III.—GEOLOGY.

Art. XXXI.—*On some Railway Cuttings in the Weka Pass.*

By Professor F. W. Hutton, F.G.S.

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Plate XIV.

In the construction of the railway through Weka Pass, several excellent sections have been made in the younger beds between Waipara and the railway viaduct over Weka Creek. These I examined on the 18th of November last, and the observations I made are, I think, of sufficient interest for publication.

Rocks exposed.

5. After leaving the river gravels of the Waipara the first cuttings on entering the pass show a series of horizontal beds of silt and fine gravel; but without any fossils that I could see.

4. A little beyond the 42nd mile-stone from Christchurch we come to a series of marine sandstones and fossiliferous conglomerates, dipping 12° S.E. by E. The junction between these beds and the horizontal gravels is not exposed, but no doubt the two are unconformable. This marine series is as follows :—

	Feet.
15. Yellow-brown sands with calcareous layers (about)	175
14. Conglomerates and brown sandstones ...	70
13. Limestone and sandstone interbedded ...	15
12. Conglomerates and brown sandstones ...	40
11. Sandy clays and sandstones	20
10. Shell-beds and brown sandstones... ...	50
Total (about)	370 feet.

This brings us to a gully in which stands the 43rd mile-stone from Christchurch, and the next cutting to the north shows the following section (Pl. XIV., fig. 1), where a fault brings a brown sandstone against a series of sandy conglomerates with comminuted shells, dipping 15° S.E. by E. The fault runs about east and west, and does not appear to be of any great importance.

3. Unfortunately another gully follows, and the next cutting shows the following rocks, dipping 20° E.S.E. :—

	Feet.
9. Brown sandstone	10
8. Rust-coloured rubbly limestone with beds of sand and broken shells	18
7. Brown sandstone	25

A gully now follows, and the section is continued in the next cutting as follows :—

	Feet.
6. Sandy clay	?
5. Rust-coloured rubbly calcareous sandstone ...	20
4. Soft brown sandstone	15
3. Rust-coloured sandy limestone with beds of sandstone	30
2. Soft brown sandstone with calcareous bands	50
1. Rust-coloured sandy limestone and sandstone, the sandstones increasing in importance upwards	25

These rusty limestones, from 8 to 1, form what are known as the Mount Brown beds, the total thickness of which is here between 200 and 250 feet. These beds rest unconformably on laminated argillaceous sandstones with grey calcareous bands, which get more numerous downwards. Very fortunately, this is well seen in the section a little south of the Weka Pass Hotel, and also a little south of the 44th milestone from Christchurch. (Plate XIV., fig. 2.)

The rocks on both sides the plane of discordance dip 20° E.S.E., while the plane of discordance itself dips, roughly, 30° in about the same direction, but is irregular. At first sight it might be thought that this plane of discordance was a fault; but the low *hade*, the uneven surface, and the absence of any friction breccia, show, I think, that such is not the case. It seems to me that the older series was horizontal when the newer series was deposited on its denuded edges, and that both have been tilted since.

Dr. Hector has always maintained that the Mount Brown beds rested unconformably on the lower rocks in the Waipara District,* while I have held the contrary view. I now gladly acknowledge that I have been wrong, and that the Mount Brown beds must be separated from the underlying series.

2. These underlying rocks in the Weka Pass are as follows :—

5. Laminated argillaceous sandstones with grey calcareous bands, which get more numerous downwards.
4. Blue sandy marl and sandstones.

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* See Hector, "Prog. Rep. Geol. Surv., 1868-9," p. 12: also Sir J. von Haast, "Reports, Geological Explorations, 1870-71," p. 14.

3. Dark-grey sandy marl, interstratified with grey sandy limestone.
2. Grey sandy limestone passing gradually into
1. Weka Pass stone.

