## Art. LIV.—*The Physiography of Wellington Harbour.*

By J. M. Bell.

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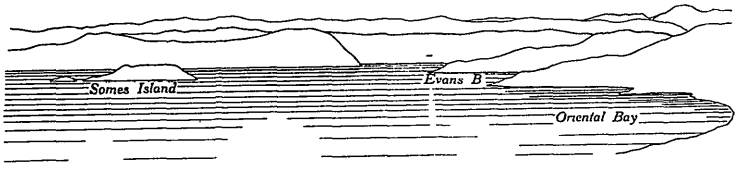
### Introduction.

The site of the capital of New Zealand was chosen primarily because of the existence of a spacious land-locked harbour, with good anchorage for ships, in a convenient part of the Dominion's land area.

Owing to its harbour, to its central position, and its choice as the country's capital, Wellington's commercial supremacy in the Dominion seems assured. For these economic reasons, if not from purely scientific interest, it is well to understand the effect of the various forces which have acted together to form Wellington's harbour, generally known as Port Nicholson.

### The Harbour To-day.

The harbour is a fine sheet of water, about nine miles long by five miles wide, land-locked save at the comparatively narrow entrance, only 88 chains wide. A number of islets, and two small islands known as Somes Island and Ward Island, appear on its surface; while several shoals either almost or totally below its surface render navigation somewhat difficult in places.




View from Kelburne Kiosk.

High hills almost completely surround the harbour, rising in general in steep slopes from the water's edge. There are, however, several fair-sized areas and small patches of level or gradually sloping land close to the edge of the harbour. By far the largest of these is that which forms the relatively wide valley of the Hutt River, extending north-eastwards from the north-eastern end of the harbour. This plain has a width of nearly two miles and a half near the harbour, and gradually narrows as it extends inland.

Westward from the narrow channel connecting Port Nicholson with the open sea is a low range of hills, which may for convenience sake be called the Seatoun Hills, owing to the settlement of that name at their eastern base. These are connected with the Kilbirnie Hills, to the west, by a narrow sand isthmus between Evans and Lyall Bays.

The Kilbirnie Hills attain their maximum altitude in Mount Victoria, which rises some 648 ft. above the sea. To their westward is the low and relatively flat land on which the City of Wellington stands, having a slope on the northern side to Lambton Harbour and on the southern side to Island Bay.

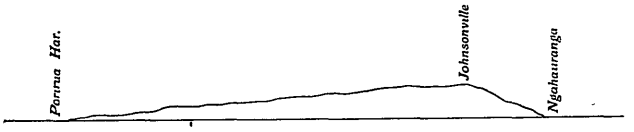
Westward of the city rise the Karori Hills. These are partially separated by the Karori Valley from the main range of hills extending north-

eastwards along the edge of the harbour and bordering the Hutt Valley to the westward.

A view from any prominent position in the hills around Port Nicholson discloses an elevated country stretching in all directions, broken by narrow valleys and deep ravines. If this elevated country be viewed from a point on the eastern side of the harbour, one is struck with the general uniformity in height attained by the crests of the various hills on the west side. Since this even skyline is quite independent of the structure of the country rocks (consisting of highly folded and shattered argillites and grauwackes), it apparently exhibits an elevated plain of erosion, or peneplain.

When the country to the east of the harbour is viewed from the west, at least three, and possibly more, ridges of hills are evident. In each of these ridges the hills seem to rise to an approximately uniform altitude, though there is a marked difference in the general height of the several ridges. Naturally, the highest ridge visible is that farthest east. Below this inner one the two other conspicuous even-crested ridges stand out in step-like blocks. Apparently the crests of all these ridges represent various levels of the old peneplained surface so well seen to the west of the harbour.

From a high point on this western land the crests of the hills, though in




SECTION, PORIRUA TO NGAHAURANGA.

general of uniform height, seem gradually to descend in altitude towards Porirua.

