

## Chatham Islands.

### The Physical Features and Structure.

By R. S. ALLAN, M.Sc., Otago University.

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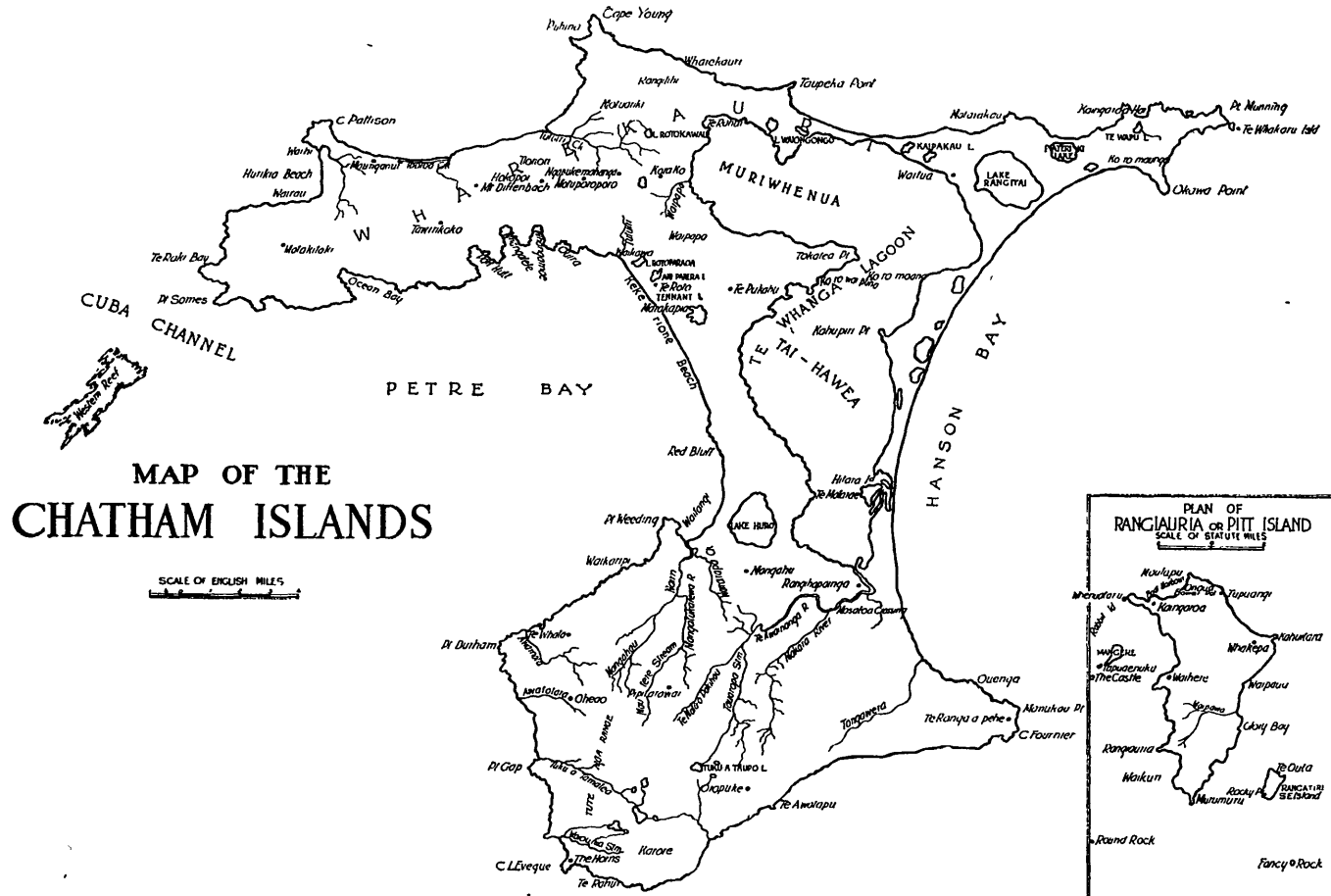
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#### 1. BRIEF HISTORICAL SUMMARY.

THE physical features of the Chatham Islands were first investigated by Dieffenbach in 1840 or thereabout, and since that date several writers have made references *inter alia* to the surface features of the group. Travers (1868) includes comment thereon, but little idea of the topography can be gathered from his remarks. Robertson (1890) and Forbes (1893) give general accounts of the Chatham Islands, in which some observations are of value. Especially valuable, however, is the very accurate topographical map prepared by John Robertson and S. Percy Smith in 1868 and 1883, which goes with the latter's report. Florence (1900), also, gives useful notes on general topography, climate, etc. Cockayne (1901) gives an excellent account of the physiography as it influences plant ecology. The most recent report on the subject is found in Skinner's memoir on the Moriori, the extinct inhabitants of the group (1923).

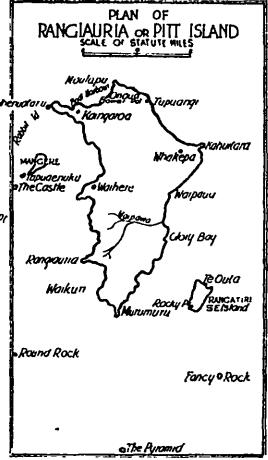
#### 2. PHYSICAL FEATURES.

(a) *Size, shape, etc.*—The group of the Chatham Islands comprises the Main or Chatham Island (Rekohua) and the group of small islands lying to the south east, of which Pitt Island is the largest. The area of the Main Island is 222,490 acres, of which lagoons occupy 46,000 acres. The greatest length of the island as



# MAP OF THE CHATHAM ISLANDS

SCALE OF ENGLISH MILES



a whole measured from north to south from Cape Young to Te Rahui is 30 miles and the greatest breadth across the northern portion of the island from Te Whakaru Island to Te Raki is 35 miles. For convenience in description, Chatham Island may be divided into three portions—a northern, a central, and a southern. The northern portion consists of two peninsulas, lying on either side of the northern and widest portion of Te Whanga Lagoon, and connected only by the very narrow strip of land which in the north separates the lagoon from the ocean.

