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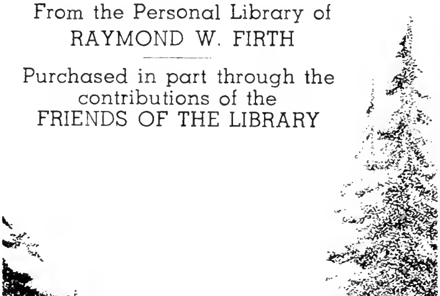

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New Zealand Nature Notes.

SHORT SKETCHES

OF THE

GEOLOGY, BOTANY, ZOOLOGY, AND ETHNOLOGY OF NEW ZEALAND

(WITH NOTES ON ENGINEERING-WORKS)

FOR THE USE OF

Members of the Australasian Association for the Advancement of Science, Wellington Meeting, January, 1923.

WELLINGTON.

BY AUTHORITY: W. A. G. SKINNER, GOVERNMENT PRINTER.

1922.

New Zealand Nature Notes.

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NEW ZEALAND NATURE NOTES.

THE GEOMORPHOLOGY OF WELLINGTON.

The Origin of the Port Nicholson Depression.

The Port Nicholson depression—containing one of the world's finest natural harbours, the location of which has determined the position of Wellington, the capital of New Zealand—may be described as an area of subsidence partially submerged, so that it now comprises

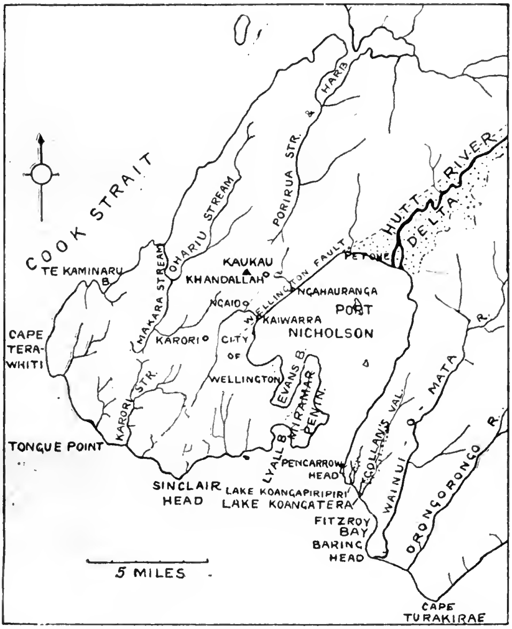


Fig. 1.—Map of Port Nicholson.

a broad sheet of water (Port Nicholson) and several embayed ridges between this and the sea to the south (fig. 1).

The depression is almost surrounded—to west, north, and east—by a higher-standing land-surface. The dominant features of the high-standing area, and also of the unsubmerged portions of the area of subsidence, are mature ridges and spurs, but remnants of a dissected peneplain may be traced on some of the ridges, and most of the valleys are rejuvenated. In the western part the average relief is fully 1,000 ft., and several ridges rise to more than 1,500 ft. above the sea; while to the east the ridges are successively higher until, at a distance of seven miles, the Rimutaka Range (3,000 ft.) is reached. The smaller valleys are insequent, but there is a distinct longitudinal, and occasionally trellised, drainage system developed on strongly folded (nearly vertical) sedimentary strata with occasional crushed zones, or shatter-belts, parallel to the general north-north-east strike. The mature ridges of the depressed block show a similar parallel arrangement. As a result of depression of the maturely dissected surface these ridges (Miramar Peninsula and the Kilbirnie Hills) and their spurs are separated by drowned valleys, and their highest peaks now reach only 400 ft. to 600 ft. above sea-level, while an almost complete absence of islands from

FIG. 2.—Eastern shore-line of Port Nicholson.

the northern portion of the harbour suggests that subsidence was there much greater than farther south.

The north-western boundary of the depression is a well-preserved fault-scarp (see p. 8), but the remaining boundaries are embayed by submergence. The embayed eastern shore-line is traced along the half-submerged side of a prominent and steep-sided longitudinal ridge (fig. 2). It has been cliffed by marine erosion, and still later prograded, with the formation of a cuspate foreland.

Along all the shore-lines initiated by the subsidence there are wave-cut cliffs of varying height according to the exposure. On the exposed outer (southward-facing) coast cliff-recession has taken place to a very considerable extent, truncating the ends of the half-submerged ridges, and large areas of cut platforms lie at the cliff-bases. Along this outer coast the shore-line of the depressed area is, or, rather, was before a small uplift which accompanied the earthquake of 1855, in an early mature stage of development, considerable modification of the initial embayed outline having resulted in part from the cutting-back of points and in part from bay-filling. A sand isthmus, which ties Miramar Peninsula, a former island, to the mainland, effects a decided smoothing of the initial outline (fig. 3).

Port Nicholson has a smooth floor, with a maximum depth of 100 ft. in the middle. This indicates that a large accumulation of

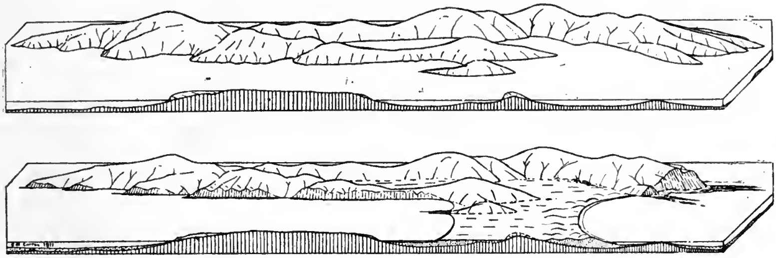


FIG. 3.—Diagram showing Miramar Peninsula as a land-tied island. Above is the initial form; below, cliffing and modification of the outer coast of the depressed area are shown.

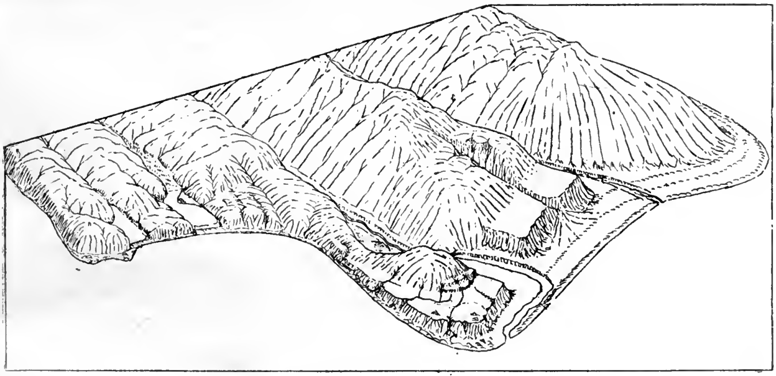


FIG. 4.—Diagram-sketch of the southern end of the tilted area east of Port Nicholson. From left (north-west) to right (south-east) the coastal features shown are: Pencarrow Head, Lake Koangapiripiri, Lake Koangatera, Fitzroy Bay, Baring Head, Wainui-o-mata River, Orongorongo River, Cape Turakirae.

sediment has taken place, the material burying the submerged mature land-surface.

Though its north-western boundary is a fault-scarp (fig. 5), the depression is not simply a small fault-bounded tectonic block. The absence of companion fault-scarps, no less than the positive physiographic evidence, indicates that faulting must be regarded as merely an incident in the formation of the depression. The principal event appears to have been the sharp downwarping of a belt of land about thirty miles long, elongated in a north-north-east and south-south-west direction (and extending an unknown distance farther to the south-south-west beneath the sea). The depth of downwarping that must be assumed is variable, the maximum being perhaps in the neighbourhood of 1,500 ft., or perhaps rather more, where the broadest part of Port Nicholson now is. The width of the strip affected also varies in different parts, but is at least ten miles where Port Nicholson is widest. Both depth and width diminish, though irregularly, to the north-east up the Hutt Valley.

The movement of downwarping took place comparatively recently. Though the outer coast of the partly drowned area is now approaching submaturity of outline, the initial shore-line (after submergence) can still be restored, and it is seen that the change in the normal subaerial land-forms that has taken place since submergence is inappreciable. The surface that was warped and incidentally faulted to produce the depression was therefore like that of the surrounding district to-day—maturely dissected, with a somewhat fine texture of dissection and a relief of rather more than 1,000 ft. Such strongly differential movement of a small earth-block in very recent times is unusual even in New Zealand, though it was common enough in somewhat earlier times when the mountain masses were blocked out and the river-courses determined by the movements to which the name " Kaikoura " has been applied.

The evidence in support of the hypothesis of warping to account for the submergence of the Port Nicholson area is much more conclusive for the eastern than for the western side of Port Nicholson. In the critical area on the western side ancient strand-lines do not survive, but have been cut completely away by modern marine erosion. The only positive evidence of warping found there is a progressively more extensive drowning of valleys as the entrance to the harbour is approached ; but there is also weighty negative evidence in the absence of a traceable fault-scarp separating the obviously depressed Port Nicholson area from the high-standing land to the west.

The evidence on the eastern side is more striking.* It is of three kinds : (1) Uplifted wave-cut platforms (ancient strand-lines) on the outer coast are very strongly tilted endwise towards Port Nicholson (fig. 4) ; (2) there is progressively more extensive drowning of valleys as the harbour-entrance is approached (fig. 4) ; (3) the inferred tilting towards the centre-line of the depression is so strong that it must have considerable effect on the regimen of streams. The larger streams east of the harbour are for the most part parallel to the hinge-line of warping, and, as might thus be expected, are but little affected ; but the valleys of small headwater streams tributary to these and entering them from the west show striking aggradational effects, which can be ascribed only to headward tilting in spite of the steep gradients normal to such streams, even when mature, in this district of strong and fine-textured relief. These effects may be seen well developed in the western branch of the Wainui-o-mata, and in the western tributaries of the Mangaroa (fig. 6).†

* This evidence is set out more fully in a paper by the present writer entitled " The Warped Land-surface on the Eastern Side of the Port Nicholson Depression," *Trans. N.Z. Inst.*, vol. 53, pp. 131–43, 1921.

† *Loc. cit.*, pp. 140–42 ; *Geomorphology of New Zealand*, p. 238.

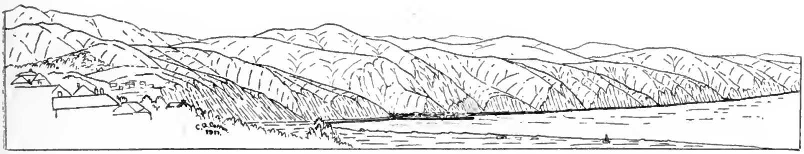


FIG. 5.—Fault-scarp forming the north-western boundary of the Port Nicholson depression.

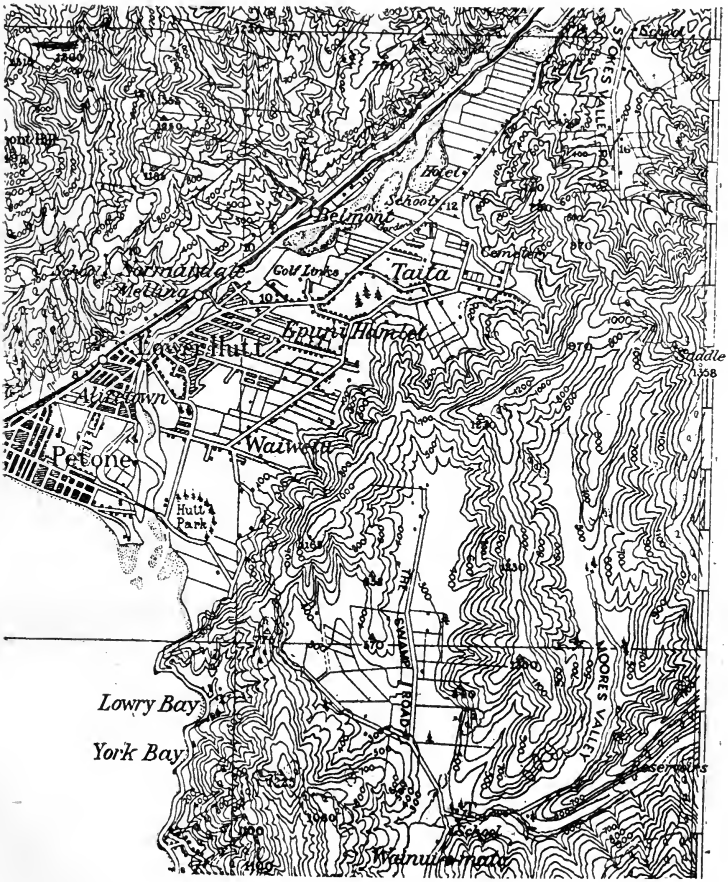


FIG. 6.—Map of the Hutt River delta, which partly fills the Port Nicholson depression, and the aggraded valley of the western branch of the Wainui-o-mata. Note the contrast between the fault-scarp forming the straight north-western side of the depression and the embayed eastern side. Approximate scale, ½ in. + = 1 mile.

THE WELLINGTON FAULT-SCARP (figs. 1 and 4).

The fault-scarp referred to above as forming the north-western boundary of Port Nicholson trends approximately south-west to north-east. Its south-western part forms the steep slope of the Tinakori Hills, and its north-eastern continuation extends far up the valley of the Hutt River. The scarp appears to have been submaturely dissected and very recently rejuvenated. It seems to have come into existence as an accompaniment of the formation of the Port Nicholson depression. When rejuvenation took place, however, though probably the floor of the depression again sank, the land on the north-western side of the fault appears to have risen. The newer scarp thus cuts a submaturely dissected surface with a rather steep general slope towards Port Nicholson, blunt-ended spurs alternating with streams, a few only of which are now mature at their

FIG. 7.—Raised rock platform and beach, backed by sea-cliffs, southward from Breaker Bay, Wellington.

mouths. Above the newer scarp would rise the somewhat worn facets of the earlier, dissected scarp. All the streams would cascade into Port Nicholson from the mouths of hanging valleys. These characteristics are still recognizable, though they have been somewhat modified in the post-faulting period.

Access.—Visible from Wellington. A good point of view is the radio station on Tinakori Hills. Take Karori tram to Northland; thence walk.

RAISED BEACHES AT WELLINGTON.

The Wellington earthquake of 1855 was accompanied by a sudden uplift, or, more strictly, tilting of a large block of country. According to the account received by Lyell from eye-witnesses and embodied in the later editions of the *Principles of Geology*, the hinge-line of the tilt coincided roughly with the north-western coast of the Wellington Peninsula, and the uplift increased to 5 ft. at Wellington, and thence to 9 ft. at a point on the shore of Palliser Bay, about fifteen miles in a direct line east-south-east from Wellington.

As a result of the movement extensive areas of the rock platforms cut by wave-action along the southern coast in the neighbourhood of Wellington during a relatively long period of stillstand were raised permanently above high-water level (fig. 7).

The rock platform is surmounted by stacks, and numerous irregular hollows in it are filled with gravel. Wave-cut cliffs rise behind the platforms, with occasional sea-caves at the base, and there is generally a convex beach-ridge of gravel at the former shore-line. Both beach and platform now support a scanty growth of vegetation, the seaward limit of which is a new beach-ridge. The most extensive rock platforms stretch out seaward from the base of the cliffs at the southern end of Miramar Peninsula (fig. 3). The raised beaches have been largely destroyed in the course of road-construction, their presence allowing of the cheap formation of roads along the foreshore, but a strip about a mile in length along the eastern shore of the southern end of Miramar Peninsula still remains in a good state of preservation.

Access.—The best of the raised beaches and associated features may be seen in the course of a walk from Lyall Bay (tram-terminus) eastward around the south end of Miramar Peninsula. Keep to the foreshore as far as Breaker Bay quarry, thence take the road through a cutting to Seatoun (tram-terminus). On the sides of this cutting almost horizontal "earth pillars" may be seen pointing southward (Cotton, *Geomorphology of New Zealand*, fig. 35).

High-standing Wave-cut Platforms.

West and east of the downwarped Port Nicholson area the coasts are of the multicycle uplifted type, and the uplift (which has left its impression on the land also, in the form of multicycle subaerial features) was no doubt general prior to the occurrence of the local subsidence. Wave-cut rock platforms with a thin veneer of gravel and coarse sand occur at various levels. They are reduced to narrow benches by cliff-cutting marine erosion in the intermediate and present cycles, and in many places have been cut away altogether.

West of Port Nicholson the high platforms that survive are only two in number, and the higher of these is represented by but one small remnant. The lower is traceable for several miles—from Cape Terawhiti to beyond Tongue Point (fig. 1)—but for a great part of this distance only in the section exposed along the sea-cliffs, in which the even top of a cut bench can be very distinctly seen from seaward. This is covered, however, by a thick accumulation of talus, the slope of which quite obscures the profile of the bench. At Tongue Point, however, quite a large remnant of the bench survives.

East of Port Nicholson there is an extensive series of benches, each the remnant of a cut platform (figs. 5 and 8). These are tilted endwise very steeply (about 175 ft. per mile) towards the depressed area.* On the lower benches there is a considerable quantity of gravel, and at Baring Head some stacks survive on the platform which forms the Head.

Access.—The platforms at Tongue Point may be reached by walking westward along the foreshore from Island Bay tram-terminus; or, more easily, by road and bridle-track—motor-car to end of South Makara Road (in the valley of the Karori Stream), thence on foot three miles to McMenamen's homestead at Tongue Point.

To visit the platforms east of Port Nicholson it is necessary to proceed by motor-car by way of Petone or Lower Hutt and the Wainui-o-mata Valley (note aggradation due to tilting—see p. 6),

Fig. 8.—Uplifted marine platforms between Baring Head and Cape Turakirae, Wellington.

to the last farm-buildings before the mouth of the Wainui is reached (twenty-four miles from Wellington). Here the Wainui-o-mata is crossed on a plank bridge, and a steep slope undercut by a meander of the stream, since cut off, must be climbed. There is an indistinct track, which leads over a low gap, to Fitzroy Bay. Proceed along the lowest, or Baring Head, platform to Baring Head, where the tilt of this platform becomes obvious and an excellent view of the higher benches is obtained.

C. A. Cotton.

* For a description of these see C. A. Cotton, "The Warped Land-surface . . . ," *Trans. N.Z. Inst.*, vol. 53, pp. 131–43 (refer to pp. 136–38), 1921.

THE WILD INDIGENOUS PLANTS OF THE CITY OF WELLINGTON.

Here is included all the area within the city boundaries together with the forest reserve at Day's Bay. Much, though nominally "city," is open country containing many remnants of the almost continuous original forest covering, and there is also an extensive coast-line which provides many types of coastal habitats. In consequence, about 37 per cent. of the total New Zealand lowland and coastal floras, taken together, are gathered together into a small compass.

