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FURTHER NOTES ON THE "PERMO-CARBONIFEROUS CLIFFS" AT DARLINGTON, MARIA ISLAND.

By R. M. Johnston, F.S.S.

Maria Island, lying to the east of Spring Bay, must be regarded as the most southerly outline of the great granite axis forming the eastern fringe of Tasmania, traceable northwards through Schouten Island, Freycinet's Peninsula, Bicheno, Falmouth, St. Helens, Eddystone Point, to Gladstone. Crossing the narrow Banks' Strait it may be further traced through Clarke Island, Cape Barren Island, Long Island, Goose Island Hummock Island, the Strzelecki Peaks, and Killicrankie Range of Flinders Island, and the elevated masses of granite forming the interesting cluster of islets known as the Kent's Group. From this point the granite axis is again traceable through the rocky shoals, reefs, and islets to the most southerly limit of the Australian mainland at the granite headlands of Wilson's Promontory.

Maria Island, like Bruni Island, is divided into two parts—North Maria and South Maria. The two divisions are connected, between Oyster Bay on the west and Reidle Bay on the east, by a narrow strip of sand two or three miles long, giving the island, as a whole, somewhat the appearance of an ancient hour-glass. The greatest length lies between Cape Boulanger on the extreme north, and Cape Peron on the extreme south, covering a distance of about 15 miles. The greatest breadth, about 10 miles, lies in a line between Long Point on the west, and Ragged Head on the east; that is within the larger division of the North Island. Maria Island, as a whole, covers an area of about 38 square miles, and, as its mass in the north rises rapidly, with fantastic outline, from the sea to a height of over 3000 feet, it presents a very imposing appearance as seen from the nearest part of the mainland, six or seven miles distant.

The general geological features of both North and South Divisions of the island are very similar, and closely agree with those of the Schouten Island and Freycinet's Peninsula, with which at one time, no doubt, they were connected.

Thus, in all, we find the easterly half entirely composed of grey and, sometimes red, granites, often coarsely porphyritic. The large tabular crystals of the various kinds of felspar are particulary conspicuous in places. Flanking the granites on their western side, in a more or less well-determined north and south trough or valley, occur metamorphic rocks of Archæan age, together with schists, slates, and close-grained limestone, probably of Lower Silurian age. In such situations stream-tin has been sparingly found, both on Maria Island and on the Schoutens. The great mass of the western half of both divisions is occupied mainly by the prevailing diabasic greenstones of the country, and form, as elsewhere throughout Tasmania, its loftiest and most characteristic physical features. The border of the greenstone ranges, in the southern and western portions of the northern division, is low-lying, composed of scrubby sand-dunes, enclosing marshy lagoons. Towards the north-east, at Darlington, occur fine sections of limestones, mudstones, and conglomerates of Permo-Carboniferous age.

Nowhere throughout Australia and Tasmania are there so complete a series or finer sections of the marine rocks of Permo-carboniferous age exposed than those occurring in the grand precipitous sea-cliffs near Darlington, at the north-western extremity of Maria Island. Darlington, the only settlement, wherein live a few families engaged in pastoral occupation, is most charmingly situated underneath the shadows of the two curious lofty peaks of Mount Maria, nearly 3000 feet high, whose well-known features, as seen from the seaward side, have suggested the fanciful idea of "Bishop and Clerk," a name by which they are now known. The northern outlook from the settlement is especially grand, as it embraces the distant outlines of the fantastic chain of serrated granite ranges of the Schouten Island and Freycinet's Peninsula. Away to the extreme north these crests melt away towards the cultivated settlements around Swansea and Great Swanport, at the head of Oyster Bay; while to the left stands out the bold coastline of the mainland, lying between Cape Bernier and Okehampton, near the entrance to Spring Bay.

Immediately to the north and east of Darlington, along the coast-line, occurs a low-lying spur of the diabasic greenstone, which suddenly terminates at the western shoulder of the great cliff-encircled half-moon bay lying directly under "The Bishop and Clerk."

