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REPORT ON THE HYDRAULIC LIMESTONES OF MARIA ISLAND.

Geological Surveyor's Office,
Launceston, 19th September, 1890.

SIR,

I HAVE the honor to report, in accordance with your instructions, on the occurrence of hydraulic limestone suitable for the manufacture of Portland cement at Maria Island.

The ground examined is the property of the Maria Island Company, and is situated in the north-western corner of the Island. A plan and two sections of it are appended to this Report, and will be frequently referred to in it.

Geological features.—As will be seen from the map, the western part of the ground is composed of greenstone, similar in every respect to the great greenstone masses of the mainland, well seen in the gorge of the Prosser's River, above Orford, immediately opposite Maria Island. This igneous rock cuts off the limestone formation along a line indicated on the plan. Eastward of this line the country consists of beds of limestones and shales, reaching at any rate to Cape Boulanger ; further to the eastward the greenstones and granites again cut them off. The north coast line affords a magnificent section of the strata, as vertical cliffs rise sheer from the beach to a height of as much as 400 feet. It is noteworthy that the ground slopes inland from the top of the cliffs, so that we have the unusual sight of ridges and valleys rising to the coast line instead of falling towards it. This topographical peculiarity is of importance in determining the site for the proposed cement works.

It has become customary, locally, to speak of the bands of hydraulic limestone as "Blue Lias," from the superficial resemblance of the stone to the bluish hydraulic limestones of the Liassic period in England. This is quite a misnomer, however, as the Maria Island beds are much older than the Lias, being of carboniferous age; they belong to the lower marine beds of our carboniferous system, which underlie the oldest coal seams yet found either here or in New South Wales. They are extremely rich in fossil remains, the most important of which are named in Johnston's Geology of Tasmania; the genera *pachydomus*, *aviculopecten*, *spirifera*, *productus*, and *fenestella* are very abundantly represented. Owing to the extreme steepness of the cliffs it is not possible to examine the section presented by them so closely throughout as is desirable, but I was able to compile the following section from observations in such parts as could be scaled. It is yet very imperfect, especially in the upper part, where the face of the cliff could only be closely examined by a person lowered over it by ropes. The section includes the strata seen between points G and H on the plan. The direction of the dip is a little more to the south than the line joining these points, being about S. 28° E., but the amount of the angle of dip is low, being only 4°, and the coast line section may be fairly considered as along the line of the dip. The beds in the cliff, therefore, come down to the beach, but cannot be clearly followed there on account of the great amount of fallen débris. The figured section appended shows the main features, but is on too small a scale to show details such as are now given :—

	Thickness.		Description of Beds.	Total Thickness of Strata.		
	Feet.	Inches.		Feet.	Inches.	
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	
Fenestella Zone.	43	0	Shaly limestones, very rich in *spirifera* and *productus*	258	0	f
	2	6	Dark shaly mudstone	215	0	
	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	h
	124	0	Mudstones with but little lime, very rich in species of *fenestella*, *stenopora*, &c.	210	9	g
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	f
	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	e
	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	d
	1	0	Calcareous shale	21	0	
	2	0	Solid limestone	20	0	
	1	6	Limestone full of boulders	18	0	c
	3	6	Calcareous shale	16	6	
	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	b
	5	0	Impure limestone with boulders	5	0	
			Sea Level	0	0	

The section is best read from the bottom upwards. The lowest beds, about 87 feet thick, have been aptly called the Pachydomus zone by Johnston in his Geology of Tasmania, on account of the immense number of shells of this genus found in it. It is overlaid by mudstones, forming a bed about 124 feet thick, characterised by extreme abundance of Fenestella fossils. This may be called the Fenestella zone *par excellence*, though this genus is abundantly represented from bottom to top of the section in all the shaly beds separating those of limestone, as well as in the latter themselves. The bed of volcanic ash or tuff, which lies on top of the Fenestella mudstones, is about 21 inches thick; it is found at the foot of the high cliffs just above high-water mark, about 10 chains west of point G. on the map; again, half-way up the face of the steep slope at the head of the deep little arm of the sea, about a quarter of a mile further

west; and again, at the top of the cliff some five chains still further on, at an elevation of 185 feet above sea level. From its peculiar character, quite distinct from any of the associated beds, it will serve as a valuable datum line by which to recognise the stratigraphical position of the beds further inland.

