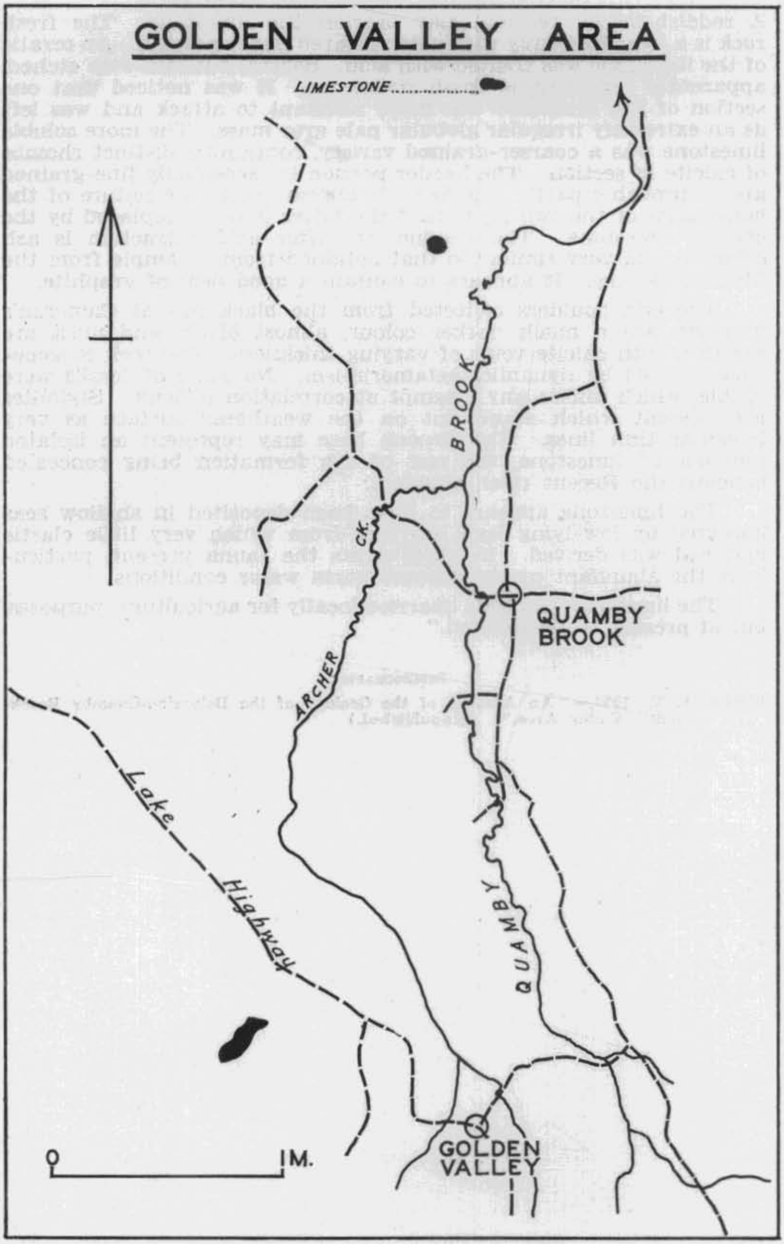

FIG. 16.—Golden Valley Area.

GORDON RIVER

Introduction.

This general locality contains probably the largest areas of the stone in the State. Because of its inaccessibility, however, it has never been considered from a commercial viewpoint and, consequently, has never been examined closely by officers of the Department.

In 1938, F. Blake, on a visit up the Gordon by boat to a copper prospect at Nicholls Range, noted the limestone and mapped its extent along the river banks. He shows, on his accompanying map, three areas of limestone adjacent to the river. The most westerly extends from Eagle Creek to Abel Creek, a distance of eight miles, the centre one from the Franklin River to the Olga River, six miles; and the most easterly for about 1½ miles on either side of the Maxwell River mouth. In all these areas, the river more or less follows the strike of the limestones; that is, north-north-west, and the width of the beds appears to be of the order of half to one mile.

In the course of his report, Blake says:—

The rocks consist of an interbedded series of limestones, quartzites and slates which have been referred to as the Gordon River Limestone Series. They extend over a north-westerly trending belt along which Gordon River flows to Macquarie Harbour, and are well exposed in the banks of that stream. The limestones are generally massive blue-grey types, but shaley and argillaceous varieties occur in places. A series of anticlinal and synclinal folding, with northerly trending axes, is suggested by measurement of the strikes and dips of the beds through a section along Gordon River, from Butler's Island to Nicholls Range. The limestone occurs in three, and the quartzites in four, separate belts approximately parallel. The available evidence is insufficient to show if they represent beds of the same horizon which have been repeated owing to folding and/or faulting, or whether they were deposited at different stages."

These limestones thus noted along the Gordon River itself have been reported by prospectors and others as extending a long way to the south, even down to the Harwood River almost to its junction with the Davey. Whether these belts of limestone are continuous and whether they all join up to the south is a matter for future mapping but their inaccessibility, at least away from the Gordon River makes them, at present, a matter of academic interest only.

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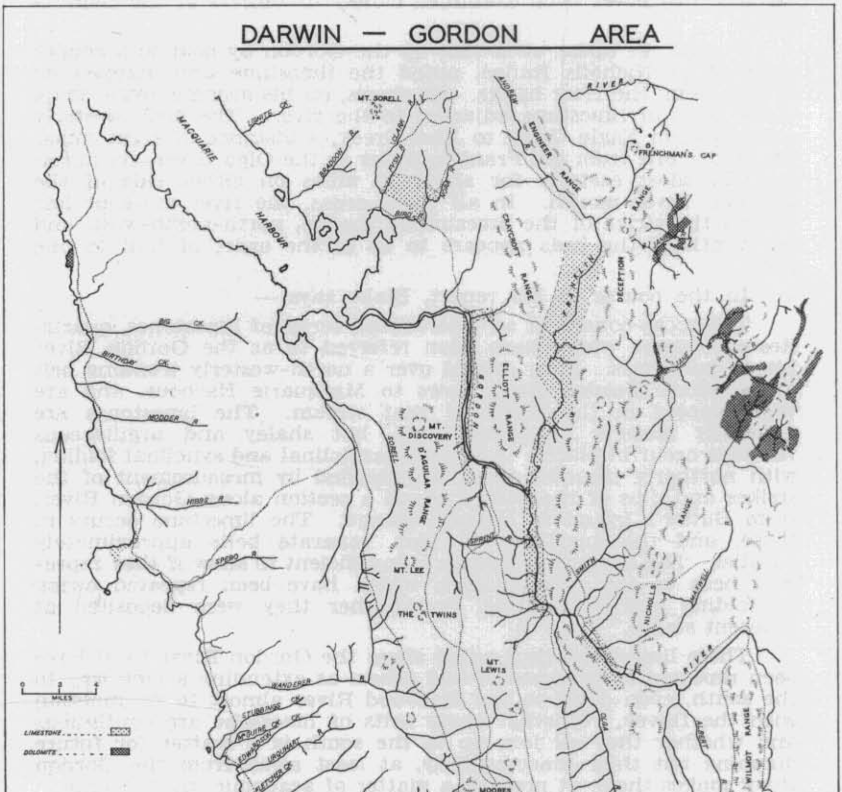

FIG. 17.—Gordon River Area.

GUNNS PLAINS

Introduction.

In 1909, W. H. Twelvetrees, in Geological Survey Bulletin No. 5, stated that "a small lime-burning industry exists at the Plains, and the lime which is of excellent quality, finds a ready sale at Ulverstone at two shillings per bushel bag. The stone is also used for metalling roads at the Plains." He also remarked that "the cave on the Limestone Reserve on the east side of the valley, officially opened this month by the Hon. the Premier, possesses spectacular merits which make it an undoubted asset from the tourist point of view."

Apart from these aspects, the limestone was not explored from a commercial viewpoint until 1951 when a group of businessmen and farmers from the Ulverstone district, led by Mr. A. Kimberley, formed a company known as the North-Western Farmers Lime Company Ltd. The object was to develop an area of limestone at Gunns Plains for use in agriculture and possible sale to A.P.P.M.. This company engaged Mr. Russell Searle, a limestone engineer from Wellington, New Zealand, to advise them on installation of a plant and requested geological advice from this Department. The result of this advice is given in a report by Hughes in 1951, as follows:—

Location and Access.

Gunns Plains is a prosperous farming centre, located on pleasant river flats and rising valley slopes on either side of the River Leven. It is connected by good roads to Ulverstone, 13 miles away and to the railway at Preston (on the Nietta line) only three miles distant.

Topography.

The valley floor of the Leven in this district is considerable, averaging five miles in length by three-quarters of a mile in width. The topography has first been conditioned by the different rock types, the wide valley here being first due to the erosion of the readily-soluble limestone. The Leven enters the Plains by a narrow deep gorge eroded with difficulty into the hard conglomerates and quartzites and after meandering slowly through the flat wide water-meadows again enters a deep gorge cut into resistant Cambrian rocks. On either side of the Plains the hills rise fairly steeply at first and then as the basalt covering of the plateau is reached steepen to very high angle slopes.

The detailed topography of the limestone areas is typical. Numerous sink holes occur over the whole district, streams disappear underground and re-emerge many chains away, and cavities in the rock faces are numerous. Cliffs up to 200 feet high fringe the river and creek beds.

Geological Map.

On the accompanying geological map are shown the principal rock types outcropping in this district. The limestone, which is the important rock type as far as this report is concerned, belongs to the Gordon Formation of the Ordovician and is underlain apparently conformably by a series of conglomerates and quartzites, the Owen series of the Ordovician. Lying unconformably below this latter series, and outcropping to the north of the limestone in the Leven Gorge are slates and other members of the Dundas Series of the Cambrian.

In one locality a small remnant of post-limestone quartzite may be observed. No definite age can be assigned to this but perhaps it is equivalent to the Crotty Quartzite at the base of the Silurian.

During the Tertiary Period, when a good deal of the limestone had already been eroded away, an outpouring of lava formed the extensive basalt deposits, the rich soil from which is so important to North-Western prosperity.

Under the basalt, on steep hillsides may be seen remnants of Tertiary river gravels, and huge conglomerate boulders brought down by Pleistocene heavy rainfall, litter many limestone areas. These Tertiary and Pleistocene deposits, because of their thin coating and limited extent are not distinguished on the geological map, but Recent river alluvial flats are separately coloured.

Structure.

The geological structure in the vicinity of Gunns Plains is dominated by a large dipping syncline which almost reaches the proportions of a basin. The axis of this syncline strikes at 120° and is located about the position of the valley south of the caves. Except where the bedding is influenced by a few minor flexures and faults, mainly to the north, all dips to the north of this axis are southerly, and to the south, all are northerly. It is noted that the horizontal distance across the limestone beds is much less on the southern side of the axis than on the northern and this may be due to three causes, all of which probably operate here:—

1. The beds to the south are generally more steeply dipping.
2. Minor folds occur to the north, which causes repetition of the beds. These minor folds and flexures appear very small and some are only a few feet across.
3. Faulting has also caused some repetition.

No minor folding or faulting has been observed south of the synclinal axis; but just to the south of this appears a thin bed of quartzite which seems to indicate the top of the limestone. The bottom of the limestone can be found where the Owen Conglomerate beds begin, so that the thickness of the limestone beds in this area can be measured; and it is found to be almost 3,000 feet.

To the south and west then, the limestone is limited by its dip and here the underlying Owen Conglomerate beds come to the surface. To the east and sometimes to the west the limestone disappears under Tertiary basalt. To the north a large south-dipping fault brings Cambrian sediments into faulted relationship with the limestone. Smaller faults, echoes of this large one, and parallel to it, occur in the limestone to the north of the area.

The Limestone.

This rock is the typical dark-blue, high-grade limestone of the Gordon Formation which outcrops in the north of the Island at Melrose, Railton, Mole Creek, Flowery Gully, Loongana and other localities. Although in places it appears massive, it is usually well bedded, the beds varying in width from a few inches to several feet. Fracturing, particularly in a vertical plane, is reasonably common but there does not appear to be any shearing in this district and no igneous intrusion appears to have interfered with the original constituents, as no samples showed the presence of calcium silicates. In certain areas white calcite veins and bunches are common but this is not the pure calcium carbonate, as an analysis of the white crystals showed two per cent of magnesium carbonate.

Quantity.

No overall estimate of the quantities present has been attempted as these are far in excess of any present-day needs, but on the geological map the limestone areas are coloured blue. This does not mean, of course, the limestone actually outcrops over all this area. In some places it is covered by soil and basalt debris; in others by Tertiary gravels and Pleistocene glacial material. All these coverings, however, are but thin skins and here and there limestone protrudes from under each of these covers. Certain areas, however, are available where the overburden is practically negligible. The recent alluvium, shown on the map, covers limestone at no great depth, but as the limestone could not be obtained from beneath this except by sub-surface workings, it is differentiated on the map.

Quality.

The quality of the limestone throughout the area is good and very consistent. In one locality beds were channel sampled over two faces. One face, in five-foot samples, showed, over 75 feet, an average $CaCO_3$ content of 87.8 and the other, over 130 feet, showed, in six-foot samples, an average $CaCO_3$ content of 87.1 per cent. Altogether in the district, 46 samples were taken and the results of these showed an average calcium carbonate content of 87 per cent. Most of the samples taken showed the percentage of $CaCO_3$ in either the eighties or nineties. The magnesium carbonate content of the samples varies considerably and in some samples is surprisingly high. In the majority, the percentage is under three, but many have four or five per cent and the highest contains 12 per cent. The acid insoluble portion of the samples is quite constant, varying (except in one sample) from three to 12 per cent. Of this acid insoluble portion the majority consists of SiO_2 (82 per cent), Al_2O_3 (12 per cent) being the only other consitituent of any appreciable amount. In some of the samples small specks of pyrite could be detected but an estimation of the sulphur content showed that one sample contained 0.2 per cent, a few 0.1 per cent, but the majority less than 0.1 per cent.

Accessibility and Ease of Quarrying.

As the district is a rich agricultural one, it is closely settled and, consequently, roads are numerous so that no outcrop is very far from a road of some sort. Moreover, the greatest density of roads is on the plains about river level and the limestone outcrops on the hill slopes on either side so that there could always be a road below the base of a possible quarry. In certain localities the limestone outcrops boldly in cliff faces or on very steep slopes with little or no overburden, thus forming natural quarry sites.

All these points, however, will be discussed in greater detail when dealing with individual selected sites.

Individual Sites.

I.—*Winduss's Property.*

This site (or rather sites, for there are two possible quarry sites) appears to be far the most favourable in the district and for this reason a more thorough survey and sampling of the area was undertaken than at other sites.

This area has many advantages from a quarrying point of view. There are two natural faces of almost vertical rock with little or no overburden and of the order of 100 feet in height at the faces, with the hill sloping more gently behind these for another hundred feet. These faces are looking north-easterly and as the dip of the beds is to the south there is a component of dip inwards from them. This deposit is close to a good road and to electric power. A permanent stream runs through the area and there are good stretches of flat ground for building purposes. The rock faces themselves are some two hundred feet each in length; the number one face is 75 feet high, rising a further hundred feet to the crest of the hill, some 250 feet in. The Big Face is over a hundred feet in height and the hill behind it rises another 150 feet to the hilltop, 250 feet in. Millions of tons of limestone could thus be obtained from this area with no overburden but a little soil.

The grade of stone is this property is comparable with that generally in the district and, except for one five-foot bed, is of good even quality, averaging about 88 per cent $CaCO_3$.

These two faces were carefully channel sampled, that is, a section was taken right across the beds and divided into widths of 3 feet to 10 feet, which generally corresponded with the individual beds. It is, of course, possible for these beds to vary laterally in grade, but over this small area the grade of the samples should indicate the average grade of the beds. The attached sections show the position of the various samples, which may be shown diagramatically as follows:—

No. 1 Face

Sample 9 (20′)
8 (4′)
7 (5′)
6 (4′)
5 (5′)
4 (5′) Main Rock Face
3 (5′)
2 (6′)
1 (6′)
10 (5′)
11 (5′)
12 (5′)
13 (8′)
14 (5′)
— 25′ No outcrop
15 (3′)

Big Face

Sample 18 (5′)
17 (5′)
16 (5′)
19 (8′)
20 (5′)
21 (6′)
22 (6′)
23 (6′)
24 (6′)
25 (7′)
26 (7′) Main Rock Face
27 (5′)
28 (6′)
29 (6′)
30 (5′)
31 (7′)
36 (3′)
35 (8′)
34 (10′)
32 (7′)
33 (7′)

Sample 37 was a general sample taken over several beds at the outcrop nearer the road and contained on lease 305P/M, 24 acres, held by H. L. Munro.

Detailed results of this sampling are as follows,—

Sample	Width	In-soluble	Al_2O_3 & Fe_2O_3	CaO	$CaCO_3$	MgO	$MgCO_3$	S
	feet	%	%	%	%	%	%	%
1	6	9.7	1.2	47.2	84.2	2.2	4.5	0.2
2	6	7.8	0.6	49.1	87.6	1.5	3.1	under 0.1
3	5	3.3	0.3	52.8	94.2	0.8	1.6	,,
4	5	8.1	0.7	49.6	88.5	0.9	1.8	,,
5	5	3.9	0.5	52.6	93.9	0.8	1.6	,,
6	4	7.2	0.6	50.4	89.9	1.0	2.1	,,
7	5	5.4	0.4	51.8	92.4	0.7	1.4	,,
8	4	4.4	0.5	52.2	93.1	0.9	2.0	,,
9	20	11.7	0.8	47.3	84.4	1.3	2.8	,,
10	5	19.4	1.4	39.1	69.8	4.1	8.7	,,
11	5	4.9	0.6	51.9	92.6	0.9	1.8	,,
12	5	8.5	0.8	47.6	85.0	2.4	4.9	0.1
13	8	12.4	1.2	45.6	81.4	1.9	3.9	0.1
14	5	7.7	0.6	49.7	88.7	1.0	2.2	under 0.1
15	3	5.4	0.4	51.5	91.9	0.9	1.9	,,
16	5	8.3	0.8	49.7	88.7	0.7	1.4	,,
17	5	4.4	0.6	52.1	93.0	0.6	1.2	,,
18	5	4.7	0.6	51.9	92.6	0.6	1.2	,,
19	8	12.8	1.1	47.1	84.1	0.7	1.5	,,
20	5	8.9	0.9	49.3	88.0	0.6	1.2	,,
21	6	10.8	0.9	48.5	86.6	0.6	1.2	,,
22	6	4.6	0.7	52.1	93.0	0.6	1.3	,,

Sample	Width	In-soluble	Al_2O_3 & Fe_2O_3	CaO	$CaCO_3$	MgO	$MgCO_3$	S
	%	%	%	%	%	%	%	% under
23	6	7.2	0.7	50.4	90.0	0.7	1.4	0.1
24	6	10.2	1.0	48.5	86.6	0.9	1.8	,,
25	7	11.8	1.0	47.7	85.1	0.8	1.7	,,
26	7	6.0	0.7	50.9	90.9	0.9	1.8	,,
27	5	7.3	0.8	49.7	88.7	1.2	2.6	,,
28	6	4.2	0.8	50.1	89.4	2.5	5.3	,,
29	6	5.4	0.8	49.6	88.5	2.0	4.2	,,
30	5	8.3	0.6	47.9	88.5	2.1	4.4	,,
31	7	8.1	0.8	47.3	84.4	2.7	5.6	,,
32	7	14.0	1.1	43.5	77.6	2.8	5.9	,,
33	7	7.2	0.7	49.3	88.0	1.6	3.3	,,
34	10	12.0	0.9	46.2	82.5	1.7	3.6	,,
35	8	8.6	0.7	48.4	86.4	2.2	4.5	,,
36	3	9.8	0.8	44.8	80.0	4.4	9.2	,,
37	—	6.5	0.8	49.3	88.0	2.4	5.0	,,

It can be seen that the $MgCO_3$ content varies considerably, but if a low magnesium content was desired at any time, it is interesting to note that samples 16 to 26, that is, the upper 66 feet of the Big Face, contain less than two per cent $MgCo_3$.

In each tenth sample, the acid insoluble portion was separately analysed and an overall average showed 83 per cent of it consisted of SiO_2 and 10 per cent Al_2O_3. Details of samples are as follows:—

Sample	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO
	%	%	%	%	%	%
1 ..	83.2	9.0	0.7	0.7	0.6	1.3
10 ..	83.1	10.0	0.7	0.6	0.5	1.5
20 ..	85.5	8.6	0.6	0.5	0.5	1.3
30 ..	80.0	12.7	0.6	0.7	0.5	1.0

II.—*Limestone Bend.*

In the southern portion of the area and just after the Leven emerges from its upper gorge is a large bend in the river containing flat meadows. To the north of these flats and on the opposite side of the river are limestone cliffs, some 200 feet in height and fringing the river for hundreds of feet along the strike of the beds. Unfortunately, the base of these cliffs is the river itself, which would make quarrying from their face very difficult. However, the eastern end of the ridge ends in river flats and although there is not a sheer face in this direction, a quarry site could be easily opened and very little overburden would result. As can be seen on the plan, the hillside rises at about 30° and the top of the hill, nearly 200 feet above the flat, is in a distance of 400 feet. The reserves in this area are almost limitless and the quality is high, the average $CaCO_3$ content being 90 per cent. Two samples were taken—one (44) from flat level to 80 feet; and the second (45) from 90 feet to the top. These showed—

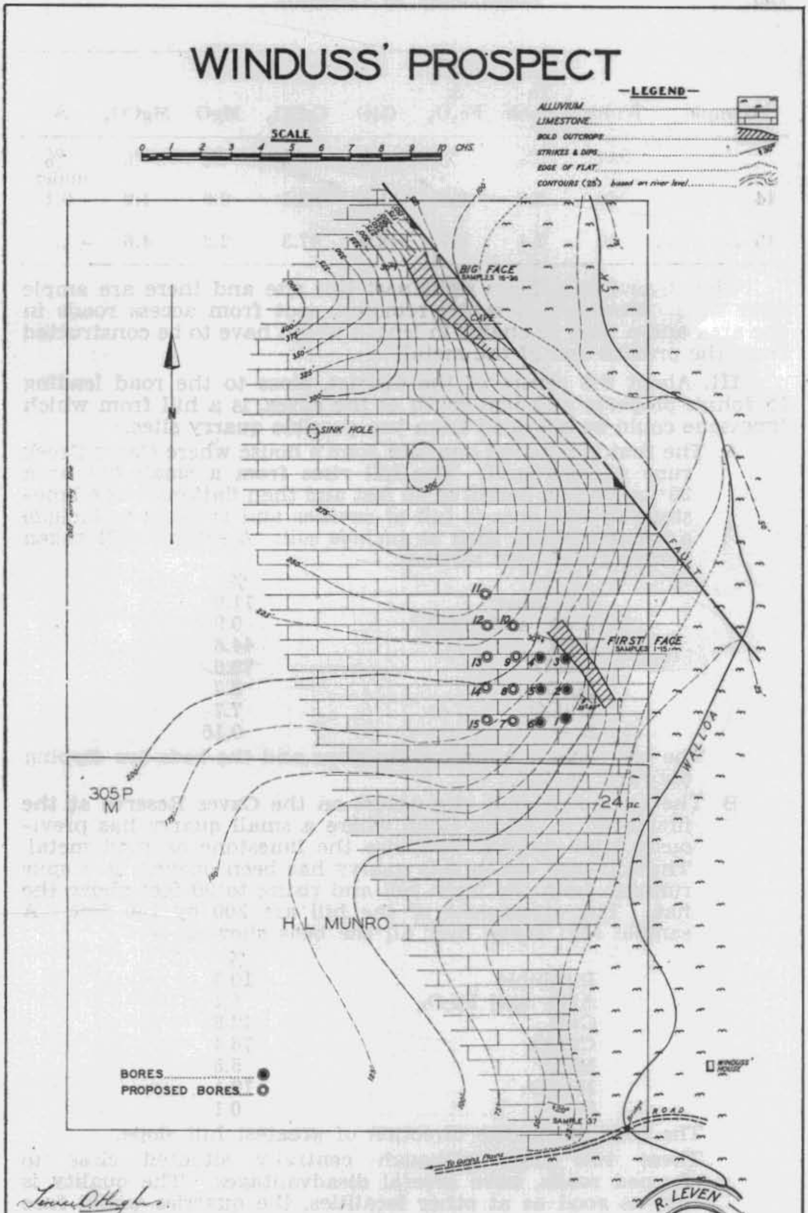

FIG. 18.—*Winduss' Prospect.*

Sample	Width	In-soluble	Al_2O_3 & Fe_2O_3	CaO	$CaCO_3$	MgO	$MgCO_3$	S
	feet	%	%	%	%	%	%	%
44	80	5.0	0.6	51.8	92.5	0.9	1.9	under 0.1
45	90	7.4	0.7	48.9	87.3	2.2	4.6	,,

The River Leven flows right past this site and there are ample river flats. However, it is the remotest spot from access roads in the area and a road 50 chains in length would have to be constructed from the present end of the metal.

III. About the centre of the district, close to the road leading to John's property and just south of the caves, is a hill from which limestone could be obtained from two possible quarry sites.

A. The first is situated opposite John's house where Caves Creek runs underground. The hill rises from a small flat at a 20° angle to a height of 90 feet and then flattens. The limestone in this area is full of cavities and is likely to include a lot of rubbish, such as surface soil. A sample (42) taken from all the beds showed: —

	%
Insoluble	11.6
Al_2O_3 and Fe_2O_3	0.9
CaO	44.6
$CaCO_3$	79.6
MgO	3.7
$MgCO_3$	7.7
S	0.16

The hill slope is almost a dip slope and the beds are dipping outward at 10°.

B. The second possible site occurs on the Caves Reserve at the first bend in John's Road where a small quarry has previously been opened, to utilise the limestone as road metal. The hill into which this quarry has been opened, is a spur running from the main hill and rising to 90 feet above the flat. The dimensions of the hill are 200 by 150 feet. A sample (41) taken over all the beds showed:—

	%
Insoluble	10.3
Al_2O_3 and Fe_2O_3	1.1
CaO	42.8
$CaCO_3$	76.4
MgO	5.8
$MgCO_3$	12.1
S	0.1

The beds dip in the direction of greatest hill slope.

These two sites, although centrally situated close to formed roads, have several disadvantages. The quality is not as good as at other localities, the quarries would face south and in one case the limestone would contain a certain amount of rubbish while in the other the quantities available would not exceed one hundred thousand tons.

IV. Where the metal road ends, to the south of the area but to the north of the river are extensive outcrops along the face of a small hill which rises from the flat at an angle of 30° to a height of 80 feet and then flattens. The beds average three feet in thickness and dip into the hill at 15°. A small stream flows from the hill near this point. The quality of the limestone is good and, except for its southern aspect it would appear a good quarry site for limited production. A sample (40) taken over all the beds showed:—

	%
Insoluble	4.7
Al_2O_3 and Fe_2O_3	0.6
CaO	50.7
$CaCO_3$	90.5
MgO	2.0
$MgCO_3$	4.2
S	0.1

V. *Other Sites.*

In several other localities, quarrying could be satisfactorily carried out but the sites mentioned appear the most favourable. Twin hills of limestone rise behind Last's Dairy on the western side of the Leven and a composite sample (43) was taken across beds 30 feet in width on one hill and 60 feet on the other. This showed limestone of good quality, viz:—

	%
Insoluble	5.3
Al_2O_3 and Fe_2O_3	0.6
CaO	51.2
$CaCO_3$	91.4
MgO	1.3
$MgCO_3$	2.7
S	0.1

Another area that might be considered because of its high level position is on G. Clark's property and could be approached from the Preston Plateau and not from the lower Gunns Plains. Bold cliffs, 50 feet high, fringe the gully of a small creek which disappears underground. The dip of the beds is into the hill from the gully. A sample (46) taken over the 50 feet showed:—

	%
Insoluble	11.6
Fe_2O_3 and Al_2O_3	1.0
CaO	47.5
$CaCO_3$	84.8
MgO	1.1
$MgCO_3$	2.3
S	0.1

On the first big bend on the road from Gunns Plains to Preston are bold outcrops of limestone on a steep hill slope. Two samples were taken across the beds which dip into the hill at 20°. One (38) included beds from road level to 50 feet and the other (39) from 50 to 80 feet. These samples showed:—

	38	39
	%	%
Insoluble	6.4	8.0
Fe_2O_3 and Al_2O_3	0.8	0.8
CaO	47.8	47.0
$CaCO_3$	85.3	83.9
MgO	3.5	3.7
$MgCO_3$	7.3	7.7
S	0.1	0.1

Conclusions.

Enormous quantities of high-grade limestone outcrop on steep hill slopes fringing alluvial flats at several localities in the Gunns Plains area and, although quarries could be successfully operated at many of these sites, it is considered that either of the two cliff faces on Winduss's property is the most promising site.

As the result of these investigations, the company instituted a drilling campaign behind the Number 1 Face at Winduss's property. The beds indicated by these bores over an extensive area showed almost the exact percentages of $CaCO_3$, MgO_3 and SiO_2 as those sampled in Number 1 face, indicating that, in this area, laterally the lime content of the bed remains constant.

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VI HAMPSHIRE

Introduction.

It has been customary to show on geological maps of Tasmania large deposits of limestone south-east of Hampshire. At one time in geological history, larger deposits of limestone did exist where now is this district, but the beds have been silicified and metamorphosed to such a degree that they cannot be considered as a source of limestone. Narrow beds of fairly pure re-crystallised limestone do occur in more siliceous sediments. Reid, in 1924, showed on his geological map large areas of limestone around the headwaters of Limestone Creek. Thomas and Henderson, in 1943, investigated certain beds for the possible production of Wollastonite. Hughes, in 1950, took some further samples from Limestone Creek.

Location and Access.

Hampshire Railway Station is almost 16 miles by road and rail from Burnie, and from it a metalled road runs to Natone, crossing Limestone Creek at about 1½ miles. The main outcrops are situated on the eastern bank of Limestone Creek, 60 chains south of the Natone Road Bridge.

Geology.

The most common sedimentary rock type outcropping in this area is chert or hornfels containing bands of limestone and calc-silicate bands composed mainly of wollastonite. The main outcrops are in the vicinity of a granite intrusion and show a fairly wide area of contact metamorphism. Outcrops of granite can be seen at many points in the area, but, unfortunately, any actual contacts between the granite and the sedimentary rocks are masked by overlying Tertiary basalt or detrital material from this.

Doubtless these sediments were originally typical Gordon River Limestones, but they have suffered silicification and contact metamorphism to such a degree that they are no longer recognisable as such. Even the fairly pure bands of limestone consist of re-crystallised material. This alteration occurred during the Devonian and is associated with the granite intrusion.

The Limestone.

Over much of the area limestone is not apparent, but an outcrop on the eastern bank of Limestone Creek, 60 chains south of the Natone Road bridge, shows a thinly bedded series of rocks in which may be seen five bands of limestone varying in thickness from three inches to three feet, contained in beds of hornfels and calc-silicate rock. These beds strike at 160° and dip to the south-west at 15°. The thickness of the outcrop exposed is 25 feet. An analysis of the limestone taken from the various bands showed:—

	%
Acid Insoluble	8.4
CaO	51.0
MgO	0.4
Ignition Loss	38.0
$Fe_2O_3 + Al_2O_3 + TiO_2$	1.6

The siliceous portion of the outcrop showed:—

	%
Acid Insoluble	68.0
CaO	21.6
MgO	0.6
Ignition Loss	2.6
$Fe_2O_3 + Al_2O_3 + TiO_2$	6.7

This second analysis is of a representative sample taken across the silicate and calc-silicate beds and shows that the minerals are in the following proportions:—

	%
Calcium Carbonate ($CaCO_3$)	6
Wollastonite ($CaSiO_3$)	38
Silica (SiO_2)	48

This does not mean that the minerals are in that proportion in each bed as some are wholly siliceous and others chiefly composed of wollastonite.

Almost a mile to the north-west and twenty chains from the Emu River are other outcrops, but the exposures are poor, although the grade appears similar. Thus, while limestone does occur at Hampshire and is of good commercial grade, its limited extent and narrow width make it an object of geological interest rather than an economic proposition.

The occurrence of wollastonite suggests a possible market for this material, although again its economic concentration probably is limited to quite narrow beds.

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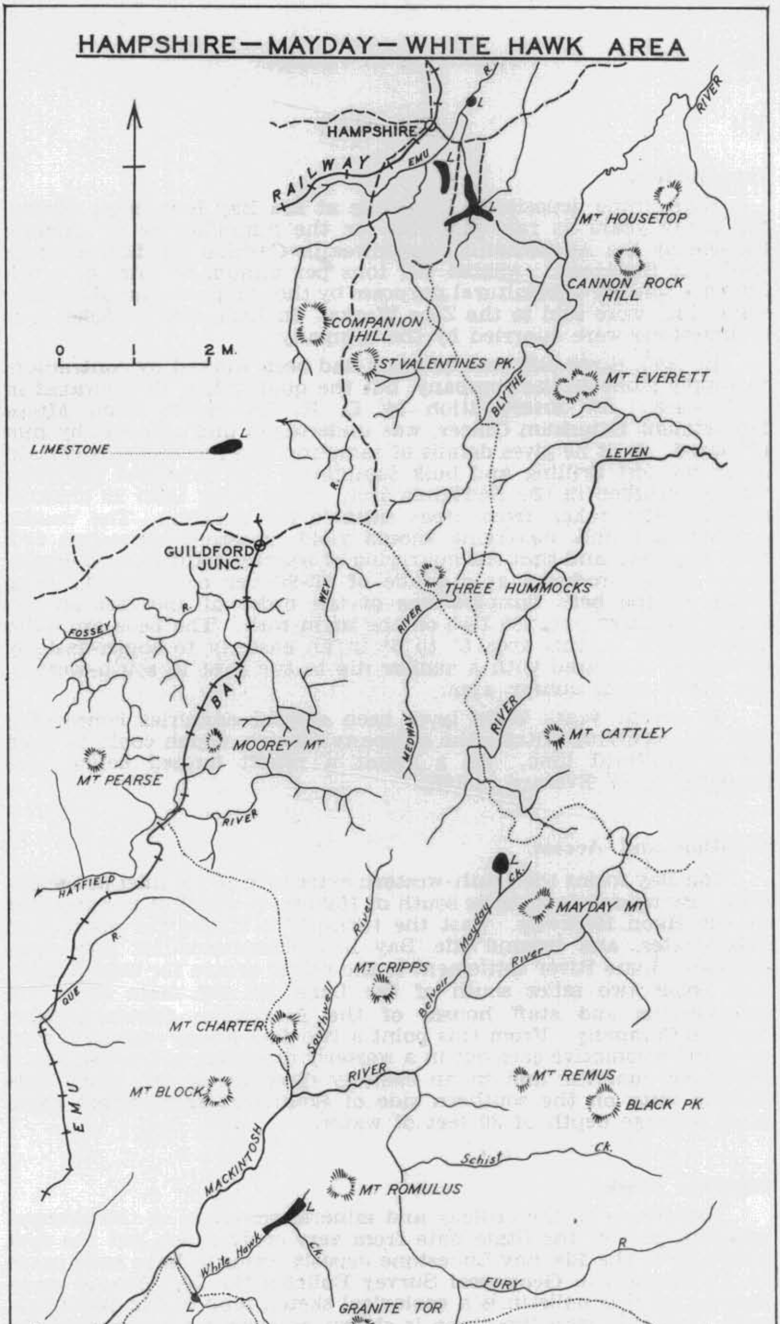

FIG. 19.—Hampshire, Mayday, White Hawk Creek.

VII IDA BAY

Introduction.

High-grade deposits of limestone at Ida Bay have been worked for many years as raw material for the manufacture of calcium carbide by the Australian Commonwealth Carbide Co. Ltd. at their works at Electrona. Almost 900 tons per annum of fines or quick lime are sold for agricultural purposes by the company and previously some fines were sold to the Zinc Works. In 1955, nearly 18,000 tons of limestone were quarried by the company.

In 1945, three different quarries had been worked by contractors to supply stone to the company, but the quality had deteriorated in each case. An investigation by D. R. Dickenson, then Mines Department Extension Officer, was undertaken and a report by him prepared. In it he gives details of sampling and recommends certain areas for test drilling and bulk sampling. The principal sampling was undertaken in the Newlands area, where more than 90 channel samples were taken from areas suitable for working. The results showed that bulk quarrying should yield limestone averaging 92.5 to 93 per cent, and that the quarrying of selected bands would enable stone to be produced at a grade of 95-96 per cent $CaCO_3$. The width of the beds sampled was of the order of 100 feet on the Eastern Quarry and 200 feet on the main wall. The beds are quite flat, dipping in this area 5° to 8° in an easterly to south-easterly direction, compared with a similar dip to the west to south-west in the other main quarry area.

In recent years there have been several enquiries concerning deposits occurring outside the company's leases, which could be used for agricultural lime. As a result a report quoted below, was prepared by G. Everard in 1951.

Location and Access.

Ida Bay forms the south-western extremity of the inlet of Southport. By road it is 65 miles south of Hobart, to which it is connected by the Huon Highway. Past the turn-off to Hythe the main road deteriorates, and beyond Ida Bay it is unsuitable for low slung vehicles. Lune River settlement is the postal centre for this district, and about two miles south of the Lune, on the main road, are installations and staff houses of the Australian Commonwealth Carbide Company. From this point a two-foot gauge railway served by diesel locomotive goes out in a westerly direction to the company's limestone quarries, and in an easterly direction to the Deep Hole loading jetty on the southern side of Southport Inlet where there is an average depth of 30 feet of water.

Previous Work.

References to the geology and mineral resources of the extreme southern part of the State date from very early times, but the first reference to the Ida Bay Limestone deposit seems to have been made by Twelvetrees in Geological Survey Bulletin No. 20. Among maps illustrating this bulletin is a geological sketch map of Ida Bay Coalfield. On this map limestone is shown as covering an area of the order of 1,000 acres, but boundaries are left indefinite, and in the text the limestone is assumed to cover a square mile. The deposit is discussed as a source of raw material for the manufacture of cement, and results of chemical analyses are given.

Department of Mines publication, Mineral Resources No. 7, " The Coal Resources of Tasmania," mentioned the Ida Bay limestone deposits in discussing the general geology of the Catamaran Coalfield. An accompanying map on a scale of 1/80,000 shows an area of limestone much greater than that given on Twelvetrees's map.

In 1926 the then Government Geologist, P. B. Nye, reported on " The Limestone Quarries at Ida Bay," giving the results of detailed sampling at different levels of quarry faces.

Geomorphology.

The area is one of strong relief, the variation in altitude being from sea level at Ida Bay, to over 1,700 feet at the summit of Sugarloaf.

The principal topographic feature is a spur running out from an inland plateau. To the north and south of the spur are the broad alluvial plains of the Lune and D'Entrecasteaux Rivers, respectively, and their tributaries. Islands of basalt, dolerite and older sediments outcrop through alluvial deposits, more particularly on the plain of the Lune. The spur is the watershed for tributaries flowing north or south to join the main streams.

The crest of the spur is not of even height, but consists of two hills, Sugarloaf and Caves Hill of about 1,700 and 1,400 feet respectively, joined by a saddle rising to 850 feet. Caves Hill is connected to the plateau of the hinterland by a similar saddle of about 1,000 feet in height. These saddles have been formed by back cutting of small streams lowering the height of the spur at favourable points.

Caves Hill is elongated in a lateral, and Sugarloaf in a meridional direction, so that the spur as a whole is T-shaped, with the cross-piece of the T forming the extremity. This extremity is the eastern fall of Sugarloaf and is a sharp even slope, with an almost linear extension from north to south, in the manner of an escarpment, but fading out rather rapidly in either direction. At the base of Sugarloaf there is a more gradual and confused slope, diversified by hills of basalt and dolerite, down to the main road.

Geology.

The youngest deposits in the area are Recent alluvial accumulations brought down by the rivers, and these are underlain by dolerite and older sediments, which on the plain north of the Sugarloaf appear as low hills rising out of the alluvium. Earlier than these were gravels of Tertiary age which form a thick apron on the northern side of Caves Hill.

The Caves Hill-Sugarloaf spur terminates in the scarplike eastern fall of the Sugarloaf, which is here interpreted as a fault, with the downthrow to the east. The spur itself is divided into two parts by a meridional fault passing through the saddle between the two hills, the downthrow again being to the east.

On the northern side of the Sugarloaf, Ordovician limestone is in contact with Recent alluvium and rises above it in cliffs and steep slopes to a height of about three hundred feet above the plain. Dolerite overlies the limestone, and persists right to the summit. On the southern side, Permian mudstones intervene between limestone and dolerite. The limestone has an average dip of 15° east and passes under the dolerite on the northern side, and under the mudstone on the southern side of the Sugarloaf, before the eastern escarpment is reached; and as the downthrow of the fault is to the east, there are no further outcrops of limestone in this direction.

On the northern side of Caves Hill, the base of the limestone is hidden by the Tertiary gravels previously referred to, although elevation subsequent to their deposition has caused deep corrosion by streams which disappear into caves in the limestone. The limestone rises out of the gravel beds in cliffs which may be of very ancient origin, now being revealed by erosion of later accumulations. Permian mudstones overlie the limestones and compose the remainder of Caves Hill. The limestones appear on the southern side of the hill below the mudstones, and on both sides, dip down under them to the west.

Geological History.

The geological history of the area begins in the Ordovician period with the deposition of clear water, free from sediment, of a great thickness of limestone. Subsequently, these deposits, together with any later ones that may have covered them, were elevated above sea level and gently folded into a broad arch. Then they were eroded until only part of the limestone remained, in the form of a hill with a broad, dome-like top and cliffed sides.

After a great interval of time, the area was again submerged in the Permian Period, resulting in the accumulation of shore line, and relatively shallow water, deposits completely burying the limestone.

During the Jurassic Period, elevation above sea level again occurred, during extensive epeirogenic activity, followed by intrusion of dolerite magma. The dolerite entered along the contact of mudstone and limestone, which marked the ancient land surface formed during the interval between Ordovician and Permian sedimentations. Large blocks of Permian and Triassic mudstones were lifted bodily to make room for the intrusive magma.

The erosion which followed this grand emergence has continued to the present day, with only minor fluctuations of level supervening. Thus Tertiary gravels were deposited along the northern side of Caves Hill, only to be eroded when a minor elevation of the land caused streams to corrode their beds. This erosion of the Tertiary deposits is proceeding now. The effective result, from the economic aspect, has been the deposition, and preservation from erosion, the limestone remaining from the Ordovician transgression and the subsequent emergence, and its partial denudation, so as to render it available to quarrying operations at the present day.

The Limestones.

Petrology.

Ida Bay limestones are tough, crystalline rocks of various shades of grey, and similar in appearance to the crystalline Ordovician limestones at Beaconsfield, Flowery Gully, and the equivalents of these in different parts of the State. They tend, on the whole, to be relatively light in colour, but dark and mottled varieties also occur.

Sometimes the rocks are reddish or brownish owing to the development of hydrated oxides of iron. These iron minerals are often included in recrystallising calcite, so that a particular specimen shows innumerable red or brown specks. The coloured calcite may be peripherally arranged around cores of uncoloured calcite. These pecularities do not seem to be in any way related to the calcium carbonate content. The chief impurities are graphitic and cherty inclusions, but these are irregularly distributed and do not form laminae as with some Flowery Gully stone.

Ida Bay limestones are well bedded and strongly jointed, but within the rectangular blocks so formed, the stone is massive and tough.

Chemical Analyses.

The numerous analytical results given in the table on page 137 attest to the uniformly high grade of the limestone. Since in no case does the calcium carbonate content fall below 90 per cent, an average grade higher than that figure may be confidently expected. After the acid insoluble residue, the chief impurity is magnesia, which, although it may be objectionable for some purposes, e.g., the manufacture of calcium carbide, is in this small concentration a positive advantage in limestone to be ground for agricultural lime. The other constituents are negligible, being less than one per cent.

Microtopography.

The disposition of the deposits is very favourable to quarrying operations. In the erosion of limestone, solution is probably more effective than denudation, and a considerable proportion of meteoric water passes underground via solution channels. In common, therefore, with many other deposits, the Ida Bay limestones rise in steep slopes above the other types of country. The vertical jointing of limestone is also very favourable to cliff formation, and cliffs ocur in the Ida Bay deposits. In some instances, as stated above, these cliffs are of ancient origin and have been revealed once again by preferential denudation of less consolidated strata.

These topographic features, common to limestones, are accentuated more on the northern than the southern side of the Caves Hill-Sugarloaf Spur. However, steep slopes with light overburden are the general rule on both sides, although the heavy growth makes appraisal of quarrying potentialities a difficult task on the southern side of the Spur. In connection with overburden, it should be noted that swallow holes, and solution channels filled with sediment, often replace the more normal type of overburden.

Other features of interest are large sink holes, caves and subterranean water-courses, any of which might affect the desirability of a particular locality as the scene of quarrying operations, and affect the extraction of stone. Some streams enter the limestones at the base of cliffs on the northern side of the Spur, and at elevated places on the southern side, to become subterranean channels, which have not been observed to reappear at the surface.

Mineral Leases and Quarries.

At the present time the Australian Commonwealth Carbide Company holds, as current or prospective leases, all the limestone deposits on the northern side of the Caves Hill-Sugarloaf Spur, except for two small separated areas shown on the geological map, and a reserve of 40 acres. On these leases four quarries have been opened, and one of these is in productive operation. The other three have been producers, but limestone is not now being taken from them.

A narrow-gauge railway line traverses the leases and terminates at the quarry on 8461/M. This is the largest and first-opened quarry, and was originally served by a tram-line that is now abandoned. Later quarries were opened on 8828/M and 9717/M, when the railway line had progressed that far from its starting point at Ida Bay. Subsequently the line was continued to the original quarry. The latest quarry to be opened is just below and a little to the west of the saddle between Sugarloaf and Caves Hill. A road has been built up to it, and stone is brought down by truck to the loading bin on the railway line.

Four leases were taken up for limestone on the southern side of the Spur and have since been allowed to lapse. Of these, one was in dolerite country where no limestone outcrop is now visible; the other three were each, in part, on the limestone area delineated on the southern side of the Spur. No limestone appears to have been taken from any of these leases. Access to them could have been gained either over the saddle from the northern side of the spur or by a tramway from Leprena, now collapsed and overgrown,

At the present time, to gain access to the limestone area on the southern side of the Caves Hill-Sugarloaf Spur, the best approach would appear to be from the main road at the most southerly point shown on the map herewith. This was the site of an old sawmill, and the remains of a tram-line can be followed in for nearly three-quarters of a mile. At a distance of about a mile and a half is the old tramway from Leprena, and a further distance of about a mile would bring one to the limestone. A road along this route would have an easy grade, but would require a fair amount of clearing and would have to cross some soft places.

Conclusion.

The effects of the information gained in this investigation have been to reduce considerably the probable area of limestone, and give it a more definite outline. It has also demonstrated that Sugarloaf, formerly referred to as a "Limestone mountain," consists principally of dolerite with limestone only at its base. The Ordovician limestones, in fact, do not rise to any great altitude, and this is more consistent with their type of occurrence met with elsewhere, and with their plan as a basal formation beneath the Permo-Triassic sequence in the south-eastern part of the State.

On the economic side, it has been demonstrated that workable deposits of limestone exist on the southern side of the Caves Hill-Sugarloaf Spur within a distance of three miles from the road to Leprena, and that these deposits are of approximately the same grade as those on the northern side of the Spur.

Reg. No.	Map Ref.	Acid Insol.	S	Fe_2O_3	Al_2O_3	MgO	CaO	$CaCO_3$ (calc.)
		%	%	%	%	%	%	%
646/51 ..	1	5.8	0.1	0.4	tr.	1.2	50.7	90.5
647/51 ..	2	5.7	0.1	0.3	0.1	0.8	51.6	92.2
648/51 ..	3	1.0	0.1	0.2	0.1	0.6	54.6	97.5
649/51 ..	4	3.1	0.1	0.2	0.1	0.9	53.1	94.8
650/51 ..	5	3.5	0.1	0.3	0.2	0.7	52.9	94.5
651/51 ..	6	3.2	0.1	0.4	0.1	1.6	52.0	93.0

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VIII. LOONGANA

Introduction.