From the point where the diabasic greenstone spur terminates, the coast-line north and east encircling the half-moon bay is walled in by perpendicular and partly overhanging cliffs, composed of stratified marine beds of the Permo-Carboniferous system. Looking downward from the crest of one of these perpendicular cliffs, in the direction of the "Bishop and Clerk," whose slopes and crest, composed of diabasic greenstone, rise abruptly from above the 400 feet perpendicular stratified fossil cliffs to a height of nearly 3000 feet, the half-moon bay and its environing fossil cliffs present a scene of exceeding grandeur. Along the base of the cliffs of stratified rocks there is a narrow marginal strip of low flat rocky ledges, upon which have accumulated, at certain points, vast quantities of fossiliferous blocks of limestone and mudstone, which, by the continuous undermining action of the great open sea-rollers, have been detached from time to time from the overhanging ledges on the face of the beetling cliffs.

The huge blocks which have fallen from these overhanging cliffs are strewn about or tumbled upon each other in the wildest confusion, while the fossils on the surface of the limestone masses, by the weathering action of sea and air, stand out in bold relief in greatest perfection.

The genus Pachydomus, with its large globose specific forms, is especially noticeable. Blocks, 40 and 50 tons in weight, seem at first sight to be made up of a compacted conglomerate of these large fossil bivalves; but a closer inspection reveals the presence of numerous associates. Originally, in my larger work, on "The Geology of Tasmania," for the sake of convenience in description, I provisionally divided the various members of the Permo-Carboniferous rocks at this place into three great divisions or zones, part characterised by differences in the *prevailing forms* of fossil life, and partly by a considerable difference in the character and composition of the successive beds or groups of strata.

(1.) *Erratic Zone.*—The lowest beds visible above sea-level have been termed by me *The Erratic Zone.* Composed of more or less impure limestones, frequently studded with great erratic boulders of quartzites, slates, schists, and granites or conglomerates of these older rocks, cemented together by limestone. Some of these huge, angular, erratic granite blocks weigh over a ton.

There is abundant evidence now to show that these huge erratics must have been borne thither by meeting ice-sheets. Similar evidence of glacial action during the age in which these rocks were formed, occur in England; Talchir and Salt Range, India; Dwyka Conglomerates, South Africa: Bacchus Marsh Conglomerates, Victoria; New South Wales; and in many parts of Tasmania, in rocks of the same horizon. Fuller details of glacial evidence are given in my observations on "The Glacier Epoch of Australia," read before the Members of this Society, in the year 1893. (See Papers and Proceedings of Royal Society of Tasmania, June, 1893.)

(2.) *Pachydomus Zone.*—Immediately above the *Erratic Zone* occurs a series of alternating beds of calcareous shale and solid limestones, characterised conspicuously by the prevalence of the large globose bivalves of the genus *Pachydomus*. This series, or *Zone*, is about eighty feet in thickness, and was termed by me originally the *Pachydomus Zone*. It must not be inferred, however, that this genus is solely confined to this division, or that this genus alone is to be found within the limits of the zone so named. All that is intended here, by the classified name, is, that in this group of beds, the genus Pachydomus dominates supremely over all other forms of life, and a forty-feet bed is almost wholly composed of their fossils. The following is a fairly typical list of the Pachydomi of this zone, with their more common associates :—

Pachydomus globosus	J. de Sow.
„ de Konincki............	R. M. Johnston.
„ Hobartensis............	„
„ gigas.....................	M'Coy.
„ carinatus	Morris.
Eurydesma cordata	„
Notomya Gouldii	R. M. Johnston.
„ trigonalis	„
„ Beddomeii......................	„
Aviculopecten limæ formis	Morris.
„ Illawarensis	„
„ squamuliferus	„
„ Fittoni	„
Platyschisma ocula	J. de Sow.
Connularia Tasmanica	R. M. Johnston.
Stenopora Tasmaniensis	Lons.
„ informis	„
Favosites ovata	„
„ sp. indet. forming broad flat patches over a foot in superficial extent.	