## GEOLOGICAL HISTORY.

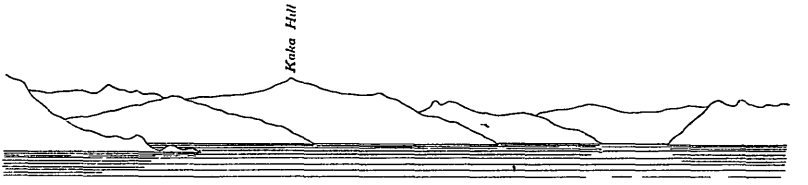
It will be interesting, now that we know what the harbour and the surrounding country are like to-day, to recapitulate the changes which have taken place in this part of the world since the very earliest geological periods.

In late Palæozoic or early Mesozoic times the sea rolled over much of the area now occupied by the present land-surface of New Zealand, and in the locality of Wellington sands and silts were being deposited on the edge of a land area within that sea. It is impossible to state exactly where that ancient land stood, or how far it extended; but since we find that the rocks now exposed around Wellington consist of a great series of argillites and grauwackes, which were originally silts and sands or deposits usually laid down close to a land-margin, it may be presumed that the deposition extended over a long period of time along a gradually sinking sea-margin.

Subsequent to this deposition the sediments thus formed were elevated above sea-level, and folded into anticlines and synclines. So soon as the land had risen above the surface of the sea, and even possibly before it had reached the surface, its wearing-away had commenced. It is not known to what heights the land rose in those ancient times. It may have been low, hilly, or even mountainous country, though from the absence of glacial *débris* in the formation succeeding the period of elevation it is gathered that, if mountains did exist, they were not elevated to levels of perpetual snow. We do know that after a long period of time, during which erosion was ever active, the land was worn down almost to the level of the sea, producing a peneplain.

The peneplain, as its name implies, was not absolutely a plain, but doubtless owing either to original greater resistance in composition, or possibly of favourable position free from attack by erosive agencies, a few hills remained above the general denuded surface.

Following the peneplanation of the land, the land-surface was again elevated, or relatively elevated, with regard to the sea. Possibly as a partial expression of this elevation, or since that event, came the faulting movements which separated the several blocks of the peneplain to the east of the harbour, tilted the block to the west thereof, and formed the original depression now occupied by Wellington Harbour. The depression in the beginning seems to have been a graben, somewhat complex in nature, which extended from the sea up the Hutt Valley. It is probable that at first the down-faulted trough was not entirely beneath the sea, but was occupied by a large stream, the antecedent of the present Hutt River. The erosive influence of this ancient stream profoundly influenced the contours of the original depression before renewed subsidence lowered at least the outer part of the graben beneath the sea.




OUTLINE OF HILLS BEHIND WELLINGTON.

The complicated graben of which the harbour and the lower Hutt Valley are the expressions by no means represents a single depressed block, but consists of several parallel and transverse blocks, not all of which have settled down equally either transversely or longitudinally. Thus the low-lying areas of country between Lyall Bay and Evans Bay, and between Island Bay and Lambton Harbour, have apparently not subsided to the same depth as the floor of the main body of the harbour, though it is not improbable that both these areas were either originally below sea-level or at least occupied a lower altitude than at present, their height above sea-level and general surface-area being increased by wind-blown sands. In the same way it seems evident that the Seatoun Hills, the Kilbirnie Hills, Somes Island, and Ward Island represent either whole blocks or portions of blocks of the peneplain which were after the time of major faulting much higher, and now owe their reduced position and more mature sculpturing, as compared with the surface of the peneplain to the west and of the various blocks of that surface to the east, to the more rapid denudation consequent on their isolated and exposed positions.

Since the final depression of the graben beneath the sea the surface of the land has been much influenced by erosive action—marine, fluviatile, and subaerial. Thus the generally flat surface of the blocks of the peneplain has been dissected by numerous streams into ridge and valley, so that the plain appearance remains only in a few places, such as near Karori and near Johnsonville; and the isolated horsts, such as the Kilbirnie Hills, have been worn into well-rounded ridges with slopes completely cloaked with the deposits of rock-decay.

