Art. VII.—*Notes on the Geology of the Patea District.*

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Previous Investigations.

Mr. John Buchanan, in a paper read before the Wellington Philosophical Society in September, 1869 (2),* mentioned the blue clay of Patea, which he placed in the Wanganui beds, but expressed a doubt as to this being its right position. It might, he thought, belong to a somewhat older formation.

In January, 1884, Professor F. W. Hutton, accompanied by Mr. S. H. Drew, of Wanganui, spent a day in the neighbourhood of Patea. In a paper on the Wanganui system (3), he writes (p. 340),—

"On the sea-coast at Patea, south of the mouth of the river, blue clay with fossils passes up gradually into a blue micaceous sandy clay, apparently unfossiliferous. Upon this lies about 12 ft. of yellow sand; then cemented gravel 4 ft. thick, followed by grey sands, and then red and yellow sands. The upper beds form the cliff, and, not being very accessible, I did not examine them closely, but I could find no fossils in the tumbled blocks. The sequence is remarkably like that at Wanganui. The yellow sand is distinctly separated from the blue micaceous clay upon which it rests, but without any appearance of unconformity. The number of species obtained from the blue clay is twenty-six, of which 77 per cent. are Recent. Three species of Pareora shells, not known from any other part of the Wanganui system, have been found in the blue clay at Patea. They are *Oliva neozelanica*, *Struthiolaria cingulata*, and a species of *Cucullaea* (fragments)."

In 1886 Professor James Park, at that time a member of the Geological Survey staff, examined the coast-line from Kai-iwi to Patea (see 4, pp. 26, 55, 56, 57, &c.). He states that there are evidences of the existence of a submerged forest between Wanganui and Patea, and describes a "drift formation" which "extends as a maritime belt from the Ruahine Range to the foot of Mount Egmont." This formation is well exposed in the cliffs between Wanganui and Patea (4, p. 59; see also 7, p. 414). From the blue clays exposed near the mouth of the Patea River Park obtained the following fossils: *Malletia australis* Q. & G. (listed as *Solenella australis* Zittel), *Atrina zelandica* (Gray), *Nucula nitidula* A. Adams, *Struthiolaria cingulata* Zittel, and fish-scales.

* This and other numbers enclosed in brackets refer to list of literature at end of paper.

Mr. W. Gibson, of the Geological Survey, visited Patea in September, 1914, with the object of reporting on the ironsand deposits of the district. His report (6) describes only the beach and dune-sands.

In 1917 Dr. J. A. Thomson published a paper (7) on the "Hawera Series," in which he makes reference to the geology of Patea. The Hawera series, he states, is well exposed in the cliffs between Wanganui and Hawera. The mudstone or claystone (papa) forming the lower part of the sea-cliff at Hawera is "probably about the same age as the Patea blue clays, which are placed by Park below the *Ostrea ingens* bed of Waitotara. It is certainly older than Castlecliffian, and is probably Waitotaran."

The observations lately published by Marshall and Murdoch (10) on the fossils collected by them at Wanganui, Kai-iwi, Nukumaru, Waipipi, &c., have an important bearing on the age of the Patea blue clays.

Last October the writer paid a brief visit to Patea, and made observations which are embodied in the following pages.

PHYSIOGRAPHIC FEATURES.

The district surrounding Patea forms part of that decidedly complex feature generally termed the Wanganui coastal plain, which, viewed broadly, may be said to extend along the south-west coast of the North Island from Paraparaumu in south Wellington to Opunake in Taranaki, and inland to the slopes of Mount Ruapehu, while if Mount Egmont and the adjoining volcanic ranges were removed the whole of Taranaki might be included in the plain. The inland portion of the area just defined is for the most part maturely dissected, and exhibits numerous irregular ridges of approximately equal height in adjoining localities, separated by deep, narrow valleys. The coastal belt, in marked contrast to the inland region, as a rule has a nearly flat surface, sloping uniformly and gently towards the sea, where it is usually, at least from Wanganui north-westwards, ended by dune-capped cliffs of considerable height. Inland of Hawera there are one or two well-marked marine terraces ("raised beaches").