The western peninsula, Whareka, is about 16 miles in length from Point Somes to Waipapa on Te Whanga Lagoon: and 7 miles at its widest base from the north of Waitangi Beach to the shore near Wharekauri. The average width in the north-south direction is about 4 miles. On the north coast two prominent peninsulas terminate in Cape Pattison and Cape Young respectively. On the south coast and to the west lies Ocean Bay, and further to the east the three smaller indentations Port Hutt or Whangaroa (the only safe harbour of the group), Whangamoe, and Whangatete. Off Point Somes, and separated from it by Cuba Channel, lies the Western Reef or Rangihokopoi which, awash at low water, is a constant menace to shipping.

The eastern peninsula is relatively small, being of narrow triangular shape  $9\frac{1}{2}$  miles in length and 5 miles wide at its base. The apex of the triangle is a rocky schist-formed cape called Point Munning, while three miles south Okawa Point forms the north boundary of Hanson Bay. Facing north, thus sheltered from the southerly and south-westerly gales, is Kaingaroa Harbour, where a refrigerating plant is established.

Most of the central portion of the island is occupied by the southern part of Te Whanga Lagoon. On the east this is separated from Hanson Bay by a narrow strip of low swamp and sand-dune, stretching 27 miles from Okawa to Owenga. On the west the land bounded by Petre Bay is of greater extent and of greater elevation, having a width in the south of  $2\frac{1}{2}$  to 3 miles and in the centre  $1\frac{1}{2}$  miles, while in the north a broad triangular area stretches into the lagoon.

The southern part of the island is a compact 4-sided block with maximum length of  $9\frac{1}{2}$  miles from Petre Bay to Pitt Strait, its southern boundary, and a breadth of 13 miles from Manakau to the Horns.

(b) *Topography of Southern Plateau.*—This block is roughly rectangular in outline, with a prominent peninsula forming the south-east corner and terminating at Manakau and Cape Fournier. It is best described as the much-dissected remnant of a plateau-area which is nearly at sea-level along the south end of Te Whanga Lagoon, but reaches a height of nearly 1,000 feet along the south coast. The highest peaks, which form the divide between the northward and southward flowing streams, lie along and very close to the south coast. The latter is a fault-coast consisting of a series of bold cliffs ranging in height from 600-700 feet. The most prominent peaks in this divide from west to east are Te Whakahewa (the Horns) (865 ft.), Karori, an unnamed peak near the south of Te

Awatapu (938 ft.), two unnamed peaks further east, respectively 865 ft. and 733 ft. and finally Te Ranga (331 ft.) forming the eastern peninsula.

From the Horns, high broken country extends in a northerly direction to Pipitarawai (931 ft.) a peak heavily wooded and difficult of access. This range from the Horns to Pipitarawai forms the main divide separating the northward flowing streams in the east from those which flow to the west.

Nearer the west coast is another stretch of high country, the Tutenga Range, which forms the north-west slopes of the block, the highest points being Whangamarine (771 ft.), Oehau (640 ft.), and Te Whata (441 ft.). An extension of this range runs north with decreasing height almost to Waitangi.

In the interior a smaller ridge diverges from Pipitarawai, and running north-east divides the Tauaropa Stream, a tributary of Te Awainga River, from the Mangatukawera and the Mangahau, which unite to form the Nairn.

In the north of the block, Mangahau (356 ft.) is a more or less isolated peak.

(c) *Topography of Central and Northern Areas.*—In strong contrast to the southern area, the northern is lowlying, while mature slopes are the rule.

As a whole this area is roughly T-shaped. On the west side is the large indentation, Petre Bay, which is roughly square in outline, which suggests that it owes its origin to subsidence of a large block formerly bounded in the south by the coast from Waitangi to Point Durham, and on the north by the coast from Waikawa to Point Somes. Apart from their straightness, both these shore-lines give evidence that they may be classed as fault-coasts.

On the east side is Hanson Bay, which stretches from Owenga in the south to Okawa in the north, and is separated from Te Whanga Lagoon, which occupies most of the stem of the T, by a very large lowlying sandspit.

The central area extending from Waitangi to Te Roto and Wai-papa, is highest at Red Bluff (244 ft.), and at Te Pukahu (210 ft.), but is generally much lower. In the main it is limestone country, and everywhere has been eroded into mature rounded slopes of monotonous regularity. Except along the west shore of Te Whanga and at Red Bluff, outcrops are rare. Most of the area is covered with fern or scrub.

The small north-east peninsula is featureless swamp-covered country with outcrops restricted to the coasts. The highest points are Waitua (90 ft.), Matarakau (126 ft.), Kaingaroa Hill (193 ft.), and Koromaunga Hill near Okawa Point.

The north-west peninsula is of greater interest. The north central area surrounding Wharekauri was a region of volcanic activity and shows volcanic piles in various stages of erosion, depending largely on whether the hills in question are composed of solid lavas or relatively soft tuffs and breccias. Rangitihi (627 ft.) is a rounded bush-covered peak, while other peaks are Puhina (327 ft.), and Motuariki.

The remainder of the peninsula is a remarkable uniform peneplain cut in the old schist undermass. The peneplain is slightly tilted, being near sea-level along the north coast, but considerably higher, in one place as much as 230 ft., along the south coast. The uniformity of the surface is broken by several volcanic residuals which have frequently been eroded into almost perfect cones. In all cases, however, the peaks represent, not craters, but blocks of the covering sheet of Tertiary rocks which have escaped complete erosion. Hence the peneplain is a "fossil plain." The main peaks of the area are Korako (588 ft.), Ngapukemahanga, Motuporoporo, Hokopoi, Dieffenbach, and Maunganui (587 ft.). Since these are in practical alignment in an east and west direction, and since the strike of the underlying schist is east and west, it seems probable that these represent a line of structural weakness. Two further peaks off this line are Tawhirikoko, and Matatakitaki (518 ft.).