We here reach the 45th milestone from Christchurch, about three-quarters of a mile south of the railway viaduct. Beyond this the Weka Pass stone forms the cuttings up to the viaduct; but at the bottom of the one furthest north the Amuri limestone shows for a short distance. This appearance of the Amuri limestone above its ordinary level is by a fault, represented in my section of the Weka Pass made in February, 1873,* the fault coinciding in position with the railway viaduct.

The beds 3 to 5 constitute the "grey marl" of Dr. Hector, and I estimate their combined thickness to be about 500 feet. Unquestionably they are conformable to the Weka Pass stone.

1. That the Weka Pass stone rests unconformably on the Amuri limestone I have elsewhere tried to prove†, and this has, I consider, been completely confirmed by my survey of the Trelissick Basin last year,‡ where a distinct unconformity is acknowledged to exist above the lower limestone; which limestone, I have shown, agrees in stratigraphical position as well as in lithological composition with the Amuri limestone.

The rocks immediately below the Amuri limestone in the Weka Pass are not seen along the railway line; but the most northerly cuttings in the pass show—

4. Dark greensands.
3. Dark-grey, micaceous, sandy clay.
2. Calcareous green sandstone with sharks' teeth.
1. Bright green argillaceous sands.

CORRELATION OF THE BEDS.

We have, therefore, in the Weka Pass five different series:—

1. The lowest contains the Amuri limestone and the underlying green sandstones, the correlations of which with the saurian beds in the Upper Waipara are not doubted.

2. Next above is the series comprising the Weka Pass stone, and the overlying grey marls and sandstones. I have elsewhere given a list of fossils from this series,§ and have shown that they agree with those from the Curiosity Shop, the Ototara building stone, and the limestones of Maerewhenua and Waihao. Since that paper was written I have been informed by Mr. J. D. Enys

* "Reports, Geological Exploration, 1873-74," p. 45, sect. 10.

† "Quar. Jour. Geol. Soc. of London," vol. xli., p. 266.

‡ "Trans. N.Z. Inst.," vol. xix., p. 392.

§ "Quart. Jour. Geol. Soc. of London," vol xli., p. 554.

that bones of *Kekenodon* have been found in the Weka Pass stone, near the caves behind the Waikari railway-station, a discovery which strongly confirms the correctness of my opinion. I can also now add that the limestone of Castle Hill, in the Trelissick Basin, is of the same age. In the Canterbury Museum there are some remains of a large bony fish from the Weka Pass stone. They are caudal vertebræ, and look to me much like those of *Histiophorus* (sword-fish).

This series forms the upper part of Dr. Hector's Cretaceo-tertiary formation, and he considers it to be not younger than Lower Eocene. His reasons for this opinion appear to be: (1.) The series is stratigraphically associated with rocks of cretaceous age; (2.) It contains many fossils in common with the cretaceous rocks; (3.) It contains no recent species of Mollusca; And (4.) decidedly mesozoic forms, such as *Belemnites superstes*, are found in it.* On these I would remark: (1.) The series is often found quite unassociated with cretaceous rocks—*e.g.*, Waikato, Golden Bay, Oamaru, Winton;† a stratigraphical break between it and the cretaceous rocks has been proved in Trelissick Basin. (2.) No list has ever been published of the fossils that are said to be "common throughout the formation," and, of course, Dr. Hector cannot expect other geologists to attach much weight to a statement which is not supported by any evidence. (3.) This is not quite correct, for *Voluta elongata*, Swainson, and *Waldheimia lenticularis*, Deshayes, are both found in the Weka Pass stone; and Dr. Hector himself, in the list of fossils sent to the Indian and Colonial Exhibition, mentions six recent species of Mollusca from his Cretaceo-tertiary formation ("Catalogue," pp. 12–14) out of thirty-four species which are named. (4.) The Belemnite is said by Dr. Hector to come from "the black marls under the chalk with flints in the Coverham or Middle Clarence Valley Section"—that is, from *below* the Amuri limestone, and not from the upper beds, which appear to be absent in the Clarence Valley.

