stand at high angles, and in two places present the phenomena of an overturned section. The first in the country, between the Clarence and Kaikoura, where the whole series, including the leda marls, are overturned 20° beyond vertical. The second, near Heathstock, where the Awatere beds are also involved; the beds here are for the most part nearly vertical, and it is only the greensand group which, in the section seen, is overturned.

And thus, when these facts are taken into consideration, it does not appear to me that, at the time when these beds were being deposited, the outlines of the present configuration of the area within which their remnants are now found, was then determined; or that this series, at least the higher beds of it, were deposited in a large bay, with inlets penetrating the mountain ranges, wherever these rocks are now found. I rather think that the evidence points to the subsidence of a very wide area until deep-sea deposits were formed and a subsequent upheaval of mountain chains, between which, and in the folds of which, the younger beds have been preserved to the present day.

ART. XCII.—*On the relation between the Pareora and Ahuriri Formations.* By Captain F. W. HUTTON, Director of the Otago Museum.

[*Read before the Otago Institute, 24th October, 1876.*]

IN 1873, in my "Catalogue of the Tertiary Mollusca and Echinodermata of New Zealand, in the Colonial Museum," I separated the tertiary rocks at Awatere, Kanieri, Pareora, Awamoa, etc., from those of Napier, East Coast of Wellington, Broken River (upper bed), etc., under the names of the Pareora and Ahuriri formation respectively. During the last two years, however, I have been gradually led to doubt the correctness of this division, and to consider it probable that both ought to be regarded as one and the same formation. This view was first forced upon my notice during my survey of Otago, by finding that, although both the Oamaru and Pareora formations were largely developed, I could find no trace of the supposed intermediate Ahuriri formation. At the time of writing my report, however, I did not consider myself justified in making the change, nor was a discussion of this nature suitable to a report on the geology of Otago. But since then the Otago Museum has received collections of fossils from Pareora and the Wairarapa, which have enabled me to go more closely into the question, and the results of that investigation I have now the honour to lay before you.

In the first place the argument against the two formations being considered the same is that out of 154 species of mollusca found in the Pareora formation, 98 have not yet been found in the Ahuriri formation; while out of 63 species of mollusca found in the Ahuriri formation, 29 have not yet been found in the Pareora formation. This is the reason that originally led me to distinguish between the two, but although of considerable weight the difference in the fossils may perhaps admit of another explanation than that of difference in age.

On the other hand, the proportion of living to recent species is nearly the same in both formations, being 37½ per cent. in the Pareora formation, and 35 per cent. in the Ahuriri formation.* This is, I think, a very strong argument in favour of the synchronism of the beds, and it is further strengthened by the fact, that at no locality are the two formations found together,† and that several of what were formerly supposed to be characteristic fossils of the Oamaru formation, such as *Pecten hochstetteri*, have been lately found by Dr Haast in beds belonging to the Pareora formation, although they are unknown in the supposed intermediate Ahuriri formation.

Now, while the similar percentage of recent to extinct forms can only be explained by similarity in age, the difference between the fossils found in the two groups of beds may perhaps admit of explanation by either difference in habitat, that is to say, by difference in the geographical positions of the beds constituting the two groups; or by difference in station, that is to say, by a difference in the conditions of the sea bottom; or, what comes to the same thing, in the difference in the deposits taking place in different localities at the same time. It is therefore necessary that we should examine both these causes in detail.

Difference in habitat.—If we look at the geographical distribution of the two formations as at present recognized, we find that the Pareora formation is extensively developed in Otago from Riverton and Te Anau Lake to the Waitaki, and is found in places all along the eastern side of the South Island, through Waipara, Motanau, Mount Cookson, River Conway to Cape Campbell and the Awatere. On the west coast of the South Island it also extends from Hokitika to Nelson. In the North Island it has only been

---

* These numbers are of course always altering as our knowledge increases. At present they stand:—

	Total Number of species.	Recent.	Extinct.	P.C. of recent species.
Pareora formation	154	58	96	37½
Ahuriri formation	63	18	45	35

† When the geology of the interior of Wellington is known, this statement may possibly be proved to be incorrect.