Exactly how far the original depression due to faulting extended up the Hutt Valley is not known, but it is very probable that its apparent area has been much increased by the erosive influence of the Hutt River.

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RAISED BEACHES NEAR WELLINGTON HEADS.—Bell.

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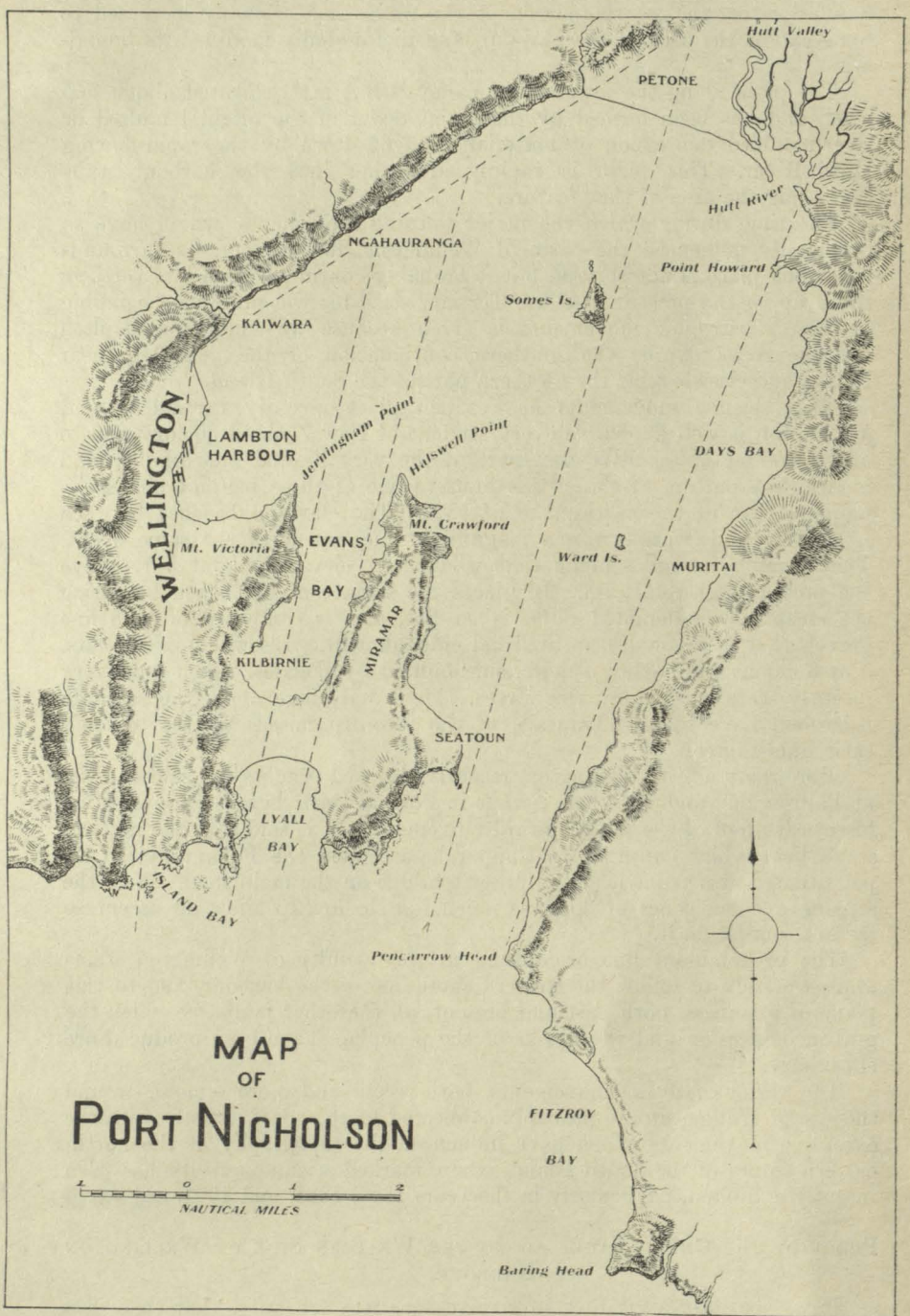