The pteridophytes and spermophytes number about 416 species, which belong to no less than 83 families and 210 genera. The largest families and genera, together with the species in each, are—Filices, 67; Cyperaceae, 35; Gramineae, 25; Compositae, 23; Rubiaceae, 21; Orchidaceae, 18; Onagraceae, 15; Coprosma, 18; Epilobium, 12; Carex, 11; Hymenophyllum and Blechnum, each 10.

So far as forest-plants are concerned, a considerable percentage can be seen within the city proper, for much of the Botanical Gardens is occupied by a fairly-well-preserved example of the semi-coastal rain-forest which originally filled the gullies and clothed many of the slopes where houses now stand closely. Unfortunately, the tall trees were destroyed long ago, but there is still a dense, rich vegetation of about 110 kinds of small trees, tree-ferns, shrubs, lianes, and ferns in general. Some characteristic plants of the New Zealand flora are represented by fine examples in this invaluable open-air museum: *e.g.*, the cauliflorous tree *Dysoxylum spectabile*, the dimorphic *Pennantia corymbosa*, *Pseudopanax crassifolium* var. *unifoliolatum* (with its juvenile and adult forms so different that at one time they were held to be distinct species), *Rubus australis* (a huge bramble), and *Myrtus bullata* with its curious blistered leaves.

At Lyall Bay typical dunes may be seen with the endemic *Scirpus frondosus*—an admirable example of convergent epharmony—as a sand-binder, and the locally endemic *Acaena novae-zelandiae* var. *pallida*. On shaded coastal cliffs there is abundance of *Phormium Colensoi*, and in its company *Senecio lagopus* and *Festuca multinodis*. *Aciphylla squarrosa* and a variety of *Raoulia australis* also occur on the coast, though they are frequently mountain-plants. The subantarctic *Crassula moschata* has on this piece of coast its sole station for the North Island. Several rather rare species are coastal—*e.g.*, *Lepidium obtusatum*, *Hymenanthera obovata*, *Coprosma Kirkii*, and *C. Buchanani*.

The Day's Bay reserve is a noble piece of almost virgin forest some 600 acres in extent. The dominant tall trees belong to the subantarctic genus *Nothofagus*, the species being *N. fusca* and *N. Solandri*, together with various forms of hybrids between them, one group of such being known as *N. apiculata*. Within the gullies the vegetation is of the rain-forest type, while the *Nothofagus* association is confined to the drier slopes. Compared with the rain-forest, its undergrowth is more open and xerophytic, as evidenced by the presence of *Cyathodes acerosa* and other drought-resisting species. But the filmy fern, *Trichomanes reniforme*, with its broad fronds curled up in dry weather, is common on the dry slopes. Near streams bryophytes are plentiful, including the huge thalloid liverwort *Monoclea Forsteri*. At its outskirts the forest merges into tall shrubland, with the usual *Leptospermum scoparium* dominant, combined, however, with young trees, so that it is really potential forest.

L. COCKAYNE.

LITTORAL PLANT AND ANIMAL COMMUNITIES OF COOK STRAIT.

A weathered platform of greywacke rocks fronting the open ocean, and with no large river discharging near-by, affords in the intertidal belt solid foothold in clear water. Such ideal conditions for marine life are found in Cook Strait, easily accessible by tram from the City of Wellington. Good collecting-ground may be found near the Island Bay, Lyall Bay, and Seatoun termini. Being an open coast, there is no heaping up of tides, so that the moderate range of about 5 ft. at ordinary springs is the rule. This allows for the development of only two or three distinct belts of plant and animal life in vertical sequence at any point. Situated as Wellington is near the middle of the Dominion, samples of the typical marine algal communities of both the northern and southern portions of New Zealand may be seen, though some especially characteristic cold- and warm-water associations are absent, such as the small moss-weed (*Bostrychia*) association of Otago and the mangrove and tunicate communities of Auckland.

Durvillea Association.—On the most exposed portions of the rocky coast outside the harbour the large kelp-weed (*Durvillea antarctica*) forms a miniature marine forest. On the shore the maximum amount of light and supply of water occur in that strip between the level of low tide at neaps and springs. Here, where the waves beat hardest and the waters are consequently most aerated, the kelp loves to grow. Its large discoidal holdfasts are fixed to the rock high up in this belt, and its large palmate leathery fronds hang down, covering the rock-face while the tide is out, and, when covered with water, stand upright by virtue of their natural buoyancy. This buoyancy is brought about not, as in many kinds of brown algae, by special air-vesicles, but by the large polygonal cells which make up the bulk of the tissue of the thallus. The upper margin of the Durvillea association is usually defined by a fringe of *Laurencia*, a dark-purple species forming tufts 2 in. to 3 in. high. Following on this is a narrow belt of the common brown alga *Xiphophora chondrophylla*, easily recognized by its branching flat thalli. Below these algae the bulk of the formation lies, and consists principally of a mixture of *Lessonia variegata, Carpophyllum maschalocarpum, Marginaria boryana, Sargassum Sinclairi*, and *Cystophora dumosa* extending some distance below low-tide mark. Beneath these large species is an undergrowth comprised of smaller red, green, and brown algae, such as *Pterocladia lucida, Caulerpa sedoides, C. Brownii, Lychaete Darwini, Zonaria Turneriana, Glossophora Harveyi, Stypocaulon paniculatum*, and others, while the rock-face itself is covered with the crustaceous corrallines *Melobesia* and *Lithothamnion*, and the branching corallines *Amphiroa, Corallina*, and *Jania*. The animals associated with the large brown algae include the herbivorous gastropods *Cantharidus opalus, C. purpurata*, and *Turbo smaragdus*, feeding on the larger algae; the large sedentary chitons, such as *Endoxochiton nobilis, Plaxiphora biramosa*, and *Sypharochiton Sinclairi*; the mussels *Mytilus canaliculus* and *M. maorianus*; and the large ear shells *Haliotis iris* and *H. australis*. Shore fishes include various blennies and the sucker-fish *Diplocrepis puniceus*, the former usually taking protection in rock-pools and gulfs, the latter freely exposing itself to the surf and relying on its pectoral disc to hold on to the rocks. The more conspicuous echinoderms are the sea-urchin *Evechinus chloroticus* and the starfishes *Asterina regularis, Asterias scabra,* and *Pentagonaster pulchellum.* Of especial interest is the fauna which is found within the hollowed-out bases of *Durvillea.* Here are found *Siphonaria zealandica,* various crustacea and worms, and the chitons *Plaxiphora egregia* and *Onithochiton neglectus.*

Corallina-Hormosira Association.—Between tide-marks there is developed, especially in rock-pools, an association in which the branched coralline *Corallina officinalis* and the brown alga *Hormosira Banksi* are often fairly well mixed. The distribution of these two algae is determined by the amount of water present, *Hormosira* affecting drier situations than *Corallina,* so that frequently *Corallina* will grow on the floor of a pool, with *Hormosira* fringing the water-line and exposed during the recess of the tide. *Hormosira Banksi* sometimes, especially on level rocks, forms a pure association. The animals associated with *Corallina* and *Hormosira* include *Turbo smaragdus, Cerithidea tricarinata, Melaraphe unifasciata,* and, in pools, blennies and shrimps.

Porphyra Association.—Conspicuous on rocks between tide-marks is an association of *Porphyra laciniata.* It forms large patches about half-tide. The thallus is like that of the sea-cabbage (*Ulva*), but of a pale-greenish colour. It has a shining appearance when dry, and the tips suffer a good deal from wilting during exposure to the atmosphere.

Barnacle Association.—The chief animal association on rocks between tide-marks is that which occupies a belt over a yard in vertical width just above the brown-algae formation. The rocks are to a large extent covered with the sessile barnacle *Chamaesipho columna.* With it are associated a number of (usually small) molluscs —*Cellana denticalata, C. ornata, Siphonaria obliquata, Monodonta coracina, Lepsiella scobina, Sypharochiton pellisserpentis,* and many others. The association is in all respects comparable with similar associations on the Australian coasts, but the species are, with the exception of one or two only, entirely different. Within Wellington Harbour the barnacle association is present, but on the more exposed rocks gives way to an association of mussels.

Zostera Association.—Extensive areas of intertidal flats in Wellington Harbour are covered with a sward of the grass-wrack *Zostera tasmanica.* With it occurs an assemblage of molluscs, including herbivorous species such as *Turbo smaragdus, Monodonta corrosa,* and *M. aethiops,* and a number of carnivorous forms, including *Cominella adspersa, C. lurida,* and *C. maculosa.* The shell locally called "cockle" (*Antigona stutchburyi*) is abundant just below the surface of the mud.

Monodonta-Amphibola Association.—On mud-flats where *Zostera* does not grow, a number of molluscs are found, mostly identical with those living among the *Zostera.* Of especial interest, however, is the presence of the *Amphibola crenata.* This is a member of the pulmonate or air-breathing order of gastropods which has returned to a life in the water. So dependent now is it on a continuous supply of moisture, which while the tide is out it gets from the moist mud, that it is unable to live for any length of time if kept without water.

W. R. B. Oliver.

NOTES ON THE MARINE FAUNA OF ISLAND BAY, WELLINGTON.

Between the tide-marks are many sheltered rock-pools, and in these are small fish, crabs, and a few interesting seaweeds. On the margins of these pools and in clefts of the rock there frequently occur the spirally coiled egg-masses of the large *Siphonaria obliquata* and of the two common limpets *Cellana radians* and *C. ornatus*. As these egg-masses become older many diatoms are found in them, and certain *Gymnomyxa*, notably *Amoeba agilis*. As the masses deliquesce they shelter a *Vorticella*, which, although marine, has a contractile vacuole. In addition to the pools there are many guts or chasms in the rock, and here there is abundance of life. The brown seaweed *Lessonia variegata*, with its buttress-like base, gives shelter to Annelids, Crustacea, and many sponges, especially Calcarea. Among the last are *Syconute dendyi* and the striking *Grantessa intus-articulata*. On the leaves and stems of the *Lessonia* are frequently found anemones, *Sagartia nutrix* and others, as well as several gastropods, noticeably the beautiful little *Cantharidus dilatatus* and the larger *Cantharidus opalus*. The stems are often bored by Polychaetes.

In the more sheltered pools is an abundant growth of coralline seaweeds, and if the masses be pulled apart they are often found to shelter *Dolichoglossus otagoensis*. This animal is from 1 in. to 1½ in. in length, and of a bright-red colour. It is allied to a Japanese species. The same seaweed shelters many young sand-stars and small sponges and Tunicates, many developing Crustacea, and worms. These masses form the nursery of the rock-pool fauna.

Beneath the stones are several interesting molluscs, as, for example, the small *Acmaea fragilis* and the great *Scutus ambiguus*, whose flattened white shell is concealed by the spacious mantle-folds, the whole surface, except the sole of the foot, a deep blue-black. Three species of *Haliotis* are found. The older specimens of *H. iris* and *H. australis* forsake the shelter of the stones. *H. iris*, coming down from Miocene times, is the *paua* of the Maori. He formerly used the animal as food, and the shell to form the eyes of gigantic carved figures. Fully exposed upon the rocks, often well above high-water mark, are two species of *Melaraphe*, allies of the European periwinkle (*Littorina*). Much less exposed, and often seeking shade, are two species of *Onchidella*.

The large Holothurian, *Stichopus mollis*, is abundant, and exposes itself freely where the sea-floor is sheltered. Under stones and in the sand smaller Holothurians are found. The starfish that is most abundant is the small, pentagonal *Asterina regularis*, usually blue, but not infrequently yellow or green. Of other starfishes that occur here the largest and handsomest is *Asterias scabra*, usually blue above and with red tube-feet. The only known specimen (now in the Victoria College museum) of the remarkable monotypic genus *Eurygonias* (*E. hylacanthus*) was found at Island Bay.

Of Ophiuroidea, the common sand-star *Ophionereis schayeri* occurs in abundance under stones. The large brittle-star, *Pectinura maculata*, abundant in some parts of New Zealand, occurs occasionally here.

The common sea-urchin is *Evechinus chloroticus*. It is of some interest to note that the Maori name is *kina*.

Of sea-anemones, the three commonest forms are *Actinia tenebrosa* (dark red in colour and exposed at half-tide), *Cradactis plicatus*, and *Anemonia olivacea*, the last usually olive-green in colour. Several other sea-anemones are found, including the extraordinary *Phlyctenactis retifera*, a large anemone frequently found floating or attached to seaweeds at the surface, but dredged once from a depth of 15 fathoms.

It will be noted that there are no Protodrilids.

These notes refer only to the commoner or more interesting forms that are likely to be met with on the Island Bay excursion, and are not designed to serve as a basis for views on the New Zealand littoral fauna as a whole.

H. B. Kirk.

ETHNOLOGICAL EXHIBITS IN THE DOMINION MUSEUM, WELLINGTON.

In a brief article only a few characteristic exhibits out of many can be dealt with.

Canoes.—The three principal types of canoes used by the Maori in former times were—(1) The double canoe; (2) the single-hull canoe with outrigger; (3) the single-hull canoe without outrigger. The first two types went out of use many years ago, but both were seen in Cook's time. The ordinary canoe of No. 3 type may be divided into three classes, as follows: (*a*.) The big capacious war-canoe, up to 80 ft. in length and 7 ft. to 8 ft. in width; ornamented with carved prow and stern-pieces, carved sideboards, painted devices, and feathers. (*b*.) Fishing-canoes, used also for any form of water carriage; plain prow and stern-pieces. Both these types were composed of a dugout hull of one, two, or three pieces ingeniously fastened together, with a top strake lashed on to raise the sides. (*c*.) Small river-canoes, without thwarts or decking, and minus any attachment or ornament —plain dugouts.

No specimen of the old-time double and outrigger canoes has been preserved, and the only specimen extant of the (*a*) class is that in the Auckland Museum. The largest specimen in the Dominion Museum is of the (*b*) class, used for fishing and ordinary travelling purposes. An old canoe fashioned with stone tools is one of the most valuable specimens.

In the cases may be seen collections of paddles, balers, carved prow and stern-pieces, and small model canoes. Fishing-gear is represented by a large number of hooks in wood, bone, and shell (a few being fashioned from moa-bone), nets and traps of various kinds, carved and plain sinkers, spear-points, &c.

Houses.—We have one high-class carved house up, though somewhat impaired by the absence of the veranda and window, the wrong situation of the entrance, and the substitution of fluted boards for reedwork in the lining. The carved posts, however, are very fine specimens, all named after ancestors. Interesting specimens of house-rafters adorned with painted devices may be seen on either side of the entrance to the main hall, and opposite that entrance the carved timbers of the front of the house. None of the highly elaborate elevated carved storehouses have been erected, owing to want of space, but parts of such are exhibited.

Stone Implements.—In stone implements are seen some very fine specimens of native workmanship, as in the case of weapons and adzes. The collection of stone adzes is large, showing a number of different types and the processes of manufacture. Of all stone implements the *patu*, a short hand-weapon, is the most symmetrical and well finished. The *mere* of nephrite is more rare. Other stone implements are pounders and beaters (used for a variety of purposes), drills, sinkers, and lamps. Of stone ornaments the neck-pendant termed *heitiki* was the most highly prized, and the manufacture thereof was exceedingly slow and laborious. An exhibit of much interest is the stump of a tree that was felled with stone tools.

Bone Implements.—In this department the most important items are weapons—viz., the curious long carved *hoeroa*, the notched *kotiate*, the *patu paraoa*, and *wahaika*. These were fashioned from whale's bones. Other bone items are mallets used by carvers, spear-points, fish-hooks, needles, cloak-pins, combs, flutes, and ornaments such as pendants of various kinds.

Wooden Implements. — In wood we have some typical Maori weapons, such as *taiaha*, *pouwhenua*, *tewhatewha*, and spears, fashioned out of hardwood by slow processes. Agricultural implements are represented by spades, picks, and the curious digging - implement termed *ko*, resembling the old Highland spade. In wood we also find combs, flutes, trumpets, tops, and other toys. Carved wooden boxes illustrate the fine work done by the Maori with stone tools. Vessels are of wood, as bowls, and bark deftly doubled up; also bowls and water-vessels of gourds, some of which are finely etched like those of various Pacific groups and Central America. The *mira tuatini*, a curious implement made by affixing the teeth of a species of shark to a wooden handle, was used wherewith to cut flesh. The curiously formed wooden coffins are specially interesting, as also are the so-called Kumara gods.

Other Exhibits.—The two dried tattooed human heads are good specimens, and must be a century old.

In textiles are shown cloaks and capes woven from the dressed fibres of *Phormium* and *Cordyline* by a peculiar process once employed by people of the Mississippi region; others of feathers and dogskin fastened on to a ground of woven fabric. Sleeping and floor mats are made by plaiting raw undressed strips of *Phormium*-leaf or of *Freycinetia*. Baskets and belts are made in similar manner.

There is also a small collection of bird snaring and trapping implements, with some long bird-spears.

ELSDON BEST.

THE MAORI OF NEW ZEALAND.

The natives of New Zealand form a branch of the Polynesian race, and are nearly related to the people of the Cook and Society Groups. The later-coming pre-European settlers in these Isles assuredly came from that region, hence the origin of the Maori of New Zealand is one with the origin of the far-scattered Polynesian race.

The original home-land of the Polynesians is a matter that has caused much interest and produced many conjectures. Most of the writers on this subject agree in locating that home-land in southern or south-eastern Asia. Professor Keane has placed the Polynesians among the Caucasic peoples in his family tree of the Hominidae, and claims that they represent the main subdivision of the Indo-Oceanic Caucasians. An interesting tradition preserved by the Takitumu clans of the North Island mentions Irihia as the name of the hidden home-land, and in this name some students of Polynesian ethnology recognize an old Sanscrit name for India—Vrihia. This name is apparently connected with *vrihi*, a name for rice, and the Maori has possibly preserved another rice-name in *ari*, which he states, was a small seed that formed one of the principal food-supplies of the land of Irihia.

Divers writers bring the Polynesians into the region termed by us Polynesia at varying dates ranging from 1000 B.C. to 450 A.D. Whatever the date may have been, the early European voyagers in these seas found them occupying an area of about 4,000 by 4,500 miles in extent. In addition to this exclusively Polynesian area there are many Polynesian colonies in far-sundered isles of Melanesia and Micronesia, from the New Hebrides to Monteverde Isle.

It is clear that the ancestors of the Polynesians were fearless voyagers, intrepid navigators of wide seas. Throughout long centuries they roamed over great areas of the Pacific, and made many long voyages repeatedly in all directions. Thus repeated voyages were made between Tahiti and New Zealand, between Tahiti and the Hawaiian Isles. A yet longer voyage was that from Fiji to Easter Island. These pre-Columbian neolithic sea-rovers, all ignorant of the compass and of the true art of shipbuilding, manned their carvel-built outrigger and double canoes, and cross-hatched great seas with their innumerable *ara moana* or sea-roads.