With regard to the correlations of this series with rocks in other parts of the world, it must be remembered that it contains *Kekenodon*, *Palæeudyptes*, *Carcharodon angustidens*, and *Aturia ziczac*. Undoubtedly it is the equivalent of the rocks at Bird-rock Point, Portland Bay, Aldinga Bay, Mount Gambier, and the banks of the Murray in Victoria and South Australia; and these rocks are considered to be Oligocene or even Miocene.

3. *Mount Brown beds.*—Fossils in these beds are not very numerous, or, at any rate, have not yet been catalogued, and the following list is taken from Sir J. von Haast's "Geology

* "Indian and Colonial Exhibition, Catalogue and Guide to the Geological Exhibits," p. 55.

† See "Quar. Jour. Geol. Soc. of London," vol. xli., p. 275.

of Canterbury and Westland," pp. 306 and 311. I have, however, brought the nomenclature up to date:—

1. *Pleurotoma latescens*, Hutton.
2. *Natica gibbosa*, Hutton.
3. *Natica ovata*, Hutton.
4. *Turritella gigantea*, Hutton.
5. *Turritella ambulacrum*, Sowb.
6. *Scalaria lyrata*, Zittel.
7. *Dentalium giganteum*, Sowb.
8. *Cardium patulum*, Hutton.
9. *Cardita difficilis*, Desh.
10. *Cucullæa alta*, Sowb.
11. *Pecten hochstetteri*, Zittel.
12. *Pecten hutchinsoni*, Hutton.
13. *Waldheimia lenticularis*, Desh.
14. *Waldheimia triangularis*, Hutton.
15. *Waldheimia* (?) *concentrica*, Hutton.
16. *Cellepora nummularia*, Busk.
17. *Fasciculipora ramosa*, Busk.
18. *Caratomus* (?) *nuperus*, Hutton.

Of these eighteen species, ten give no evidence as to the position of the Mount Brown beds, being either confined to it or else found equally commonly in both the Oamaru and Pareora Systems. Of the remaining eight species, none are exclusively Oamaru, but two are found principally in that system. The other six belong principally to the Pareora System, one of them, *Cardita difficilis*, not having been recorded as yet from any part of the Oamaru System. The palæontological evidence, therefore, such as it is, is in favour of the beds belonging to the Pareora System, and, from a stratigraphical point of view, the unconformity lends support to this view.

The Hutchinson's Quarry beds at Oamaru have always been considered, for palæontological reasons, as the equivalents of the Mount Brown beds; and last year I showed* that probably they rested unconformably on the Ototara limestone, and belonged to the Pareora System.

It now appears that the Mount Brown beds have stratigraphically a similar position, and also belong to the Pareora System.

Again, the beds immediately above the upper limestone in Trelissick basin were referred by Mr. McKay (together with the upper limestone itself) to the horizon of the Mount Brown beds; but last year I showed that they formed the base of the Pareora System at that locality.† Consequently the view now put forth,

* "Trans. N.Z. Inst.," vol. xix., p. 421.

† "Trans. N.Z. Inst." vol., xix., Art. lii.

that the Mount Brown beds belong to the lower part of the Pareora System, reconciles several different opinions, and is therefore likely to be correct.

4. The Greta beds—as the next higher beds in the Weka Pass may be called—appear to be conformable to the Mount Brown beds, although, as the section is not continuous, such cannot be positively affirmed. No unconformity is noticed by Sir J. von Haast at Mount Brown,* and I have elsewhere remarked that at present "I cannot detect any palæontological break in the [Pareora] system."†

The following fossils have been collected in the Greta beds by Sir J. von Haast and myself. They evidently belong to the upper part of the Pareora System, and about 66 per cent. of the Mollusca are recent:—