This is one of the few areas of high-grade Gordon Limestone, situated on a metalled road, that has never been exploited except as a source of road material. This is probably because, although on a road, it is over 25 miles from the nearest large town, Ulverstone, and in this part of Tasmania there are deposits of equal grade in much more accessible areas. However, the deposit is sufficiently attractive for some record to be made of it and in 1951 a report was prepared by Hughes, as follows:—

Vast deposits of limestone, sometimes occurring in cliff faces of over 100 feet in height, fringe the valley of the Leven River between the Loongana Mill and the spectacular gorge known as Hell's Gates. These deposits have never been exploited for their lime content (they have been used as road metal) and no records exist either of their extent or quality. These are the same beds which outcrop at Gunns Plains and, indeed, as the crow flies, this latter locality is only a few miles from Loongana and is separated from it by high hills caused by a large anticline which has brought the more resistant pre-limestone rocks above the limestone. This latter rock occurs in synclinal troughs in each locality and the deposits are so similar in structure, extent and quality that a general report on one would be applicable to the other.

Location and Access.

Loongana is not a postal district and is the general name for an area extending along the Leven River above Hells Gates. A few farms still flourish in the eastern part of the district, but those to the west are nearly abandoned and timber milling and log hauling are the main sources of revenue. Because of these pursuits, many second-grade roads and tracks, suitable for heavy trucks or jeeps, have been opened up, in addition to the metal road which traverses the district. The nearest post office is at Nietta, 20 miles from Ulverstone and near the terminus of the Nietta Railway Line. From here to the commencement of the deposits is about six miles.

Topography.

The topography of the district has been greatly influenced by the type of rock. To the east of the area is portion of the great basalt plateau of North-Western Tasmania. Minor plateaux of basalt occur within the area. The easily-eroded limestones have resulted in the formation of a wide valley fringed with pleasant meadows and the change of topography at Hells Gates, where the harder Tremadoc sediments outcrop, is startling. These harder rocks form steep-sided ridges north and south of the area, trending as the rocks strike east and west. The highest of these ridges to the south is Black Bluff and that to the north is called locally the Badger. Pleistocene glacial action has influenced the topography, especially in the western portion of the area.

Geological Map.

The accompanying geological map of the area shows the relationship of the limestone to the underlying sediments. Occurring apparently conformably beneath the limestone are typical Tremadoc sediments, Tubicolar sandstone and, beneath that again, conglomerate. To the west of the area are slates of Cambrian age—probably belonging to the Dundas Series—which occur in faulted relationship to the limestone. Outpourings of lava in Tertiary times have resulted in the formation of basalt plateaux overlying the limestone. This basalt forms a lighter soil than that closer to the coast and may be correlated with Edward's Hampshire type. River flats of Recent aluvium fringe the river and major creeks, except Jeanbrook Creek, which flows over the basalt plateau and then suddenly plunges many hundred feet to the Leven in a few hundred yards. Under the basalt here and there may be seen remnants of Tertiary gravels and near the road about the centre of the area huge blocks of conglomerates indicate Pleistocene glacial action. The Tertiary and Pleistocene remnants, because of their limited extent, are not distinguished on the geological map.

Structure.

As at Gunns Plains, the limestone deposits form the top of a synclinal basin, the anticline between the two being of harder Ordovician and Cambrian sediments and forming the high hills and the deep gorge through which the Leven has cut and is cutting with great difficulty. The main axis of the syncline, striking at 90°, runs parallel to the general flow of the river. The beds to the north of the axis are wider in lateral extent than those to the south. This is probably due both to their shallower dip and the greater repetition by minor folding. Minor anticlines may be observed in cliff faces in more than one part of the area. To the south, the underlying Tubicolar and Owen conglomerate beds outcrop and are apparently conformable with the limestones.

Faulting in the district is common. A large major fault coursing north-west and dipping to the east, occurs to the west of the mill where Dundas slates are in faulted relationship to the limestone. This fault crosses the Loyatea Timber Road near some camps where Dundas slate outcrops to the west and conglomerate to the east. Where Jeanbrook Creek enters the Leven the limestone is in faulted relationship to Tubicolar sandstones and a splendid section of this fault may be observed on the river bank, where it strikes at 330° and dips to the south-west at 75°. On the geological map may be seen an isolated patch of limestone to the west of the main mass. The structure that has determined this is, owing to lack of outcrop and a cover of basalt and alluvium, rather obscure. The limestone outcrops only along the bed of the creek for a few chains and is in faulted relationship with Cambrian sediments to the north. It can only be assumed that these beds belong to a small downthrust block.

The Limestone.

These beds, both in structure, extent and content, bear a marked resemblance to those at Gunns Plains, and well they might, for they are the same beds as in that locality and distant some four miles away. They belong, then, to the Gordon Limestones and consist of well-marked beds of dark-blue, high-grade, crystalline limestone, well provided with bunches and seams of white calcite. The width of the beds seems to be 1,500 to 2,000 feet, so that they have suffered more erosion than at Gunns Plains. Quantities available for quarrying are almost limitless. The limestone outcrops along either side of the Leven Valley for a distance of four miles. The width of the beds across the strike is about one mile, though this is covered in places by alluvium and basalt.

The quality of the limestone is the same as that at Gunns Plains, where intensive sampling revealed that the individual beds did not vary greatly in $CaCO_3$ content. Seven samples only were taken here and of these, four (48-51) were obtained from different beds from the road-metal quarry, situated not far beyond the bridge over the Leven. Two samples (52 and 53) were taken from composite beds at the Big Face over the Leven River and one (54), a composite of the beds in the western outcrops. These samples showed:—

Sample	Insol.	Fe_2O_3 & Al_2O_3	CaO	$CaCO_3$	MgO	$MgCO_3$
	%	%	%	%	%	%
48 ..	7.0	0.8	50.5	90.1	1.2	2.5
49 ..	8.4	1.0	49.5	88.3	1.3	2.7
50 ..	11.6	0.8	47.2	84.2	2.0	4.2
51 ..	8.0	0.8	49.2	87.8	1.8	3.8
52 ..	3.2	0.4	52.9	94.4	1.2	2.5
53 ..	8.4	0.6	48.7	86.9	2.1	4.2
54 ..	7.7	1.0	48.3	86.2	2.5	5.2

It can thus be seen that there is no great variation in the individual beds and an average grade of 88 per cent $CaCO_3$ would probably cover the whole area. $MgCO_3$ is rather high (3·6 per cent), but SiO_2 is not, averaging eight per cent.

Quarry Sites.

Natural quarry sites abound in the area and two have been opened to a limited degree for road metal. However, there is one site which surpasses all others. This I have called the Big Face and it is portion of a spur of limestone with no overburden but a little soil, situated just over the Leven River at the second bridge. Here a spur of limestone some 500 by 1,500 feet, rises to a height of 200 feet above a flat plain, through which flows the Leven. The actual sheer face is 70 feet in height and two samples were taken from this—No. 52 from flat level to 28 feet, and No. 53 from 28 to 70 feet. These showed limestone of high grade averaging over 90 per cent $CaCO_3$. Well over five million tons of limestone are readily available from this spur.

Conclusions.

The Loongana area, which is situated within 10 miles of a railhead, contains vast quantities of high-grade limestone some of which outcrops on spurs, from which it could be quarried with the greatest of ease.

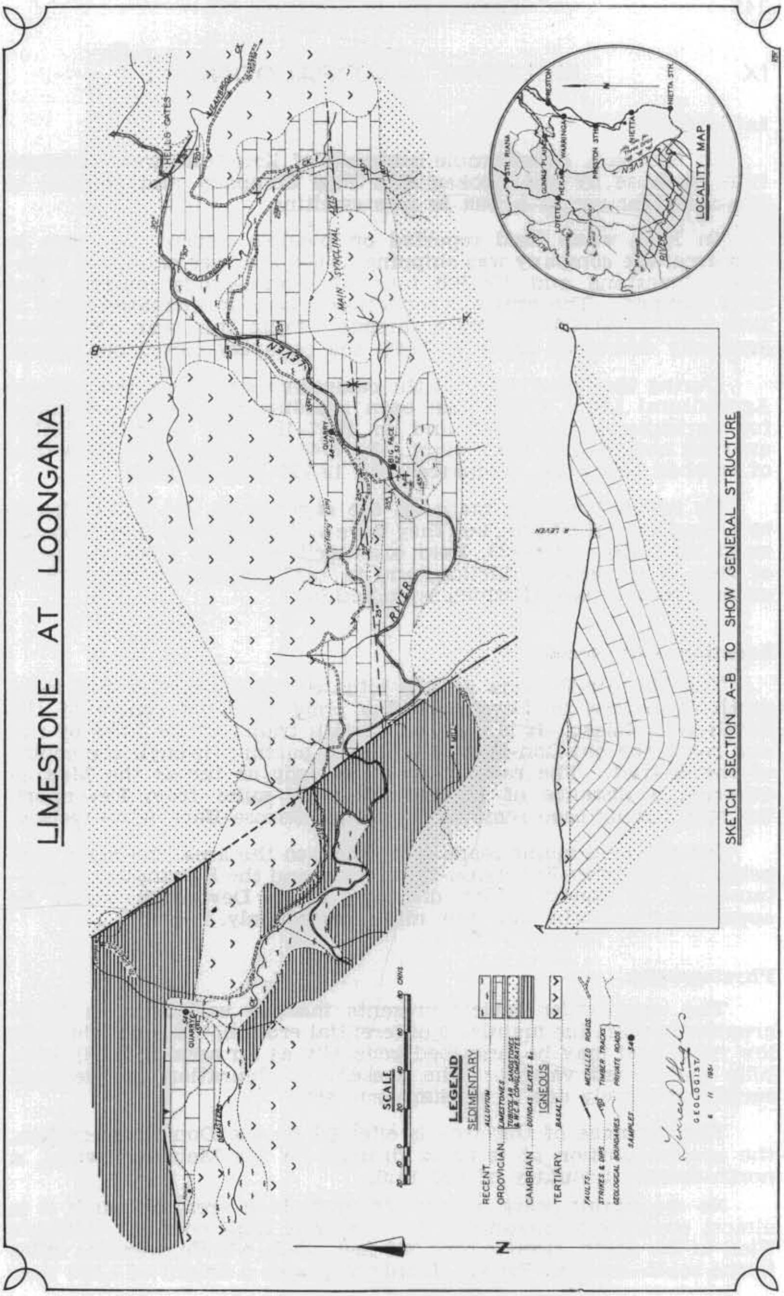

FIG. 20.—Loongana Area.

IX MELROSE AND PALOONA

Introduction.

In the past, considerable amounts of limestone were obtained from Melrose by the Broken Hill Pty. Company and shipped to Newcastle for use as a flux in iron smelting.

In 1923, when Reid reported on possible cement materials in this area, the company was shipping 50,000 tons per annum of high-grade limestone and 100,000 tons of second-grade material had been dumped. The annual production gradually increased until in 1939 nearly 300,000 tons were shipped. From this year production gradually decreased until, in 1947, the company closed operations.

During the latter years of the company's operation, the Melrose Agricultural Lime Works had been grinding the waste screenings for agricultural limestone and in 1947-48 took over the B.H.P. quarries and part of their plant. In 1948 they produced 9,644 tons of crushed limestone, compared with 13,785 tons in 1955.

No report has been made on the deposits on the B.H.P. leases by Departmental officers, but they have visited the area and reported on it generally. In 1923, Reid examined the field from the point of view of cement production, and in 1937 Henderson submitted a general report, part of which is quoted here.

Location and Access.

The Melrose-Paloona area is situated approximately five miles south-south-west of Devonport, the chief shipping centre of the North-West Coast. It is well served with transport facilities by rail and road; the old Don-Barrington tram passing through the centre of the district. The railway is in use only as far as the Melrose quarries, a distance of approximately 8½ miles from Devonport, the rails having been removed from the Melrose-Barrington section.

Several good motor roads give access to the area, the main ones being the Tarleton-Eugenana-Barrington and the Barrington-Hamilton-on-Forth roads. The distances from Devonport would be approximately eight and ten miles respectively.

Physiography.

The area under review presents marked variations in topographical relief, due mainly to differential erosion. It is of relatively low relief and may be described generally as an area of fairly high hills and broad valleys. The present configuration of the land surface is largely due to stream corrosion.

The drainage of the area is effected by the Don River system, the greater portion of it being drained by the Melrose Rivulet, a north-flowing tributary of the Don.

No mountains occur within the immediate area, although it is almost completely surrounded by relatively high country. Kelcie's Tier, to the north, rises to over 500 feet, while a little over two miles to the south-east the Brown Mountain attains a height of 1,100 feet.

The Limestone.

The limestone, generally, occupies the lowlands and flanks the low hills. In the flat country, between the few isolated outcrops which stand out prominently as rocky projections with rounded contours, its presence is indicated by a brick-red, clayey soil, hardly distinguishable from that derived from the basalt; the amount of clay overburden present is extremely variable and reaches a depth of at least 25 feet in some places. The exposure in the higher country is usually devoid of clay.

The general strike of the cleavage is north 10°-20° east with a steep south-westerly dip; owing to the upturned edges percolating waters have easy access to cleavage planes and joints, and bores put down by the Broken Hill Proprietary Company have indicated the presence of clay bands (61 per cent insoluble) up to five feet thick at depths of 100 feet.

The limestone varies in texture from compact to wavy and even schistose. The dominant colour is a bluish-grey; it weathers along cleavage planes to a lilac-coloured material.

Calcite, reprecipitated from percolating solutions, has been deposited in cleavage planes, joints, &c., and in places becomes fairly aboundant.

No limestone deposit is entirely free from impurities, the most common of which are silica, alumina, iron compounds, organic matter and sulphur. The average composition of 14 samples taken show that with probably one exception, the silica, none of the deleterious substances are present in harmful amounts for most practical purposes.

$CaCO_3$	89.1	per cent, varying from	73.1	to 95.0	per cent.
Acid Insoluble .	6.86	per cent, varying from	3.64	to 20.6	per cent.
Al_2O_3	0.40	per cent, varying from	0.14	to 0.85	per cent.
MgO	0.76	per cent, varying from	0.38	to 1.84	per cent.
Fe_2O_3	0.21	per cent, varying from	0.34	to 2.53	per cent.
MnO	0.025	per cent, varying from	0.01	to 0.09	per cent.
Phosphorus	0.01	per cent, varying from	0.01	to 0.04	per cent.
Sulphur	0.10	per cent, varying from	0.03	to 0.61	per cent.

The analyses of Nos. 1 and 11 suggest the presence of pyrite.

All outcrops with sample sections referred to are located on the geological map. The heights shown were obtained by abney level readings in conjunction with the railway survey. The contours are reasonably accurate at the individual outcrops and, while those in the vicinity of the Broken Hill Proprietary Company's area were taken from one of the company's surveys, elsewhere they are more in the nature of form-lines and are only very approximate.

No. 1 Outcrop.

This is situated about six chains north of the Broken Hill Proprietary Company's office and is nearly 400 feet long and 100 feet wide. It rises to a height of about 30 feet above the general level. The following analyses indicate the quality of the limestone:—

	Sample	
	No. 9 (Reg. No. 144)	No. 10 (Reg. No. 145)
	%	%
Moisture at 105C°.	0.10	0.10
Loss on ignition..	39.72	39.84
Acid Insoluble	8.00	7.36
CaO	50.24	50.64
MgO	0.72	0.76
Al_2O_3	0.49	0.40
Fe_2O_3	0.77	0.62
MnO	0.01	0.01
P_2O_5	0.01	0.01
S	0.06	0.04
	$CaCO_3$ 90%	90.15%

The most northerly outcrop (No. 2) occurs on A. Rundle's property approximately six chains north of the Melrose railway station and extends northward over a width of at least 400 feet for 15 chains. This outcrop rises to over 120 feet above river level and presents no features strikingly different to the general character of the limestone.

A smaller outcrop occurs to the east on Walter Lyne's property but this was not sampled.

The average quality of the stone is indicated by the following analyses:—

	(1) Reg. No. 136	(2) Reg. No. 137	(3) Reg. No. 138	(4) Reg. No. 139	(5) Reg. No. 140
	%	%	%	%	%
Moisture at 105°C.	0.12	0.06	0.06	0.06	0.06
Loss on Ignition ..	33.56	39.66	38.34	39.60	39.54
Acid Insoluble ..	20.60	8.84	10.80	8.52	7.88
CaO	41.04	50.14	48.98	50.24	50.7
MgO..	0.38	0.59	0.49	0.62	0.49
Al_2O_3	0.53	0.16	0.28	0.17	0.24
Fe_2O_3	2.53	0.84	0.98	0.77	0.90
MnO	0.09	0.03	0.01	0.01	0.01
P_2O_5..	0.04	0.01	0.01	0.01	0.01
S	0.48	0.07	0.06	0.04	0.05
SO_3	0.27	—	—	—	—
$CaCO_3$	73.1%	89.75%	87.5%	90%	90.25%

Due west of the Broken Hill Proprietary Company's Melrose quarry, and just south of the Don River, No. 3 outcrop rises to a height of approximately 180 feet above sea level, that is, 80 feet above the general ground level. The massive outcrop of limestone extends over 450 feet in length with a maximum width of at least 200 feet. A small quarry was opened by Messrs. Cornelius and Dally on the south side, many years ago for the purpose of obtaining limestone for burning.

The strike of the cleavage (15°) with the almost vertical dip shows no marked deviation from the general strike and dip of the series.

The average quality is indicated by the following analyses:—

	Sample		
	No. 6 (Reg. No. 141)	No. 7 (Reg. No. 142)	No. 8 (Reg. No. 143)
	%	%	%
Moisture at 105°C. ..	0.06	0.06	0.06
Loss on ignition ..	40.44	41.50	41.76
Acid Insoluble ..	6.56	3.64	5.28
CaO	51.34	53.22	50.50
MgO	0.78	1.00	1.84
Al_2O_3	0.17	0.14	0.34
Fe_2O_3	0.49	0.34	0.70
MnO	0.01	0.03	0.03
P_2O_5	0.01	0.01	0.01
S	0.03	0.06	0.06
$CaCO_3$	91.75%	95.0%	90.0%

Approximately one half-mile west-south-west of the Broken Hill Proprietary Company's quarry, a small outcrop (No. 4) occurs near the western boundary of G. E. Cooper's 139 acres S.S. property. It is over 300 feet in length with a maximum width of at least 150 feet and rises nearly 50 feet above the general ground level approximately 170 feet above sea level.

The character of this deposit differs in no way from the other outcrops described. A few small, isolated outcrops are exposed in the Melrose Rivulet for a further distance of four chains to the west. No outcrops occur west of this exposure.

The following analyses is indicative of the average quality:—

	Sample No. 13 (Reg. No. 148)
	per cent.
Moisture at 105°C.	0.10
Loss on ignition	40.80
Acid Insoluble	5.68
CaO	51.10
MgO	0.72
Al_2O_3	0.68
Fe_2O_3	0.92
MnO	0.03
P_2O_5	0.01
S	0.03
	$CaCO_3$ 91.2 per cent.

On the old reserved road about half a mile south of the Broken Hill Proprietary Company's quarry, a small outcrop (No. 5) occurs south of the area proved by that company by means of bores. Further south, Tertiary gravels and basalt mask any extension of the limestone.

The same average quality is maintained as the following shows:—

	Sample No. 14 (Reg. No. 149)
	per cent.
Moisture at 105°C.	0.08
Loss in ignition	40.22
Acid Insoluble	7.28
CaO	50.50
MgO	0.44
Al_2O_3	0.85
Fe_2O_3	0.70
MnO	0.04
P_2O_5	0.01
S	0.03
	$CaCO_3$ 90.1 per cent.

About 12 chains east of the Don River bridge on the Eugenana-Melrose road, A. R. Rundle has opened a quarry in the most easterly of the prominent outcrops (No. 6) for the purpose of obtaining limestone for burning. The overburden reaches a depth of at least ten feet. The limestone has almost a gneissic structure with eyes of calcite well developed. The strike is north 10° east and the dip almost vertical. This exposure is covered south of the Don River by basalt.

The average quality is indicated by the following analyses:—

	Sample No. 11 (Reg. No. 146)
	per cent.
Moisture at 105°C.	0.08
Loss on ignition	38.44
Acid Insoluble	9.64
CaO	49.48
MgO	0.72
Al_2O_3	0.40
Fe_2O_3	0.92
MnO	0.03
P_2O_5	0.01
S	0.198
SO_3	0.10
	$CaCO_3$ 88.5 per cent.

The only other exposure worth noting is the outcrop (No. 7) occurring on J. Jeffries' property about eight chains south-east of where the overhead railway bridge crosses the Melrose-Paloona road. Here the limestone is exposed over a width of at least 15 chains to a height of 240 feet on the side of a hill, rising on a grade of about one in three, where it is overlain with basalt, at approximately 460 feet above sea level.

The limestone appears to be more massive in this exposure than those further north, although there is little variation from the general composition, as the following indicates:—

	Sample No. 12 (Reg. No. 147)
	per cent.
Moisture at 105°C.	0.08
Loss on ignition	40.90
Acid Insoluble	6.00
CaO	50.70
MgO	1.12
Al_2O_3	0.70
Fe_2O_3	0.56
MnO	0.01
P_2O_5	0.01
S	0.03
	$CaCO_3$ 90.25 per cent.

Conclusion.

From this brief examination, which included only those outcrops outside the Broken Hill Proprietary Company's main quarry at Melrose and the area bored south of the Don River, it was readily apparent that almost unlimited quantities of good average-grade limestone are available; that the limestone continues to a depth far below the reach of mining operations, is without doubt.

Situated on completely cleared agricultural lands, within eight or nine miles by rail and road from Devonport, an important shipping centre, and requiring, to command the most distant outcrop, only the relaying of rails on the existing formation, for a distance of less than three miles, the conditions for economical operation with excellent transport facilities are extremely favourable.

In 1956, K. Burns was engaged in mapping an area which included these limestone deposits and he has supplied the following geological information:—

> "The oldest rocks in the district are Pre-Cambrian rocks which outcrop along the Forth River to the west. Overlying these uncomformably is a sequence of Lower Ordovician conglomerate, sandstones, and shales. These are succeeded conformably by the Gordon Limestone. the contact running north-south just west of Melrose Creek, and east-west north of the B.H.P. quarries. The general structure is a brachysyncline, elongated north-south, with the south-east portion concealed by basalt. West of the quarries, the limestone is thrown against Permian, a fault running north-north-west from Aberdeen. Tertiary (prebasaltic) gravels occur south of the Broken Hill Proprietary Company's magazine. Tertiary basalt is represented by flows south of Melrose."

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X MOINA, LORINNA AND ROUND HILL

These areas are located partly in the Sheffield and partly in the Middlesex Quadrangles and are thus part of the area being mapped by the regional staff of the Mines Department at Lorinna. This chapter has therefore been written by the regional geologist, I. B. Jennings.

Introduction.

The limestone deposits in these localities, whilst not extensive, may prove to be useful for local requirements. All these deposits belong to the Gordon Limestone formation of Lower Ordovician age. In no case are the upper beds of the limestone or the overlying Silurian and Devonian rocks present. Whilst it is not envisaged that any development is likely in these areas immediately, it is desirable to record their presence for the future.

Location, Access and Facilities.

The location map covers an area of somewhat more than 200 square miles and is centred about a point approximately 24 miles almost due south of Ulverstone. It can be seen that very little of this area is covered by the limestone deposits.

Access throughout the area is generally difficult, but all the limestone deposits lie on or close to the few metalled roads available. The Moina deposits are all close to the road leading from the Moina post office to the crossings of the Iris and Lea Rivers. From Moina this road leads back to Wilmot and thence by good roads to either the Bass Highway at Leith or to the Sheffield area. The Lorinna and Round Hill limestones lie close to the gravelled road leading from Cethana to Lorinna. However, the small limestone deposits occurring in the bed of Claude Creek, south of Round Hill, are difficult of access being in the bottom of the gorge cut by the creek.

As with the access, the power and other facilities are limited. The Moina deposits are best situated in this regard as a recent extension of the electrical power grid to the Moina Tin Tungsten Mine near Moina brings the power to within a mile or so of the limestone areas. No supply of electric power is available in the neighbourhood of any of the other limestone areas. Telephone services follow the roads described above and are thus available close to the limestone areas. No railway facilities occur near any of the limestone areas.

The only fuel supplies in the area are those afforded by the timber resources; however, these are abundant. The nearest available coal beds occur at Spreyton, some 40 miles from Lorinna, 34 from Round Hill, and 36 miles from Moina by road. These coal deposits, however, are strictly limited and the present output in the area is very small.

Physiography.

The area covered by the location map consists essentially of an elevated, dissected basalt plateau bounded to the north and partially to the west by rugged quartzite and conglomerate hills extending from Mt. Claude to Mt. Stormont. These rock barriers partially dammed the basalt flows coming in from the south, which now form the well-known Berriedale, Middlesex and February plains. Apart from the northern mountains, the older rocks are almost completely confined to the deep gorges cut through the basalts by the Forth, Wilmot, Iris and Lea Rivers.

Over the whole area the limestone deposits are far too small in relation to the overall topography to have any pronounced effect upon the physiography. Certainly, they form depressed areas due to their relatively high solubility, but these areas are small and the erosion is far from complete.

Evidences of the Pleistocene glaciation are found at many parts in the area, notably in close proximity to the limestone deposits since they tend to form the low-lying areas. However, the main centres from which the glaciers were fed lie somewhat south of here and it is mainly dissected remnants of the morraines which are preserved here. The present drainage system seems to have been modified only in detail by this period of glaciation.

Geology.

(*A*) *Stratigraphy.*

The following rock units are present in this area:—

Recent-Quaternary	Residual soils, talus and scree deposits, river alluvium and glacial tills.
Tertiary	Basalt, agglomerate and tuffs with minor interbedded clays and sands.
Devonian Unconformity	Granite intrusions.
Ordovician	Gordon Limestone, Tubicolar quartzites, sandstones, grits and shales. Owen Conglomerate.
Unconformity	
Cambrian	Quartz and Quartz Felspar Porphyries, Slates, Argillites, Greywackes & lavas.

(*B*) *Structure.*

The Ordovician rocks have been closely folded and faulted. The axial trend of the folds is roughly north-west over the majority of the area, but swinging more closely to east-west at Mt. Stormont. The major folds are large-scale Anticlinoria and Synclinoria and four orders of folding can be recognised. These folds are closely paralleled by a system of strong thrust faults. Locally the rapid lensing out of the Owen Conglomerate deflects the faulting somewhat. Differential movement between the fault blocks is taken up by a series of north-east trending tear faults.

A later system of normal faults of Tertiary age is superimposed upon this structure and it is often difficult to determine the age of any particular fault without mapping over some distance.

The limestone areas have been preserved in down-faulted blocks and in the centre of synclines. At Tin Spur and Moina the limestone close up to the granite has been completely altered to a skarn rock consisting of garnet, epidote and diopside with fluorite, vesuvianite and magnetite. The ore bodies at the Moina Tin Tungsten Mine in the skarn rock carry appreciable quantities of scheelite as well as wolframite and cassiterite.

The Limestone Areas.

(*A*) *Round Hill.*

The three small deposits in the vicinity of Round Hill are the smallest and least important deposits in the area. Two of the deposits occur in the bed of Claude Creek along the axis of the Claude Creek synclinorium. The third deposit occurs in the No. 3 Adit (water tunnel) of the Round Hill Mine. The limestone was encountered during the exploration of this area and for many years the underground water issuing from the limestone served as a useful source of water for the mine. The limestone does not outcrop at the surface, being covered by glacial till. As exposed in the adit, the rock is a dense, blue-grey limestone, closely jointed and containing numerous knots and stringers of calcite. As far as is known the limestone is unfossiliferous. Due to its position the limestone can hardly be expected to be of economic importance.

The small areas of limestone in the bed of Claude Creek lying about half a mile west and south of Round Hill proper are also of very doubtful economic value. These occurrences are the remnants of the once extensive Gordon Limestone in this area. The widespread erosion has removed all but these two small blocks which have been preserved along the axis of the folds. In both cases the limestone overlies dense quartzites of the Tubicolar sandstone formation. The lower of the limestone masses is about 50 feet thick and extends up the creek mainly along the west bank for about 1½ chains. The limestone is fairly massive and weathers to a light-grey colour. The beds are close to the base of the limestone formation and may have been affected to some extent by the widespread silicification of the underlying rock. The high silica content may also be partly original. At the lower outcrop the beds dip south at 30° and strike 115° magnetic. The higher deposit is extentially similar but the limestone is more closely jointed and crushed. The attitude of the bedding is difficult to determine here but it appears to dip flatly to the north down the pitch of the fold. Both the deposits are relatively impure, small in size and difficult of access. They are therefore of little economic importance.

Analysis.

Upper Locality Claude Creek.

Reg. No.	853
Acid Insoluble	26.0%
$Fe_2O_3 + Al_2O_3$	2.8%
CaO	38.6%
MgO	1.3%
Ignition Loss	31.2%

Lower Locality Claude Creek.

Reg. No.	854
Acid Insoluble	25·9%
$Fe_2O_3 + Al_2O_3$	3.5%
CaO	36.6%
MgO	2.5%
Ignition Loss	31.7%

A further analysis of a "typical limestone from Claude Creek" is given by Hughes in his report on the area dated 9/11/48:—

	%
SiO_2	10·12
Al_2O_3	1.45
Fe_2O_3	2.29
MnO	0.03
P_2O_5	0.03
CaO	43.50
MgO	3.81
Ignition Loss	38.04

This is notably purer than the analyses given above and apparently represents a bed of selected limestone whilst the other samples are from chip samples across the whole outcrop and therefore represent an average.

(*B*) *Lorinna.*

The two areas of limestone on this area have been termed "Barrett's" and "Campbell's" limestones locally, as the main outcrops occur on land occupied by Messrs. Barrett and Campbell.

Campbell's Limestone.—The best outcrops of this limestone occur as a series of cliffs rising about 100 feet from the alluvial flats on the east bank of the Forth River about 10 chains downstream of the bridge. Although this limestone deposit is quite extensive, the majority of it is obscured by alluvium, glacial till and basalt talus east of the cliffs.

From an economic point of view Campbell's limestone is the most important. The cliff faces to the east of the Lorinna Showground offer good sites for quarrying operations. However, the face may become rather too high if developments are carried too far to the east. The limestone is underlain by the Tubicolar sandstones to the south-west and are faulted against Cambrian porphryies to the north. The limestone has been preserved as a narrow belt close up to the fault. The limestone is light-grey when weathered, generally massive but strongly jointed by major joint system trending 20°. The beds strike about 150° and dip 35°-40° to the east. The limestone contains a few calcite veins and fossils. An impure shaley bed occurs at the base of the cliffs.

Analyses of a chip sample up the cliff face at the Showground are as follows:—

Reg. No.	852
	%
Acid Insoluble	10.6
$Fe_2O_3 + Al_2O_3$	1.4
CaO	47.7
MgO	1.7
Ignition Loss	39.3

Barrett's Limestone.—The main occurrence of this limestone is again in a narrow down-faulted block, which trends north-west along Limestone Creek, about half a mile south of the Lorinna post office. Downstream from the bridge over Limestone Creek for about half a mile, this creek has cut a deep gorge in the limestone so that some very good sections are exposed. Numerous caves may be found along the creek bank and it must be expected that the limestone mass in general is cavernous. The limestone is, as usual, a light blue-grey when weathered and dark-blue to black when fresh. It is quite massive and in the upper part of the outcrop very thickly bedded in beds up to 20 feet thick. The main jointing is strong but widely spaced. They are vertical or dip south at about 80° and strike about east-west.

Lower down the creek the limestone occurs in beds about two to three feet thick, which contain numerous thin impure bands, giving the outcrop a wavy banded appearance. Frequently the rock has a white spotted appearance due to small calcite inclusions. The regional dip is to north at 10° and the strike is about 75° magnetic. A few local variations in dip and strike occur due to a few small faults but there is no widespread shearing of the rock as is often seen elsewhere.

Analysis of Barrett's Limestone:—

Reg. No.	851
	%
Acid Insoluble	14.0
$Fe_2O_3 + Al_2O_3$	1.7
CaO	45.9
MgO	1.5
Ignition Loss	37.3

The site selected for the sample was a small hill situated about two chains along the south bank of Limestone Creek from the bridge.

(*C*) *Moina.*

Whilst a large area of the alluvial flats of the Iris River west of Moina is underlain by limestone it is almost completely obscured by river alluvium, glacial till and basalt talus. At the bridge over the Iris an outcrop of thinly-bedded limestone occurs. The limestone beds are fossiliferous containing corals and bryozoans. They also contain numerous calcite veins along the bedding planes. The banded appearance of the outcrop is due to the varying degrees of purity of the rock. The quartzite beds associated with the limestone are up to two feet thick. The lack of outcrop makes it difficult to ascertain the position of these beds within the formation. Since it would be extremely difficult to select the pure beds alone for quarrying purposes, a chip sample across the whole outcrop was taken. The result given below indicates that the deposit is of no economic value.

Reg. No.	577
	%
Acid Insoluble	61.8
$Fe_2O_3 + Al_2O_3$	6.1
CaO	16.7
MgO	0.9
Ignition Loss	13.9

Further outcrops of the limestone occur downstream between the bridge and the Iris-Lea Junction. Near the junction of Bismuth Creek and the Iris, about 10 feet thickness of limestone is exposed over a small area. This outcrop is much more massive and thickly bedded than the higher occurrence, but has a foliated appearance due to the slightly impure bands. The outcrop is strongly jointed, being close to a major fault, but is not schistose. Analyses of this outcrop are:—

Reg. No.	855
	%
Acid Insoluble	9.2
$Fe_2O_3 + Al_2O_3$	2.2
CaO	47.0
MgO	2.9
Ignition Loss	38.6

Summary.

Of the deposits described in this area, most are either inaccessible or impure. Power and transport facilities in the area generally are poor and there is at present no local demand for limestone. Should any such demand arise in the future the Lorinna deposits appear to offer the best prospects for large scale operations. Small local demands in the Moina area could be satisfied by the deposits in Bismuth Creek. However, other outcrops in that general area occur in the vicinity of the junction of Brampton Creek with the Iris River and these should also be sampled.

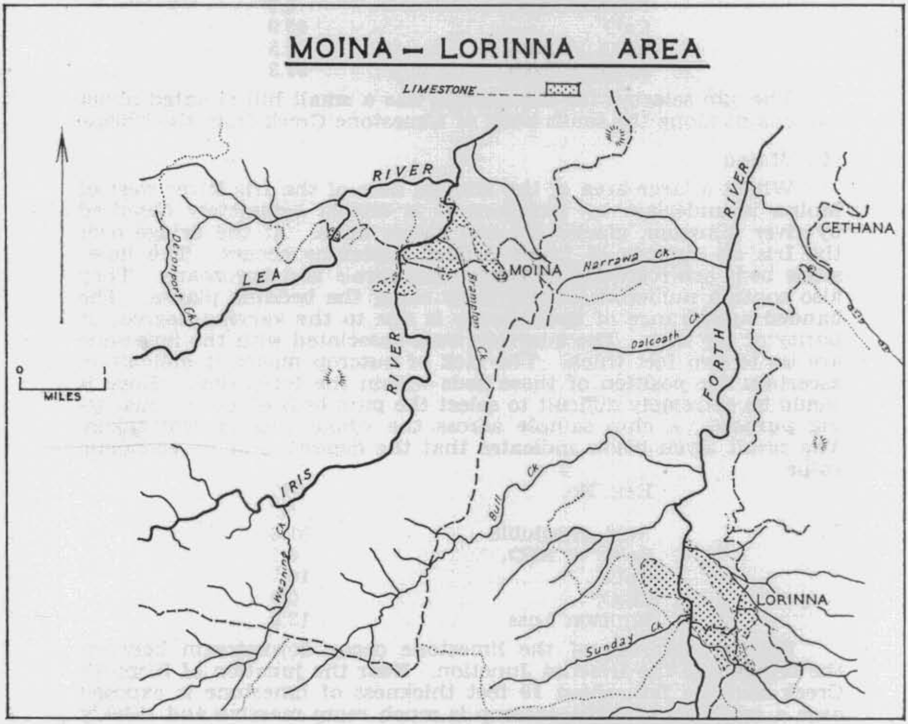

FIG. 21.—Moina-Lorinna Area.

XI MOLE CREEK, CHUDLEIGH AND LIENA

Shortly, the Department of Mines is to publish the Geology of the Middlesex Map Quadrangle, which has been prepared by the regional staff at Lorinna. In this mapping is included a huge limestone area stretching from Liena in the west to Chudleigh in the east. These beds have recently been mapped by the regional staff and a description prepared by I. B. Jennings, who has written this chapter.

Introduction.

Although the presence of limestones in this district has been known since the early days of settlement, there has been little attempt to exploit them. The interest in the limestone has been largely centred upon the numerous limestone caverns, whilst small amounts of limestone have been used for road dressing and very minor quantities burnt for agricultural purposes. At present the caves at Liena (the King Solomon Caves) and at Mayberry (the Marrakoopa Caves) are open to the public. However, many other caverns exist in the area and some of these may be equally suitable for development.

About 1840, small quantities of limestone were quarried and burnt for agricultural purposes in the Dairy Plains district but this has long been abandoned. At present the lime requirements for this important agricultural district are satisfied by carrying limestone from Railton (35 miles) and Melrose (55 miles). The continued use of artificial fertilisers for agriculture must inevitably increase the already significant demand for lime in this area. As this report indicates, immense quantities of readily-accessible, high-grade limestone are available and it is indeed surprising that no effort is made to meet this demand locally.

Whilst the production of limestone and its products for agricultural purposes appears to be the most promising immediate development, industrial uses should by no means be discounted. The vast forest resources south of Liena are at present under active development and this suggests that the establishment of a paper pulp industry is not impossible. Adequate power and transport facilities in close proximity to the limestone deposits make the area attractive for the establishment of almost any industry requiring large quantities of limestone.

The areas selected for sampling were chosen primarily for their proximity to transport and have barely touched the great mass of limestone available. Even so, the analyses indicate that limestone pure enough for all but the very highest grade metallurgical and chemical purposes is available. Doubtless even higher grade limestones could be located if required for special purposes.

No comprehensive geological survey has previously been conducted in this area. The present survey was carried out by traversing all the geological boundaries and plotting these onto air photos on a scale of 45 chains to one inch. The contoured base map was prepared by photogrametrical methods by the Lands and Surveys Department and is the most accurate map available for the area. Very little extrapolation of the geological boundaries has been incorporated and the map can be regarded as essentially factual. The survey was conducted during January and February, 1956, as part of the regional geological survey of the Middlesex Quadrangle. Only the limestone and immediately adjacent areas are shown in the accompanying map as it is anticipated that a complete geological map of the whole quadrangle will be published soon.

Location, Access and Facilities.

The area occupied by limestone consists of an elongated basin trending roughly east-west from the Mersey River at Liena to beyond Chudleigh. The basin is thus over 16 miles long and assumes a width of about six miles at its broadest part. The limestone extends eastward beyond Chudleigh and may well form an unbroken belt from Liena right through to Quamby Brook. However, since the most important deposits occur in the vicinity of Mole Creek township, and west of there, and that east of Dairy Plains is very largely obscured by alluvium, it has not been considered necessary to extend the map beyond these limits. The approximate co-ordinates of the Mole Creek township on the State four-mile map of Tasmania are north 884000 east 437000.

Access and facilities throughout the area are generally good. Mole Creek is joined to the Bass Highway at Deloraine by a good all-weather highway which is at present undergoing extensive reconstruction and sealing. West of Mole Creek a good gravel road connects this town with Mayberry and Liena. Beyond Liena a third-class road, negotiable in dry weather only, leads over Gad's Hill to the Forth Valley. The secondary roads indicated on the plan are all fairly good gravel roads, negotiable in all weathers. A second-class rcad leading through the saddle between Mts. Roland and Gog gives access to the agricultural districts surrounding Sheffield and Beulah.

Electric power is available to most points of the area as far west as Mayberry. Mole Creek is connected by rail via a branch line which joins the main north-west railway system at Lemana Junction, three miles west of Deloraine.

The area east of Mayberry is largely occupied by farms, but west of there the farms become poorer and more scattered and timber becomes increasingly important. In general, the flat areas covering the limestone are occupied by farms, whilst the foothills of the Western Tiers and the western portion generally are important for timber. To the north the slope of Mts. Roland, Magog and Gog offer appreciable supplies of timber but are difficult of access. There are no known workable deposits of coal in the area and firewood is the only source of fuel.

Physiography.

The physiography of this area is controlled in a striking fashion by the varying degrees of resistance to erosion of the rock types present. The limestone forms an elongated basin of chiefly low-lying country often covered by alluvial deposits. The northern and western rim of the basin is formed by the hard quartzites and conglomerates of Mts. Roland, Gog and Magog, whilst the southern margin is formed by the Western Tiers. Thus there are three major physiographic units: (1) the Mt. Roland, Magog and Gog area; (2) the limestone area; and (3) the Western Tiers. These can best be described separately.

(1) *The Mts. Roland, Gog and Magog Area.*—This chain of mountains has a dominating influence on the established drainage system. The chief river is the Mersey, which rises well south of here in the Central Highlands and flows roughly from south to north until it meets the southern slopes of Mt. Roland. The river is then diverted by the resistant quartzites forming this mountain to run in an east-west direction along behind Mts. Roland and Magog until it escapes through its deep gorge between Mts. Gog and Magog and continues away to the north again.

All these mountains are composed of dense, resistant quartzites and conglomerates which dip steeply to the south under the limestone at Mole Creek. They appear again in one or two places at the foot of the Tiers, thus forming a major synclinorium running about east-west.

(2) *The Limestone Area.*—As a general rule througout Tasmania, the Gordon Limestone is expressed topographically by mature valleys occupied by buttongrass swamps. The limestone is usually eroded to base level forming poorly drained areas of little use for agriculture. This is markedly so in the high rainfall areas of west and south-west Tasmania. In the Mole Creek district, however, whilst the limestone produces subdued topography in comparison with the other rocks present it has by no means reached the maturity of buttongrass swamps. In some areas, particularly to the west, the limestone exhibits considerable relief and cliffs of 100 feet in height are not uncommon. The immature dissection of the limestone at once has important economic aspects since: (1) the better drainage thus afforded yields high-class agricultural land; and (2) the resulting topography affords a number of easily-worked potential quarry sites. Factors contributing to the less mature profile in the limestone here than elsewhere are: (1) lower rainfall; (2) less run-off, as much of the water from the Central Plateau drains away to the south; and (3) for a large part of its geological history the limestone has been protected from erosion by a blanket of Mesozoic sediments and dolerite intrusions. In fact, the limestone has not yet been deeply dissected beneath the Permian unconformity, something of the order of a maximum of 600 feet. The dissection varies regularly throughout the area, the east and north portions being very much more mature. In the western portion around Liena and Mayberry and along the foothills of the Tiers the limestone obtains its greatest relief.

(3) *The Western Tiers.*—This profound escarpment forms the southern limit of the limestone, except for the areas in the Mersey Valley. The Tiers are capped with dolerite and underlain by Permian and Triassic sediments. These rocks, being very much less durable than the dolerite, erode away much more quickly so that the dolerite is left unsupported and falls away in great slabs, resulting in a vertical face mantled by coarse scree deposits.

The general impression gained from a cursory glance at the face of the Tiers is that it is a fault scarp. However, a study of the geology of the area reveals no trace of this and the scarp seems to have been produced by erosional processes only. The actual processes involved cannot be established in detail at this time, but a regional survey over a very much wider area should clear up this problem.

The most likely explanation for the formation of the scarp is that the Mersey River was first established along an east-west course at the south side of Mts. Roland and Magog. The river cut downwards through the Permian sediments to the basement of quartzites and then migrated laterally to the south down the dip to these rocks until it encountered the limestone. During this process the river cut a steep scarp in the overlying Permian rocks which has retreated to its present position. Meanwhile the river became entrenched in the limestone roughly in its present position.

Geology.

(*A*) *Stratigraphy.*

The following rock units are present in the area:—

Recent and Quaternary	River alluvium, outwash deposits, scree and talus, residual soils.
Tertiary	Basalt flows, tuffs and agglomerates with interbedded clays and sands.
Jurassic	Dolerite.
Triassic	Freshwater sandstones and shales.
Permian	Siltstones and shales with minor coal beds, unfossiliferous pebbly mudstones and some sandstones, fossiliferous marine pebbly sandstones and mudstones, quartz sandstones and shales, fossiliferous marine pebbly mudstones and marls, basal conglomerates and/or glacial till.
Unconformity	
Devonian	Granite.
Silurian	Crotty quartzites and sandstones.
Ordovician	Gordon limestone, Tubicolar quartzites with minor grits and shales, Owen conglomerate.
Unconformity	
Cambrian	Quartz and quartz felspar porphryies, lavas, tuffs and breccias, slates, sandstones, greywackes and argillites.
Unconformity	
Pre-Cambrian	Quartz mica schist, garnet mica schist.

It is not proposed to give a full account of all these rocks as they are to be treated fully in a forthcoming publication. For the purpose of this bulletin the limestone and rocks immediately above and below it are the most important.

The Tubicolar Quartzite.—This name has been widely adopted by the geological survey and other in the past to describe the formation (or group) lying stratigraphically between the Owen Conglomerate and the Gordon Limestone. However, with the recent advances made in stratigraphic nomenclature, the term is invalid, since it contains no geographic sense and also since the Tubicolar casts occur in other formations, notably the Crotty Quartzite, the Owen Conglomerate and the Caroline Creek beds. The stratigraphy of this portion of the sequence needs revising and this is at present under investigation. However, in order to avoid the introduction of new terms prematurely, it shall be retained for the purpose of this publication.

Johnston (1888) proposed the name Magog Group for these rocks in this locality, but it is by no means clear that the sequence is complete in his locality and his locality is not strictly defined.

The Caroline Creek beds also occupy a similar stratigraphic position, but again they are not well defined. The definition of this sequence simply refers to a fossil locality. Certainly, as defined, the Caroline Creek beds do not constitute a mappable unit. In some, perhaps most, localities in this general area, typical Caroline Creek beds are missing and the limestone passes either abruptly or transitionally through passage beds into the Tubicolar quartzites. The Caroline Creek beds contain a distinctive fauna of Tremadocian age and are therefore an important stratigraphic unit. They also contain the Tubicolar casts characteristic of the Tubicolar quartzites. At Railton and Melrose, these beds, consisting of ferruginous sandstones and shales with some quartzites, conformably underlie the Gordon Limestone.

The questions to be solved therefore, are:—

(1) Are the Caroline Creek beds simply a facies variation of the upper beds of the Tubicolar quartzites?

(2) Where the beds are apparently missing, is this due to intense silicification which may have altered the rocks and destroyed or rendered the fossils difficult to extract?

In support of this it may be stated that the areas in which the Caroline Creek beds are apparently absent, the Tubicolar quartzites are fairly close to granite contacts, This is so at Moina, Lorinna, Round Hill and in the Mersey upstream of the Liena bridge. At Melrose, Railton and the Florentine area, where the formation has been recognised, the rocks are some distance away from the known granite areas. The Tubicolar quartzites once thought to be unfossiliferous except for the worn casts, do yield a number of imperfect brachiopod casts upon closer inspection. It may well be that closer inspection of these areas will yield useful index fossils which may clear up this problem.

It will be necessary to review this section of the stratigraphy and redefine the various formations in the areas where they are best exposed.

The Gordon Limestone.—The immense limestone deposits of this area are all derived from this formation. The precise thickness of the limestone in this area is not known, but from the known width of outcrop and dips it would appear to be in excess of 3000 feet.

Typically, the limestone is a dense, blue rock, grey in weathered outcrops, massively bedded, but sometimes sheared and almost schistose. The rock emits a foetid odour when freshly broken and contains nodules of pyrite and films of graphite material along shearplanes as well as the normal knots and veins of calcite. However, a number of variations from the "typical" type are present. Sometimes the limestone is thinly bedded and contains numerous shaley bands partially replaced by limonite. This type is relatively impure, but may produce spectacular effects in caverns giving a grey and pink banding of unique beauty. The limestone is not equally fossiliferous, most of the beds are relatively unfossiliferous, but a few are packed full of bryozoans and corals. The latter are "biohermal limestones," which represent the old coral reefs, the detritus from which formed the less fossiliferous beds.

The limestone outcrops in a typical fashion. Underground drainage with numerous caverns and sink holes are the rule over most of the limestone areas. Karst topography is developed locally on limestone hills and collapse structures are common. The latter are particularly well developed where a dolerite sill directly overlies the limestone. The limestone dissolves away beneath the dolerite leaving it unsupported and it collapses in a jumble of huge disoriented blocks. The result is commonly found as dissected limestone hills capped by a collection of enormous dolerite boulders. The interpretation of these structures is not always easy as they may also be scree or glacial deposits. However, a number of them lie too far out from the foot of the Tiers and contain boulders far too large to have been formed from scree deposits. One such "boulder" is so large that a good sized quarry has been opened up on it. Some cases are, of course, of doubtful origin and, since it appears certain that scree, glacial and collapse structures are all present, the interpretation of those lying in close to the foot of the Tiers must be accepted with reserve.

