Oamaru locality is rich in small species, which perhaps points to insufficient collecting in the Canterbury locality; but certain larger forms present in one list are wanting in the other. For example, we do not find, in the former, species of *Astraea, Calliostoma, Cardium, Cucullaea, Lima, Mactra, Mytilus, Pecten, Struthiolaria, Trochus,* and *Turbo,* or find them comparatively rarely; while the latter are relatively poor in species of *Bathytoma, Dentalium, Drillia, Latirus, Mangilia,* and *Turris* By the kindness of Mr. Morgan, Under-Secretary for Mines, I have been allowed to see the lists of fossils to be published in the forthcoming bulletin on the Oamaru District, by Professor Park, and I find that this discrepancy is not sensibly removed even with longer lists There does seem, however, to be a slight preponderance of extinct forms in the species predominant at Castle Hill over those common at Target Gully, which indicates a rather older set of beds at the former place

On comparing the list of fossils with that obtained by the author at the Lower Waipara Gorge* it is found that the resemblance is closer, the only marked difference being the presence of the numerous oysters of various species at Waipara, whereas they are practically absent from the mid-Canterbury district There is a remarkable similarity in the percentage of Recent forms from both these localities, which suggests an approximately identical age I have not been able to compare these lists with those from the beds in similar position in the Weka Pass section, as they have not been published up to the present date; and in face of the fact that these, and others of equal value for the purpose of correlation of our Tertiary series, are likely to appear at an early date, it seems unwise to comment further, or to attempt to draw conclusions which may be entirely upset after a consideration of fuller evidence

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Art XXIV.—*An Unrecorded Tertiary Outlier in the Basin of the Rakaia.*

By R Speight, M.Sc., F G S, Curator of Canterbury Museum

[*Read before the Philosophical Institute of Canterbury, 6th December, 1916, received by Editors, 30th December 1916, issued separately, 30th October, 1917*]

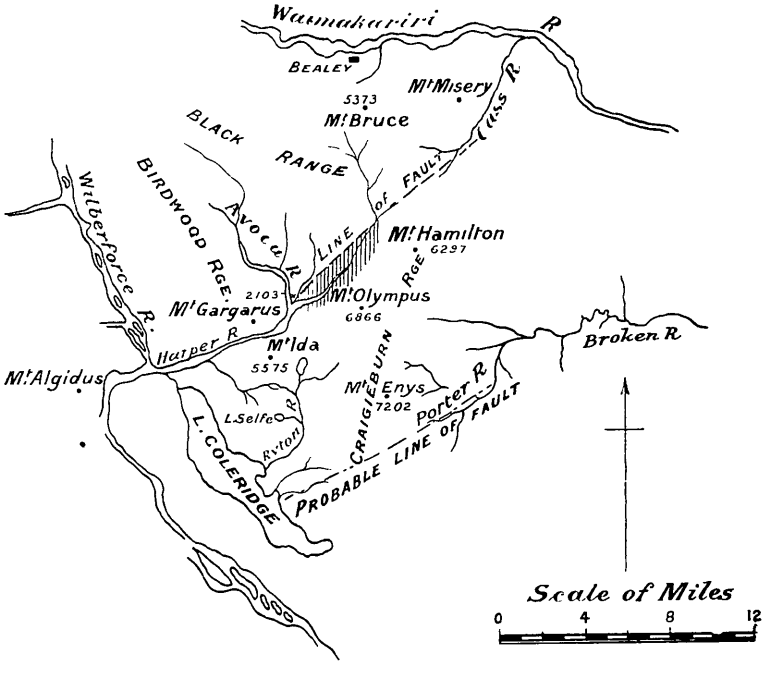
The following is a brief note on some of the features of a hitherto unrecorded occurrence of Tertiary sedimentary beds at the head of the Harper River, a tributary of the Wilberforce, one of the main feeders of the Rakaia This river rises in a saddle between the northern end of the Craigieburn Range and Mount Misery, and flows in a straight narrow valley in a south-west direction for some fifteen miles till it joins the Wilberforce It receives its principal supply of water from two tributaries—first of all, an unnamed stream which joins it about three miles from its source, rising at the eastern