Maunganui is a picturesque rugged pile composed of some 500 ft. of tuffs overlying a flow of monchiquite and a limestone. The northern side represents an old cliff-face and gives evidence of minor fluctuations of level discussed below.

(d) *Lakes and Lagoons.*—A large area of this island-group is covered by lakes and lagoons. Of these the most noteworthy is Te Whanga Lagoon, which occupies about one-fifth of the total area of the island.

It is roughly shaped like an inverted L. The southern arm is called Tai-Haweia, while the northern east-west wing is Muriwhenua. On the north and east sides the lagoon is bounded by long low-lying sand-bars. The northern bar is the older, and is covered for the most part with peat swamp. The eastern spit stretches from Okawa Point almost to Owenga—a distance of 27 miles.

The length of the lagoon, north and south, is 15 miles; while the length of the north arm is 9 miles. The widest part of the southern stretch is 5 miles across.

The west side from Tokatea Point to Te Matarae is bounded by low limestone cliffs. From the former point west and north to Te Rahui the cliffs are still lower and consist of limestone, schist, and basalt.

Little is known as to the depth of the lagoon, but it seems that it is generally shallow. After prolonged south-west gales the waters are banked up, exposing large tracts of weed-covered bottom.

Cockayne notes that "the floor of the lake consists of sand or of sandy, peaty mud, formed from the decay of many generations of plants." (1901, p. 272.)

The lagoon can be crossed by two main fords. One from Korowaipuna to Kahupiri Pt.—a distance of 4 miles—lies for part of the way on a submerged shelf of hard limestone. This is the main thoroughfare from Waitangi to Kaingaroa. The second ford crosses the narrow southern area from Te Matarae to Hitara Island.

The eastern side of the lagoon is bounded by an extensive line of moderately-recent sand-dunes, through which the lagoon periodically breaks a passage out to sea. No evidence was obtained as to how often this overflow occurred, but it may be noted that it was running freely at the time of our visit.

This large lagoon is almost certainly a cut-off arm of the sea, the inner coast being clearly an old sea-cliff. This old shore-line probably commenced in the north near Taupeka Point, followed the present western margin of the lagoon to Te Mataarae and thence by way of Lake Huro to Petre Bay.

Lake Huro, which lies between the southern end of Te Whanga and Waitangi, was formerly part of Te Whanga. It is separated from Petre Bay on the west and from Te Whanga on the east by low sand-hills or swampy ground.

Lakes Rangitai and Pateriki in the north-east peninsula are probably of like origin. They are both surrounded by low-lying peat swamp and have been separated from Te Whanga by the formation of sandspits. Pateriki is separated from the sea on the north only by a small line of very recent dunes.

Several other lakes, e.g., Wharo, Waiongongo, Kaipakau, and Te Wapu, owe their form and position to similar circumstances.

Another type of lake is represented by Rotokawau, and some others unnamed lying on the flat peneplain in the north-west peninsula of the island. These lakes are small and shallow, and occupy depression in peat land. They probably fill areas which have been burnt out of the peat by ancient fires. There is usually no drainage into them—at least by way of streams.

A third type of lake is found near Te Roto. Here is a series of fairly large lakes of beautiful, clear fresh water. These are, from north to south, Rotoparaoa, Ahi-Parera, Te Roto, Tennant Lake, and Marakapia. These lakes are picturesquely situated in a series of bush-surrounded depressions, Tennant Lake and Marakapia being of considerable size. Their origin is not clear, but their presence is probably due to a combination of two factors—the formation of old and recent sand-dunes on their seaward side and solution of the underlying limestone. No data as to depth are available.

(e) *Streams.*—The two largest streams are the Nairn and Te Awainanga. The Nairn rises from the great peat swamp area on the north side of the Tutenga Range. Its two main tributaries, the Mangahau and the Mautere, flow in a north-east direction, and drain a large area. The main part of the Nairn flows north to enter the sea at Waitangi—the chief township. In early whaling days the mouth of the Nairn gave a safe anchorage and a constant supply of fresh water.

Te Awainanga, the largest stream in the group, which has its source in the high swampy country round Lake Tuku-a-Taupo, drains nearly one-third of the southern plateau region. The main tributaries are the Makara, Tauaropa, and Te Mata-o-pakihau. At Moeatoa Ford, Te Awainanga passes over a basalt flow as a picturesque waterfall. The stream here has considerable volume, and the fall is a potential source of electrical power. Below this, Te Awainanga flows through low swampy flats into the south end of Te Whanga.

Both these streams, in fact most of the streams of the island, are very sluggish; their water is a dark-brown colour, and where their bed is not on basalt, it is usually covered by a layer of peaty mud. The streams which drain the south-west corner of the island

are very different. The Awatotara, the Tuku-a-Tamatea, and the Waipurua are all vigorous streams of fresh pure water. They are older than the uplift which gave rise to the plateau, and hence have cut out deep narrow gorges. The Waipurua stream enters the sea over a ledge of columnar basalt, falling about 40 ft., and forming a magnificent spectacle when the creek holds any volume of water.

Few creeks enter the sea on the southern coast—the divide between the north-flowing and south-flowing drainage systems being very close to the sea cliffs; in fact one can stand about 50 yards from the cliff-face and look northward right down the valley of the Tongarewa Creek to its mouth near Owenga.

In the northern half of the island the drainage-system calls for little description. The Waihi in the west, the Tutuiri near Tioriori, and the Waipapa running into Te Whanga, are all of fair size and drain large areas of swamp land. Of these three the Tutuiri has the largest watershed. The water is always tea-coloured and slightly acid.

The relation between drainage lines and geological structure will be discussed later.

(f) *Swamps*.—There is little of the surface of the island that has not at least a superficial covering of peat. The climate seems to be peculiarly suitable for the luxuriant growth of peat-producing plants. Accumulation of peat is as a rule most extensive in cool, damp climates such as that of Ireland, and the Chatham Island deposits seem therefore to be formed under normal conditions.