The next zone of limestones overlying the tuff is characterised by great abundance of shells of Spirifera and Productus, and might be called the Productus zone; it is probably about 75 feet thick in all. The succeeding beds of limestone, seen in the section to be at least 320 feet thick, containing very numerous fragments of crinoid stems, may be called the Crinoid zone. While it is convenient to divide the strata into these zones, the prevalence of certain genera throughout the whole of them, and of the most characteristic fossils of one zone in those both above and below it, make it very doubtful if, in the present state of our knowledge, it will be possible to relegate the strata found further inland to them with any certainty. The division is proposed as a provisional one, pending more close examination of the fossil contents of the beds.

It is worthy of note that the boulders found abundantly in the lowest strata are all of metamorphic slate and sandstones and granite; I was not able to find a single greenstone boulder among them, though this rock is now close alongside. This is evidence towards the conclusion that the greenstone is of later formation than the strata of the lower marine carboniferous beds, and that the latter were not deposited on the flanks of greenstone masses as has been contended.

Manufacture of Cement.—The quarries opened to procure limestone for burning have as yet been confined to the lower beds of the Crinoid zone and those below it down to the zone of the Fenestella sandstone. The limestones of the Pachydomus zone have not been worked. It has been suggested that it would be a good plan to build any future works for the manufacture of cement near point H. on the map, and obtain the limestone from the adjacent cliffs. Examination of the details of the Pachydomus zone in the above section will show that for 47 feet above sea level the limestone exists in thin beds separated by bands of shale, and that the largest beds of limestone are full of boulders, which render them quite unfit for cement manufacture. Operations would be necessarily confined to the 40-foot bed of Pachydomus shells. This also contains much sand and gravel, and I doubt very much if it would be found fit for making cement. Its value in this respect can only be ascertained by breaking down and grinding a very large parcel of the stone, say four or five tons at least, and having analyses made of the powder, or, better still, having the ground material burned in a cement kiln by a practical man. Both tests should be made before deciding on this bed as the source of the raw material for the cement manufacture. As this limestone dips under the Fenestella mudstone the quantity of it that could be readily got out, though very large, is yet much less than could be obtained from the beds higher up. Further, the use of this bed would necessitate either hoisting the stone to the works, or having it carried by a tramway along the steep face of the cliffs for probably six or seven chains before a site for works could be obtained lower than the bottom of this limestone, which is only about 47 feet above the sea. Still another objection is that almost the whole of this bed at the point where it appears is on the Crown reserve which fringes the shore. Owing to the dip of the strata the bed is at such a depth as to be useless by the time the Company's ground is reached. Even if this limestone should prove to make good cement it is therefore very unlikely to be worked. The low ground near the engineer's house appears to me to be a much better site for the works than on the north coast; they could then be situated below the quarries, but close to them. Little more than half a mile of tramway, over easy ground, with a grade of not more than a foot in a chain, would connect them with the jetty; and they would be able to be supplied with water from the old reservoir up the creek. The outflow pipe of this reservoir is about 126 feet above sea level, and the top of the embankment about 140 feet. By repairing and raising the embankment, which could be done without very large cost, a fine water supply could be obtained, delivering water to the works under a head of over 50 feet at the least. This water supply could only be brought on to the north coast site by a long race round the western side of the high greenstone hill shown on the plan. The mid lle spur, on which quarries C. E. D. and F. are situated, will be the best source of the raw material; and I should say that the works should be on the point of the spur below point C. The top of the mudstones would naturally form the bottom of the quarries, and gives thus the approximate level of the hoppers for the stone-breakers. Between this level and the low ground south of the engineer's house there is both fall and space for a large system of works, through which the material could pass from higher to lower levels by gravitation, or with but little handling, to the tramway at the bottom.

The cement made hitherto has been from stone obtained from the quarry at A, with the exception of a little from the one at C; the product was of about the same quality in each case. Owing to the dip of the beds, the stone worked at A will not be found in the southern part of the middle spur, but should come in above the quarry at F. From below C to above F, therefore, it is probable that all the limestones will be of a hydraulic character. The cuttings in the old quarries at E, D, and F, show limestones of exactly similar appearance to that in A and C; though I am not aware that any practical test has been made of them. These limestones are in beds averaging about a foot to eighteen inches in thickness, though often much thicker, and are separated by thin layers of shales; this will render the quarrying extremely easy, though there will necessarily be a good deal of refuse shale to be got rid of; this can be readily run to spoil in the valley on the west of the spurs. Some of the calcareous shale may be found useful to correct the excess of carbonate of lime which is likely to be found in some of the limestone beds. Without much more accurate surveys than have yet been made, it is impossible to form any close estimate of the quantity of material here available, especially as we cannot yet tell what proportion of the whole will have to be rejected; but I do not think that a million tons would be too high an estimate of the probable quantity of limestone in the spur between C and the coast. Still more can be obtained along the base of the spur which runs from the point G down to the quarries at B. The upper part of this spur is all composed of the Crinoid limestones seen in quarry B, which are of too pure carbonate of lime to be of use except in

small quantities for correcting any deficiencies in lime that might be found in the lower hydraulic beds. The latter dip under the Crinoid strata, and the amount of stripping would be too great to allow them to be profitably followed into the hill to any great distance; but all the lower ground round the foot of the spur could be worked from near the coast to the present kilns and on up the creek for a long distance. The supply of raw material easily reached is therefore practically unlimited.