The principal streams north of the Manawatu River have cut deep, rather narrow, steep-sided valleys in the soft rocks of the coastal area, one result of which is that the railway from Wellington to New Plymouth has to descend into and ascend out of each valley by a more or less steep grade. The inland hills, as a rule, do not descend gently to the nearly flat coastal belt, but rise with some abruptness from its inner margin. Thus the surface of the coastal belt and the plane joining the tops of the inland hills and ridges are distinctly unconformable. Hence the Wanganui coastal plain (*sensu lato*) really consists of an ancient well-dissected coastal plain bordered on its seaward side by a younger less-dissected coastal plain.

The physiography of the area immediately surrounding Patea does not differ from that of other parts of the coastal belt between Wanganui and Hawera. The gently sloping coastal plain, as elsewhere, ends in dune-capped cliffs, here about 100 ft. high. The Patea River flows at grade through the plain in a deep relatively narrow valley with cliffed sides. A mile from the sea the river is slightly entrenched in the valley-bottom, so that the small flats on either side are above ordinary flood-level. This seems to indicate recent slight elevation of the land; but, as there also seems to have been a slight depression in recent times, as shown by a submerged forest at the mouth of the Waitotara River another explanation

of the entrenchment seems desirable. This may be found in the fact that during the Recent period the sea, as shown by the cliff, has cut away several miles of land, thus shortening the course of the Patea River, and allowing it to deepen its channel for some distance above its present mouth.

Geology.

The stratigraphical geology of the Patea district is very simple. Almost horizontally-bedded claystones, known in geological literature as the Patea blue clays, are unconformably overlain by beds of gravel and sand belonging to Thomson's Hawera series. A small patch of gravel and sand forming a low hill in the Patea Valley east of the town bridge is probably quite distinct from the Hawera beds. Sand and silt form the surface of a low-lying flat near the mouth of the Patea River. Of more importance are the iron-bearing dune-sands that cap the sea-cliffs and extend for some distance back from their margin.

Patea Blue Clays, &c.

The Patea claystones are of the type which throughout New Zealand is popularly called "papa." Like the Wanganui clays, they contain a considerable amount of fine micaceous sand, which, according to the view expressed by Marshall and Murdoch in their paper on the Tertiary rocks of the Wanganui district (10, p. 118), was probably derived from the granites of north-west Nelson. Some layers consist almost entirely of fine sand, and in places these may be crowded with shells. The claystones are exposed only along the coast-line and in the Patea Valley, where, as previously mentioned, they form cliffs on either side. A thin bed of limestone outcrops on both sides of the Patea Valley between Kakaramea Railway-station and Pirinoa Pa. This is probably at a lower horizon than the Nukumaru limestone.

During his visit to Patea last October the writer collected the following fossils from shelly layers in the sea-cliff half a mile to a mile north-west of the mouth of the Patea. The identifications have been made by Mr. John Marwick. Living species are marked by an asterisk :—

Ancilla sp.
Crepidula gregaria Sow.
Dentalium solidum Hutt.
**Glycymeris laticostata* (Q. & G.)
Lucinida levifoliata Marsh. & Murd.
Miltha sp.
Ostrea sp.
Phalium fibratum Marsh. & Murd.
Polinices huttoni Iher.
Terebra sp.
**Verconella mandarina* (Duclos)
Verconella cf. *nodosa* (Mart.)
**Spisula ordinaria* (E. A. Smith)

In addition to the above the writer saw, but did not collect, *Voluta* sp., *Flabellum* sp., and plant-remains of various kinds. At one place worm-casts such as are commonly called "fucoids" were exceedingly abundant.

At the brickworks quarry, on the south side of the Patea River, near the bridge leading to the town, *Atrina* sp.—perhaps *A. zelandica* (Gray)—was collected.