Some forty generations ago two of these Polynesian Vikings discovered the Isles of New Zealand and returned to eastern Polynesia. Twelve generations later the first Polynesian settlers arrived on these shores, but during that period the northern parts of the North Island had been occupied by an unknown people, a dark-skinned folk who probably came from the western Pacific. These early settlers were the descendants of castaways, the crews of three vessels that made land on the Taranaki coast. These two peoples intermarried, and hence the Melanesian characteristics so often observed among our Maori folk.

Communication between New Zealand and Polynesia was kept up for generations, but finally ceased, save for certain drift voyages. The last vessels to leave these shores for Polynesia, so far as we are aware, sailed about two hundred and fifty years ago. Since that time the Maori has been isolated in these Isles.

Inset—Nature Notes.

The Polynesian race is one that presents many points of interest to students of anthropology. The question of its origin has interested many writers, and its feats in deep-sea voyaging and colonizing across seven thousand miles of ocean have a fascination for ethnologists. Those interested in ethnographical lore, in comparative mythology, religion, and sociology, find here one of the most interesting fields for research. Owing to its long period of isolation in the Pacific region, in many far-scattered lands of small area, and to its being cut off from peoples of a higher culture-plane to the west and east, the Polynesian race has preserved many crude processes and arts. At the same time, these neolithic folk are remarkable for the possession of a high order of mentality, and it is this fact that renders their concepts such an interesting study. The cosmogonic and anthropogenic myths of the Maori people of these Isles are remarkable productions ; the esoteric versions of the same are pitched upon a high plane of thought, and contain many analogies with those of Oriental lands.

The student of comparative religion finds much interesting data in Maori lore. The superior concept of the Supreme Being, the conception of various spiritual potentiæ, the belief in two distinct spirit-worlds, in neither of which is there any suffering inflicted on the human soul—all these carry proof of the remarkable powers of introspective thought as possessed by the Maori. The belief in the purification of the human soul after death is perhaps the most striking result of such powers.

The universal personification that is so marked a feature of Maori mythology imparts a peculiarly mythopoetic aspect to the folklore, superior myths, and even to the vernacular speech of the Maori folk. No Oriental people excelled in such imagery the cannibal natives of these Isles.

The social system of the Maori is another subject of much interest, inasmuch as it illustrates certain institutions of communism that make for cohesion and the preservation of order, and supply the place of civil law. In this phase of social life we find that the social unit s neither the individual nor yet the true family, but the extended family, or family group.

A study of the implements and industrial processes of the Maori shows the low-water mark of his achievements—as, for example, his rude methods of fire-generation and weaving, his primitive agricultural implements and lack of missile weapons. On the other hand, his ingenuity and artistic talent were marked by most ingenious devices employed in taking birds, by his remarkable accomplishments in decorative art. The making of a war-canoe and the building of a superior house were tasks that proved the energy, skill, and indomitable patience of the Maori artisan.

An interesting feature of Maori culture is the fact that we find therein certain arts, institutions, and artifacts that are unknown in Polynesia, but are found in the western Pacific. These Maori-Melanesian parallels seem to be traceable to the region of New Guinea. Quite possibly these intrusions are referable to the earliest inhabitants of New Zealand.

Elsdon Best.

PHYSIOGRAPHIC NOTES ON AUCKLAND.

The beautiful symmetrical Rangitoto fitly stands sentinel in advance of the host of perfect volcanic cones which here, there, and everywhere stud the surface of the gently rolling lowlands of the Auckland District. But the subdued landscape, the numerous tidal creeks, the indented shore-lines, the wave-cut cliffs, all present a history not less interesting than that of the volcanic cones. For the area occupied by Auckland City and northward of it the history is this: A wide belt of weak sediments, flanked westwards by a submeridional volcanic range, has been largely reduced by normal erosion to near sea-level. Elevation of the area ensues, punctuated apparently by two periods of approximate standstill, marked at the present day—one most clearly, the other less so—by erosion surfaces immediately adjacent to Waitemata Harbour. Both are well below the level of widespread uplands which represent the maturely dissected peneplain of the earlier cycle. Uplift recommences, and deep stream-valleys are excavated in the broad erosion surface now conspicuous at low levels north-westward of Auckland. Suddenly there is a change, and a movement of depression causes the sea to advance into, or "drown," the newly cut valleys, with the result usual in such cases—the formation of numerous harbours, inlets, and tidal creeks.

Since, the "drowning" waves have been actively cutting back headlands, and, with the assistance of tidal currents, insilting the mangrove-dotted inlet-heads, and forming perfect miniature examples of barrier-beaches, spits, and other such shore-line features. The subsidence has now ceased and uplift has again begun, leaving its traces in shore-line platforms, as at Milford, raised about 5 ft. above normal high-water level, and in such small elevated strand-plains as those well displayed near Buckland's Beach.

Southward from Auckland City, on the other or western coast of the isthmus, lies the extensive Manukau Harbour, and around its shores is an area of totally different character from that farther north. In generalized terms it is a lowland more or less sharply bounded eastward, along a margin due to faulting and flexure, by irregularly warped uplands of resistant rock. It is largely built of soft incoherent silts laid down in a great estuary into which the Waikato River poured its waters, and which was separated from the Tasman Sea by a great barrier-beach, or similar accumulation, extending between resistant headlands nearly thirty miles apart. Behind this beach lofty sand-dunes arose, and, migrating eastward, covered up a portion of the estuarine deposits. To-day the sand-dune range, not yet destroyed by the ever-encroaching waves, forms the western margin of the lowland.

But the area has meantime been called upon to share the sharp uplift which led to the excavation of the trenches now forming the channels of Waitemata Harbour, and, in like manner to this latter, the present Manukau Harbour had its birth in the movement of subsidence which followed this uplift, and which seems, from evidence in the Manukau area, to have been quantitatively only a few feet less than the latter in its differential effect.

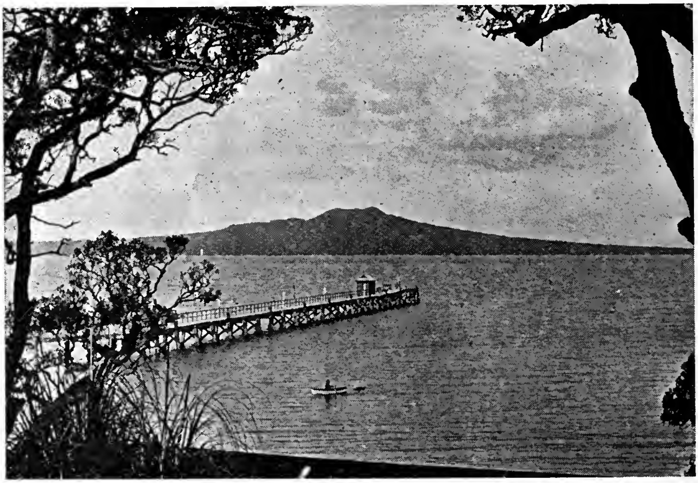
The commencement of volcanic activity manifested in the volcanic cones post-dates, in general, the sculpture of the present valleys, for the latter are often occupied by lava-streams.

Ejections of tuff, as a rule, preceded the outwelling of lava and the ejections of the scoriae which have formed most of the prominent cones in and around Auckland City. Less prominent tuff-cones are, however, frequent; with few exceptions they have wide craters now occupied by lakes, swamps, or inlets of the sea. Rangitoto is the only important cone owing its main elevation to accumulation of lava.

J. A. Bartrum.

RANGITOTO ISLAND AND ITS VEGETATION.

Guarding the entrance to Auckland Harbour, reaching a height of nearly 1,000 ft., and presenting from all points of view a long, gradually curving outline crowned with a triple peak, lies the Island of Rangitoto, the largest and the most recent of the many volcanic



[*Home Studios, Takapuna, photo.*

Fig. 9.—Rangitoto Island, Auckland, a lava-cone with a scoria-cone within its crater.

cones of the Auckland District, a locality characterized by Hochstetter as "one of the most remarkable volcanic districts of the earth."

Landing and ascending by an excellent track to the summit, the visitor at once notices that the whole of the island, except the cinder-cone with its wonderfully well-preserved crater, consists of lava-streams with an average inclination of from 4° to 6°. Of the

5,600 acres which make up its area, more than 5,000 are occupied by these streams. Their surface is everywhere rough and difficult to traverse, being composed of masses of basalt of all sizes and shapes, rough and sharp-edged, and piled into ridges separated by irregular depressions or chasm-like holes. That the lava is comparatively recent is evident; and good judges have estimated that not more than five hundred or six hundred years have elapsed since the close of volcanic activity. No streams of water exist, nor could such be expected, as the heaviest rainfall is at once absorbed by the porous surface.

Seen from a little distance the greater part of the island appears to be covered with a low scrubby forest; but once on shore it is found that there are considerable areas almost bare of vegetation except a few lichens and mosses. From the summit of the cone these spaces stand out black and distinct against the dusky green of the tree-clad portions. The most abundant tree is the "Christmas tree," or pohutukawa (*Metrosideros tomentosa*), which probably constitutes four-fifths of the ligneous vegetation. Outside Rangitoto it usually forms a tree 50 ft. to 60 ft. in height, but on the island it is seldom more than 20 ft., and often much less. About Christmas it is loaded with masses of crimson flowers. The broadleaf (*Griselinia lucida*) takes the second place, its stiff and leathery yellow-green leaves being everywhere conspicuous. Many other small trees are common, but space will not allow a reference to them here. It may be remarked, however, that *Senecio Kirkii*, one of the most beautiful shrubs in the Dominion, which usually grows in the shade of dense forests as an epiphyte, or more rarely on the ground, on Rangitoto flourishes among bare basaltic rocks exposed to blazing sunshine!

Growing in the shade of the *Metrosideros* or among the open rocks are large masses of two species of *Astelia*. With these flourish the orchids *Dendrobium Cunninghamii*, *Earina mucronata*, and *E. suaveolens*, species usually epiphytic, but on Rangitoto mainly rupestral. With them are associated many ferns and mosses, including the club-mosses *Tmesipteris* and *Psilotum*, the systematic position of which has been so often debated. Rangitoto is the only locality in New Zealand where the latter is at all plentiful.

One remarkable fact remains to be mentioned. Elsewhere in New Zealand the various species of *Trichomanes* and *Hymenophyllum* are essentially inhabitants of moist, shaded forests. On Rangitoto alone the kidney-fern (*Trichomanes reniforme*) and three species of *Hymenophyllum* flourish among the basaltic rocks exposed to full sunshine. In summer the fronds are curled up, withered, and appear to be dead; in winter they are fresh and green and vigorous, and apparently at home with their surroundings.

Rangitoto has many points of interest to the lover of nature. Its vegetation, save on the cinder-cone, is very much in its virgin condition, and likely to remain so. It is a matter for congratulation that the whole island is now an inalienable reserve for the benefit of the people of Auckland.

T. F. CHEESEMAN.

THE FOREST OF THE WAITAKEREI RANGE.

The nearest locality to Auckland where a really characteristic example of the indigenous vegetation can be seen is the Waitakerei Range, distant about fifteen miles in a westerly direction. It forms a much broken and dissected plateau about twenty-two miles in length with a width of eight or ten, its average elevation being about 1,000 ft. On the eastern side it rises gradually from the low undulating country through which the northern trunk railway runs, but on the western side drops very abruptly into the Pacific Ocean, the sea-cliffs ranging in height from 400 ft. to 800 ft. The central portion of the plateau is occupied by two streams: one, the Nihotapu, flowing southwards into the Manukau Harbour; the other, the Waitakerei, pursuing a northern course for several miles and then turning abruptly to the westward and discharging into the sea. Both these streams descend from the plateau by waterfalls of considerable height, that on the Waitakerei measuring 373 ft.

At the commencement of European settlement the whole plateau was covered with dense and luxuriant forest, and a considerable part of the central and western portions are still untouched. The eastern slopes have suffered severely, and in some places are denuded almost to the summit. The commonest tree is the tawa (*Beilschmiedia tawa*), which probably forms three-fifths of the forest. Other common species are the rata (*Metrosideros robusta*), the tangeao (*Litsaea calicaris*), and the rewarewa (*Knightia excelsa*). Large forests of the kauri (*Agathis australis*) formerly existed on the eastern slopes, but practically the whole of these have been cut down. A considerable quantity still remains in the central and western parts of the district, and, as the first of these is now reserved, much may yet escape destruction. The red-pine, or rimu (*Dacrydium cupressinum*), is still comparatively plentiful. A few species like *Pittosporum Kirkii*, *Drimys axillaris*, and *Ixerba brexioides* are confined to the higher part of the plateau. The undergrowth is chiefly composed of *Alseuosmia macrophylla*, the supplejack (*Rhipogonum scandens*), kiekie (*Freycinetia Banksii*), and various species of *Astelia* and *Gahnia*. Ferns are abundant, especially in the deep and narrow gullies, where the Hymenophyllaceae are particularly well represented. In the higher central valleys the ground is carpeted with mosses and Hepaticae, particularly of the genera *Hypnum*, *Isothecium*, *Hypopterygium*, *Plagiochila*, and *Gottschaea*.

Altogether the Waitakerei Range affords an excellent illustration of the forest of northern New Zealand, and is well worth a visit.

T. F. Cheeseman.

THE KAURI FOREST.

The kauri pine (*Agathis australis*), the most noble and impressive of the forest-trees of New Zealand, and one with few equals in other countries, has a limited range, being confined to the district between the North Cape and a line drawn from Tauranga Harbour on the

FIG. 10.—Interior of Waipoua Kauri Forest, North Auckland. The slender stems are those of the taraire (*Beilschmiedia taraire*).

east coast to Kawhia on the west. Although it will flourish in almost all soils and situations save those which are exceedingly wet, it prefers hilly and somewhat rugged localities and a poor and clayey soil. Usually it forms little clumps or small groves rather than continuous forests. These groves may contain from a dozen to a hundred or many hundreds of trees. Usually they are separated by forest tracts in which few kauris are present. Rarely the groves may almost coalesce, forming a forest in which the kauri is the dominant although by no means the sole tree. Nowadays such instances are rare; for the ravages of sixty years of sawmilling have swept the forest out of existence, or very greatly changed its appearance, reducing what was once a noble and magnificent spectacle to a scene of utter ruin and desolation.

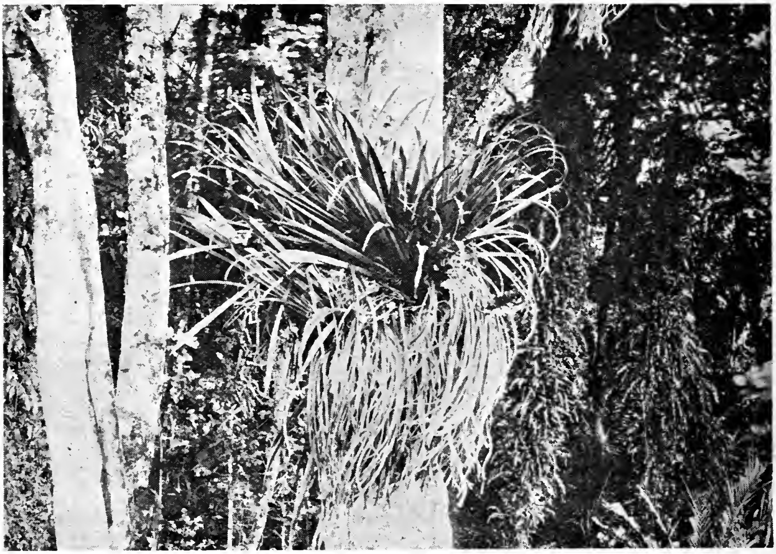


FIG. 11.—The Kahakaha (*Astelia Solandri*) growing on the smooth trunk of the taraire. The climbing fern *Blechnum filiforme* covering tree-trunks on the right.

A kauri forest has a very remarkable and distinctive appearance. Even when seen from afar it can be recognized by the manner in which the trees stand far above the adjoining forest, by their peculiar ramification, and by the dark, dusky-green colour of the foliage. But it is from the interior of the forest that the kauri is seen to the best advantage, and its majestic size and noble proportions can be best appreciated. On all sides rise the huge columnar trunks, sometimes towering up for more than 80 ft. without a branch, and tapering but slightly from the base upwards, smooth, grey, and glistening. At the base of the trunk is the large mound of debris produced by the fall of the bark, which is regularly cast off in large flakes. It is from this peculiarity that the bole of the kauri is so free from the climbers and epiphytes that commonly clothe the larger trees of the New Zealand forest. From the top of the trunk spring, almost from one point, the short but immensely thick branches. These, with the branchlets and foliage, form a high vaulted roof to the forest, through which a varying amount of daylight filters to the ground. As large trees of other species seldom grow plentifully intermixed with the kauri, the forest has an open appearance not usually seen in the New Zealand woodlands. Under the vaulted roof of branches the eye can penetrate far and wide among the massive trunks, which have hence been compared to the pillars of some vast Gothic cathedral.

So much for the physiognomy of the kauri itself. But one of the most distinctive features of the kauri grove of any size is the peculiar nature of the associated vegetation. Although few really large trees grow intermixed with the kauri, smaller trees and shrubs do, together with certain herbaceous plants and ferns. And wherever a clump of kauri exists these plants are found, or, at any rate, the greater portion of them. Space does not permit of a full account, but it may be allowable to mention the names of prominent species. Of shrubs or trees there are the taraire (*Beilschmiedia taraire*), the neinei (*Dracophyllum latifolium*), the mairehau (*Phebalium nudum*), the tapairu (*Senecio Kirkii*), and the climbing ratas (*Metrosideros florida* and *M. albiflora*). Of non-shrubby plants the most noteworthy are the "kauri-grass" (*Astelia trinervia*) and *Gahnia xanthocarpa*, together with the ferns *Lomaria discolor* and *Lygodium articulatum*. These, and many others, are those which delight to grow in association with the kauri, although by no means so certain to appear in company in the ordinary forest.

A young kauri—say, from fifty to a hundred years old—differs entirely in appearance from the mature tree. It has a narrow conical and sharply pointed outline, and is furnished with a succession of short slender branches inserted at right angles to the stem. As the tree increases in size the lower branches are cast off one by one, but it is only by slow degrees that the bushy-topped shape of the adult is assumed. It is a curious fact that young kauris are not commonly found among the mature trees, the reason probably being that the amount of light is not sufficient for the growth of the very young tree. The juvenile kauri is usually found on the outskirts of the forest proper, and is accompanied by such trees as the white tea-tree (*Leptospermum ericoides*), the towai (*Weinmannia sylvicola*), the toru (*Persoonia toru*), the maire (*Fusanus Cunninghamii*), the rewarewa (*Knightia excelsa*), and others. Such localities have been very truly called the nursery of the kauri. Granted sufficient time, this mixture of young kauris and other trees would develop into a forest of mature kauris; and in point of fact the intermediate stages can be observed without difficulty.