Almost the whole of the north-west peninsula, which is in the main a slightly-tilted peneplain, is peat-covered. The swamp-area extends from the foot of Korako and passes west to the end of the peninsula. From Tawirikoko to the west coast the swamps are very extensive, and contain a large volume of water. Another extensive area is found between Motuariki and Cape Young. The watersheds of the Waipapa and the Tutuiri drain yet another peat-covered region. The north-east peninsula from Taupeka Point eastwards is likewise monotonously low-lying and swampy. Smaller swamps are found near Lake Marakapia and again in great extent round about Lake Huro. The Nairn and Te Awainanga streams drain many square miles of swamp covering the southern plateau.

Peat swamps are in fact so general that they are a hindrance to geological investigation. The main outcrops of rocks are to be found along the shore-lines. In winter the swamp areas are impassable, and even in such a favourable season as our expedition experienced, many of the bogs and sphagnum depressions were so wet as to make dangerous any attempt at walking across them. Peat must have been forming for a considerable period. At Whangate Bay there are cliffs of peat nearly 40 ft. in height—these cliffs contain at least three buried forests. It is of interest to note that in the present swamps are numbers of large totara (*Podocarpus totara*) logs. The totara is not now found growing anywhere in the Chathams.

(g) *Coast-lines*.—For its size the Chatham Island group has a great linear extent of coast-line: and, since the rocks of the group



FIG. 1.—Schist coast, Waikawa, looking west along the strike.

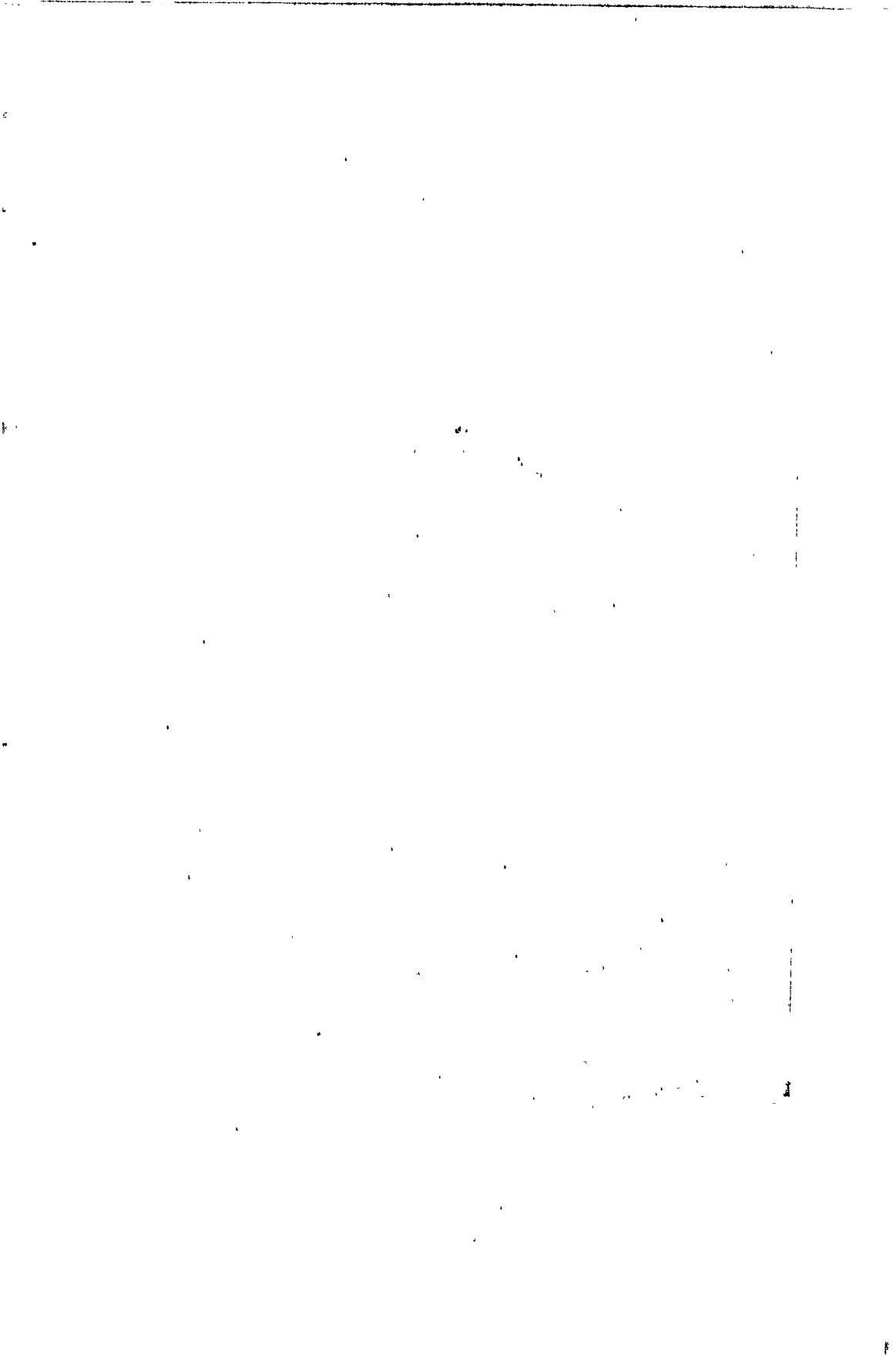
*(Photo by Wm. Martin.)*



FIG. 2.—Uplifted platform, Mopihanga Creek, Ouirā Bay.

*(Photo by Wm. Martin.)*





are extremely diverse—metamorphic, sedimentary and volcanic rocks being represented—the variety of coastal profile is considerable.

(1) Coasts cut into quartz-mica-schists. This type of coast is beautifully illustrated along the south shore of the north-west peninsula from Waikawa to Point Somes. (See Fig. 1.) The shore is approximately parallel to the east and west strike of the schist, while there is an average uniform seaward dip of  $30^{\circ}$  S. As a rule the shore-zone is wide and the profile regular and of slope less than the angle of the dip. Weathering seems to occur most readily in the direction of the strike, hence fissures running in this direction are the rule.

