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Author(s): Chas. W. Andrews

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A DESCRIPTION OF CHRISTMAS ISLAND (INDIAN OCEAN).*

By CHAS. W. ANDREWS, B.Sc., F.G.S., Assistant in the British Museum (Natural History).

ONE of the most interesting of the lonely islets of the Indian Ocean is Christmas Island, which lies about 190 miles south of Java, in S. lat. $10^{\circ} 25'$, E. long. $105^{\circ} 42'$. The seas around it are of enormous depth, and soundings of over 1000 fathoms occur within 2 or 3 miles of its coasts. To the north and north-west is Maclear Deep, in which 3200 fathoms were found, and to the south is the more extensive Wharton Deep, with upwards of 3000 fathoms. The island, in fact, rises from the summit of the low submarine ridge which separates these two abysses, and on the westward end of which the Keeling-Cocos Islands are situated.

The first mention of the island occurs in a map by Pieter Goos, published in Holland in 1666, in which it is called *Moni*. In subsequent maps, this name and that of Christmas Island are applied to it indifferently, but it is not known by whom the island was discovered and named. The earliest approach to a descriptive account is found in Dampier's '*Voyages*,' † in the following passage:—

"After leaving New Holland, the ship tried to make Cocos, but was driven to a more easterly course, and met nothing of remark till the twenty-eighth day. Then we fell in with a small woody island in lat. $10^{\circ} 20'$. Its longitude from New Holland, from whence we came, was, by my account, $12^{\circ} 16'$ W. It was deep water about the island, and there was no anchoring; but we sent two canoes ashore, one of them with the carpenters, to cut a tree to make another pump; the other canoe went to search for fresh water, and found a fine small brook near the south-west point of the island, but there the sea fell on the shore so high that they could not get it off. At noon both the canoes returned on board, and the carpenters brought aboard a good tree; the other canoe brought aboard as many boobies and man-of-war birds as sufficed all the ship's company when they were boiled. They got also a sort of land animal, somewhat resembling a large crawfish without its great claws. The island is a good height, with steep cliffs against the south and south-west, and a sandy bay on the north side, but with very deep water steep to the shore."

The date of Dampier's visit was March, 1688. The next account of the island is given by Captain Daniel Beekman ‡ in 1718. He remarks that "the island looks exceeding pleasant, being covered with lofty trees, and may be known by the following directions: Coming from the north-westward, it appears pretty high, with a saddle in the middle ;

* Paper read at the Royal Geographical Society, November 28, 1898. Map and Sections, p. 104.

† '*Dampier's Voyages*,' vol. i. p. 472. Ed. 1829, London.

‡ '*A Voyage to and from the Island of Borneo, in the East Indies*,' etc. London, 1718. No. I.—JANUARY, 1899.]

the westernmost land is the highest, trenching away to the northward to a low flat point; the easternmost point is low, but bluff. I sounded within 8 miles of the low point, but had no bottom with the 100-fathom line out. The island is about 7 leagues from east to west."

This writer gives a remarkable sketch, in which the heights are ridiculously exaggerated, the hill over the north-western point being made to look like a high mountain with three peaks; his estimate of the length of the island also is much in excess of the truth.

In 1771, the *Pigot*, East Indiaman, attempted to find an anchorage, but failed. The crews of this and other passing vessels reported the occurrence of wild pigs, coconut palms, and lime-trees, none of which really existed.

The first attempt at an exploration of the island was made by the frigate *Amethyst* in 1857, from which a boat's crew was landed with the object of attempting to reach the summit, but the inland cliffs proved an insuperable obstacle, and the ascent was abandoned.

In 1887, the surveying vessel *Flying Fish* (Captain Maclear) was ordered to make an examination of the island. The coast was found to consist of steep limestone cliffs, and it was only after sailing nearly all round the island that an anchorage was found in a bay with a white shingle beach on the north coast; to this the name Flying Fish Cove was given, and it is now the site of a small settlement. Another white beach was seen towards the north-west point, but no anchorage was found near it. A number of men were landed, and some collections of the plants and animals were obtained, but, since the island seemed of little value, no serious attempt at exploration was made.

In the following year H.M.S. *Egeria* (Captain Pelham Aldrich) called at the island, and remained about ten days. Captain Aldrich and his men cut a way to the top of the island, and sent home a number of rock specimens obtained on the way, and Mr. J. J. Lister, who accompanied the expedition as naturalist, made extensive collections both of the fauna and flora, but had not time to penetrate to the middle of the island.

In 1890 H.M.S. *Redpole* called at the island for a few hours, and Mr. H. N. Ridley, of the Singapore Botanical Gardens, who was on board, collected a number of plants not previously recorded, and has written an interesting account of his visit.*

Although Messrs. Lister and Ridley had made valuable collections of the flora and fauna of the island, the shortness of the time at their disposal rendered it impossible for them to penetrate far into the interior, or to make any examination of the geological structure. Nevertheless, the rock specimens brought back by the *Egeria* showed that the island probably consisted mainly of coral and foraminiferal limestones, resting on a basis of volcanic rocks; and a very interesting

* *Journal*, Straits Branch of the Royal Asiatic Society, June, 1891, p. 123.

paper,* in which the results of the expedition were summarized and the probable structure of the island discussed, was published by Rear-Admiral Sir W. J. L. Wharton in the *Proceedings* of this Society for 1888.

It seemed desirable, however, that a more complete examination of the island should be undertaken, and, if possible, collections should be made at different seasons of the year, and in 1896 Sir John Murray generously offered to pay the expenses of such an expedition. I was fortunate enough to be able to avail myself of this opportunity, and, the Trustees of the British Museum having granted the necessary leave of absence, I left England at the beginning of May, 1897.



FLYING FISH COVE—REEF AT LOW WATER.

At that time the only means of access to the island was by the small sailing-vessels belonging to Mr. G. Clunies-Ross of Cocos-Keeling Islands, which are employed in carrying various supplies from Batavia to those islands, and on their way down usually touch at Christmas Island to land stores for the little colony established in Flying Fish Cove. Unfortunately, one of these vessels had left shortly before I arrived in Java, and I therefore had to wait some weeks before an opportunity of getting to the islands occurred; but at length, on July 23, I sailed from Batavia in the *J. G. Clunies-Ross*, a yawl of about

* To this paper I am indebted for much of the information as to the early history of the island given above.

46 tons burden. After a rather rough passage of five days, we sighted the island from the south-west, having run past it in the night. We arrived off Flying Fish Cove soon after sunset, but did not anchor till the following morning (July 29).

Seen from the south-west, the island appears as a long green ridge nearly level at the top, there being only slight elevations at the north-west and south-east ends. The ridge descends seaward in a succession of terraces, the upper ones bounded by comparatively gentle slopes, the lower by a high and nearly vertical cliff, below which there is a narrow platform sloping gently down to the sea-cliff. This is usually about 15 to 30 feet high, and is much undercut by the heavy swell that is continually breaking against its base. On approaching nearer, it can be seen that the whole island is covered with a dense forest, only broken by the grey face of the high inland cliff which runs round the greater part of the island, rising like a wall above the tall trees growing on the shore terrace.