One of the most interesting of the peculiarities of the kauri is its copious production of a resin to which the name of "kauri-gum" is ordinarily applied. In a fresh state every part of the kauri is filled with a transparent turpentine, which exudes from the slightest wound. An injury to the bark, a broken branch, even bruised leaves, at once cause a copious flow. At first soft and viscid and of whitish colour, it gradually hardens on exposure to the air and becomes more transparent, forming lumps ranging in size from small tear-drops to masses many pounds in weight. These pieces may be found in the forks of the branches, in hollows or depressions on the trunk, or concealed in the mound of debris at its base. But, in addition to the resin met with in the living kauri forest, very much larger quantities can be found buried at various depths on the sites of previous forests, although these must have ceased to exist for hundreds or even many thousands of years. That these deposits are in many cases of enormous antiquity can be proved by the changes that have taken place in the physical configuration of the country since they were formed. Kauri-gum has been found under the beds of shallow lakes; it has been dug up in quantity at considerable depths in swamps; and it has been excavated from strata overlaid by sand-dunes themselves of no very recent formation; while in not a few localities it has been observed in beds dipping under the present level of the sea, and on the Auckland Isthmus in strata overlaid by lava-streams.

All through the North Auckland Peninsula are large areas of rolling open lands of poor quality, intersected by swampy gullies, and covered with a heath-like vegetation mainly composed of tea-tree (*Leptospermum scoparium*) and other shrubs, together with sedges, a few herbaceous plants, terrestrial orchids, and some ferns. Almost everywhere these areas contain deposits of kauri-gum—sometimes close to the surface, at other times buried at considerable depths. These "gumfields," as they are called, have for many years afforded a living to some thousands of "gum-diggers," who annually produce from 7,000 to 10,000 tons of gum. These nomadic diggers, wandering over hill and swamp, armed with spade and gum-spear, are a familiar and picturesque sight to travellers in the North Auckland districts.

It may well be asked in what manner did the kauri forests of the past disappear, what vegetation succeeded them, and what have been the series of changes which have resulted in the present plant covering of the gumfields. The answer to these questions is, however, still uncertain and incomplete.

T. F. Cheeseman.

AUCKLAND MUSEUM.

Probably that portion of the Museum which will prove most interesting to a visitor from abroad is the Maori Hall, which is devoted to collections illustrating the manners, customs, and mode of life of the Maori race. Here can be seen a magnificent example, 84 ft. in length, of a war-canoe, carved and decorated from end to end, and in a perfect state of preservation. It is the last survivor of the fleets of war-canoes mentioned by all early travellers and explorers from the time of Cook to the establishment of British rule. Here, too, will be found a superb specimen of a *whare whakairo*, or meeting-house, without which no Maori village in olden times would be considered complete. Two elaborately carved storehouses are also exhibited. These differ from the meeting-houses in their carvings and other ornamentation being on the outside of the house instead of in the interior. Round the walls of the hall are placed many ancient and valuable carvings, several of them dating back to a time long prior to the introduction of iron tools. In the show-cases are arranged the smaller articles. The visitor should pay special attention to a case devoted to the exhibition of a series of carved coffins or burial-chests, sixteen in number, used to receive the bones of chiefs of high rank. Several of these are believed to be from two hundred to three hundred years old.

Within the limits of a short notice it is impossible to mention more than a fraction of the many treasures contained in this part of the Museum. Suffice it to say that almost all the features of Maori life are well represented. Their weapons; their axes, gouges, and chisels; their fish-hooks and fishing-implements; their bird-snares and bird-spears; their miscellaneous tools and implements; their elaborately carved feather boxes; their musical instruments; their varied personal ornaments; their cloaks and other articles of clothing—all are to be seen, and in most cases illustrated by numerous examples. In a room adjoining the Maori Hall is a small foreign ethnographical collection, serviceable for comparison with the work of the Maoris.

The main hall is devoted to the zoological and geological cellections. In the centre of the lower floor stands an elaborate group comprising a skeleton of the largest species of moa (*Dinornis maximus*) and a life-size restoration, 10 ft. in height, of the bird itself. Surrounding these are examples of the nearest living allies of the moa—the ostrich, the emu, and the cassowary. Occupying the remainder of the centre of the hall are some fine groups of mammals obtained under the provisions of a special bequest made by the late Mr. Mackechnie. In the wall cases on the north and east sides of the hall are placed the foreign birds; on the south side the smaller mammals.

The New Zealand birds, of which the Museum possesses a fairly representative collection, will be found on the north side of the gallery; the fishes are shown on the south side; while the reptiles, including a varied set of preparations of the celebrated tuatara lizard, must be sought for at the eastern end. The geological collections, both New Zealand and foreign, are placed in a separate room opening out on the Maori Hall.

T. F. CHEESEMAN.

ROTORUA AND TAUPO DISTRICTS.

The Town of Rotorua, near the southern extremity of the lake of the same name, is 171 miles by rail south-east from Auckland. The surrounding district forms part of what is known as the thermal belt or region of the North Island. This region extends north-eastward from Mount Ruapehu (9,175 ft.) to White Island in the Bay of Plenty, a distance of over 150 miles, and contains within its limits several semi-active volcanoes, numerous geysers, and countless hot springs. The prevailing rocks are andesites, rhyolites, agglomerates, tuffs, and pumiceous drifts, late Tertiary to Recent in age. These in many places have been profoundly altered by the action of heated waters and vapours.

The thermal district contains many lakes, some of which fill explosion cavities, whilst others occupy downwarped hollows or areas dammed by volcanic debris.

FIG. 12.—Mud volcano at Waiotapu.

FIG. 13.—Mount Tarawera, showing the rift blown out by the eruption of 1886.

The chief points of interest near Rotorua are the Sanatorium grounds, with several boiling springs and artificial geysers; Hamurana, a large cold-water spring; Tikitere, with immense pools of fiercely boiling mud; and Whakarewarewa, where one may see every phase of solfataric action. Here are mud volcanoes, sinter deposits, steam-vents, numerous boiling springs, and geysers, the largest of which are known as Pohutu and Wairoa.

About fifteen miles south-east of Rotorua is Mount Tarawera (3,770 ft.), which in the early morning of the 10th June, 1886, suddenly burst into eruption. As a result 130 lives were lost, and the surrounding country buried by the ejected debris. A great rift—or, rather, series of explosion cavities—nine miles in length, was formed. The bottom of a small lake, Rotomahana, was blown out,

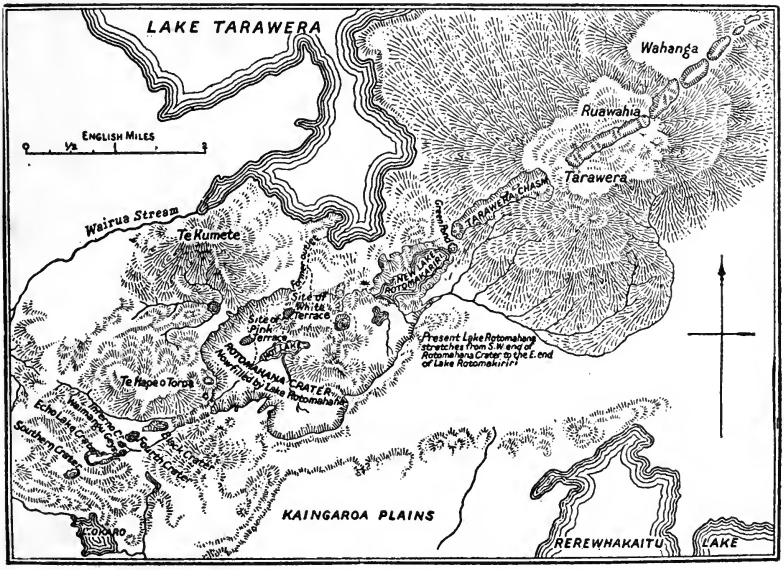


FIG. 14.—Map of Tarawera volcanic rift after the eruption of 1886.

and the adjoining Pink and White Terraces destroyed. Since the eruption a new Lake Rotomahana, much larger than the old lake, has been formed. The Tarawera rift, the major axis of Lake Rotomahana, and Waimangu, greatest of geysers, lie on an approximately straight line. As a geyser Waimangu was in regular operation only during the years 1900–4, but in later years there have been several spasmodic outbursts.

About the end of May, 1922, a long series of earthquakes began in the district at the north end of Lake Taupo, and at the time of writing had not entirely ceased. During June there were days on which at least a hundred shakes were perceptible to the senses. The shocks were nearly all mild, but a few were sufficiently strong to shake articles off shelves and slightly to damage chimneys.

P. G. MORGAN.

THE PLANT-LIFE OF THE HOT LAKES DISTRICT.

The pumice substratum, notwithstanding the considerable rainfall, in many places has only permitted the establishment of a more or less xerophytic vegetation, so that the commonest plant formation is shrubland with *Leptospermum scoparium* dominant. Where there is the poorest and driest soil there may be almost pure stands of *Dracophyllum subulatum*, a shrub virtually confined to the Volcanic Plateau Botanical District. A very beautiful plant with the same range as the above epacrid is *Gaultheria oppositifolia*, which, when it grows in company with *G. rupestris*, a species of extremely wide range, gives rise to the polymorphic hybrid *G. fagifolia*.

Where soil-conditions, climate, and shelter permit trees to be established there is a fine taxad rain-forest. For instance, splendid forest, but now much reduced in area, can be seen from the train at Mamaku.

The effect of heated ground, together with the special chemical characteristics of the soil in the vicinity of hot springs, fumeroles, &c., brings about both epharmonic changes in plastic species and the establishment of special plant associations. Thus, the low tree or tall shrub *Leptospermum ericoides* is changed to a prostrate shrub; yet *Leucopogon fasciculatus*, with usually an ecologically equivalent growth-form, under identical conditions remains quite erect. Where exposed to steam from a stream of hot water various pteridophytes grow with extreme luxuriance, especially *Gleichenia circinata*, *Histiopteris incisa*, and *Lycopodium cernuum*. Certain ferns in the area being considered are restricted to places where the steam is especially powerful: such are *Gleichenia linearis*, *Schizaea dichotoma*, *Nephrolepis cordifolia*, *Dryopteris parasitica*, and *D. gongylodes*. In the hot pools themselves with a maximum temperature of 75° C. there is an association of *Schizophyceae*.

The eruption of Mount Tarawera in 1886 led to a considerable area of vegetation being buried so deeply by volcanic ash that an absolutely new habitat, destitute of plant-life, was provided for plant colonization. Nineteen years after the eruption the deep water-courses of the steep slopes were occupied thickly, except on their ridges, by *Arundo conspicua* and *Coriaria sarmentosa* (fig. 15). On the flatter ground the new vegetation was extremely open. The most interesting point is that none of the colonizing species had come any distance, for all were plants of the immediate neighbourhood. On Tarawera itself and the area adjacent there are multitudes of the flat cushions of a variety of *Raoulia australis*, just as certain members of the same genus, after the destruction of the tussock-grassland, occupied the depleted slopes of Central Otago. A large majority of these plant settlers were wind-borne, the number of species brought by birds being very few.

L. COCKAYNE.

Fig. 15.—New vegetation (in 1905) on the deep volcanic ash ejected during the eruption of Mount Tarawera in 1886. The tussocks are those of the toetoe (*Arundo conspicua*); they are at least 5 ft. high.

THE TONGARIRO NATIONAL PARK.

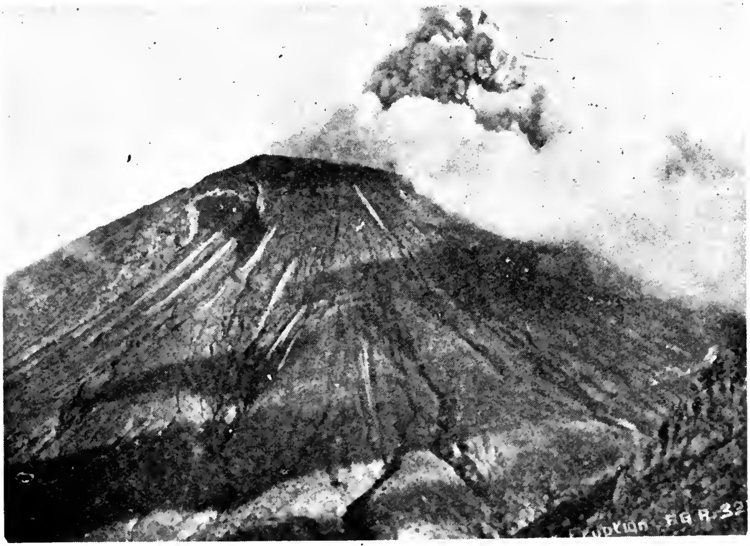
The Tongariro National Park, one of the five national parks of New Zealand (the others being Mount Egmont, the Waimakariri, Mount Cook, and the Sounds), is the chief one located in the North Island, and includes within its boundaries the great volcanic cones of Ruapehu, Ngauruhoe, and Tongariro.

Largely owing to the presence of the volcanoes of the Tongariro National Park, New Zealand has a reputation as a volcanic country which is not entirely deserved. True, at various epochs of bygone geological eras there have been districts where volcanic action has been intense, notably in the South Island near Dunedin, at Banks Peninsula, at the eastern base of the Southern Alps, in Marlborough, and in the North Island in the vicinity of Auckland, on Coromandel Peninsula, near the Bay of Islands, and at Egmont; but the greater part of the land-surface has been formed by the more orderly processes of denudation, sedimentation, and vertical uplift in which paroxysmal action has played a very subordinate part. On the whole, the Tertiary era was the time of greatest volcanic activity, especially in the North Island, and present-day manifestations, interesting though they may be, show a decline in energy which may herald approaching extinction. But periodicity is such a characteristic feature of volcanic action that we cannot predict this for certain, and present decline may be merely the prelude to more intense activity in the near future. If this is to occur, then the value of a volcanic observatory would be very great indeed.

The only existing active foci in the North Island lie on a line stretching in a north-east direction from Ruapehu towards White Island, in the Bay of Plenty, but several of the points of special interest are located within the actual boundaries of the Park. Its most striking landscape feature is Mount Ruapehu (9,175 ft.), not so graceful or symmetrical as Egmont, but still a noble-looking mountain, undwarfed by any neighbouring height, and rising from a circular base some forty miles in circumference to a summit truncated by a crater nearly a mile across. The appearance of size is increased by the fact that it rises direct from a plateau for close on 6,000 ft. with slopes which are regular and uninterrupted. It is a composite cone, perhaps a twin cone, constructed of flows of lava and interstratified layers of ash and scoria. The summit-crater is almost filled with ice, which has used the hollow as a "collecting-ground," the excess overflowing the low parts of the crater-ring chiefly towards the east, while a part moves in the direction of a small hot lake in the middle of the crater, formed by the action of the escaping steam on the ice, the supply of water being constantly replenished by the melting of the small icebergs which break away from the ice-front as it reaches the hot water. The lake is about 400 ft. across, and is depressed considerably below the general level of the ice in the crater. No doubt its conditions vary somewhat with the varying activity of the volcano. Ruapehu has never displayed within historic times any pronounced activity, though the lake on top is hot and has occasionally discharged mud over the slopes of the mountain. Its scenic interest is increased by the presence of

[*F. G. Radcliffe, photo.*

FIG. 16.—Mount Ruapehu, from Horopito.



[*F. G. Radcliffe, photo.*

FIG. 17.—The cone of Mount Ngauruhoe, showing smoke-like cloud of fumes and tuff-particles emitted during an eruption.

a considerable amount of ice on the outer slopes, which is organized in places into definite glaciers.

About ten miles north-east of Ruapehu lies the beautiful sugarloaf cone of Ngauruhoe (7,515 ft.), which is separated from it by a distinct and low saddle—in fact, there is no apparent geographical connection between the two mountains. The last-named cone is always more or less active, and on numerous occasions, notably in 1909, it has discharged ashes over the surrounding country, and lava has been reported as occurring in the throat of the crater. The last discharge of lava may have occurred as late as 1869, when there was a somewhat severe eruption, but doubt has been cast on this statement. The crater is continually altering in form as a result of the constantly recurring periods of activity. Steam and sulphurous gases frequently form clouds which envelop the cone, and should be avoided, if possible, by persons making the ascent.

About two miles farther on in linear sequence lies Tongariro (6,458 ft.), a somewhat shapeless mass, which is apparently the base of a volcano, analogous in bulk to Ruapehu, whose top has been destroyed by a paroxysmal explosion. On the irregular summit thus left, and on a line with both Ruapehu and Ngauruhoe, lie two active points, the Red Crater and Te Mari (5,641 ft.). Ngauruhoe may be regarded as belonging to the same series, for it is apparently a point of activity located on the truncated summit of a greater Tongariro, and is really a secondary cone. The Red Crater has within recent geological times discharged lava, ash, and mud. The crater has been breached by a lava-flow which has run down into another of the crateral hollows on the top of Tongariro. Te Mari has at times been quite active, and has thrown ashes as far as the northern shore of Lake Taupo. At the present time it is discharging steam and sulphurous gases.

Between these two active centres lies an extinct crater now occupied by the Blue Lake (5,570 ft.), one of the most picturesque and weird spots on the top of the mountain. Both on and off the line of active vents are others which were formerly of importance, though some of the craters, such as the Oturere Crater, may have been areas of collapse rather than of extrusion. On the northern side of the mountain facing Lake Roto-aira are the Ketetahi Hot Springs, noted for their thermal activity.

There are one or two other points on the Park which present features of interest, notably the lakes on the saddle between Ruapehu and Ngauruhoe, called Nga Puna a Tama, which occupy the sites of small explosion-craters; while to the west of Ruapehu lies the buttress of Hauhangatahi (4,983 ft.), volcanic in origin, and evidently belonging to the Ruapehu series, judging from the similarity in the nature of their lavas. On the eastern flank of the mountain lies the Rangipo Desert — perhaps the only true desert in New Zealand— formed of scoria and ash washed from the upper slopes of the volcano, with masses of lava rising at intervals through the loose debris.

The line of volcanic vents continues north-east beyond the limits of the Park, through Pihama, south of Lake Taupo; through Taupo itself, where the Island of Motukaiko and its outlying reefs give evidence of volcanic activity, to Tauhara, near the north-east corner of the lake; and so on to Tarawera, Mount Edgecumbe, Whale Island, and White Island—the last being a very active centre.

The foundation of these volcanoes was laid during the middle and latter part of the Tertiary era on underlying sedimentaries of early Mesozoic age, but the extrusive processes became most active during the Early Pleistocene and later, the volcanic development being no doubt a manifestation attendant on, though not necessarily a consequence of, the elevation of the central portion of the North Island. The deeply entrenched beds of the Rangitikei, Wanganui, and Mokau Rivers, which rise in the vicinity of the volcanic zone, demonstrate this upward movement, and there is biological evidence based on the distribution of plants and animals which suggests that an arm of the sea existed in late Tertiary times right into the heart of the Island, if not actually across it, dividing it into two or more detached fragments, which have been subsequently joined as a result of these elevatory movements.