As already mentioned, the cliffs east of the Patea River were examined by Hutton in 1884. He states that twenty-six species of Mollusca were collected from the blue clays, of which 77 per cent. were Recent (3, p. 340). His Wanganui lists mention the following twenty-five species, twenty of which are Recent, as indicated by a prefixed asterisk :—

**Verconella nodosa* (Mart.)
Olivella neozelanica (Hutt.)
**Ancilla australis* (Sow.)
**Ancilla depressa* (Sow.)
**Voluta arabica* Mart.
**Terebra tristis* Desh.
**Natica zelandica* Q. & G.
Polinices ovatus (Hutt.)
**Cerithidea bicarinata* (Gray)
Struthiolaria cingulata Zitt.
**Calyptraea maculata* (Q. & G.)
**Crepidula costata* (Sow.)
**Crepidula monoxyla* (Less.)
Dentalium solidum Hutt.
**Mactra discors* Gray
**Mactra ovata* (Gray)
**Mactra scalpellum* Reeve
**Zenatia acinaces* Q. & G.
**Gari lineolata* (Gray)
**Chione mesodesma* (Q. & G.), or perhaps *C. marshalli* Cossmann
**Dosinia anus* (Phil.)
**Dosinia subrosea* (Gray)
**Divaricella cumingi* (Ad. & Ang.)
Cucullaea attenuata (?) Hutt.
**Glycymeris laticostata* (Q. & G.)

Hutton's names have been revised so as to correspond with modern nomenclature, and some changes in the specific names have been made on the authority of Suter. In his paper on the Pliocene Mollusca of New Zealand, published in the *Macleay Memorial Volume* (1893), Hutton gives a list of Wanganuian Mollusca which broadly is the same as that published by him in 1886, but, besides making changes in nomenclature, he omits eight of the Patea records. It is hardly necessary to go into details. Hutton's lists, whichever may be taken, show a high percentage of Recent species as compared with Marshall and Murdoch's Waipipi list, and differ still more in this respect from the list of fossils collected by the writer west of Patea. If all the fossil records are combined, a total of thirty-four identified species is obtained, of which twenty-five, or 73 per cent., are Recent.

Since there is reason to believe that the Patea claystones are at least as old as the Waipipi beds, as shown by stratigraphical considerations, as well as by the occurrence of a species of *Cucullaea* (*C. attenuata* ?), *Dentalium solidum*, *Phalium fibratum*, and *Miltha* sp., it seems likely that several of the shells identified by Hutton and Park as belonging to species still living really represented extinct species. Be this as it may, the Patea beds clearly belong to the lower part of the Wanganuian formation—that is, to the stage called "Waitotaran" by Thomson. By restricting the definition of "Waitotaran" it would be possible to introduce a third stage into the Wanganuian, and into this the Patea claystones would no doubt fall.

Hawera Series.

As developed near Patea the Hawera series appears to be typically 30 ft. to 40 ft. in thickness. The lower layers consist of beach-worn pebbles mixed with much sand; the upper layers are almost wholly sand, which in places is nearly black owing to titaniferous magnetite being present in large quantity. Current-bedding is everywhere very noticeable, and some of the black sand appears to be wind-blown. Along the sea-coast the Hawera beds form the top of the cliff, and therefore cannot be closely examined. On the sides of the Patea Valley their contact with the Waitotaran beds is clearly marked by a sudden change from steep grassy slopes above to claystone cliffs below, and by numerous small springs. At one or two places near Patea, road-cuttings allow the Hawera beds and their contact with the Waitotaran claystones to be closely studied. For example, on the Wanganui road, about a mile from Patea Railway-station, brown weathered claystone (Waitotaran) is overlain by a thin layer of

gravel, above which comes 15 ft. of pebbly sand and 4 ft. or 5 ft. of loamy subsoil and soil. The seepage from these beds supplies a water-trough. On a branch road up a small valley south of the railway-station Waitotaran claystone is seen to be overlain by 30 ft. or 40 ft. of sand, mostly dark-coloured, the lower layers of which contain many pebbles of greywacke and numerous fragments of claystone. Another water-trough indicates a permanent water-seepage from the base of these beds.