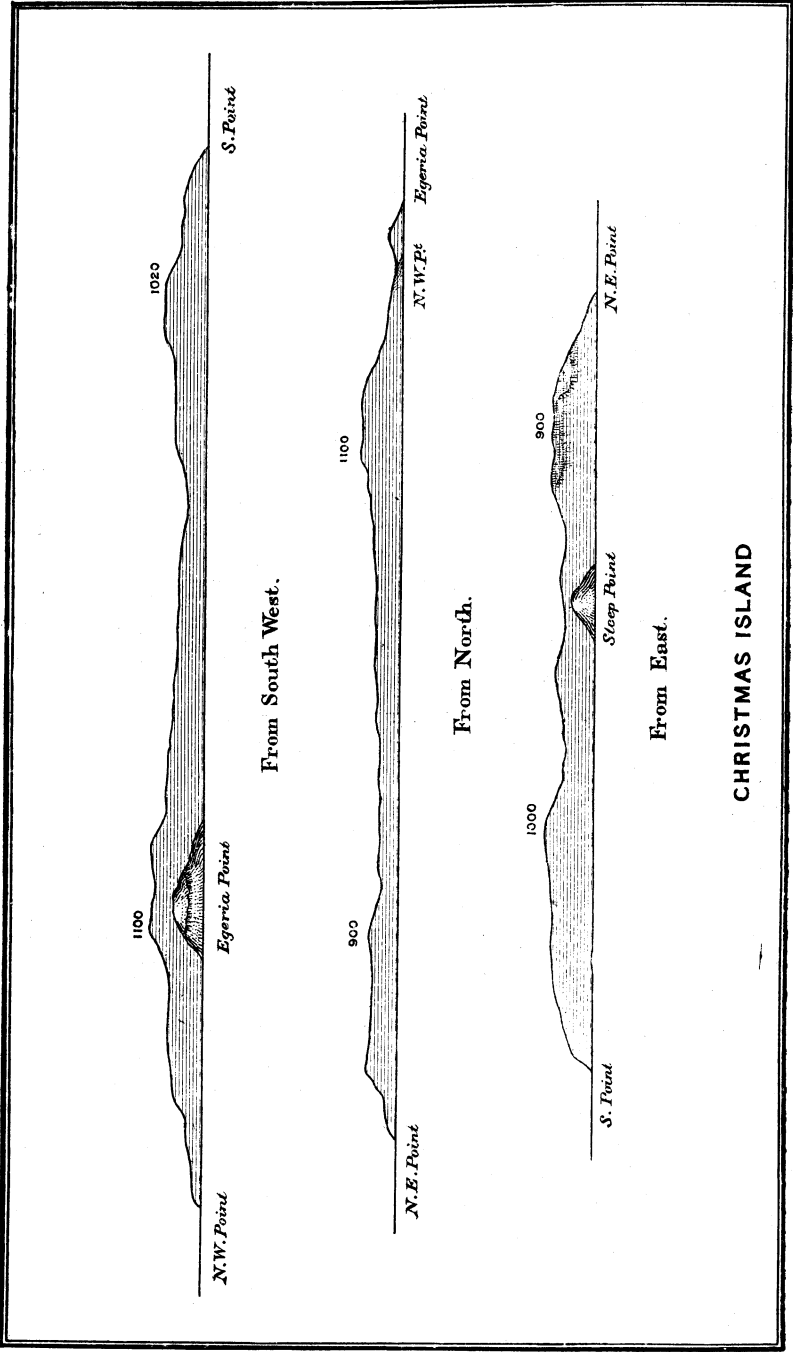
If the coast be examined in a boat or from the top of the sea-cliff, it will be seen that a submarine terrace in the shape of a fringing reef is being formed round the greater part of the island. It varies greatly in width, and also in its depth below the surface; in some places it is partly dry at low water, in others some fathoms deep. Outside the edge of this reef, the water deepens suddenly.

The greatest length of the island, from North-East Point to Egeria Point, is about 12 miles. The greatest width from north to south is about 9 miles; the least $3\frac{1}{2}$ miles. Its area may be roughly stated as 43 square miles.

The outlines of the land, as seen from the south-west, east, and north, and sections* across it at various points are shown in the diagrams. From these it can be gathered that it consists of a central plateau, highest toward the north and east, and descending to the sea on all sides by a succession of terraces separated by slopes or cliffs. In most places the arrangement of these, from the edge of the plateau downwards, is (1) a steep slope strewn with blocks; (2) a broad terrace, followed by a similar slope (this seems to be wanting on the south); (3) a second terrace, terminating in a cliff 200 or 300 feet high; (4) the shore terrace sloping gently down to the sea-cliff; (5) the present fringing reef. There are, however, many local differences, the more important of which will be noticed below.

The Central Plateau.—The edge of the central plateau is roughly parallel to the coast, receding farthest from it opposite the principal headlands. It is highest along its northern and eastern borders, where there is a raised rim, the average height of which above the sea is

* The sections across the western and north-eastern parts of the island are mainly founded on a survey of roads made by Mr. G. Ross in 1897.



about 800 feet. Towards the south it slopes away so that its edge is only from 400 to 450 feet high, but there are some slight elevations above this general level. On the west the upper terraces are replaced by a gentle slope, and even the first inland cliff is not well marked except towards North-West and Egeria Points.

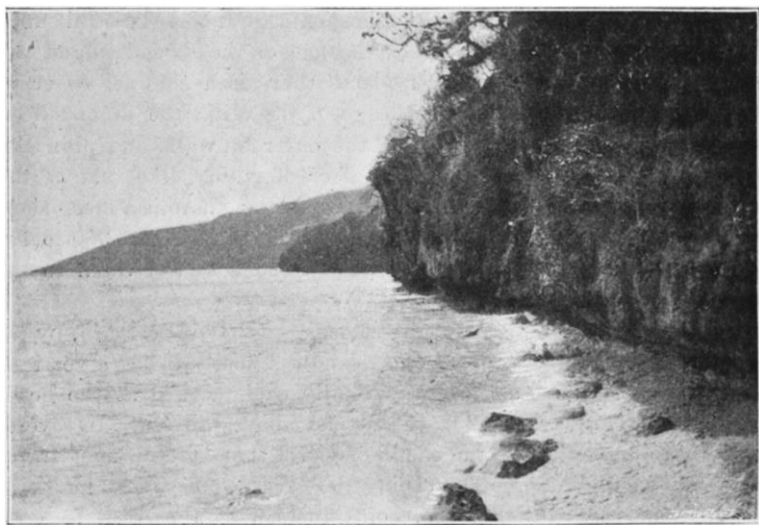
Along the raised rim of the plateau there are a number of hills, the highest of which (Murray Hill) occurs towards North-West Point. It is a nearly flat-topped hill, divided by an oblique valley into a larger and rather higher western portion, and a lower eastern one; the greatest height is about 1170 feet. The summit is formed by masses of dolomitic limestone, and on its lower slopes there are beds of shelly limestone, and a peculiar deposit which seems to be mainly made up of tiny spherules of altered volcanic glass. The outer face is very steep, but toward the south the land first descends gently, then rises a little, finally sinking to the general level of the plateau in a long gradual slope. On the south-western side there are occasionally patches of rounded pebbles, which are of a volcanic nature, and are, perhaps, derived from the bed above mentioned. Similar nodules occur in many places on the higher parts of the island.

The next highest hill (Ross Hill) is over South Point. It also has a flat top covered with dolomitic limestone, in which traces of gastropod shells are visible. On its outer side there is a low cliff, and below this a long steep slope covered with blocks of limestone in the wildest confusion, and thickly overgrown with creepers and brushwood. Towards the plateau also the descent is rather abrupt.