This shore appears to have been due initially to faulting, but has since been depressed and is now approaching a mature stage. The tributaries of the streams that enter the indentations on this shore (Ocean Bay, Whangaroa, etc.) have been converted into independent streams. In other words, the bays are small drowned valleys, the creeks are betrunked, and the small river-systems are dismembered. More recently a slight uplift occurred and there is a wave-cut platform, now 10-15 ft. above high-water. This is clearly seen on the basaltic columns which are intrusive into the schists at Ouirā Bay. Fig. 2.

A rather different coast-type is found in the schist area from Kaingaroa to Point Munning. Again the strike is parallel to the coast but the dip is very steep—from  $65^{\circ}$  to  $80^{\circ}$  N. The coast is therefore very rugged and broken, consisting of a series of razor-back ridges running east and west. Stacks are of frequent occurrences.

(2) Coasts cut into sedimentary and tuffaceous rocks. Such coasts are well developed in the Wharekauri-Cape Young-Tioriori section in the north of the island. The rocks differ considerably in hardness and stratification; tuffs, massive or well bedded, soft green-sands, and occasionally lava-flows and dykes go to make a most irregular coast. Generally the cliffs are abrupt and youthful, talus-slopes are not greatly in evidence, but well-defined wave-cut platforms are a feature.

At Red Bluff cliffs cut in hard limestone and tuff rise sheer from the sea. South of Waitangi fine cliffs are cut into tuffs and tuffaceous limestones. Wide, flat, and remarkably regular wave-cut platforms are here beautifully developed. The shelf is often more than 20 yards wide and is covered at high-water. In places it is littered with large fallen blocks of tuff. It stops suddenly, and there is a vertical drop into deeper water (about 6 fathoms at Waitangi cattle-yard).

Similar platforms are cut into well-bedded tuff at Owenga, at various places on Pitt Island, viz., Onoua, Moutapu, Kahuitara, on the north and east coasts of South-east Island, and elsewhere.

(3) Dune-coasts. Sand-dunes, some of Pleistocene age and others formed within the history of man, form large stretches of the coast-line. The most notable rise from a huge spit running from Okawa to Owenga, 27 miles, which cuts off an extensive arm of the sea to form the large lagoon, Te Whanga. The dunes here reach a height of 60 ft., but the average is much less. On the inner side

of this spit are great stretches of fine sediment covered with salt-marsh vegetation. This area seems to be gradually encroaching on the lagoon region. (For a description of the salt-marsh areas see Cockayne, 1901.)

A coastal strip of high dunes runs from Matarakau to Wharekauri, and another from Waikawa to Waitangi. Much of this dune-formation is of recent origin, and this is accounted for by the introduction of stock, which tramped down or ate out the succulent plants formerly acting as binding agents fixing the dunes. Immediately north of the mouth of the Nairn, fifty years ago low swamp extended almost to high-water mark, but there is now on the seaward side of the swamp which extends inland to Lake Huro an extensive zone of dunes a quarter of a mile wide and 50 to 60 ft. high. These dunes and others elsewhere have been planted in coarse grass, which helps considerably to check further advance. These facts, given by Messrs. Seymour and McClurg, receive support from the occurrence of seams of peat, containing large logs, which outcrop on the Waitangi Beach.

At the north end of Kekerione Beach from Waikawa to Te Roto, and again further north between Taupeka and Matarakau, advancing dunes are burying former extensive forests of karaka (*Moriore kopu*, *Corynocarpus laevigata*).

Although the introduced stock may upset the equilibrium between vegetation-control and dune-formation, this factor cannot be the only one at work. An area covering several square miles of more ancient dune (in the formation of which stock played no part) is found on the shores of Te Whanga between Waipapa and Titi-rangi.

In several localities the existence of more than one cycle of dune-formation is shown, and different phases of the present cycle may be noted. Thus at Te Roto, dunes are forming at an alarming rate, i.e., progradation is occurring; while at Maunganui and elsewhere on the north coast the first cycle dunes are suffering degradation by the continued action of the sea-waves.

(4) Coasts cut in volcanic rocks. At Maunganui the coast shows several interesting features. Maunganui itself stands guard as a bold, rugged rampart over the western end of the north-west peninsula. On the seaward side it rises almost perpendicularly from sea-level to a height of nearly 600 ft. Its lower portions are protected by huge talus slopes covered with native bush. The cliff is of a composite nature being cut into limestone, overlain by limburgite and followed by a huge accumulation of coarse volcanic tuff. It gives evidence of relative uplift in recent times. The seaward slopes of the peak are obviously wave-cut. At the present time they are distant 150 yds. from high-water mark. Since uplift, progradation has occurred—a line of high sandhills of some antiquity lies between the cliffs and the sea. These were much more extensive 50 years ago (*vide* C. Seymour) and were covered by *akeake* (*Olearia Traversii*) and *karaka* forests half a mile in width.

Thus we have the following sequence of events:—

- (1) Cutting back of the cliffs.
- (2) Uplift and formation of talus slopes.
- (3) Progradation.
- and (4) Cutting back of the first cycle dunes.

Further evidence of this uplift is found in the same area. A pronounced terrace runs from Maunganui towards Wairau separating the higher peat-plateau from a lower swamp-area nearly at sea-level. The latter is of the nature of reclaimed ground and is still accumulating. It is separated from the sea by a wide fringe of high sand-hills running the length of Hurikia Beach. The schist-reef forming Cape Pattison may have allowed sand-bars to accumulate inland, and these have been slightly uplifted. The height of the terrace is approximately 50 ft. above sea-level. The uplift seems to have been relatively old, since the terrace is in places almost obliterated.

A similar terrace fronted by flat swamp is found round the mouth of the Taoroa Creek, east of Maunganui. It also shows mature features.

Turning now to examine the volcanic coasts of the southern half of the main island, one sees that the west coast from Waikaripi to Durham Point and thence to Gap Point is low-lying with a gradual slope from the coast to inland ridges. The beach is composed of rounded boulders, the monotony being occasionally broken by the presence of large trachytic dykes.