All the conditions appear very favourable for advantageous and cheap working, provided that the quality of the hydraulic limestones is uniform and suitable; this has yet to be ascertained. The owners have satisfied themselves that the cement made from quarries A and C is of first rate quality. This is not a question for me to pronounce upon, and the reports of the specialists who have examined and tested the cement must speak for themselves; if they are as favourable as I was informed they were, what has been proved is that one of the lower, (C), and one of the higher, (A), beds of the strata of hydraulic limestone has been shown to make good cement. As to the intermediate beds we know nothing, except that they appear to the eye to be identical with those tried; this is not, however, sufficient proof to warrant the expenditure of a large capital. It is now necessary to open up the whole bed of probable raw material from top to bottom, by means of cuttings into the middle spur at various levels, or by means of shafts sunk along its course; in cases of this sort analyses of small samples are more likely to be delusive than useful, and so sufficient quantities must be taken to give practical working tests which will prove the average value of the stuff. With the machinery on the ground as it is, it would be no difficult matter to practically test a parcel of, say ten tons, of limestone taken as evenly as possible from all the various beds. The stone should be put through the stonebreaker and mills and reduced to powder; the bulk of this should be bricked and burned at some well known and reliable cement works, and small parcels analysed. The opening of the beds by such a test would also give an approximate estimate of the amount of refuse shale and mudstone that will have to be rejected, thus allowing a fair estimate to be made of the quantity of material that can be got from a given area, and the cost of winning it; the expense of making it is, of course, considerable, but it would be most rash to erect expensive works without so doing.

I would recommend open cuttings and shafts for testing the ground rather than drills, unless, indeed, enough bores were executed to secure enough weight of cores for a working test, as it is of the utmost importance to secure samples which will fairly represent the average composition of the mass. In order to produce cement of a uniform quality it will be necessary to have uniformity in the raw material. This contains occasional stones, shells, and shale bands, which cannot be got rid of altogether before going into the grinding mills. It will have to be managed so that the percentage of deleterious materials will never exceed a certain amount. Taking a large sample for the preliminary tests will be the only way to secure that the deleterious substances are duly represented, and are not either in excess of or below the average. In actual working it will doubtless be arranged that the stonebreakers will be fed from a large paddock of broken-out limestone, brought indiscriminately from all parts of the quarries, so as to keep the material always of the average composition. It is important that the preliminary tests should be of material as near as possible to this average composition. I lay great stress on these matters, because it is not always understood by the general public how continually varrying is the composition of any given limestone bed, and how essential it is for good working that the material treated should be of uniform quality.

Disturbances of the strata.—Among the numerous troubles frequently arising in working such deposits as those under consideration, the occurrence of faults in the strata is often to be numbered. In the present case there does not appear to be any reason to anticipate that any such will be found, the beds being, as far as can be seen just now, quite undisturbed. In the top of B quarry, however, there are signs of flexure of the strata to a small extent, which is probably only local. The test pits and cuttings above recommended would settle this question also. Should faults be found to occur it is quite conceivable that a different arrangement of the works would be required from that which would be otherwise adopted. This is not likely, but still possible.

Buhrstone.—Throughout the Crinoid limestone beds occur numerous irregular bands aud masses of cellular chalcedony, very similar to buhrstone. On the beach below the high cliffs large quantities of this may be seen, and flat pieces of considerable size are common. If this stone should prove to have a commercial value for milling purposes there would be no difficulty in obtaining it in considerable quantities. I cannot speak as to its practical value.

Taking into consideration that good cement has already been made, and that there are extremely good facilities of all sorts for making and shipping large quantities of it, there is every reason to hope that this important industry will soon be established and flourish in Maria Island.

I have, &c.

A. MONTGOMERY, *M.A.*, *Geological Surveyor.*

The Secretary of Mines, Hobart.

N.

VINEYARD

VINEYARD

Boundary of Freehold

RESERVE

CEMETERY

BANK

HOTEL

GREENSTONE

THE GREENSTONE AND LIMESTONE

APPROXIMATE BOUNDARY BETWEEN

LIMESTONE

DIP OF STRATA (to S.28°E)

ENGINE HOUSE

STONE

ENGINE HOUSE

RESE ROAD ONE CHAIN WIDE

BERNACCHI'S CREEK

PUBLIC RESERVE
4. 0. 17.