Over North-East Point is another elevation (Phosphate Hill), which, though not so high (900 feet), is particularly interesting on account of the extensive deposit of phosphate of lime which is found there. This substance is strewn over the surface in blocks of all sizes, and in some places it is found to a considerable depth; in others, however, it can be seen to rest directly on an irregular surface of dolomitic limestone, occasional pinnacles of which project through it. At the northern end of the hill the phosphate is found on both outer and inner slopes, but farther south on the plateau side only, the outer being occupied by a reef of limestone, which descends to the terrace beneath in a low cliff. The area actually covered by this thick deposit of phosphate of lime is about half a mile long by a quarter broad, but an immense quantity occurs in the form of irregular nodules and blocks scattered over all the slopes and terraces of this part of the island. There are other less extensive beds over Flying Fish Cove, and also at several points along the eastern edge of the plateau. Probably, when the islands were still low and not covered with forest, they formed the homes of myriads of sea-birds, and the guano thus formed, after undergoing alteration mainly through loss of its organic matter, gave rise to the hard phosphatic rock now existing. At the same time the

limestones on which it rests have often been phosphatized, and lumps of coral consisting mainly of phosphate of lime are sometimes found. The extensive accumulations of guano which must have taken place, point to a time when the rainfall was much less than at the present day, a condition which may, at least in part, have been dependent on the circumstances that the islands were low and probably free from forest.

On the eastern rim, between Phosphate Hill and Ross Hill, there are several smaller elevations, all presenting similar characters, viz. having on their seaward side a steep talus slope or low cliff, a flat top, and a moderate declivity on the inland side. Between the hills both on the north and east coasts, the rim of the plateau varies a good deal in character. As a rule, its outer edge is marked by a kind of rampart of



NORTH COAST, LOOKING NORTH-EAST TOWARDS SMITH POINT.

lines of limestone pinnacles separated by channels, but sometimes it descends by a gentle slope; in either case beneath the cliff or the slope there is always a steep talus-strewn declivity passing down to the first terrace.

The northern part of the plateau within the elevated rim is particularly characterized by the presence of numerous low hills (about 50 feet), with more or less flat tops covered with blocks and pinnacles of limestone. Further south there are several step-like ridges, running in an approximately east-and-west direction; their southern face is covered with blocks of limestone, composed mainly of rather fresh-looking corals. In a few places similar limestones form extensive reefs, cut up into deep channels and holes. These reefs, when covered with thick bush, form almost impenetrable obstacles.

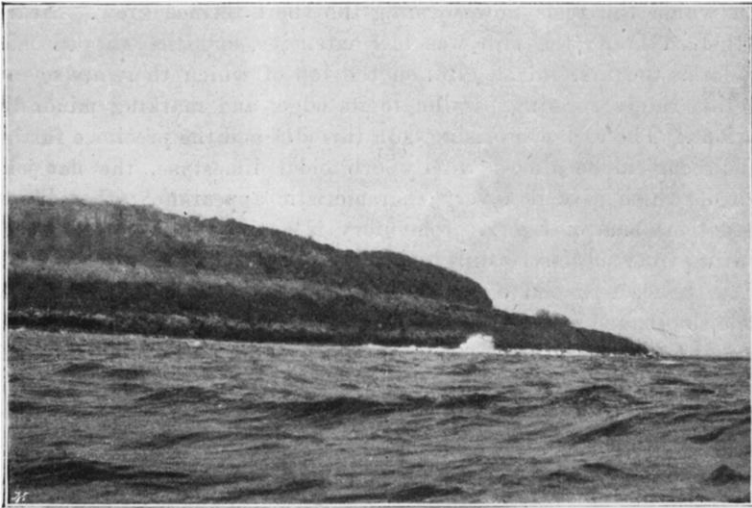
The Upper Slopes and Terraces.—As already mentioned, there is beneath the edge of the plateau a steep slope usually covered with talus; where the rocks composing it are exposed they are found to consist of foraminiferal and coral limestones, and are often full of angular fragments of older limestones. Beneath this slope is a level terrace varying in width from a few yards to a quarter of a mile or more, and bounded on the seaward side by a second steep declivity, or in places by an actual cliff. The rocks composing this usually show very distinct traces of coral, and sometimes seem to be entirely composed of it. This slope is absent on the southern side of the island.

The next terrace also varies considerably in width; on its outer margin there is usually a broad belt of limestone pinnacles, separated by channels. In the neighbourhood of Steep Point, it rises into a rounded hill covered with blocks of phosphate of lime. This hill must have formed a small islet at the time the foot of the second inland cliff was washed by the sea. In other places there is a channel 40 or 50 yards wide running parallel to the edge of the cliff; the inner side is formed by a cliff 30 or 40 feet high, the outer by walls and pinnacles separated by branching channels, the floor of which, like that of the main channel, is perfectly level. Towards the sea there is a steep slope covered with blocks of limestone. When the sea was from 350 to 400 feet higher than at present, this channel formed a sort of canal in the reef parallel to the coast.

Beneath the terrace just described comes the first inland cliff, by far the most conspicuous feature of the island. Usually it has a vertical, or nearly vertical, face, and it is especially well marked at the headlands. Its summit is from 250 to 300 feet above the sea. In several places about 150 feet above the shore platform there are distinct traces of wave action, the most notable being the presence of caves along this line. In some cases beneath this point, instead of a vertical face, we find a steep slope of limestone with coral in position of growth, apparently the remains of a narrow fringing reef, founded upon and partly composed of talus. The fact that the elevation of this cliff has been of an intermittent character is further shown by the fact that where the slopes of the island are gentle and no high cliff has been formed, there is either a succession of minor cliffs separated by terraces and partly built up of coral rock, or merely a slope with ledges of coral limestone. Although these minor cliffs and ledges may be continuous for some distance in any given locality, they do not always correspond to those found a few miles off. It must also be noted that the geological structure and even the origin of this cliff is not everywhere the same, a point that will be referred to more fully below.

The shore terrace slopes gently down from the foot of the first inland cliff to the sea-cliff, which is from 15 to 30 or more feet high, and is often undercut by the waves to a remarkable extent, so that it sometimes

overhangs more than 20 feet. The inland side of this terrace is usually covered with pinnacles of rock similar to that forming the cliff above, and formed part of the fore-shore planed down by the waves. Near the sea the terrace is clearly a raised fringing reef resting on a foundation of talus; the corals are often very fresh in appearance. In some localities this platform has been cut into the older rocks (orbitoidal limestones, basalts, etc.) which form the basis of the island, and in such places small streams may occur, the water being held up by the volcanic rocks. The point where these are best developed is on the east coast, where there are two or three muddy brooks and a small fall of excellent water, which gushes out over a bed of basalt just above high-water mark.



NORTH-WEST POINT.

On the south, where the cliffs are exposed to the full force of the swell produced by the south-east trade wind, which blows most of the year, the coast scenery is very fine. The cliffs are cut into numberless narrow inlets, and their summits are often completely bare of vegetation for some distance from the sea. Blow-holes are very numerous, and several columns of spray rising high above the trees may often be seen at once.

At various points round the coast there are shingle beaches. The most important of these are those in Flying Fish Cove and West White Beach (see map), at both of which landing is fairly easy. There are also two or three others on the north coast, several on the east, and one or two towards the northern part of the west coast; most of these are small, and are shut in by cliffs, and covered at high water.