The limestone weathers differentially, and since it is dipping steeply, the less soluble bands show out clearly as strike ridges on the air photos. Despite this, it is difficult, and in places impossible, to trace important structures which are clearly visible in the underlying quartzites. Probably many of these structures die out in the limestone due to their well-known ability to flow under long-term stresses.

Throughout the area the limestone is dipping fairly steeply and some care must be taken with the choice of quarry sites. It is also desirable to avoid the highly-sheared zones if production for aggregate purposes is envisaged. These zones produce a flakey particle shape which is undesirable for use in cement.

Like most limestone areas the depth of weathering is most erratic and thin weathered zones may well be encountered extending down into the main limestone mass. It would require an extremely detailed drilling programme to delineate all such zones, but in the main they are expected to be minor features only.

The limestone is overlain apparently conformably by the Crotty Quartzite and unconformably by the Permian sequence and by the various Tertiary and Recent deposits. Occassionally a dolerite sill is intruded between the limestone and the Permian rocks.

Crotty Quartzite.—Quartz sandstones and quartzite of this formation have been mapped in the Den area. Although the area occupied by these rocks is extensive, no good outcrops were located so that little useful information regarding the formation is available. The outcrops occur along the axes of the synclines making up the Mole Creek synclinorium.

The Permian Sequence.—The unconformity between the Gordon Limestone and the base of the Permian system is well exposed at many points. The lithology and thickness of the basal Permian formation is variable. At Dairy Plains the basal beds are of glacial origin, whilst under Western Bluff they are well rounded and distinctly bedded conglomerates.

The Permian sequence passes upwards transitionally into the Triassic rocks. The transition beds contain two thin beds of impure coal. In many areas a disconformity has been postulated between the Permian and Triassic systems. Probably what happens is that the fall in sea level, indicated by the coal horizon, is such that at some points there will be a continuous deposition, in others a coal or shallow or fresh-water facies and at others a period of non-deposition and erosion. It would be surprising, indeed, if such a fall in sea level were to produce uniform conditions throughout the whole of the area now occupied by Tasmania.

Jurassic Dolerite.—The familiar dolerite of presumed Jurassic age occurs as sills intruded into the Mesozoic rocks. It forms the capping to the Western Tiers and has also been intruded at points along the Permian unconformity as described earlier.

Tertiary Basalt.—Basalts occur throughout the area, but the main area is the high plateau to the west of Mole Creek forming the divide between the Forth and Mersey Rivers. The basalts vary from massive columnar jointed types and closely jointed basalts to agglomerates and tuffs. Often beds of sediments have been laid down between the various flows or beneath the whole basal series. These sediments consist of highly-clastic clays and quartz sands.

River Alluvium.—Large deposits of this material overlie the limestone along portion of the Mersey. The most extensive deposit appears to be upstream of the Union Bridge and here it consists of rounded and sub-rounded gravel, cobbles and boulders in a ferrugenous clayey matrix. Immediately downstream of the Liena Bridge the alluvium exhibits excellent imbricate structure. Similar deposits occur along all the minor streams in the limestone areas and much of the low-lying limestone areas are covered by a thin deposit of residual gravels and boulders.

Outwash Deposits.—Derived from the conglomerate and quarzite of Mts. Roland and Gog, these occur along the lower slopes of the mountains. The deposits are irregularly but definitely bedded, they have steep depositional dips and are composed of material from the nearby hills. A good example of this may be seen in the gravel pits about half a mile north of the Union Bridge.

Scree and Talus.—Widespread scree and talus deposits occur along the slopes of the Western Tiers. The material comprising these is almost exclusively dolerite, but on the lower slopes Permian boulders are mixed with the dolerite. Similar deposits also occur above the outwash fans along the slopes of Mts. Roland and Gog, but they are less extensive and are, of course, composed of boulders of quartzite and conglomerate.

Residual Soils.—The limestone weathers back to produce chocolate to brown-coloured residual soils of considerable depth where deeply weathered. If adequately drained such soils are highly prized for agriculture. In this area, thin superficial alluvial gravels and sands are often found mixed with the residual limestone soils.

(*B*) *Structure.*

The overall structure of this area should be fairly clear from the geological map. The limestone is folded into a complex east-west trending synclinorium which pitches gently to the east. Thus the underlying quartzites close around the western end of the syncline up-pitch to the west of Liena. Further west of this area the structural trends swing around somewhat to the north-west and it can be noticed that some of the smaller folds and many of the thrust faults in this area tend to swing in that direction also. The thrust faults which trend roughly parallel to the folds are quite large features and the beds near them are profoundly disturbed. An excellent section through one of these thrusts can be seen at Alum Cliffs near Mole Creek township. Here the beds on the upthrown side of the fault are drag folded and faulted in an incredible fashion. The downthrown block, however, does not seem to be disturbed very greatly at all. The thrust planes dip at a fairly flat angle, usually about 30° to the north or south depending upon the throw of the faults. Complimentary to these great thrusts are a series of transcurrent or tear faults trending about north-south. These take up differential movements between the thrust blocks as one moves ahead further than its neighbour. The tear fault running roughly along the Mersey River at Liena is a good example of this. It can be clearly seen in this locality how on one side of the tear fault the Ordovician and older rocks have been tightly folded and thrust whilst on the other side the folds, though still intense are somewhat more open. Obviously, the country to the west of this tear fault has been compressed more than that to the east and the difference in compression is expressed by the movement along the tear fault.

Many of the smaller folds are wonderfully exposed. Barren Tier is an almost perfect example of an anticline in rocks of a differing hardness. The overlying limestone has been eroded away leaving the quartzites exposed in a great anticline which has scarcely been touched by erosion. The present surface of this hill almost exactly corresponds to the surface of the fold.

Several orders of folding are present. First order folds are represented by the Mole Creek Synclinorium and by the major anticlinoria of Mts. Gog and Magog to the north of it. The Barren Tier fold is a second order fold, but many of the other second order folds are partially or completely thrust out. Third order folds have their axes approximately 200 feet apart and are also frequently over thrust. Fourth order folds are the smaller drag folds associated with the larger structures. They are generally too small to be indicated on a map of this scale.

The tectonic history of the Ordovician rocks, therefore, is dominated by this intense compression acting in a north-south direction. Major folds have been formed which have at first yielded by folding and flowage, but later have been forced to rupture and overthrust with a resulting pattern of minor folds, thrust and tear faults. During this process the limestones have been able to withstand to some extent the outright fracturing which so profoundly smashed the underlying quartzite. Instead of yielding by rupture, it accommodated the stresses to a degree by flowage and thus does not exhibit the intense local smashing of the quartzites.

The Permian and younger rocks have not been affected by this compression at all. The Permian sediments are flat-lying with shallow dips and no folding. Small faults have been observed in the Permian rocks, but some of these are large enough to disrupt the sequence. The dolerite intrusions were certainly responsible for some of the post-Permian faulting. Where the dolerite has intruded along the Permian unconformity, it has uplifted the sediments above it along a system of normal faults. These faults may be clearly differentiated from the later Tertiary faulting as they do not cut the basement rocks.

The Limestone Areas.—As mentioned earlier, it would be almost impossible to thoroughly sample all the possible quarry sites in this area. Also, it is hardly necessary to calculate the tonnage of limestone available, as this is so large that no serious depletion of reserves can be envisagled. As an example, the hill at Site No. 7, locally known as the Dog's Head, is a relatively small deposit compared with some of the other sites. This hill, however, contains in excess of 100 million tons of limestone above the level of the surrounding country.

The sites chosen for sampling are mostly close to the township of Mole Creek and therefore close to rail, road and power facilities. They are indicated on the geological map.

Site No. 1.—This is situated1¼ miles west of Mole Creek township on the south side of the road and about five to six chains from it. The limestone here strikes approximately east-westwards and dips away from the quarry face. The limestone outcrops almost continuously up the hill and is generally massive, but there are a few zones of near vertical shearing. The site was carefully sampled by cutting channels across all the available outcrops. However, since the outcrop is not quite continuous, this hardly seems justified as the bands which are obscured may be of quite different purity to the average. A few small caverns can be seen in the area sampled but they do not appear to reach any large proportions.

Results of the sampling are as follows:—

Reg. No.	Acid Insol.	Fe_2O_3 + Al_2O_3	CaO	MgO	Ign. Loss
	%	%	%	%	%
542 ..	5.6	0.8	48.5	2.2	40.8
543 ..	4.4	2.0	50.3	1.6	41.1
544 ..	3.2	0.6	52.5	1.2	41.6
545 ..	11.8	2.0	46.5	1.4	37.6
546 ..	6.0	1.6	50.2	1.0	40.9
547 ..	8.9	1.8	48.1	1.3	39.7
548 ..	9.5	1.0	47.2	2.5	39.5
549 ..	5.8	0.8	51.5	0.7	40.8
550 ..	6.2	1.2	50.5	1.2	40.5
551 ..	6.4	0.8	50.4	1.2	40.5
552 ..	4.2	0.6	50.8	2.2	41.5
553 ..	4.0	0.5	52.0	1.2	41.6
554 ..	6.0	0.7	50.0	1.8	41.5
555 ..	9.7	0.9	49.3	0.6	39.3
575 ..	7.0	0.6	48.9	2.1	41.2
576 ..	8.3	0.6	49.5	1.0	40.4

Site No. 2.—This site is on portion of the same hill as No. 1 site. It is about three miles west of Mole Creek township on the south side of the road near the bridge over Sassafras Creek. The limestone again strikes about east-west and favourable quarry sites with respect to the bedding could easily be chosen. This site was sampled by chip sampling across all the available outcrops which is about 50 per cent complete. In the field the rock appears similar to that at Site No. 1 but the analyses indicate that it is slightly higher grade. This could be due to the method of sampling.

Reg. No.	556	557	558	559
	%	%	%	%
Acid Insoluble	2.1	2.3	2.9	4.0
$Fe_2O_3 + Al_2O_3$	0.4	0.5	0.4	0.6
CaO	53.0	52.0	52.8	52.1
MgO	1.4	2.2	1.1	1.2
Ignition Loss	43.1	43.0	42.6	42.1

Site No. 3.—This site lies directly behind the hotel at Mole Creek. The ridge consists of several small folds and a quarry sited at the foot of the hill would open up a small anticline striking east-west with most of the south limb removed by erosion. Thus at first the beds would dip into the quarry face but as work progressed the dip would flatten and then dip gently into the hill. The limestone is quite massive, but higher up the hill, patches of residual Permian and dolerite boulders would be encountered. However, by this time, the face would be about 100 feet high and it could be extended east-west for a considerable distance.

Reg. No.	560	561	562	563
	%	%	%	%
Acid Insoluble	7·0	7·8	7·5	10·0
$Fe_2O_3 + Al_2O_3$	0.6	0.9	0.8	0.8
CaO	51.0	49.7	50.3	48.9
MgO	0.4	1.2	1.0	0.9
Ignition Loss	40.9	40.3	40.2	39.3

Site No. 4.—This site lies on the east side of the South Mole Creek road, near the junction of the road leading to Western Creek. The limestone here is massive and shows little signs of shearing. It dips gently into the hill and, as indicated by the contour plan, an enormous quantity could be obtained by working east with the quarry face parallel to the road.

Reg. No.	564	565	566
	%	%	%
Acid Insoluble	8·0	7·5	9·8
$Fe_2O_3 + Al_2O_3$	0.8	0.8	0.8
CaO	49.0	49.5	48.9
MgO	1.7	1.6	1.0
Ignition Loss	40.3	40.6	39.5

Site No. 5.—This site is on the east end of the ridge sampled at Sites Nos. 1 and 2. The limestone here is massive and unsheared and folded into a number of gentle folds. By working up along the pitch of these folds a great number of quarry sites could be obtained. The dips would be variable.

These folds are a reflection of the east-pitching Barren Tier anticline. High up on the ridge a number of small caverns were observed.

Reg. No.	567	568	569	570
	%	%	%	%
Acid Insoluble	11.0	10.4	8.1	7.5
$Fe_2O_3 + Al_2O_3$	1.0	0.7	0.7	0.6
CaO	47.2	45.4	49.4	49.6
MgO	1.6	3.6	1.1	1.6
Ignition Loss	38.9	39.6	40.3	40.6

Site No. 6.—Several possible quarry sites are available in this vicinity. The samples were taken at the Public Works Department quarry and beyond this to the top of the hill. Sample No. 1 is a continuous chip sample across the beds exposed in the quarry, and No. 2 is a series of chip samples across all the exposed beds above the quarry. The limestone is generally massive but locally sheared. Solution openings along the joints may be seen in the quarry and at several points on the hill above.

Reg. No.	571	572
	%	%
Acid Insoluble	4.9	5.0
$Fe_2O_3 + Al_2O_3$	0.4	0.6
CaO	50.2	51.2
MgO	1.9	1.1
Ignition Loss	42.0	41.8

Site No. 7.—This site is some distance from the Mole Creek township and therefore not so conveniently sited with respect to the transport facilities. It is, however, quite close to the second-class road running along the north edge of Barren Tier. As mentioned earlier, this hill, known locally as the "Dog's Head," contains in excess of 100 million tons of limestone, much of which could be easily obtained from quarries on the south side of the hill. The steepness of the hill slopes would probably prove to be disadvantageous, however, since the quarry face would soon become too high and it would have to be developed in benches. As indicated by the anayses, the limestone averages about 90 per cent $CaCO_3$. It may prove to be a useful source of agricultural lime.

Reg. No.	573	574
	%	%
Acid Insoluble	6.0	6.4
$Fe_2O_3 + Al_2O_3$	0.5	0.5
CaO	51.2	50.2
MgO	0.8	1.4
Ignition Loss	41.4	41.4

Summary.

The limestone deposits surrounding Mole Creek township are conveniently situated with respect to power and transport facilities. The deposits are so huge that the lime requirements for the whole State could easily be satisfied for centuries without serious depletion of the reserves. Numerous convenient quarry sites are available. The limestone averages over 90 per cent $CaCO_3$ and much of it would be in excess of 95 per cent $CaCO_3$. It is therefore high enough grade for most ordinary purposes. By careful sampling, even higher grades could probably be obtained. Many of the prospective quarry sites have little overburden and stripping costs are expected to be low. The limestone is cavernous and small caves may be expected in almost any locality. However, it is extremely doubtful if they will be large enough to cause any serious inconvenience. As with most limestone areas, deep weathering in certain thin zones may be encountered. These are expected to be small in comparison to the main limestone mass. Again, like most limestone areas in the State, no local supplies of coal are available, but adequate firewood supplies could easily be obtained close to the main limestone area. However, it is of interest to note that at Railton, it is found cheaper to import coal from the north-east than to use firewood obtained locally.

Being essentially an agricultural and timber-getting district, no large pool of local labour can be expected. Any influx of outside labour would certainly strain the housing facilities of the district, which are at present fully occupied.

Summing up, it may be stated that the area offers a great potential for the establishment of any industries requiring large quantities of limestone. With increasing demands for agricultural limestone and lime both locally and in the surrounding districts serious consideration could well be given to the production of these products in the area. The Mole Creek district probably has the largest reserves of freely-accessibile high-grade limestone in Tasmania.

XII QUEENSTOWN

The Mt. Lyell Mining and Railway Company quarries limestone for its own needs at Queenstown. A request was made to their geological staff for information concerning the limestone deposits there and the following account was prepared by M. Solomon.

Gordon Limestone.

This formation varies from blue-grey massive limestone, through shaley limestones and calcareous shales, to dark-grey shale. It overlies the siliceous Owen Conglomerate and is succeeded by Crotty quartzite, the basal member of the Eldon Group.

Undergoing more rapid denudation than the contiguous conglomerate and quartzite formations, it usually occupies valley floors in which the exposures are often concealed by debris from the flanking more-resistant beds.

The distribution of the Gordon Limestone is indicated in the accompanying map; the chief areas of outcrop are along the Queen River and the Garfield River, along the eastern flank of the West Coast Range, and in the Linda Valley.

The limestone facies is generally a dark blue-grey colour and is either thin-bedded, with half to three inch bands of shale, or is massive with few visible partings. It is often well-jointed and breaks with a knobbly structure, a feature which assists in quarrying operations. Limestone outcrops at the old Smelters Quarry, Queenstown, at Hall's Creek quarry, south of Lynchford, at several points along the Queen River Valley, and at the old Darwin flux quarry, half a mile east of Darwin. Elsewhere the formation is only occasionally exposed or is shaley. Its thickness varies from 500 feet to 1,800 feet.

South of the West Coast Range, great thicknesses of Gordon-like limestone may be observed; much of this may be the stratigraphic equivalent of the Owen Conglomerate.

Chemical Composition.

Where free from shale bands, the Gordon Limestone generally has a calcium carbonate content of well over 80 per cent and is low in impurities, particularly magnesia. Analyses of limestones from the Halls Creek quarry and the old Smelters quarry are given in the accompanying table.

Workings and Production.

The only limestone being worked at the present time is near Halls Creek, one mile south of Lynchford. The Mt. Lyell Company has been quarrying there since the end of 1932, and to June, 1956, had removed 118,700 tons at an approximate rate of 5,000 tons per annum.

Prior to 1932, all the limestone required by the company was taken from the Smelters quarry in Queenstown. Unfortunately, no figures of production from this quarry are available. The lower 60 feet of this cut is flooded and is now being filled with waste.

The North Lyell Company quarried Gordon Limestone from a point about half a mile east of Darwin for use in its smelters at Crotty. Quarrying operations ceased about 1911 and the excavations are now largely flooded.

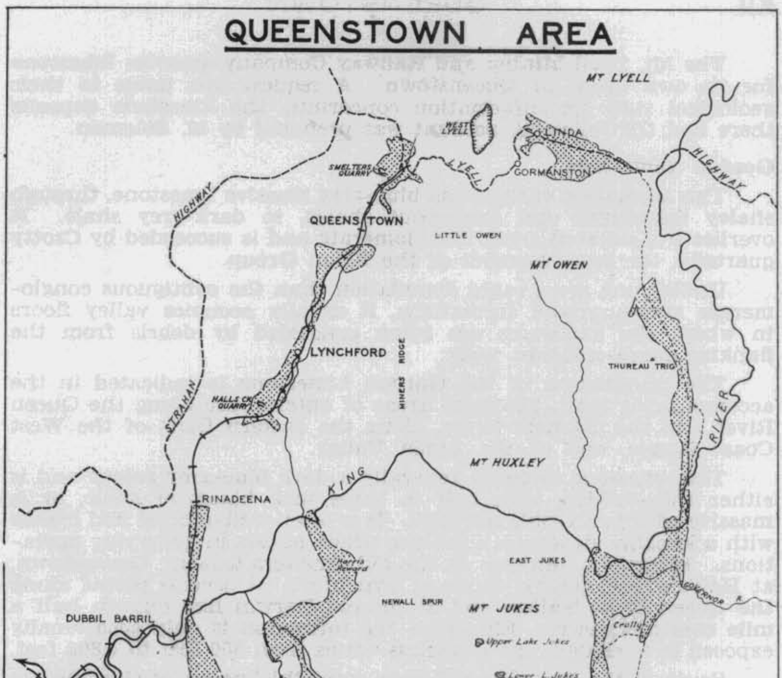

FIG. 22.—Queenstown Area.

There are no other workings for limestone in this area.

Uses.

During smelting operations, the Mt. Lyell Company uses approximately 7 tons of crude limestone per week as a flux. The proportion of each year during which the furnaces are operating is variable but probably averages two-thirds.

The remainder of the quarried limestone is burnt for lime, which is used for neutralising acidity in the flotation plant, and when recovering flue dust in water. Approximately three lbs. of lime per ton of ore are used in the mill, and between 2,000 and 3,000 tons of limestone are burnt per annum.

Reserves.

There are no reliable estimates of the reserves of limestone in the Queenstown area, but there is sufficient limestone available at Halls Creek to satisfy the Mt. Lyell Company's demands for many years.

Removal of limestone from the Smelters quarry would involve considerable overburden problems and might yield only a relatively small tonnage. The old Darwin quarry would yield a fair quantity of limestone, with pumping and some overburden stripping.

The only other outcrop that might possibly be considered in discussing ore reserves near Queenstown is that adjacent to the road about three-quarters of a mile north of Lynchford. Once again, quarrying here would involve overburden removal.

Chemical Analyses of Gordon Limestone.

	I.	II.	III.	IV.	V.
	%	%	%	%	%
Fe	0.4	0.6	0.4	0.4	0.4
Al_2O_3	2.9	0.9	1.1	1.1	0.9
SiO_2	10.9	3.3	2.8	3.8	3.2
$CaCO_3$	83.4	95.1	86.1	88.8	89.3
MgO	3.0	Tr.	Tr.	Tr.	Tr.
Total	100.6	99.8	90.4	94.1	93.8

I. Grey limestone from the Smelters quarry. (Gregory, 1905.)

II. Black limestone from the Smelters quarry. (Gregory, 1905.)

III. Limestone from Halls Creek quarry. (October, 1952.)

IV. Limestone from Halls Creek quarry. (October, 1952.)

V. Limestone from Halls Creek quarry. (October, 1952.)

XIII THE RAILTON AREA

The Railton area is situated in Map Square 37 (The Sheffield Sheet) which is a part of Tasmania being regionally mapped by I. B. Jennings, who has written most of this section. An account of limestone occurrences other than those at present being worked is contained in an unpublished report by T. D. Hughes in 1954, "Limestone Deposits near Railton."

Introduction.

The bulk of the limestone quarried in Tasmania comes from the Ordovician limestones in this area. This large production is due primarily to the works conducted by the Goliath Portland Cement Company. Other works conducted at various localities in the general area by Mr. A. R. Blenkhorn for many years have also yielded appreciable quantities of stone. Some years ago limestone was quarried at "Dally's" for the production of agricultural and building lime.

Despite the importance of the area, comparatively few outcrops of limestone occur, due to the overlying cover of alluvium. Thus few good quarry sites are available, but this is offset by the proximity of a deep-water port at Devonport and by the first-class transport facilities and abundant power supplies.

The production of limestone for use at the cement works can be expected to increase significantly during the next few years and it seems certain that the district is destined to be the largest producer of limestone for many years to come.

Location, Access and Facilities.

The township of Railton is situated in a broad limestone valley about 10 miles south of Latrobe. The limestone outcrops all lie close to the township itself.

Transport facilities throughout the district are generally good. A first-class road connects Railton and the Bass Highway near Latrobe and continues on to Sheffield. The numerous secondary roads in the area are all fairly good gravel roads negotiable in all weather. A system of timber tracks, passable only in dry weather, gives access to the timber-clad hills west of Railton.

The main North-Western railway line passes through Railton township and is thus located close to the main limestone area.

Adequate electric power is available close to the limestone deposits and telephone facilities are provided throughout the district. Fuel presents similar, though perhaps less severe, problems to most of the other limestone areas. Adequate firewood supplies may be obtained locally, but no coal is now produced in the district. Coal from the "New Bed" coalfield, two and a half miles north-west of Railton was produced some years ago, but these workings have long been abandoned. On present-day prices, Mr. Blenkhorn finds it more economical to use coal imported from the north-east of the State than to buy firewood locally for lime burning.

Physiography and Geological History.

The physiography of this area is controlled closely by the various rock units and by the geological history of the district. Essentially, the area consists of a fairly mature Pre-Cambrian limestone valley containing inliers of younger rock. Three separate sets of topography of various ages combine to produce the existing physiography.

(1) *The Pre-Permian Limestone Valley.*

The accompanying geological map scarcely covers enough area for this to be recognised. The valley runs approximately north-west-south-east and is flanked on either side by steep quartzite hills. The floor of the valley has not been eroded very much below the level of the Permian unconformity. The existing outcrops of limestone in the area are remnants of the old valley floor which have so far escaped erosion. They have been, and still are, protected from erosion by the overlying younger rocks.

(2) *The Permian-Jurassic Rocks.*

The old valley was submerged at about the beginning of the Permian and thick deposits of sediment laid down over the old topography. During the early Permian, at least, the quartzite ridges to the east and west must have stood above the Permian seas as island areas. Subsequently, during the Jurassic these young sediments were intruded by dolerite. The most compact level of intrusion in the limestone areas is that intruded as a discontinuous sill-like mass along the Permian unconformity. Higher intrusion above the Permian coal measures also occur. Following these intrusions, the area was elevated above sea level and, for a long period, subjected to denudation. During this time most of the recently-deposited Triassic and Permian sediments, together with much of the intruded dolerite, was removed. The stream beds again cut down into the limestone basement. The area again began to assume the rough valley slope of the Devonian time.

(3) *The Tertiary-Quarternary Rocks.*

Following this denudation, the areas were extensively faulted during the Lower Tertiary. The faulting was followed by extensive basalt intrusions which filled the existing stream beds and therefore in places directly overlies the limestone. The majority of this basalt has since been removed, but beneath the few fragments which remain, the relicts of the Lower Tertiary topography are still preserved.

Thus, whilst the present topography in the Railton area has been derived since the Tertiary basalts, it has always been primarily influenced by the Ordovician rocks. The limestone area flanked by its eastern and western quartzite ridges has almost always formed a low-lying area influencing the drainage system developed. The present erosional agencies are continuing and modifying, in the same general manner, an interrupted erosional cycle which began in the lower Devonian.

The limestone areas are drained by small, fairly mature streams, much of the drainage probably being underground. Due to the fast run-off, the drainage over the Permian rocks and Caroline Creek beds is accomplished by a network of seasonal creeks, which are dry for the most part of the year.

There are a few farms in the area and chiefly in the basalt areas, but the majority of the district is not cleared. Some useful milling timber is obtained from the hills to the west of Railton, but the remainder produces an open growth of stunted eucalypts which are cut for firewood and paper pulp.

Geology.

(*A*) *Stratigraphy.*

The following formation are present in the area:—

Recent	Residual soils, alluvium.
Tertiary	Basalts and agglomerates.
Jurassic	Dolerite.
Permian	Marine pebbly mudstones, quartz sandstones and coal measures, fossiliferous pebbly mudstones, conglomerates and glacial till.
Unconformity	
Ordovician	Gordon Limestone. Caroline Creek beds.

Caroline Creek Beds.

These red ferruginous sandstones with associated shale and quartzites were discovered about 1861 by Gould. At his type locality a number of *Asaphia,* the trilobites of Tremadocia age have been described, together with some important brachiopods. Johnston (1888) referred to these beds as of Cambrian age, but most modern stratigraphers place the Tremadoc at the base of the Ordovician system. This is based upon the first appearance of graptolites in Tremadocian rocks, but whilst the majority of workers agree on this, there is apparently not yet complete agreement.

The Caroline Creek beds conformably underlie the Gordon Limestone in this area, but the formation has been recognised also at Melrose and in the Maydena area. However, in some areas the formation as first described appears to be missing. This point is discussed more fully in the section dealing with the limestones at Mole Creek.

Gordon Limestone.

As mentioned earlier, although the greater part of the Railton valley is underlain by this limestone there are comparatively few outcrops of the rock, due to the superficial cover of alluvium. Where it outcrops, the weathered rock is a light blue-grey in colour, but freshly-broken surfaces are dark blue-grey to black. Calcite veins are common, and the limestone, though thickly-bedded, is often sheared and schistose. The limestone has been folded into a major syncline and the beds are therefore often steeply dipping. The exact thickness of the formation cannot be determined, due to the paucity of outcrops, but it appears to be in excess of 2,000 feet and may well be as much as 3,000 feet thick. Generally, the limestone is not highly fossiliferous, but this varies somewhat between the different beds. The limestone is irregularly weathered and in the cement works quarry excellent examples of unweathered pinnacles of limestone beneath the overlying residual clays may be seen. The thick mantle of residual clays obscuring much of the limestone is of great importance in the production of cement as a source of alumina. However, at Blenkhorn's lime works the deep weathering is a disadvantage.

Some small faults are exposed in the various quarries and they are usually deeply weathered in association with abundant, thick, calcite veins. Great masses of perfect rhombohedral calcite crystals may be recovered from these veins.

Due to the thickness of the beds the attitude of the bedding has little influence upon the quarrying practice. If anything, Mr. Blenkhorn prefers to quarry in the direction of dip to avoid having an overhanging face. The closely-sheared, almost schistose zones do not significantly interfere with quarrying practice. A few small caverns have been encountered in the quarries, but never extend any great distance.

Since both Blenkhorn and the Goliath Company's quarries are now some distance beneath the general level of the valley floor, it could reasonably be expected that acute water trouble would be met. However, this is not generally so. At the cement works quarry an average of about 60,000 gallons per day must be pumped and it is only after heavy prolonged rains that the lower benches cannot be worked. At Blenkhorns a steady influx of 1,200 gallons per day is encountered.

The Permian Sequence.

Although large areas of the Railton district are underlain by Permian rocks, very few outcrops occur. From a reconstruction of the available bore logs, together with the known outcrops, a fairly satisfactory stratigraphic sequence can be obtained. The basal beds consist of conglomerates and/or glacial tills which at surface are usually represented by a buff to grey coloured soil containing numerous boulders of the Ordovician and older rocks. This is overlain by a fosiliferous marine sequence of uncertain thickness and thence by the quartz sandstones and associated coal beds in the New Bed area west-north-west of Railton. Above the coal measures the sequence is not clear, but certainly the deeply-weathered, pebbly mudstones on Brown Mountain form part of the Upper Permian sequence in this area. It is not known whether these beds are fossiliferous, as practically no outcrops of them exist. The top of the sequence is missing and it is interrupted on Brown Mountain by a dolerite sill.

The Tasmanite shale beds which occur north and east of Railton well outside the area mapped may not be represented in this area. Where they occur along the Mersey, they occupy a stratigraphic level about 50 feet above the top of the basal tillite. They are not on the same stratigraphic horizon as the coal and are not related to the coal measures in any way.

The Jurassic Dolerite.

The general behaviour of the dolerite intrusions has been described earlier. One sill is intruded into the Permian rocks some distance above the coal measures whilst another series of transgressive, but essentially sill-like, bodies ramifies through the general level of the Permian unconformity. The lower sill does not outcrop very well and generally the boundaries cannot be located precisely. Due to the extensive talus accumulations of the slopes of Brown Mountain the exact base of the upper sill is often difficult to determine.

The Tertiary Basalts.

The distribution of these rocks has been indicated on the accompanying geological plan. Mainly the massive closely-jointed types are represented here and no interbedded lake sediments have been observed.

Quarternary to Recent.

Alluvial deposits occur widespread throughout the Railton area. The big majority of the limestone deposits are covered by poorly-drained areas of residual soil and gravels. Scree and talus deposits occur along the slopes of the hills to the east and west of the district and locally achieve importance as sources of road metal.

Structure.

As mentioned earlier, the Railton valley consists of a broad syncline which has been cut by Tertiary faults. The main fault lies to the west of the area mapped. It trends about north-west and runs in between the north end of the Badgers and Brown Mountain. Several smaller faults probably associated with this main line of faulting also occur in the area. The Devonian rocks have been faulted by the dolerite intrusions but, due to the poor outcrops, the smaller faults are difficult to locate and trace.

The limestone dips quite steeply along the limbs of the syncline but flattens appreciably in the centre of the fold. Strike faulting and minor drag folds probably also occur but cannot be demonstrated from the existing outcrops. The closely sheared limestone areas appear to be located out on the limbs of the main fold where considerable differential movement between the beds has occurred. Near the smaller faults the limestone has been brecciated and deeply weathered.

Limestone Workings.

The principal limestone works in this district and, indeed, in the whole of Tasmania, are the quarries of the Goliath Portland Cement Company. Here both limestone and clay overburden are utilised in the cement manufacture. The main quarry is at present being worked, in four benches, to a depth of 100 feet. The average grade of stone from the quarry is between 80 and 90 per cent $CaCO_3$, although stone as low as 70 per cent $CaCO_3$ is occasionally used and grade sometimes rises to 95 per cent. The ratio of limestone to overburden up to 1944 averaged 1 : 2 but since 1944, due to the development of lower benches, it has averaged 2 : 1. The total production of limestone from this quarry to 1956 has been two and a half million tons. The annual production at present is almost 150,000 tons, but this is expected to be increased during the next few years.

FIG. 23.—Goliath Portland Cement Co., Portion of Open-Cut.

The Railton Lime Works operate quarries on the opposite side of the railway and Railton-Latrobe road from the cement works. Limestone of average grade of 90 per cent $CaCO_3$ is crushed for agricultural use and burnt for both agriculture and building lime. The limestone for burning is selected from the best grade of stone in the faces being worked and that for crushing from the whole of the available stone. In 1955, approximately 2,200 tons were crushed and almost half that tonnage burnt in four vertical continuous type kilns. The kilns are loaded with limestone and coal (from East Coast mines) in the ratio 3½ to 1.

About three miles to the north-west of the cement works is an old quarry known as "Dally's," where limestone has been worked intermittently for many years and usually burnt on the spot. The occurrence of limestone is in the form of a small ridge and in the past the stone has been won largely from a south-facing quarry. The direction of hill slope is almost the same as the strike of the limestone cleavage (320°) which here is very accentuated. Thus the breaking of stone can be facilitated by making the face of the quarry parallel to the hill slope. A north-facing quarry could easily be opened on the other side of the hill and from a face 250 feet in length and 60 feet high some quarter of a million tons of stone obtained. A series of samples taken from the quarry (1 to 5) and from the northern side of the hill (6) show a remarkably even grade of stone, namely:—

FIG. 24.—Railton Lime Works, Portion of Quarry.

Sample No.	CaO	$CaCO_3$ (Calc.)	MgO	$MgCO_3$ (Cal.)	Insol.	Fe_2O_3	Al_2O_3	Ig. Loss
	%	%	%	%	%	%	%	%
1	51.2	91.6	0.5	1	6.3	0.5	0.2	41.1
2	51.6	92.1	0.5	1	5.5	0.4	0.3	41.6
3	51.7	92.3	0.5	1	5.6	0.5	0.1	41.4
4	51.2	91.6	0.6	1.1	6.1	0.5	0.3	41.3
5	51.6	92.1	0.6	1.1	5.5	0.5	0.3	41.4
6	51.2	91.6	0.7	1.3	5.5	0.6	0.2	41.4

Between half and one mile north of Dallys are two other areas of small outcrop where ruined kilns show that lime has been burnt in the past. A sample taken from one of these showed:—

	%
CaO	53
$CaCO_3$ (Calc.)	94.7
MgO	1.3
$MgCO_3$ (Calc.)	2.3
Insol.	1·9
$Fe_2O_3 + Al_2O_3$	0.4
Ignition Loss	43.1

XIV SMITHTON

Introduction.

Limestone and dolomite abound in the Smithton area, and different varieties of it have been used for agricultural purposes. At the present time, two companies are working a Recent spring deposit and a Pre-Cambrian dolomite respectively. Limestone has been quarried in the past from an outcrop three miles south of Smithton and used for agricultural and structural purposes—and a small quantity burnt in a kiln on the spot. More recently the A.P.P.M. of Burnie have utilised limited quantities of this stone in their mills. There has been a doubt as to the age of this limestone, but as it might possibly be Ordovician it is included in this section. During the comprehensive survey of the Smithton area (1929-1931), which resulted in the publication of Bulletin 41, officers of the Mines Department examined the limestone deposits. Much of the material for this chapter is taken from that publication.

Location and Access.

Smithton is located in the Far North-West of Tasmania. It is a rapidly-growing town connected by good road and rail with the rest of the State and has a port for small tonnage vessels and an aerodrome. The limestone outcrops only in two localities, viz., to the east of the Lower Scotchtown road, three miles south of Smithton, and in the south bank of the Duck River, at a point about 30 chains upstream from the bridge at Smithton.

Geology.

The authors of Bulletin 41 place all the sedimentary rocks of the area in the "Cambro-Ordovician," say they are probably all comparable, and divide them into several stages. These sediments were then, in the Devonian, intruded by a long continuous dolerite dyke, running north and south and about 20 chains west of the limestone quarry. The limestones were included in the "Slate, Breccia and Limestone Stage" which was correlated with the Dundas Slates of western mining districts.

In 1952, Carey and Scott re-interpreted the geology of the Smithton district. They agreed that the slates and breccias belonged to the Dundas Group (of the Cambrian), but added the "dolerite dyke" to this, stating that it was not an intrusive rock but the lava phase of the Dundas. They placed the other "stages" of the previous authors (the quartzites and dolomites) in the Carbine Group, which is unconformity below the Dundas and may form the base of the Cambrian, or the top of the Pre-Cambrian in Tasmania.

Of the age of the limestone, Carey and Scott have this to say:—

> "The stratigraphic position of this limestone is uncertain. No limestones have been recorded from the Dundas Group in Tasmania, although the correlates of the Dundas Group in South Australia do contain limestone. However the facies of the Dundas Group in the Smithton district, as elsewhere in Tasmania, is typically eugeosynclinal, whereas the facies of the correlates in South Australia are miogeosynclinal. On palaeogeographic grounds, therefore, the limestone is somewhat alien in the Dundas Group. However, the overlying Junee Group in Western Tasmania

> normally contains limestone which often overlaps the basal conglomerates and rests on the Dundas Group. Perhaps the most likely interpretation, therefore, is that this crinoidal limestone should be correlated with the Junee Group of Ordovician Age. For the present, however, neither hypothesis can be substantiated or excluded."

A third theory as to the age of the limestone cannot be quite excluded. This is that it is the same age as the dolomite which occurs very close, although, due to surface erosion, very little outcrop can be seen. Indeed, it may be postulated that the limestone is in effect a bed in the dolomite which suffers from a deficiency of magnesia. This deficiency may be due to the fact that the dolomites may be, in part at any rate, dolomitised limestones and this particular bed has not been attacked by magnesium-rich solutions. Or it may be that at some stage of recrystallisation, magnesia was lost. Certainly the texture of the rock suggests recrystallisation and the general appearance suggests dolomite beds rather than Gordon Limestone.

The Limestone.

A description of the limestone is given in Bulletin 41, viz.:—

> " *Limestones*.—A dark-blue crystalline variety of limestone occurs towards the top of the Slate Stage. This rock is usually massively bedded, with bedding-planes four to five feet apart."

The outcropping rock has a somewhat fine, cellular appearance, due to the weathering out of small circular grains. When the rock is broken and fresh surfaces obtained, the circular grains are visible in the rock, and strongly suggest the oolitic texture. On examining a specimen under the microscope, the rock is found to consist of crystalline calcite, with a few small grains of pyrite and limonite. The apparent oolitic grains are visible as circular sections, and are composed of calcite crystals. There is no sign of concentric or radiating structure, nor can any definite nuclei be recognised. The general character of the rock suggests that the grains are of detrital origin, and represent rounded pieces of calcitic material. This view is confirmed by Mr. F. Chapman (Commonwealth Palaeontologist), to whom a specimen was submitted. Mr. Chapman (correspondence 21.5.31) reports as follows:—

> " The rock is a crinoidal limestone, in which rounded and waterworn ossicles of crinoids are embedded in a calcitic matrix—a rather unusual occurrence."

Further support is given in the occurrence of beds resembling fine conglomerates in the quarry at Lower Scotchtown. These beds consist of grounded grains and rod-like pieces of limestone up to one-quarter of an inch in size, set in a finer matrix, with some of the finer grains also present. These larger grains probably represent large pieces of crinoids. Thus the fine grains are not true oolites, though it is convenient to retain the word to describe the texture.

The " oolitic " texture is most pronounced on weathered surfaces, while it is not so apparent on fresh surfaces. However, there generally appears to be some of the fine grains present even in dense fine-grained limestone, so that it is probable that all the beds have more or less of the "oolitic " texture.

Analyses of the limestone are tabulated below:—

Analyses of Limestone.

	(1)	(2)	(3)
		S. 120	S. 32
	Reg. No. 1300	Reg. No. 1996/30	Reg. No. 1805
	per cent.	per cent.	per cent.
SiO_2	0.76	0.52	1.08
FeO .. .. .. / Fe_2O_3	0.31	0.56	1.38
Al_2O_3	0.38	0.36	0.22
MgO	0.29	0.50	7.53
CaO	53.85	54.23	46.40
TiO_2	—	Trace	Trace
S	—	0.068	0.11
P_2O_5	—	0.068	0.077
CO_2 and loss	44.11	43.30	44.12
	99.70	99.606	100.917

(1) Representative sample across 12 feet in quarry (western side). Lower Scotchtown road. (Fine-grained type, with little, if any, oolitic texture.)

(2) "Oolitic" limestone from quarry. Lower Scotchtown road.

(3) "Oolitic" limestone. South bank of the Duck River, 30 chains upstream from the bridge at Smithton.

These analyses show that the rock is practically a pure limestone. The third analysis indicates some replacement of calcium by magnesium.

The limestone outcrops only in two localities, viz., to the east of the Lower Scotchtown road, some three miles south of Smithton, and on the south bank of the Duck River, at a point about 30 chains upstream from the bridge at Smithton. In the former locality it is exposed in a small quarry, where the beds are at least 40 feet thick, and dip to the west at an angle of 45 degrees. Here the limestone is overlain and underlain by purple and grey slates, the greatest possible width of the limestone being five chains. The exposures on the Duck River bank near Smithton are limited to a few small outcrops, and the relationships of the limestone to other members of the Slate Stage are obscure. Slates and breccias outcrop

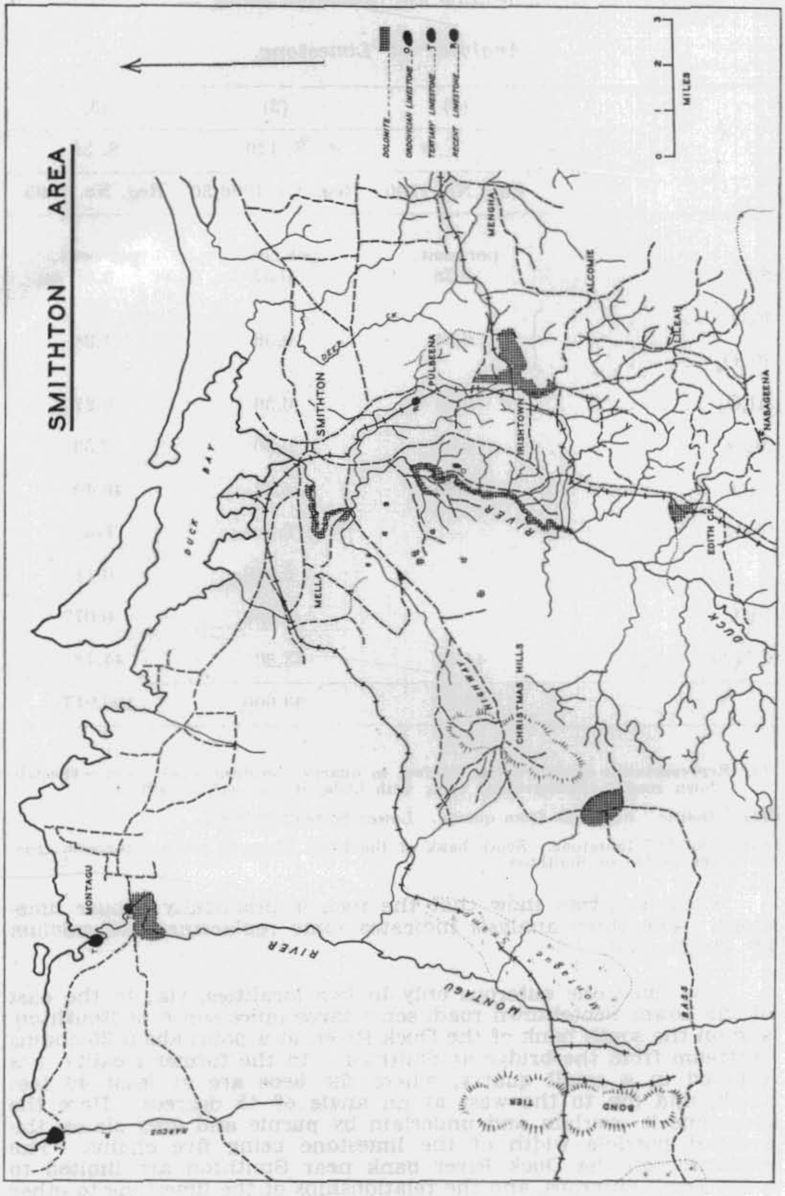

FIG. 25.—Smithton Area.

about five chains to the east, while dolomites occur about 10 chains to the west. However, in view of the fact that dolomites also occur about 10 chains to the west of the limestone bed near the Lower Scotchtown road, it is not unreasonable to assume that those two occurrences of limestone form portions of a single bed in the slates."

The Lower Scotchtown road deposit has been opened by a quarry some five or six chains east of the road. The quarry is at the foot of the south side of a low hill, and the limestone can be traced by outcrops across the summit of the hill for a distance of five to 10 chains. The facilities for working are good and quarries could be opened up on the hill."

Since this report was written, the A.P.P.M. have opened a quarry on the north side of the hill and have obtained some thousands of tons of high-grade material. This quarry is not now operating and it would appear that the overburden of slate and fault material had been getting progressively thicker.

On the Duck River are only two small outcrops and conditions are generally unsuitable for easy working.

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XV SOUTH COAST

Introduction.

Limestone outcrops in several localities in the vicinity of the mouth of New River, on the central south coast of Tasmania. Although of high grade, owing to its inaccessibility, it has never been considered commercially and no close examination or sampling of it has been made. A visit was made to the area by Twelvetrees (1915) and Blake (1938), both of whom mention the limestones.

Situation and Access.

The limestone is reported from three localities, viz., near the mouth of New River; at Shoemaker Point, seven miles south-east of this; and along the lower western slopes of Precipitous Bluff or to the east of New River. New River enters the sea at almost the exact centre of the south coast of Tasmania and in a totally uninhabited area. A foot track, which is cleared from time to time, connects the end of the road at Cockle Creek with the New River, in a distance of 22 miles.

Topography.

From the sea-coast, the land surface rises sharply to a height of 200 feet and then extends for some two miles inland in the form of low ridges and plains to the foothills of Pinders Peak and Precipitous Bluff, both of which exceed 4,000 feet in height. The latter rises steeply from narrow plains to the east of New River Lagoon. Along the western slopes of this mountain the limestone stands out in bold cliff faces, but the outcrops of it on the coast are flat and largely covered by sandhills.

Geology.

The sequence of the Gordon Limestone overlying the Owen Conglomerate (both of Ordovician age) seems quite normal in this area. The outcrops of limestone near the mouth of New River and north along the slopes of Precipitous Bluff are of beds contained in a syncline striking generally north and enclosed in underlying quartzites and conglomerates. The beds at Shoemaker Point, which Twelvetrees records as striking 10° to 20° east of north and dipping 50-60° to the south-east, are probably on the western limb of the next syncline to the east. The present structure is rather obscured by the overlying flat-bedded Permian mudstones, sandstones and conglomerates and by the Recent sands.

The Limestone.

Blake reports that the limestone outcropping on the extreme eastern end of New River Beach consists of small exposures of dark blue-grey limestones with included narrow bands of black slates, while the limestones which are prominent along the lower western slopes of Precipitous Bluff in which many caves are developed are generally light to dark-grey in colour and contain much distributed crystalline calcite.