The first eruptions of the region were in all probability rhyolitic in character, since there is a widespread distribution of pumice of that nature in Tertiary sedimentary deposits of the surrounding country, as well as lava-flows of the same lithological character over a more restricted area; but these do not show within the limits of the Park. If they do exist they are completely masked by the later volcanic material, which consists of augite-hypersthene andesites and hornblende-hypersthene andesites, the former being far in excess of the latter in geological importance. During the last stages a little olivine appears, indicating a more basic facies. Although the andesites form the most recent rocks of Ruapehu and its associated cones, there is an extensive deposit of pumice over the whole central area of the Island, forming a thin veneer in most places, but thick drifts along the watercourses and at times on the mountain-slopes. The recency of this pumice covering is shown not only from its position on the top of all other surface material, but from its containing charred logs in such numbers and in such positions as point to the destruction of the forests at a quite recent date. The source of this pumice is doubtful, but it has been suggested that it came from Taupo as the result of a paroxysmal explosion which formed the basin now occupied by the lake. The general evidence, however, points to tectonic movements as being responsible for the formation of this basin. The earthquakes recently recorded from that district clearly indicate that the crust in its vicinity has not yet reached a condition of stability.

R. Speight.

THE PLANT-LIFE OF THE TONGARIRO NATIONAL PARK AND ITS ENVIRONS.

The area here dealt with includes the loftiest part of the North Island, together with its extension to the Main Trunk line from Waiouru to Waimarino. Nothing is said about the forest associations, since such do not differ greatly from those in certain other parts of the North Island. What follows is devoted to the flora and vegetation of the open country, nearly all of which lies at an altitude of more than 3,000 ft.

The pteridophyte and spermophyte flora, limited as above, consists of about 185 species belonging to forty-three families and ninety-six genera. The most important to note of the species are the following, which do not extend to the South Island; some (marked with a star) are very rare, or wanting, except in the Volcanic Plateau Botanical District or its immediate neighbourhood: *Ranunculus nivicola, Pimelea buxifolia, Dracophyllum recurvum,* D. subulatum,* Logania depressa,* Veronica laevis, V. tetragona,* V. Hookeriana,* V. spathulata,* Ourisia Colensoi,* Euphrasia tricolor*, and *Raoulia australis* var. *albosericea* (= *R. albosericea* Col.).

Coming to the vegetation, the most characteristic plant association is that of the desert. That there should be such a feature of the landscape in a forest climate seems a paradox. But it is not a climatic but an *edaphic desert*, its presence depending on the porous pumice soil, little retentive of moisture and easily moved by the wind, and the loose scoria of the mountain-slopes. It is also, in part, a primary stage of succession which has its climax—according to circumstances — in pumice fell-field, tussock-grassland, or even forest. In places there is retrogressive desert (*e.g.*, part of the Onatapu Desert).

The most characteristic species of the association is *Dracophyllum recurvum*, which forms reddish open cushions or almost mats. Frequently the pumice sand blown by the wind builds dunes, which, gaining stability through certain plants having secured a footing, sometimes support more than twenty kinds of shrubs, herbs, semi-woody plants, and grasses. The ultra-desert species which occupy, at wide intervals, unstable slopes of scoria are *Luzula Colensoi, Claytonia australasica, Gentiana bellidifolia*, and *Veronica spathulata;* but elsewhere the *Claytonia* is often found at times in shallow water, and the gentian under highly mesophytic conditions.

Next in interest to the above is the pumice fell-field (named by me originally "shrub-steppe") occupying flattish ground at about an altitude of 3,600 ft. to 4,500 ft. The plants grow on low, flat mounds of fine pumice and humus. The usual species present number twenty-five (fifteen shrubs, six semi-woody plants and herbs, three tussock-grasses, and one fern).

Tussock-grassland occupies much of the lower part of the open country, with *Danthonia Raoulii* var. *rubra* dominant, and *Dracophyllum subulatum* and the beautiful *Euphrasia tricolor* as characteristic species.

Finally, the "winter-bogs" must be noted, where the plants endure extreme conditions, since the habitat becomes dry in summer. *Carpha alpina, Oreobolus pectinatus, Hypolaena lateriflora* var. *minor*, and *Celmisia glandulosa* are common members of this peculiar association.

L. Cockayne.

THE GEOLOGY OF THE "MINERAL BELT" OF NELSON.

The "Mineral Belt" of Nelson and west Marlborough is a great band of magnesian igneous rocks, varying from six miles to about half a mile in width, which stretches in a very definite and little broken line for about seventy miles, from D'Urville Island at the north-east of Nelson Province approximately south-westward to the upper waters of the Wairau River in west Marlborough. It forms rugged country of strong relief, which, according to Bell, Clarke, and Marshall, represents a portion of an ancient dissected peneplain covering a great part of the northern portion of the South Island. The areas occupied by the magnesian rocks are generally detected very readily in the field, even at considerable distance, by the peculiar and stunted nature of their vegetation, which contrasts strikingly with that flourishing on the near-by areas of sedimentary rock.

In 1859 Dr. F. von Hochstetter visited Nelson, and, as a result, his well-known publications early demonstrated the exceedingly interesting nature of the ultrabasic igneous rocks of the " Mineral Belt " to petrologists throughout the world. Dunite, a rock composed almost wholly of somewhat granular olivine, was named by Hochstetter after Dun Mountain (3,703 ft.), a conspicuous, brown, grass-covered, rounded knob, prominent near the Town of Nelson, and composed in large part of this rock. Even before the visit of the eminent Austrian geologist the " Mineral Belt " had become famous in the early " fifties " on account of its alluring but illusory deposits of copper-ores and chromite, which were even then being mined at various places near Nelson, and north-eastwards at Croiselles and D'Urville Island.

Little is known of the geology of the " Mineral Belt " other than that portion near the Town of Nelson, which has been described comparatively recently by Bell, Clarke, and Marshall in *Geological Survey Bulletin No. 12* (1911). For this reason the present description applies chiefly to this latter, or the Dun Mountain area.

Stratigraphically the ultrabasic rocks form sill-like masses intrusive into argillites, greywackes, and coarser rocks of Permo-Carboniferous age (or thereabouts), which are quite insignificantly metamorphosed by the intrusion. In the same (Maitai) series there is a prominent somewhat argillaceous limestone, which for nearly nine miles forms the west wall of the magnesian intrusion. Westward of the limestone the argillites appear to underlie with perfect conformity conglomerates and fossiliferous sandstones containing middle and upper Triassic forms. The limestone and some of the closely adjacent argillites of the Maitai series are sparingly fossiliferous, and Dr. C. T. Trechmann has assigned a Permo-Carboniferous age to them. The stratigraphical relations of these strata to the Triassic seem explicable only on the supposition of overfolding or overthrusting, or a combination of the two, and there is indeed strong evidence of faulting in topography and in the actual in-tilting of Tertiary strata along the west margin of the Triassic rocks, where the comparatively lofty strike ridges in which they outcrop border the low-lying Waimea Plain.

In facies the rocks of the intrusive zone are highly interesting, but have been very incompletely studied from areas not included in the Dun Mountain Subdivision. Here serpentine, derived from the olivine-enstatite rock harzburgite, forms the main portion of the mass, and exhibits local gradation into fresh harzburgite. Near Dun Mountain itself there is serpentine derived from the dunite outcropping in that mountain. Dyke-like intrusions of doleritic and dioritic rock are fairly numerous, chiefly as a western fringe to the ultrabasic rocks near their contact with the enclosing sediments. The most interesting dykes, however, are those of websterite, a remarkable, coarse, diallage rock with subordinate enstatite, and of an unusually rare rock called rodingite, which has an exceedingly high lime-content (31·04 per cent.) and a very high specific gravity (3·502).

Hutton originally described the rodingite as a saussurite gabbro, a name by which it continued to be known for many years, but Bell, Clarke, and Marshall determined the supposed saussurite as grossularite (lime-aluminium garnet), and introduced a new name, "rodingite," for the rock. The coarse greenish-white crystals of the grossularite are moulded on subordinate diallage, which is practically the only other constituent, and often show alteration to a mineral identified as prehnite. The normal rodingite occurs as more or less narrow dykes intrusive throughout the general peridotite, but varieties termed "prehnite rodingite" and "serpentine-prehnite rodingite," in which prehnite has replaced the original grossularite, form an important belt separated from the eastern margin of the peridotites by a strip of sediments over half a mile wide.

In discussing the origin of the rodingite, Bell, Clarke, and Marshall reject any possibility of assimilation of adjacent limestone by the magnesian magma, and suggest some form of differentiation as the controlling cause.

A chrome-iron ore, or more strictly a spinelled mineral intermediate between chromite and picotite, forms separate grains in the dunite and serpentine, and is frequently segregated in the latter to form nodules and small, discontinuous, scattered, lens-like veins which furnished nearly 4,000 tons of ore before mining operations were abandoned in 1866. The Dun Mountain tramway, a popular route to the top of the mountain, was built in order to transport this ore.

Copper lodes occur in shear-zones in shattered serpentine, and in the Dun Mountain area are found chiefly near where the serpentine merges into the dolerites and diorites forming the western margin of the "Mineral Belt." The lodes are numerous but highly discontinuous, and only a comparatively few feet in greatest dimension. After a long unprofitable struggle since 1855 against unfavourable conditions, mining practically ceased about twelve years ago. The site of the most important operations was in the valley of Roding River, a few miles south-west of Dun Mountain. In this area the gangue is chiefly serpentine or occasionally rodingite. The unoxidized ore shows two main associations—cupriferous pyrrhotite (containing up to 1·5 per cent. of copper) and minor chalcopyrite, both intimately intermixed, or else pyrrhotite and native copper. In both the pyrrhotite is the earlier mineral, and the presence of native copper with it is ascribed by the authors of the Dun Mountain bulletin to differential oxidation of the pyrrhotite, though the conditions permitting such oxidation are not stated. The same writers consider that the lodes are genetically connected with the intrusions of rodingite.

The oxidized superficial portions of the lodes show the usual minerals, and from some of the outcrops large blocks of native copper have been obtained.

Mr. C. P. Worley states that specks of platinum have been found, as might be expected, in the alluvium of some of the streams draining the peridotite belt.

J. A. Bartrum.

THE VEGETATION OF A PORTION OF THE "MINERAL BELT."

After following the easy but gradually ascending track to the Dun Mountain (Nelson) for some miles through noble southern-beech (*Nothofagus*) forest, the tree-community abruptly comes to a halt and the widest part of the celebrated "Mineral Belt" is entered, its barren-looking vegetation offering a striking contrast to the tall green trees at its margin. This sudden alteration in the nature and aspect of the plant covering is apparently due to the high magnesian content of the soil. But the change, almost without transition, from luxuriant forest to xerophytic shrubs, tussock-grassland, and bare rocky ground to no small extent exaggerates the barren aspect of the "Mineral Belt" vegetation, for really it is not different in appearance or ecological characteristics to certain other allied communities of the so-called "dry" New Zealand mountains. Most of the species, indeed, are common enough, but there are a few local endemics — *e.g.*, *Pimelea Suteri*, *Myosotis Monroi*, perhaps also the local forms of *Poa acicularifolia* and *Cassinia albida*, as also the so-called *Coprosma Cunninghamii* and a species of *Festuca*. Such forest-trees as overstep the line are dwarfed to shrubs—*e.g.*, *Nothofagus fusca*, *N. cliffortioides*, *Weinmannia racemosa*, and some others.

The vegetation is made up of shrubland, fell-field, and tall tussock-grassland, the last-named with rather small *Danthonia flavescens* dominant.

The following are common members of the shrubland : *Phormium Colensoi*, *Exocarpus Bidwillii*, *Nothofagus fusca*, *N. cliffortioides*, *Pittosporum divaricatum*, *Hymenanthera dentata* var. *alpina*, *Leptospermum scoparium* (sometimes dominant, from 6 ft. high to prostrate), *Griselinia littoralis*, *Cyathodes acerosa*, *Suttonia divaricata*, *Veronica* sp. (apparently related to *V. buxifolia*, perhaps locally endemic), *Coprosma propinqua*, *C. foetidissima*, *C. Cunninghamii* (or an undescribed species), *Olearia virgata* var., *Cassinia albida* var. In places the association gets more and more open until it merges into the fell-field. The latter, where the ground is extremely stony with many loose stones on its surface, is represented by but few species, the most interesting being *Notothlaspi australe*, *Pimelea Suteri*, *Colobanthus quitensis*, and *Myosotis Monroi*. Other species of fell-field are *Poa acicularifolia* var., *Claytonia australasica*, stunted *Leptospermum scoparium*, *Dracophyllum rosmarinifolium*, and *Helichrysum bellidioides* (very grey in colour).

The foregoing lists are far from complete, but, in any case, the florula is quite small. It is interesting to note that none of the species of *Olearia* or *Senecio* so characteristic of subalpine scrub are present, while the shrubland itself is closely related to river-terrace scrub.

In conclusion it must be pointed out that the remarkable plant covering so briefly described in this note, together with the virgin forest adjacent, form that splendid national domain—the Cawthron Park—given by the late Mr. T. Cawthron to the people of New Zealand.

L. Cockayne.

THE CAWTHRON INSTITUTE, NELSON.

The Cawthron Institute of Scientific Research owes its origin to the munificent bequest of the late Thomas Cawthron, merchant, of Nelson, who left the sum of nearly £240,000 for the purchase of land and the establishment and maintenance of a technical school, institute, and museum, to be called the Cawthron Institute.

On the advice of a commission of New Zealand scientific men, it was decided that the Institute should be a research Institute, the chief object of which should be to investigate problems in connection with the industries of New Zealand, particularly agriculture and horticulture.

"Fellworth," the site of the Institute, is a large private house which has been fitted up as a collection of laboratories, offices, a museum, and a library.

The museum is of interest in that it contains a photographic record of the work of the Institute, maps showing the progress of the soil survey of the Nelson Provincial District, an interesting entomological collection, and an irreplaceable set of Sevres and Meissen ware.

The grounds of the Institute have been laid out to demonstrate the effect of different fertilizers on a number of different types of soil, and will be found of great interest to students of agriculture.

The library probably contains the most complete collection of entomological literature to be found in Australasia.

T. H. Easterfield.

GEOLOGICAL NOTES ON BANKS PENINSULA, CANTERBURY.

The oldest rocks of Banks Peninsula are slates and greywackes exposed near Gebbie's Pass at the head of Lyttelton Harbour, and covering them are rhyolites with dykes of pitchstone. The great mass of the peninsula has, however, been built up chiefly of andesites and basalts poured forth from the two great craters of Lyttelton and Akaroa. Subordinate later eruptions, also of andesites and basalts, took place from Mount Herbert (3,050 ft.), the highest elevation of the mountain complex, lying to the south of Lyttelton Harbour.

The whole area suffered from extensive stream-erosion when the land was higher, but subsequently depression set in, and the combined effect of these two agencies on the complex volcanic mass is responsible for the dominant landscape features. An impressive view of Akaroa Harbour is obtained from the hilltop (1,200 ft.); the great caldera lies below, its entrance guarded by giant cliffs, rising sheer 500 ft. on the southern side. The stream-enlarged hollow with its drowned valleys is ten miles in length, and into the centre stretches the small peninsula of Onawe—noted historically as the scene of the massacre of South Island Maoris by the conquering chief Te Rauparaha, but interesting geologically for the presence of a mass of syenite and gabbro at its extremity, the only occurrence of plutonic rocks in the district.

At the head of Lyttelton Harbour may be seen rhyolites and pitchstones and excellent exposures of loess. A road follows the shore of the harbour, and then climbs for 1,000 ft. to the crest of the Lyttelton crater-ring, from which point a magnificent view is obtained. Looking east there lies the enlarged crater of Lyttelton, with Quail Island in the centre, and finger-like peninsulas dividing the drowned valleys; in the middle distance is the long gentle slope accordant with the lava-flows which issued from Mount Herbert; and far beyond the indistinct medley of hills forming the mass of the peninsula.

R. Speight.

THE FLORA OF BANKS PENINSULA.

Banks Peninsula is a congeries of steep volcanic hills of oval outline about thirty to thirty-five miles long and fifteen to twenty miles wide. In the centre are the crests of Mount Herbert and Castle Hill, rising approximately to a height of 3,000 ft. Botanically speaking, the peninsula is an island, for were it isolated from the plains by a strait five miles wide its vegetation would probably be little different from what it is now. Like all insular districts off the New Zealand coast it has its distinctive species, and these are interesting and striking—three rock-plants, *Senecio saxifragoides*, *Veronica Lavaudiana*, *Celmisia Mackaui*, and a fourth plant, *Cotula Haastii*, usually to be found in dry tussock formations on the seaward side of the peninsula. It is true that these species have been reported from other parts of the province; but, with the doubtful exception of the fourth mentioned, they are at present not known to botanists elsewhere than on Banks Peninsula. The first three species are striking and handsome plants, found on the moister rock-faces with a southerly aspect. *Senecio saxifragoides* is confined to the Lyttelton Hills, and is usually found at an altitude of from 800 ft. upwards anywhere between Gebbie's Pass, at the head of Lyttelton Harbour, and the Lyttelton lighthouse, and on the harbour side of the hills only. It is worth looking for—a herbaceous plant with a rosette of large rounded hairy leaves, closely appressed to the rocks. *Celmisia Mackaui*, the rarest of the three, is only to be found near Akaroa, and is scarcely likely to be gathered by the casual visitor. *Veronica Lavaudiana* is found in similar localities to *Senecio saxifragoides*, and is abundant all over the peninsula. It produces masses of corymbose white flowers, pinkish in the bud, and is often cultivated locally in gardens. Everywhere, indeed, on the peninsula the rocky faces and promontories provide forms of interest in addition to the endemic species already mentioned. In such situations will be found representatives of the genera *Metrosideros*, *Astelia*, *Earina*, *Colobanthus*, *Dracophyllum*, *Anisotome*, &c., that are not to be met with in the bush below. Indeed, the vegetation of the rocky cliffs here is a highly distinctive one.