Thomson (7, p. 416) explains the Hawera beds as having been deposited upon a wave-eroded surface of the Wanganuian beds during an advance of the sea. The writer's observations, though entirely supporting most of Thomson's statements, lead rather to the conclusion that the Hawera beds were formed wholly or mainly at a somewhat later stage—namely, during the subsequent retreat of the sea, caused by land-elevation.

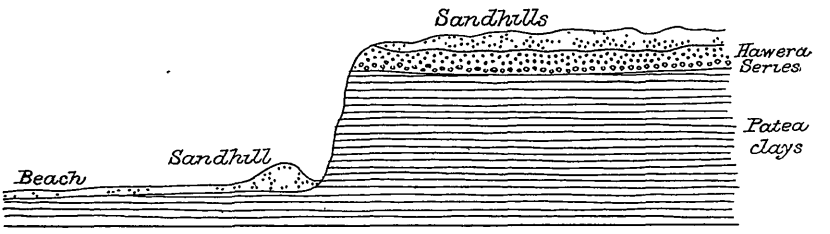
As has been shown by Thomson, the Hawera series is unconformable to the Wanganuian formation. Since the Upper Wanganuian or Castlecliffian is of Upper Pliocene age, the Hawera series falls into the Pleistocene. No shells were seen in it at Patea, but at Hawera Thomson collected a large number of Recent species from a shell-bed at the base of the series.

The Hawera beds, as pointed out by Thomson, give rise to a rich soil of great importance to the agriculturist.

Post-Hawera Deposits.

In the small valley south of the Patea town bridge there is a low hill formed of fine gravel and sand, similar in appearance to the gravel and sand of the Hawera series. Since this hill is far below the general level of the Hawera series, one must suppose that the material of which it is composed represents a rewash of the Hawera series.

The ferriferous sand-dunes capping the cliffs have already been mentioned several times. The material of which they are formed has probably been partly derived from the Hawera beds (as suggested by Thomson), and



SECTION WEST OF MOUTH OF PATEA RIVER.

partly from an ancient belt of dunes formed on the old coast-line immediately after the last elevation of the land had ceased. The prevailing wind is probably from the south-west,* and hence as the sea attacked the land, and cliffing advanced, the bulk of the ancient dune-sand was blown inland. Wind-action is strong at the cliff-edge, and keeps it clear of loose sand. Although some sand falls or is blown over the cliff, this loss is more than counterbalanced by sand derived from the Hawera series. R. Pharazyn, in 1870 (1, pp. 158–60), explained the present dune-sands on top of the cliffs along the shore of the Wanganui Bight as the remnant of a wide belt formed before cliffing began, but the idea that the sand was blown inland as the cliffs advanced was not clearly expressed in his paper.

* In summer there is a frequent sea breeze.

The observations made by Thomson (7, pp. 415–16) and by the present writer support the view that the ironsand of the dunes is mainly derived from the Hawera series. The rich ironsand deposit found on the beach between tide-marks west of the mouth of the Patea River may also be ascribed mainly to material derived from the Hawera series—that is, for the most part it represents a concentration of the material that falls or is blown over the cliffs.

Probably owing to the construction of moles at the mouth of the Patea River, material is at present accumulating on the beach immediately to the west of that river. Consequently cliff-erosion by the sea in this locality has ceased, and a narrow strip of sandhills, perhaps half a mile long, has formed close to the base of the cliffs, as illustrated by the annexed section.

GEOLOGICAL HISTORY—GENERAL REMARKS.