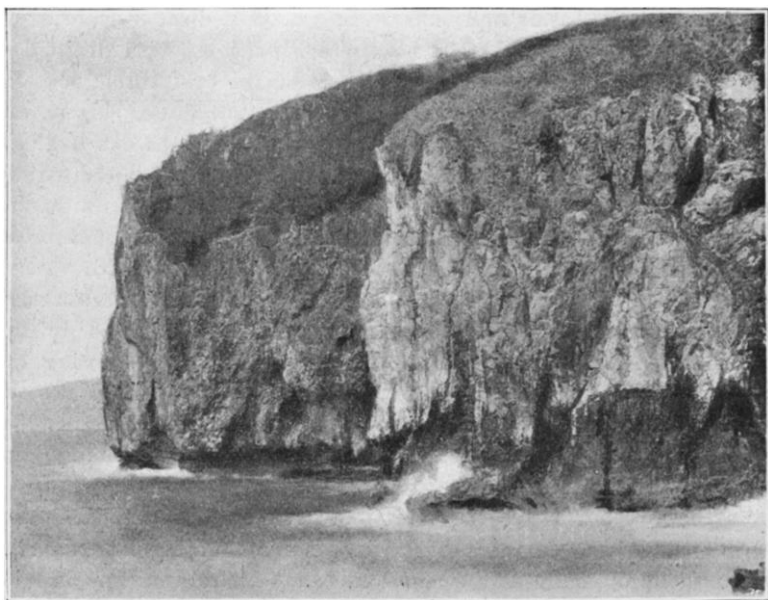
The above is a brief account of the usual plan of the island, but there are several localities in which considerable divergences from this occur. One of these is Steep Point, where a deep fissure, forming a narrow valley, has cut off an angle of the first inland cliff, and the portion thus isolated has tilted forward so that the usual shore platform, if it ever existed, has been carried beneath the sea, and the headland, which is 150 to 200 feet high, is, in fact, part of the first inland cliff.

Again, on the east coast, near North-East Point, extensive slips or faults have taken place, the result being that the ordinary terraces are replaced by a single precipice 500 to 600 feet high, the foot of which is covered by talus of enormous blocks of limestone. In this case the edge of the island as far back as the second inland cliff has slipped down beneath the sea, and has helped to build up the foundation upon which the reefs now forming the shore terrace grew. Nearer North-East Point the slip was less extensive, and the slipped mass here forms the first inland cliff, on the top of which there are several step-like ridges running parallel to its edge, and marking minor dislocations. The rock comprising both this cliff and the precipice further south seems to be almost wholly orbitoidal limestone, the flat joint faces of which give it a very characteristic appearance; the cliff on the southern side of Egeria promontory is similar, and the small cliffs resulting from successive slips can be seen in the photograph.

At the western end of the island the upper cliffs are replaced by gentle slopes, and even the first inland cliff is ill defined, except towards North-West and Egeria Points. Another characteristic feature of this region is the occurrence of several valleys running down to the sea in a generally south-westerly direction. These first commence as a shallow depression at about 400 feet, but as they are followed seawards, deepen to a narrow gorge which cuts through the first inland and sometimes the sea cliff also. The scenery of these valleys is the most picturesque on the island, and reminds one a little of the dales in the mountain limestone in the Peak District. The floor is generally formed of volcanic rock (basalt), and in the wet season is occupied by a small stream, which descends to the sea by a succession of falls and rapids; at the time of my visit water was only found in the northernmost valley.

The last locality to be described is Flying Fish Cove, by far the most important, because it seems to supply the key to the structure of the island as a whole. In the large-scale map of this district, it will be observed that at this point the sea-cliff is interrupted, and its place taken by a long curved stretch of white shingle beach, in front of which a broad fringing reef stretches from one end of the cove to the other. Behind the beach is a nearly level platform, composed mainly of blocks and fragments of coral mingled with talus from the cliff above. This level has been, for the most part, cleared and planted with coconut palms, fruit-trees, and vegetables, and is the site of "Clunies-Ross

Settlement," which consists of some nine or ten houses, workshops, and stores. The cliff forming the back of the cove is about 500 feet high in the middle, but decreases in height towards the ends, and towards the north the slope becomes less steep. For the greater part of its length it consists of alternations of low, more or less vertical cliffs, with steep talus slopes; but towards the southern end, the upper part forms overhanging precipices 200 feet or more in height, while the lower portion is covered by a talus slope of limestone blocks, often as large as a fair-sized cottage. Some of these lie far out on the reef. In this cliff and in its immediate neighbourhood we have almost the only section from which it is possible to get an idea of the nature of the foundation upon which



STEEP POINT.

the upper reefs have been established; almost everywhere else the central portion of the island is concealed by the investing covering of more recent limestones which have formed round the island, either as sediment derived from the higher coral masses, or as reefs which have grown on the slopes of the island during its elevation. The circumstance that nearly all the rocks of the island are white limestones, often largely made up of fragments of older beds or containing fossils derived from them, renders the interpretation of the facts observed a matter of great difficulty. It will not be necessary, however, here to enter into details of the geology of the island, and only a brief sketch of the structure of the neighbourhood of Flying Fish Cove is given.

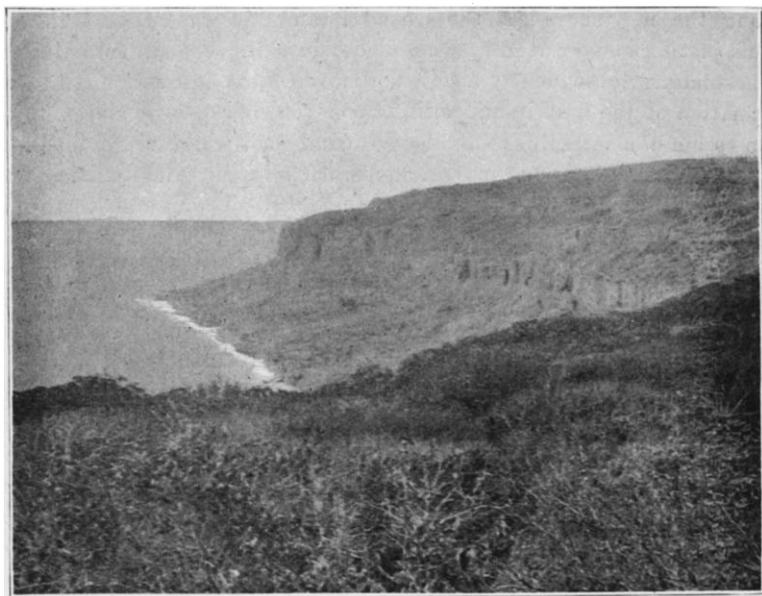
Round the greater part of the cove, about halfway up the cliff, there is a thick bed of yellow foraminiferal limestone, the nearly vertical face of which is from 15 to 60 feet high. Beneath this, and apparently penetrating its lower surface, are several masses of volcanic rock, mainly basaltic. Above the limestone is another bed of basalt, upon which there are thick bands of palagonite tuffs, and occasionally traces of basalt above these again; but the upper slopes are so thickly covered with soil and fallen blocks of limestone, that it is difficult to determine the exact structure of this part of the cliff. About the middle of the cove, the hard limestone is found at a rather higher level, apparently the result of faulting, but its relations to the volcanic series are the same. Southward of this the bed dips downward towards the shore, and the basalt and tuffs resting upon it disappear abruptly, their edges being overlapped by hard white limestone with *Orbitoides*. This rock forms the upper 50 feet or so of the cliff throughout its northern half, and on the summit occurs in low cliffs, ridges, and pinnacles. At the southern end of the cove it thickens out to a cliff some 250 to 300 feet high, the lower part of which is penetrated by masses of basalt. On the terrace above the cliff to the southward this limestone is found on the eastern and western sides of a broad belt of basalt, which forms a series of rounded hills with valleys opening toward the sea. On the eastern side its base is about 500 feet above the sea; on the west, where it is largely concealed by the more recent deposits forming the cliffs and terraces representing the first inland cliff, it is only 300 to 350 feet. No doubt this limestone once completely covered the basalt, but has been removed by denudation; and, in fact, further south the volcanic rock is completely concealed by limestones.