Though visitors will perhaps search for these rare and distinctive species first, there are certain aspects of the florula that are sure also to attract attention. Cook Strait is not, as is well known, a barrier for North Island plants; but there is a considerable number of such species which become rarer as we go south, and finally dwindle out at Banks Peninsula. It is thus the southern limit—on the east coast, at least—for the nikau-palm (*Rhopalostylis sapida*), the karaka (*Corynocarpus laevigata*), the pigeon-berry (*Hedycarya dentata*), the titoki (*Alectryon excelsum*), and about a dozen other species. Unfortunately, however, the forest which once clothed two-thirds of the peninsula from summit to base has been nearly completely destroyed, and it is now becoming increasingly difficult to see anything of its original glory. There is, indeed, only one spot left where the lower taxad forest can be seen in its primeval beauty. An easy motor run of thirty miles from Christchurch over level roads will take the visitor to Price's Valley, where there are a few acres of magnificent forest in good preservation. Here will be found huge specimens of black and white pine, with a considerable admixture of totara. The black-pine (matai, *Podocarpus spicata*) is easily recognized by its brownish-black bark, which is hammer-marked (*i.e.*, covered with circular patches about 2 in. in diameter, which suggest that it has been repeatedly struck by a heavy hammer). Its trunk is tall and straight, and often more than 3 ft. in diameter. The white-pine (kahikatea, *P. dacrydioides*) is usually more tapering, with rougher, greyer bark, and with even more characteristic hammer-markings than the matai. The totara (*P. totara*) becomes much more common as we ascend through the forest, and is easily recognized by the long strips of pale-brown bark hanging from a trunk which is more massive even than in the other species, often reaching a diameter of 5 ft., though the tree is usually not so tall as the black or white pine. Many other species of trees are, of course, to be found in this forest, together with a dozen or two different kinds of shrubs and perhaps eight or ten lianes, amongst which *Rubus cissoides* (a lawyer, well marked by its yellow prickles) here reaches an unusual size, climbing to the tops of the tallest trees.

Though this taxad forest was dominant on the peninsula, there are remnants near Akaroa of what was probably an earlier forest. On the seaward and eastward side of the Akaroa hills there has stretched at one time, near the summit of the hills, a beech forest consisting chiefly of *Nothofagus fusca*, but containing also a number of curious variant forms, possibly hybrids between *N. fusca* and *N. Solandri* or *N. cliffortioides*, of both which latter species a few more or less typical specimens are to be found. This beech forest is of special interest because of its isolation, and because it has apparently been driven seaward by the stronger and more aggressive taxad forest, and would, even perhaps without the intervention of man, have become extinct in a few thousand years. It still contains in places some very fine stands of the magnificent *Nothofagus fusca*.

In the centre of the peninsula, on the bald crests of the highest hills, is to be found a somewhat unexpected formation of subalpine plants. This is most easily reached from the Hilltop Hotel, on the Akaroa-Little River Road. A climb of two hours from here will bring the tourist to the summit of Mount Sinclair, where he will find when he comes above the bush-line of mountain totara and cedar (*Libocedrus*) an assemblage of plants containing such subalpine forms as *Ourisia macrophylla* (var.), *Veronica Lyalli* (var.), *Raoulia glabra, Raoulia subsericea, Olearia cymbifolia, Drapetes Diffenbachii,* and, more rarely, *Oreomyrrhis andicola, Euphrasia zelandica, Epilobium macropus,* and various grasses, several of considerable rarity.

Banks Peninsula belongs to Cockayne's Eastern Botanical District, but its vegetation is sufficiently distinctive to constitute it a well-defined sub-district. It is to be regarded rather as an outlier of the Kaikoura coastal region than of Otago—*i.e.*, its affinities are northern rather than southern.

R. M. Laing.

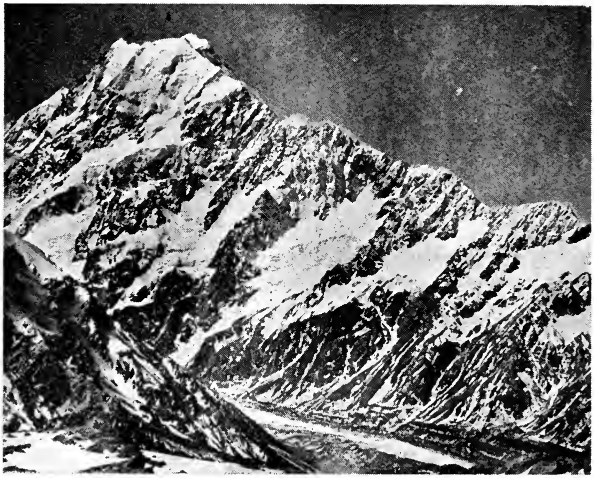
CANTERBURY MUSEUM.

The Canterbury Museum was founded by Dr. von. Haast in 1861, and he held the office of Director till his death in 1887. Largely owing to his energy and enthusiasm, and to the use he made of his finds of moa-bones for the purpose of exchange, the collection developed rapidly, and the Museum gained a widespread reputation throughout the scientific world. This collection was subsequently arranged on scientific lines by Captain Hutton, who held the office of Curator from 1892 to 1905. These two distinguished scientific men laid the foundations on which the subsequent development of the institution is based.

The chief feature of interest is the collection of *Dinornis* remains, which includes the greater part of the moa material obtained from Glenmark, Kapua, and Enfield, as well as representative material from other places. Owing to the fact that the two Curators mentioned above were primarily geologists, the geological section of the Museum has been strongly developed, and it includes thoroughly representative mineral, petrological, and palaeontological collections from New Zealand and from foreign countries, there being a good assemblage of New Zealand Tertiary fossils, including many types. Other departments of the Museum have, however, received adequate attention. A special feature has been made of the New Zealand natural-history collection, notably the birds. The insect material includes the Fereday collection of Lepidoptera, as well as representatives of the groups worked over by Captain Hutton, including many of his types. A noteworthy exhibit is the skeleton of the Okarito whale (*Balaenoptera sibbaldi*), which till quite recently was the largest in any museum in the world. This was obtained through the energy of Mr. Edgar F. Stead during the curatorship of Mr. Edgar R. Waite.

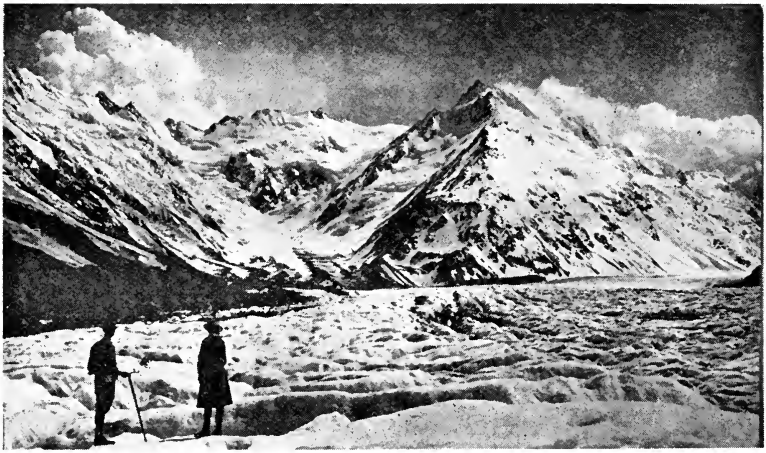
There is a very good collection of ethnological material, especially that from the Pacific islands. The Maori collection is small, but includes several articles of exceptional interest; and the Moriori material is probably the best in the country, and includes at least two collections made in the early days by residents at the Chatham Islands. The herbarium, founded by Sir Julius von Haast, and containing many of his specimens, comprises a fairly complete series of New Zealand plants.

R. Speight.



[*F. G. Radcliffe, photo.*

FIG. 18.—Mount Cook as seen across the Hooker Valley.



[*F. G. Radcliffe, photo.*

FIG. 19.—The Tasman Glacier. To the left of the centre the Rudolph Glacier joins the Tasman.

THE SOUTHERN ALPS.

The Southern Alps are usually considered to extend from Mount Aspiring (9,975 ft.), west of Lake Wanaka, to about the head of the Grey River, in north Westland. The mountains of western Otago, however, should be included in the alpine system ; and, so far from terminating in north Westland, the range continues north-eastward through Nelson and Marlborough to the southern shore of Cook Strait. North of the Grey River the range is known first as the Spenser Mountains, next as the St. Arnaud Mountains, and then, although still of considerable height, is for many miles without a definite geographical name.

The mountains of western Otago, with Earnslaw (9,200 ft.) and Tutoko (9,042 ft.) as their highest points, form a congeries of ranges separated by deep valleys, some of which are occupied by lakes, and others, the fiords, by the waters of the sea. They seem to owe their present height to simple uplift rather than to the operation of folding forces, and are therefore to be regarded as belonging to a block-mountain system.

From Mount Aspiring northwards the Southern Alps appear on the western side as a definite, deeply dissected, but unbroken range, dropping steeply to the moraine-covered lowlands of Westland. On the eastern side, broken into somewhat irregular ranges by the river-valleys, &c., they extend many miles towards the Canterbury Plain. Greywackes and argillites of Trias-Jura age, strongly but irregularly folded and clearly much faulted, form almost the whole of the Canterbury mountains. West of the main divide these rocks gradually pass into schistose greywackes and phyllites, and finally into closely folded mica-schists, on the whole striking north-north-east, or somewhat to the west of the trend of the range. On the extreme western margin of the Alps there is some gneiss, which, like the schists, may represent highly metamorphosed sedimentary rocks. Separated from the Alps proper and from one another by deep valleys, several mountains, formed wholly or mainly of granite, overlook the Westland lowlands.

Hochstetter, Haast, and Hutton explain the Southern Alps as a folded mountain-range, forming a huge geanticlinal, of which only the eastern half has been preserved. The western half, according to Hochstetter, is " buried in the depth of the main " (? downfaulted), or, according to Hutton, has been removed by erosion. The geological studies of recent years show that the western side of the Southern Alps is bounded by a great fault, and that, as it now stands, the range is an uplifted block, tilted slightly south-eastward, and probably somewhat, but not greatly, modified in structure by a compressive force acting from the south-east. The writer thinks that uplift occurred in the Pliocene and perhaps also in early Tertiary times. The folding of the rocks is conceived as belonging mainly to an earlier period, probably the late Jurassic or early Cretaceous. The Spenser and St. Arnaud mountains have the same structure as the Southern Alps, and, as previously indicated, are essentially one and the same range.

Among the higher alpine peaks are the following : Mount Aspiring (9,975 ft.); Mount Cook (12,349 ft.), Mount Tasman (11,497 ft.), Mount

Malte Brun, Mount de la Bêche, and several others in the Mount Cook group, all over 10,000 ft. Farther north are Mount Adams, Mount Lambert, Mount Evans (8,612 ft.), Mount Whitcombe (8,656 ft.), and others over 8,000 ft. high. Still farther north the alpine range is under 7,000 ft. in height, but several mountains in the Spenser Range reach heights of over 7,000 ft., the highest being Mount Franklin, 7,571 ft. Some of the branch ranges in Canterbury reach heights of 8,000 ft., and, in the case of Mount Arrowsmith (9,171 ft.), over a thousand feet more.

Owing to the heavy snowfall, the glaciers of the Southern Alps, in proportion to the heights of the mountains and the size of the snowfields, are unusually large, and, moreover, descend to low levels. Thus on the eastern side the Tasman, Mueller, and Hooker glaciers have their terminal faces at 2,354 ft., 2,550 ft., and 2,880 ft. above sea-level. On the western side the Fox Glacier descends to 620 ft., and the Franz Josef, as elsewhere described under a special heading, to 692 ft. above sea-level.

P. G. Morgan.

GLACIERS AND GLACIATION IN THE MOUNT COOK DISTRICT.

The Hermitage Hotel, beautifully situated in the Hooker Valley, close to the terminal moraine of the Mueller Glacier (fig. 20), and almost at the base of Mount Cook itself, is approached by a good road, and is thus within an easy day's journey of Timaru by service motor-cars. Here, in the very heart of the Southern Alps, the visitor may, without leaving the hotel, hear the boom of avalanches and enjoy unrivalled mountain scenery. Névé-fields and hanging glaciers are all around, and the evening glow on the snow-capped summit of Mount Cook, as seen from the Hermitage, is a sight no traveller visiting New Zealand should miss.

A walk up the Hooker Valley by the side of the glacier to the Hooker Hut affords a fine view of Mount Cook at close quarters, and of the glaciated trough of the Hooker Valley, with hanging tributary valleys and truncated spurs. The surface of the Hooker Glacier, as in the case of all the glaciers on the eastern side of the main divide of the Southern Alps, is heavily covered with moraine. The track to the Hooker Hut passes along a ridge of stranded lateral moraine for a considerable distance.

A walk or ride of several hours from the Hermitage brings one to the Ball Hut, just below the junction of the Ball and Tasman glaciers, and situated between the rocky wall of the Tasman Valley and a high ridge of stranded lateral moraine bordering the great Tasman Glacier. From this point a short walk over the ice of the Tasman Glacier (clear of moraine from this to the head, excepting medial ridges) brings into view the magnificent ice-fall of the Hochstetter Glacier, which descends from Mount Cook. It is necessary to spend a night at the Ball Hut.

This excursion may be extended up the Tasman Valley as far as the Malte Brun Hut, which is reached by walking about eight miles

FIG. 20.—Glaciers of the Southern Alps. (From Marshall's *Geology of New Zealand.*)

1. Hochstetter Dome.
2. Elie de Beaumont.
3. Mount Green.
4. Mount Darwin.
5. Malte Brun.
6. Mount de la Bêche.
7. Mount Haidinger.
8. Mount Haast.
9. Mount Tasman.
10. Mount Cook.
11. Mount Hicks.
12. Mount Stokes.
13. Mount Sefton.
14. Mount Sealey.

up the glacier. The Malte Brun Hut stands on a bench on the eastern side of the glacier, and from it a splendid view is obtained of the névé-field at the head of the Tasman, and of the surrounding peaks and hanging glaciers. If a stay is made at Malte Brun Hut it may be used as a base for an expedition to the Hochstetter Dome, on the main divide, at the head of the Tasman Glacier.

Numerous short trips from the Hermitage can be arranged, and experienced mountaineers have the choice of many fine climbs.

The road from Timaru (via Fairlie) to the Hermitage passes through the Mackenzie Plain, and thence up the Tasman Valley. The Mackenzie Plain occupies a large tectonic depression lying between the main range of the Southern Alps and an outlying complex of faulted blocks. The depression is filled in with alluvium to form a basin-plain, traversed by the rivers of the Waitaki system. There is considerable interfingering of the alluvium with glacial moraines. The large lakes in the basin—Tekapo, Pukaki, and Ohau—are held up by dams of terminal moraine in valleys enlarged by glaciation.

It is clear that the glaciers, nestling now close to the main divide, were at one time enormously extended. Very striking evidence of the great former extension of the Tasman Glacier, for example, is seen in the presence of prominent terraces of stranded lateral moraine high on the sides of the Tasman Valley, overlooking Lake Pukaki and the rapidly growing delta at the head of the lake. There are also hanging valleys.

That the modern glaciers are still corrading is evidenced by the milky appearance of the rivers that flow from them. So fine is the rock-flour they carry that much remains in suspension even after the water has passed through the large lakes Pukaki and Tekapo.

C. A. Cotton.

THE PLANT-LIFE IN THE VICINITY OF MOUNT COOK.

A rapid acquaintance with the floristic and ecological characters of the New Zealand high-mountain plants can be gained with far greater ease in the confines of the Mount Cook National Park than anywhere else in New Zealand. Usually to visit the high-mountain plant associations entails an arduous climb of several hours. From the Hermitage, on the contrary, only a few yards away there is primitive subalpine scrub, while a leisurely walk of two or three miles, or less, without any climbing, enables a large percentage of the plants to be seen in their primeval habitats. There are certainly some which never descend into the valleys, but nearly all such can be reached by the excellent track leading to above the shrub-line on the Sealey Range.

The total number of species of pteridophytes and spermophytes in the area under consideration is about 380, which belong to 54 families and 146 genera. This is about 40 per cent. of the whole New Zealand high-mountain flora, many species of which are of local distribution, while others are restricted to localities much drier than that of Mount Cook. Most of the genera of the Mount Cook florula contain few species, the following alone having each ten or more: *Carex*, 17; *Veronica*, 16; *Celmisia*, 15; *Epilobium*, 14; *Coprosma*, 12; *Ranunculus*, 10. But the greater part of the area is botanically unexplored, so that the above estimate may be considerably below the mark.

The natural shrubbery near the Hermitage is made up chiefly of the following: *Dacrydium Bidwillii, Phyllocladus alpinus, Podocarpus nivalis, Discaria toumatou, Aristotelia fruticosa, Gaya Lyallii, Hymenanthera dentata* var. *alpina, Coprosma rugosa, C. propinqua, C. parviflora, C. rhamnoides*, and *Senecio cassinioides*—the last-named abundant,

FIG. 21.—The Mountain-lily (*Ranunculus Lyallii*), the largest buttercup in the world.

and very showy when in full bloom with its multitude of yellow flowers.

The famous *Ranunculus Lyallii* (fig. 21), known as the "mountain-lily," grows luxuriantly in many parts of the Hooker Valley, and in its company is *Celmisia coriacea*, almost the finest of this beautiful genus. When the stiff-leaved *C. Lyallii* is also present, hybrids between the two may sometimes be found.

The species of *Veronica* are not as numerous as in some localities, but almost the most charming of all, *V. macrantha*, is both extremely vigorous and abundant. *V. Hectori*—of the whipcord form, and so characteristic of the Fiord and South Otago Botanical Districts—and *V. Buchanani* have here apparently their northern limits. Another shrub characteristic of the south, but here also abundant, is *Olearia moschata*. In fact, the area occupies a rather critical position, situated as it is at the eastern limit reached by the heavy westerly rain, and not very far from the southern limit of the botanical district—the Western—to which it belongs.

In hollows on the mountains the snow often lies long into the summer, when the steeper ground adjacent has been for many weeks clear. Such hollows—*e.g.*, on the Sealey Range—have a special

FIG. 22.—The vegetable sheep (*Raoulia eximia*), a plant of the daisy family forming hard cushions on rocky ground, Mount Torlesse Range, Canterbury.

vegetation consisting of a thick mat of *Danthonia oreophila* var. *elata* (not known elsewhere), *Astelia monticola* (a distinct species not yet described), and a species of *Aciphylla* related to *A. Monroi* but much larger. At a higher altitude similar hollows are the growing-place of *Celmisia Hectori*, which is absent on the drier ground.

The small piece of forest (Governor's Bush) near the Hermitage has *Nothofagus Menziesii* as its sole tall tree—not *N. cliffortioides*, as one might expect. The association gradually changes into low forest of *Phyllocladus alpinus*, which in its turn gives place to subalpine scrub much as already described but containing many more species.

L. COCKAYNE.

THE FRANZ JOSEF GLACIER, WESTLAND.

The Franz Josef Glacier, remarkable for the low altitude of its terminal face, is situated on the western side of the Southern Alps, a little over sixty miles as the crow flies south-west of Hokitika, and not many miles north of Mount Cook. The front of the glacier lies approximately in latitude 43° 26′ south and longitude 170° 11′ 30″ east of Greenwich. It is now easily reached by motor-coach from Hokitika (road-distance ninety-five miles), or from the rail-head at Ross, fifteen miles south-west of Hokitika.