An analysis of limestone from the latter locality showed:—

	%
Silica	0.06
Alumina	0.59

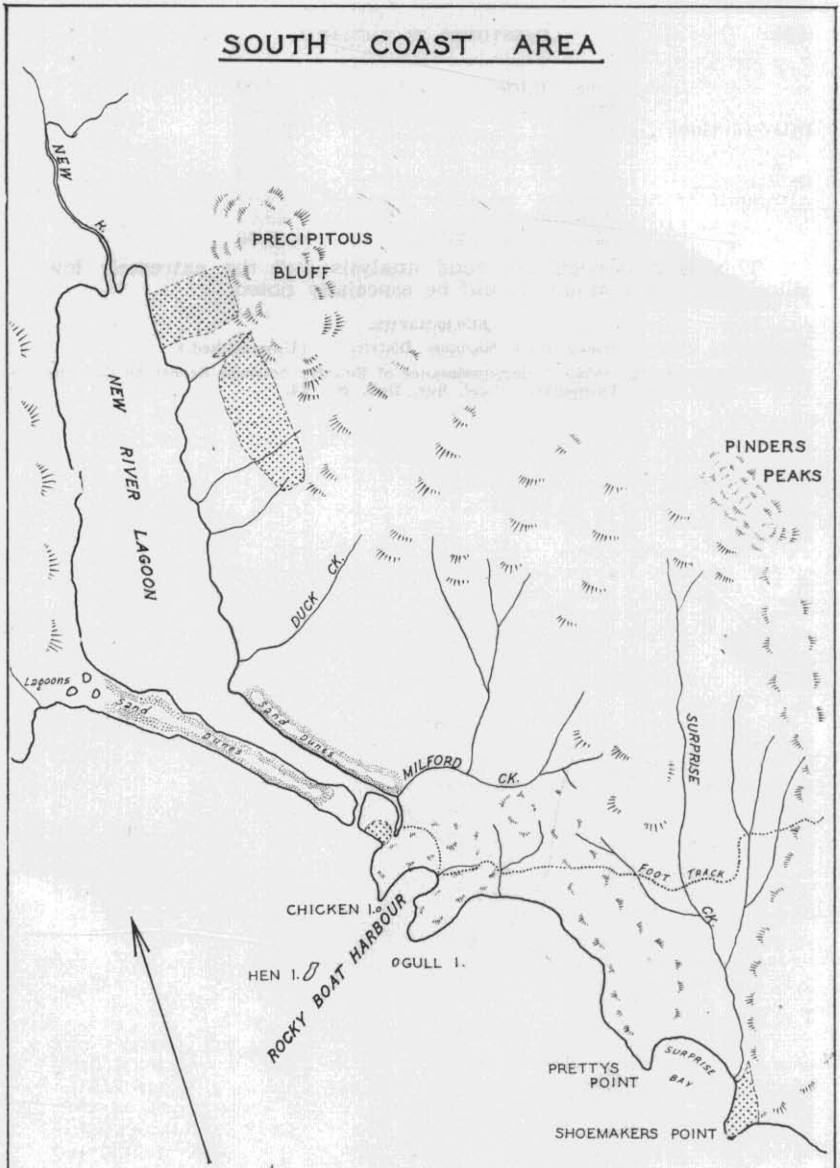

FIG. 26.—South Coast Area.

5 cm

Iron Oxide	0.09
MnO	Trace
P_2O_5	Trace
Sulphur	0.19
CaO	55.38
MgO	0.39
Ignition Loss	43.02
Moisture at 105°C.	0.08

This is a particularly good analysis and the extremely low silica and iron content should be especially noted.

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XVI MISCELLANEOUS LIMESTONE DEPOSITS OF THE WEST COAST

In many places on the West Coast mining fields, limestone beds of the Gordon Formation have been reported and many of the Geological Survey Bulletins contain references to these deposits. Because of their inaccessibility, these limestones have not been exploited, except for the use of them as a flux in smelting at Queenstown now, and previously also at Zeehan and Darwin. Consequently, no detailed reports are available and no idea of grade can be stated except that as they belong to the Gordon Formation, the grade should be comparable with these deposits in other parts of the State and particularly with those in the type area. Bulletins in which the Ordovician limestones of the West Coast are mentioned are Numbers 3, 8, 10, 15 16, 32, 33 and 44.

Zeehan Area.

Although the geological map shows a considerable area of limestone in the Zeehan district, the only spot at which any considerable bulk of limestone is exposed at the surface is at the foot of the hill on which the old smelting works stood. At this place, the limestone has been quarried to provide flux required for smelting. Beyond the limits of the quarry, the exposures at the surface are usually masked by the button-grass vegetation covering the flats which coincide with the areas underlain by limestone.

The limestone is dense and bluish in colour, contains a few argillaceous bands, and succeeds a basal shaley member.

In 1949, Gill and Banks, in a paper dealing with the stratigraphy of the Silurian and Devonian in the Zeehan area, had this to say:—

" Argillaceous and arenaceous impurities were observed in some of the beds, and some appear to contain carbonaceous material. Calcite veins are common, and pyritic inclusions occasional. Certain horizons are considerably leached, while others remain compact. The limestone is often sheared. The limestone has a characteristic physiographic expression as a lowland, and judging by this criterion, it has a thickness of the order of 2,000 feet."

The host rocks in some silver-lead mines of this field contain limestone beds. The large cavities and underground water channels of these rocks make ore extraction difficult. Not far from the Zeehan area, the limestones have been reported from South Dundas. Here they outcrop in four separate localities and in at least three they are apparently interbedded with sandstones, slates and quartzites.

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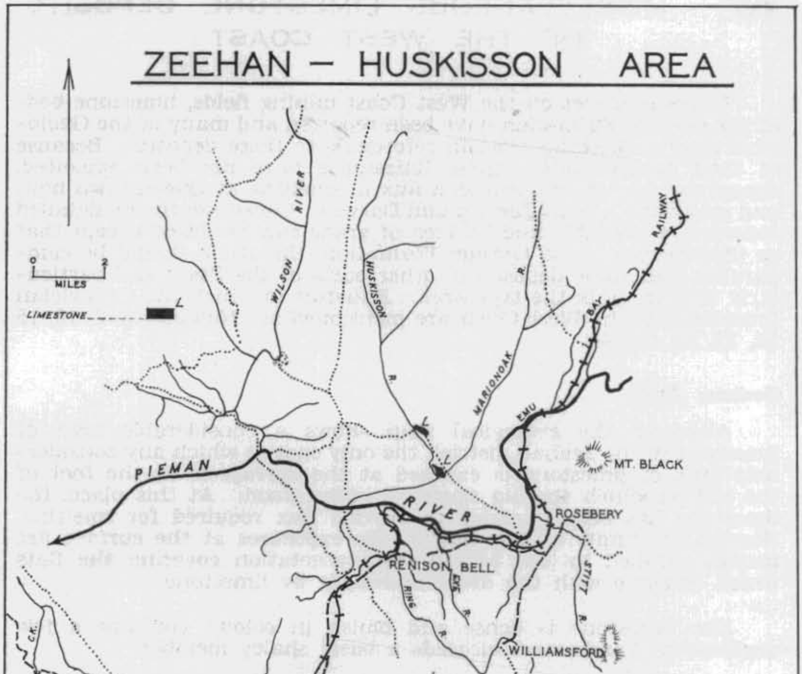

FIG. 27.—Zeehan-Huskisson Area.

5 cm

Pieman River Area.

In the vicinity of the Pieman River and many of its tributaries, that is in the central West Coast region, are many separate limestone outcrops. Some of these may be listed as follows:—

1. On the coast line at a point about two miles north of the mouth of the Pieman River, there is a dense limestone of a slatey-blue colour. The rock is only exposed for a few feet and appears to strike north and south and dip to the east.

BIBLIOGRAPHY.

Bulletin 10, "The Mt. Balfour Mining Field." (L. K. Ward, 1911.)

2. At the *Victorian Magnet Mine*, near the Whyte River, a Pieman tributary, limestones occur in the form of lenses in the more prevalent sandstones. The limestones are dense bluish rocks, and usually contain much clayey material which renders them impure.

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Bulletin No. 33. "The Silver-Lead Deposits of the Waratah District." (P. B. Nye, 1923.)

3. *Corinna Road*. Between the Corinna road and the Savage River, a few miles north of the Pieman River, is a series of rocks consisting of limestones, dolomites and black slates. These rocks strike from 37° east of north to 25° west of north and apparently conformably succeed to the west a series of slates and tuffs, which probably are of the Dundas Group.

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Blake, F., 1939. "Corinna Alluvial Goldfield." (Unpublished.)

4. *Wilson-Huskisson River Areas*. The Wilson and Huskisson Rivers are south-flowing tributaries of the Pieman that enter that river between Corinna and Rosebery. In the bed of the Wilson a few chains north of its junction with the Harmon is a bar of compact blue limestone, which extends also to the eastern bank. The general strike of the beds, according to Waterhouse, appears to be generally east and west with a dip to the south of 60°. Further to the east, limestone outcrops on the north-eastern slope of Mt. Merton and further still in the valley of the Huskisson, where Taylor gives the beds a strike of 305°, with a dip to the north of 50° and a stratigraphical thickness of the order of 1,000 feet. Taylor also states that there appears to be harder crystalline bands in the limestone separated by softer, more argillaceous bands. The latter erode more easily, leaving the former standing as low ridges, up to 30 feet above the valley floors.

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TAYLOR, B. L., 1954.—"The North Pieman Mineral Area." (Unpublished.)
WATERHOUSE, L. L., 1914.—"The Stanley River Tin Field." *Geol. Surv. Bull. No.* 15.

5. *Mt. Farrell Area*. Limestones outcrop in the White Hawk Creek, at its junction with the Sophia River, about three miles north-east of Tullah, and again a further three miles upstream. The limestone is interbedded between two sandstones; that below contains coarse pebble-beds and that above is fairly uniform and fine in grain. The thickness of the whole series is only 130-150 feet, the strike is about 10° east of north, and the dip to the west at 47-75°.

The limestone is a massive one of a dark bluish-grey colour, wherein part of the calcium carbonate has recrystallised. There are very perfectly developed joint planes, of which the best marked series dip eastward at an angle of 50°-60°.

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Bulletin No. 3. "Mt. Farrell Mining Field." (L. K. Ward, 1908.)

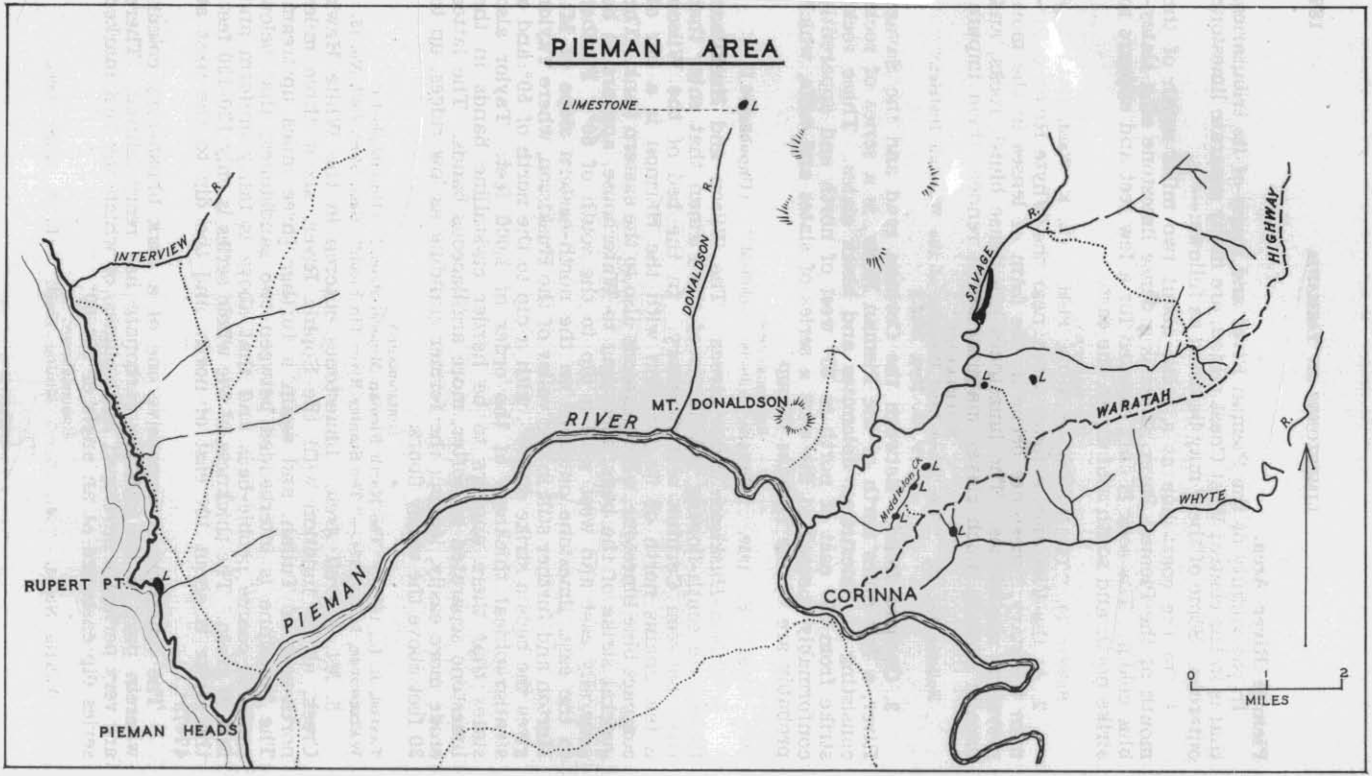

FIG. 28.—Pieman Area.

Darwin-Kelly Basin Area.

Large deposits of limestone occur on either side of the West Coast Range to the east of Macquarie Harbour, but more especially to the south of these mountains. The largest area is a few miles inland from the old port at Kelly Basin, an inlet of Macquarie Harbour. From this point, the old North Lyell Railway ran and in the following acount of the limestones by Hills in 1914, the mile pegs represent those distances along the railway from Kelly Basin:—

"The series is characterised essentially by the presence of extensive beds of limestone, but there are associated therewith, intercalated beds of slate and quartzite. This relation can be seen to especial advantage in the railway cuttings south of the 5-mile. The series is there seen to consist of a succession of synclinal and anticlinal folds of alternating beds of limestone, slate and quartzite. The limestone varies in purity in the different beds, the purer varieties being bluish-grey to black in colour, while the impure varieties are of a greyish hue. These impure limestones are either argillaceous or siliceous.

At the 3½-mile the anticlines and synclines can be well seen, the beds at this point consisting of impure siliceous limestone, which has resisted the weathering agents sufficiently to form high hills, through which the Bird River has corroded its present channel. It is in the gorge of this river that these folds are so well shown.

The purer limestone has been so rapidly eroded that it generally occupies low-lying or flat country. This is well seen in this district for, wherever these pure limestone beds occur, the country is inclined to be flat.

At the 4½-mile there is a development of caves in the limestone, and these are regarded by the people in the district as of great beauty.

At the 2½-mile, the limestone is succeeded by the Tertiary sediments of Macquarie Harbour.

This limestone series is also seen in the Clark Valley, from about three miles above the point of the debouchure of that river northwards. The same alternation of limestone, both pure and impure, with the quartzites and slates occurs here.

Going northwards along the North Lyell Railway from the 10-mile, no limestone is observed until Darwin is reached, where it occurs outcropping in flat country. At this point the purer limestone beds occur. They have been worked as a source of limestone for fluxing in connection with the North Lyell smelters. At the 14½-mile the limestone and quartzites are seen in a cutting about 15 feet deep.

Between the 11 and 15 mile the limestone always appears at a lower level than the white Crotty sandstones which overlie the series we are now considering. Very often the only indication of the presence of the limestone is a soft black pug, which represents the residue left from the process of decay of the limestone, where such products have not had an opportunity of being removed, owing to the protective action of the overlying more-resistant sandstone.

Northwards of the 15-mile the limestone solely occurs outcropping either in the flats or in the river beds. The significance of this has already been discussed.

This limestone series also occurs on the western side of Mt. Jukes. It can be seen outcropping in the bed of the Newall River, and the whole series with the associated quartzites occurs in the neighbourhood of Kallemback's Creek.

The strike of this series is markedly constant, varying from due north to north 20° west. Only in one case was the strike observed to swing to the east of north, and only very occasionally is it as far to the west as to give a north-west strike. The series being folded, the dip varies from point to point, being generally vertical, but sometimes inclined to the east or west at high angles.

The rocks of this series are fossiliferous, the organic remains being confined to certain beds of limestone. It is very difficult to collect a representative suite of fossils from the limestone, as they are only shown on the weathered surface of the rock, and even then only in restricted horizons. The best development of these fossils occurs at the Darwin quarry. From the palaeontological evidence here gathered, these limestones may be correlated with those occurring at Zeehan and Queenstown. The Gordon River limestones also belong to the same horizon."

In 1951 an analysis of a limestone sample stated to have come from Darwin showed: —

	%
CaO	49.80
MgO	2.20
Acid Insoluble	5.2
Fe_2O_3	0.4
Al_2O_3	0.2
P_2O_5	Trace
Ignition Loss	41.7
MnO_2	Trace

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Mayday Area.

An area of limestone exists in the vicinity of Mt. Mayday that has been mapped, though not in detail, by geologists working in a special prospecting area held by R. H. Needham, of the Burnie Board Timber Pty. Ltd.

This is apparently a typical occurrence of Gordon Limestone overlying conglomerate and quartzite beds and occurring for about a mile along a valley of one of the headwaters of Mayday Creek. This creek is a tributary of the Mackintosh River, which is a tributary of the Pieman River.

The limestone area is situated almost 10 miles south-east of Guildford Junction on land held by the A.P.P.M., of Burnie, and it is expected that at some future date the company may use it for constructing roads and possibly also in its works.

CHAPTER 5—THE PERMIAN LIMESTONES

AVOCA DISTRICT

Regional mapping in the Avoca district is at present being carried out by F. Blake. Deposits of limestone included in this area are described by him as follows:—

Introduction.

Beds of poorly-exposed limestones occur on either side of St. Pauls River valley where the outcrops can be traced for over eight miles, usually high along the valley slopes. On the northern side, the limestones extend around the western base of St. Pauls Dome into the South Esk River valley in the vicinity of Ormley.

There is little evidence to show that these deposits have been exploited in the past, although it is probable that small quantities of the lime content were used in the cementing mortars of the stone buildings by the early settlers at Avoca.

Location and Access.

Avoca is a small town on the Esk Highway and Conara-St. Marys railway, situated alongside the South Esk River, about 40 miles south-east of Launceston. An access road from Avoca follows St. Pauls River valley easterly past the township of Royal George (11 miles), while branch roads serve farms and the Merrywood colliery.

Topography.

Both the South Esk and St. Pauls rivers have wide flat-floored valleys with meandering streams and pleasant grass lands. From the river flats the sides of St. Pauls valley rise sharply in wooded tiers and ledges to within 400 feet of the top. Above this altitude the rise is extremely steep to St. Pauls Dome (3,368 feet) on the north side and Snow Hill (3,175 feet) on the south, where the slopes are almost bare of vegetation.

Geology.

The accompanying locality map of the district shows the limestone outcrops in relation to topographical and cultural features.

The basement rocks in the area consist of quartzites and slates of the Mathinna Group intruded by granites of Devonian age, and are exposed on the lower slopes of the hills on the sides of the main valleys. Almost level bedded Permian sediments overlie the older rocks further up the hillsides, where they are distinguished by stepped ridges and plateaux. The stratigraphical sequence is as follows:—

Siltstone.
Sandstone.
Limestone.
Mudstone.
Sandstone.

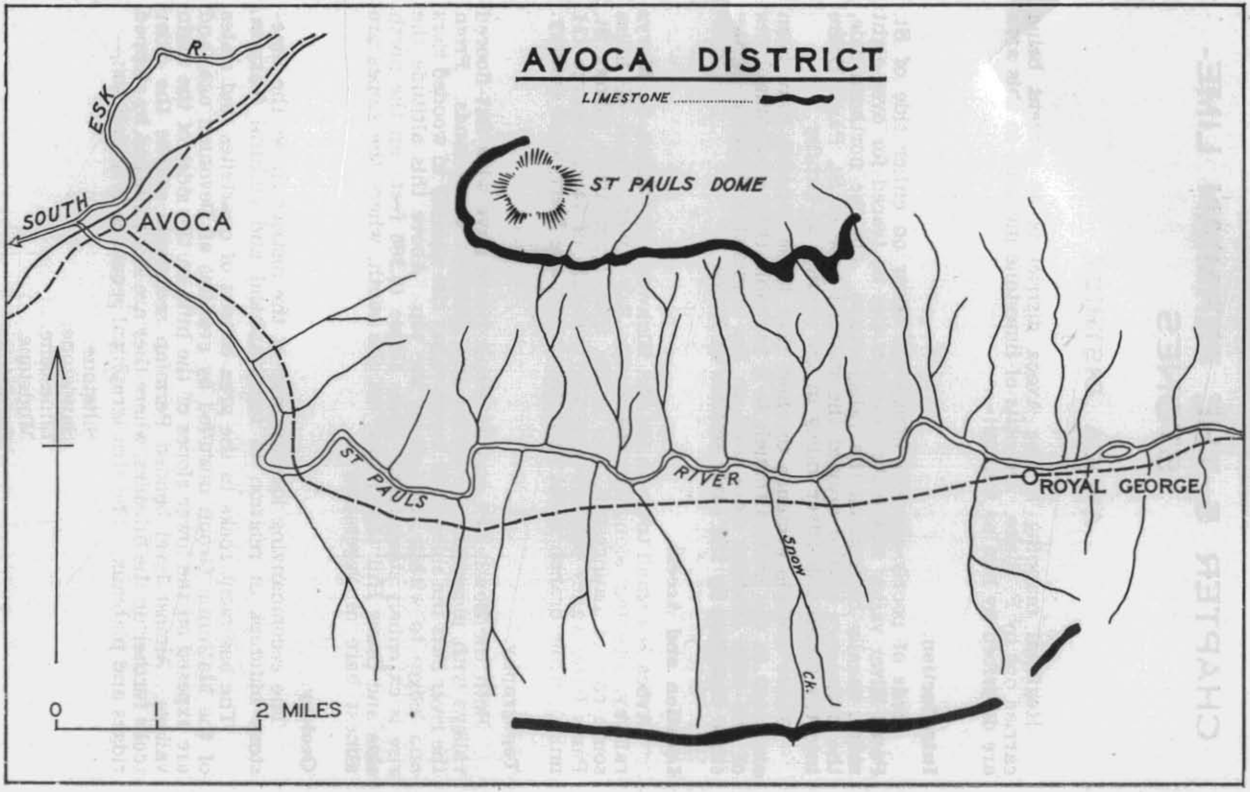

Fig. 29.—Avoca Area.

The Permian strata are succeeded by Triassic sediments, commencing with Ross sandstones and passing upwards into shales and feldspathic sandstones with accompanying coal measures. The mountain tops are represented by exposed sills of Jurassic dolerite overlying the Triassic and Permian rocks. Some small transgressive bodies of dolerite also intrude the older rocks. The youngest rocks in the area cover the floors of the South Esk and St. Pauls valleys. They comprise Tertiary basalt flows covering Lower Tertiary clays and gravels, while the basalt is largely overlain by a thin sheet of Upper Tertiary sands.

The Limestones.

The limestone beds range up to 60 feet in thickness. They are generally situated high on the main valley sides and are difficult to locate owing to poor outcrops. They usually appear on even grassy slopes and low saddles about the heads of small streams, but only occasionally on steeper slopes and small cliffs.

Access to the outcrops is difficult and only one road penetrates to within easy distance of an exposure. This occurs at nearly 1½ miles south-east of Royal George township where shallow pits have opened up a small area of the limestone.

The rock is light-grey in colour, sometimes with a pinkish tinge, and is highly fossiliferous. Occasional pebbles of quartz and quartzite are included in the limestone and some shaly bands occur along the bedding planes. The lower beds are nearly always extremely silicified as also is the top of the underlying mudstone.

From an economic aspect these limestones must be considered as low grade. Overburden is no problem but access is difficult and, owing to the low slopes in the limestone localities, suitable quarry sites would be hard to obtain.

II BEACONSFIELD

Introduction.

In 1914, W. H. Twelvetrees investigated some Permian limestones in the vicinity of West Arm, a few miles north of Beaconsfield, with a view to their use in the manufacture of cement. He found that the limestones were mostly calcareous mudstones and that often they occurred at or below sea-level. However, he reported that mixed with the better grade limestone south of Beaconsfield, some beds perhaps could be used. Although some trenches were put in at one locality the project was never developed. The following remarks are largely taken from his report.

Location and Access.

Permian beds enclose West Arm, a large stretch of water leading from the Tamar River, just north of Beauty Point and near the river's mouth. Beauty Point is a first-class port and good roads are plentiful in the district.

Geology.

The Permian rocks here consist of mudstone, mudstone conglomerate, shale and limestone. They have a general north-westerly strike with a flat dip to the north-east.

The Limestone.

On the northern shore of the Arm, north of Soldier's Point, the steep bank shows beds of yellowish pebbly grit and clayey sandstone. Below these and not higher than high-water mark are calcareous beds, the softened upper surface of which can be seen at low tide. Two bands of impure limestone appear to be separated by about 30 feet. The outcrop distance of the first is 46 feet along the foreshore and of the second 115 feet. The dip of the beds is to the north-east. A sample showed in analysis:—

	%
CaO	20.0
SiO_2	53.4
$Al_2O_3 + Fe_2O_3$	6.2
Ignition Loss	19.0

At half a mile up Anderson's Creek from its mouth at York Town, some calcareous beds showed in analysis:—

	%
CaO	3.4
SiO_2	78.2
$Al_2O_3 + Fe_2O_3$	8.4
Ignition Loss	6·8

But a sample from a boulder found on the hill to the west showed:—

	%
CaO	37.6
SiO_2	23.0
Al_2O_3	5.8
Fe_2O_3	1.8
MgO	0.9
Ignition Loss	30.4

indicating that beds of time limestone may exist in this area.

At Blue Stone Ford, a further half mile up the creek, are flat beds lying under water except when the creek is low. An analysis of a sample (but not taken by a departmental officer) showed:—

	%
$CaCO_3$	66.00
SiO_2	29.15
$Al_2O_3 + Fe_2O_3$	2.20
Moisture	2.43
MgO	0.22

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III BOTHWELL

Although of very low grade and limited in extent, these deposits are recorded, as in the past, probably some eighty years ago, they were worked and the ruins of an old kiln indicate that the limestone was burnt on the spot.

The quarry is situated about seven miles east of Bothwell and may be reached by following a road which, at three miles from Apsley on the Jericho road, branches to the west. At one mile along this road a small gully crosses it and the quarry is half a mile up this.

The workings are quite small and consist of a face 10 feet in height and about 500 feet in length.

A grab sample from this material showed:—

	%
$CaCO_3$	24
SiO_2	68

IV LIMESTONE AT CAMPANIA

Introduction.

For some time prior to 1951, several farmers of the Richmond Municipality had been interested in obtaining local supplies of limestone suitable for crushing for agricultural needs. A possible source of supply that had received some attention was a deposit situated on the property of Mr. Dunbabin, "Ivanhoe," Brown Mountain.

Location and Access.

This deposit is located some eight miles north-north-east of Campania and can be reached by a motor road from there. The turn-off to "Ivanhoe" leaves the Colebrook Road two miles north of Campania and is followed first east and then north for five to six miles until "Ivanhoe" is reached. Half a mile beyond the homestead a track branches to the right and follows the course of White Kangaroo Rivulet for almost a mile where it crosses by means of a ford.

Geology.

On the west bank of the stream at this point may be seen boldly outcropping exposures rising in cliff faces in places over a hundred feet in height. These rocks consist mainly of Permian mudstones, but contain bryozoal limestone and calcareous mudstone beds, the whole flatly bedded, dipping a little north of west at 3°.

The Limestone.

Three samples taken across the beds have been analysed with the following results:—

Constituents	I. Per cent.	II. Per cent.	III. Per cent.
Acid insoluble ..	35.9	43.6	62.7
Al_2O_3	2.9	4.8	4.2
Fe_2O_3	1.2	2.0	1.6
CaO	36.8	31.1	20.5
MgO	0.7	0.4	0.6
Ignition Loss	22.7	18.5	10.6

Number three sample was taken just below the ford over a width of four feet at creek level. Almost six hundred feet upstream from the ford the rock face has been weathered into a series of small caves and inlets. These beds are composed of a grey and cream, rather silicious, bryozoal limestone, containing small aggregates of calcite, which north and south along the strike appears to become more silicious. No. 1 sample was taken from creek level to 10 feet, and No. 2 sample from 10 to 15 feet. Above this are thick beds of silicious mudstone.

From the analysis it can be seen that there is too much CaO to satisfy the CO_2 (or Ignition Loss) so that all the CaO is not in the form of calcium carbonate. A thin section of rock obtained from Sample 1 shows the presence of anorthite felspar so that portion of the CaO is contained in this. The remaining CaO is in the form of wollastonite or calcium silicate—a metamorphic mineral formed as a result of dolerite intrusion. The theoretical percentages of the various minerals present may be calculated as follows:—

Mineral	I. Per cent.	II. Per cent.	III. Per cent.
Magnesium Carbonate ($MgCO_3$) ..	1.4	0.8	1.2
Calcium Carbonate ($CaCO_3$).. ..	50.0	41.1	22.7
Wollastonite ($CaSiO_3$)	14.9	11.2	11.2
Felspar ($CaO.Al_2O_3.2SiO_2$) ..	7.9	13.0	11.5
Silica (SiO_2)	24.8	32.3	52.0
Iron Oxide (Fe_2O_3)	1.2	2.0	1.6

The only lime available to the soil when this material is crushed and spread is that contained in the $CaCO_3$, so that the available CaO in each sample may be expressed as follows:—

I. .... 28%; II. .... 23%; III. .... 12.7%.

It can thus be seen that even in the best sample the lime content is too low to consider it as a commercial proposition.

Qualities Available.

Had the analysis revealed limestones of good grade, an approximate estimate of tonnage could have been made and it would have been found that these were quite large as the samples were taken over nearly twenty feet and the beds extended for many hundreds of feet laterally. However, the grade being what it is, there is no point in elaborating the sampling and estimating available tonnages.

Ease of Quarrying.

As mentioned above, the limestone beds outcrop at creek level and thick mudstone beds occur above them, so that even if the grade were good, the amount of overburden would preclude the economic winning of any quantity of limestone.

Proximity to Markets.

Although this limestone does occur at the extremity of agricultural land, it is easily accessible as far as roads are concerned and closer to potential users than any other recorded deposit.

Conclusion.

The poor grade of the beds sampled and the large overburden of mudstone seems to preclude the exploitation of this material for agricultural needs.

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V CENTRAL PLATEAU

A report on limestone deposits at Bronte was prepared by F. Blake in 1947, as follows:—

General.

Following the request for an endeavour to find limestone deposits suitable for agricultural purposes in the vicinity of Bronte, an examination was made in that area, with the result that beds of Permian limestone were located and sampled.

Location and Access.

The deposits are situated on both sides of the steep valley of Serpentine Creek, 4½ miles by road, north of Bronte post office. Access is gained from Lyell Highway at Bronte by way of the road leading to Great Lake, which passes through the area.

Limestone Deposits.

Permian limestones outcrop at four points along the sides of Serpentine Creek gorge. On the west side the upper bed is exposed in road cuttings for a distance of 200 yards along the Bronte-Great Lake road. It is interbedded with siliceous mudstones and dark-grey shales and dips at a low angle to the south-east. The limestone varies in thickness from four to 10 feet but, in places, includes from one to four narrow shale bands varying from two to 12 inches in width.

The road cuttings in this locality range up to 15 feet in height but, as the limestone is principally in the lower portion, extensive quarrying into the hillside would soon become uneconomic owing to the increasing overburden of other rocks. Apart from the above considerations, small quarries for extracting limited quantities of limestone are practicable.

On the east side of the valley, approximately half a mile south-east of the road cutting exposure, the upper head of a small tributary valley trends north-westerly to join Serpentine Creek. At this point the limestone is well exposed and averages six feet in thickness along a length of about 100 yards. In these outcrops shale bands within the limestone bed are not prominent and appear to be almost totally absent. Overlying strata consists of pebbly sandstone, and dark-grey pebbly shales occur below the limestone. Here the limestone is more regular and massive and the quarrying facilities better than at the road cuttings on the opposite side of the valley. However, the absence of an access road and the rugged nature of the approach creates a transport problem.

A lower thin limestone bed, 15-18 inches in thickness and some 70 feet below the upper bed, is exposed in cliff faces on either side of Serpentine Creek valley in the same locality. This bed is too narrow for economic quarrying and almost inaccessible for transport.

Sampling.

Six representative samples of limestone were cut across the upper bed exposures.

Samples No. 1 and No. 2 were taken from six feet of limestone at different points along the outcrop on the east side of the valley.

Samples Nos. 3, 4 and 5 represent thicknesses of six feet, nine feet, and eight feet respectively, at the northern end, middle, and southern end of the road cutting exposure on the west side of the main valley. In these three samples the following bands, interbedded with the limestone at the above points, were excluded:—

No. 3 Sample—Shale band, three inches wide.
No. 4 Sample—Shale band, 12 inches wide.
No. 5 Sample—Four Shale bands, each four inches wide.

Sample No. 6 represents a picked band of limestone, 18 inches in width which persists throughout the greater length of the road cutting exposure.

The following table of analyses shows the results of the sampling:—

Sample	Constituents	Percent.
No. 1	SiO_2	31.92
	CaO	33.08
	MgO	0.84
No. 2	SiO_2	31.72
	CaO	32.93
	MgO	0.64
No. 3	SiO_2	41.36
	CaO	25.45
	MgO	0.91
No. 4	SiO_2	51.94
	CaO	19.34
	MgO	0.80
No. 5	SiO_2	52.00
	CaO	18.03
	MgO	0.78
No. 6	SiO_2	13.88
	CaO	42.72
	MgO	0.45

The above results indicate that the limestone in the road cuttings is generally low in lime but that the persistent 18-inch band is of much higher grade.

The average quality of the upper bed on eastern side of Serpentine Creek valley is of better quality throughout than that exposed in road cuttings further to the west.

VI CYGNET AREA

In 1950 a search for sources of agricultural lime in the Huon area led to the examination of a deposit of limestone near Cygnet by G. Everard. He reports as follows:—

Location and Access.

Glaziers Bay, from which the surrounding district takes its name, is a shallow indentation in the left, or eastern, bank of the estuary of the River Huon, and lies 24 miles south-west of Hobart, to which it is connected, through Huonville, by the Huon Highway. Silver Hill, where the limestone deposit examined is situated, is in the Glaziers Bay district and connected by road with the town of Cygnet, three miles east-south-east.

Topography.

The area is one of strong relief due to igneous intrusion and block faulting, followed by normal erosion. The angular course of the lower Huon suggests fault control. Subsequent drowning gave the wide estuary of the Huon and the inlet of Port Cygnet. Where the Huon and Port Cygnet are parallel, small streams enter them at right angles from the intervening land, leaving a watershed between, of which Silver Hill is part.

Geology.

Permian mudstones are the typical country rocks, and where undisturbed by igneous intrusion, have slight dips, usually to the west and south-west. Recent deposits may be found in river valleys and form islands in the Huon. Dolerite is present in the area, but the principal igneous rock is the alkaline intrusive, possibly of Tertiary age. Contaminated rocks fringe the intrusive masses.

The Limestone.

The only known deposit of limestone in the area is situated on a spur in a steep-sided valley of a stream on the western slope of Silver Hill. The limestone is revealed by shallow pits and trenches, now partly filled up with soil, and from three of these it was possible to obtain clean grab samples. The deposit could not be traced for more than about a chain along the strike because of a thin overburden of hard, sun-baked soil covered with grass; and, although almost certainly more extensive than this, the limestone bed appeared to pass into mudstone at no great distance in either direction. At the places where the samples were taken there was a minimum thickness of twenty feet of limestone. The dip of the limestone bed itself could not be determined, but the mudstones nearby had slight dips to the south-west. For a distance of about forty feet down the slope of the spur, the limestone had as overburden, only a thin cover of soil debris, but at its upper boundary passed in under the overlying mudstones..

The limestones are fine-grained dark-grey rocks which weather to a pale colour on exterior surfaces and then appear not unlike the mudstones. They contain a great variety of organic remains. Under the microscope they are seen to consist largely of cryptocrystalline calcite. Angular quartz grains are fairly numerous and are largely of silt dimensions. There is a light staining of limonite and this mineral also occurs in minute grains. Felspar and felspar altered to calcite are also common. Numerous remains of micro-organisms are present.

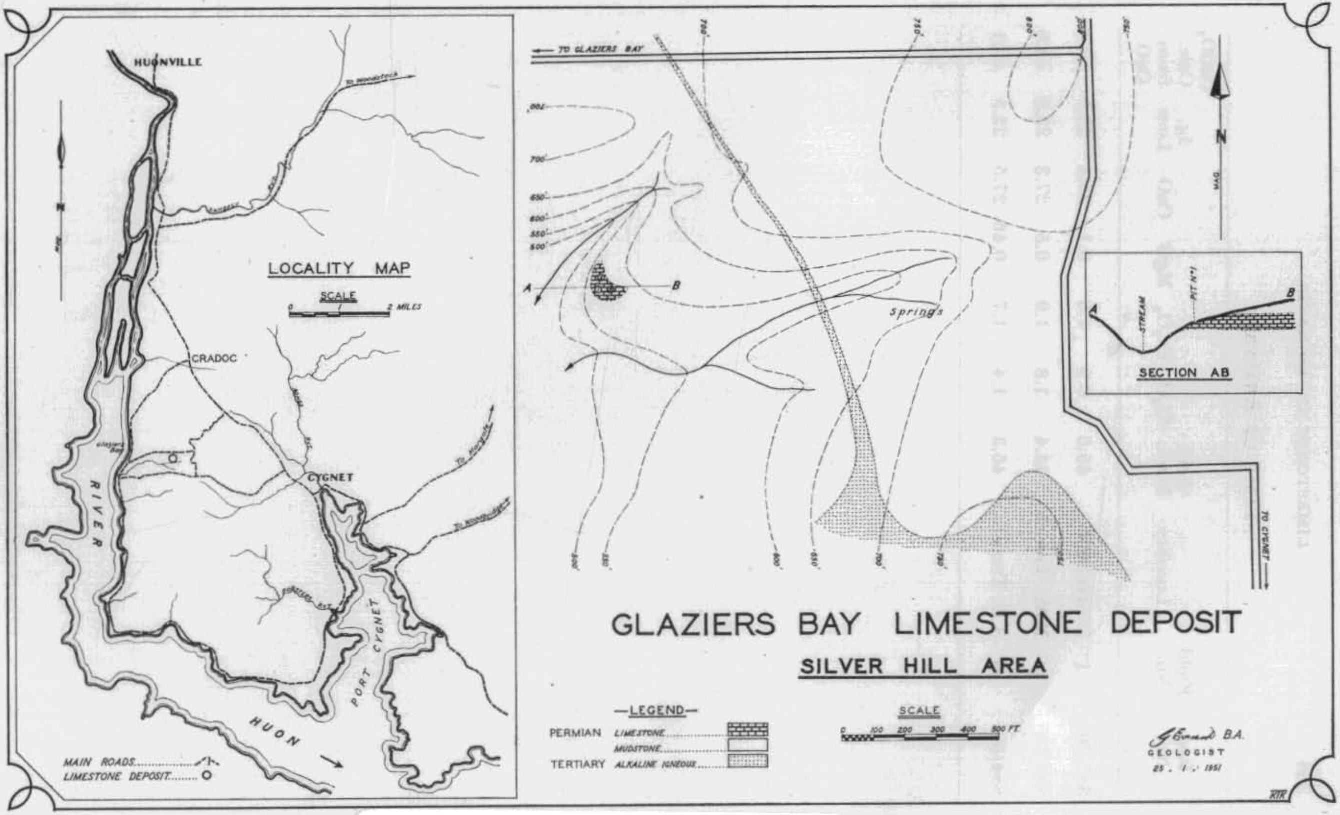

FIG. 30.—Glaziers Bay Area—Cygnet.

TABLE OF ANALYSES.

Reg. No.	Field No.	Locality	Acid Insol.	Al_2O_3	Fe_2O_3	MgO	CaO	Ig. Loss	$CaCO_3$ Calc. from CaO
882/50	1	Central Pit	45.6	0.9	1.6	0.1	28.3	23.5	50.5
883/50	2	N.W. Trench	44.4	1.8	1.9	0.5	27.3	23.8	48.9
884/50	3	S.E. Trench	45.3	1.4	1.7	0.46	27.5	23.5	49.1

VII DALMAYNE

Introduction.

Limestone covers a wide area to the east of the Dalmayne Coal deposits but, except for small cliffs along Piccaninny Creek, does not outcrop freely. In 1926, P. B. Nye investigated these deposits as a possible source of limestone for cement manufacture. Samples taken showed that the limestones were a lower grade than the beds at Mt. Peter, further to the south, and that these rocks had suffered silicification to a minor degree. Two reports were made by Nye in 1926 and this chapter consists of material taken from them.

Location and Access.

Dalmayne is a defunct colliery eight miles south of St. Marys, the terminus of the railway line from Conara. The limestones lie a mile and a half to the west of the Tasman Highway near Piccaninny Point and were crossed by the old aerial tramway from the colliery to the old jetty there.

The basal beds of the Permian here consist of conglomerates and grits unconformably overlying the Mathinna slates and quartzites. These basal beds pass upwards into interbedded sandstones and shales, which in turn are succeeded by the limestone. In the Piccaninny Creek area the thickness of the Permian beds below the limestone is 170 feet and the limestone also has a thickness of 170 feet. Above the limestone are Permian beds of only 30 feet in thickness and these are overlain by the lower coal measure beds of the Triassic.

In Piccaninny Creek, the basal beds of the Permian overlie the Silurian quartzites at an altitude of 260 feet, while the limestones overlie the basal beds at 430 feet. On the north-eastern corner of old lease 8135/M the quartzites extend to altitudes of 600 feet, while about the centre of the lease the basal conglomerates occur at 330 feet above the sea. This difference in altitude of the Silurian basement may be due to faulting or simply the uneven floor of the Permian sea.

The Limestone.

Limestone outcrops on the old Dalmayne leases in the creeks and gullies and as small cliffs on the hillsides. The boldest outcrops are along Piccaninny Creek, where most of the sampling was done. The plan shows two areas of limestone of approximately 100 and 200 acres respectively. The average thickness of the limestone is about 100 feet and subtracting a third for voids, solution channels and overburden, the reserves should be of the order of 20,000,000 tons. The limestone, especially on the ridge along which the track to the coal mine passes, could be quarried with practically no overburden.

Several samples were taken, principally at Piccaninny Creek. No. 1 Sample represents the upper portion which consists generally of white, pink, and light-coloured types. In some beds, silicification has taken place, small irregular veins (up to two inches wide) of silica occurring parallel to the bedding planes.

Sample No. 2 represents the middle beds which consist partly of the light coloured types of the upper portion and partly the darker ones of the lower.

Sample No. 3 represents the lower portion which consists for the most part of dark-grey and greyish-brown types of coarser grain. Sample No. 4 consists of small pieces of stone broken over the whole thickness of the beds.

Sample No. 5 is from a selected band, five feet thick, of the pink beds at Piccaninny Creek.

Sample No. 6 is a sample from a small cliff face south of and immediately below the track to the coal mine.

Sample No.	SiO_2	Fe_2O_3	Al_2O_3	$CaCO_3$	$MgCO_3$
	%	%	%	%	%
1 ..	20.16	2.29	0.43	77.60	0.29
2 ..	20.28	3.86	1.54	75.32	0.36
3 ..	23.52	2.00	2.68	71.69	0.50
4 ..	24.60	2.86	0.34	72.00	0.86
5 ..	7.20	0.44		90.23	0.60
6 ..	17.40	1.00		79.25	0.75

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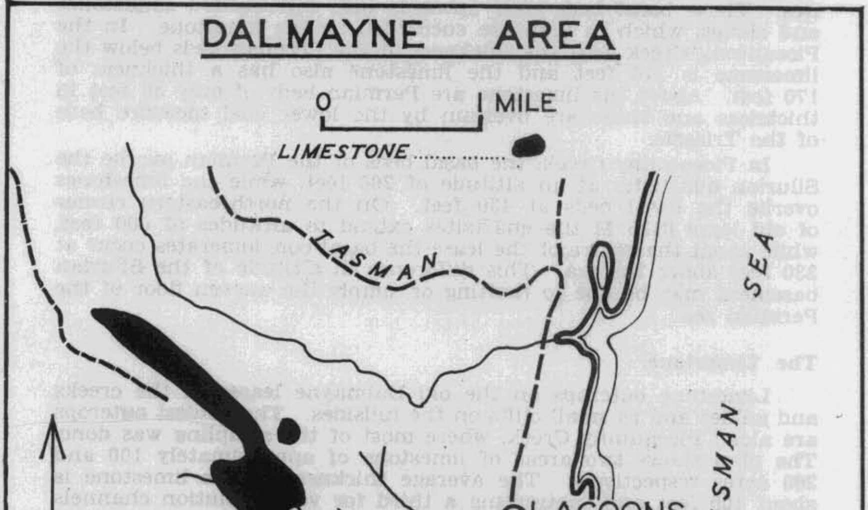

FIG. 31.—Dalmayne Area.

VIII LITTLE DENISON RIVER

Introduction.

The need for agricultural limestone in the Huon area has led to the investigation of all possible sources of lime in that district. The report of limestone at the Little Denison River led to an investigation of the deposit by F. Blake, but both the grade and aspect of the stone seem to preclude the use of this material. The report is quoted as follows:—

Location and Access.

The deposits are situated on the north-eastern slopes of Little Denison River valley, above the road crossing. This stream junctions with Huon River about six miles above Judbury township.

Good access is available by road from Huonville, via Judbury, in a distance of 18 miles to within half a mile of the deposits, from a road following Little Denison River.

Previous Literature.

Reference is made to the limestones in an unpublished report and geological maps made by R. J. Ford in 1955 for the Hydro-Electric Commission.

Topography.

The principal topographical feature of the area consists of the steep side of Little Denison River valley rising sharply 80 feet from a flat floor to the base of cliff faces, along which the limestones are exposed. The cliffs rise 60 to 80 feet higher to the top of the limestone beds.

Geology.

The rocks in the area consist of Permian mudstones and limestones dipping at low angles to the south-east. These are well exposed on the steep north-east side of Little Denison River valley over a distance of approximately two miles, where the stratigraphical succession (Ford, 1955) is as follows:—

Woodbridge Glacial Formation.
Berriedale Limestone.
Bundella Mudstone.

The Limestone.

The limestone deposit outcrops in a series of steep cliffs commencing some 50 to 80 feet above the valley floor. It occurs in the form of numerous narrow beds of limestone, four to six inches in thickness, separated by shaley mudstone bands of a similar width. Pebbles of quartz, quartzite and granite, up to three inches in size, are distributed through the limestones, and in some beds they are numerous enough to form conglomerates.

The limestones are generally fine grained and dark-grey in colour which weather at surface to a light-grey or buff colour. A large variety of fossil remains is present, consisting predominantly of brachiopods and bryozoans.

Quality.—A 10-ft. sample taken across the lower beds, including limestone and shale bands has been analysed with the following results:—

	%
Acid Insoluble	61.7
Fe_2O_3	4.1
CaO	17.0
MgO	0.6
Ignition Loss	15.3
$CaCO_3$ (calc. from CaO)	26.8

This analysis indicates that the lime content of these beds is too low for commercial use at the present.

Quantity.

Large quantities of limestone occur in this area. The beds are exposed laterally for about two miles and have a maximum thickness of 90 feet. Owing to the low grade of the deposit, as indicated by the preliminary sampling, there appears to be little necessity to estimate possible tonnages at this stage.

Quarrying.

Conditions for quarrying are difficult and likely to prove costly owing to a thick overburden and the location of the limestone beds on steep cliffs high above the valley floor.

Proximity to Markets.

The deposit is easily accessible by roads to the adjacent agricultural district of the Huon valley, where lime is in constant demand.

Conclusion.

The low grade of this limestone occurrence, coupled with thick overburden and difficult quarrying facilities, appears to preclude the deposit from economic operation at the present time.

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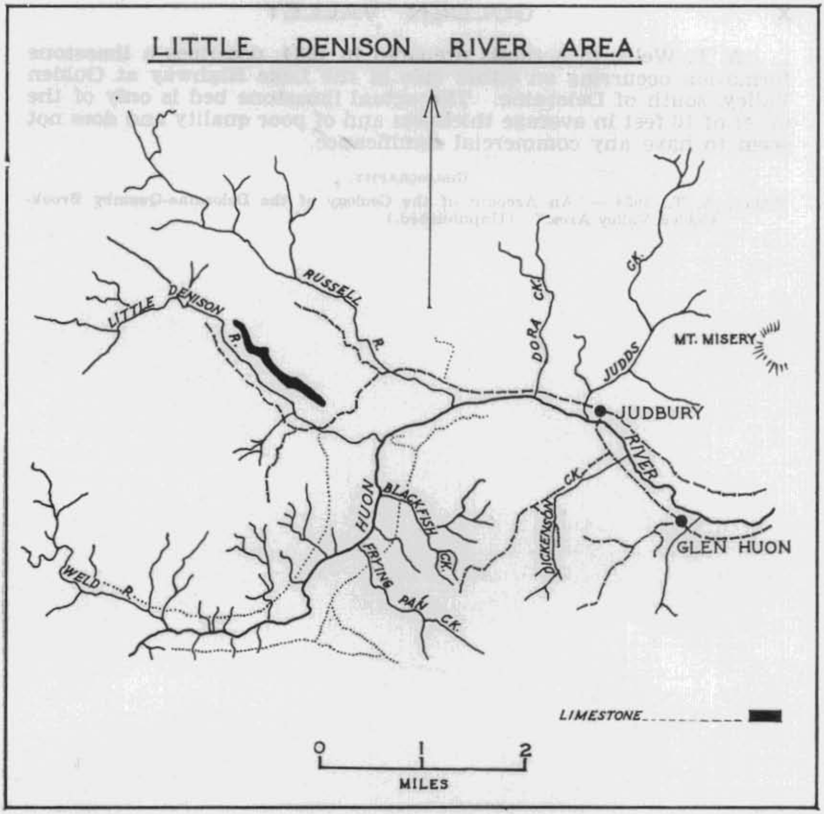

FIG. 32.—Little Denison River Area.