Further inland, above the orbitoidal limestones comes the steep slope of the second inland cliff, which is here largely composed of corals; shells of mollusca are also found, and there are some beds of foraminiferal limestone without *Orbitoides*. Above this cliff is a long slope with lines of limestone pinnacles parallel to its edge, and above this again the upper inland cliff or rather slope. Along the foot of this there are some ridges of coral limestone; but towards the summit it rises into rounded hills of dolomitic limestone, with a great many blocks of phosphate of lime here and there. These hills are probably the remains of islets along the edge of the lagoon (now the plateau) before the first elevation of the island took place.

The history of the island, as far as it can be made out, seems to have been as follows: At first, at no great depth, there was a submarine bank upon which numerous foraminifera, including *Orbitoides*, lived, and the shells of which formed thick beds of limestone. The foundation of this bank was volcanic, and from time to time lava was erupted through and upon the limestones: the occurrence of thick

bands of palagonite tuff indicates that the eruptions were submarine. Some elevation took place, and the beds of tuff became consolidated by the infiltration of lime. In the next place, the whole was covered with thick beds of white limestone crowded with large *Orbitoides*. These strata seem to have overlapped the edges of the beds of tuff, and in places it can be seen that they dip away from the central mass. The deposits resting on the orbitoidal limestones are for the most part covered with recent accumulations, but they appear to have been mainly foraminiferal limestones.

Upon the foundation thus prepared extensive reefs grew up and



EGERIA POINT.

formed an atoll-shaped group of islands, the reef-flat and islands being now represented by the raised rim of the plateau and the hills rising from it, the lagoon by the central plateau itself. The rounded hills and lofty pinnacles found within the raised margin are probably the remains of knolls and masses of coral growing up in the lagoon, such as may be seen in the Cocos-Keeling Islands at the present day. The height of the hills over North-West and South Points may be accounted for by supposing either that they are points of local elevation greater than that affecting the main mass of the island, or that they represent the higher parts of the bank, upon which reefs were formed before the greater part of it was near enough the surface for the growth of reef-corals. During the formation of these higher reefs, the material

derived from their wear, mingled with the remains of organisms living round the coast, formed thick deposits of limestone round the flanks of the island.

The first important movement which took place seems to have resulted in the elevation of the northern and eastern sides of the island, the south and west probably remaining submerged. At this time the reefs forming the second inland cliff grew round the north and east coast, and probably some of the ridges of coral limestone running across the middle of the island were formed near the new shore-line on the side of the lagoon.

The next extensive elevation affected the whole area equally, and along the new shore-line the second inland cliff was cut back into the reefs just formed, or even in some places into the central foraminiferal limestones. Subsequently a series of movements of elevation led to the formation of the first inland cliff, or, on the more gentle slopes, to the succession of small cliffs and ridges of coral rock which represent it.

During these various movements much slipping and faulting took place round the island; the effects of this at Steep Point and North-East Point have already been described. As a result of this, and of the action of the waves around the coast, a submarine talus slope was formed, upon which a fringing reef was established, and at the next elevation this was converted into the shore terrace, while its margins were cut back into the present sea cliff. Finally, as already mentioned, a reef is now growing round the island which some day may form yet another raised terrace.* It is a point of some interest that Mr. Andrew Ross, during the eight or nine years he has been residing on the island, has noted the occurrence of two slight earthquakes, the most severe occurring in October, 1895; this was followed by heavy falls of rock from the cliffs.

Climate.—The climate of Christmas Island is delightful, and during the greater part of the year resembles a very hot English summer tempered with sea-breezes. The maximum temperature recorded during my stay was 89° Fahr. on November 20; the minimum, 70° Fahr. on February 13, when it was raining heavily. The greatest range of temperature in twenty-four hours was 14°. The average maximum and minimum may be taken as about 84° Fahr. and 75° Fahr. respectively, the former occurring an hour or two after mid-day, the latter shortly before sunrise. The prevailing wind is the south-east trade, which blows about three hundred days in the year. During this

* In the above account of the probable history of the island, I have frequently used the terms "elevation" and "upheaval." It would have been better to have used Suess's expression, "negative movements of the shore-line," as there is no evidence as to what share in the changes in the relative levels of land and sea must be ascribed to actual elevation of the former.

time the sea in Flying Fish Cove is calm, and ships can anchor safely. Between December and May the wind now and then shifts round to the northern quarter for some days at a time, and sometimes blows hard from that direction. At such times the sea along the north coast and in the cove is tremendous, and the valley is filled with spin-drift which wets everything, and rises above the high cliff like smoke. The rain also is very heavy and may continue for a week, but usually the mornings are fine. Occasional heavy showers occur at other times, and in the higher parts of the island are frequent at night. Very heavy dews keep the vegetation fresh even after a long spell of dry weather. The



MOUTH OF SYDNEY'S DALE.

island is perfectly healthy, there being no marshes or stagnant pools, while on the other hand there is a fair supply of good water.

Vegetation.—As already mentioned, the whole island is covered with forest, except the spray-swept edges of the sea-cliff and the vertical faces of the inland ones. Near the sea there is usually a belt of thick low forest of ironwoods (*Cordia*), nyamplons (*Calophyllum*), waroo (*Hibiscus*), etc., mingled with pandanus, which in places forms impenetrable jungles. Outside this the cliff usually has a scanty covering of coarse grass and clumps of bushes (*Pemphis*, *Scævola*, etc.). Within it, on the other hand, the rich phosphatic soil supports a thick forest of lofty trees. One of the most remarkable of these is a species of

Gyrocarpus, or winged-fruit tree, to give a translation of the native name, the fruits of which have two membranous expansions, something like those of the fruits of the ash, by means of which they are carried long distances; except during the rainy season this tree is completely destitute of leaves, and since it is very common it gives a very peculiar aspect to the forest near the coast. Other notable trees are the Boognor (*Berrya*), the timber of which is extremely good, and has been called teak; the buttress tree (*Eugenia*), round the base of which buttress-like outgrowths occur, sometimes 10 feet high by 15 or 20 long, and not more than 2 or 3 inches thick—many of the other trees have buttress-like supports, but in none are they developed to this extent; the stinking-wood tree (*Celtis*), the peculiarity of which is perhaps sufficiently explained by its name; the wild sago palm (*Arenga Listeri*). The last is peculiar to the island, and is valuable on account of the excellent sago that it supplies; in favourable localities it may reach a height of from 60 to 70 feet.

Numerous creepers scramble among the treetops and bind them together, and many ferns, including the large birds'-nest fern (*Asplenium nidus*), grow on their trunks and branches, adding greatly to the beauty and variety of the forest scenery. The orchids are few and small. In the middle of the island, besides the comparatively open forest of large trees, there are patches and belts of extremely thick bush, in which the trees, mostly nettles, are not more than 20 to 30 feet high: the undergrowth consists of pandanus, ferns, and creepers, which together form a matted mass exceedingly difficult to get through at the best, and, if growing on a reef of jagged limestone rocks, quite impassable.