1. *Carcharodon megalodon*, Agassiz.
2. *Purpura textiliosa*, Lamarck.
3. *Fusus australis*, Quoy and Gaimard.
4. *Fusus spiralis*, Adams.
5. *Siphonalia mandarina*, Duclos.
6. *Siphonalia dilatata*, Quoy and Gaimard.
7. *Siphonalia orbita*, Hutton.
8. *Pisania lineata*, Martyn.
9. *Nassa incisa*, Hutton.
10. *Oliva neozelanica*, Hutton.
11. *Ancillaria australis*, Sowerby.
12. *Ancillaria hebera*, Hutton.
13. *Voluta corrugata*, Hutton.
14. *Drillia wanganuiensis*, Hutton.
15. *Triton spengleri*, Lamarck.
16. *Natica neozelanica*, Quoy and Gaimard.
17. *Cerithidea bicarinata*, Gray.
18. *Struthiolaria cincta*, Hutton.
19. *Calyptra calyptraiformis*, Lamarck.
20. *Turritella rosea*, Quoy and Gaimard.
21. *Turritella tricincta*, Hutton.
22. *Rotella neozelanica*, Homb. and Jacq.
23. *Zizyphinus punctulatus*, Martyn.
24. *Cantharidus tenebrosus*, Adams.
25. *Panopæa orbita*, Hutton.
26. *Corbula* (?) *dubia*, Hutton.
27. *Mactra discors*, Gray.
28. *Zenatia acinaces*, Quoy and Gaimard.
29. *Paphia neozelanica*, Chemnitz.
30. *Paphia ventricosa*, Gray.

* "Rep. Geol. Expl., 1870-71," p. 15. No. 12 is the Mount Brown beds.

† "The Mollusca of the Pareora and Oamaru Systems": "Proc. Linn. Soc. of N.S. Wales," Series 2, vol. i., p. 206.

31. *Venus meridionalis*, Sowerby.
32. *Venus stutchburyi*, Gray.
33. *Cytherea multistriata*, Sowerby.
34. *Dosinea grayi*, Zittel.
35. *Dosinea limbata*, Gould.
36. *Cardita australis*, Lamarck.
37. *Cucullæa alta*, Sowerby (?)
38. *Pectunculus laticostatus*, Quoy and Gaimard.
39. *Pectunculus globosus*, Hutton.
40. *Pectunculus cordatus*, Hutton.
41. *Pecten diffluxus*, Hutton.
42. *Pecten neozelanicus*, Gray.
43. *Anomia alectus*, Gray.
44. *Placunanomia neozelanica*, Gray.
45. *Ostrea edulis*, Linné.
46. *Waldheimia lenticularis*, Deshayes.

These beds seem to be the equivalents of the Motanau beds, which have about 55 per cent. recent species, and to be younger than those at the lower gorge of the Waipara, which contain only 43 per cent. recent species.

Judged by the percentage test alone, the Greta beds would have to be called Pliocene, but the occurrence of *Carcharodon megalodon*—a wide-ranging oceanic shark, highly characteristic of the Miocene in Europe and North America—necessitates a greater age. The high percentage of recent species may be due, in part, to the liberal amount of variation that I allow to each species; but I do not think that this will account for all. It is, I think, evident that the dying out of old species and the introduction of new ones has gone on slower in New Zealand than in Europe; and it is to be expected that such has been the case, for the seas of New Zealand have not been subjected to the great changes in temperature which were caused in the Northern Hemisphere by the glacial epoch; nor are the facilities for immigration so great in New Zealand as they are in continental countries, or in Australia.

5. Of the silt and gravel beds that succeed the Greta beds, and to which, as I have already said, they appear to be unconformable, I will merely remark that they resemble the beds forming the low hills that lie between Amberly and the mouth of the Waipara; those forming the Moeraki Downs, south of the Ashley; as well as those of Racecourse Hill, Little Racecourse Hill, and Woolshed Hill near the Malvern Hills. Of these, Little Racecourse Hill is of later date than the time of the greatest extension of the glaciers, for it contains large angular blocks mixed up with the shingle. I suspect, therefore, that these silt and gravel beds in the Weka Pass are of post-glacier, but, at the same time, of Pliocene age.