X GOLDEN VALLEY

A. T. Wells, in a thesis prepared in 1954, describes a limestone formation occurring on either side of the Lake Highway at Golden Valley, south of Deloraine. The actual limestone bed is only of the order of 10 feet in average thickness and of poor quality and does not seem to have any commercial significance.

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WELLS, A. T., 1954.—" An Account of the Geology of the Deloraine-Quamby Brook-Golden Valley Area." (Unpublished.)

XI GRANTON-BERRIEDALE-GLENORCHY DROMEDARY

From one of Hobart's northern suburbs, Glenorchy, north across the Derwent River to Dromedary for a distance of fifteen miles are beds of Permian limestone which here and there have been or are being worked. Owing to large-scale faulting the beds are not continuous, but they can be seen at several localities, including the type area, Granton. Numerous quarries were developed here in the past and the stone was burnt in kilns, which are a familiar sight on the Lyell Highway between Granton and New Norfolk. Limestone was once also burnt at Dromedary and at Berriedale. A large limestone quarry at Glenorchy is used as a source of road metal.

(A) **Granton.**

Limestone has been burnt at Mt. Nassau, near Granton, for a long time, but of recent years production has greatly declined and today a kiln is burnt only intermittently. In 1948, H. G. W. Keid conducted an extensive sampling campaign and this portion of the chapter is quoted from his report:—

The Mt. Nassau Limestone Quarry is situated about half a mile south from the Lyell Highway and about 13 miles from Hobart.

In the year 1928, Mr. P. B. Nye, Government Geologist, reported on the property at Mt. Nassau, then referred to as Mr. Rathbone's property. Nye records the geological sequence and allots a thickness of approximately 200 feet to the limestone beds which occur as the mid-section of the Permian strata. Nye states that "the stone is quarried and burnt for the production of quicklime," but has not given any analyses of samples of the stone.

Quarrying has been carried out on each side of Quarry Creek. From the excavations, it is noted that the beds are dipping at a low angle towards the west of south-west. The excavations have been carried forward until a maximum depth of about 45 feet has been reached.

On the eastern side of the creek an excavation has been made of a total length of approximately 1,200 feet with an average width of 60 feet. The maximum height of the quarry wall is 45 feet, but the average depth of excavation would not exceed 16 feet. It is evident that the difficulty experienced in removing the spoil has been a controlling factor in closing this quarry, for large quantities have been stocked within the limits of the excavation and access to the working faces without its removal would be difficult.

Present quarrying operations are being carried out on the western side of the creek. The excavation here measures about 650 feet in length, with an average width of about 45 feet. The maximum height of the quarry wall is 35 feet but the average height would not exceed 24 feet. As these workings are progressing in a westerly direction, the floor is becoming lower and, as the quarry advances, increasing difficulty in the removal of water must be expected.

The limestone of the quarry is well bedded in tiers ranging in thickness from nine inches to 27 inches. The tiers are separated from each other by bands of calcareous shales ranging to 27 inches in thickness. The present working face has a total height of 35 feet, of which approximately 11 feet is represented by shaly bands which have to be excluded as spoil. After quarrying, the stone from the tiers is broken by spalling to a size for convenient loading by hand and at the same time a proportion of the stone is discarded as spoil in the belief that its quality is such as to prevent complete burning in the kilns.

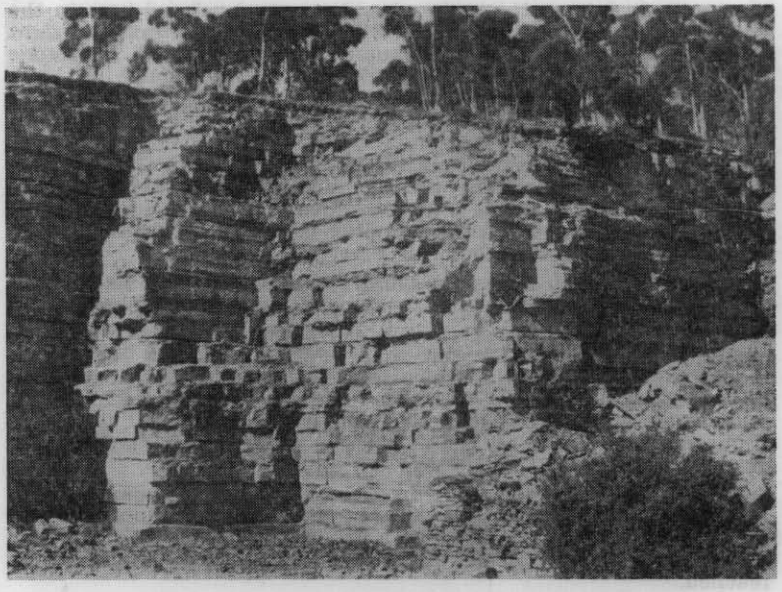

FIG. 33.—Limestone Quarry, Granton.

It is doubtful, therefore, whether the present operations yield more than 25 per cent of the stone excavated as a product for the kilns and it is obvious that the quarry now idle did not yield a high proportion when operating. As the amount of overburden in the present quarry is increasing with depth, the position appears to be becoming uneconomic, for a progressively lower proportion of the product will reach the kilns.

For the purpose of this examination, all the tiers in the present quarry were sampled, as also were the principal shaly bands. A number of the tiers in the idle quarry were also sampled. The product at the kiln site was also sampled to determine the grade of the kiln feed. In all, 39 samples were taken and, when sampling in the quarry, all the stone from the tiers was included in the sample and there was no discard as occurs in practice. The analyses of the 39 samples is included herewith, and for purposes of comparison, a number of analyses of samples recorded in 1929 as from the same quarry is also attached. Samples 19 to 22, inclusive, represent the analyses of the principal shaly bands.

TABLE 1.

ANALYSES OF SAMPLES OF MT. NASSAU LIMESTONES.

Per Cent.

Sample No.	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Ignition Loss
1 ..	19.9	0.9	1.8	42.0	0.7	33.5
2 ..	21.7	0.9	1.8	41.2	0.6	32.8
3 ..	19.1	0.2	2.1	42.8	0.4	34.2
4 ..	21.5	0.8	2.6	40.4	0.8	32.9
5 ..	34.4	0.9	3.1	33.0	0.6	26.7
6 ..	18.7	0.4	1.5	43.4	0.4	34.6
7 ..	33.1	1.3	2.5	34.1	0.5	27.6
8 ..	15.6	0.7	1.3	45.4	0.6	36.3
9 ..	21.4	0.9	2.5	40.7	0.6	33.0
10 ..	41.8	2.2	5.8	25.1	0.9	21.8
11 ..	23.4	1.1	2.8	39.3	0.7	32.0
12 ..	33.3	1.3	2.9	33.4	0.6	27.6
13 ..	29.3	1.2	3.7	34.9	0.5	28.8
14 ..	52.9	2.0	7.2	17.5	0.7	15.5
15 ..	44.6	1.9	4.7	24.6	0.6	20.8
16 ..	31.0	1.2	4.2	33.1	0.7	27.3
17 ..	27.0	1.1	3.5	36.3	0.6	29.8
18 ..	43.2	2.0	4.8	24.3	0.6	20.9
19 ..	53.8	3.1	11.7	10.7	1.2	12.5
20 ..	54.2	2.8	9.5	13.1	1.2	13.0
21 ..	59.5	3.6	10.3	8.9	1.2	10.4
22 ..	50.2	3.4	9.9	15.0	1.1	14.9
23 ..	25.3	1.0	1.8	38.7	0.7	31.3
24 ..	17.6	0.6	1.2	44.1	0.5	35.5
25 ..	30.4	0.9	4.1	33.0	0.8	27.1
26 ..	28.4	0.9	2.0	36.6	0.7	29.8
27 ..	22.6	2.0	1.8	40.0	0.7	32.5
28 ..	24.3	0.9	1.7	39.0	0.6	31.8
29 ..	30.0	1.0	2.1	35.5	0.6	28.9
30 ..	29.5	1.0	2.0	36.0	0.6	29.2
31 ..	41.2	1.7	5.0	25.5	1.0	22.2
32 ..	16.9	0.6	2.0	43.0	0.9	35.1
33 ..	30.0	1.3	4.2	33.0	0.9	27.9
34 ..	26.0	1.4	2.2	37.2	0.8	30.7
35 ..	42.6	1.6	5.8	24.8	1.0	21.3
36 ..	29.2	1.1	2.4	35.9	0.6	29.9
37 ..	31.3	1.1	3.1	34.2	0.7	28.5
38 ..	26.50	1.14	2.51	36.80	0.70	30.40
39 ..	24.88	1.00	1.82	38.80	0.66	31.72

A composite made up from the above samples showed the presence of P_2O_5 : 0.1% and MnO : 0.02%.

TABLE 2.

ANALYSES OF MT. NASSAU LIMESTONES (1929).

$CaCO_3$	$MgCO_3$	MgO	SiO_2	Fe_2O_3	Fe_2O_3+ Al_2O_3	Al_2O_3	P_2O_5	SO_3	H_2O	Ig. Loss
59.89	—	1.09	31.40	1.79	—	4.45	—	—	—	—
86.40	—	0.72	10.32	0.91	—	2.27	—	—	—	—
68.90	—	1.09	25.40	1.29	—	3.39	—	—	—	—
68.93	—	0.36	26.64	1.86	—	2.54	—	—	—	—
70.70	—	0.24	23.56	2.14	—	3.74	—	—	—	—
63.60	—	0.50	30.04	1.86	—	4.50	—	—	—	—
78.49	—	0.60	17.60	1.60	—	2.40	—	—	—	—
63.26	—	1.01	29.72	1.56	—	2.64	—	—	—	—
65.26	—	1.23	27.28	1.64	—	2.7	—	—	—	—

Reference to the analysis shows that the kiln feed (samples 38, 39) has a calcium carbonate content of approximately 69 per cent. This grade has been gained by selective methods which have resulted in the discard of a large proportion of the stone quarried. It will also be noticed that several of the tiers of stone have yielded analyses of a higher grade than the kiln feed.

The following table shows the analyses of the tiers in their essentials only, i.e., silica, lime and loss on ignition. The progressive average grade of stone for 9, 11, 13, 15, &c., tiers has also been calculated and recorded.

The average grade of stone for the first (bottom) nine tiers contains 72 per cent of CaO and Ignition Loss, recorded here as $CaCO_3$ as compared with 69 per cent for the Kiln feed. Similiarly for 11 tiers and 13 tiers the grade is 68·9 per cent and 65·2 per cent, respectively. The two latter figures are in excess of sample 38 and only slightly less than those for sample 39 which are the individual analyses of the two samples of the Kiln feed.

(See Tables 3 and 4.)

The analyses show that it is only in the upper tiers that there is an appreciable falling off in grade and they suggest that for at least 13 tiers the entire product, after excluding the shaly bands, could be sent to the kilns for burning and the resultant product be equal to that now being produced. An increase in production and a saving in manpower should result.

The upper tiers of stone may need selective treatment.

TABLE 3.

ANALYSES OF LIMESTONE—RATHBONE'S QUARRY AT MT. NASSAU—PRESENT WORKING FACES

Tier No.	Sample No.	Sample Thickness	Band Thickness	Total Thickness	Total Thickness Limestone	SiO_2 %	Average SiO_2 %	CaO %	Average CaO %	% Loss on Ignition	Average Loss on Ignition %	Average $CaCO_3$ %
1	1	21	—	21	—	19.9	—	42.0	—	33.5	—	—
2	2	21	4	46	42	21.7	—	41.2	—	32.8	—	—
3	3	11½	3	60½	53½	19.1	—	42.8	—	34.2	—	—
4	4	11	2	73½	64½	21.5	—	40.4	—	32.9	—	—
5	5	21	1	95½	85½	34.4	—	33.0	—	26.7	—	—
6	6	18	3	116½	103½	18.7	—	43.4	—	34.6	—	—
7	7	15	5½	137	118½	33.1	—	34.1	—	27.6	—	—
8	8	13	—	150	131½	15.6	—	45.4	—	36.3	—	—
9	9	14	—	164	145½	21.4	23.3	40.7	40.1	33.0	32.1	72
10	10	14	4	182	159½	41.8	—	25.1	—	21.8	—	—
11	11	11	4½	197½	170½	23.4	24.8	39.3	37.6	32.0	31.3	68.9
12	12	12	4	213½	182½	33.3	—	33.4	—	27.6	—	—
13	13	11	5	229½	193½	29.3	25.6	34.9	37.2	28.8	31.0	68.2
14	14	9	7	245½	202½	52.9	—	17.5	—	15.5	—	—
15	15	15½	21	282	218	44.6	28.1	24.6	35.6	20.8	29.6	65.2
16	16	27	22	331	245	31.0	24.2	33.1	35.9	27.3	29.2	65.1
17	17	20	27	378	265	27.0	28.2	36.3	35.9	29.8	29.2	65.1
18	18	17	12	407	282	43.2	28.8	24.3	35.2	20.9	28.1	63.3

TABLE 4.

OLD QUARRY.

Tier No.	Sample No.	Sample Thickness	Band Thickness	Total Thickness	Total Thickness less Bands	SiO_2 %	Av. SiO_2 1	Av. SiO_2 2	Av. SiO_2 3	CaO %	Av. CaO 1	Av. CaO 2	Av. CaO 3	% Loss on Ignition	Av. L.o.I. 1	Av. L.o.I. 2	Av. L.o.I. 3	Av. $CaCO_3$ %
1	27	19	—	19	19	22.6	—	—	—	40.0	—	—	—	32.5	—	—	—	—
2	23	19	6	44	38	25.3	—	—	—	38.7	—	—	—	31.3	—	—	—	—
3	24	19	1½	64½	57	17.6	—	—	—	44.1	—	—	—	35.5	—	—	—	—
4	25	4	2	70½	61	30.4	—	—	—	33.0	—	—	—	27.1	—	—	—	—
5	26	21	1½	93	82	28.4	—	—	—	36.6	—	—	—	29.8	—	—	—	—
6	28	20	8	121	102	24.3	—	—	—	39.0	—	—	—	31.8	—	—	—	—
7	29	18	5	144	120	30.0	—	—	—	35.5	—	—	—	28.9	—	—	—	—
8	30	21	2	167	141	29.5	—	—	—	36.0	—	—	—	29.2	—	—	—	—
9	31	9½	3	179½	150½	41.2	22.2	31.0	26.6	25.5	31.4	33.4	37.5	22.2	25.5	27.7	30.5	68
10	32	6	2	187½	156½	16.9	—	—	—	43.0	—	—	—	35.1	—	—	—	—
11	33	8	3	198½	164½	30.0	21.8	31.1	26.4	33.0	30.9	33.1	37.5	27.9	25.3	27.7	30.6	68
12	37	16	8	222½	180½	31.3	—	—	—	34.2	—	—	—	28.5	—	—	—	—
13	36	22	15	259½	202½	29.2	21.0	31.0	27.0	35.9	28.8	31.5	37.0	29.9	23.6	26.7	30.3	67.3
14	34	18	16	293½	220½	26.0	—	—	—	37.2	—	—	—	30.7	—	—	—	—
15	35	13½	8	315	234	42.6	20.6	34.6	27.8	24.8	26.9	30.1	36.2	21.3	22.1	25.7	29.8	66
16	38	—	—	—	—	26.5	—	—	—	36.8	—	—	—	30.4	—	—	—	—
	39	—	—	—	—	24.88	—	—	—	38.8	—	—	—	31.7	—	—	—	—
Average of 38 and 39		—	—	—	—	25.68	—	—	—	37.8	—	—	—	31.1	—	—	—	68.9

Compared with the product of other limestone quarries in Tasmania, where calcium carbonate content at times exceeds 90 per cent, the limestone of Mt. Nassau is a low grade one. As the depth of overburden is increasing rapidly, a progressively higher proportion of stone quarried will be discarded, and the necessity for opening new quarry faces will have to be considered. Suitable sites are available in the district.

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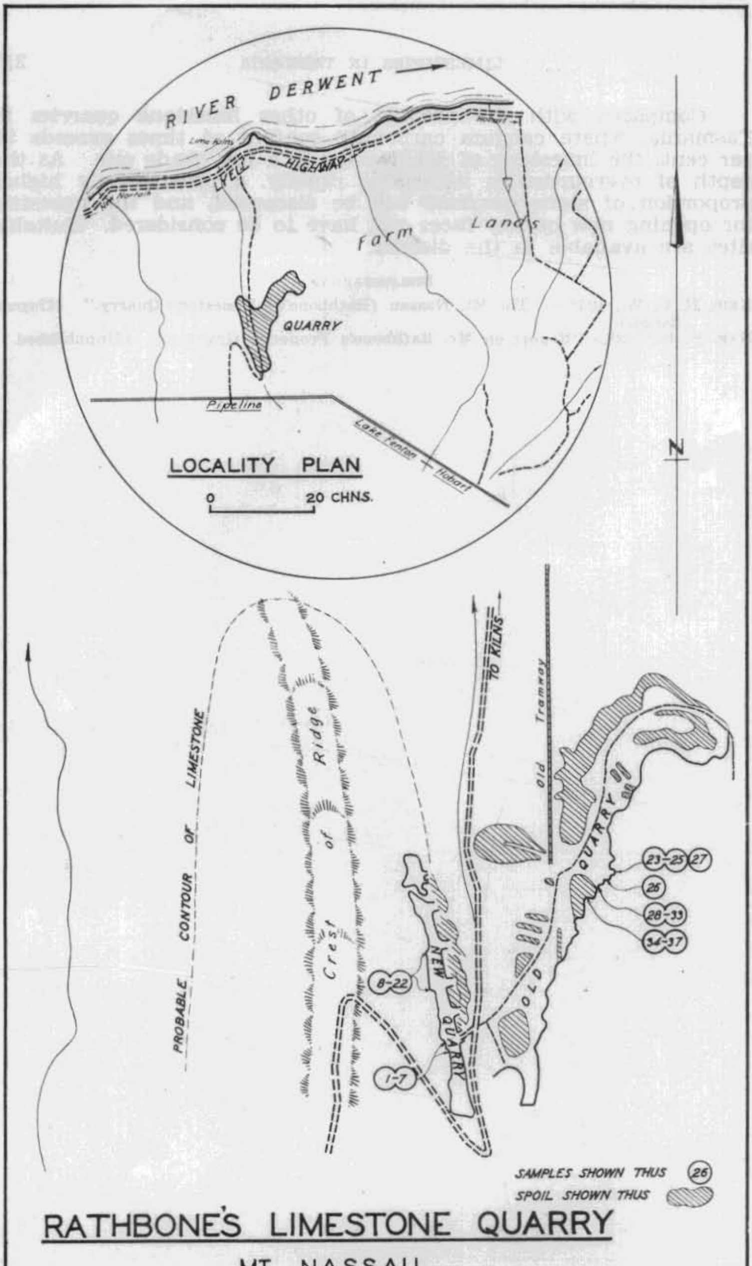

FIG. 34.—Rathbones Quarry—Mt. Nassau.

(B) **Berriedale.**

In 1922, a proposal to establish cement works near Berriedale, led to an investigation by A. M. and W. D. Reid, and the information for this section is largely taken from their report. Already at this time, limestone was being quarried nearby and burnt in kilns near the quarry by the Hobart Brick Company.

Location and Access.—The deposits are situated six miles northwest of Hobart and a mile west of the main highway, main railway and the River Derwent at Berriedale.

Topography.—In the immediate vicinity of Berriedale, the country is gently undulating, but half a mile westward of the town, the foothills of Mts. Faulkner and Hull rise steeply to heights of 1,000 to 1,500 feet above sea-level. It is on the eastern flanks of these hills between the 700 and 1,300 feet contours that the beds of limestone are exposed. The contour is such that the limestone can be removed on an extensive scale by open cutting or quarrying methods.

Geology.—The limestones here are thickly bedded and the beds are separated by bands of calcareous shale containing many rounded pebbles of quartz and varying in thickness from three to eight inches. The limestones are rich in fossils and, although the quality of the limestone varies slightly, each particular bed retains a fairly uniform composition. The limestone beds vary in thickness from 12 to 30 inches, the whole aggregating 250 to 350 feet in thickness. In the upper beds are found occasional bands of chalcedony which was deposited from infiltrating solutions containing silica, and in the lower, quartz pebbles are not uncommon. In general, the beds are fairly horizontal, but a slight inclination is noticeable, varying in degree and direction in different localities.

Above the limestones proper are calcareous mudstone beds in which Spirifera are very abundant and, above these again, hard siliceous *Fenestella* mudstones.

The Limestones.—No actual tonnages of limestone were estimated, but the deposits extend nearly twenty chains into the hill before being cut off by dolerite; they are fully 200 feet thick and extend along the front of the hill without interruption.

Several samples for analysis were taken from the quarry of the Hobart Brick Company (Numbers 1 to 5) and one from outcrop limestone generally (6). These showed:—

Sample No.	Thickness	Silica	Fe_2O_3	Al_2O_3	$CaCO_3$	$MgCO_3$
	inches					
1 ..	15	19.36	0.57	3.59	76.39	0.72
2 ..	22	28.36	2.93	2.27	65.87	0.72
3 ..	15	19.60	1.43	2.17	76.39	0.72
4 ..	24	18.68	1.43	2.53	77.37	0.72
5 ..	16	25.20	1.21	2.39	69.44	0.87
6 ..	—	29.72	1.72	5.00	62.76	0.79

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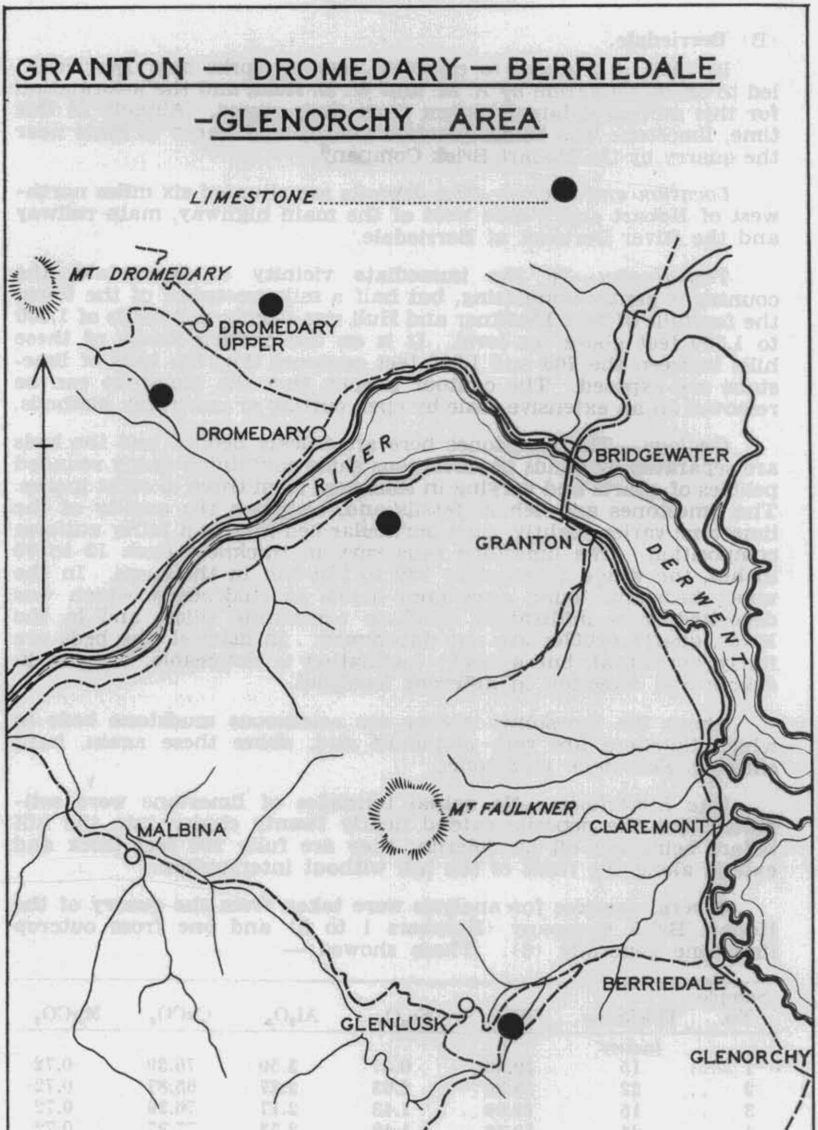

FIG. 35.—Granton-Berriedale-Glenorchy Area.

(C) Dromedary.

The Dromedary area lies between the mountain of that name and Bridgewater and to the north of the River Derwent. Limestone outcrops in, and in the past has been obtained from, several different localites, but there is no production at the present time.

About a mile to the west of the Upper Dromedary Road, and near the top of the hill, is an old quarry, about three hundred feet in length and 25 to 30 feet high. In this the limestone occurs in beds one to two feet in thickness and separated by a few inches of richly fossiliferous shale. No attempt was made at systematic sampling of this deposit but a sample taken across one bed selected at random showed:—

	%
Acid Insoluble	21.2
$CaCO_3$	76.8

The limestone appears to continue up the hill for a further hundred feet above the quarry and to be then succeeded by beds of shales and sandstones.

A smaller quarry has been opened just to the east of the Upper Dromedary-Broadmarsh road, where the beds are exposed, showing about ten feet of limestone covered by up to five feet of marl and limestone. A sample of limestone taken over the ten feet showed:—

	%
Acid Insoluble	28.9
$CaCO_3$	66.9

On top of the hill, north of Dromedary, are many small pits up to eight feet deep which have been worked for limestone. In the vicinity are remains of old kilns. Marl, here, too, is overlying the limestone and has probably been formed by the solution of the $CaCO_3$ and its re-precipitation. An analysis showed that the marl containd 85 per cent of $CaCO_3$ and it is in such a fine state that it should be immediately available for agricultural needs. A sample of limestone taken over six feet from one of these pits showed:—

	%
Acid Insoluble	41.4
$CaCO_3$	55.2

(D) Glenorchy.

A large limestone quarry, showing over a hundred feet width of stone, is operating in Glenorchy. It is situated near the top of Tolosa Street on the southern side and almost two miles from the Glenorchy tram terminus. The stone is dark-blue in colour and although fossiliferous, not as markedly so as that at Granton. Almost horizontal bedding planes are very prominent, but shale beds between the limestone blocks are very sparse and, where they do occur, quite thin. The stone breaks well along right-angled joint planes.

In the past, the stone has been used by the Electrolytic Zinc Company, but at present it is quarried and crushed only for aggregate and road metal. The annual production is of the order of twenty-five thousand tons.

FIG. 36.—Limestone Quarry, Glenorchy.

XII GRAY

After an examination of the limestone in the vicinity of Gray, near St. Marys, in 1951, G. Everard reported:—

Introduction.

This report is concerned with calcareous strata on the southern fall of Mt. Elephant, extending from the immediate neighbourhood of Gray, at the junction of the Tasman Highway and the road to Dalmayne Colliery, along the Tasman Highway past the head of Elephant Pass, and thence about four miles in a north-easterly direction parallel with a short minor road.

Location and Access.

Gray is situated about four and a half miles south of the railway terminus at St. Marys, along the Tasman Highway on the East Coast of Tasmania.

Previous Work.

Reference is made to the area under consideration in a report by J. Milligan on Fingal and the East Coast published in 1849. Gould's report of 1861 on coalfields is illustrated by a geological sketch map which includes the Gray district. This map is notable for its delineation of limestone outcrops, but the map rather illustrates the geological structure of the district, than gives the correct position and slope of the outcrops; thus limestone is shown close to the summit of Mt. Elephant, whereas, in fact, its position is on the lower slopes. A report made by Twelvetrees in 1901 contains a sketch map showing part of the Gray area.

Topography.

The area is one of strong relief, there being a difference in altitude of about two thousand feet between the summit of Mt. Elephant and a point in the bed of Wardlaw Creek, one and a half miles distant.

Two separate drainage systems are represented. To the north and west of Gray are the headwaters of the streams feeding the Break O'Day, a mature river flowing across a flood plain in a broad level valley to join the South Esk near Fingal. South-east of Gray are numerous streams flowing down the slopes of Mt. Elephant to unite as Wardlaw Creek and enter the sea at Saltwater Inlet. These streams, including the Wardlaw, flow through deep chasms with precipitous cliffs. They descend rapidly to sea level whereas the Break O'Day Plain has a general level of about eight hundred feet above the sea. The watershed between these two drainage systems is a narrow ridge carrying the road to Dalmayne Colliery at its junction with the Tasman Highway. In future times river capture seems inevitable at this point, which would result in rejuvenation of the mature valley of the Break O'Day and reversal of its drainage.

In sharp contrast to the broad level Break O'Day Plain, stretching westward from Mt. Elephant, the country to the south and east is a jumble of steep-sided valleys with narrow ridges separating their sinuosities. The denudation of these interfluves is still at an early stage and precipitous cliffs are common in the harder strata at the heads of valleys.

Before entering the sea, streams on the eastern fall cross a narrow coastal plain diversified with sandhills and lagoons.

Geology.

Upturned edges of Lower Palaeozoic strata, in places invaded by granites, are overlain by an interconformable horizontal succession of Permian and Triassic deposits. The horizontal strata have been discordantly and concordantly intruded by dolerite with the formation of sills at various levels above the limestone, which occupies a more or less central position here, in the Permian succession, together with irregular transgressive intrusions. Mt. Elephant, a residual of erosion, is a flat-topped pile of horizontal sedimentary strata protected by a thick capping of dolerite. Dolerite debris, on the southern slopes, showing fine flat jointing is indicative of small sills, and terraces with springs have been formed where sills outcrop.

The area is crossed from north to south by systems of anastomosing faults which are very difficult to trace in detail. To the west, the Break O'Day Plain is itself a shallow trough-faulted area between the Cornwall and Silkstone faults, and, although the valley is essentially due to erosion and not to faulting, it is perhaps significant that alluvium is much more extensive in this down-faulted area than elsewhere in the valley. Conversely, Mt. Elephant, although a residual of erosion, is bounded longitudinally by sub-parallel zones of faulting on either side.

The Limestones.

The Permian and Triassic beds are almost horizontal, having but a slight dip to the south, and the limestone occupies a central position in the Permian succession, being overlain by mudstone and underlain in some localities by mudstone or shale and in others by a fine sandstone. The thickness of limestone is about one hundred feet and it outcrops as a fringe or apron around the southern end of Mt. Elephant, below the Tasman Highway on the south-western aspect and below a short branch road on the south-eastern, but is not completely continuous, being cut out in places by faulting. Limestone also extends for a short distance on the south-eastern side of Wardlaw Creek, below the Dalmayne road, and again just to the north of the road junction at Gray, on the side of a gully.

The actual outcrops are in the form of cliffs or protruding joint blocks on steep slopes. The maximum height of sheer cliff is approximately fifty feet, the base of the cliff consisting of talus slopes and fallen blocks.

In hand specimen the rock is light-grey to almost white in colour, with glittering facets of crystalline calcite on newly-fractured surfaces. It is very highly fosiliferous. Under the microscope, innumerable fossils and fossil fragments are seen. The chambers of gasteropod shells and interseptal interstices of corals being filled with crystalline calcite and occasionally with clumps of quartz grains. Small angular fragments of quartz are disseminated through the rock, but in very small amount. The matrix is a very fine grained mass of calcite with a small amount of silica and is stained with very fine laminated material. The bulk of the impurity is contained in the matrix and consists of finue clayey and shaly particles.

Although dolerite appears in the field in close proximity to the limestone, no actual contact was observed and no minerals of thermal metamorphic origin were observed under the microscope.

The chemical analyses, given in the table, show that these rocks are somewhat impure limestones. Percentages of magnesia, alumina and iron are quite small and the impurities are contained in the acid insoluble portion. There may be also a small but measurable proportion of phosphorus in some instances.

From the economic aspect, these limestones are not high grade, but contain more lime than is common with the Permian limestones of the State, and it seems probable that stone could be obtained from the deposit suitable for crushing and use as agricultural lime.

The outcrops, being cliffs or on steep slopes, are well adapted for quarrying and the overburden generally is light. The deposits are situated close to a main highway and within five miles of a railway terminus. They constitute a possible reserve of some magnitude of limestone suitable for agricultural purposes.

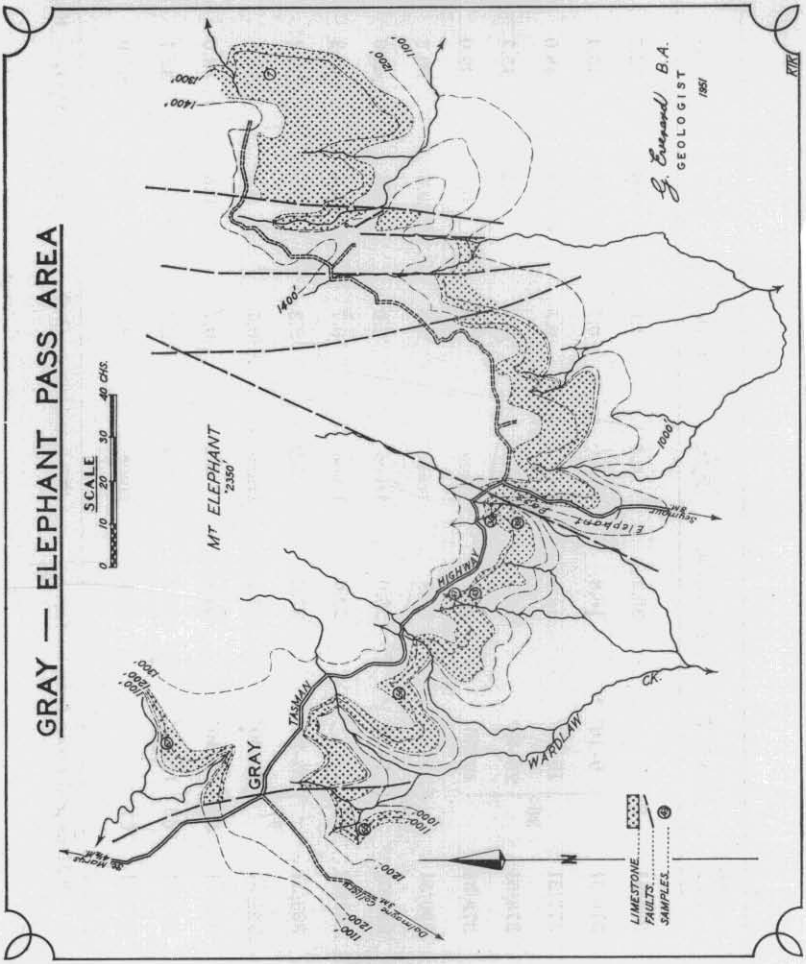

FIG. 37.—Gray-Elephant Pass Area.

Reg. No.	Map Ref.		Acid Insol.	P_2O_5	R_2O_5†	MgO	CaO	Ignition Loss	$CaCO_3$ calc. ‡
375/51	7		36.2	0.1	1.9	0.6	32.7	28.1	58.4
376/51	36	0–10′ *	16.8	trace	0.7	0.4	45.4	36.6	81.1
377/51		10–25′	12.8	0.1	0.5	0.5	48.0	38.0	85.7
378/51		25–40′	16.2	trace	0.7	0.5	45.7	36.6	81.6
379/51		40–55′	26.7	trace	1.3	0.5	39.0	31.3	69.7
380/51	39	0– 5′	40.8	trace	2.3	0.6	30.2	25.7	53.9
381/51		5–10′	23.6	trace	2.0	0.5	40.6	33.4	70.7
382/51	43		22.6	trace	0.7	0.4	42.3	34.1	75.5
383/51	47	25–35′	37.3	0.2	2.3	0.6	32.2	27.4	57.3
384/51		40–50′	17.9	trace	0.7	0.5	45.1	36.0	80.1
385/51	56	20–40′	20.8	0.2	0.7	0.5	43.0	34.7	76.8
386/51	66	10–40′	36.2	0.4	2.2	0.6	32.7	27.4	58.4
387/51	67		22.4	trace	0.9	0.4	42.0	33.8	75.0

* Measured down from surface. † Calculated from CaO. ‡ $R_2O_3 = Al_2O_3 + Fe_2O_3 + TiO_2$.

XIII HOBART AREA

(A) Proctors Road.

Early in 1950, Mr. J. E. Whitton, who was operating a quarry for the extraction of stone for the manufacture of concrete bricks and for road making, exposed some beds of calcareous material which, on analyses, proved to have a fair CaO content. It was hoped to develop this limestone for agricultural purposes and several samples were taken for analysis. The result of these samples showed a much higher CaO content than could be satisfied by the CO_2 (ignition loss) and further samples were taken and thin sections and ground samples of the rock were examined microscopically.

Location and Access.—The quarry is situated on the west side of Proctors Road, almost three miles from Hobart.

Geology.—The quarry has been opened in a series of greyish-green, indurated shales bearing only a few fossils, alternating with multi-coloured highly-fossiliferous bands. In a lower opening, situated just above creek level, the rock is white and more homogeneous and resembles quartzite. These rocks have been assigned to the Grange Formation of the Permian. They are almost completely enclosed in a series of dykes and sills of Jurassic dolerite. The Permian rocks have suffered a degree of contact metamorpism from the dolerite, and because of this, lime silicates have been formed. They are rather flat bedded, dipping to the west at about 6°.

The Limestones.—The quarry face has been sampled by Departmental officers on two occasions. In March, 1950, G. Robertson took four samples from beds, 12 feet six inches in thickness, exposed on the quarry face. These samples showed:—

Sample from	CaO	MgO	Insol.	Fe_2O_3	Al_2O_3	Ig. Loss	TiO_2
	%	%	%	%	%	%	%
Bulk Grab Sample ..	35.9	0.3	46.2	1.1	0.7	14.4	0.2
Top Band 6′ 6″ ..	31.0	0.3	49.3	1.2	1.7	15.8	0.2
Middle Band 2′	9.4	0.5	75.8	2.2	2.8	8.2	0.6
Bottom Band 4′	4.22	0.1	34.7	0.7	1.2	20.2	0.2

The high proportion of acid insoluble and the low proportion of ignition loss, compared with the production of lime (CaO), suggested that the lime was not present only as calcium carbonate, but was present as both the carbonate and the silicate.

By allotting the full amount of the ignition loss to CaO to give calcium carbonate ($CaCO_3$) and then allotting sufficient insoluble as silica to absorb all the remaining lime, it was found that there was an excess of insoluble as shown below:—

Regn. No.	$CaCO_3$	$CaSiO_3$	X.S. Insoluble
169/50	32.7	36.4	27.4
170/50	35.9	22.5	37.7
171/50	16.78	—	75.8
172/50	45.9	34.1	17.0

A further series of samples were taken by the Chief Geologist, H. G. W. Keid, during the period 4th to 7th July, inclusive, and he reports as follows:—

> "There have been two openings made on the area, the lower of the two being situated only a little above the creek level and is designed for the accommodation of hoppers for the storage of the crushed product from the quarry. In this lower opening the rocks have the appearance more of a quartzite than a limestone, although a few fossils were visible. Field tests with acid failed to show effervescence, except on the shell fragments, and the analysis of samples taken from this site showed an exceptionally high proportion of insoluble matter.
>
> In the main quarry the exposures were sampled in widths representative of bands which were more or less prominent in the face of the quarry. It was considered that these bands could possibly be hand picked during quarrying and so give some degree of selective mining if the analyses suggested that this course was advisable. Twelve samples were taken from the main quarry in widths ranging from five inches to 48 inches to show the grades of the tiers relative to each other.
>
> Hand specimens of the rock were also taken with a view to microscopic examination. Micro slides of the specimens showed the presence of considerable quantities of wollastonite and some garnet.
>
> The presence of these minerals suggest that the rocks have been subject to some degree of contact metamorphism, resulting in the alternation of normal limestones to the wollastonite-garnet bearing rocks now exposed.
>
> The results of the analyses of the fourteen samples taken are shown below. In this table the calculated percentages of calcium carbonate, calcium silicate and excess insoluble are shown.

Reg. No.		Sample No.	Acid Insol.	Al_2O_3	Fe_2O_3	P_2O_5	CaO	MgO	Ig. Loss	TiO_2	CaO as $CaCO_3$	CaO as Sil.	$CaCO_3$	$CaSiO_3$	X.S. Insol.	Depth of Sample
548/50	..	1	39.0	1.3	0.9	0.20	45.0	0.4	12.7	0.1	16.1	28.9	28.8	59.9	8.0	22½″
549/50	..	2	68.8	7.3	1.3	0.06	14.3	0.4	7.0	0.4	9.0	5.3	16.0	11.0	63.0	13″
550/50	..	3	40.7	1.0	0.8	0.10	44.3	0.2	12.5	0.1	15.9	28.4	28.4	58.8	10.3	16″
551/50	..	4	27.1	1.4	0.7	0.10	47.0	0.4	22.8	0.05	29.0	18.0	51.8	37.2	7.9	17″
552/50	..	5	39.3	2.1	0.9	0.10	40.5	0.4	16.2	0.1	20.6	19.9	36.8	41.2	18.0	12″
553/50	..	6	72.8	3.8	1.9	0.09	10.3	1.2	9.6	0.3	10.3	—	18.4	—	72.8	14″
554/50	..	7	70.8	4.6	1.9	0.18	11.6	0.7	10.0	0.3	11.6	—	19.1	—	70.8	21″
555/50	..	8	70.2	5.0	2.4	0.02	11.2	0.2	9.8	0.2	11.2	14.5	20.0	30.0	70.2	5″
556/50	..	9	51.1	3.3	1.0	0.20	30.5	0.3	12.6	0.1	16.0	—	28.6	—	35.6	32″
557/50	..	10	83.8	4.3	3.0	0.07	2.8	0.9	4.2	0.3	2.8	—	5.0	—	83.8	48″
558/50	..	11	84.9	2.4	2.3	0.09	1.3	1.3	6.5	0.1	1.3	—	2.3	—	84.9	22″
559/50	..	12	83.0	4.2	2.5	0.13	3.6	0.5	4.6	0.3	3.6	—	6.4	—	83.0	26″
560/50	..	13	78.5	6.9	1.1	Tr	6.9	0.4	5.4	0.2	5.6	—	11.0	—	78.5	30″
561/50	..	14	79.1	4.7	1.0	0.03	9.1	0.2	4.9	0.2	6.2	3.1	11.1	—	76.0	22″

In some of the samples the ratio between the CaO (lime) and the loss on ignition is just sufficient for the formation of calcium carbonate by the combination of the two factors. In such cases there is no calcium silicate present and the silica is then shown all as excess insoluble. This silica would be in combination with the alumina and iron in the formation of clay or it may be present as quartz grains as shown in some of the micro slides. It is noticed in all cases that magnesium oxide is present to a small degree. It is certain that this occurs also as the carbonate but the amount is insignificant and the figures shown as calcium carbonate are therefore all slightly in excess of actual fact. They are, however, definitely representative of the grade of limestone.

The analyses show that the highest percentage of available calcium carbonate to be expected for the beneficiation of soils would be 29 per cent and in this instance 18 per cent of lime is held as the stable silicate to give 37.2 per cent of calcium silicate, which cannot be regarded advantageously for the treatment of soils.

In the main quarry a face of approximately 11 feet was measured at the point of sampling. Sample 1 was taken from a low wall in the middle of the quarry where the quarry had been deepened to test the underlying material. A section of nine inches of highly-siliceous rock was revealed below the sample, but was repeated in the main face of the quarry where it was sampled as Sample No. 2.

Samples 2 to 9, inclusive, represent the full face of the quarry and they reveal that of the total thickness of 11 feet a thickness of 40 inches shown by Samples 6, 7 and 8, is extremely hard and siliceous and would, in any scheme designed for the production of limestone, have to be discarded."

A petrological examination of some specimens of this material was made by G. Everard, who reports:—

"The specimens did not correspond with samples previously taken and sent for analysis, but were selected for lithological characteristics obvious to the eye. These specimens, four in number, were ground, and ground fragments of the requisite size microscopically examined in immersion media. Pieces from the samples, from which the thin sections were cut, were then similarly treated.

THIN SECTION.

1. *Greenish mottled rock.*—Under the microscope this rock shows a very fine-grained ground mass with aggregate polarisation and semi-opaque irregular greenish bands, which are possibly the relics of depositional laminae. In the ground mass are irregular crystals of garnet, radiating needles of wollastonite and occasional small masses of recrystallised calcite.

2. *White Rock.*—Consists wholly of angular to subangular quartz grains in cryptocrystalline to opaque ground mass.

ROCK FRAGMENTS.

1. *Green and White Mottled Rock.*—Consists chiefly of wollastonite with lesser calcite and quartz in about equal amounts. Minor garnet. Fine plates of chloritic material (green).

2. *White Rock.*—Contains wollastonite, calcite and quartz in about equal amounts.

3. *Pink Rock.*—Consists of cryptocrystalline calcite, with minor wollastonite, and reddish brown garnet (melanite).

4. *Green Rock.*—Chiefly calcite, with some greenish chloritic material and a little reddish-brown garnet.

5. *Yellowish-green Rock Forming Beds about Three feet Thick Half-way down Main Quarry Face.*—This rock consists of calcite and quartz, and much green chloritic material with minor minerals.

The examination shows that the rocks are an arenaceous limestone (Specimen 1 - 4) and a calcareous mudstone (Specimen 5). The aranaceous limestone has been partially metamorphosed by the heat and pressure of surrounding doleritic intrusions, with development of wollastonite, but the reaction of silica and calcium carbonate to give calcium silicate has not been completed. The calcareous mudstone has suffered less alteration, but neither rock contains carbonate of lime in sufficient quantity to make it suitable for crushing for use as agricultural lime. Although the calcium carbonate content is very uneven, there is no simple way in which the rock containing the higher proportion could be selectively quarried.'

(B) Cascades.

Narrow limestone beds of poor quality are exposed in creek beds a few hundred feet north and west of the Cascade Brewery, which is located in one of Hobart's suburbs. The Hobart Rivulet has eroded the mudstones which outcrop abundantly in the vicinity, sufficiently to expose about six feet of blue limestones over a length of at least fifty feet. The beds are striking at N. 40° E., and have a dip to the south-east of 8°. Two samples were taken by T. D. Hughes in 1947, the upper over three feet six inches, and the lower over two feet six inches. Limestones are also exposed in the bed of the tributary which joins the Hobart Rivulet from the north, just below the Brewery. The creek fall follows the dip of the beds so they are exposed for several hundred feet. No great thickness is exposed and the lime content seems to diminish to the north. These limestones, on account of the small thickness exposed and the immense thickness of overburden, are of little economic interest.

Sample No.	643/47	644/47	645/47
	%	%	%
$CaCO_3$	70.8	14.01	39.37
CaO	39.65	7.85	22.05
MgO	0.32	1.0	0.48
Acid Insoluble	25.76	76.52	55.0
$Fe_2O_3 + Al_2O_3$	1.2	4.68	3.04
Ignition Loss	32.0	8.32	18.08

XIV LILYDALE DISTRICT

Introduction.

The limestone deposits occurring between Karoola and Bangor in the Lilydale district of north-eastern Tasmania are, from an economic point of view, most disappointing. They consist merely of a narrow bed of limestone contained within mudstone and sandstone.

Location and Access.

This limestone bed is located on a hillside, immediately east of the Pipers River bridge on the Karoola-Bangor road and is some hundred feet above the river flats. The slope of the hillside is about 35°.

The Limestones.

This is a narrow bed, only three feet thick, of a limestone containing numerous fossils of *fenestella, spirifer, pecten,* &c. Above the limestone are sandstones, here about thirty feet in thickness.

Nearly thirty years ago, a trench was dug into the hill, across the beds, and this showed the limestone to be only three feet in thickness.

A sample of this limestone showed, on analysis:—

	%
Acid Insoluble	14.7
Al_2O_3	0.9
Fe_2O_3	1.0
CaO	45.0
MgO	1.2

However, because of its narrow width and the fact that it is overlain by so much overburden, it could not be considered as a commercial proposition.

XV MARGATE

Introduction.

Small quantities of limestone, mostly of a powdery nature, have been obtained in the past from a small hill in the Margate area of southern Tasmania. A report was prepared by T. D. Hughes in 1947, and in 1953-54 further investigations were made on behalf of the owner of the property.