Animal Life.—As must be expected in an oceanic island, the fauna is not a rich one. There are only five species of mammals, consisting of two kinds of rats, a shrew-mouse, and two bats. The presence of the rats and shrew must be accounted for by supposing that they were drifted to the island on floating wood, while the bats reached the island by flight. Owing to the abundance of food and absence of enemies, the rats swarm everywhere. At nightfall they appear in troops, and in the bush, within the circle of light round the camp fire, twenty or thirty could sometimes be counted at once, and their peculiar querulous squeaking could be heard on all sides. They get into the tent at night, and even in the house at Flying Fish Cove I have had them run over me while sleeping. They eat nearly everything that can be eaten, and are particularly destructive to the fruits and vegetables that are now being cultivated. A reddish-brown species is by far the more numerous; it is an expert climber, and I have seen it run up the trailing bush-ropes like a squirrel. The second species is black, with thick coarse fur; it is a comparatively sluggish animal, and lives in burrows in small colonies. Both species are peculiar to the island.

Of the bats, one is a small insectivorous species, the other a large

fruit bat. The latter is very common, and a great nuisance, both on account of the quantities of fruit, especially papaias, that it destroys, and also because of the noise it makes, its cry being a horribly harsh scream, apparently uttered during both the inspiration and expiration of its breath. One remarkable peculiarity is that this bat has to a great extent abandoned nocturnal habits, and several may often be seen circling about high in the air in the bright hot sunlight, sometimes



FOREST ON PLATEAU.

even in the middle of the day. It is found only in the island, and, according to Mr. O. Thomas, its nearest ally is a native of Lombok.

The land-birds, except the birds of passage and a small rail, are all peculiar to the island. They include two kinds of pigeon, a hawk, an owl, a thrush, a species of *Zosterops*, and a small swift (*Collocalia*). The large fruit pigeon (*Carpophaga*) is very common, and its deep booming note is the most striking sound in the forest in the daytime. The small ground pigeon, with its bright metallic green back, grey head, and chestnut breast, is the most brilliantly coloured of the island birds,

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but when running among the fallen leaves, its colours harmonize so well with its surroundings that it is very difficult to see. The owl is chiefly remarkable for its peculiar note, which resembles the short bark of a small dog, usually repeated five or six times, but sometimes continued much longer. At night in the forest, half a dozen of these birds may often be heard barking in answer to one another.

The birds of passage nearly all come in the rainy season, and arrive after north and north-east winds; they include whimbrel, plover, snipe, wagtail, swifts, and some others.

The sea-birds are the most conspicuous of the inhabitants, the island being the breeding-place of thousands of frigate-birds, gannets, boobies, etc. The frigate-birds and gannets build in the high trees near the coast; of the former there are two species, one considerably larger than the other—these nest in different localities. These birds are the most important source of the food-supply of the island. They are usually caught thus: A man, armed with a pole 10 or 12 feet long and a red cloth, climbs a high tree near the coast, and, standing on the top-most branch, waves the red rag. The birds are attracted by this, swoop round to investigate, and are knocked down with the pole; in this way enough to supply food for the few inhabitants can usually be obtained without much difficulty.

The reptiles are few and small. There are five or six species of small lizards and a little blind snake (*Typhlops*), which lives in damp places under logs and rocks.

Insect life is fairly abundant. The number of species of butterflies is small, but some of them are very common. Moths are numerous: one grey-and-black species may be seen in thousands, packed together in solid masses several feet long, on rocks and branches of trees. The number of beetles is not very large, but there are several wood-borers which cause great damage to certain trees. After north or north-east winds swarms of dragon-flies often appear, having most probably been blown across from Java.

There are several species of land-crabs, the most common being a little red crab living in burrows all over the island. The robber-crab (*Birgus latro*) is also very numerous, and if one sits down for a short time anywhere in the forest, numbers can be seen approaching from all sides. They are good climbers, and ascend trees in search of food.

The land mollusca and spiders need not be noticed here. One remarkable circumstance is the occurrence of no less than four species of earthworms, two of which are peculiar to the island; their nearest allies seem to be natives of Sumatra and the Aru Islands. It is difficult to account for the presence of these animals in an oceanic island, since both they and their ova are quickly killed by sea-water.

Inhabitants.—For some years Mr. Andrew Ross, brother of Mr. George Ross, the owner of Keeling-Cocos Islands, has been settled in Flying

Fish Cove with his family and a few men from Cocos. During his stay some substantial houses have been built, wells sunk, and fruit-trees and coconut palms planted, and a small experimental plantation of coffee was also made, and the results leave no doubt that the island is well suited for coffee-growing. Recently a number of coolies have been imported from Java to make the necessary preparations for working the valuable deposits of phosphate of lime. When I left the island in May, 1898, the total population was about forty.

Finally, I must express my deep obligation to Sir John Murray, who rendered my visit to the island possible. My thanks are also due to Messrs. G. and A. Clunies-Ross for their hospitality and assistance while I was on the island; and to their nephew, Hugh Ross, who accompanied me everywhere on my various expeditions, and whose knowledge of bush life was of the greatest value to me.

Before the reading of the paper, the PRESIDENT said: We are going to hear this evening a very interesting account of an isolated island in the Indian ocean, which has remained uninhabited during all the centuries until the last ten years, and therefore has developed its flora and fauna without the interference of man. This of course gives the island a special interest to geographers and to all men of science. Mr. Andrews has been, I believe, several weeks in the island, and has forced his way across it through the forest. We have to thank Sir John Murray for having initiated the plan of exploring this island. I now call upon Mr. Andrews to read his paper.

After the reading of the paper, the following discussion took place:—

The PRESIDENT: Sir William Wharton, who gave so interesting an account of Christmas island a few years ago, very much regrets he is unable to be present this evening. I am also sorry to say my friend, Captain Pelham Aldrich, on whose journal Admiral Wharton's account was based, is also unable to be present; but several scientific men are here, and I am sure the meeting will be very much interested to hear their remarks on Mr. Andrews's paper. I will first call upon Prof. Judd.

Professor JUDD: In listening to the very interesting and fascinating paper which has been given to us to-night by Mr. Andrews, I could not help recalling a conversation which I had with Prof. Huxley shortly before his death. We had been discussing that ever new subject, the origin of coral-reefs, when Huxley observed, "I am convinced, from all that is being done now, that we shall not find any simple, easy explanation of all coral-reefs; that the study of coral-reefs is one of the very greatest complexity; that the conditions under which they were formed must have varied greatly in different cases; and that one theory of their origin will probably not be found to suit all the cases." I think that the experience of the last few years will tend to convince every one of the truth of this observation.

There are, I think, two ways in which the study of coral-reefs may be approached—the first is the method which, by the great liberality of Sir John Murray and the wonderful enterprise of Mr. Andrews, has been so well exemplified in the paper placed before us to-night. This method is to find some example of an undoubted coral-reef, which happens to have been raised above the level of the sea, and then cut into by the action of denudation. In that case we get a coral-reef which has been actually dissected. We can observe all the internal structure of the mass,

CHRISTMAS ISLAND

Partly from a survey by

C.W. ANDREWS, F.C.S.