The change in topography at Waikaripi is very marked. From Waitangi south to Waikaripi the sea-front is formed of tuff and then horizontally-bedded limestone cliffs 200-300 ft. high. These cliffs terminate abruptly at Waikaripi where the volcanic series commences. The presence here of a strong fault seems the obvious inference.

On the opposite side of the island from Tongarewa past Owenga to Manukau Point the same type of boulder-coast is found.

From Gap Point to the Horns (Cape L'Eveque) and thence along the whole of the southern coast of the island to Cape Fournier and Manukau Point there is a series of perpendicular cliffs ranging from 400 to 800 ft. in height. The coast-line is not straight, but must clearly be ascribed to faulting. It is now somewhat broken, and cut in places by deep gorges. In most cases the small streams draining the swampy plateau discharge into the sea by high falls. The divide between these and the northward-flowing drainage-systems is close to and approximately parallel to the line of cliffs. It seems probable that before the submergence of the Pitt Strait block, the highest point of the Greater Chatham Plateau was close to the present line of cliffs. Although this coast was observed at the Horns and at the Manukau end, it is perhaps most accessible at a central spot, Te Awatapu.

At this locality a block of some 300 acres has slipped half way to the sea. The height of the upper cliff is about 750 ft., while the top of the slipped block is about half that. Up till quite recently this area has been inaccessible from land, but a track has now been cut down the cliff-face and the former covering of primeval bush

has been felled. The slipping movement is probably still in progress; within the last two years a huge block has dropped two feet. Great landslips from the upper cliffs occur periodically, and thus immense accumulations of talus have collected and are still forming. Elsewhere along this part of the coast talus slopes at sea-level are unusual. Wave-cut platforms have been noticed in many places.

The average height of the seaward cliffs in other portions of the southern plateau is approximately 200 ft. The surface is most irregular, and probably cracked considerably during dislocation. It has subsequently been greatly modified by the deposition of detrital matter. Small lakes or centres of inland depression are common. Talus slopes are finely developed and of great size.

The cliffs along the whole of this coast are being reduced by a succession of rock-falls and land-slides. Bands of relatively soft ash between successive lava-flows become excavated, thus hastening the destruction.

(h) Pitt Island and smaller island groups. The group of islands known collectively as Rangiauria or Pitt Island consists of three main land-masses of which Pitt Island proper is by far the largest and most important. Mangere, lying off the north-west coast, and Rangatira or South-east Island are also utilised for pastoral purposes. Smaller rocky islets are numerous, the most important being Rabbit Island (Wharekaikite Motu) off Whenuataru, Little Mangere (Tapuaenuku) and the Castle (Rangiwehao) south-west of Mangere, and the Star Keys some twelve miles east of Kahuitara (North Head). Still smaller islands are numerous, especially off the southern Murumuru coast; of these Round Rock (Rangituke), Fancy Rock, and The Pyramid (Te Rekokoe) are most noteworthy; several dangerous reefs are known. The group as a whole is urgently in need of a thorough marine survey, the danger of neglect being shown by the great number of wrecks here during the last century.

Pitt Island is roughly triangular in outline, the apex being directed to the south (Murumuru Peninsula). The base of the triangle from Whenuataru to Kahuitara is six miles wide. The length of the island from Moutapu to Murumuru is 9 miles. The width from Waihere to Kahuitara is 6 miles, while from Rangiauria to Glory Bay it is 4 miles. The area of the main island is 15,630 acres, or approximately  $24\frac{1}{2}$  square miles.

The north-west coast from Whenuataru to Moutapu is cliff-bound but contains two small harbours, Flowerpot Harbour or Onoua, the chief port of the island, and Parimatu(?) or Boat Harbour, a small cove a mile further to the west. The latter is used as a shelter during the somewhat prevalent south-east storms. Flowerpot Harbour may be used in certain winds only and under suitable conditions, loading or unloading being by means of surf-boats. From Moutapu a stretch of sandy beach runs south-east four miles to North Head or Kahuitara, a rugged peninsula of volcanic rocks. South of North Head the coast is rocky or sandy by turn, and the coast-line swings, first into Waipaua Bay, and second, into Glory Bay which gives a good anchorage in most winds. From Glory Bay to Murumuru the coast is irregular and rugged in the extreme. On the north of the west coast Waihere Bay forms a large indentation 3 miles across.

Most of the coast is bounded by high, precipitous cliffs, but Waihere beach composed of sand lying at the foot of slipped cliffs and fallen detrital blocks, is nearly one mile in length. The south arm of Waihere Bay terminates in Waihere Bluff with vertical cliffs rising 700 to 800 ft. from the sea. Thence south to Murumuru the coast is again very irregular and rugged. Rangiauria forms a bold point with steep cliffs nearly 700 ft. in height. Murumuru rises sheer to the trigonometrical station 600 ft. from the sea.

The topography of Pitt Island is that of a plateau of a general height of 200-300 ft., much dissected by subaerial and stream erosion. On it are several high, bold ramparts of volcanic rocks, of which the most striking are Waihere (971 ft.), Whakepa (754 ft.), and Rangiauria (678 ft.). Two farther prominent heights are Whapaka (937 ft.) on Mangere, and Rocky Peak or Whakarere-oro (678 ft.) on South-east Island.

Smaller peaks of 608 and 702 ft. are found near Whakepa, of 424 ft. near Glory Bay, and of 596 ft. at Murumuru; Kaingaroa (393 ft.) is the highest point in the north of the island. The Pyramid (Te Rekokoe), a small pinnacle 6 miles south of Murumuru, reaches a height of 566 ft.

A line extending from Waihere to Whakapa divides the island into two distinct areas, so far as mere description is concerned. North of this line the land belongs to different members of the Hunt family, which has been resident on the island since about 1840. Most of this northern block, with the exception of relatively small areas near Waihere and Whakepa, has been cleared of the native bush which formerly reached sea-level all over the island, and now forms fine pastoral lands which rival the best New Zealand land in stock-carrying capacity. These favourable conditions are in a large measure due to a mild climate, and a soil derived from limestones and volcanic tuffs.