Location.

The limestone is situated near the top of a small, partially-cleared hill, Harts Hill, one mile south of the Margate hall. Margate is a small town on the Channel Highway, fifteen miles south of Hobart. A motor road leads right to the deposit.

Geology.

No real outcrop of limestone occurs, but on the hillside may be seen scattered boulders up to two feet in diameter and the position of these, together with the rock types, give some indication of the extent of the limestone. These dip gently 2 - 3° to the south-east and are rich in Permian marine fossils. On the top of the hill boulders of fossiliferous mudstone indicate that the limestone forms a narrow bed in the more extensive mudstones.

The Limestone.

Lithologically, the limestone boulders are very similar to that quarried at the type area at Granton, and it is expected that shale bands would separate limestone beds. Because of its elevated position, the limestone has weathered very rapidly to a soft, friable marl which, in places, forms a cap of appreciable depth over the solid stone. The depth, however, varies considerably from place to place as it forms pockets in the unweathered limestone. The remains of a small pit show where some quantities of this material have been removed years ago. Because of lack of outcrop, it is difficult to estimate quantities of stone available, but a maximum width of 40 feet, with an average of 20 feet is indicated. An overburden of up to 25 feet at the hilltop can be expected. Reserves of stone and marl should be between three and five hundred thousand tons.

Four samples of the limestone were taken from boulders at different localities and showed on analysis:—

Reg. No.	639/47	640/47	641/47	642/47
	%	%	%	%
$CaCO_3$	72·44	81·69	78·83	79·93
CaO	40·55	45·75	44·15	44·65
MgO	0.39	0.40	0.39	0.43
Acid Insoluble	23.68	15.44	17.60	13.44
$Fe_2O_3 + Al_2O_3$	1.76	0.92	0.96	0.84
A_2O	0.3	0.18	0.1	0.4
Ignition Loss	32.38	36.72	35.87	37.80

An officer from the Government Analyist's Department has visited the site and taken a series of samples of the marl, which averaged 77 per cent of $CaCO_3$. This contains very little hard material and could be spread in the state in which it comes from the ground. This deposit could doubtless furnish a limited amount of agricultural lime for local needs.

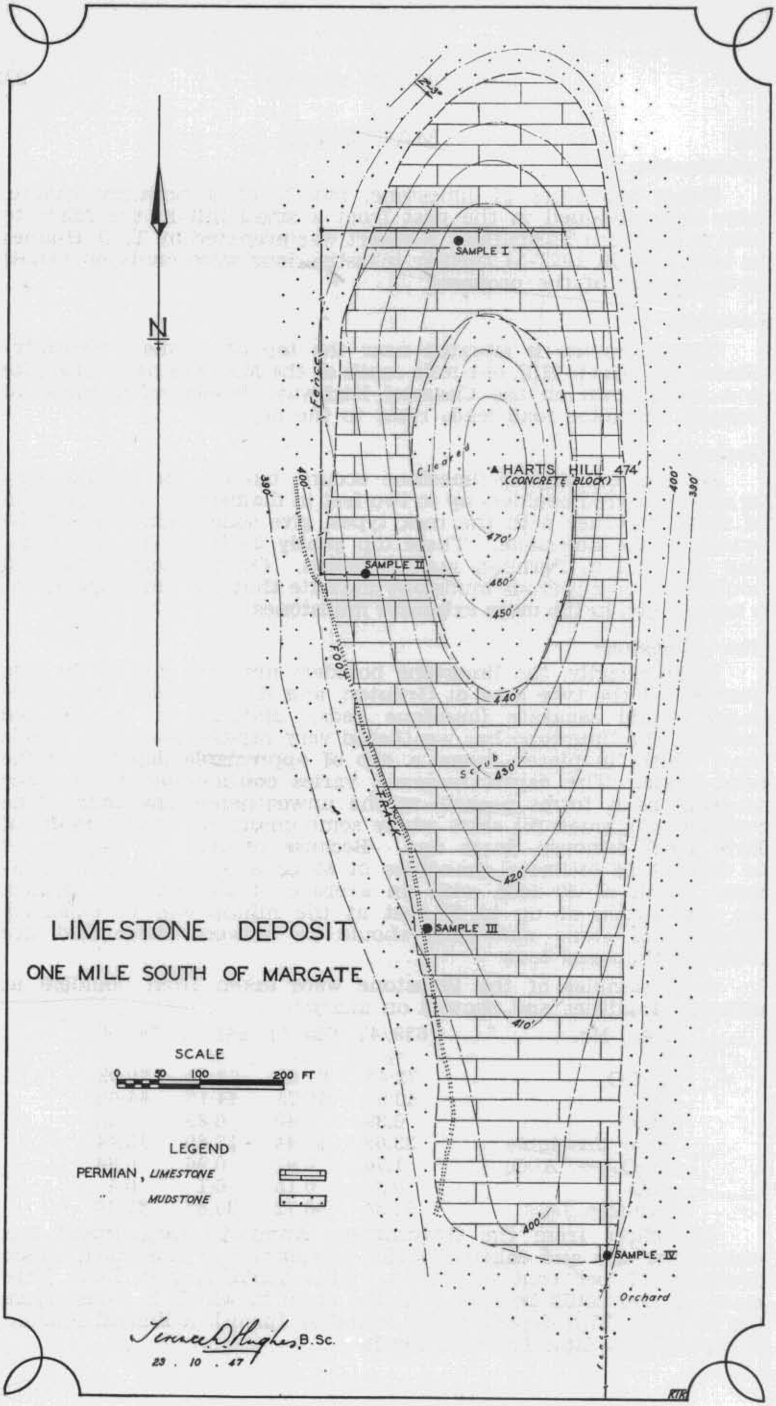

FIG. 38.—Margate Area.

5 cm

XVI MARIA ISLAND

Large deposits of Permian limestone, some of it of remarkable high grade for that age, outcrop boldly on Maria Island. From 1923 to 1927, the National Portland Cement Company operated these deposits but in the latter year, owing to prohibitive competition from Victoria producers were forced to close down. Their largest production was in 1925, when 32,000 tons of cement were sold at a value of £162,870.

In 1951, a group of Hobart businessmen, headed by Mr. G. Debnam, became interested in exploiting the rock as a source of ground limestone for agricultural purposes. A report by G. Everard was made as follows:—

Location and Access.

Maria Island lies off the east coast of Tasmania, its southern extremity, Cape Peron, being nearly opposite Cape Bernier and about three miles therefrom, while Cape Boulanger, the most northerly point, lies a little south of east from Orford, about nine miles away.

A motor vessel of 50 tons burden, running a weekly service, preserves a direct connection with Hobart. The island may also be reached via Triabunna which has a regular bus service to Hobart, but then special arrangements must be made for the crossing from Spring Bay.

Previous Work.

In 1900, A. Montgomery reported on " The Hydraulic Limestone of Maria Island." His attention was confined to the area in the extreme north-westerly part of the island north of the Darlington Settlement, and more particularly to the limestone cliffs in Half Moon Bay, of which he gives a geological section.

R. M. Johnstone refers to Maria Island in his " Geology of Tasmania," and in 1900 published " Further Notes on the 'Permo-Carboniferous' Cliffs at Darlington, Maria Island." This account deals chiefly with the palaeontology of the limestones, but reference is made to the general topographical and geological features of the island and analyses are given of cements made from the limestone.

Maria Island is briefly mentioned in the " Coal Resources of Tasmania " and a geological map of the island is given as part of the geological map of the Triabunna-Buckland Coalfield by H. G. W. Keid.

Topography.

Maria Island has a maximum length of about 15 miles from Cape Boulanger to Cape Peron, and a maximum width of 10 miles from Long Point on the western coast to Ragged Head on the eastern.

The island consists of two parts, formerly two islands, but now tied together by a sandspit. South Maria Island is much the smaller, but is structurally similar, its western coast being entirely of dolerite hills, the slopes of which descend into the water unbroken by any coastal plain; its eastern coast is rugged and composed of granite, while sedimentary rocks are to be found in the interior.

North Maria Island, with which this report is concerned, has a range of mountains rising above 2,000 feet, close to its eastern coast and descending in steep slopes and precipices to sea level there. The mountain range descends to the west in long interfluvial ridges into a region of jumbled topography with a maximum elevation of about 600 feet. The south-western portion of the North Island is a broad plain bearing alluvial deposits and diversified with sandhills. The eastern coast is composed of innumerable little bays with prominent headlands and backed by cliffs. Some have minute sandy beaches and there are small streams with waterfalls. The western coast is more open with long sandy beaches between rocky headlands. Half-moon Bay, which forms the north coast of the island is a long arc of limestone cliffs.

Streams flowing down from the mountains to the western coast have cut steep-sided valleys with interfluves, as mentioned above, but on entering the region of jumbled topography, change direction rather abruptly and reach the coast via water gaps between steep-sided hills.

Geology.

The mountain range, including Mount Maria (2,300 feet) and the Bishop and Clerk (2,100 feet), consists of a great thickness of dolerite overlying sandstone above mudstone and limestone. This dolerite is the remnant of a sill formerly having a much wider extension. The sandstone is similar to the Triassic sandstones found elsewhere in the State. The mudstones and limestones contain numerous fossil remains which establish their age as Permian.

Along much of the eastern and northern coast the flat-lying Permian rocks emerge as cliffs, sheer above the sea; to the west they are cut off just as sharply by dolerite. This contact forms a long straight line, offset at one point, and is due to a major longitudinal fault with a cross-fault. Jurassic dolerite occurs west of the major fault and in some places are sandstone remnants, both overlain and underlain by dolerite, demonstrating the sill-like nature of the intrusion. A similar phenomenon may be observed at the base of the dolerite on the Bishop and Clerk, where there are smaller sills separated by beds of Triassic sandstone. This evidence favours a downthrow of 1,700 feet to the west along the major fault line.

Curious evidence of recent movement along this fault line exists. The streams flowing westward from the slopes of the mountains, have cut fairly broad sub-mature valleys, and just before they pass from limestone on to dolerite, have deposited alluvial flats into which they are now entrenched a few feet. These flats are similar to the ones now existing where these streams enter the sea, except for the absence of sandhills. Either these flats were at the original mouths of the streams or movement along the fault temporarily dammed their waters. In both cases it is necessary to postulate a small recent uplift of the down-faulted side.

Eastwards from the major fault line, the Permian sedimentary rocks extend under the dolerite capping of the Mount Maria Range to the northern part of the eastern coast. The south-eastern coast has a selvage of granite. About a quarter of a mile south of Four Mile Creek, Silurian quartzites outcrop and form a southern boundary of the Permian rocks.

The Limestones.

The Permian sequence may be divided into a calcareous, and argillaceous and an arenaceous facies, according as to whether the particular strata are composed principally of limestone, mudstone or sandstone. The calcareous facies is the lowest and is succeeded by the argillaceous and the arenaceous in that order. Into this pile of horizontal strata deep valleys have been cut by the streams flowing westward from the Mount Maria Range of mountains, namely Bernacchi, Counsel and Four Mile Creeks. Thus these three streams, and their numerous tributaries, have exposed the basal limestone beds in the bottoms of their valleys, as shown in the map herewith.

The various components of the calcareous facies are best exposed in Half-moon Bay on the northern coast of the island, just east of Cape Boulanger. A diagram of this exposure is contained in both Montgomery's and Johnston's reports. However, the succession at this exposure is not necessarily repeated elsewhere, because beds may thin out and disappear along the strike and other beds take their place.

Further exposures occur in the quarries opened by the National Portland Cement Company and earlier exploiters of the limestone deposits. However, these quarries are all at no great distance from the cliffs at Half-moon Bay. One quarry is actually on the coast at the foot of the cliffs at their lowest point, and operated principally in what has been called the pachydomus Zone, after the name of a very prominent fossil bivalve of which the strata there are largely composed. The other quarries lie on the slopes of the valley of Bernacchi Creek or of a northern tributary of the same the headwaters of which have been cut off by the advance of the sea into Half-moon Bay. These quarries being close to the cliffs also suffer from the same defect in limestone quality which may be noted there, that is partings and occasional beds of mudstone or shale.

Limestone is also available towards the head of Bernacchi Creek, where there is a dam, and along the opposite side of the valley. On crossing the interfluve, considerable deposits may be observed in the valley of Counsel Creek, particularly along its northern side. Similar limestones may be seen at the head of Four Mile Creek, but here the topographic relief is not so strong and suitable places for quarrying are less frequent. The most favourable topography for quarrying exists in the valley of Counsel Creek just east of the major fault line. Here steep slopes of limestone rise sharply above a small alluvial flat. A little further upstream, limestone spurs formed by tributaries of the main stream form almost equally favourable sites. Limestone from these places gave somewhat more favourable assays than that from the old quarries north of Bernacchi Creek, as may be seen in the appended table.

A partly-formed track and road runs out from the site of the cement works to within little more than 20 chains of where samples 7, 8 and 9 were taken. This particular locality does not seem to have been prospected for limestone, although signs of activity could be seen further up towards the headwaters of Counsel Creek in the vicinity of sample 10. Pits and costeans had also been excavated on the ridge south of Four Mile Creek. But here greater transport difficulties would be experienced and the site, as previously mentioned, is not particularly suited to quarrying operations. The quality of the Maria Island limestones is similar to that of Permian limestones elsewhere in the State and some specimens resemble very closely the limestones near Gray in the St. Marys district. Better-class Permian limestones contain about 80 per cent carbonate of lime and there is ample supply of this type of stone on Maria Island. The principal defect of Permian limestones is the occurrence in them of mudstones and shale, but these deleterious beds lens out along the strike and, by careful selection, suitable quarrying sites free from mudstone and shale may be obtained. The above-mentioned sites on the north bank of Counsel Creek are those most favourable for limestone prospecting.

The alluvial flats in the beds of the creek where they cross the major fault line may hold supplies of clay. There are old clay pits in the upper alluvial flat of Bernacchi Creek, and Counsel and Four Mile Creeks and other minor streams seem to be similar in all respects. Clay used in the manufacture of cement on Maria Island was brought from a pit on the coast at Bloodstone Point. Further supplies exist in this locality, but suitable material may exist in more convenient places. The mudstone itself may also, when ground, provide suitable material.

Conclusion.

There is, of course, no reason to doubt that suitable materials exist on Maria Island for the manufacture of Portland Cement, because good quality cement was previously produced there in large quantity, and inspection shows that enormous supplies similar to those previously obtained yet remain. The old quarries, however, seem to have produced a fairly large proportion of waste, and efforts, apparently, had been made by the National Portland Cement Company to obtain a higher grade limestone. These efforts were discontinued and the works were closed, because of lack of a market, not through depletion of raw material or manufacture of an inferior product. The analytical results tabulated herewith give reason to believe that a better grade limestone, relatively free from mudstone, is obtainable on the northern side of Counsel Creek. Localities numbered 7, 8 and 9 are all readily accessible and the topography is ideal for quarrying.

MARIA ISLAND LIMESTONE

Map Ref.	Lab. No.	Locality	Acid Insol.	Fe_2O_3	Al_2O_3	CaO	MgO	S	P_2O_5	$CaCO_3$ Calc.
7	..974/51	Counsel Creek	12.4	0.7	0.5	47.6	0.8	trace	trace	85.0
8	..975/51	East Spur, Counsel Creek ..	17.6	0.6	0.7	43.7	0.9	trace	trace	78.0
9	.. 976/51	Middle Spur, Counsel Creek ..	13.8	0.5	0.5	46.8	0.8	trace	trace	83.5
10	.. 977/51	Old Lease, Counsel Creek ..	21.1	0.7	0.7	42.5	0.6	trace	trace	75.9
14	.. 978/51	Middle Spur, Darlington ..	19.4	0.8	1.2	42.0	1.0	.11	.12	75.0
15	.. 979/51	Fossil Cliffs	25.7	1.2	1.5	39.1	0.8	.24	.1	69.8
16	.. 980/51	North Quarry, Darlington ..	21.8	0.9	1.0	41.0	0.9	.12	trace	73.2
17	.. 981/51	Middle Quarry, Darlington ..	22.4	0.9	1.0	41.8	1.0	trace	.14	74.6

Meanwhile, the company (Maria Island Agricultural Lime Company) had begun development work and in January, 1953, Everard made an inspection of a quarry they had opened up. He reports:—

> " The quarry is situated on the southern side of a small intermittent stream, flowing into Counsel Creek from the south. This locality was formerly part of the area leased by the National Portland Cement Company during its period of operation, and was prospected for limestone, although no records are available. A track leads from the quarry, through the water gap occupied by Counsel Creek, which stream has to be crossed three times, to the Darlington settlement and the principal jetty, a distance of about two and a quarter miles.
>
> The new quarry has been opened well within the limestone zone at an elevation of about 300 feet above sea level, on the northern fall of an east-west running ridge, about 150 feet below the crest, and about 70 feet above the dry bed of the creek previously referred to. Limestone, or a shaly member of the limestone formation, forms the bed of the creek, and limestone is exposed on the crest of the ridge about 220 feet above the creek. The whole ridge thus consists of limestone, except for what other beds may be included in the limestone formation.
>
> The quarry itself is still in an early stage of development, a face about 35 feet wide by 13 feet high having been exposed. This includes four feet of overburden and nine feet of limestone in which there is a band of shale four inches thick, about three feet six inches above the floor. The limestone is well bedded and jointed, and at one place clay has penetrated along the joints from the surface down to the floor of the quarry.
>
> The limestone is a coarse-grained, pale-grey stone, replete with fossil remains. The cleavage planes of calcite are very prominent, occasioning the coarse-grained appearance, and contributing very materially to ease of spalling and crushing, while the strong jointing and bedding are of great assistance in quarrying. Two chip samples were taken at the face and, as shown in the table of analyses appended, confirm the first favourable impression of the grade of the stone. It will be noted that, in either sample, the percentage of soluble carbonate was in excess of 90 per cent.
>
> Reference to the report of December, 1951, will reveal that the Counsel Creek area was suggested as an alternative to the old quarries near Bernacchi Creek and at Fossil Cliffs, because of the lower grade limestone and great proportion of waste material obtained from the old workings. Good exposures were found on the north side of Counsel Creek, but as against the present site, these exposures gave limestone of slightly lower grade. The present site is therefore preferable, providing that it is equally free from beds of shale and mudstone and accumulations of

redeposited silica, but, owing to the lack of natural exposures, this condition can be proved only by further work on the site. With this proviso, the present quarry is well sited for working, and is producing limestone of very good quality.

As regards accessibility, too, the present site has the advantage over those of the northern bank of Counsel Creek, that another crossing of the creek is avoided. The old workings at Fossil Cliffs and Bernacchi Creek had a great advantage in accessibility, but this was more than offset by lower grade limestone and greater proportion of waste.

Stone from the present quarry has to be hauled over two miles to the crushing plant near the jetty at Darlington. In dry weather this gives no difficulty, but further attention to parts of the track will be necessary before it can be made readily passable at all seasons. Improvement has already been made by rebuilding bridges and metalling portions of the road with beach pebbles. Supplies of coarse metal from screens are readily obtainable.

Assuming a suitable market and economic transport from Maria Island, there is nothing in the evidence presented unfavourable to further development of the new quarry. If unforseen difficulties should arise, other suitable sites could be found in the Counsel Creek area."

LIMESTONE DEBNAM'S QUARRY, MARIA ISLAND.

Field No.	Lab. No.	Acid Insol.	Fe_2O_3	Al_2O_3	S	P	$MgCO_3$	$CaCO_3$
3 H 35	37	8.0	0.5	0.7	.04	.01	1.3	88.9
3 H 36	38	5.8	0.4	0.4	.03	.01	0.8	92.1

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XVII MT. PETER

Introduction.

These deposits have never been actually worked, but in 1926 they were investigated by P. B. Nye with the object of determining if they could be used in the manufacture of cement. It was found that, although the beds as a whole were too low in calcium carbonate, higher-grade material could probably be selected which would satisfy the cement makers' requirements. Much of this chapter is quoted from Nye's reports:—

Location and Access.

Mt. Peter is located, close to the sea, on the central east coast of Tasmania. The road to Coles Bay passes a couple of miles to the west and the limestone deposits are a further two miles east of the mountains; indeed, they reach almost to the sea. The port of Coles Bay is almost eight miles south of the limestone deposits.

Geology.

On the eastern flanks of Mt. Peter and adjacent to Saltwater Lagoon, down to sea level are beds of Permian rocks. The lowest beds here consist of conglomerates which pass up into sandstones, these being overlain in turn by limestones at an altitude of 110 feet. The limestones extend right to the summit of the hills (380 feet) so that the thickness is at least 270 feet. The same limestones are observed outcropping on the hills for one or more miles to the north of Saltwater Lagoon. The western boundary of the lime stone is determined by a north-south fault with a downthrow to the west to the order of 500 feet, bringing Triassic sandstones against the limestone.

The Limestone.

The limestone at Saltwater Lagoon extends over an area of 200 to 350 acres and the maximum thickness is about 300 feet. Assuming an average thickness of 200 feet over 200 acres, the reserves would be of the order of 80,000,000 tons.

Three samples were taken in the area. These are only general samples taken over wide thicknesses of the beds but they do indicate the general quality of the stone.

Sample I. represents 70 feet of limestone on the western fall of a spur above Saltwater Lagoon. Sample II. represents 150 feet of underlying beds on the eastern fall of the spur. Sample III. is a roughly representative one taken from a larger sample of 200 feet of limestone near Saltwater Lagoon.

Sample No.	I.	II.	III.
	%	%	%
Silica	15.4	18.4	7.8
Fe_2O_3	2.15	2.29	0.4
Al_2O_3	0.45	2.51	0.3
$CaCO_3$	82.40	76.50	88.80
$MgCO_3$	0.29	0.65	0.60

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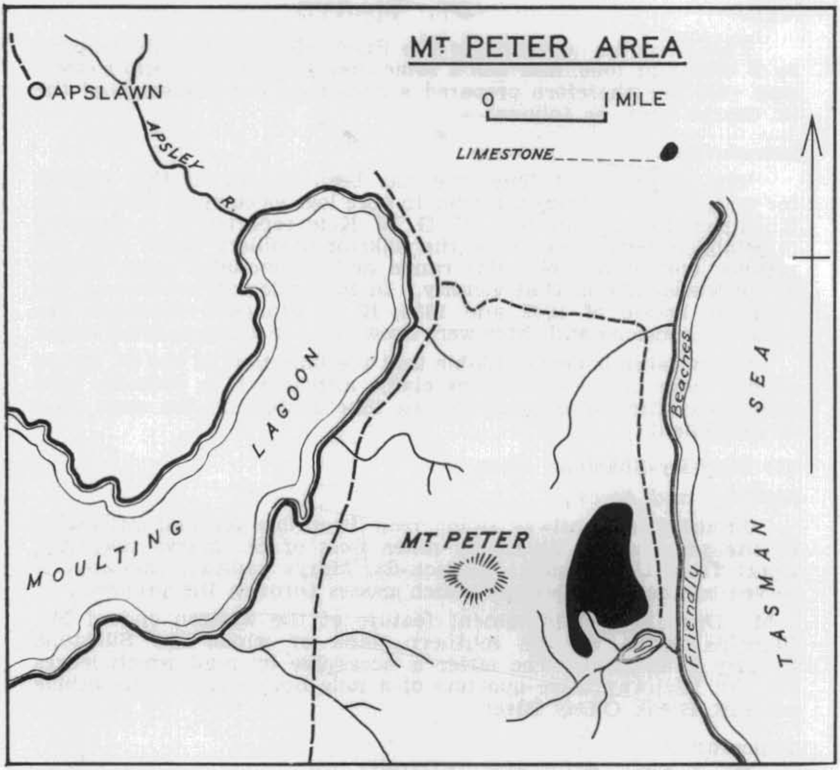

FIG. 39.—Mt. Peter Area.

XVIII ST. MARYS

This area lies adjacent to the Snow Hill Quadrangle mapped by F. Blake in 1956, and has a somewhat similar geological succession. He has therefore prepared a report on the limestone of the St. Marys area, as follows:—

Introduction.

The existence of limestone has been known in this district for many years and was recorded in bore logs as early as 1888 on the Killymoon Estate. In 1922, H. G. W. Keid reported on a proposal to establish cement works on the Silkstone Colliery leases near the western end of Mt. Nicholas range and he included some details of the limestones in that vicinity. In his geological reports on the Frodsley Estate of 1932 and 1933, K. J. Finucane describes two areas of limestone and these were shown on the accompanying maps.

No evidence is now available that the limestone of the St. Marys district have been used commercially, although it is probable that small quantities were burnt for the lime content in the early days of settlement.

(1) Frodsley-Silkstone Area.

Location and Access.

Frodsley is a railway siding near Brodribbs agricultural estate of the same name, about six miles west of St. Marys township. Apart from the Conara Junction-St. Marys railway, the area is served by the Esk Highway which passes through the property.

Mt. Durham is a prominent feature at the western end of Mt. Nicholas range, on the southern flank of which the Silkstone Colliery is situated. The latter is accessible by road which leaves the Esk Highway three-quarters of a mile north-east of the bridge crossing Break O'Day River.

Topography.

Break O'Day River flows sluggishly over a wide, cultivated plain in a general westerly direction through the area and is fed by small streams from the north and south. On the north side of the main valley the land is open and gently undulating for little more than a mile, but further north it rises steeply to Mt. Nicholas range about Mt. Durham.

Geology.

The flat floor of Break O'Day valley is covered by Tertiary Sediments, while the fringing lower slopes consist of Permian fossiliferous mudstones, succeeded by limestones and pebbly sandstones. Ross sandstones, followed by Felspathic sandstones and shales, of Triassic age overlie the Permian strata on the steeper slopes. Upper Mesozoic dolerite, in the form of a sill, covers the Triassic rocks along the top of Mt. Nicholas range, and smaller bodies of this rock intrude the Permian strata near the bottom of the valley.

The Limestones.

Poorly exposed limestones occur on the Frodsley Estate at two localities on opposite sides of the Break O'Day plain, in each instance at altitudes slightly above the valley floor.

On the southern side limestone outcrops in the bed of a small creek about a quarter of a mile south of Esk Highway. From here to the western boundary of the property numerous pieces of limestone are scattered over the surface. Since only a few feet of the rock is exposed, the full thickness of the beds cannot be indicated. The limestone belt extends westerly into the adjoining Malahide Estate. On the Killymoon Estate (Ransom's), to the east, a bore hole in 1888 revealed beds of limestone 133 feet in thickness at 24 feet below the surface. Although there is little doubt that large quantities of limestone occur at shallow depths below the surface in this area, the land is only slightly undulating and is generally unsuitable for quarrying the rock.

On the northern side of the river, limestones are again in evidence on the western slope of low dolerite capped hills, about three-quarters of a mile north-east of Frodsley homestead. A shallow trench up the hillside reveals some poorly exposed limestone up to 25 feet in thickness. West of the trench, on a gently sloping surface, many large blocks of the limestone indicate that the total thickness of the beds approximates 40 feet. No other outcrops occur in the vicinity but the belt can be traced by means of boulders for over half a mile to the north. Owing to the gentle hill slopes, quarrying facilities in this area are poor, a maximum face of 15 feet only would be possible, in the upper beds. Easy access is available by way of an unsurfaced vehicle track from Frodsley homestead.

In 1922 Keid reported limestones, to a thickness of 80 feet, on Horseshoe Cliffs along the northern slopes of Mt. Durham. These occur on Crown land to the north of the Silkstone Colliery leases. The area is some four miles north of Frodsley Siding in rugged country, and is difficult of access. Unlimited supplies of limestone are reported to be available in this locality.

The quality of the limestones in the Frodsley-Silkstone area is illustrated by the following analyses:—

Locality	SiO_2	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	$CaCO_3$	MgO	MnO_2
Silkstone (Mt. Durham)..	18.08	1.08	—	1.20	78.32	0.32	—
Silkstone (Mt. Durham)..	7.80	1.00	—	1.72	89.38	0.21	—
Silkstone (Mt. Durham)..	12.24	1.57	—	1.83	83.45	1.15	—
Silkstone (Mt. Durham)..	11.52	1.43	—	2.27	83.90	1.15	—
Silkstone (Mt. Durham)..	10.12	1.86	—	2.18	84.97	1.00	—
Silkstone (Mt. Durham)..	8.60	1.72	—	1.52	87.38	1.00	—
Silkstone (Mt. Durham)..	30.52	—	5.70	—	62.41	—	—
Silkstone (Mt. Durham)..	26.11	—	2.60	—	70.10	—	—
Silkstone (Mt. Durham)..	11.31	—	3.10	—	85.20	—	—

Locality	SiO_2	Fe_2O_3	Fe_2O_3 + Al_2O_3	Al_2O_3	$CaCO_3$	MgO	MnO_2
Silkstone (Mt. Durham)..	10.20	—	4.60	—	82.87	—	—
Silkstone (Mt. Durham)..	16.52	—	4.88	—	76.68	—	—
Silkstone (Mt. Durham)..	23.26	—	3.10	—	71.96	—	—
Silkstone (Mt. Durham)..	9.32	—	1.61	—	88.48	—	—
					86.73		
Mt. Nicholas	23.00	—	—	—	69.28	—	—
Frodsley ..	16.64	2.07	—	3.89	76.22	0.43	—
Ransom's ..	8.72	0.36	—	2.88	87.73	0.11	0.82

(2) St. Marys-German Town Area.

Location and Access.

This area is situated north of the town of St. Marys along the eastern end of Mt. Nicholas range, to the west of Tasman Highway. The northern part, at the farm settlement of German Town, is reached by road, leading north from St. Marys in a distance of four miles. The southern locality is accessible by a road deviating north-west from Tasman Highway, at a point one mile north of the town.

Topography.

The principal topographical feature of the area is the steeply rising slopes at the eastern end of Mt. Nicholas range, which are dissected by small east and south flowing streams.

Geology.

The basement rock here consists of granitite porphyry or granodiorite of Devonian age upon which the later Permian sediments were laid down The latter strata in ascending order comprise sandstones and grits, mudstones, limestones, pebbly sandstones and siltstones Dolerite of Upper Mesozoic age intrudes the Permian rocks in places. In the vicinity of German Town the Permian sediments are overlain by small flows of Tertiary basalt.

The Limestones

The best outcrops of these rocks occur on cliffs and steep hillsides about $1\frac{3}{4}$ miles north of St. Marys, on the edge of farmlands principally comprising 49 acres purchased from the Crown by W., G., T., C., and H. Maney (A. Davis, owner).

The limestones are well exposed in slightly dipping beds on a cliff face, 45 feet high and extending laterally for about 300 feet. The total thickness of limestone beds is 50 feet. Some siliceous beds from two to six inches in width occur and narrow shale bands are also included. From the cliff the limestones can be traced along the outcrop for over half a mile westerly, as far as Wright's farm on the St. Mary-German Town road.

The following analysis of a chip sample, taken through a thickness of 40 feet at the cliff outcrop, shows the chemical composition of the limestones, together with the included siliceous bands and shaly partings:—

	%
Acid Insoluble	37·6
$Fe_2O_3 + Al_2O_3$	1·3
CaO	32·1
MgO	0·3
Ignition Loss	26·8
Moisture	1·10

This analysis indicates that the deposit as a whole is generally low in lime content, however, by selection of the higher grade limestone and discarding the siliceous and shaly bands during quarrying operations, a much higher product could be obtained.

Quarrying facilities at this site are good. Overburden is light and a wide natural platform at the cliff base make an easy working approach. For transport purposes, only 300 yards of road would be required to connect the site with the existing road to the property.

At German Town, one mile north of the above occurrence, limestones are again exposed to a limited extent on 100 acres originally purchased by Henry Lohrey. Few outcrops are available for inspection but the belt can be traced along the hill slopes for about a quarter of a mile. Here the limestones are overlain and partly covered by basalt. Good access is available to the limestone outcrop from the road terminal at Lohrey's homestead, by way of a vehicle track extending 15 chains to the east. Suitable quarry sites are not available in this locality.

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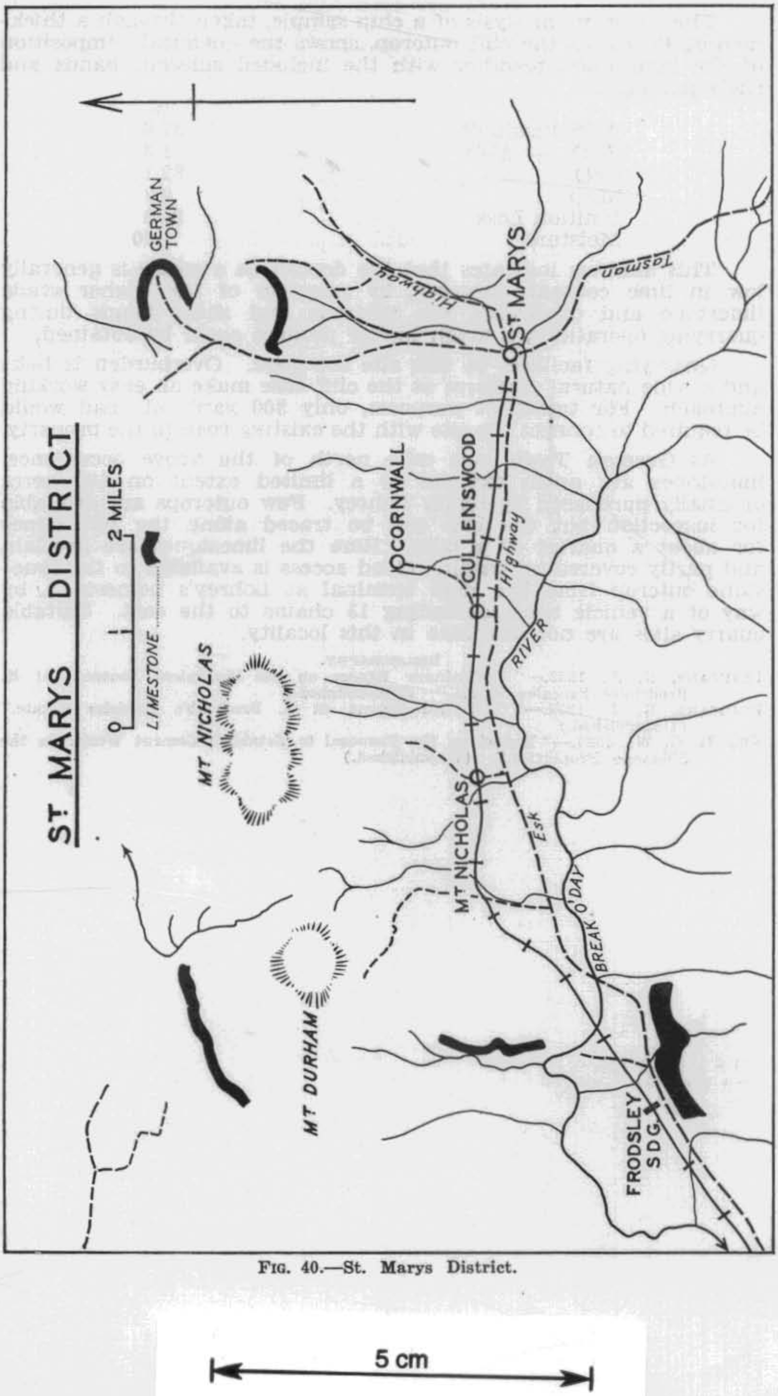

Fig. 40.—St. Marys District.

XIV SORELL

Introduction.

Limestone beds have been opened by means of small quarries and pits on the north-western slopes of a hill at Pawleena, about four miles north-north-east of Sorell. This limestone closely resembles that examined at Whitton's Quarry, Proctors Road (see above) and while some of the beds are composed of reasonably pure limestone, much of it consists of greenish siliceous rock with low calcium carbonate content.

Location and Access.

The limestone is located on a hill close to and east of the road, leading from Sorell, almost half a mile south-south-east of Cherry-Tree (Pawleena) State School. This road branches north from the Arthur Highway just east of the township of Sorell.

Geology.

These Permian, flat-bedded rocks are exposed on the north-west slopes and summit of the hill. Jurassic dolerite encloses the rocks on the other three sides and also occurs at the base of the hill, so that nowhere are the sediments far from dolerite and they have been locally metamorphised to some degree. What dip there is, is at a low angle to the south.

The Limestone.

This is best exposed in an old quarry near the base of the hill where narrow bands of grey and cream sugary textured limestone, alternate with white flinty or green bands. The rock is closely bedded and jointed. Almost eight feet of limestone is exposed in a quarry and prospect holes indicate the limestone for about 200 yards. However, sampling would indicate that the grade varies considerably from bed to bed and even in the higher lime content rock, much of the lime would be bound up with the silica in lime-silicates. A sample of the better class of stone showed:—

	%
Acid Insoluble	25·2
Fe_2O_3 and Al_2O_3	1·4
CaO	46·7
MgO	0·3

indicating that some lime and silica are in combination.

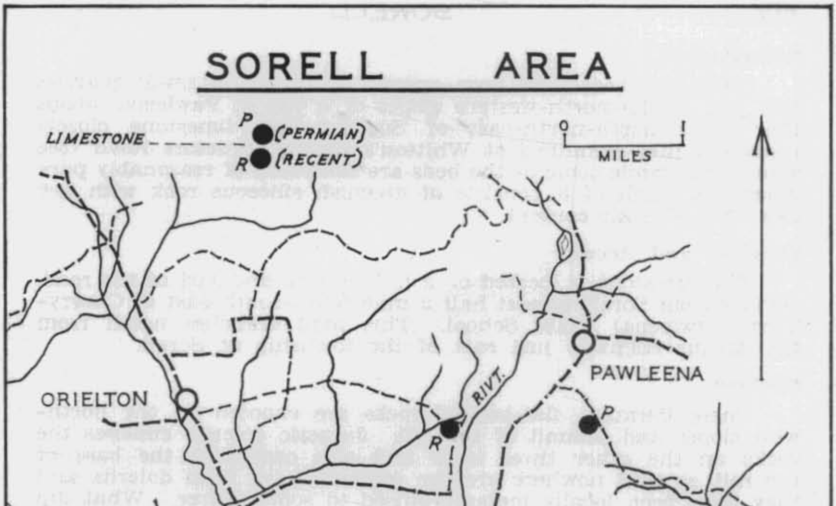

FIG. 41.—Sorell Area.

CHAPTER 6—TERTIARY LIMESTONE

I FLINDERS ISLAND

Introduction.

During 1949 and 1950, G. Everard made a comprehensive examination of the limestones on Flinders Island. Although the limestones range in age from Tertiary to Recent, he has described them all under the one heading and for convenience his report is quoted only in this section as follows:—

Distribution.

Limestones occurring on the eastern plains of Flinders Island are lithologically distinct from those occurring on the western side, and outcrop differently. On the eastern plains, deposits have been exposed in the valleys of small streams, on the floors of lagoons and in drains, but actual outcrops of any extent are rare. The known deposits, except for those exposed on the floors of lagoons, are usually buried beneath a cover of sand or gravel, and have been revealed accidentally. To locate further similar deposits pitting or boring would be required.

At two places limestone has been quarried; at one for agricultural lime, and at the other for road material. The former is on the property of W. G. Holloway (original purchase 27/15), on the other side of Vinegar Hill from Lady Barron, with which it is connected by a bush track. The latter place is a cut in a bank above a small creek, where uncompacted calcareous material, underlying surface sand accumulations, has been exposed. It is highly probable that deposits similar to these two, exist beneath surface deposits in the southern portion of the eastern coastal plain.

In the Five-Mile Lagoon area, soft earthy limestone is exposed in two pits, one to the east and another just south of Wingaroo homestead. This material would be very suitable for local use, but there seems to be no great quantity of it. Small outcrops occur, in various parts of the district, of a very compact tough limestone, disposed in a bed about 18 inches thick, thinning out laterally into clayey bands with hard nodules. On some lagoons are to be found thin, tough discs of calcareous material, about two inches in diameter which seem to be formed by evaporation.

The limestone deposits on the western side of the Island are much more extensive than those on the eastern side. There is a small remnant of a deposit overlying sand, on a hill on the southern coast just west of the mouth of Big River. At Loccota just where the road from Big River turns off the granite to enter the long straight section, occur two small outliers of limestone; and at Trousers Point, a few hundred yards to the west, there are a few acres of limestone of varying thickness overlying granite which has been well smoothed by wave action prior to the deposition of the limestone.

The narrow coastal plain between Loccota and Ranga contains no limestone until a point about two miles south of the junction of the roads to Loccota and Lady Barron.

At this point a narrow tongue of limestone crosses the road as a long low ridge with steep sides, and continues in a south-westerly direction for a few hundred yards. Further inland, limestones fringe the foothills of the Strzelecki massif and run up both sides of the valley between the massif and Reid's Peak. This valley becomes a small gorge towards its head with steep cliffs of limestone on the northern side and of granite on the southern, the limestone on the southern side cutting out about half way up the valley, where a tributary stream enters.

The lower slopes on the western and southern sides of Reid's Peak are limestone, and a low ridge of limestone crosses the Loccota road just south of its junction with the road to Lady Barron. Then alluvium intervenes, but further out towards the coast there is a large area of limestone level with the general surface of the plain, which is not many feet above high tide level. This limestone seems to be of no great thickness, and passes laterally into calcareous clays, and sands with calcareous nodules, in the same way as the limestone beds in the Five-Mile Lagoon district.

Several small areas of limestone occur along the lower slopes of what may be a fault line scarp, running north-westerly from Ranga, and there are other small outcrops north of Pat's River, overlying sand or granite, while other small areas, sometimes directly on top of the quartzites, are to be found on the narrowing plains which end at Sawyer's Bay.

On the plateau between Reid's Peak and Pillinger's Peak, at an elevation of about 300 feet above sea level, there is a fairly considerable area of limestone overlying sand. A smaller area at a lower elevation, further to the north-east, underlies the sand; but this appears to be a much thinner deposit, and is not raised above the general level of the plateau.

At Sawyer's Bay, granite hills crowd in on the coastal plain, which is there reduced to a narrow strip of alluvium. But in the neighbourhood of Emita, limestone again occurs, and is found resting directly on top of granite. North of Emita is the largest area of limestone on Flinders Island. It forms a range of hills rising to about 600 feet, two miles inland from the coast, and extending northwards to the Five-Mile Lagoon road.

Two not very large areas of limestone, separated by the alluvium of a small floodplain of a creek, occur on the northern side of Tanner's Bay in the district known locally as the "West End". Similar deposits are to be seen at Boat Harbour, and there are outcrops of limestone about half a mile from the junction of the Boat Harbour and Killiecrankie roads at a fairly high elevation.

A large area of limestone exists on both sides of the main road to Palana opposite Mt. Blyth and here the limestone overlies thick beds of loose sand.

Pratt's River crosses a large limestone area which it has practically severed into two portions by corrading down to underlying sand and gravel. Limestone occurs on the hill slopes on either side at heights in excess of 400 feet.

Some small scattered outcrops of limestone are to be found on the sandy slopes overlooking the Arthur River. These are small residuals of erosion, often only some scattered pieces of rock. Some outcrops, however, are still large enough to be undoubtedly *in situ*, and directly overlie loose sand.

Topography.

The limestone areas of Flinders Island have a characteristic microtopography, which distinguishes them from other parts of the Island, and connects them with limestone areas elsewhere. The subject has an economic interest insofar as topography is conducive or otherwise to easy quarrying conditions.

Theoretically, the important consideration is that limestone is much more liable to attack by solution than any other common rock, because the insoluble carbonate of lime of which it consists can be converted to the soluble bicarbonate by the action of water charged with carbonic acid. Usually, rain water which has absorbed carbonic acid gas from the atmosphere, does not confine its solvent action to the surface, but penetrates underground by pores and joints, to carve out caverns and tunnels in the rock. Eventually the caverns and tunnels collapse, and the debris is then dissolved and swept away leaving behind residual areas demarcated by cliffs and sharp slopes, which are in turn attacked.

On Flinders Island the limestones, because of their extremely porous nature, have been peculiarly susceptible to erosion by solution, and the above processes have proceeded to an advanced stage. Except where protected by granite, the limestones have in most areas been almost completely removed, and erosion has bitten into the underlying beds. However, in the Ranga district erosion has proceeded only as far as the base of the thick limestone beds and the topography consists of low hills and ridges of limestone, with sharp slopes down to intervening areas of sand and alluvium. Limestones fringe the base of the mountainous granite areas with similar slopes and cliffs to alluvial flats.

Further northwards in the vicinity of the Pat's River aerodrome, limestone forms a capping to sandy hills, as here erosion has gone much deeper.

The flat plain of limestone in the Ranga district, extending to the coastal sand dunes and probably continuing underneath them to the coast, demands a special explanation. This limestone seems to be part of an extensive, but relatively thin bed. It is exposed on a low lying plain, only slightly above the water table, and therefore the water becomes saturated with lime, and tends to lie stagnant instead of flowing away. The drains now cut on the plain will facilitate removal of the limestone, although this is an enormously lengthy process, of course, on any human time-scale.

At Emita the limestones rest directly on the granite which controls the topography. Small swallow holes, however, are numerous. Rain water proceeds underground by these holes, which are constantly being enlarged, until it reached the granite, over which it flows to reappear as springs.

The limestone hills north of Emita do not show any topographical peculiarities. The relatively normal contours probably reflect the controlling influence of the underlying granite. Dry valleys and occasional small basin shaped depressions show the prevalence of underground drainage.

The limestone in the valley of Pratt's River has perhaps suffered slightly less erosion than that elsewhere on the Island. Only very fine contouring could indicate the very irregular surface here. Small domes and depressions are innumerable, as a result of solution and underground drainage.

On the western side of the Island there are no beds of limestone covering a sufficient area, or thick enough to exert any special influence on the topography.

Stratigraphy.

The foraminiferal limestones, the distribution of which has been described, are the uppermost sedimentary strata on Flinders Island, if local accumulations of dune sand be excepted. There are also alluvial beds, constituting the flood plains of creeks and rivers, which are still in the process of deposition, and therefore must be subsequent to the limestones; but these occupy an even more insignificant part of the total area of the Island than the dune sands.

In the Ranga district, limestone extends from within 50 feet of mean sea level to 340 feet above it; north of Emita, in the Lughrata district, it reaches from within 50 feet to 450 feet above sea level; and from Pratt's River to the Quoin in the extreme north of the Island, the limestone has a vertical range of 500 feet.

Interbedded with this limestone are some very much thinner beds of sand, and occasionally the limestone itself is somewhat siliceous; but generally it exhibits a remarkable uniformity, both laterally and vertically. On the evidence of the foraminiferal remains it contains, the age of the limestone has been estimated by Miss Irene Crespin, Commonwealth Palaeontologist, to be between Upper Pliocene and Pleistocene, and deposition is said to have taken place in water less than 50 fathoms deep, and under temperate climatic conditions, similar to those now prevailing on the south-eastern portion of the Australian continental shelf. The porosity and lack of compaction of the more massive portions of the formation suggests somewhat rapid deposition due to correspondingly rapid submergence.

Below the thick limestone beds, are beds of sand, gravel and clay, with one or more beds of dense, tough limestone about 18 inches in thickness and tending to thin out laterally and be replaced by clays containing calcareous nodules. Bores put down at "Wingaroo" in the Five-Mile Lagoon districts have penetrated as far as 80 feet into the sandy beds without reaching granite. The succession of limestone to sand and gravel indicates rapid submergence.

The limestones were best developed on the western side of the Island, where they must have been at least 500 feet thick. Before erosion it is probable that limestone covered all the low lying country between the outcrops of granite and Silurian slates and quartzites on the western side of the Island, in contrast to the eastern side where, as only very small residuals are now to be seen, limestones must have been of no very great thickness, and were perhaps not represented at all in places.

On the western side, however, the sandy strata, which are seen to underlie the limestones in those localities where both formations are present, are often missing altogether and the limestone rests directly on the granites, slates or quartzites. The explanation would appear to be that the ancient rocks, where they directly underlie the limestone, were formerly small rocky islands, similar to those still fairly common in the surrounding waters at the present day, with precipitous slopes into deep water. This environment while conducive to the formation of limestone beds, which require clear deep water, would not result in the formation of any depth of sand.

Petrology.

The Flinders Island limestones are all of the non-recrystallised fragmental types. They vary greatly in their relative degrees of consolidation, some limestones on the eastern coastal plain, e.g., those at "Wingaroo" and Lady Barron, have hardly any degree of consolidation at all when fresh, although specimens exposed to the atmosphere invariably harden. The limestone of the Dutchman deposit is perhaps the loosest and least consolidated of them all, and could be shovelled up without difficulty. On the other hand, thinly bedded limestones exposed in the Five-Mile Lagoon district, at Ranga, and at the foot of the eastern slopes of the low hills in the Lughrata district are extremely dense and tough. Although all intermediate stages of consolidation can be found, it is convenient, for practical purposes, to divide the Flinders Island limestones into three classes according to their degree of consolidation:—

(1) Unconsolidated types found usually as isolated deposits, often buried under sand, on the eastern plains.