recognized at the White Cliffs, Taranaki, the upper end of the Manawatu Gorge, and doubtfully in the upper parts of the Wanganui and Rangitikei Rivers. In Hawke Bay and Auckland it is unknown. On the other hand, the Ahuriri formation is largely developed in the north from Cape Rodney and the Kawau, to Auckland and the Waikato. It occurs again largely between the East Cape and Napier, and all down the east coast of Wellington to the Wairarapa, and is found again on the west coast at Waitotara. In the South Island, on the contrary, it is only known in two limited localities, viz., the Hurunui Mound in the Nelson district, and the upper beds of Castle Hill Station on the Broken River, a branch of the Waimakariri. It would thus appear that the Pareora formation is almost entirely confined to the South Island, and the Ahuriri formation to the North Island, the two, as I have already stated, never yet having been observed in contact. Let us now see if this difference in geographical distribution will in any way account for the difference in the fossils of the two groups of beds.

Up to the present date 300 species of marine mollusca are known to inhabit our seas, and of these, 122, or 41 per cent., are only found north of latitude 42° S.; 40, or 13 per cent., are only found south of that latitude; while 138, or 46 per cent., are found both in the north and the south. The number common to both would, however, be much smaller if those species had been omitted that are so rare either in the north or the south, that we could hardly expect that they would be found as fossils when the present sea bed becomes dry land. Nevertheless, we see that there is a considerable difference at present between the marine shells of the north and south of New Zealand.

If, now, we arrange in the same way, the 179 species of fossil shells found in the Ahuriri and Pareora formations, we find that 41, or 23 per cent., are found only in the north; 82, or 46 per cent., are found only in the south; while 56, or 31 per cent., are common to both north and south. We see, therefore, that the difference in the Ahuriri and Pareora formations is considerably greater than the present difference, and we should not, I think, be justified in supposing that the difference between the fossils of the Ahuriri and Pareora formations was caused altogether by their different geographical distribution, although probably a certain amount of influence may be attached to it.

Difference in station.—Turning now to the other possible cause, we find that in all the localities for Ahuriri fossils the rocks are more or less calcareous, while in all the localities for Pareora fossils the rocks are either clay or sandy clay, with the exception of Mount Caverhill, Lyndon, and Mount Cookson in the southern part of the district of Nelson. Here,

then, we have a reason quite sufficient, apparently, to account for the difference between the fossils of the two formations; but we still have to account for the calcareous rocks of Lyndon, Mount Cookson, and Mount Caverhill having been classed with the clays of the Pareora formation, rather than with the calcareous rocks of the Ahuriri formation. Only nineteen species of shells are known from these localities. Of these eight are common to both the Ahuriri and Pareora formations in other localities, nine are found only in the Pareora or Wanganui formations, while two are found only in the Ahuriri formation. We thus see that, while the fossils of these localities are more nearly related to those of the Pareora than to those of the Ahuriri formation, still the percentage of species common to both is above the average. The percentage, however, is nearly the same at Motanau, and even equal to it at Napier, so that this explanation is not altogether satisfactory.

But although neither difference of habitat nor difference of station appear to be quite capable of explaining the great difference between the fossils of the Ahuriri and Pareora formations, I think that the objections that can be urged against them are of little weight in comparison with the almost identical percentage of extinct forms in both, and it will be better to consider both formations as one until decisive proof can be got to the contrary. When the geology of the Wellington district is better known, proof one way or the other will probably be obtained; for the rocks in the Manawatu Gorge and the Upper Wanganui belong probably to the Pareora formation, while those on the East Coast and also at Waitotara belong to the Ahuriri formation.

Dr. Hector, in his recently published Geological Sketch Map of New Zealand, places his Kanieri series with the Hawke Bay series, and in this I think he is right; but he places the Awatere series with the Wanganui series of Shakespeare Cliff, and this I cannot agree to; for the fossils of the Awatere series are closely related to those from Motanau and Kanieri, and only 42½ per cent. of them are recent, while the fossils from Shakespeare Cliff are very distinct, and 75½ per cent. of them are recent.

ART. XCII.—*Descriptions of some new Tertiary Mollusca from Canterbury.*

By Captain F. W. HUTTON, Director of the Otago Museum.

[*Read before the Otago Institute, September 5th, 1876.*]

LAST year Dr. J. von Haast sent a collection of Canterbury tertiary fossils to the Otago Museum, with the request that I would describe the new