The terminal face of the Franz Josef Glacier is approximately 692 ft. (as determined in 1909) above sea-level, and about eleven miles from the sea-coast. It has a width of about half a mile. The nominal head of the glacier, at Graham Saddle, seven miles and a half to the south-east, has an elevation of 8,759 ft., but neighbouring

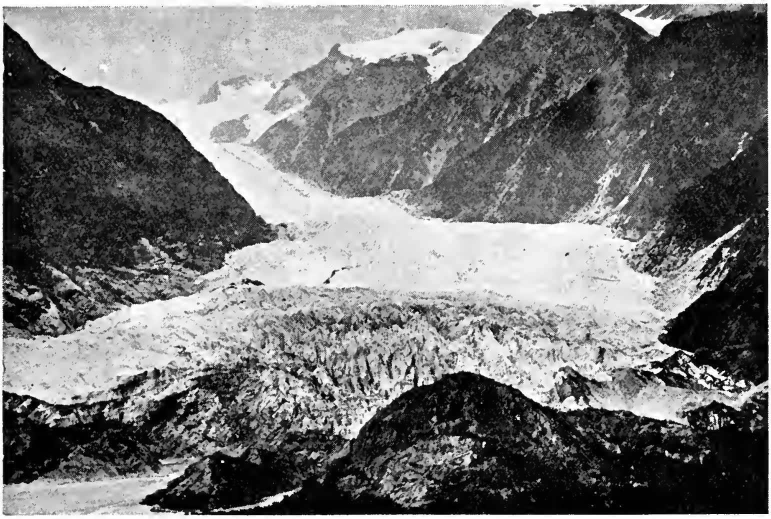


FIG. 23.—The Franz Josef Glacier.

peaks, Mount de la Bêche and Minaret Peaks, rise to heights of over 10,000 ft.

About half-way from Graham Saddle to the terminal face the feeding snowfields converge in order to enter a comparatively narrow valley. Here is the "Great Icefall," and thence downwards the upper surface of the glacier is everywhere less than three-quarters of a mile wide. The low altitude to which the ice descends may be attributed to the narrowness of the containing valley and its steep grade. As determined by observations made in 1908, the surface of the glacier, towards the centre of the valley, but near the terminal face, moves at the rate of about 2 ft. per day in summer. Higher up, towards the icefall, the motion is no doubt more rapid. In winter the motion is presumably slower.

The ice-front at the present time, so far as the writer knows, is retreating. Twelve to fourteen years ago there was a considerable advance, but for a long time previous to that the glacier had been retreating, probably almost continuously. J. M. Bell estimates the retrogression in quite recent times (during the last 150 years) at 41 chains, and there can be little doubt that on the whole the glacier will continue to lose ground during the next few hundred years.

The almost complete absence of moraine on the surface of the Franz Josef Glacier, especially near the terminal face, allows its beauties to be seen to full advantage. There are innumerable pinnacles or seracs and irregular cavities in the much-broken ice, so that travel over it is difficult and in many places impossible.

A few miles south of the Franz Josef Glacier is the Fox Glacier, less visited and possibly less beautiful, but having its terminal face at a still lower altitude—namely, 620 ft. above sea-level.

P. G. Morgan.

THE VEGETATION NEAR THE FRANZ JOSEF GLACIER.

The special botanical interest which the immediate vicinity of the Franz Josef Glacier affords lies in the plant colonization, now in progress, of ground left bare by the retreating ice, and in the effect of a large glacier at so low an altitude (terminal face, 692 ft.) in altering the altitudinal distribution of certain high-mountain species.

On the eastern side of the glacier a fairly wide belt of ice-worn rock extends from the margin of the ice to the well-established scrub above. At a few yards distance from the ice colonizing commences with the establishment of patches of the moss *Rhacomitrium symphiodon*. Decaying below, the moss rapidly forms raw humus suitable for seed-germination. The rock itself (a quartzose schist) is marked by many depressions, grooves, and cracks, which also, invaded by the moss, are the special places where seeds germinate when brought by wind or water from the scrub or forest. Plants at various stages of development are fairly frequent, the advantage of ultimate survival, where several grow together, being all in favour of the first-comers. More than thirty species of pteridophytes and spermophytes take part in the invasion. The following list includes the most important species: *Hymenophyllum multifidum* (grows on solid rock and forms soil), *Lycopodium varium*, *Agrostis pilosa*, *Poa novae-zelandiae*, *P. Cockayniana*, *Schoenus pauciflorus* (where water lies), *Earina autumnale*, *Carmichaelia grandiflora*, *Coriaria sarmentosa*, *Metrosideros lucida*, *Gunnera albocarpa*, *Gaultheria rupestris*, *Dracophyllum longifolium*, *Veronica subalpina*, *V. Lyallii*, *Coprosma rugosa*, *Olearia avicenniaefolia*, *O. ilicifolia*, *O. arborescens*, and *O. Colensoi*.

Between the first arrival of the plants and their ultimate union into scrub there is a long period, but this is greatly shortened if even a thin layer of moraine is left on the rock by the retreating ice.

Farther back from the rock which is being invaded is a broad belt of tall scrub with the shrubs mentioned above, together with various rain-forest species—*e.g.*, *Asplenium bulbiferum*, *Polystichum vestitum*, *Carpodetus serratus*, *Weinmannia racemosa*, *Melicytus ramiflorus*, and other mesophytes. There is also a good deal of *Metrosideros lucida*, so that the scrub will eventually become forest of the same character as that forming the next belt of vegetation.

A good many species usually confined to the subalpine belt descend near the ice to within about 1,500 ft. altitude, or even much less. The following are examples: *Agrostis Dyeri*, *Poa novae-zelandiae*, *Geum parviflorum*, *Anisotome Haastii*, *Dracophyllum Kirkii*, *D. Traversii*, *Veronica subalpina*, *V. linifolia*, *Coprosma serrulata*, *Celmisia coriacea*, *C. bellidioides*, *Olearia Colensoi*, and *Leucogenes grandiceps*.

L. Cockayne.

THE GEOLOGY OF THE DUNEDIN DISTRICT.

Our present detailed knowledge of the distribution of igneous rocks in the Dunedin district is due almost entirely to the work of Dr. Marshall and his students. Briefly, the region consists of a series of Tertiary sediments resting on the planed surface of mica-schists. On the eroded surface of these the volcanic complex was built up. The mica-schists are probably the altered form of late Palaeozoic or early Mesozoic sediments. The immediately overlying beds are gritty sandstones with seams of exploitable lignite, which, traced into regions immediately adjacent to the Dunedin district, are seen to be covered by beds which in two or three localities have been found to be fossiliferous. In one of these places is a limestone with fragments of bivalve shells and belemnites which is probably of late Cretaceous age, while in another, recently found by Fyfe, the sandstone contains early Eocene molluscs. These are followed by glauconitic mudstones, loose sands, marls with "Oligocene" (?) Foraminifera, shark, fish, and penguin bones, a thin band of greensand, and a thick series of loosely cemented calcareous sandstones with terebratulids, echinoids, and a few molluscs, which pass up into impure limestones with a more abundant molluscan fauna, shown recently by Finlay to be of approximately "Miocene" age.

The earlier portions of the volcanic rocks are exposed in the southern, western, and eastern portion of the Dunedin igneous complex. They consist chiefly of a series of dolerite and basalt flows, with some trachyte in the east, and a minor amount of tinguaite and trachydolerite. A succession of twenty-six such flows is exposed in the Otago North Head. The later volcanic rocks forming the west, north-west, and central portion of the region consist more largely of trachydolerite and phonolite. Extensive explosions occurred near Port Chalmers and Portobello, resulting in the formation of large necks filled with breccia, from which radiate a series of tinguaite dykes. The extent to which hypabyssal bodies such as laccolites or sills are associated with the above-mentioned lavas is not yet quite clear. Between successive flows there may have been very short intervals of time, so that the upper flow may rest on the unweathered scoria of the first;

or there may elapse a considerable interval with deep erosion and some sedimentation, so that between the flows are stratified leaf-bearing tuff-beds and even conglomerates. Though of small thickness generally, such deposits rise to a thickness of 100 ft. in Fraser's Gully, immediately west of Dunedin. Rarely carbonaceous beds are seen, and a single stratum of oil-shale is known. A series of small basalt-flows poured out from scattered vents after the older volcanic rocks of the region had been greatly eroded were the latest products of igneous activity.

The region now reached a mature state of erosion. The two main valleys draining the volcanic hills ran in opposite directions, their heads separated by a low divide. The region subsided beneath the sea, the minor valleys all became deep embayments, and the main divide was flooded over, so that a long through-channel was formed—the present Otago Harbour, the southern opening of which was closed by the formation of the sandspit tying the Taieri Peninsula to the mainland, where South Dunedin and St. Kilda now stand. Sandbars also have very nearly closed entrances to the outer or oceanward series of drowned embayments. The effects of a later minor uplift can be recognized locally in the presence of raised beaches and of two-cycle valley-forms seen in the Kaikorai Valley (for example), west of Dunedin.

W. N. Benson.

THE FLORA OF DUNEDIN.

The earliest settlers found the Dunedin district bush-clad from the water's edge almost to the summits of the highest hills. Human necessity has led to the clearing-away of much of this primeval covering, but a wise foresight has set apart as a reserve a number of forest remnants, some even within the city. In these more or less unmolested areas there has been preserved almost every species of the primitive vegetation.

The great variety of plant stations, resulting from an altitudinal range of 3,000 ft. and a somewhat complex topography, is well reflected in the diversity and number of species represented in the district. Within a ten-mile radius there may be gathered over five hundred species of flowering-plants and a still larger number of cryptograms, exclusive of naturalized and other introduced species. This list is inclusive of seventy-five ferns and one hundred and fifty marine algae. Of the total assemblage, close on 90 per cent. still exists in the area bounded by the visible horizon of the city.

The great majority of the indigenous species are endemic, but the same cannot be said of the genera, which are for the most part Australian also. Indeed, only nine endemic genera are met with in the neighbourhood of Dunedin.

As elsewhere, the physiognomy of the forest is sombre, but far from unattractive. The visitor is struck as much by the infinite variety in the shades and hues of green of the New Zealand bush as he is by the absence of green in the native-grass lands locally represented on Flagstaff, Chain Hills, &c. Conspicuous blossoms are the exception rather than the rule, most of the flowers being small and unisexual either in structure or in function. Where not wholly green, the dominant colours are white, yellow, and blue, the only local plant having red flowers being the beautiful scarlet mistletoe (*Elytranthe Colensoi*) ; but the resplendent golden blossoms of the kowhai (*Sophora microphylla*), the exquisite pure-white flowers of the bush-clematis (*C. indivisa*), or the myriad blooms of the lacebark (*Hoheria angustifolia*), manuka (*Leptospermum*), and lawyer (*Rubus australis*), lend a charm to the landscape in their respective flowering seasons.

The visitor with little time at his disposal, and wishing to make a first-hand acquaintance with the native plants, is recommended to visit the Town Belt ; but, as the larger timber-trees and a considerable portion of the undergrowth have been removed, a much better though slightly more distant locality would be the forest-clad slopes of Flagstaff or Swampy Hill. Indeed, of all the trips available, none is more comprehensive than that which follows the Leith to its source on Swampy Hill. A good road leads right to the Leith Saddle, and from this point the final ascent is both easy and interesting. In a distance of seven miles many distinct ecological formations will be seen, each with its distinctive species, thus affording the visitor an excellent opportunity to make a rapid survey of the local florula.

Flora of Leith Valley.

The first trees to attract attention after turning into Woodhaugh Valley from George Street are the tree-fuchsia or konini (*F. excorticata*) and the dark-green, glossy-leaved broadleaf (*Griselinia littoralis*) growing near the foot of the cliffs on the left, and festooned with the scrambling vine (*Muehlenbeckia australis*). On the opposite side of the valley the common panax (*Nothopanax Colensoi*), with even darker foliage than the broadleaf, is equally conspicuous. Shortly after passing the paper-mills the well-known kowhai (*Sophora microphylla*) is a conspicuous plant, especially in the flowering season, as, to a lesser extent, is the narrow-leafed lacebark (*Hoheria angustifolia*). Beyond the bridge a few minutes' walk leads to a clump of taxads, more commonly designated pines. This clump contains specimens of the rimu (*Dacridium cupressinum*), rendered conspicuous by its drooping branchlets ; of the black-pine or matai (*Podocarpus spicata*), and miro (*P. ferruginea*), and of the stringy-barked totara (*P. totara*), all useful timber-trees formerly occurring here in such numbers as to suggest the name of Pine-tree Hill, now shortened to Pine Hill. By the time the Leith Valley School is reached the valley has narrowed appreciably, and an almost unbroken stretch of native verdure is entered, consisting at this point of the trees already mentioned and a host of smaller trees and shrubs, conspicuous among which are the beautiful crinkly-leaved lemonwood (*Pittosporum eugenioides*) and the 7–9-foliate patete (*Schefflera digitata*). A few tree-ferns (mostly *Hemitelia*), the wineberry (*Aristotelia racemosa*), and the brittle-stemmed mahoe (*Melicytus*) are also noticeable, while the reddish tints of the pepper-tree (*Drimys colorata*) contrast strongly with all. Nicholl's Creek and then Morrison's Creek are successively passed before a steep ascent leads to a piece of fairly open flat land where a number of new plants appear, chief of which are the conical-shaped kawaka or native cedar (*Libocedrus Bidwillii*) and the small-leafed panax (*Nothopanax simplex*). As Sullivan's dam is approached the weeping-mapau (*Myrsine divaricata*) and the snowberry (*Gaultheria*) become conspicuous members of the association, as are numerous *Coprosma* and panax. From here to the top *Coprosma foetidissima*, better and appropriately known as the "Stinkwood," appears and becomes the dominant shrub, as the rimu, cedar, and *Nothopanax simplex* are among the trees.

A short distance beyond the summit of the Leith Saddle a dark gate and turnstile mark the spot where the bush should be entered. The bed of the creek when reached is followed for some distance, and affords an excellent opportunity of seeing quite the majority of the ferns of the district as well as a number of the less common trees, such, *e.g.*, as *Panax Edgerleyi* and the pokako (*Eloeocarpus Hookerianus*). The subalpine-shrub zone is entered on leaving the bush, and the shrub-daisy (*Olearia ilicifolia*) here occurs in large numbers, along with three varieties of tutu (*Coriaria*), a speedwell (*Veronica buxifolia*), *Cassinia*, *Gaultheria*, &c. A very noticeable plant in this zone is the Spaniard or spear-grass (*Aciphylla Colensoi*)—a member of the carrot family.

A short stretch of grassland containing numerous orchids, heaths, and heath-like plants, as well as grasses, leads to the summit, where will be found the sphagnum swamp that gave rise to the name Swampy Hill. Here, unattached to any substratum of soil, are several orchids, buttercups, cushion-plants (*e.g.*, *Oreostylidium*), &c., while near-by may be seen the only local examples of the divaricating alpine wineberry (*Aristotelia fruticosa*), contrasting strongly with the large-leafed species of the low-level forest.

If one has time and energy for a second excursion Maungatua (3,000 ft.) is well worth a visit, if for no other reason than that upon it may be gathered some forty-seven plants not met with nearer to Dunedin. On the summit six of our seven species of grass-trees (*Dracophyllum*) are found, five of our seven celmisias or mountain-daisies, two of three gentians, seven sedges, four grasses, two speedwells, a buttercup (*Ranunculus gracilipes*), an eyebright (*Euphrasia Dyeri*), a chickweed (*Stellaria gracilenta*), and sundry others. A copy of the catalogue of the plants of the district, prepared by the Dunedin Naturalists' Field Club, and procurable either from the honorary secretary of that club or of the Otago Institute (price 1s.), will be found a useful adjunct on such excursions as are indicated in these notes.

W. Martin.

THE OTAGO UNIVERSITY MUSEUM.

The foundation of the present collections of the Museum of the University of Otago was laid by Dr. Hector (afterwards Sir James Hector, F.R.S.), who organized a large and excellent natural-history collection for the New Zealand Exhibition held in Dunedin in 1865. This material formed the basis of the present Museum collections, but it was not until 1877 that the central block of the present buildings was completed and opened, the first Curator being Captain F. W. Hutton (afterwards Professor Hutton, F.R.S.). Captain Hutton was succeeded by Professor T. J. Parker, F.R.S., under whose direction some of the most striking exhibits were added. Notable among these is the series of elasmobranch skeletons, not surpassed in any museum in the world. The method by which they were prepared was worked out by Professor Parker and Edwin Jennings, Museum taxidermist. On the death of Professor Parker in 1897 Dr. W. B. Benham, F.R.S., was appointed to the Chair of Biology and became Curator of the Museum.

A notable benefaction was the gift by Dr. T. M. Hocken, in 1907, of his great collection of books, manuscripts, and pictures relating to early New Zealand and the Pacific, and his large ethnographic collection. The Hocken collection includes the largest series in existence of manuscripts relating to the settlement of New Zealand.

The zoological collections are extensive, being especially strong in New Zealand birds and their eggs, in New Zealand fishes, and in the invertebrates. Of special interest is the series of extinct birds, the collection of moa-remains being very extensive, and including eggs, feathers, muscles, skin, and footprints, as well as the largest number of individual skeletons in any museum.

The foundation of the ethnographic department was laid by a series of gifts of New Guinea material by James Chalmers (" Tamate "), missionary to New Guinea and Polynesia. The large collection from the Solomons, the important New Hebridean collection, and the extensive Maori section have also been built up by gifts. Perhaps the most notable exhibit here is the material from the moa-hunters' camp at the mouth of the Shag River, which reveals the stage of culture reached by the earliest inhabitants of these southern districts. Their culture would seem, on the whole, higher than that of the tribes found in occupation at the beginning of the nineteenth century.

H. D. Skinner.

THE MICA-SCHISTS OF CENTRAL OTAGO.