(2) Lightly consolidated porous types, constituting the bulk of the limestone found on the western side of the Island. Surface capping and contained lenses of tough fine grained material are common.

(3) Well consolidated limestone disposed in rather thin beds, in the sands, &c., underlying the main deposits of porous limestone or outcropping on the eastern plains.

There is no correlation between the relative physical properties of these rocks and their lime content, but the physical properties determine, of course, the ease with which the rock may be processed, and also the purposes for which it is ultimately suitable

(1) *Unconsolidated Types.*

Seen under the microscope, the unconsolidated material is a mass of grains which are aggregates of very finely crystalline calcite. The grains are of various sizes down to very finely divided material. There are also single crystals of calcite in size of the order of ·02 mm., and rarer single crystals of quartz and felspar of about the same order of size. The material also contains organic matter in the form of root hairs, but organic remains belonging to the animal kingdom seem all to be of macroscopic dimensions. It is apparently a deposit formed in shallow disturbed water, poorly supplied with sediments from the land. Many of the calcite granules are heavily stained with iron. This description applies equally to samples from the deposits at Lady Barron and the Dutchman, the former being coarser in grain and poorer in lime.

Limestones of types 2 and 3 were examined in thin section:—

(2) *Lightly Consolidated Porous Type.*

This rock consists essentially of organic remains including foraminiferal tests, echinoid spines, holothurian remains and fragments of bryozoa and mollusca, all cemented together by very fine grained colourless, crystalline calcite. The shelly fragments are in size of the order of ·02 mm., except for occasional larger molluscan remains which are, however, rather rare and tend to occur in small pockets. Otherwise the grain size is remarkably uniform, and the calcite which cements the fragments together appears as a thin crystalline growth on the surface of the grains, and has the appearance of having flowed over them, leaving interstices which account for the high porosity of the rock.

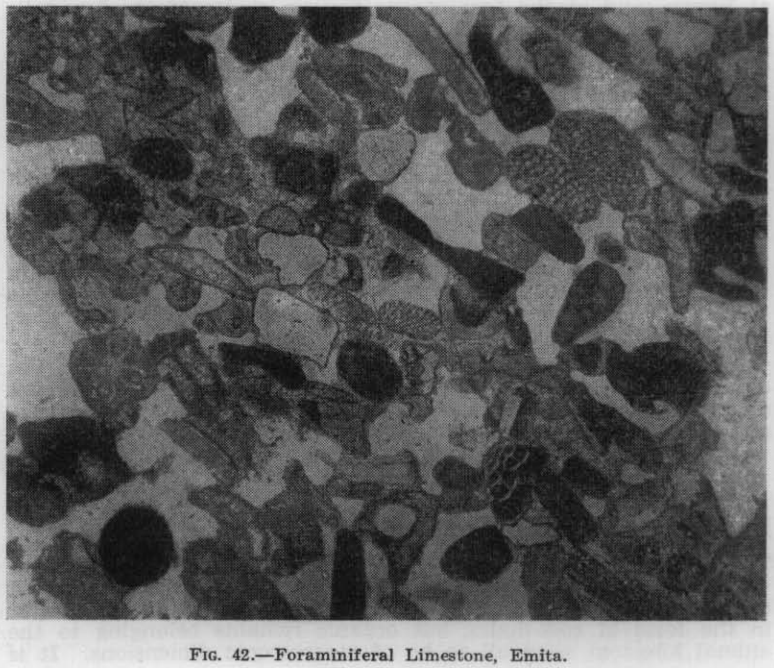

FIG. 42.—Foraminiferal Limestone, Emita.

The chief impurities are rather uncommon crystals of quartz and felspar, both rounded and angular, and much rarer crystals of topaz and garnet. The organic remains are faintly stained with iron and there are a few opaque grains of limonite. The quartz and felspar show little signs of alteration, although some of the felspar crystals are corroded.

It may be noted here that this rock would be easily broken down, by fracturing the thin cementing calcite, into the original fragments, and would then be a very suitable fineness for agricultural lime.

The loose and porous nature of the deposit suggests fairly rapid deposition, and its freedom from muddy sediment indicates very clear water receiving little detrital matter from any neighbouring land surface, while the organic remains show that general conditions must have been very similar to those now appertaining.

This type of limestone has given rise to a secondary variation. It often has a surface capping or contains lenses of a hard, tough rock, dense and without many pore spaces. The organic remains have been almost completely replaced by calcite, and concretionary laminae are frequent. This variety has arisen by the solution and redeposition of calcite in the rock.

At Emita, between the road to Emita Jetty and that up to the old wireless station, there is a loose and friable deposit of fine high grade material In thin section it is a structureless aggregate of very fine grained semi-opaque material, although there are curved bands that may be depositional laminae. It seems to be a secondary deposit derived from a high grade porous limestone placed at a higher elevation. (Samples F.I. 31, F.I. 21.)

(3) *Dense Well Consolidated Type.*

These limestones have a semi-opaque groundmass, enclosing organic remains, including foraminifera and broken fragments of Molluscs. In it are embedded angular, sub-angular and rounded grains of quartz and rarer felspar. With a high power objective, the groundmass may be resolved into a fine mosaic of calcite, and possibly some clay mineral which, however, is too fine-grained to be identified. There are also small rounded masses, and the infillings of shells and tests, consisting of coarser grained colourless calcite. The carbonate of lime content varies considerably from sample to sample, and the rock was originally a calcareous mud.

A variant of this type exists at " Wingaroo ", in a pit just south of the homestead. It is less compacted and contains numerous pore spaces, and is soft and friable; but has a similar appearance under the microscope. (Sample F.I. 56.)

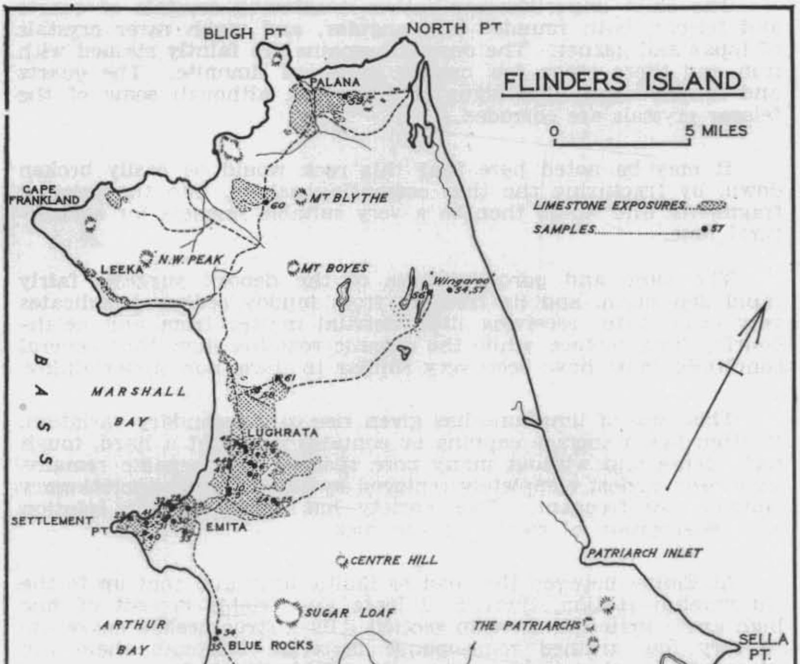

FIG. 43.—Flinders Island Area.

ANALYSES OF LIMESTONES FROM FLINDERS ISLAND

Reg. No.	Field No.	Locality	Acid Insol.	Al_2O_3	Fe_2O_3	P_2O_5	MgO	CaO	$CaCO_3$ (calc.)
577/49	1	W. Holloway's Quarry, Lady Barron floor—9″	2.9	0.2	0.5	0.01	1.8	51.2	91.4
578/49	2	W. Holloway's Quarry, Lady Barron floor—9″ – 1′ 3″	9.7	0.6	0.7	0.02	1.7	47.3	84.5
579/49	3	W. Holloway's Quarry, Lady Barron floor—1′ 3″ – 3′ 11″	38.2	0.5	1.8	0.01	1.2	30.7	54.8
580/49	4	W. Holloway's Quarry, Lady Barron floor—3′ 11″ – 7′ 1″	24.7	0.2	0.9	0.02	1.6	38.8	69.2
581/49	5	4 chains N.E. of Holloway's Quarry	28.0	0.6	0.9	0.01	1.4	36.8	65.7
582/49	6	10 chains N.E. of Holloway's Quarry	3.2	0.2	0.6	0.02	1.6	50.6	90.4
193/50	F.I. 55	E. of Dutchman Hill	14.8	0.7	0.8	0.12	0.6	45.3	80.9
192/50	F.I. 54	Pit, N.E. of Homestead "Wingaroo"	21.5	0.8	0.9	0.03	1.2	39.1	69.8
195/50	F.I. 57	Pit, N.E. of Homestead "Wingaroo"	30.5	0.4	0.8	0.02	0.9	36.1	64.4
194/50	F.I. 56	Pit, near Homestead, "Wingaroo"	22.1	1.6	1.0	0.04	1.1	38.8	69.3
816/49	F.I. 53	Drain, S. of Ferguson's Jetty	36.8	0.2	0.3	0.03	1.1	33.0	58.9
815/49	F.I. 52	Drain, S. of Ferguson's Jetty	33.6	0.2	0.4	0.04	1.1	34.8	62.2
727/49	F.I. 38	Old stream bank, Ranga	24.4	0.3	0.6	0.11	0.7	40.3	72.0
726/49	F.I. 37	J. A. Ferguson's Property, Ranga	19.3	0.4	0.6	0.08	0.6	43.3	77.3
725/49	F.I. 36	Cliff on P. Dart's Property, Ranga	18.8	0.3	0.9	0.15	0.7	43.5	77.7
814/49	F.I. 51	J. A. Ferguson's Property, Ranga	3.0	0.1	0.2	0.2	0.6	52.1	93.0
812/49	F.I. 49	S. G. Moyles' purchase, Ranga	7.6	0.3	0.7	0.02	0.4	49.9	89.1
621/49	F.I. 13	Sinkhole on J. Blunstone's, Whitemark	12.6	1.0	0.4	0.06	0.7	47.0	83.9
548/49	F.I. 1	Near school, Whitemark	4.5	0.4	0.4	0.02	0.5	51.6	92.2
549/49	F.I. 2	Near school, Whitemark	12.6	1.0	0.4	0.06	0.7	47.0	83.9
639/49	F.I. 19	Coast Parry's Bay	87.1	5.1	2.0	nil	0.4	0.7	1.2
636/49	F.I. 16	Coast Parry's Bay	38.0	2.5	1.3	0.01	0.6	29.1	62.0
637/49	F.I. 17	Coast Parry's Bay	26.9	2.2	1.4	0.01	0.5	36.8	65.7
638/49	F.I. 18	Coast Parry's Bay	19.0	1.0	1.3	0.02	0.6	41.4	74.0
619/49	F.I. 11	Quarry on aerodrome reserve	10.3	0.6	0.6	0.01	0.7	47.4	84.8
620/49	F.I. 12	Quarry on aerodrome reserve	36.8	0.7	0.9	0.02	0.7	32.9	58.8
642/49	F.I. 22	Quarry on aerodrome reserve	34.7	0.4	1.3	0.03	0.7	32.6	58.2

Reg. No.	Field No.	Locality	Acid Insol.	Al_2O_3	Fe_2O_3	P_2O_5	MgO	CaO	$CaCO_3$ (calc.)
634/49	F.I. 14	Side of main road N. of aerodrome	31.9	3.3	1.4	0.01	0.6	32.8	58.6
635/49	F.I. 15	Quarry, McKenzie's purchase $\frac{12}{14}$	3.2	0.3	0.2	0.01	0.7	51.7	92.3
640/49	F.I. 20	Quarry, McKenzie's purchase $\frac{12}{14}$	4.7	0.5	0.7	0.01	0.9	48.5	86.6
788/49	F.I. 39	McKenzie's purchase N. of aerodrome	23.6	1.2	0.8	0.03	0.6	39.1	69.8
724/49	F.I. 35	Quarry, W. side road, Blue Rocks	26.0	1.8	1.3	0.02	0.8	37.0	66.1
723/49	F.I. 34	Quarry, E. side road, Blue Rocks	20.1	0.9	0.7	0.01	0.8	39.5	70.5
797/49	F.I. 40	Near R. Morton's homestead, Emita	32.6	0.4	0.4	0.04	1.1	34.4	61.4
789/49	F.I. 41	Coast S. of Jetty, Emita	3.7	0.5	0.4	0.05	2.5	48.7	87.0
643/49	F.I. 23	Coast S. of Jetty, Emita	5.9	0.3	0.7	0.06	1.5	48.6	86.8
675/49	F.I. 33	Road to J. Woods' House, Emita	14.5	1.3	0.9	0.04	0.6	45.8	81.8
672/49	F.I. 30	J. Woods' property, Emita	4.0	0.6	0.6	0.06	0.7	52.7	94.1
673/49	F.I. 31	E. side of road to Emita Jetty	0.2	0.1	0.1	0.01	0.7	53.3	95.2
641/49	F.I. 21	Quarry on road to Wireless Stn., Emita	0.2	0.3	0.1	0.03	0.8	52.0	92.7
674/49	F.I. 32	Road to old Jetty, Emita	16.0	1.2	0.9	0.05	1.9	43.4	77.5
670/49	F.I. 28	Near old Jetty, Emita	0.4	0.1	0.1	0.02	0.8	50.3	82.8
671/49	F.I. 29	Road W. of Emita P.O.	14.7	0.2	0.4	0.02	1.3	44.4	79.3
617/49	F.I. 9	E. M. Cooper's purchase N. of Emita	19.2	0.5	0.4	0.03	1.2	42.1	75.2
618/49	F.I. 10	E. side of main road, N. of Emita	21.1	0.3	0.5	0.05	0.7	42.4	75.7
666/49	F.I. 24	A. R. Cooper's purchase, Lughrata	24.4	1.1	1.2	0.04	0.8	39.5	70.5
667/49	F.I. 25	A. R. Cooper's purchase, Lughrata	13.5	0.7	0.7	0.02	0.5	46.4	82.9
615/49	F.I. 8	A. R. Cooper's purchase, Lughrata	7.9	0.6	0.4	0.05	0.8	49.5	88.4
791/49	F.I. 43	Pit, W. side of road, Lughrata	27.5	1.2	0.8	0.05	0.5	37.6	67.2
792/49	F.I. 44	Pit, W. side of road, Lughrata	12.3	2.2	0.2	0.04	0.9	43.9	78.4
668/49	F.I. 26	A. T. Trueman's purchase $\frac{7}{31}$, Lughrata	13.2	1.0	0.2	0.02	0.8	47.0	83.9

Reg. No.	Field No.	Locality	Acid Insol.	Al_2O_3	Fe_2O_3	P_2O_5	MgO	CaO	$CaCO_3$ (calc.)
669/49	F.I. 27	A. T. Trueman's purchase $\frac{7}{31}$, Lughrata	5.9	0.6	0.6	0.01	0.6	51.7	92.3
614/49	F.I. 6	Lughrata	7.9	0.6	0.6	0.05	1.3	48.9	87.3
615/49	F.I. 7	Lughrata	0.5	0.4	0.1	0.01	0.8	48.9	94.8
550/49	F.I. 3	A. Stackhouse's purchase, Lughrata	26.4	1.5	1.5	0.06	0.7	37.5	70.0
551/49	F.I. 4	A. Stackhouse's purchase, Lughrata	19.7	0.5	0.6	0.01	0.7	42.4	75.7
552/49	F.I. 5	A. Stackhouse's purchase, Lughrata	9.4	0.3	0.2	tr.	0.7	48.0	85.7
793/49	F.I. 45	Quarry, E. side main road, Lughrata	13.3	2.1	1.2	0.05	1.0	43.3	77.3
794/49	F.I. 46	Quarry, E. side main road, Lughrata	11.4	2.6	0.9	0.03	0.8	44.8	80.0
790/49	F.I. 42	Lughrata, W. of main road	19.0	1.4	0.5	0.06	0.4	41.9	74.8
795/49	F.I. 47	W. side of main road, Lughrata	5.9	1.0	0.6	0.05	1.2	48.6	86.8
238/50	F.I. 58	S. of road to Wingaroo	15.6	1.2	0.9	0.02	0.6	43.1	77.0
241/50	F.I. 61	N. side of road to Wingaroo	4.4	0.4	0.5	0.06	0.6	53.2	93.2
240/50	F.I. 60	Pit, W. of main road near Killiecrankie	15.8	0.3	0.7	0.04	0.6	42.7	76.4
239/50	F.I. 59	Palana	10.2	0.3	0.7	0.08	0.9	47.9	85.5

Limestones—10

Note on the Analyses.

The principal impurities of the Flinders Island limestones are sand and clay, both insoluble in acid. There is also, on the average about 1 per cent each of magnesia and alumina and a minute proportion of phosphorous anhydride in combination. Oxides of iron are present to the average amount of 1 per cent, as the mineral limonite, which is the colouring material in the rock.

The extreme variation in calculated carbonate of lime content is from 52 per cent in a somewhat clayey rock from Parry's Bay, to 95·2 per cent in a white powdery reprecipitated limestone from Emita, in which the chief impurity is probably also clay. Between these extremes there is a wide scatter, but the limestones in any one deposit are of fairly even quality, and a reasonable estimate of the grade of limestone from that deposit may be made. The samples are, however, of differing orders of importance, because, whereas some samples represent a normal type which is present in quantity, others are of peculiar types having a more limited distribution.

The rocks are "straight" limestones with the impurities introduced during deposition by normal physical conditions in fairly shallow water. The term "calcareous sandstone" used by Johnston has not been found applicable to any of the rocks examined.

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II GEILSTON BAY

Introduction.

A small deposit of Tertiary limestone or travertine, as it is usually called in this deposit, occurs at the head of Geilston Bay, one of Hobart's eastern suburbs. This has been worked intermittently almost from the first settlement and already in 1836 a quarry had been opened up. These deposits are well described by P. B. Nye in his Underground Water Supply Paper No. 3 and Carey and Henderson (1945) have something to say of their origin.

Location and Access.

The area around Geilston Bay, an inlet of the eastern shore of the Derwent, is now a suburb of Hobart. The limestone deposits cover part of a shallow-basin-like depression of about 10 acres occurring to the south of the head of Geilston Bay.

Geology.

The Tertiary beds here consist of interbedded clays, sandstones and limestone having a dip to the south at a low angle. These beds are overlain to the north and west by basalt and further narrow beds of limestone occur above the basalt.

The Limestone.

The limestone is of a yellowish-brown colour and is very dense, hard and compact. It contains a number of cavities sometimes lined with calcite; and in the joints in some places contains clay and sand but generally appears to be of fairly good quality.

In the strata seen in the quarry, being worked in 1924, were several beds of limestone, varying in thickness up to six feet, inter-bedded with sandstone and mudstone and overlain by 10 feet of basalt. At that time the stone was used by the Electrolytic Zinc Company and earlier the lime had been burnt in a kiln on the spot. Today, all that can be seen is a large pit with water in it and the remains of the old kiln.

Carey and Henderson have an interesting theory of the origin of the limestone here, and say:—

> "The Geilston travertine occurs near the north-western end of the senkungsfeld where the Springs sandstone comes to the surface and is nipped off by the intersection of the Lindisfarne and Flagstaff faults. When the reservoir formed by the Springs sandstone trapped in the sengkunsfeld becomes filled with water and overflows, the overflow would take the form of a spring at Geilston exactly where the travertine is now found. Now during part of the Miocene period Australia generally endured an epoch of aridity. It was during this epoch that the numerous deposits of bauxite in Tasmania and elsewhere were formed, also the widespread veneers of "duricrust" and "grey billy" and laterite, so characteristic of many parts of Australia. During this arid epoch the seepage from the Geilston spring evaporated round the spring, and in this way built up the extensive travertine deposit. The banding in the travertine reflects the cyclic variations of climate during

the long epoch of dessication. The leaves and snails preserved in the travertine were fossilised in the same way as leaves and shells are rapidly fossilised round travertinous deposits forming today.

The Geilston travertine which is overlain by Pliocene basalt is therefore a fossil spring and testifies to the long history of senkungsfeld as an underground water storage basin."

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CAREY, S. W. AND HENDERSON, Q. J., 1945.—"Prospects of Underground Water Supply in the Bellerive-Risdon District." (Unpublished.)

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III KING ISLAND

Three outcrops of Tertiary limestone are known on King Island, and although of good quality they are very limited in area and do not compare with the Recent lime sands and semi-consolidated limestones in quantity, accessibility or availability to plant life.

The first of these, is situated in the centre of the Island, half a mile south of the Naracoopa Road and within 100 yards of the Sea Elephant River. All that can be seen are a few lumps of limestone that have been taken from a small pit now filled with water.

The second deposit is fairly extensive, but it outcrops along the shore-line and the greater part of it occurs below high tide level. Four miles north of Naracoopa, on the east coast, is a small creek, Blowhole Creek. A cart track from the road to the Cable Station leads to the mouth of this creek. For three-quarters of a mile north of this, Bryozoal limestone of Miocene age outcrops in shallow platforms along the shore below high-water mark. A grab sample taken at intervals along these outcrops gave the following analysis:—

	%
Insoluble	0·7
Fe_2O_3 and Al_2O_3	0·8
CaO	54·7
MgO	0·4
Ig. Loss	43·3

To the south of Blowhole Creek is a smaller outcrop, but portions of this do occur above high-water level. The outcrop measures 400 by 30 feet and rises to about 10 feet above low-water level. Two samples from this showed:—

	Top 7′ 6″	Bottom 2′ 6″
Insoluble	1·4	16·0
Fe_2O_3 + Al_2O_3	1·6	12·0
CaO	52·6	34·6
MgO	0·8	1·5
Ig. Loss	43·2	32·8

Doubtless these beds extend in shore under the sand dunes. At 100 feet in from the creek mouth is a small outcrop along the bank.

The other outcrop is situated near the central south coast and at present some miles from the nearest road. On the west bank of a creek which flows into a marsh to the east of Big Lake may be seen a small well-bedded outcrop of limestone. The total exposed width of the beds is 15 feet and the outcrop extends over two chains. It is covered and surrounded by Recent Sands. A sample taken across the beds showed the following analysis:—

	%
Insoluble	4·4
Fe_2O_3 + Al_2O_3	2·6
CaO	51·1
MgO	0·6
Ig. Loss	41·7

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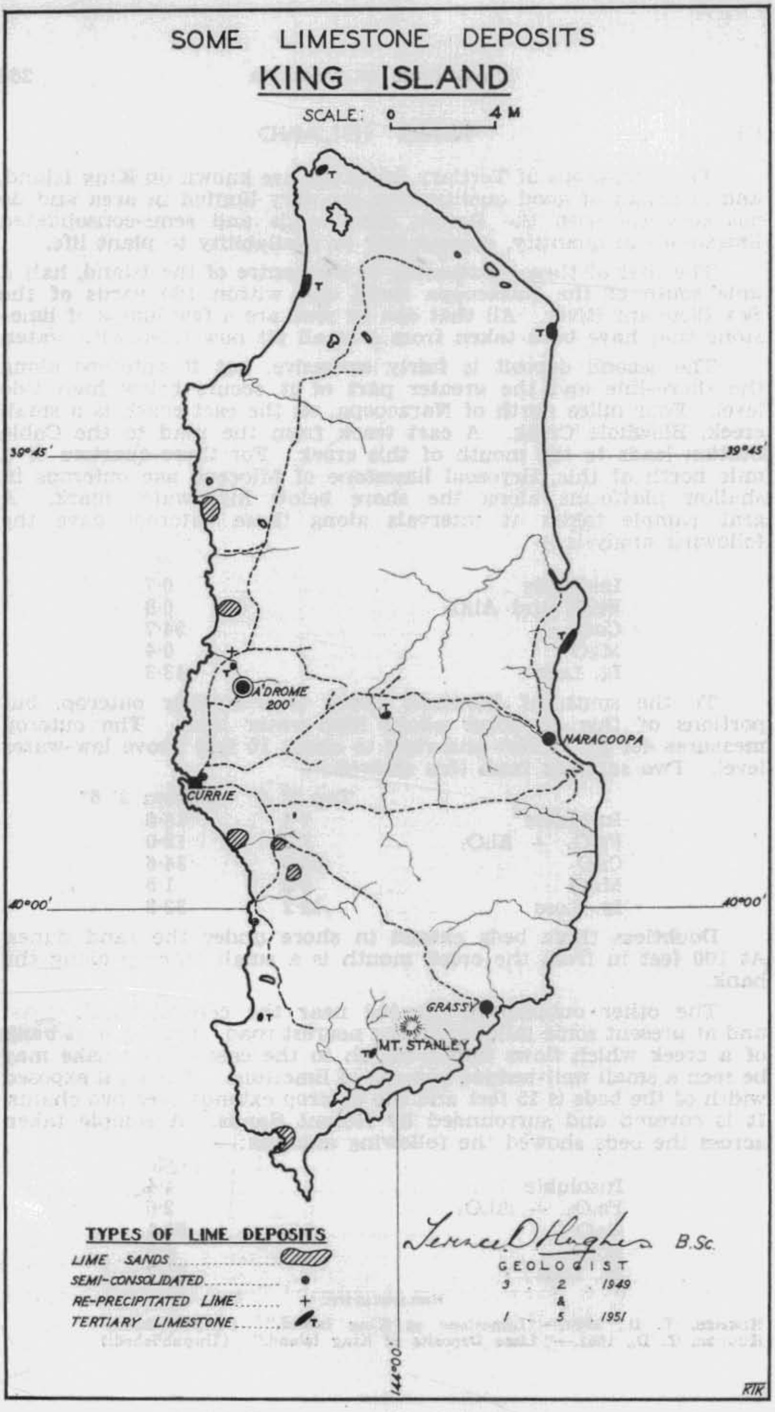

FIG. 44.—King Island Area.

IV MARRAWAH DISTRICT

During his survey of the Underground Water Resources of this district P. B. Nye recorded certain details of the Tertiary limestones there. These rocks occur in two distinct areas. Between one and two miles west of Marrawah and not far from the West Coast of Tasmania are three small but distinct outcrops. The limestone is white to creamy in colour and is composed largely of small fossils and pieces of fossils. The lowest outcrop is 190 feet and the highest is 250 feet above the sea and the limestone occurs on the flanks of basalt hills.

The other occurrence is in the vicinity of the town of Redpa to the east of Marrawah. Limestone occurs north and north-west of Redpa but the principal deposit is on the west side of the western Welcome River flat to the south-south-east of Redpa. Here the limestone has a somewhat different appearance from that near Marrawah, being pinkish and much harder. It stands out in the typical limestone scattered crags and peaks. The base of this limestone is visible and it overlies with great unconformity the Lower Palaeozoic limestone and dolomite. The base is at a height of 135 feet above sea level and its thickness from 50 to 100 feet.

Samples taken from both these occurrences indicate that while they both are extremely low in silica, that at Redpa particularly, is very high in magnesium. Details of the analysis are:—

Locality	Reg. No.	$CaCO_3$	CaO	MgO	Insol.	Fe_2O_3 + Al_2O_3	A_2O	Ig. Loss
Marrawah ..	257/44	82.66	46.29	7.58	1.2	0.88	—	43.66
	258/44	84.71	47.44	7.24	0.4	0.60	—	43.70
Redpa ..	654/47	64.82	36.3	20.0	0.2	0.90	1.86	39.6
	655/47	62.32	34.9	16.8	0.4	0.80	0.2	46.3
	656/47	70.35	39.4	12.4	1.5	1.20	0.1	44.9

Tertiary limestone has also been reported both to the north and the south of Marrawah. Twelvetrees (1908) says that at Cape Grim polyzoan limestone in horizontal beds, dipping eastward under basalt composes the sea front on the West Coast, immediately south of the Cape. A small outcrop may also be seen in a creek bed two miles from Temma which is well south of Marrawah. This is of pinkish colour and contains abundant fossils. It is 250 feet above sea level.

In the Montagu district too, Tertiary limestone can be seen in several places; at the mouth of the Harcus River, near the mouth of the Montagu River and further up the Montagu, just below the West Montagu Road crossing In all these occurrences, the outcrop is close to sea level.

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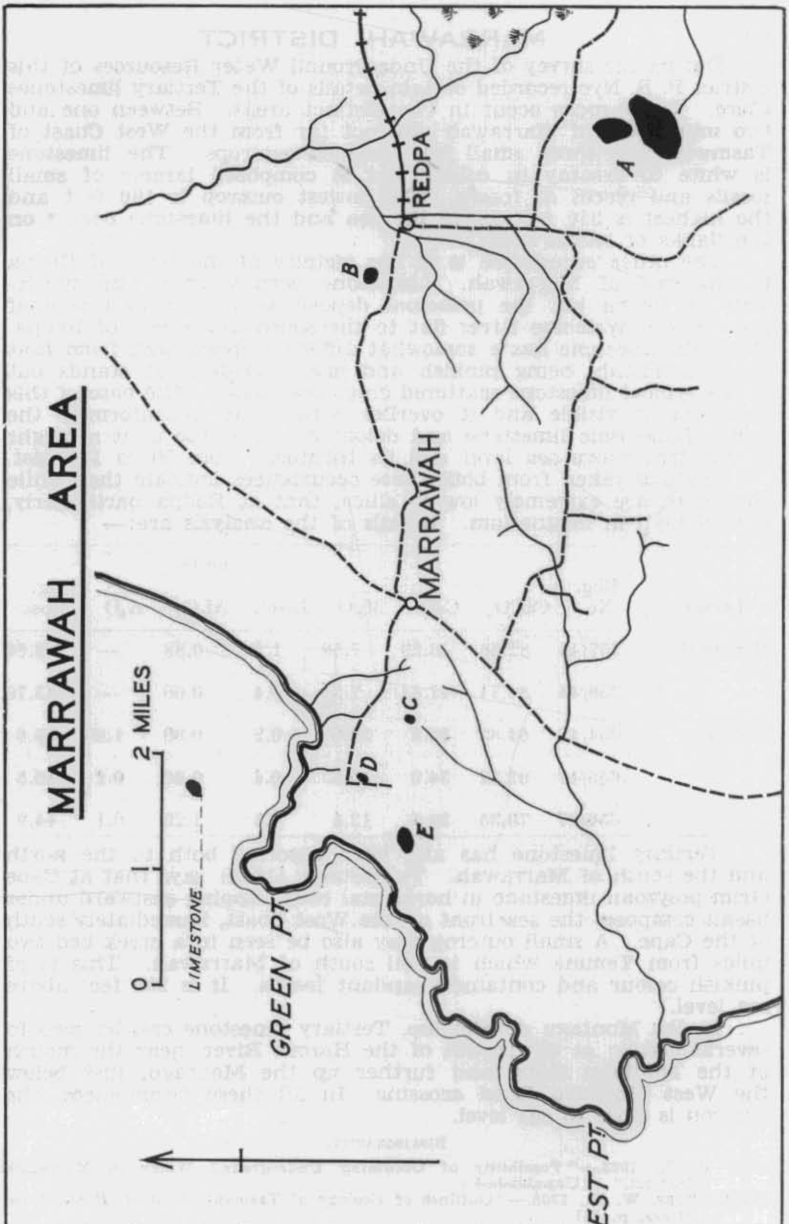

FIG. 45.—Marrawah Area.

CHAPTER 7—RECENT LIMESTONES

I BRIDPORT

The scarcity of limestone deposits in the north-eastern part of Tasmania, has lead Messrs. E. & M. Mills of Jerusalem Plains to experiment in the use of low-grade lime sands for agricultural needs. In 1951, therefore, a hand boring campaign was undertaken on the property, by the Department of Mines, to investigate these deposits. Preliminary work had indicated a reasonably large deposit of calcareous material and it was hoped that this would prove useful for agricultural purposes. Portions of two reports by H. G. W. Keid are quoted:—

> "Jerusalem Plains is an extensive low-lying sandy coastal plain situated in the north-eastern part of Tasmania, on the broad promontory extending from West Sandy Cape to East Sandy Cape. The Plains are distant about seven miles from Bridport over roads which are only in part gravelled. On the northern and western boundaries of the Plains, large sand dunes occur, most of which are now settled and carry reasonable growths of grass and scrub.
>
> The occurrence of calcareous deposits in the area has been known for a considerable period. Several attempts have been made to burn some of the material for the production of agricultural lime. It is not known how successful these efforts were but it is doubtful whether any lime was produced. The open cuts are generally of very shallow depths.
>
> The greater part of the area on which the deposit occurs is low-lying and flat with, in parts, a tendency to be swampy. There is, however, a fairly prominent ridge extending in a general north-easterly direction over a distance of approximately 30 chains. The highest point of the ridge, about 16 feet above the flat occurs near its north-eastern end. It was on this ridge that boring was concentrated to determine the quantity of material available.
>
> The boring has shown that material of at least four types occurs.
>
> On the surface there is a sandy soil which extends to a depth of approximately two feet
>
> In some of the bores immediately under the surface sand is a layer of material containing boulders of almost pure calcium carbonate, which may be up to 18 inches thick, or may occur as smaller particles. Complimentary to this material in the same layer is a brown to reddish-brown non-calcareous material. It is apparent that the hard calcareous nodules result from reprecipitation of lime which has been dissolved from the surrounding material which thereby becomes impoverished of lime. It is doubtful, however, whether the average grade of this layer would be lower than the general grade of material which occurs below it and which represents the greater proportion of the deposit.

This lowest layer is composed of fine grained sand in which finely divided shell material occurs.

A total of 19 bores were put down on the ridge to prove the extent of the deposit there. It has been shown that similar material occurs on the flat country but as the water table is only a few feet below the surface no further boring was done there. None of the bores were taken much below the water table which corresponds more or less with high-tide mark and appears to be constant. The estimates for quantities of material available have been confined to that which occurs between water table and the surface.

A Bore Plan has been prepared and cross sections have been drawn showing the comparative extent of the three main layers. These have been marked as Overburden, Barren material with Calcium Carbonate nodules, and General Grade.

The bores have proved an area of 12 acres and to the depth of the water table show an average depth of 12·5 feet. On the basis of 12 feet in depth the total quantity of material to water level would be 418,000 tons.

On the basis of area as shown in the sections drawn across the ridge, of the total tonnage available 5·7 per cent or 24,000 tons is overburden; 71 per cent or 300,000 tons are of the general grade and 22·6 per cent or 95,000 tons are represented by the material referred to as being Barren with Calcium Carbonate nodules.

As it would appear that the grade of the latter material is not less than the average it may be assumed that some 395,000 tons of calcareous material are available for use in agriculture."

The lime sand here is similar to that used for agricultural purposes on King Island but of generally lower $CaCO_3$ content. It is composed of rounded shell fragments and foraminiferal tests mixed with angular quartz grains. The percentage of lime varies but in the bores and test samples varied from 30 to 40 per cent.

Experiments have been carried out by the Chief Chemist in the beneficiations of these sands so that they could be transported economically. These tests show that the sands could be concentrated by flotation but at perhaps a cost which could not compete with agricultural lime from other sources.

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II FLINDERS ISLAND

Many of the lime deposits on Flinders Island are of Recent origin but these have all been included in the report by Everard which is included under the Tertiary Section.

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III KING ISLAND

The tremendous development of Closer Settlement farms on King Island and the general acidity of much of the soil there has resulted in the need of greatly increased supplies of agricultural lime. This has lead to the investigation of the sources of lime on King Island by Hughes in 1951 and 1954.

Lime available for agricultural needs abounds on King Island in several different forms and it is largely a matter of locality which deposits are the most favourable.

Types of Deposits.

I. LIME SANDS.

On the West and South coasts of the Island are long stretches of beach, behind which the "sand" has accumulated to form hundreds of acres of dunes. These dunes may appear as mounds of bare sand, they may be covered by grass or by low but thick scrub. This "sand" is in reality composed largely of shell and other marine organism fragments and often has a calcium carbonate of as much as 90 per cent. In places it is quite shallow but in others appreciable thicknesses should cover the sandy soil or bedrock.

These dunes have been formed by wind, the prevailing westerlies blowing the fragments in from the shore line. Thus the contour of the country, especially where bare of grass and scrub, is constantly changing.

Four of these dune areas have been examined during a recent visit but it should be pointed out that other deposits of lime sand occur in many places down the West Coast.

(a) Surprise Bay.

Surprise Bay is located at the extreme South of the Island, a distance of about 20 miles from Currie. A well-formed road may be followed most of the way, although the last couple of miles consists of an unmetalled track across the dunes. A sample taken from dunes just behind the beach showed the following constituents:—

	%
Acid Insoluble	3·2
Fe_2O_3 Al_2O_3	0·2
CaO	48·2
MgO	2·7
Ignition Loss	44·0

Calculations based on the CaO MgO content show a calcium and magnesium carbonate percentage of 91·3. A screen test of this lime sand resulted as follows:—

Screen Sizes	Per Cent Weight
44	17·4
60	43·3
100	37·4
—100	1·9

(b) *Badger Box Creek.*

The dunes cover a large area near the mouth of the Creek. The spot from which samples were taken is about a mile and a half from the South Road near its junction with the Grassy Road and can be reached by driving a vehicle over the paddocks and dunes.

Two samples were taken, one from the surface and the second from three feet. The depth of this deposit varies and is, in places, quite shallow, bottoming on a brownish sandy soil.

An analysis of these samples showed:—

	Surface	3 feet
Acid Insoluble	44·0	35·1
Fe_2O_3 Al_2O_3	1·3	1·1
CaO	28·4	32·5
MgO	1·2	1·2
Ignition Loss	24·1	29·1

giving a calcium and magnesium carbonate content of 53 per cent and 60·4 per cent respectively.

Screen tests showed the following:—

Screen Sizes	Per Cent Surface	Weight 3 feet
44	3·3	18·4
60	7·9	27·0
100	68·8	45·7
—100	20·0	8·9

(c) *Buttons Deposit.*

This is a dune deposit which has been used as a source of lime for Closer Settlement and other farms. A track may be followed for 2½ miles from the North Road at a point one mile north of Pass River. Trucks may be driven right to the dunes where two small pits have been opened. The deposit covers several hundred acres from the beach to some hundreds of yards inland and portion is covered by grass and scrub.

Two samples were taken, one from the surface of the dunes, 50 yards from the beach and the other from the present pit at three feet from the surface. Analysis of these showed:—

	I.	II.
Acid Insoluble	4·7	17·8
Fe_2O_3 Al_2O_3	0·5	0·6
CaO	47·7	41·6
MgO	2·4	2·0
Ignition Loss	42·8	36·7

which indicated a calcium and magnesium carbonate content of 90 per cent for the surface sample (I) and 78 per cent for the other.

Screen tests showed the following partical size:—

Screen Sizes	Per Cent I.	Weight II.
44	1·5	3·4
60	17·4	11·3
100	68·7	62·5
—100	12·4	22·6

(d) Loorana.

These dunes, which lie to the South of those at Buttons, are very similar but of slightly lower grade. They may be reached by driving across the paddocks for half a mile from the North Road at Loorana. The dunes cover several hundreds of acres, a great deal of which is covered by thick scrub. All stages of gradation from pure wind-blown fragments to consolidated rock may be seen in this area The rock, although solid, can be easily broken and has been laid down in beds which have all sorts of angles of false dip. Some of the lime has been dissolved and then re-precipitated to form cementing material.

A sample of the dune "sand" from the surface gave the following analysis:—

	%
Acid Insoluble	26·7
Fe_2O_3 Al_2O_3	0·8
CaO	37·1
MgO	1·6
Ignition Loss	32·6

(e) Grahams.

This deposit although of the same origin, is quite a distance from the Coast. About five and a half miles along the Grassy Road from the intersection of the South Road a new road runs south. From this point also an old road which links the Grassy and South Roads runs in a westerly direction. At 2·8 miles along this road, the plain country, over which it has been passing gives way to the first of the coastal lime-sand hills and small blows are apparent here and there where the grass cover has been removed.

Where the lime sand is exposed to the air, it hardens and sometimes concretions of purer lime material are formed. The hard material is only a thin crust on the surface and in a few inches the sand is quite soft and free running. The top two feet from the surface is a mixture of lime-sand, humus and roots, but below this the material seems fairly constant. Samples were taken by clearing the surface of an open-blow and the following results were obtained:—

Sample No.	Depth from Surface	$CaCO_3$	$MgCO_3$	Al_2O_3 + Fe_2O_3	Acid Insol.
1 ..	2′– 4′	66.8	3.1	1.6	26.7
2 ..	4′– 6′	70.3	3.1	1.3	23.5
3 ..	12′–15′	68.7	3.1	1.2	25.2

A screen analysis of the samples showed—

Sample No.	+44	+60	+100	—100
1	53.4	21.4	18.3	6.9
2	52.6	22.0	19.0	6.4
3	37.6	24.9	27.5	10.0

(*f*) *Barnes.*

A similar deposit occurs near the intersection of the Grassy and South Roads. A sample taken from near the surface of a small blow showed:—

	%
$CaCO_3$	57·1
$MgCO_3$	2·5
$Fe_2O_3 + Al_2O_3$	1·1
Insoluble	37·3

and a sizing test showed:—

	%
+ 44	17·8
+ 60	21·5
+100	45·7
—100	15·0

II. Consolidated Lime Sands.

In other parts of the Island are beds of rock similar to those described at Loorana. That is consolidated rock showing bedding planes but at the same time very soft and easily crumbled. These beds of rock are still of recent origin and owe their consolidation to cementing agents and not to pressure. They have not been formed under the sea but under such conditions as now exist.

Of the three deposits examined, the Loorana is the poorest in lime and also does not show the width of outcrop of the other two.

(*a*) *Camp Creek.*

Just outside the township of Currie and bordering the North Road to the east and Camp Creek to the south are small cliffs of lime rock. The actual outcrop is about a chain in length and 12 feet high but pieces of similar stone may be found on the surface up to 50 feet above the road. A sample taken over this 12 feet was analysed with the following result:—

	%
Acid Insoluble	17·3
Fe_2O_3 Al_2O_3	1·0
CaO	43·2
MgO	1·0
Ignition Loss	36·7

This represents a calcium and magnesium carbonate content of 80 per cent.

(*b*) *Dripping Wells.*

On the sea coast just south of the mouth of the Etrick River and close to the South Road are small cliffs of earthy material from which there are constantly running springs and seepages. This outcrop is 15 feet in height and extends for three chains or more. The lime sand has not become quite so consolidated or bedded here as at Camp Creek but due to the amount of water an appreciable percentage of it has been dissolved and re-precipitated as hard stalactites. A composite sample of the earthy and stalactite material was tested as follows:—

	%
Acid Insoluble	0·4
Fe_2O_3 Al_2O_3	0·5
CaO	53·4
MgO	0·5
Ignition Loss	45·2

representing a total carbonate content of 99 per cent. A sizing test showed the following:—

	%
44	34·1
60	20·9
100	31·4
−100	13·6

The consolidated material was also sampled and resulted:—

	%
Acid Insoluble	22·3
Fe_2O_3 Al_2O_3	1·2
CaO	41·4
MgO	0·7
Ignition Loss	33·5

which shows a carbonate content of 74 per cent.

III. Re-Precipitated Calcium Carbonate.

On the east bank of Little Porky Creek, just north of the North Road and near the Butter Factory is a third type of deposit. This is lime that has been dissolved and then re-precipitated, not as at Dripping Wells as stalactites, but as a powder, in a much finer state than the original shell fragments. This deposit has a similar origin to that near Sorell and the calcium carbonate content (80%) is much the same. A sample gave the following analysis:—

	%
Acid Insoluble	10·4
Fe_2O_3 Al_2O_3	2·2
CaO	44·3
MgO	0·6
Ignition Loss	41·9

Unfortunately this deposit is very limited in extent.

Bibliography.

Hughes, T. D., 1951.—"Lime Deposits of King Island." (Unpublished.)
Hughes, T. D., 1954.—"Lime Sands at King Island." (Unpublished.)

IV LOW HEAD

About one mile north of the Low Head Aerodrome and a quarter of a mile from the sea, is an area of 20 acres or so covered intermittently with hummocks and "stalagmites" of limestone. This deposit was probably formed by precipitation from lime-impregnated waters. Portion of the deposit is friable and could easily be crushed to a fine powder. Other parts have become hardened into rock-like masses.

Three samples have been analysed with the following results:—

1. Soft White Material—

	%
Acid Insoluble	17·2
$Al_2O_3 + Fe_2O_3$	2·0
CaO	43·3
MgO	0·6

2. Hardened Material—

	%
Acid Insoluble	1·6
$Al_2O_3 + Fe_2O_3$	0·4
CaO	52·9
MgO	1·0

3. Impure Sandy Material Occurring Between the Hummocks Formed of 1—

	%
Acid Insoluble	37·4
$Fe_2O_3 + Al_2O_3$	3·1
CaO	31·2
MgO	0·8

Although this deposit covers an appreciable area, it occurs merely as a crust, and not even as a continuous crust over the sand. Consequently, no great tonnage could be obtained. However, local needs for small amounts of agricultural lime could perhaps be satisfied.

V REKUNA

In various places in the southern Midlands, dolerite has weathered along joint planes to form a marl composed largely of $CaCO_3$. This marl sometimes, as at Rekuna, becomes concentrated into small pockets and may have a restricted local use as agricultural lime. Nowhere, however, are these pockets of any size.

Rekuna is a siding on the main railway line between Brighton and Campania. In an old quarry a mile east of Rekuna, the marl can be seen forming as seams and crusts in the solid dolerite, and near a ridge top to the north of this are small pockets of it near the surface. The material is soft, friable and extremely fine grained and although only averaging between 60 and 70 per cent $CaCO_3$ is excellent for agricultural purposes.

VI SMITHTON

One of the most attractive sources of agricultural lime occurs at Pulbeena, a small railway siding about four miles south of Smithton. Recent deposits formed in freshwater ponds and swamps and probably fed from hot springs, consist of a fine friable calcium carbonate powder with narrow bands of peat. Near the surface the limestone has become hardened for a thickness of about nine inches. There is an overburden of one to four feet of soil. The lime deposit varies in thickness from six to nine feet, and where the overburden is greatest, the lime beds are thicker. An area of 30 acres has been partly proved and doubtless in the vicinity are other areas.

Two pits are now being operated, one on either side of the railway line. In one the material is loaded by a dragline scraper on to a conveyor belt and tipped straight into railway trucks; in the other it is loaded on to side-tip trucks and from these tipped into the railway trucks.

The material is very fine grained (it has been stated that 75 per cent is —200) but, the water table being very close to the surface here, it is often wet and has to be put on the ground by special wet spreaders.

Three samples of this material were taken by the authors of Bulletin 41 and the analyses of these showed:—

Sample No.	SiO_2	Fe_2O_3	Al_2O_3	MgO	CaO	Ig. Loss
1579 ..	0.48	0.56	0.24	1.72	53.76	43.70
1269 ..	0.88	0.44	N.D.	1.35	52.59	44.90
1270 ..	0.84	0.52	N.D.	1.51	52.39	44.72

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NYE, P. B., FINUCANE, K. J. AND BLAKE, F., 1934.—"The Smithton District." *Geological Survey Bulletin,* No. 41.

VII SORELL

A deposit of soft friable calcium carbonate containing several clay beds occurs at Pawleena, about four miles north of Sorell. Some years ago, the Electrolytic Zinc Company were using some of this material and a hand boring campaign was undertaken by the Department to gain some idea of the extent of the deposit.

This deposit, like that at Pulbeena, consists of re-precipitated calcium carbonate but contains a lot more contamination by clay bands and averages 70 per cent $CaCO_3$. Two pits have been worked, that operating in 1949 averaged over 80 per cent $CaCO_3$ but the beds lense out to the sides and the clay bands increase.

The boring showed that the limestone occurred in beds averaging three feet in thickness below two feet of soil overburden. The lateral extent of material over 70 per cent showed about 500 feet by 100 feet.

This material like that at Pulbeena, would be excellent for agricultural limestone. Unfortunately, it is limited in extent and contains, in places, large percentages of clay.

CHAPTER 8—THE DOLOMITES

Although deposits of dolomite are quite extensive in Tasmania, they have not, except in the Smithton District, been exploited commercially. The largest exposures occur in inaccessible West Coast country and the deposits in the south are mainly part of a Caves Reserve and not far from extensive limestone deposits.