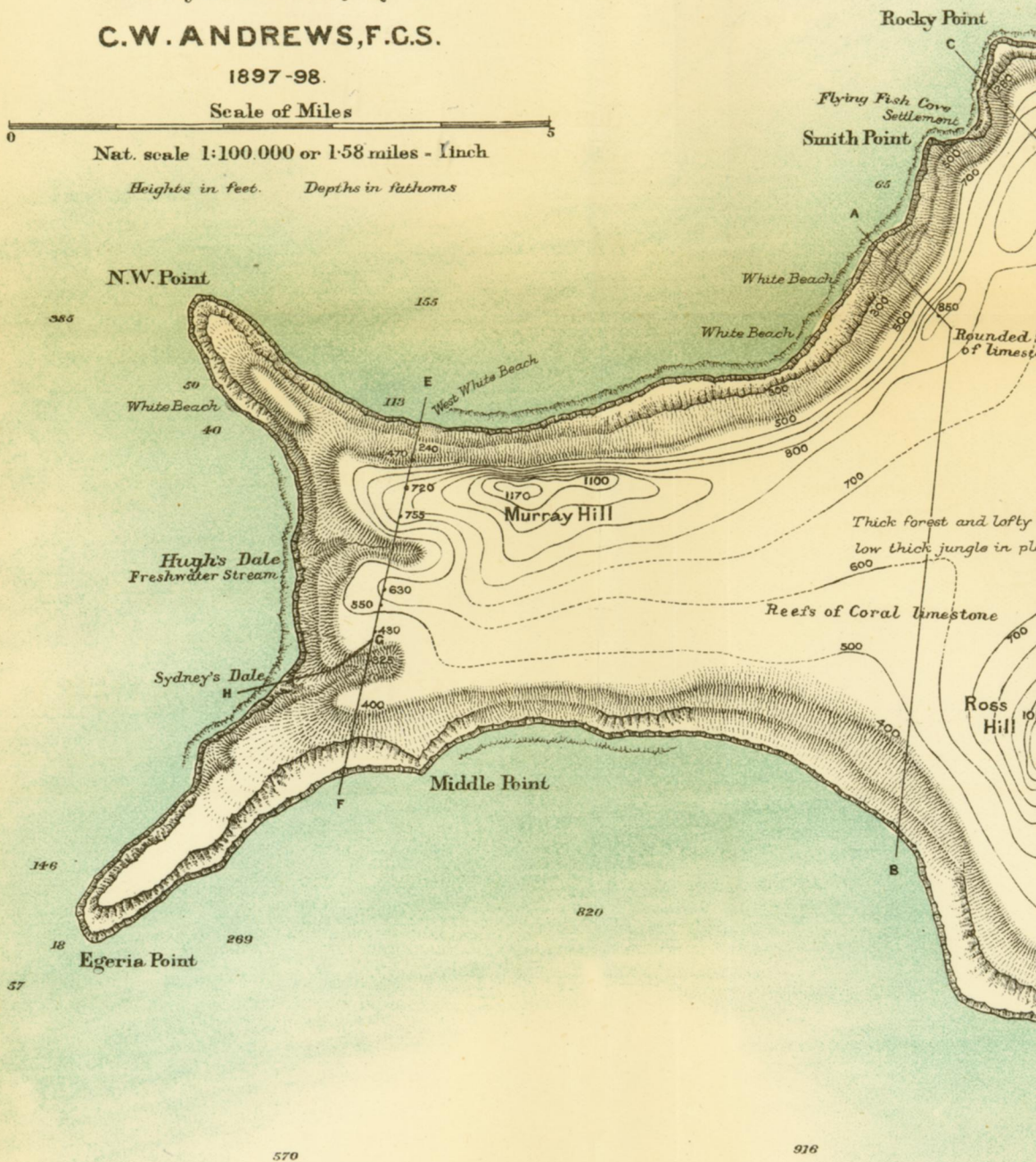
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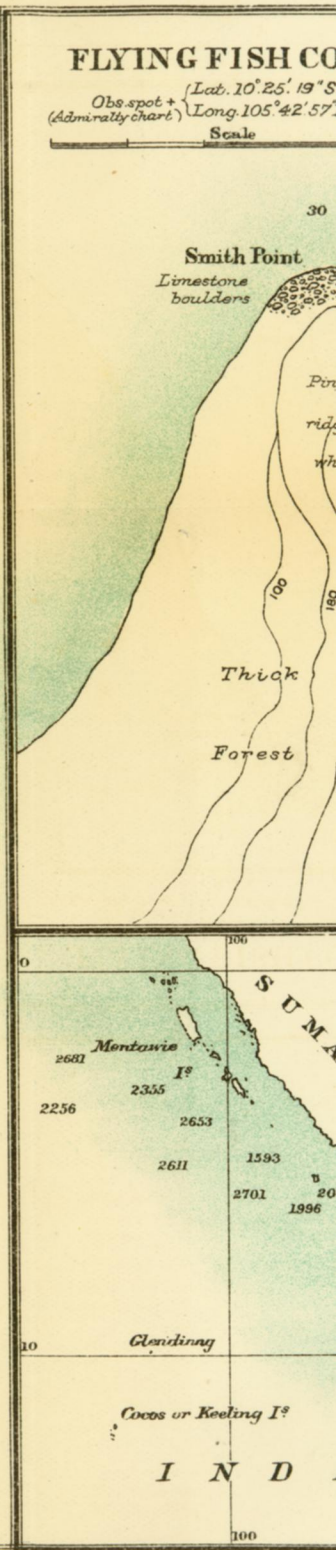
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Heights in feet. Depths in fathoms



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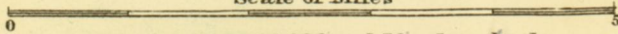