South of the Waihere-Whakepa boundary, with the exception of the "Glory Clears," the south half of the island is densely bushed, and communication can be maintained only by boat or by horse over ill-constructed and little-used bush-tracks. Outcrops of rocks are practically confined to the summits of the hills and to the often unscalable coastal cliffs.

The drainage-system of Pitt Island consists of small streams and creeks, most of which have their sources in small swamps in the uplands. The two main streams are the Tupuangi in the north and the Waipaua in the south. The Tupuangi has its headwaters on the northward-facing slopes of Waihere Hill whence it flows north for two miles in a relatively deep valley cut through tuff and marl, and enters the sea at the north end of the Onekura Beach. Near its mouth it broadens into a small lake, formed by the seaward accumulation of sand-dune. It is the only lake of any size on the island. The Waipaua is the largest stream, but the volume of water is small. It enters the sea one mile north of Glory Bay through a small gorge cut into soft tuff. It has two main branches, the south-west and larger tributary draining the high land round Rangiauria, while the north-east branch drains some of the high land between Waihere and Rangiauria.

Of the smaller creeks the Waipapaku enters the sea some two miles north of the Waipaua; another creek of note has its source at the north end of Waihere beach, flows north and enters the sea at Flowerpot Harbour, where it cuts a small gorge through the limestone down to the underlying tuff. Although the volume is small, it could probably be utilized to drive a water-wheel and so give a small local supply of electricity.

At the south end of Pitt Island, on both sides of the Murumuru peninsula, from Waikuri to Murumuru on the east, some interesting geomorphological phenomena can be observed. This peninsula is composed for the main part of horizontal or nearly horizontal volcanic tuffs which are moderately coarse-grained and as a rule imperfectly bedded. The mass is strengthened, however, as at Murumuru itself, by intrusive masses of basalts. Murumuru trigonometrical station is 596 ft. high, but the average height of the area is about 350 to 400 ft. The coast line is extremely precipitous and extensively dissected by deep ravines—where flow the master-streams. The inter-fluves have been reduced to steep, sharply-defined razor-backs.

On the sides of these sharply-angled ridges the process of "abstraction" is well depicted. Besides the action of the master-streams, on the seaward slopes and upper seacliff surfaces small streams, more often than not dry, finely dissect the whole surface of this area with small ravines separated by narrow, steep-sided ridges. This good example of consequent drainage and abstraction seems to be in a more advanced stage of the cycle than that figured by C. A. Cotton.\*

As a result of this abstraction another process is clearly illustrated on this coast. By the formation of the ravines described many points or headlines become separated from the main block by a narrow ridge. This eventually becomes undermined by wave action and the formation of caves, or disintegrates under the continued action of the streams. Thus innumerable stacks are formed which as a rule are steep-sided and more or less conical. On the map prepared by Smith and Robertson about sixteen small islands are dotted around the Murumuru Peninsula. A few of these are, however, of volcanic origin. Many stacks are unmapped, and many more partly-formed stacks were noted.†

A short stretch of dune-coast is also present on Pitt Island extending from Tapurangi to Kahuitara; it is probable that the small Tupurangi Lake owes its formation to this cause. Advancing dunes are also gradually covering Kaingaroa Hill at a height of nearly 400 ft.

The writer was unable to visit Mangere, which lies some 3 miles off the north-west of the main island. It is roughly club-shaped, with the club-head directed to the north and the east. The north-east coast is a magnificent cliff of tuff 900 ft. high. It slopes quickly to almost sea level at the south-west end and a landing may be effected there under suitable weather conditions.

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\*C. A. Cotton, *Geomorphology of New Zealand*, Pt. 1, p. 68, Fig. 65b, 1922.

†For the formation of stacks, see Cotton *loc. cit.*, p. 406, Fig. 395.

The rectangular South-east Island, or Rangatira, is lowest in the north, but rises rapidly to 678 ft. in Rocky Peak in the south. The coasts, except the northern, are rugged, bold cliffs. A good landing can be made at Te Outa in the north under favourable circumstances. This island lies 2 miles south-east of Glory Bay. It is  $1\frac{1}{2}$  miles long in a north and south direction and 1 mile wide.

### 3. GEOLOGICAL STRUCTURE.

The structural features of the Chatham Island group may best be considered if the main island is divided into three large areas. The largest of these is the Southern Plateau of volcanic rocks; this area includes all the land south of an east-west line from Waitangi to the east coast a mile or so north of Owenga.

The second region lies to the north of this line and south of an indefinite line drawn from Te Roto to the north-west corner of Te Whanga Lagoon. This is the district in which limestone is the main rock.

Finally, the third structural unit consists of the schist arcas found in the northern parts of the island. This last region may be further subdivided into (a) an eastern schist area, including the Waipapa Creek, Taupeka Point, and the North-east Peninsula; (b) a western schist area running from Waikawa to Cape Pattison; and (c) a north central division of volcanics and sedimentaries stretching from Tioriori in the west to Wharekauri in the east.

(a) *The Southern Plateau Area.*—Almost the whole of this block is made up of a succession of horizontal lavas and tuffs. The structure is fairly clear and simple.

The shape of the area is determined by a series of three or more parallel fault-fractures. The main line of faulting trends in a north-east direction. The southern coast which consists of perpendicular cliffs ranging from 600 to 700 ft. in height is clearly along this trend line. A strong fault runs from the Horns (Cape L'Veveque) to Cape Fournier. The northern shore of Pitt Island represents the southern side of the block which has been relatively depressed to form Pitt Strait.

The coast on the north-west side of the block, from Point Durham to Point Weeding, has the same general trend, and may be ascribed to faulting. The majority of the streams draining this block, the Makara, Te Awainanga, Te Mata-o-Pakihau, the Mautere, the Mangahau, and the middle part of the Awamata, all flow sub-parallel in the same north-east direction.