Freehold

Boundary of

RESE ONE CHAIN WIDE

Metstone without Limestone

Hard Limestone and Calcareous Shale

Calcareous Shales

MAP OF NORTHERN PART OF BERNACCHI'S FREEHOLD

MARIA ISLAND

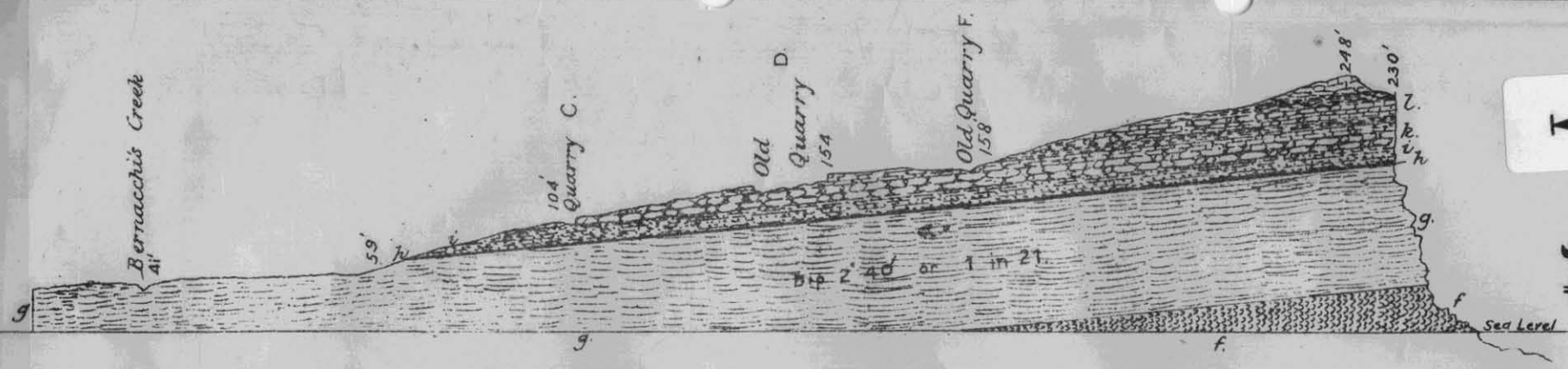
SCALE

0 10 20 30 Chs

5 CHAINS TO ONE INCH

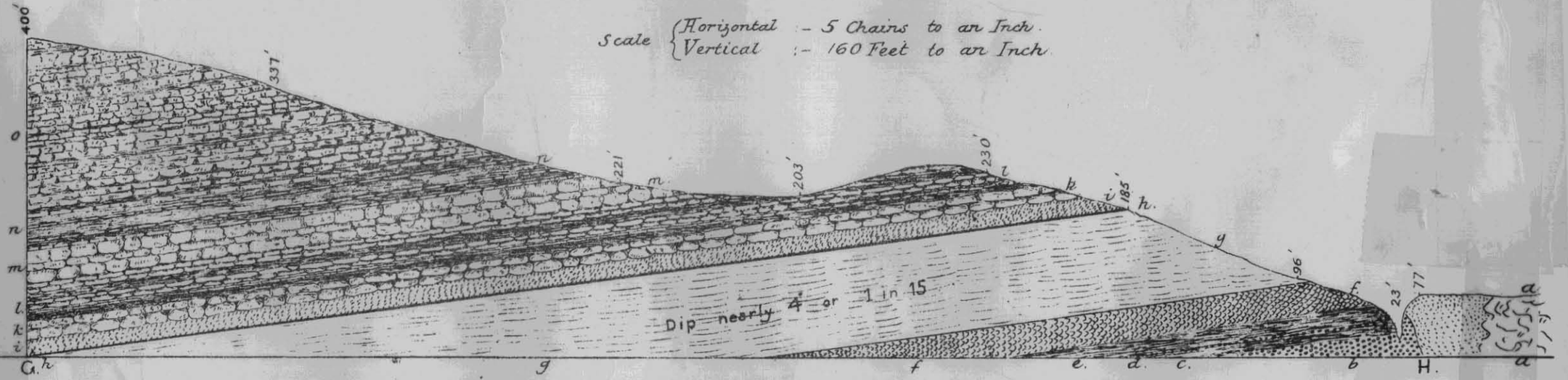
5 cm

MARIA ISLAND



SECTION THROUGH MIDDLE SPUR FROM CREEK TO COAST

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



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.

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