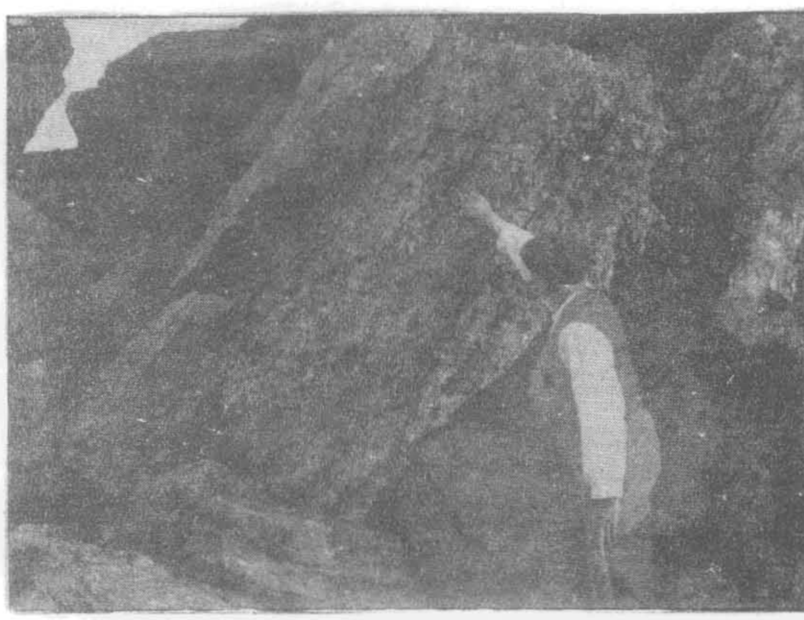
(3.) *Fenestella Zone.*—Succeeding the *Pachydomus* beds there occurs a series of thin, friable, shaly, rusty mudstones, more or less decomposed towards the upper surface, and almost wholly composed of the crushed, laminated frond-like layers of the common species of *Fenestella*. These beds are now estimated to be about 124 feet in thickness, and are generally overlaid, as more recently observed by Mr. Montgomery, by a thin band or layer of volcanic ash or tuff, which he describes as being very hard, full of small glittering granules of glassy quartz, felspar crystals common, also fragments of various rocks. It decomposes into a yellowish-brown clayey stone, which still shows the glassy quartz granules very distinctly. As the whole of the beds of the cliff have a distinct uniform dip of about 1 in 15 in a direction south by east (S. 28° E.), this band, traceable at sea-level to the north, may be followed in the same position, continuously, to the higher surface north and west, where at a height of 185 feet, near the cliff top, and at the head of a deep gully or arm of the sea, it may be again observed in a more or less decomposed state. Mr. Montgomery draws particular attention to the position and peculiar character of this band, as he is of opinion it may serve as a valuable datum line by which to recognise the stratigraphical position of the beds further inland, where among a higher series they are to be found—as also along the higher members of the sea cliffs to the east occur the limestone bands, quarried for the Portland Cement Works of the Maria Island Company. The works lie inland, in a valley, towards the head of Bernacchi's Creek.

The common forms, *Fenestella internata*, Lons., *F. plebeia*, M'Coy, and *Protoretepora ampla*, Low, make up the greater part of the *Fenestella Zone*. Associated with them, however, may be found the following typical forms, viz :—

Spirifera Tasmaniensis	Morris
„ Darwinii	„
„ glaber	„
„ duodecimcostata	M'Coy
Productus brachythærus	G. Low.
Strophalosia Clarkei...................	Eth.
„ Jukesii	Eth. Jr.
Pleurotomaria Morrisi..................	M'Coy.

(4.) *Productus Zone.*—The series of beds overlying the Fenestella Zone are divided by Mr. Montgomery into two groups. The first group in succession termed by him *The Productus Zone* is about 30 feet thick, composed largely of beds of blue hydraulic limestone from 6 inches to 4 feet thick These are the beds chiefly worked at the quarries for the production of Portland cement. The blue limestone bands are separated from each other invariably by beds of calcareous shale and mudstone. The limestones are replete with the common forms of Spirifera, Strophalosia, Productus, Aviculopecten, Stenopera, Crinoids, and Fenestella. Pachydomus, common, but less frequent.

(5.) *Crinoid Zone*—The next and highest groups in position of the Darlington beds are estimated by Mr. Montgomery to be about 320 feet thick, and are termed by him the *Crinoid Zone*. This zone is composed of limestones, consisting chiefly of crinoid remains, occurring in beds from six inches to four feet thick, separated by thin shaly partings. Mr. Montgomery states that this limestone seems very pure, except that it frequently contains bands and masses of chalcedony *(Buhrstone)*, formed by the infiltration and segregation of silicious solutions. The beds of the larger quarry at the Portland cement works are stated to belong to the lower part of this series. The buhrstone referred to might yet prove to be of commercial value for milling purposes, as it is very abundant and easily quarried. It is greatly to be regretted that the manufacture of Portland cement at this place has failed of success, seeing, as Mr. Montgomery has reported, that good cement has already been manufactured there, and that there are good facilities of all sorts for making and shipping larger quantities of it.