The trend-line second in importance is not parallel to any shore-line but gives a noticeably meridional course to many of the streams, as in the upper branch of the Makara, the Tauaropa, the Nairn, and part of the Wairarapa.

A third series of faults trending west-north-west is also indicated. The northern boundary of the block from Waitangi to the east coast north of Owenga is a fault-boundary; in fact it is probable that the sea has broken right across the island along this line. This line



of weakness is also followed by some of the streams, viz., the Tuku-a-Tamatea and the Waipurua. The large Awainanga makes several almost right-angle turns and follows this trend for short distances.

Finally a north-north-west fault-direction is shown by the coastline from Point Durham to the Horns. This trend is followed in the lower course of the Awamata, and again, after a change to the north-east line, in the upper stretches of the same stream.

Thus the drainage of this area is clearly determined by a series of persistent fractures or lines of weakness. The area affords an excellent example of Hobb's "lattice-drainage."

As illustration, the two largest streams, the Nairn and Te Awainanga, may be taken. The Nairn flows almost due north, but its two main tributaries, the Mangahau and the Mautere, both flow to north-east. Te Awainanga shows the relation of drainage to structure even more fully. Its headwaters (the Tauaropa) flow due north till joined by Te Mata-o-Pakihau which flows to the north-east, the two uniting in the main stream or Te Awainanga, which continues in the latter direction until it turns sharply to the east-south-east, and shortly afterwards is joined by the Makara. This tributary at first flows north, but turns north-east before entering the main stream. Below the junction the main stream also turns north-east before it enters the swamp at Rangihapainga. Hence practically the whole course of both these streams has been determined by fractures which have provided lines of weakness along which the streams could erode their channels with comparative ease.

Several streams, however, especially in the south-west corner of the block, enter the sea by deep narrow gorges; these streams were in existence prior to the uplift and cut gorges as the land rose.

(b) *Central Limestone Area*.—Over most of this area horizontal limestone either outcrops or immediately underlies the surface deposits. The land is low-lying and calls for no special mention as far as tectonics are concerned.

(c) *Northern Schist Area*.

(1) *North-west Peninsula*. Over this area the average strike of the schist rocks is about  $80^{\circ}$  E. (Mag.). It varies within the limits  $65^{\circ}$  to  $102^{\circ}$  E. The dip, in the main, is from  $28^{\circ}$  to  $30^{\circ}$ , either to the south or the north. These schists then form a series of short-limbed anticlines and synclines.

Dr. Marwick, who kindly noted strikes and dips between Whangatete Bay and Ocean Bay, saw that in one or two localities the strike is extremely variable. An area of great irregularity is on the west side of Whangatete Bay, where there are meridional strikes.

The "fossil-plain," and line of volcanic residuals in this area have already been discussed.

(2) *North Central Area*. This area is important stratigraphically but gives few tectonic data, except that here we have another centre of violent volcanic activity. The main peaks are Rangitihi, Puhina, and Motuariki. The tuffs, which are extensively developed, show great variation in strike and dip, probably indicating proximity to the centre of eruption.

(3) North-east Schist Area. Schists are found in Waipapa Creek, on the shore of Te Whanga, at Taupeka Point, and from Matarakau to Cape Munning and Okawa. The structure of the area is somewhat complex.

In the main the schists strike, as in the north-west area, in an east-west direction. However, two series of schist rocks are found in the section at Matarakau. The lower consists of blue-grey silky mica-schists which strike east and west, and dip south at 30°. These are overlain by more massive quartz-schists which strike north and dip at 30° to the west. Hence the upper series has been thrust over the lower. The lower series is derived from a mudstone, and is more liable to give way to strain than is the upper. It forms the incompetent member of the series. When faulting occurred, the upper more resistant quartz-schist has been moved over the lower more pliable mica-schist, and the strike has locally been swung round into a north-south line.

From Kaingaroa east to Munning Point and Okawa the quartz-schists strike normally, east and west. Here they are highly tilted and dip to the north at high angles ranging from 65° to 82°.

#### SUMMARY.

The island group in its present form is due to two factors. Immediately after the faulting that blocked out the main masses, Chatham Island appears to have consisted of four isolated islands. The largest of these was the southern plateau which was separated by an arm of the sea from the north-central area. The old shore-line followed the west coast of the lagoon from Waitangi to Taupeka. Further in the north-east the Kaingaroa block existed as a schist-island, and in the north-west the Cape Pattison area was separated from Maunganui.

The next phase was probably a slight uplift and the formation of the extensive sand-bars which now link up these old land-masses.

Pitt Island seems to be a faulted remnant of a greater Chatham Island, and the 14-mile wide Pitt Strait is clearly a sunken trough, or perhaps an area which failed to rise when faulting occurred. Mangere and Rangatira are but recently separated from Pitt Island.

Taken as a unit the Chatham Island group represents but a small part of a formerly extensive land area.

#### REFERENCES.

- COCKAYNE, L. A Short Account of the Plant Covering of the Chatham Islands. *Trans. N.Z. Inst.*, vol. 34, pp. 243-55, 1901.
- DIEFFENBACH, E. Account of the Chatham Islands, *Roy. Geog. Soc. Journ.*, vol. 2, p. 195, 1842.
- FLORENCE, R. S. Chatham Island, *N.Z. Official Year Book*, 1900.
- FORBES, H. O. The Chatham Islands and their Story. *The Fortnightly Review*, May 1893, p. 669.
- ROBERTSON, J. A. Chatham Islands, *Proc. & Trans. Queensland Branch R. Geog. Soc. Australasia*, vol. 5, pp. 72-92, 1890.
- SKINNER, H. D. The Morioris of Chatham Islands, *Memoirs of the Bernice P. Bishop Museum*, vol. 9, No. 1, pp. 7-15, 1923.
- TRAVERS, H. H. On the Chatham Islands, *Trans. N.Z. Inst.*, vol. 1, pp. 173-180, 1868.