Hutt Valley
PETONE
Hutt River
NGAHAURANGA
Point Howard
Somes Is.
KAIWARA
WELLINGTON
LAMBTON HARBOUR
Jerningham Point
Halswell Point
DAYS BAY
Mt. Crawford
Mt. Victoria
EVANS BAY
Ward Is.
MURITAI
MIRAMAR
KILBIRNIE
SEATOUN
LYALL BAY
ISLAND BAY
Pencarrow Head
MAP OF PORT NICHOLSON
FITZROY BAY
Baring Head
1 0 1 2
NAUTICAL MILES

Similarly, too, the wearing-action of the waves has probably increased to some extent the area of the harbour, and undoubtedly modified its boundaries.

The plain along the lower Hutt Valley is but little elevated above sea-level, and has been formed by the laying-down in the original faulted or river-modified depression of material brought down by the rapid-flowing Hutt River. This plain is rapidly advancing into the harbour, thus decreasing the area of that feature.

The time during which the major faulting movements, which have so profoundly influenced the basin of Wellington Harbour and its surroundings, took place is not certain, but it probably continued from late Tertiary times up to the present. A late Tertiary date for the probable beginning of these diastrophic movements is given because we know that faulted Miocene rocks overlie the southern continuation of the peneplain near Nelson and elsewhere at the northern part of the South Island.

That seismic movements have taken place recently in and around Wellington is well known to every student of New Zealand geology and to every Wellingtonian. We owe part of the very limited area of flat land on which a portion of the city is built to one of these tectonic changes—namely, that of the earthquake of 1855. The elevated beaches between Lyall Bay and Seatoun are a magnificent monument of the same event. They stretch for miles along that wild shore, elevated about 5 ft. above the present high-tide level. In places the surface of the beach bordering the steep marine-denuded cliffs is so flat, and is composed of such fine gravel, that it resembles an artificial embankment. Elsewhere occur flats, 5 or 6 chains wide or even more, surmounted by skerries, which until very recently were washed by the waves. Here and there along the seashore fishermen have taken advantage of the recently raised beaches to erect their huts thereon.

More remote from Wellington, recently elevated beaches are said to exist at Palliser Bay and elsewhere; while in Porirua Inlet there is an interesting historical proof of the same upward movement. It is said that the man-of-war's boat which captured Te Rauparaha ascended the Pahautanui to his pa, situated at a point near the present bridge on the main road. Now the stream, even in times of flood, is much too shallow to allow an ascent so far in a similar craft.

The predominant line of faulting in the vicinity of Wellington seems approximately to follow the western shore-line of the harbour, and to this plane of weakness, both past and present, all the other faults by which the graben depression and the blocks of the peneplain have been produced are subsidiary.

The various faulting movements, both recent and more remote, around the site of Wellington are probably connected more or less directly with the extensive movements which have influenced the topography at the north-eastern corner of the South Island, where marked seismic activity has been recently exhibited, particularly in the years 1855, 1888, and 1901.

## Proof of the Great Fault along the Western Side of Wellington Harbour.

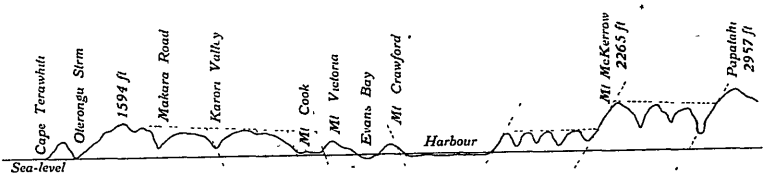
It will be interesting now to give reasons why we know that there has been in the past extensive movements along the western side of the harbour or along the line of major faulting. Even the most casual observer will note that the slope of the hill is remarkably steep—much steeper than the

natural angle of rest for the products of decay of such shattered rocks as the argillites and grauwackes of Wellington. This steepness in itself, in the absence of any other explanation, such as glacial erosion, marine denudation, &c., is a physiographic proof of faulting.