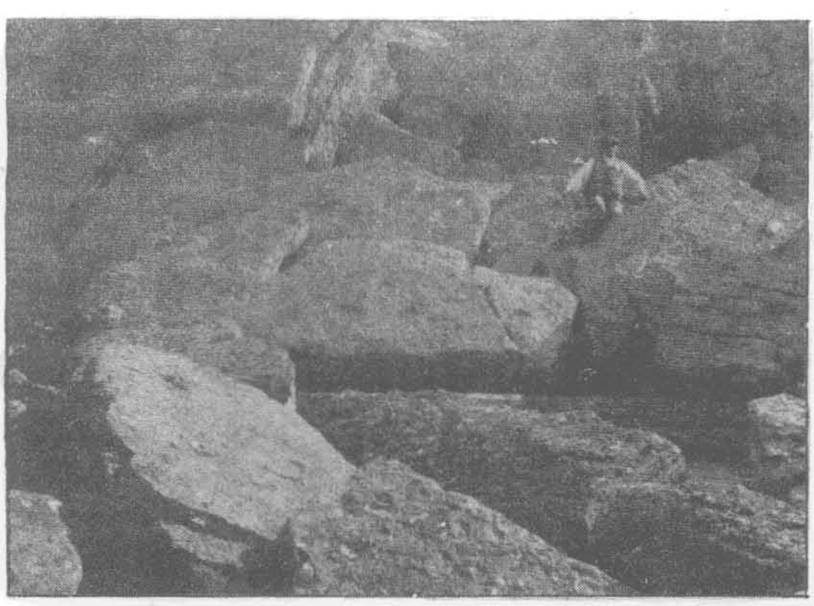
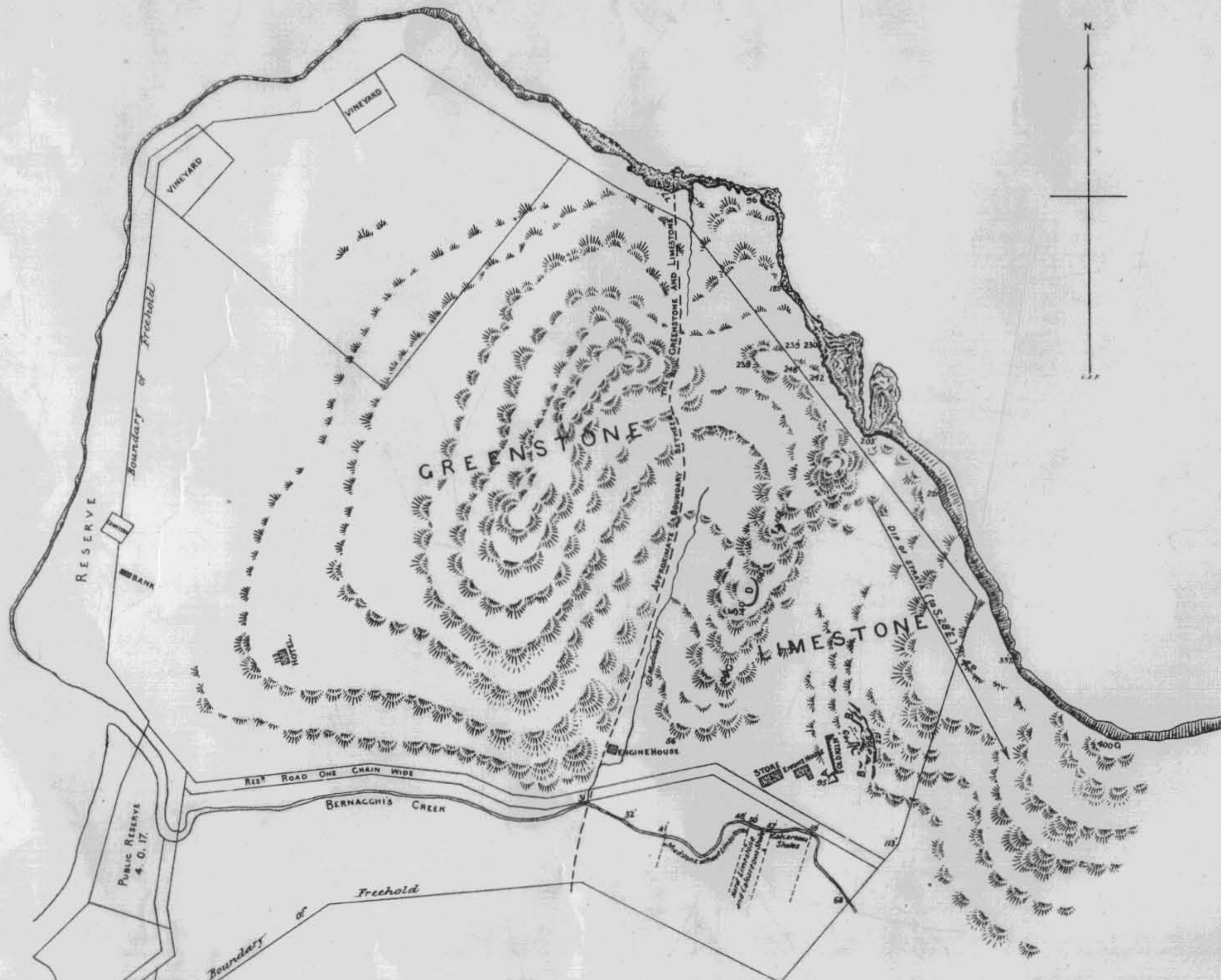