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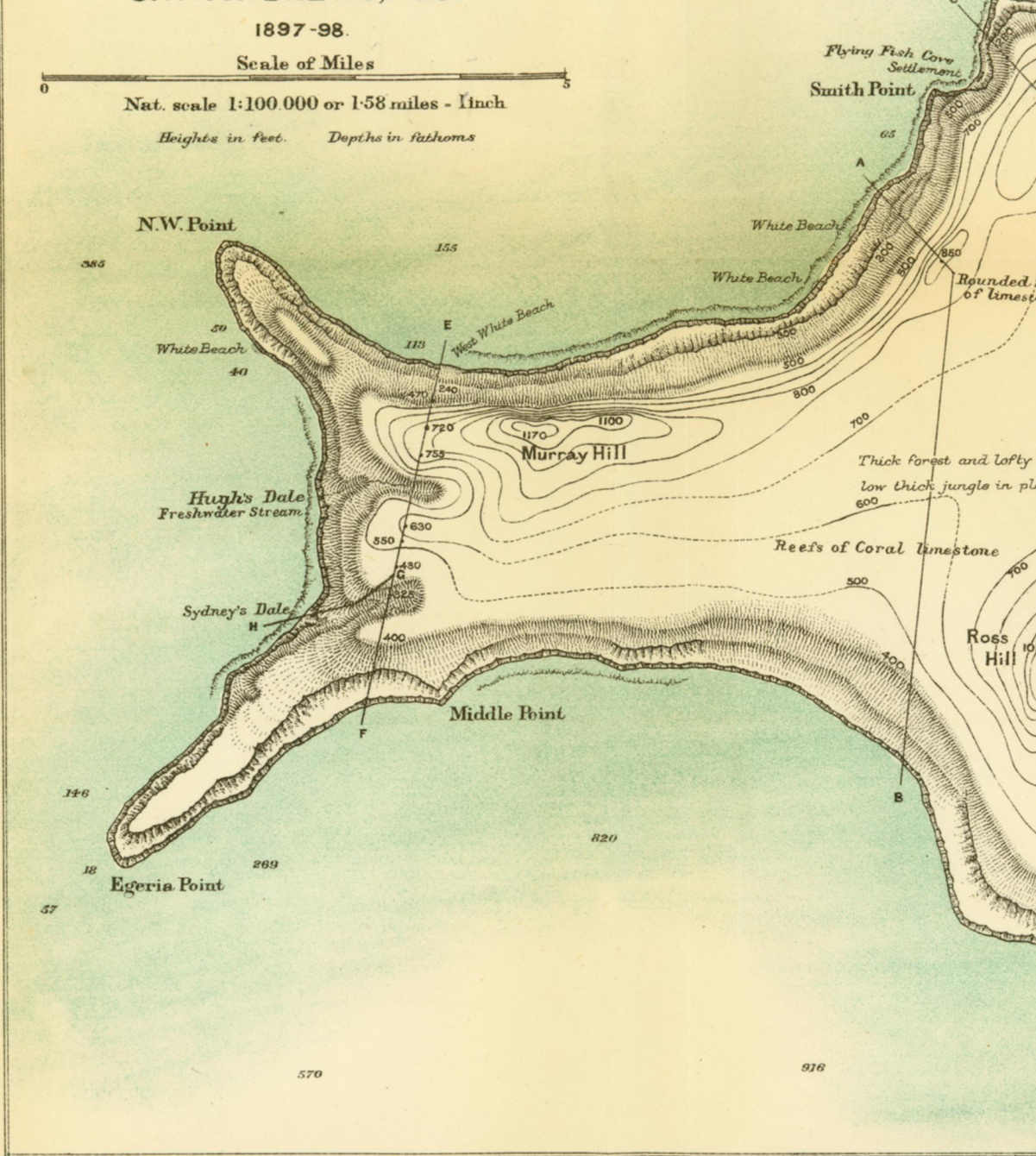
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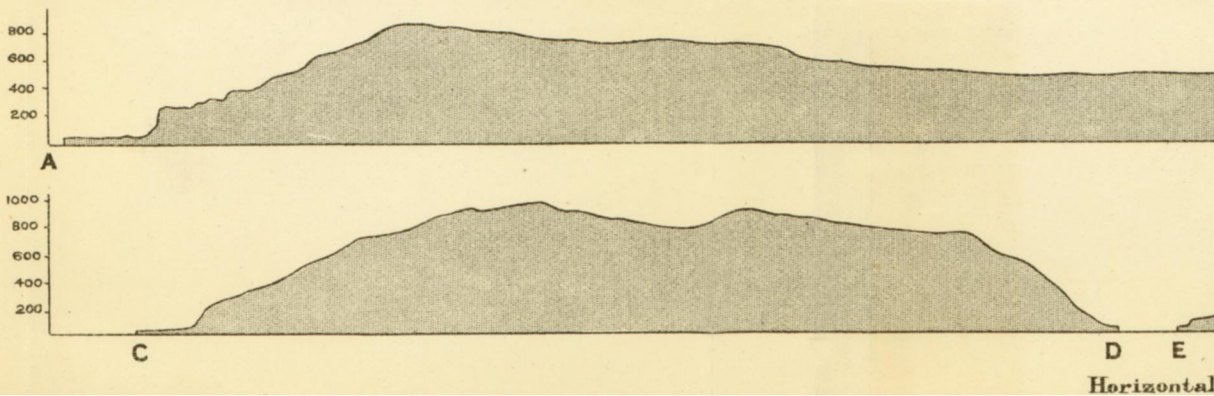


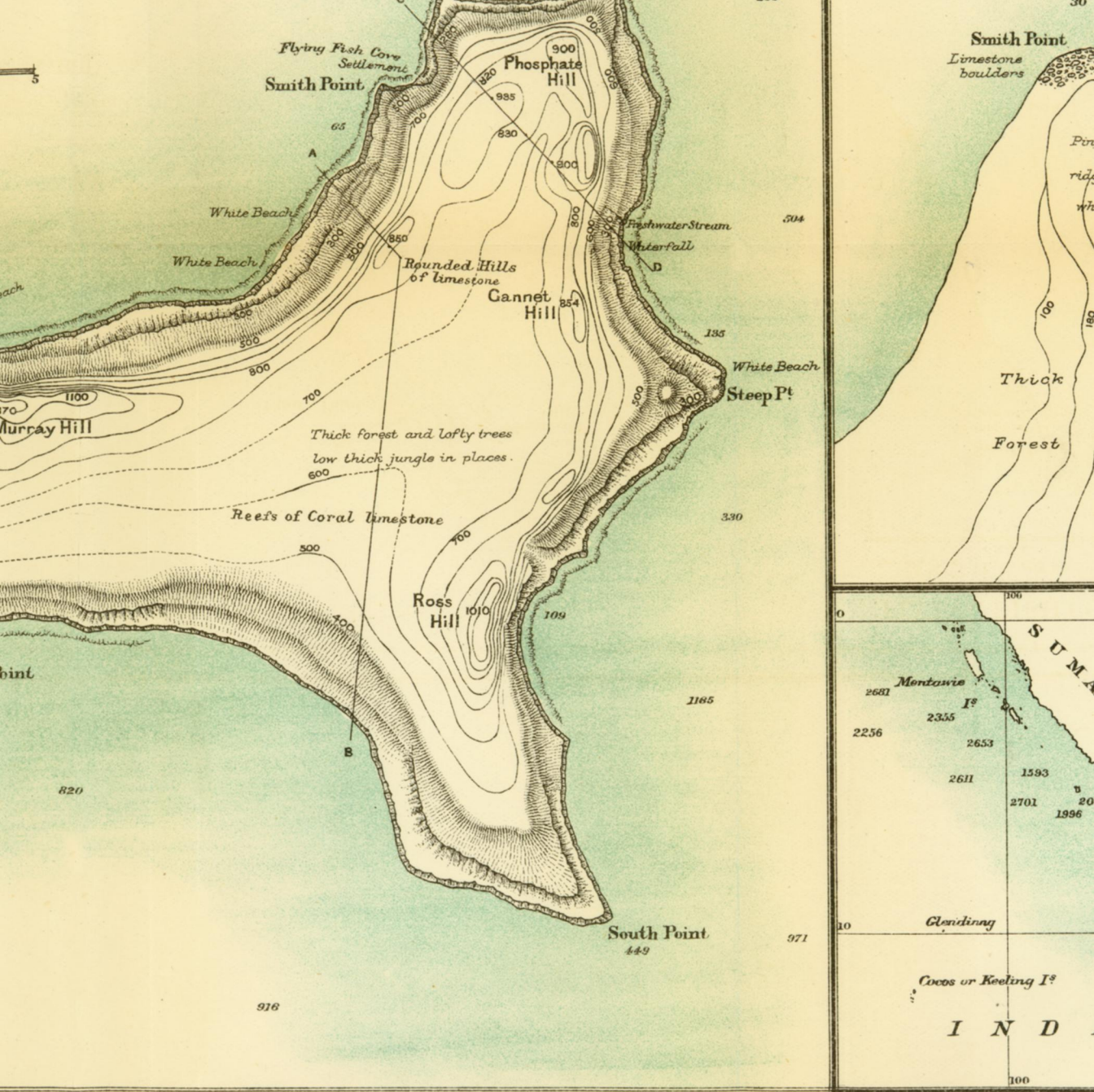
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