One of the most puzzling formations in New Zealand is a broad zone of mica-schists running out from the Southern Alps south-eastwards through Otago to the sea. The planes of schistosity, which may be in the main parallel to the original bedding-planes, dip generally at small angles to the south-west or north-east from a broad anticline, the axis of which runs down to the sea-coast about ten miles south-west of Dunedin. Locally, however, the schists dip steeply, or are crumpled. Interstratified in these are rarely chloritic or hornblendic schists. To these rocks all ages, from Archaean to Jurassic, have been assigned. They are not associated with plutonic rocks, but a fairly regular passage may sometimes be traced outwards from the axis where the metamorphism is greatest through decreasingly metamorphosed rocks into greywackes which resemble both those of Ordovician age in the western parts of the Island and those in the fossiliferous Permo-Carboniferous or Triassic series, and, indeed, merge without apparent break into such fossiliferous rocks in north-eastern Otago. The Geological Survey and the majority of other geologists have held that the schists are ancient, and must be separated by obscure unconformities from these fossiliferous rocks. Dr. Marshall has, however, emphasized the complete absence of any material derived from the schists in the adjacent greywackes, and has described in detail an apparent passage between the unaltered greywacke and the mica-schist, traced along a line of section in the southern flank of the anticline—namely, from Balclutha to Lawrence, a distance of about twelve miles. He concludes, however, that the schistose structure is not a direct mechanical effect of pressure, there being little sign of crushing or strain, but is rather the effect of chemical action stimulated by mechanical pressure, which has caused the regular orientation of the secondary crystal-grains developed, and especially of the flakes of mica which replace the alkali-feldspar. On the other hand, the longer diameter of the quartz-grains is generally perpendicular to the plane of schistosity.

In other regions, particularly in north-western Otago, though it has been asserted that there is an observable transition of greywacke into schist, this is not supported as yet by such detailed observations, and in places there seems, instead, to be a rather sharp break between them, so sharp that it can be detected by differences in the topography. In supporting Dr. Marshall's general views as to the age of the schists, the writer has suggested a working hypothesis of the structure of the apparent anticline, which may also be found to explain the passage, sometimes gradual and sometimes very sharp, between the unmetamorphosed and metamorphosed rock-types. In this it is suggested that the "anticline" is not simple, but is an arched packet of recumbent sheet-folds, the schistose structures of which were developed by recrystallization during folding under the weight of the overlying folds. The upper sheets would therefore be noticeably less metamorphosed. Subsequent block-faulting would bring the less metamorphosed higher sheets down to the level of the more metamorphosed lower sheets. Out of this "mosaic of differentially moved blocks" the general peneplain was cut at the commencement of the Tertiary times, and erosion following the later post-Tertiary (?) crust-movements (which moved diversely the same series of crust-blocks) has produced topographic forms that vary with the lithological character of the blocks, a suggestion which incorporates the conclusions of Professor Cotton concerning the geographic evolution of Central Otago. The difficulty in the way of testing this hypothesis is the absence of any readily recognizable sedimentary series within the schists and the adjacent rocks, and much investigation, therefore, will be necessary before it can be either accepted or rejected.

W. N. Benson.

LIST OF LOCALITIES.

Geology.

Physiography. — Kaipara Harbour and other North Auckland inlets (drowned river-valleys); Lake Taupo; Wellington (fault-scarps, crush-zones, raised beaches, see p. 3), Muka-Muka Cliff, Palliser Bay (9 ft. uplift of 1855 quoted by Lyell and Suess; Marlborough Sounds (drowned river-valleys); Kaikoura Mountains; Southern Alps (see p. 45); Arthur's Pass and Otira Gorge; Buller River and gorges; Canterbury rivers (terraces and fans); Central Otago (block mountains); fiords, Western Otago (drowned valleys).

Glaciation Phenomena.—Fiords, Western Otago; Lakes Manapouri, Wakatipu, Wanaka, Tekapo and neighbourhood.

Glaciers.—Tasman, &c. (Mount Cook Hermitage) (see p. 46); Franz Josef (see p. 51); Fox (Central Westland) (see p. 46).

Volcanoes.—Active: Ngauruhoe (National Park) (see p. 32); Tarawera; White Island. Dormant: Ruapehu (National Park). Extinct: Mount Egmont; environs of Auckland; Rangitoto.

Igneous Rocks.—Dunedin (see p. 53); Oamaru; Banks Peninsula (see p. 40); Dun Mountain, Nelson (see p. 36); Coromandel Peninsula.

Fossiliferous Localities.—Pliocene: Wanganui; Petane and Ngaruroro River; Motunau. Miocene: Pakaurangi, Kaipara Harbour; Mount Brown; Pareora; Oamaru. Older Tertiary: Waihao Forks; Hampden; Wangaloa; Weka Pass. Cretaceous: Waipara; Amuri Bluff; Selwyn Rapids. Jurassic: Nugget Point. Triassic: Nugget Point; Mount Potts (plants). Permo-Carboniferous: Dun Mountain, Nelson. Silurian: Lankey's Gully, Reefton. Ordovician: Collingwood; Preservation Inlet.

Geysers and Thermal Phenomena.—Rotorua and environs, Whakarewarewa, Waimangu (quiescent); Waiotapu; Wairakei; Taupo.

Limestone Caves.—Waitomo.

Gold.—Waihi (quartz-mining); Blackwater, near Reefton (quartz-mining); Rimu gold-dredge (near Hokitika).

Coal.—Huntly, Pukemiro; Westport Coal Company (Denniston and Millerton); State Coal, Greymouth; Kaitangata.

Kauri-gum.—North Auckland.

J. Marwick.

Chief Passes of the Southern Alps.

Harper's Pass (3,141 ft.).—Chief pass used by Maoris in olden times. Route via Hurunui River to Teremakau River. First crossing of Alps by white man made by this pass in 1857 (Mr. Leonard Harper).

Arthur's Pass (3,038 ft.).—Waimakariri and Bealey Rivers to Otira and Teremakau Rivers. Known to Maoris in former times but seldom used. Present route to West Coast is over this pass.

Browning's Pass (4,815 ft.).—At head of Wilberforce River (tributary of Rakaia) and leading over into Arahura River.

Mathias Pass (4,700 ft.).—At head of Mathias River (tributary of Rakaia) and leading over into Hokitika River.

Whitcombe Pass (4,025 ft.).—At head of Rakaia River and leading into Whitcombe and Hokitika Rivers.

Dennistoun Pass (6,500 ft.).—By Rangitata and Havelock Rivers to Batson Creek, Perth River, and Wataroa River. Alpine pass.

Sealey Pass (5,800 ft.).—From Godley Glacier, at head of Godley River, to Joyce Glacier, Scone Stream, and Perth and Wataroa Rivers. Alpine pass.

Lendenfeldt Saddle (7,991 ft.).—At the head of Tasman Glacier to Whymper Glacier and Wataroa Rivers. Alpine pass.

Graham's Saddle (8,739 ft.).—From Tasman and Rudolf Glaciers to Franz Josef Glacier. Used extensively as a pass from the Hermitage to the Franz Josef.

Pioneer Pass (9,000 ft.).—A difficult alpine pass leading over to the Fox Glacier.

Harper's Saddle (8,559 ft.).—From Hooker Glacier to La Perouse Glacier. Alpine pass.

Copland Pass (6,950 ft.).—The easiest alpine pass for crossing either from east to west or from west to east. Used extensively by tourists with limited alpine experience. Leads from Hooker Glacier to Copland and Karangarua Rivers.

Fyfe's Pass (about 7,000 ft.).—Leads from the head of the Mueller to the Landsborough River. Alpine pass.

Haast Pass (1,716 ft.).—A remarkable low pass leading from the Makarora River, at the head of Lake Wanaka, to the Haast River. Free from snow except for occasional falls during the winter. Used as a stock route.

T. A. Fletcher.

Botany.

The following list gives those localities of botanical interest which are accessible from the principal cities and tourist resorts of New Zealand :—

Kauri Forest (see p. 22).—Trounson's Park (eight miles from Kaihu) ; Great Barrier Island ; Waitakerei Range (fifteen miles from Auckland, see p. 22) ; Kauri Gully, Auckland Harbour.

Mixed Forest.—Waitakerei Range (see p. 22) ; Ngongotaha Mountain and Hongi's Track (near Rotorua) ; Mamaku (near Rotorua) ; Mount Hauhungatahi (near Waimarino) ; Kapiti Island ; Wilton's Bush, Gollan's Valley, Wainui-o-mata, and Hutt–Waikanae Road (in vicinity of Wellington) ; Dean's Bush, Christchurch ; Banks Peninsula (see p. 41) ; Leith Valley, Dunedin (see p. 54) ; Mount Cargill ; Catlin's River ; Longwood Range ; Stewart Island.

Beech Forest.—Tongariro National Park ; Mount Hauhungatahi ; Mount Egmont ; Gollan's Valley, Wainui-o-mata, and Hutt–Waikanae Road ; Mount Torlesse ; Mount Cook (see p. 48) ; Dun Mountain (near Nelson, rejuvenated forest) ; Catlin's River ; Longwood Range ; head of Lake Wakatipu ; track to Milford Sound.

Pohutukawa Scrub.—Rangitoto (see p. 20).

Subalpine and Alpine Vegetation.—Mount Egmont; Tongariro National Park (see p. 35); "Mineral Belt," near Nelson (see p. 39); Mount Torlesse; Mount Cook (see p. 48); Swampy Hill, near Dunedin (see p. 54); Stewart Island.

Mangrove.—Auckland Harbour (near Henderson, Stanley Bay, Devonport).

Hot Springs Vegetation.—Rotomahana; Otumokokiri, near Waiotapu; Wairakei Valley, near Taupo.

Other types of vegetation, such as manuka scrub, tussock-grassland, sand-dunes, swamp, bog, may be seen in several of the localities mentioned.

W. R. B. Oliver.

Agriculture and Forestry.

Ruakura Farm of Instruction, Hamilton.—Nearly 900 acres, situated on the fringe of the great Piako Swamp. The greater part of the farm is now highly developed and equipped. A wide range of cropping has been practised, but, in keeping with the essentially dairying character of the district, pasture development and management is now a leading feature. The pedigree live-stock includes Milking Shorthorn (with Australian Darbalara blood) and Jersey cattle, Southdown sheep, and Berkshire pigs. A flock of crossbred sheep is also run. The other branches of the establishment are the poultry section, the apiary, and the horticultural section, including an orchard of considerable size. Ruakura is the principal farm instructional institution of the New Zealand Department of Agriculture.

Weraroa Central Development Farm, Levin.—On 750 acres of land converted from heavy forest. The neighbourhood is ideal dairying country, and the farm has developed on lines consistent with the requirements of that industry. Noted herds are Friesian (blending Dutch and American blood) and Red Poll. Berkshire pigs and Romney cross sheep are kept.

Other Governmental experimental stations are situated at Moumahaki (general farming) and Te Kauwhata (fruit and viticulture).

Lincoln Agricultural College, near Christchurch.—Two farms, 800 and 1,500 acres. Live-stock includes horses, cattle, sheep, and pigs. Most attention is directed to sheep-raising and cereal-growing. Students spend three years at the College and do all the work.

Horticulture.—The public gardens at Auckland, Palmerston North, Wellington, Christchurch, and Dunedin are well worth seeing.

Forestry.—Government plantations are situated at Whakarewarewa (near Rotorua), extending to Tikitapu and Rotokakahi Lakes, with nursery at Whakarewarewa; Waiotapu; Kaingaroa Plains (near Galatea); Hanmer (with nursery); Conical Hills (nursery at Tapanui); Naseby.

Flax (Phormium) Industry.—The best localities for studying the flax industry within easy distance of Wellington are Shannon and Miranui, on the Palmerston North Railway line.

Engineering-works in New Zealand.

Engineers and others who are interested in public works and other undertakings will find inspection of many works throughout the Dominion of considerable value. To such, attention is directed to the undermentioned :—

Auckland.—In and around the city there are the city drainage-works, which are on the combined system, with discharge into the ebb tides of the outer harbour ; city electric tramways, a feature being a few of the steep grades ; city water-supply, with the new Nihotapu Reservoir ; city concrete streets, the first constructed on a large scale in the Dominion ; destructor, dealing with household garbage ; Grafton reinforced-concrete arch bridge. Of the Harbour Board's works the reinforced-concrete wharves, the tide-deflecting moles, electric cranes, reclamations, and the dry dock are particularly interesting.

Napier.—The successful construction of a harbour on an open coast in the presence of drifting shingle is well illustrated by the outer breakwater. The long reinforced-concrete bridge carrying road and railway across the Inner Harbour is a work worthy of a visit.

New Plymouth.—The development of a harbour in face of a large littoral sand-drift is a lesson in such work. The oil-wells should not be missed, nor the fine asphalted country roads.

Wanganui.—Attention is directed to the harbour-works, the bridges over the river on which the town stands, and particularly to the passenger-lift giving access to the higher levels of Durie's Hill.

Wellington. — In and around the City of Wellington the hilly country has required the development of many interesting works, of which the following may be pointed out : Sewage drainage of the low-lying parts by the Shone system, the compressed air required being derived by power obtained from the destructor ; the general gravitation system with sea outfall, and minor district systems with septic tanks ; city water-supply, with the main reservoirs at Karori and Wainui, and subsidiary reservoirs in the city, those at the high levels being fed by electrically operated, multistage, centrifugal pumps ; tunnels for roads and tramways passing through ridges at Seatoun, Karori, and Hataitai, the last for tramway traffic only ; electric tramways, particularly the hill systems ; the cable tramway to Kelburn. The recently introduced municipal milk-supply should be studied. The development of the storage and handling of exports and imports on the wharves will be found to be a useful study ; also the Pipitea reinforced-concrete wharf, the patent slip, and the boat-harbour. On the railways, the Rimutaka incline, of 1 in 15, operated by the Fell system of centre rail ; and the recently installed automatic electric signals on both double and single lines may be seen at work.

Christchurch.—At Christchurch, the City of the Plains, may be seen water-supply from artesian wells, and the pumping-station to supply the reservoir ; sewage farm, sewage-pumping station, preliminary-treatment septic tanks, refuse-destructor, electric tramways, and street works.

Lyttelton.—This place is the seaport for Christchurch and part of the Canterbury Provincial District, and separated therefrom by the lip of an extinct volcanic crater which is pierced by a railway-tunnel. Lyttelton has an artificial harbour in an inlet of the sea, where moles have been constructed, and extensive dredging carried out by modern machines, the most interesting being the dredge on the Fruhling system.

Timaru.—Here is another example of a harbour being constructed with great success on an open coast, where there is a large shingle-drift, and which is subject to very heavy seas.

Dunedin.—The city has many interesting works, of which may be mentioned the following: Sewage with sea outfall, water-supply with reservoirs, asphalt streets, and the electric tramways. The Otago Harbour Board's activities embrace wharves, reclamations, control and deepening of the channel to Port Chalmers and at the Heads. The works at the Heads dealing with the littoral sand-drift have been a great success. There are two dry docks at Port Chalmers. The Dunedin cable tramways, giving access to the hill suburbs (three in number), are very interesting. The Maori Hill electric tramway is interesting as being one of the very earliest constructed electric tramways.

Westland.—The west coast of the South Island provides a field in which the mining engineer will be at home. The coal-mines north of Westport, also at Reefton and in the Grey Valley; the gold-bearing reefs in the Reefton region; the alluvial-gold dredge at Rimu, and a few sluicing claims, may be seen with profit. In connection with the coal-mines, the railways, tramways, inclines, bridges, and other works required to bring the coal to market are an education. Attention is drawn to the harbour-works at Westport and Greymouth, controlling river-embouchers through shingle-drift. The Otira railway-tunnel, now nearing completion, is five miles and a quarter in length. It passes through the Southern Alps, on a grade of 1 in 33; it may be seen during the journey from Christchurch.

R. W. HOLMES.

ELECTRIC-POWER STATIONS IN NEW ZEALAND.

The question of electric-power supply in New Zealand is of especial interest in view of the liberal policy adopted by the Government in the development of the water-power resources of the Dominion. The general policy adopted is that provision shall be made ultimately to supply every farm and settlement in the Dominion to which lines can be extended profitably.

At present two large Government hydro-electric-power stations are in operation. Lake Coleridge started supply in 1916, and is now developed up to 16,000 h.p. The power-station is located in the Rakaia Valley, sixty-three miles west of Christchurch, and is accessible by motor-car, or train and motor-coach, by a good road from Christchurch. The Waipori Rapids plant has been developed by the Dunedin City Council to 8,000 h.p., and extensions to 12,000 h.p. are in hand. It is accessible by motor-car, and is about thirty miles from Dunedin.

The Southland Electric-power Board is now developing Lake Monowai to 5,000 h.p. The works are in hand, and are expected to be in operation within two years. The power-station site is accessible from Invercargill by motor-car—about sixty miles.

In the North Island the Horahora Rapids plant was constructed by the Waihi Gold-mining Company about 1910, and purchased by the Government in 1919. It has a capacity of 8,400 h.p., but is being extended to 10,000 h.p. The power-house is accessible by motor-car from Hamilton (thirty miles) or Putaruru (twenty miles).

The Waikaremoana installation has just been completed with 1,000 h.p. capacity as a first instalment of the large 40,000 h.p. plant. This 1,000 h.p. is employed only to supply Wairoa district—a distance of forty miles. It is accessible by coach or motor-car from Wairoa, Hawke's Bay.

For the Wellington District the Mangahao River power-station—24,000 h.p.—is in hand, near Shannon, and sixty-five miles from Wellington. The works are in an interesting stage, and are accessible from Wellington by motor-car (seventy miles) or from Shannon (ten miles).

Preliminary work is in hand at the Arapuni Gorge, on the Waikato River, for a development of 36,000 h.p. to 96,000 h.p., capable of extension to 144,000 h.p. This is a very interesting development owing to the method of utilization of the natural features of the ground. It is accessible by motor-car from Hamilton, via Horahora Rapids (about forty miles), or from Putaruru (about nine miles).

In addition, the New Plymouth Borough has a hydro-electric-power plant of about 2,000 h.p. on the Waiwakaiho River, about four miles by road from New Plymouth. Plans have been drawn up for extending the plant to 6,000 h.p.

Other interesting water-power developments are those of the Dominion Cement Company at Wairua Falls (2,600 h.p.), twenty miles by road from Whangarei; Hawera Electric Supply Company, in the Waingongoro River (800 h.p.), about twelve miles from Hawera; Government Tourist Department at Okere Falls (300 h.p.), about thirteen miles by road or lake from Rotorua; and the Tauranga Borough plant at Omanawa Falls (1,000 h.p.), about fifteen miles by road from Tauranga.

There are in New Zealand in all sixty-one electric-power stations, of a total capacity of 69,000 h.p., made up as follows: Water-power—27 stations, 33,500 h.p.; steam-power—10 stations, 29,970 h.p.; gas-power—22 stations, 4,460 h.p.; oil-power—2 stations, 1,070 h.p. The largest of the steam stations are the Auckland City power-station at King's Wharf (13,200 h.p.), and the Auckland Tramway power-station at Hobson Street (8,500 h.p.); the Wellington City power-station at Harris Street (5,000 h.p.), and the Wellington Tramway power-station at Jervois Quay (5,300 h.p.). The Wellington City Council is building a large station at Evans Bay (15,000 h.p.) designed to take over the load of both of these city plants, and this station is now in an interesting stage for inspection. It is easily accessible by tram-car (Miramar or Seatoun cars).

L. Birks.

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