A second proof is found in the presence of clay terraces, elevated about 300 ft. above the present level of the sea, on the steep slopes of the Karori Hills at the back of Tinakori Road. These terraces mark the silt-accumulations at the place where the subsidence of the harbourward block forming part of the original complex graben was temporarily arrested.

A still further evidence of the faulting is found in the fact that the small watercourses, such as several of the small streams between Ngahauranga Creek and Petone, do not enter the harbour at grade, as would be the case with normal drainage, but instead flow over the lower part of the fault-scarp in abrupt waterfalls.

Perhaps the most graphic evidence of faulting, however, is found in the gorged nature of all the streams along the western side of the harbour, and in the practical absence of even narrow flood-plains on the largest streams, such as the Ngahauranga. The Ngahauranga flows into the sea over a small gravel fan which it has built out into the harbour. Above this




SECTION FROM CAPE TERAWHITI TO MOUNT PAPATAHI, INDICATING PROBABLE POSITIONS OF FAULT-LINES.

flat the stream flows in a narrow V-shaped gorge-like valley with numerous waterfalls. At its headwaters, where it reaches the level of the peneplain or crest of the block dipping towards Porirua, it flows somewhat more gently.

The general character of the Ngahauranga is in marked contradistinction to drainage in a hilly or mountainous country unaffected by faulting. There one would expect, with mature topography, a broader valley, the presence of flood-plains, especially towards the mouth, and the absence of waterfalls, save at the headwaters. Of this nature, in fact, is the Porirua Stream, which descends towards the inlet of the same name down the inclination of the tilted block of the old peneplain to the west of the harbour. The stream flows throughout most of its course at grade, flood-plains are common, and waterfalls are infrequent, save at its headwaters. The reason of the difference in character of the two streams will be understood when it is remembered that the Porirua Stream flows down the natural inclination of the block; whereas the other flows contrary to this inclination, across and down the steep fault-scarp.

The actual extent of the throw of the fault at the west side of the harbour is probably not less than 500 ft.

The contrast between Porirua Inlet and Wellington Harbour is as great as that of the two streams which enter them. The inlet is mainly the result of the depression of the lower part of a well-sculptured river valley, while the harbour is primarily an area of complex tectonic subsidence, influenced to some extent by possible fluviatile erosion in the past, and by marine denudation and fluviatile sedimentation.

## APPENDIX.

The Falcon Shoals, which occur at the point where the silt and other fine *débris* carried down by the Hutt River are caused to sink by coming in contact with the opposing current of the tide, are nearly three-quarters of a mile across. The shoals consist of sand and clay, with much decomposing vegetable material emitting $H_2S$, and a few argillite pebbles. The following living species of shell-fish and other marine organisms were identified by Mr. A. Hamilton in the material brought up by the Wellington Harbour Board's dredge a short time ago.

Stichaster insignis.
Amphidotus zealandicus.
Eurynolambrus australis.
Sipunculus maoricus (?).
Echiurus novæ-zealandicus.
Aphrodite aculeata.
Pinna zelandica.
Pecten jacobeus (= P. medius).
Pecten asperrimus.
Pecten zelandicus.
Siphonalia mandarina.
Scaphella (Voluta) pacifica.
Scaphella (Voluta) *var.* gracilis.
Ancilla (Ancillaria) australis.
Turritella rosea.
Subemarginula intermedia.
Panopea zealandica.
Cardium pulchellum.
Chione oblonga.
Tapes intermedia.
Zenatia acinaces.
Diplodonta globularis.
Ostrea purpurea.
Terebratella sanguinea.
Terebratella rubicunda.
Glycimeris laticostatus.
Modiola australis.
Astralium imperator.
Barbatia decussata.
Trichotropis inornata.
Pleurotoma buchanani.