I SMITHTON

In the Circular Head Municipality of the far north-west, from Montagu in the west, to Black River in the east, extensive beds of dolomite occur. Due to its soluble nature however, except in river beds, very little of the outcrop is seen and the rock is usually covered by broad alluvial deposits. During the regional mapping at Smithton in the early thirties the dolomites were extensively studied and Bulletin 41 contains a large amount of material on these rocks.

The authors of this bulletin included the dolomite in the Dundas series of the Cambrian and estimated the thickness of the beds as up to 9000 feet. Carey and Scott later assigned the beds, to which they gave a thickness of 3000 feet, to the Carbine Group, which occurs at the base of the Cambrian or top of the Precambrian.

A description of the dolomite and results of samples taken are quoted from Bulletin 41:—

"The dolomite occurs in two main types, viz:—

(*a*) *Fine-grained type.*—This type is light-grey to dirty-white in colour and very fine-grained. It is usually thinly bedded, with numerous joints at right angles to the bedding-planes, which causes it to break in rectangular pieces.

(*b*) *Coarse-grained type.*—This type is usually white in colour, with sometimes a greyish tinge. It is more thickly bedded than the fine-grained type. The crystals range up to one-sixteenth of an inch in size. This type has evidently been produced by recrystallisation, and has probably been derived from the fine-grained type.

The dolomite is in places traversed by narrow white veins of calcite and dolomite. When the veins are of calcite, and are included in samples, they increase the calcium content, and thus cause the sample to depart from the theoretical composition of dolomite.

At Nabageena the dolomite contains irregular veins and patches of cherty quartz, while at Irishtown, quartz veins and impregnations are common in parts of the dolomite. The Duck River dolomite is free from silification, except an occasional large quartz vein.

The Duck River dolomite has been opened up in numerous small quarries from which the rock was taken for road-making. These are restricted chiefly to the vicinity of the Duck River, where the denudation of the sand has exposed the underlying dolomite. The one exception is at Edith Creek, where the dolomite forms a low hill, and has been opened up by a quarry and railway-cuttings. The quarries offer good facilities for sampling, except where filled with water or overgrown with vegetation."

Fifteen samples were taken of which one to five and fifteen were of the crystalline and the remainder of the fine-grained variety. It will thus be seen that the crystalline type is the higher grade.

ANALYSES OF DOLOMITE SAMPLES

(Expressed as Percentages)

Raw Dolomite									
Sample No.	SiO_2	FeO and Fe_2O_3		Al_2O_3	CaO	MgO	P_2O_5	C	CO_2 by Ign. Loss
1	0.08	0.24*		0.36	31.12	21.48	T.	0.02	46.73
2	0.20	0.24*		0.48	31.22	21.64	T.	0.156	46.14
3	0.12	0.12*		0.36	31.32	21.50	T.	0.032	46.68
4	0.08	0.12*		0.48	31.22	21.56	T.	0.028	46.64
		Fe_2O_3	FeO						
5	0.08	0.08	N.D.	0.40	31.60	22.22	T.	0.03	46.84
6	4.60	0.37	0.84	3.18	28.70	19.72	0.029	0.20	43.60
7	4.88	0.44	0.78	3.06	28.30	19.76	0.03	0.25	43.31
8	4.80	0.47	0.87	3.56	28.64	19.32	0.03	0.25	43.35
9	3.80	0.29	0.74	3.38	28.40	20.36	0.028	0.35	43.73
10	5.08	0.35	0.71	3.86	28.00	19.20	0.035	0.25	43.63
11	6.64	0.76	1.26	8.24	28.20	14.62	0.054	0.65	40.75
12	2.12	0.71	1.03	3.54	29.80	19.40	0.04	0.35	44.73
13	5.52	0.40	0.94	3.68	28.00	19.98	0.03	0.40	42.48
14	3.28	0.15	0.38	0.42	30.40	21.56	0.06	0.05	44.83
15	0.52	0.65	0.71	0.56	31.20	21.36	0.10	0.14	46.46

Phosphate is soluble in hydrochloric acid. Oxides of iron in Nos. 1 to 5 soluble in hydrochloric acid, and in Nos. 6 to 15 probably a small proportion is insoluble in hydrochloric acid.

* Estimated that the oxides of iron contain approximately 65 per cent. Fe_2O_3.

The localities, &c., of the various samples are described as follows:—

Sample No.

1. Across 20 feet of the north-west face in western quarry, west of Blackwood Bridge. Sample of clean dolomite only. Crystalline type.

2. Across 30 feet over total width of 60 feet. North face of northern quarry, west of Blackwood Bridge. Sample of clean dolomite only. Crystalline type, partly weathered in places.

3. Picked from 10 feet x 10 feet x 3 feet heap of dolomite obtained from shallow pits, west of Blackwood Bridge. Clean material only. Crystalline type (some soft, due to weathering).

4. Picked from 10 feet x 25 feet x 3 feet heap of dolomite obtained from shallow pits, west of Blackwood Bridge. Clean material only. Crystalline type (some soft, due to weathering).

5. Picked from 10 feet x 25 feet x 3 feet heap of dolomite obtained from shallow pits, west of Blackwood Bridge. Clean material only. Crystalline type (some soft, due to weathering).

6. Railway-cutting, north of Edith Creek, 10 feet vertical sample. Iron stains on joint-planes. Fine-grained type.

7. Three chains north of No. 6. Across 10 to 12 feet. Iron-stained on joint-planes. Fine-grained type.

8. Half a chain north of No. 7. Across 6 feet. Iron stains on joint-planes. Fine-grained type.

9. Quarry at intersection of road and railway, north of Edith Creek. Across 12 feet at west side. Jointed, weathered, and stained material. Fine-grained type.

10. Quarry at intersection of road and railway, north of Edith Creek. Across 8 feet at east side. Jointed, weathered, and stained material. Fine-grained type.

11. Quarry near Junction of Duck River and Mowbray Creek. Across 10 feet on east side. Fine-grained type, with oolitic band. Clean material.

12. Quarry near Junction of Duck River and Mowbray Creek. Across 10 feet on west side. Fine-grained type, with oolitic band. Clean material.

13. Quarry 30 chains south-west of Nos. 11 and 12. Across 10 feet. Fine grained. Fairly clean material.

14. Cutting, Wiltshire-Irishtown railway, 20 chains east of Smithton-Irishtown road. Across 200 feet. Chiefly fine-grained type. Jointed and stained.

15. Grab sample. Watson's Bend. Crystalline type.

An analysis of the insolubles from a composite sample showed:—

Constituents	Per Cent
SiO_2	82·60
Fe_2O_3	0·21
Al_2O_3	11·92
TiO_2	0·81
CaO	Trace
MgO	0·25
K_2O	4·59
Na_2O	0·26
	100·64

The authors discuss quantities available and conclude:—

> "From the above descriptions it will be realised that the extent and depth of the dolomite of the Smithton deposit are so large that the quantities available may be considered practically inexhaustible.
>
> In the Blackwood Bridge area the extent is at least 200 acres, and the depth is much greater than any likely to be reached by sub-surface quarrying methods.
>
> It is hardly necessary to express the quantities in figures, and it need only be pointed out that every 10 acres worked to a depth of 50 feet in dolomite should yield 1,700,000 tons approximately."

In 1944, D. E. Thomas investigated all the occurrences from Montagu to Black River and reached the following conclusions:—

> "*General Structure.*
>
> The dolomite at Smithton is the largest yet known in the State, but sub-surface quarrying would be necessary. The geological structure of the dolomite shows that folding is present as well as faulting. In surface outcrops this is difficult to decipher, but the stresses present have given rise to brecciated belts, which could be favourable for the accumulation of much ground water.
>
> *Grade.*
>
> In no area is the grade of the dolomite entirely uniform. The impurities are mainly the development of quartz (or quartzite) blebs, small lenses of similar material along the bedding planes, beds of quartzite (of irregular thickness but up to six inches thick), and thin beds of dolomitic shales. In places particularly near the base of the dolomite, there are beds of mudstones or shales up to three feet wide. It is thus imperative that any area on which quarrying operations are to be initiated, should be tested in detail as to grade. The geological structure is too complex to ensure that what is seen on the surface will persist in depth.

The amount of crystalline material is limited in depth in all good exposures. The large surface exposures of crystalline material along the drains at Riley's in the west and along Mowbray Creek, should thus be tested in order to prove the depth of this crystalline material. This can be done either by drilling or shaft sinking.

In the Irishtown outcrops, both near Fahey's Lane and south of the Wiltshire Railway, it would be possible to open up good quarries. Near Fahey's Lane some selection, due to the presence of quartz and cherts, would be necessary. Apart from some soil, no overburden would have to be removed. South of the Wiltshire Railway, except perhaps near the spur near the railway cutting, overburden, due to the presence of basalt and sub-basaltic deposits in the hill slopes to the south, would be an increasingly costly item in all quarrying. Whether water would be a big problem depends on the location and depth of the quarry with regard to the ancient leads beneath the basalt. There is some silicified Tertiary Limestones under the basalt, but this has not yet been found in situ.

In the Edith Creek area, normal quarrying operations are feasible, but here again there is obvious variation in grade, as well as much clayey material along the sink holes.

The railway lines are favourably located as regards Irishtown and Edith Creek; the ease of quarrying so evident; the danger of meeting underground water is small compared with the flatter areas near the swamps, that these deposits should be tested. Although surface indications show variability of product, testing should be carried out to determine the amount of workable material that is available.

The most extensive outcrop in the immediate vicinity of Smithton is in Watson's Bend, and surface indications point to its being of high grade. The maximum height above Local High-Water Mark is just over 10 feet, so that sub-surface quarrying is indicated. When the quality of this deposit is being tested, attention should be paid to the quantity of water met with in the bores and, if possible, pumping tests carried out to obtain this information. The presence of the water table at shallow depths would definitely hinder any developments here.

The same objections would prevail in connection with surface areas of crystalline dolomite along Mowbray Creek and at Riley's. Near the western boundary of the Smithton dolomite, there are abundant Spring mounds, the flow from two of these amounting to 30,000 gallons per hour, and under sufficient pressure flow out 12 feet above the normal plain level. If water of this nature was encountered, pumping would not be economical.

Careful testing is thus necessary at all the sites, and attention has to be paid not only to grade and quantity of ore, but the presence and amount of water that is encountered. The actual boring programme will be determined to a large extent by the results of assays from the various areas, which are listed below, but boring at first should be extensive rather than intensive.

From the field evidence the following are considered the most favourable areas:—

1. Watson's Bend.
2. Irishtown.
3. Edith Creek.
4. On a line from Riley's to the Mowbray Creek (where large areas of crystalline dolomite are exposed in the limited outcrops that are available)."

Since these reports were written the Duck River Dolomite Company Pty. Ltd. have begun quarrying and crushing dolomite near Smithton for agricultural purposes.

The dolomite at Black River occurs at the main road and rail crossing. It occupies the centre of a synclinal basin of which the long axis trends at 80°. The dimensions of the deposit are approximately 1500 feet x 600 feet with a maximum depth of 200 feet. The folding is overturned with steep dips to the south on the south side and shallow dips to the south on the north side. Thus the deepest portion of the deposit is on the south side. Outcrop is only intermittent and it is expected that quite a lot of the dolomite included in the estimated area will have been eroded away and its place taken by Recent river wash.

An aggregate chip sample across the outcrop showed:—

	%
$CaCO_3$	54·3
$MgCO_3$	43·9
Al_2O_3	0·3
Fe_2O_3	0·4
Insoluble	0·9

Although many factors are favourable, the fact that the dolomite only outcrops a few feet above sea level on either side of the river seems to preclude it as a commercial source.

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THOMAS, D. E., 1944.—" Dolomite in the Smithton Area." (Unpublished.)

II CRESSY

On the bank of Western Rivulet, some six miles south-west of Cressy is a small outcrop of dolomite, overlain by Permian rocks. An old kiln in the vicinity shows that in the past the dolomite has been burnt. A sample taken by C.S.I.R.O. officers showed:—

	%
$CaCO_3$	55
$MgCO_3$	45
Insoluble	Trace

III HASTINGS

Almost five miles from Hastings in Southern Tasmania and four miles from the main South Road are spectacular caves formed in dolomite. Most of the dolomite occurs in the Caves Reserve and so would not be available for commercial use.

IV HUON – CRAYCROFT RIVERS AREA

During a reconnaissance of the Craycroft Track from Glen Huon to the Frankland Range in 1935, F. Blake noted extensive deposits of dolomite, and has this to say:—

Dolomite is exposed in the bed and banks of Huon River to the east of Blake's Opening and on the northern slopes of Mt. Picton to the south of the former. The rock is again in evidence in creeks flowing easterly to Craycroft River, over open plains, on the south side of the Razorback. The dolomite is generally fine grained, but in places is slightly crystalline. It is massive or thickly bedded and although jointing is present it is not prominent. The rock is light-grey in colour, but weathers to almost white at surface. The dolomite is traversed in places by narrow white veins of calcite and dolomite Near Blake's Opening and on the northern slopes of Mt. Picton portion of some beds have been partly replaced by silica in the form of secondary quartz and chert. In the latter locality small areas exposed in cliff faces are seen to be wholly replaced by similar material.

The dolomite stage conformably overlies the slate, quartzite, &c., stage.

An analysis of clean dolomite from Craycroft Valley revealed the following percentages of calcium and magnesium oxide:—

Reg. No.	Constituents	Per Cent
582	Calcium Oxide	29·40
	Magnesium Oxide	20·92

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BLAKE, F., 1935.—"Country along Route of Craycroft Track from Glen Huon to Frankland Range."

V JANE RIVER AREA

Large areas of dolomite occur in very inaccessible country round the headwaters of the Maxwell River, and about the headwaters of, and half way down the course of the Jane River, a tributary of the Franklin River in south-western Tasmania. In the course of a visit to this area in 1936, F. Blake mapped the dolomite and described it is follows:—

The dolomites and dolomitic limestones are light to dark-grey coloured rocks varying in all degrees from fine grained, massive types, to coarsely crystalline varieties. On the southern bank of Algonkian Rivulet at half a mile above the junction with Jane River dolomitic limestone, conformably underlying slates, has assumed a schistose structure but elsewhere schistosity is absent. These rocks are exposed in the low-lying areas, along the open valleys and plains of the district.

In several instances intricate networks of honeycombed silica in the form of quartz, traverse the dolomites. This is of a secondary nature and has been formed by a process of rock replacement. Occasional thin bands of extremely fine-grained white quartzites are interbedded with dolomites to the west of Gum Ridge.

In the bed of Norway Creek an unusual dark-red variety of magnesium limestone occurs overlying massive purple and grey coloured slates. The following analysis of this rock indicates that the red colouring matter is due to the presence of iron oxides.

	%		%
Loss in ignition	40·42	P_2O_5	0·16
Moisture	0·14	CaO	25·92
Insoluble	9·96	MgO	18·26
Al_2O_3	1·01	S	0·03
Fe_2O_3	2·37		
FeO	1·51		99·97
MnO_2	0·19		

VI SURPRISE RIVER

In 1947, F. Blake took two samples of a dolomite outcropping on the Lyell Highway. This was in connection with a proposed use of this material for agricultural lime. In his report he says:—

Location.

The outcrops are exposed in road cuttings on Lyell Highway at Surprise River Valley, 119 miles from Hobart.

The Deposit.

The deposit consists of massive dark-blue dolomitic limestone. It can be traced over a length of approximately six chains along the road in deep cuttings. Away from the road, exposures are poor, owing to dense vegetation. The rock is deeply weathered along the greater part of the exposure but near the eastern boundary it outcrops in a solid mass over a length of 1½ chains to a vertical depth of 20 feet.

Sampling.

Two adjoining samples were chipped across the limestone beds at the above outcrop.

Results of partial analyses of the samples are as follows:—

1. Across 44 ft. on eastern part of outcrop:

	%
Silica	4·64
Lime (CaO)	29·34
Magnesium Oxide (MgO)	19·96

2. Across 35 ft. on western part of outcrop:

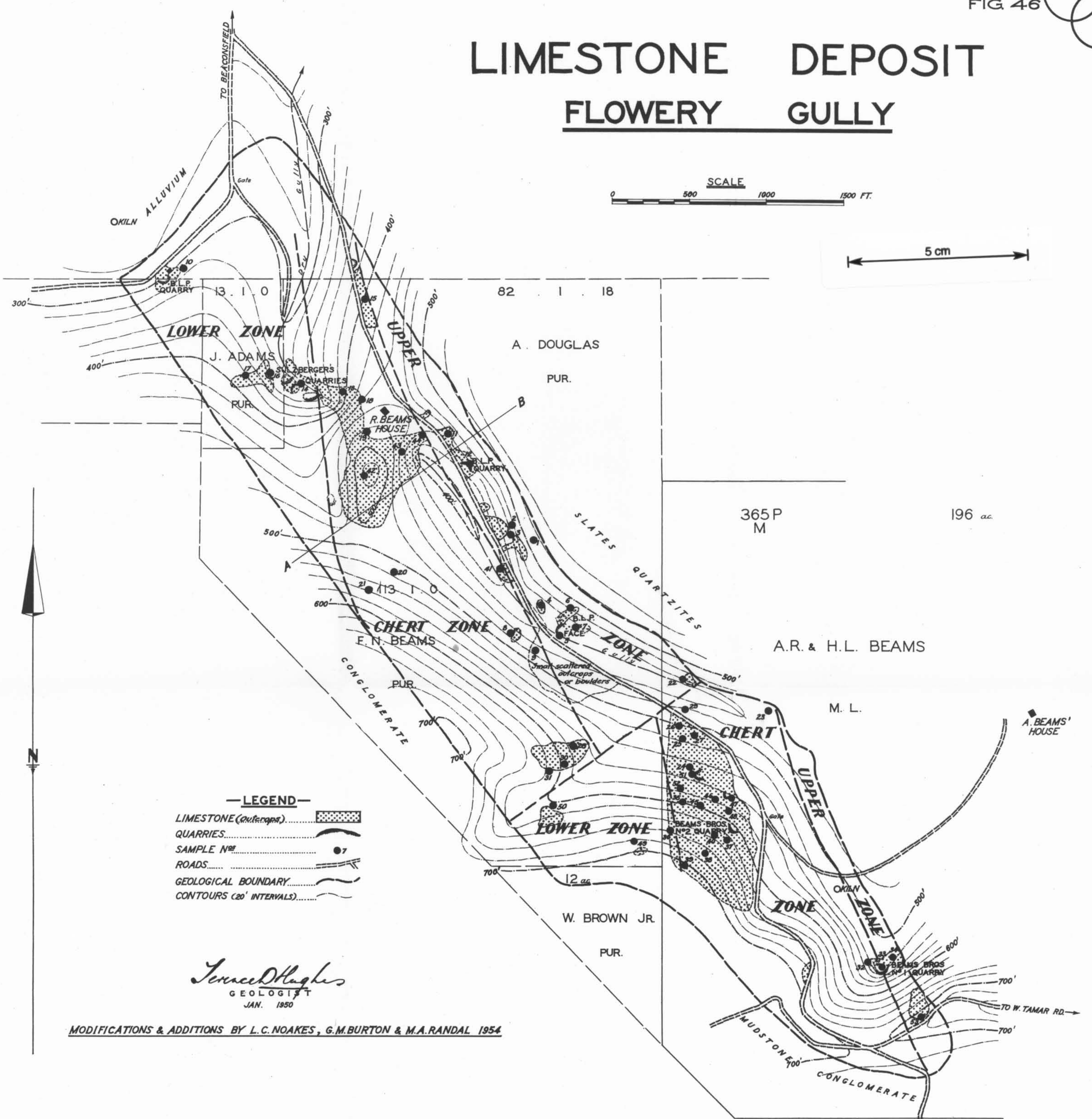
	%
Silica	3·60
Lime (CaO)	29·74
Magnesium Oxide (MgO)	20·87

L. G. SHEA, Government Printer, Tasmania.

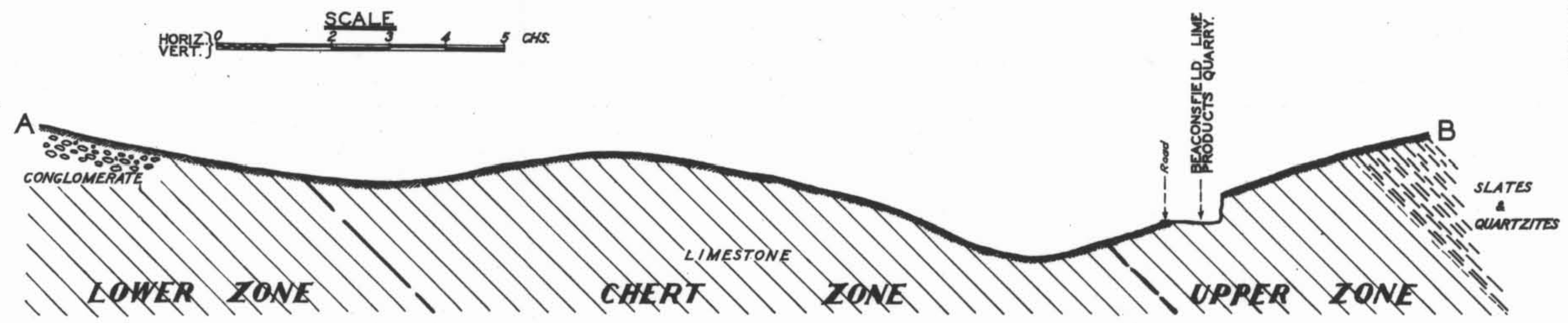
FIG. 46

LIMESTONE DEPOSIT

FLOWERY GULLY



SECTION ACROSS STRIKE OF LIMESTONE BEDS



KTR

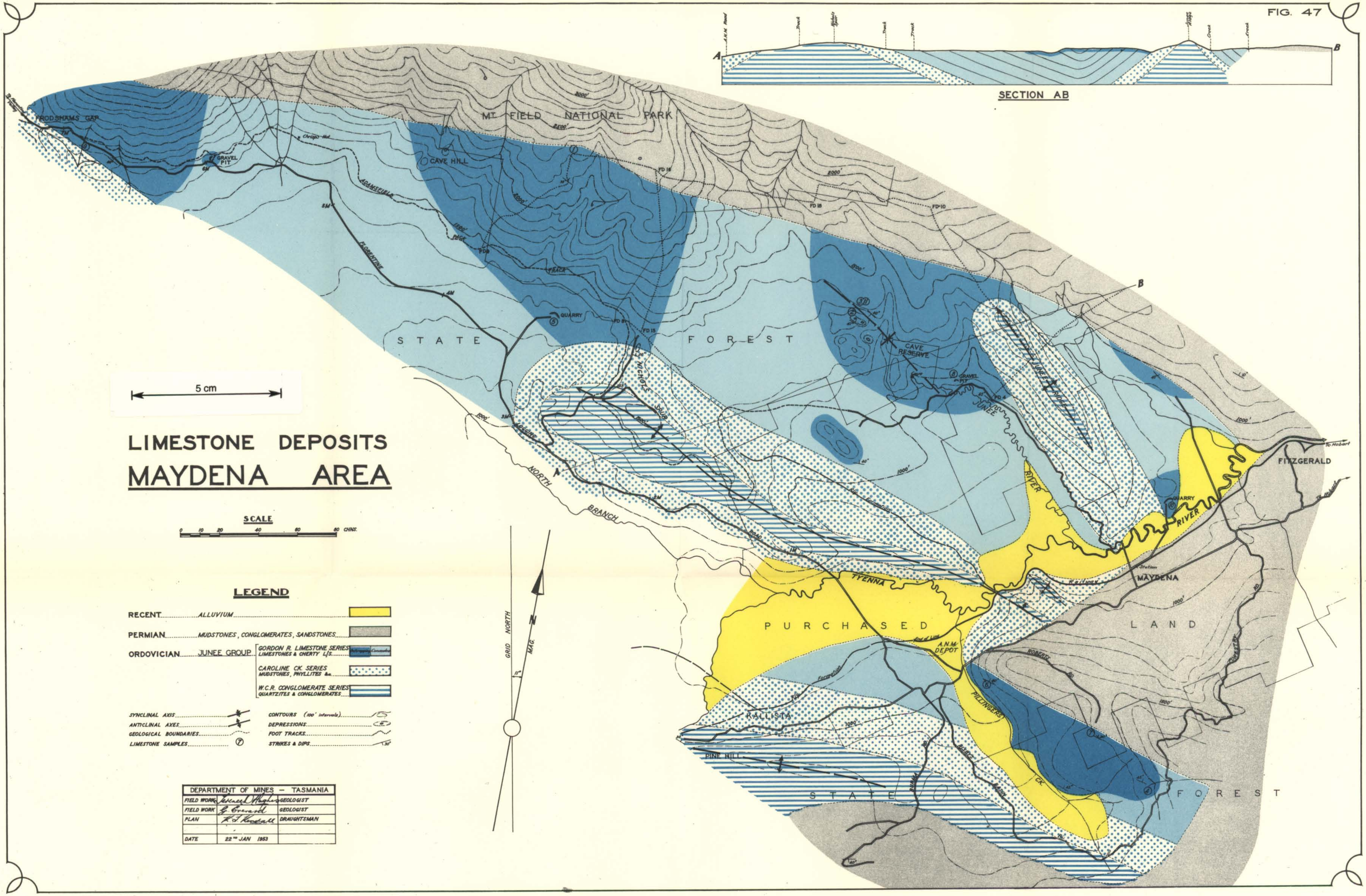
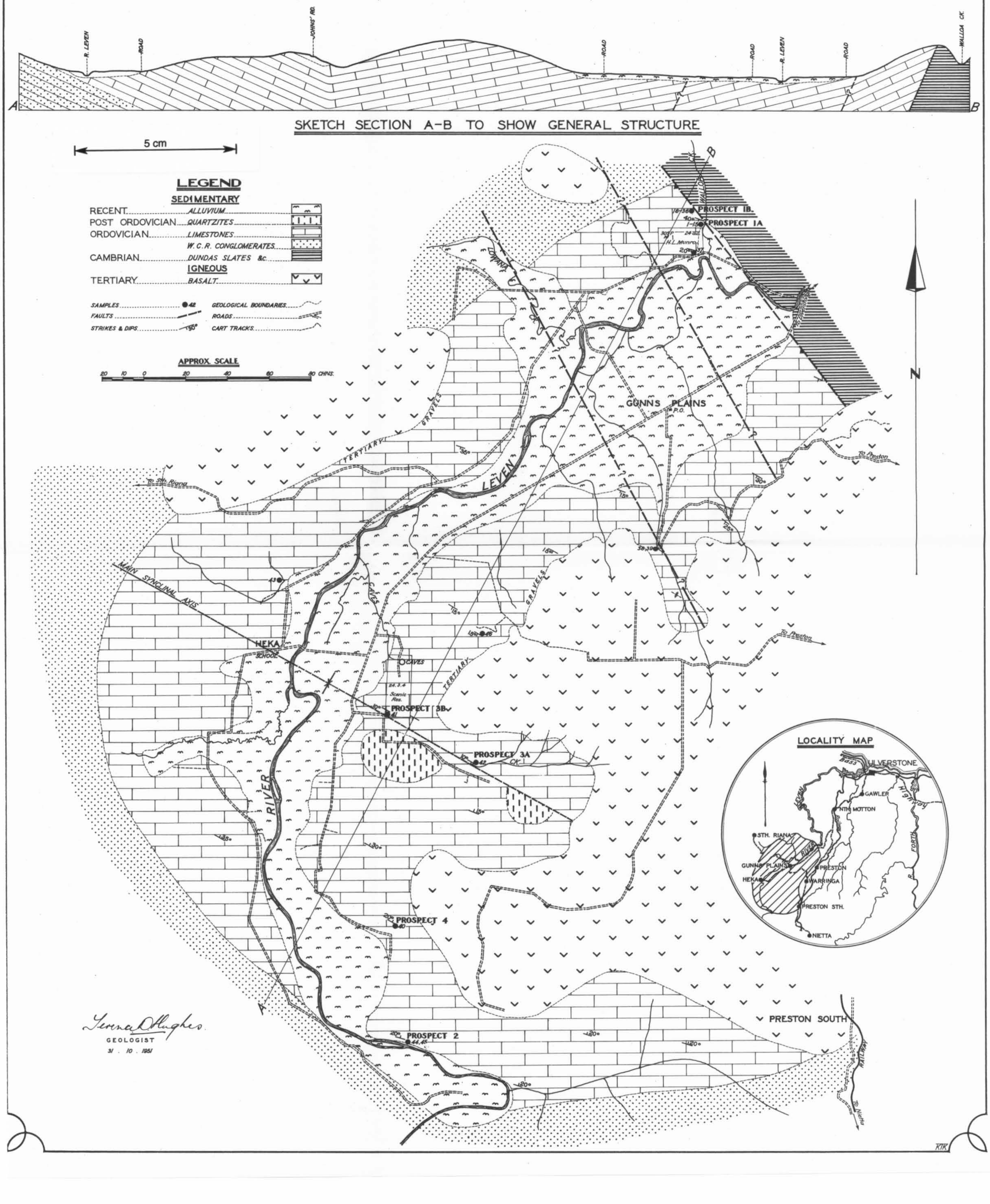

LIMESTONE DEPOSITS
MAYDENA AREA
SECTION AB
A
B
5 cm
SCALE
0 10 20 40 60 80 CHNS.
LEGEND
RECENT ALLUVIUM
PERMIAN MUDSTONES, CONGLOMERATES, SANDSTONES
ORDOVICIAN JUNEE GROUP
GORDON R. LIMESTONE SERIES LIMESTONES & CHERTY L/S.
CAROLINE CK. SERIES MUDSTONES, PHYLLITES &c.
W.C.R. CONGLOMERATE SERIES QUARTZITES & CONGLOMERATES
SYNCLINAL AXIS
ANTICLINAL AXES
GEOLOGICAL BOUNDARIES
LIMESTONE SAMPLES
CONTOURS (100' intervals)
DEPRESSIONS
FOOT TRACKS
STRIKES & DIPS
DEPARTMENT OF MINES – TASMANIA
FIELD WORK Terence D. Hughes GEOLOGIST
FIELD WORK G. Everard GEOLOGIST
PLAN R. J. Kendall DRAUGHTSMAN
DATE 22nd JAN 1953
GRID NORTH
MAG.
N
MT. FIELD NATIONAL PARK
FRODSHAMS GAP
GRAVEL PIT
CAVE HILL
ADAMSFIELD
FLORENTINE
QUARRY
S T A T E F O R E S T
CAVE RESERVE
GRAVEL
JUNEE
RIVER
NORTH BRANCH
TYENNA
FITZGERALD
MAYDENA
QUARRY
RIVER
P U R C H A S E D
L A N D
A.N.M. DEPOT
KALLISTA
PINE HILL
PILLINGERS CK.
S T A T E F O R E S T
FIG. 47

FIG. 48

LIMESTONE DEPOSITS OF GUNNS PLAINS



Leona D. Hughes
GEOLOGIST
31 . 10 . 1951

FIG. 49

MELROSE - PALOONA AREA

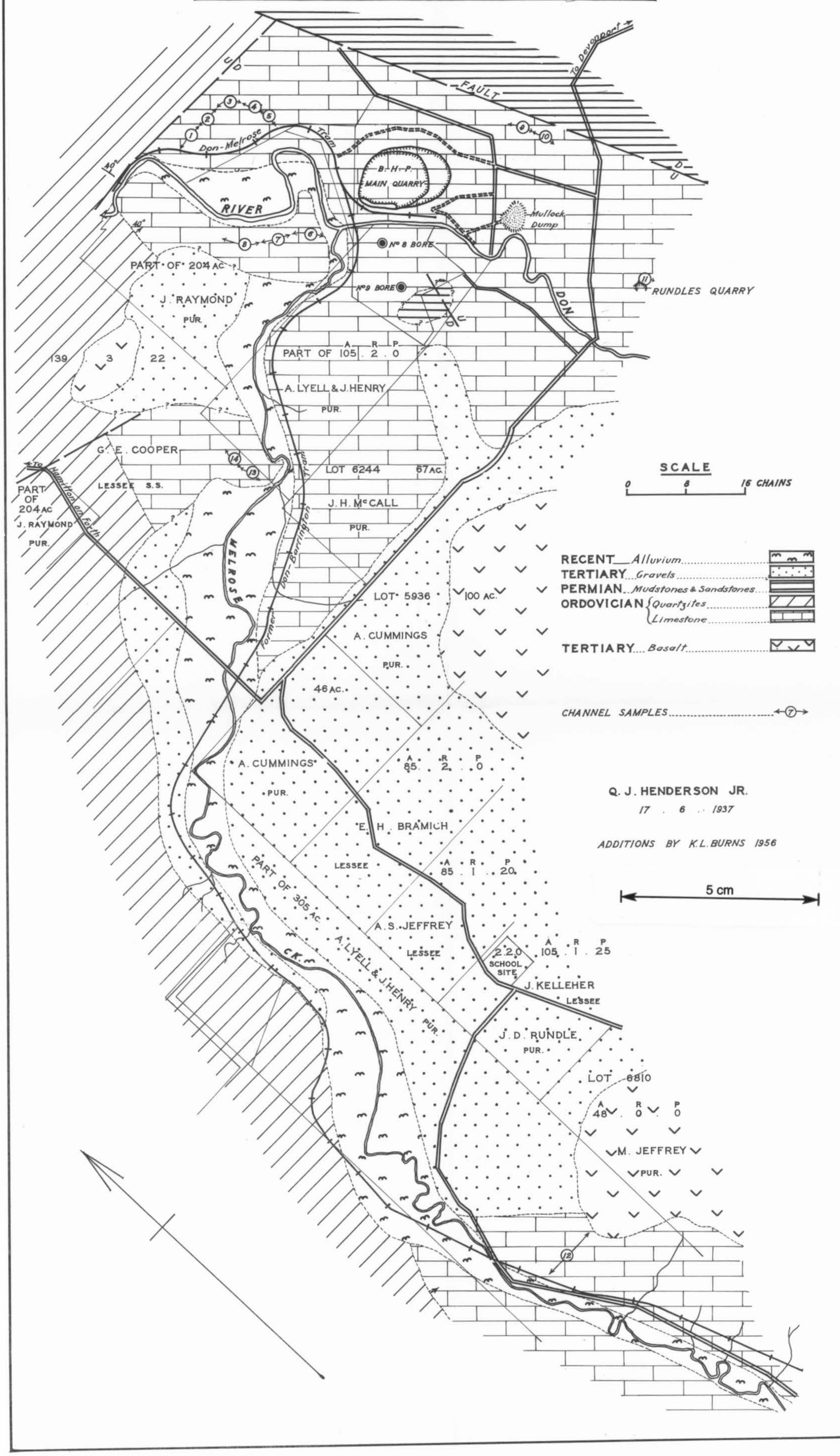
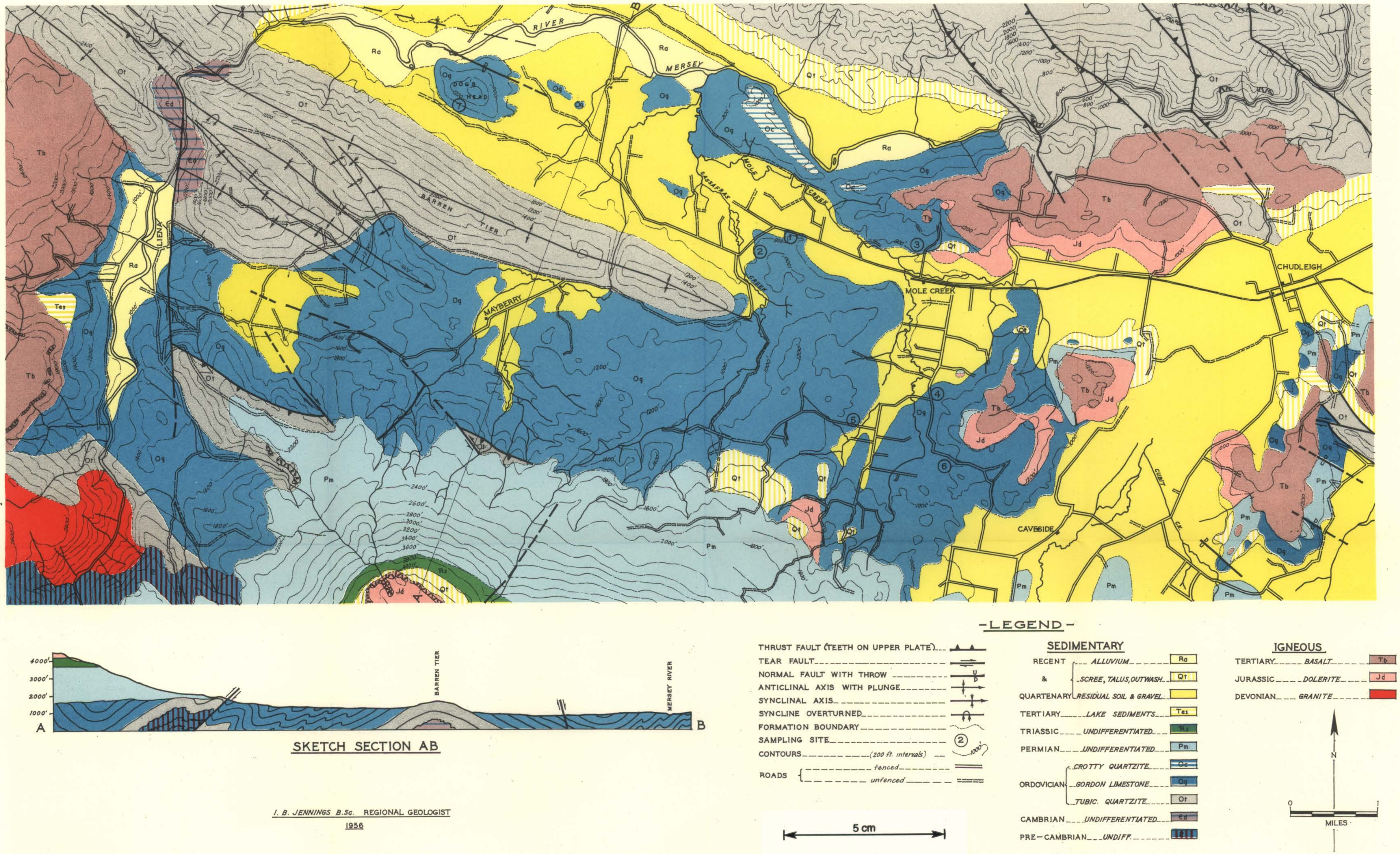


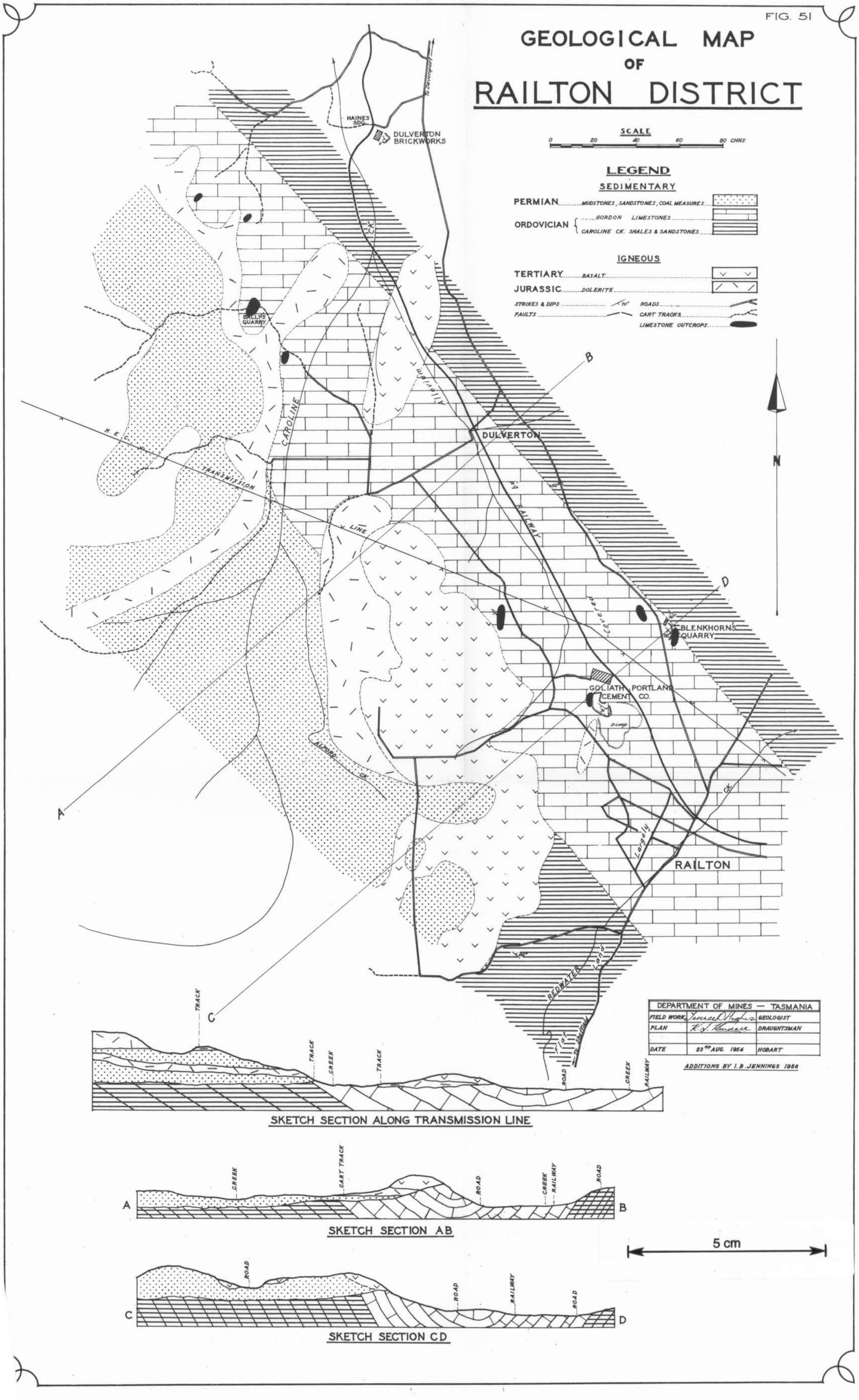
FIG. 50

MOLE CREEK DISTRICT



I. B. JENNINGS B.Sc. REGIONAL GEOLOGIST
1956

FIG. 51


GEOLOGICAL MAP
OF
RAILTON DISTRICT
SCALE
0 20 40 60 80 CHNS
LEGEND
SEDIMENTARY
PERMIAN ...... MUDSTONES, SANDSTONES, COAL MEASURES
ORDOVICIAN { GORDON LIMESTONES
CAROLINE CK. SHALES & SANDSTONES
IGNEOUS
TERTIARY ...... BASALT
JURASSIC ...... DOLERITE
STRIKES & DIPS
ROADS
FAULTS
CART TRACKS
LIMESTONE OUTCROPS
N
HAINES SDG.
DULVERTON BRICKWORKS
DALLYS QUARRY
CAROLINE
CK.
DULVERTON
H.E.C. TRANSMISSION LINE
RAILWAY
BLENKHORNS QUARRY
GOLIATH PORTLAND CEMENT CO.
Dump
ALFORD CK.
CK.
RAILTON
REDWATER
A
B
C
D
DEPARTMENT OF MINES — TASMANIA
FIELD WORK ...... GEOLOGIST
PLAN ...... DRAUGHTSMAN
DATE 23RD AUG. 1954 HOBART
ADDITIONS BY I. B. JENNINGS 1956
TRACK
CREEK
ROAD
RAILWAY
SKETCH SECTION ALONG TRANSMISSION LINE
CART TRACK
SKETCH SECTION AB
5 cm
SKETCH SECTION CD

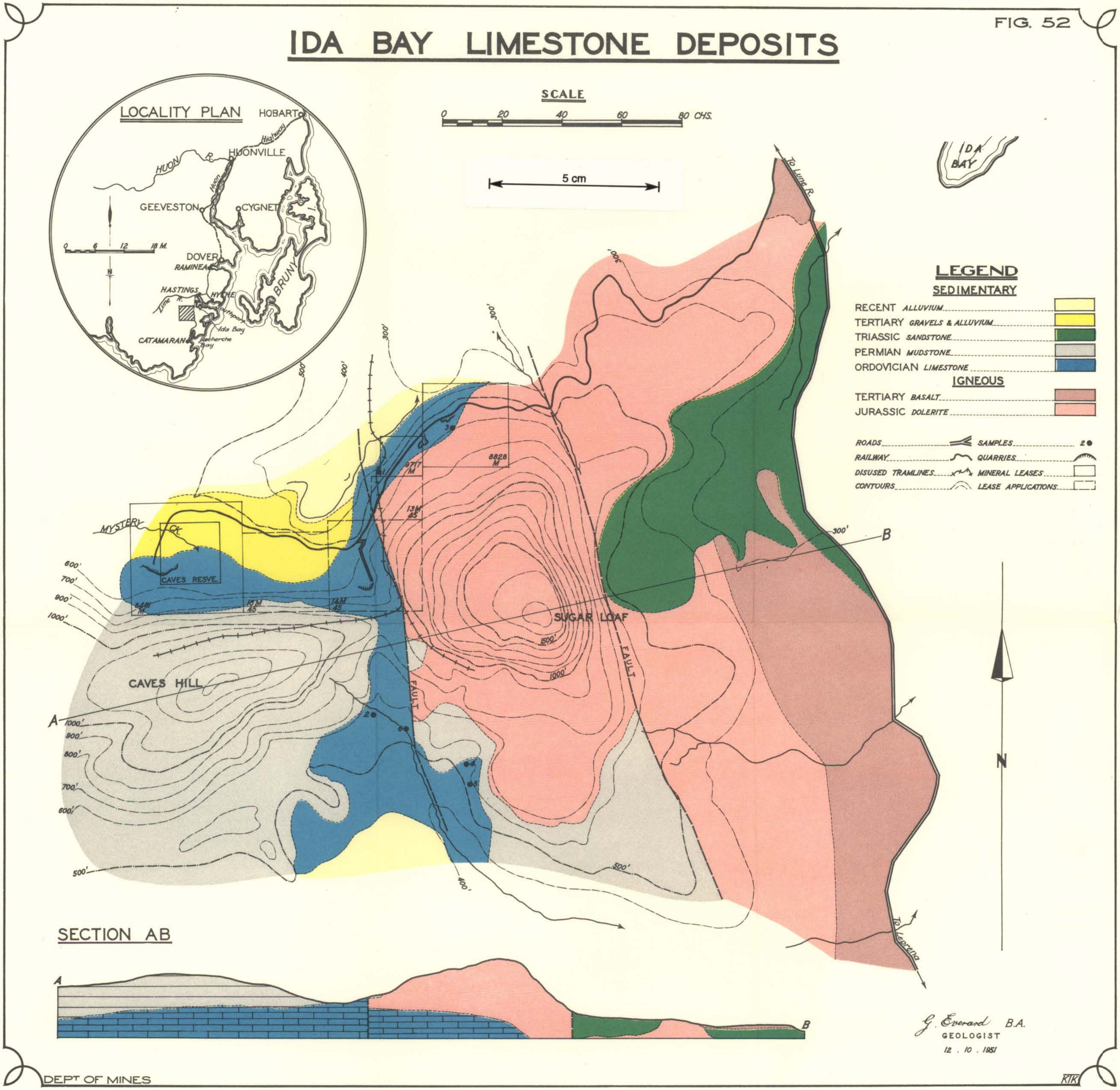


FIG. 52
IDA BAY LIMESTONE DEPOSITS
SCALE
0 20 40 60 80 CHS.
5 cm
LOCALITY PLAN
HOBART
HUONVILLE
HUON R.
GEEVESTON
CYGNET
DOVER
RAMINEA
HASTINGS
BRUNY
CATAMARAN
0 6 12 18 M.
IDA BAY
LEGEND
SEDIMENTARY
RECENT ALLUVIUM
TERTIARY GRAVELS & ALLUVIUM
TRIASSIC SANDSTONE
PERMIAN MUDSTONE
ORDOVICIAN LIMESTONE
IGNEOUS
TERTIARY BASALT
JURASSIC DOLERITE
ROADS
SAMPLES
RAILWAY
QUARRIES
DISUSED TRAMLINES
MINERAL LEASES
CONTOURS
LEASE APPLICATIONS
To Lune R.
MYSTERY CK.
CAVES RESVE.
CAVES HILL
SUGAR LOAF
FAULT
FAULT
To Leprena
N
SECTION AB
A
B
G. Everard B.A.
GEOLOGIST
12 . 10 . 1951
DEPT OF MINES
K.I.K.

FIG. 53

LIMESTONE DEPOSITS — MARIA ISLAND