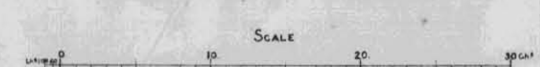
Photo-Algraphy Process.

FALLEN BLOCKS OF FOSSILIFEROUS LIMESTONE
At foot of Cliff, Fossil Cliff Bay, Darlington, Maria Island



MAP OF NORTHERN PART OF BERNACCHI'S FREEHOLD

MARIA ISLAND.



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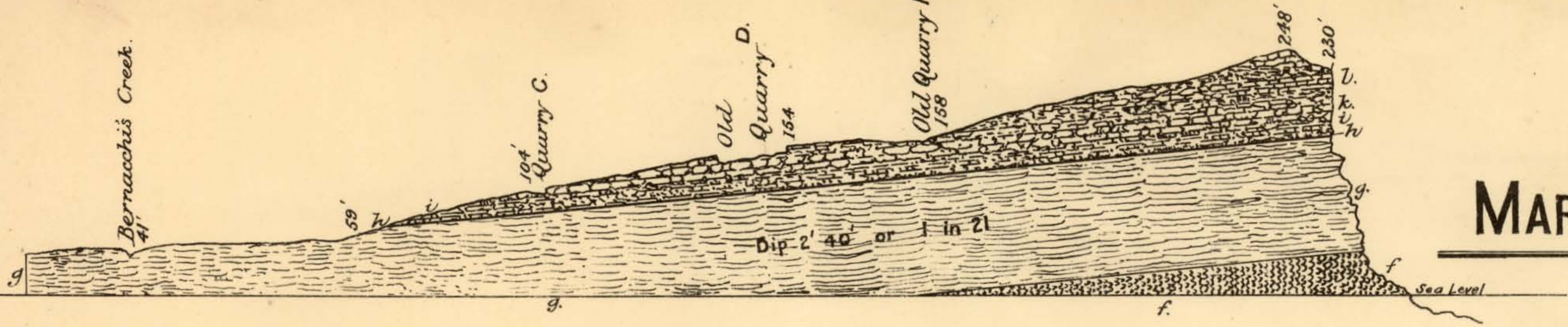
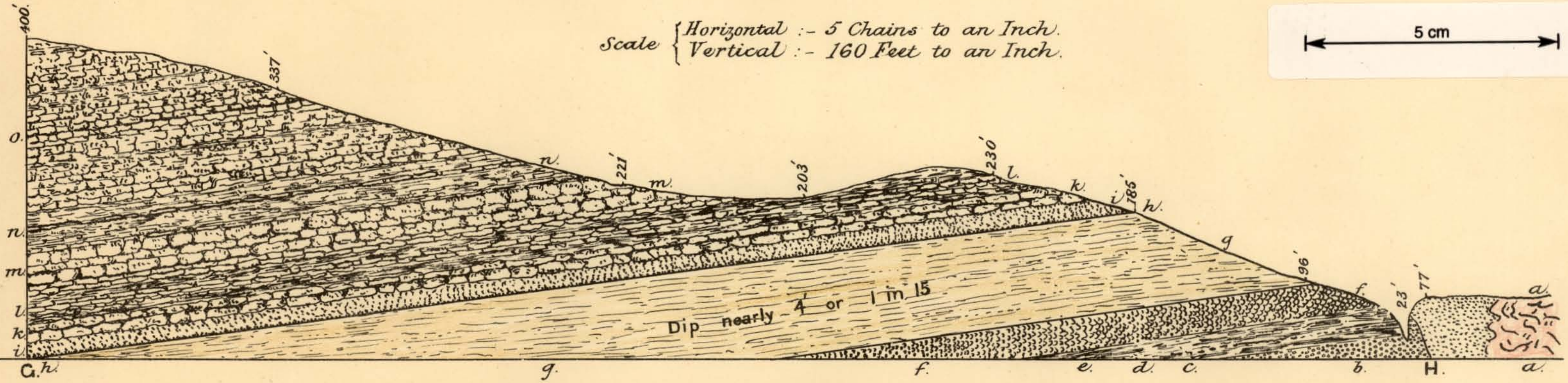
Maria Island.