The geological history of the coastal belt extending from Wanganui to Hawera has been described by Thomson in his paper on the Hawera series, and some of his statements are almost necessarily repeated in the following paragraphs. At the end of the Castlecliffian stage (Upper Pliocene) the whole of the Wanganui coastal plain (*sensu lato*) was elevated, not uniformly, but with gentle flexures which, on the whole, produced dips towards the southward. At Wanganui the uplift was not great, perhaps only 400 ft. to 500 ft.; but if Marshall and Murdoch's data (10, pp. 118–19, 127) be accepted it must have been nearly 2,500 ft. at Nukumaru, and not far short of 4,000 ft. at Waipipi. At Patea and Hawera the elevation was not less than at Waipipi, and inland, as a rule, must have been much greater. Owing to the soft nature of the Wanganuian rocks, erosion proceeded rapidly, and when elevation ceased the land was no doubt maturely dissected. Slow depression followed, and the sea, as it advanced over the land, eroded and swept away all material above its own level, thus forming a plane of marine denudation. The great amount of previous erosion and the softness of the rocks enabled it to accomplish this task without difficulty. The plane of denudation, it is fairly obvious, was not horizontal, but had a gentle seaward slope. Inland from Hawera, as previously stated, it is terraced, but in most localities it has the one uniform slope to the foot of the inland hills. Depression ceased when the land was roughly 600 ft. below its present level, and elevation began, apparently almost without delay. During the retreat of the sea the sediments deposited during the previous advance, or the greater part of them, were reassorted, and in great measure swept away. The residue, with new material brought down by the rivers of that time, forms the Hawera series. It is a remarkable fact, perhaps more consistent with Thomson's explanation of their origin than with the writer's, that the Hawera beds seem to have been deposited almost uniformly over the whole of the coastal belt from Hawera to Turakina. Towards Marton they disappear, and their place is taken by fluviatile gravels; but the country between Marton and the coast has not yet been examined in order to ascertain whether they continue along the present sea-coast towards the mouth of the Rangitikei River.

Elevation continued till the land was somewhat higher than at present, for there is evidence of recent slight depression at Patea, Waitotara, and Wanganui (Park and Thomson). At the last-named place the depression may have been considerable. A paper by Henry Hill (5) on artesian wells at Wanganui gives data that to some extent support this view.

The marine sand and gravel forming the low hill in the small valley near the Patea brickworks presumably represent a rewash of the Hawera beds deposited during a brief period of depression. Probably there were other occasional minor oscillations during the last uplift, but there is no evidence of prolonged periods of standstill.

The marine planation of a wide belt of the Wanganuian beds is a remarkable fact, which has a bearing on the geological history of other parts of New Zealand. Had the upward and downward movements of the Wanganui beds been uniform, the eroded surface would have been almost or quite parallel to the bedding-planes, more especially if there had been a hard stratum of, say, limestone just below the level of the sea at the time of greatest depression. In that case the Hawera series would have been deposited on the Wanganuian without any visible unconformity, and a contact similar to that of the Amuri limestone and the Weka Pass stone in North Canterbury would have resulted.

According to Thompson's view of the origin of the Hawera beds, their upper surface must be wave-planed; and this statement holds good in the main, even if the present writer's hypothesis of their deposition during a negative movement of the strand be correct. The planation is not confined to the area between Hawera and Turakina, but may be traced north-westward beyond Cape Egmont, and southward, with some interruption, to Otaki, and finally to the immediate neighbourhood of Wellington. The gently sloping lowland at the foot of Mount Egmont extending from Hawera to Cape Egmont and thence northward to the Kaitake Range has been wave-smoothed in the late Pleistocene. In places numerous small conical hills of volcanic origin, formed almost in Recent times, stud its surface, but evidence of planation by the sea remains. In the Shannon district, and elsewhere south of the Manawatu River, aeolian sandstones, probably younger than Castlecliffian, appear to have been planed by wave-action, an interpretation of their topography partly supported by Adkin's account (9; see also his paper of 1911), but opposed to Cotton's views (8). At present only small portions of the Wanganui coastal plain have been examined in detail by geologists. These examinations have been made independently by various workers, at various times, and for various objects. Some divergence of opinion is therefore to be expected, but this will doubtless be eliminated when the results of detailed surveys over wide areas are available.

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