Section through middle spur from creek to coast.

Scale { *Horizontal :- 5 Chains to an Inch.* / *Vertical :- 160 Feet to an Inch.* }

(5)



Section along coast from G. to H.

a. Greenstone. b. Limestone & conglomerate. c. Calcareous shale & thin beds of limestone. d. Bed of Pachydomus shells. e. Calcareous shales with thin beds of solid limestone. f. Thick bed of Pachydomus shells. g. thick bed of mudstones with very abundant remains of species of Fenestella &c. h. bed of volcanic ash. i. shaly limestone with numerous species of Spirifera, Productus &c. k. thin bedded hard limestones worked in quarries on Middle Spur. l. horizon of limestone beds worked for cement in quarry **A.** *m. horizon of crystalline crinoidal limestones in bottom of quarry B. n. mixed beds of limestone and mudstone. o. beds of hard limestone seen in face of cliff at G.*

L.S.F.

To the geologist and palæontologist, the Darlington beds of Permo-Carboniferous age are of the greatest interest. The fossils of these rocks afford a splendid field for further palæontological investigations. Professor Boehm, of Freiburg University, Baden, whom I recently induced to visit this fine section at Darlington, declared to me that to him, as a professional palæontologist, it was the grandest sight that he had ever beheld. The main object that I had in view in recording these observations is that it may perhaps induce the younger members to systematically extend our knowledge of the Permo-Carboniferous age in Tasmania, and especially of these Darlington beds. I am indebted to Mr. Montgomery's paper for the large detailed table of strata appended, and for the sections which illustrate them. (Appendix B.)

For the series of splendid photographic slides of the Darlington fossil cliffs, prepared to illustrate this paper by Mr. Beattie, I am indebted to my friend, your Secretary, Mr. A. Morton, who obtained them when he last visited the island for this purpose, accompanied by Dr. Boehm. The enlarged figures of typical fossils of these rocks, to be shown on the screen, are taken from the plates which illustrate my large work, "Systematic Account of the Geology of Tasmania."

As the limestones quarried by the Maria Island Company for the manufacture of Portland cement are of much interest, from an economic point of view, I have appended (Appendix A) a valuable analytical report of the character of these limestones, submitted to Mr. Wallace, Secretary for Mines, by Mr. W. F. Ward, Government Analyst.

Appendix A.

Government Laboratories,
Hobart, 4th September, 1900.

Dear Sir,

The samples of cement received from you on the 14th ult., and stated to be from Maria Island, have been examined, with results following :—

	1	2	3
Silica, soluble	26·2	26·5	22·4
Silica, &c., insoluble	5·0	1·1	1·2
Oxide of iron	2·6	2·2	1·8
Alumina	3·8	3·4	4·0
Magnesia	1·1	1·2	0·8
Lime, &c., by difference	56·3	63·6	53·2
Carbonic acid and water	5·0	2·0	16·6
	100·0	100·0	100·0

No. 1, cement; No. 2, blue lias clinker; No. 3, crumbling cement brick, 10 years old. No appreciable amount of phosphoric acid was found in any sample; a small quantity only of sulphate of lime is included in the lime.

To render the results more strictly comparable, they have been calculated, excluding the carbonic acid and water lost on ignition in each case, as follow :—

	1	2	3
Silica, soluble	27·58	27·04	26·86
Silica, &c., insoluble	5·26	1·12	1·44
Oxide of iron	2·74	2·24	2·16
Alumina	4·00	3·47	4·80
Magnesia	1·16	1·23	0·95
Lime, &c.	59·26	64·90	63·79
	100·00	100·00	100·00

Variations in compositions of cements from several different countries are added for comparison :—

	Per cent.
Silica	19·9 to 26·1
Alumina	5·2 „ 10·6
Oxide of iron	2·1 „ 5·0
Lime	59·1 „ 67·3
Magnesia	0·3 „ 3·5
Sulphuric acid	0·3 „ 4·2

It will be seen that in the Maria Island material the silica is rather above the maximum, and the alumina rather below the minimum given above. Alteration in these respects would probably mean improvement, but I am inclined to attribute the crumbling of sample No. 3 to mode of preparation of the cement, as there are some limestones which will yield cement or lime according to the temperature at which they are burned. A rotary kiln, very largely used in America, is a great improvement on the old forms of calciners.

Yours faithfully,

W. F. WARD, *Government Analyst.*

To the Secretary for Mines, Hobart.

Appendix B.

Detailed Description of the Darlington Beds, as described by A. Montgomery, M.A.

Zone	Thickness. Ft.	Thickness. In.	Description of Beds.	Total Thickness of Strata. Ft.	Total Thickness of Strata. In.
Crinoid Zone.	320	0	Limestones consisting chiefly of crinoid remains in beds from 6 inches to 4 feet thick, separated by thin shaly partings. This limestone seems very pure, except that it frequently contains bands and masses of chalcedony (*Buhrstone*) formed by the infiltration and segregation of siliceous solutions. The beds of the large quarry at B. on plan belong to the lower part of this series.	608	0
Productus Zone.	30	0	Beds of blue hydraulic limestone, 6 inches to 4 feet thick, worked in quarries at A. C. D. E. and F. on plan, separated by beds of calcareous shale and mudstone, amounting, probably, to nearly half the whole bulk of the beds. The limestones show fossils of *aviculopecten, spirifera, productus*, and *fenestella* in abundance; *pachydomus* common, but less frequent. Small stones not uncommon ...	288	0
	43	0	Shaly limestones, very rich in *Spirifera* and *productus* ...	258	0
	2	6	Dark shaly mudstone ...	215	0
Fenestella Zone.	1	9	Volcanic ash or tuff, very hard, full of small glittering granules of glassy quartz, felspar crystals common, also fragments of various rocks: decomposes to a yellowish-brown clayey stone, which still shows the glassy quartz granules very distinctly ...	212	6
	124	0	Mudstones, with but little lime, very rich in species of *fenestella, stenopora*, &c...	210	9
Pachydomus Zone.	40	0	Thick limestone bed, almost entirely made up of shells of *pachydomus globosus*, but containing a great deal of sand and large stones ...	86	9
	6	0	Calcareous shale ...	46	9
	0	9	Solid hard limestone ...	40	9
	2	0	Calcareous shale ...	40	0
	2	6	Limestone and shale with *spirifera* shells and a good deal of gravel ...	38	0
	1	6	Solid hard limestone ...	35	6
	5	0	Calcareous shale ...	34	0
	1	6	Solid hard limestone ...	29	0
	1	6	Calcareous shale ...	27	6
	5	0	Limestone, almost entirely composed of shells of *pachydomus* ...	26	0
	1	0	Calcareous shale ...	21	0
	2	0	Solid limestone ...	20	0
	1	6	Limestone full of boulders ...	18	0
	3	6	Calcareous shale ...	16	6
Erratic Zone.	4	0	Limestone with a great many stones in it ...	13	0
	4	0	Conglomerate of boulders of metamorphic slate and sandstone and granite, cemented together by limestone ...	9	0
	5	0	Impure limestone, with boulders ...	5	0
			Sea Level ...	0	0