* R. Speight, A Preliminary Account of the Lower Waipara Gorge, *Trans. N.Z Inst.*, vol 44, 1912, p. 231.

end of the Black Range and flowing south in a glacial trough ; and, secondly, the Avoca River, which rises in glaciers on Mount Greenlaw and joins the Harper about six miles below the tributary just mentioned. Although the main stream is called the Harper, the amount of water properly belonging to it is small as compared with the amount from its two main tributaries. It also receives the overflow from Lake Coleridge just before it reaches the Wilberforce.

The only account of the district is that given by Haast,* who traversed the whole length of the Avoca in the year 1866, but was prevented by bad weather from ascending the Harper to its source.

It is in the stretch of the river-valley between the junctions of the Avoca and the unnamed tributary with the Harper that it presents its most interesting geological features. In this locality there is developed a series of



SKETCH-MAP OF HARPER RIVER DISTRICT.

Shaded portion indicates Tertiary beds ; dotted lines, probable lines of fault.

Tertiary beds consisting of sandy clays with impure lignite, greensands, concretionary sands, and layers of concretionary shell-beds. It was not found possible under the weather conditions to detach specimens from the hard layers in the time at the author's disposal, but frequent specimens of

* J. HAAST, *Report on the Headwaters of the River Rakaia*, 1866 : a report published by the Provincial Government of Canterbury, and reproduced substantially in the same author's *Geology of Canterbury and Westland*, 1879.

Polinices, Turritella, &c., which could be identified *in situ*, indicated that the beds were probably of mid-Tertiary age. One isolated boulder found in the bed of the stream was full of the black oyster-shell which occurs in beds at the base of the Tertiary series in the Trelissick Basin and elsewhere in Canterbury, indeed, the former area is in comparative proximity, since it is on the other side of the Craigieburn Range, which flanks the valley on the south, so that it is very probable that the lower members of the Tertiary series are also represented in the valley of the Harper.

The beds are best developed on the south-eastern side of the valley, but they also occur on the north-west side as well. They are, however, forest-clad in many parts, covered with moving debris from the neighbouring greywacke hills in others, and in all places subject to slumping movements so that their relations to one another are difficult to make out. The strike of the beds is in a north-east and south-west direction, with a dip to the south-east, the strike being approximately coincident with the direction of the valley. Near the mouth of the Avoca there is the most remarkable case of weathering into pinnacle forms that I have ever seen.

The only satisfactory solution for the occurrence and position of these Tertiary beds is that they have been faulted down from a higher level and thus escaped the erosive action of frost and ice, which has in all probability removed the connecting masses from higher levels, the beds forming originally a part of the great covering of Tertiary sediments which masked the old peneplained surface of the mountain region at the close of the Tertiary era. It is noteworthy also that this occurrence marks the farthest extension of these beds to the axis of the main range in the northern part of Canterbury, and, as undoubted marine beds are in evidence, it clearly shows the transgression of the sea far inland during late Tertiary times.

If a fault origin for the occurrence is admitted then it is easy to explain the straight alignment of the valley-walls, and, further the extension of that alignment into the valley of the Cass over the saddle—a feature to which I have previously drawn attention, and suggested for it a structural origin.* The Cass Valley and the Harper are thus located on an old fault-line running north-east and south-west and parallel to those occurring in the Esk River Valley, and in the valley of the Upper Porter River, and in a wider sense, to the system of fractures oriented in the same direction which affect a large part of the north-eastern region of the South Island, as pointed out by McKay† and Cotton,‡ and called by the latter the Kaikoura system of fractures.

The general arrangement of the beds in the Harper Valley, and its characteristic form, are strongly reminiscent of valleys of similar origin in the north-east part of the province, such as the Greta and Waikari Valleys and, on a small scale, of the great structural valleys of the Kaikoura region. The relative movement of the rocks has resulted in an apparent downthrow of the beds to the north-west, and the same is true in the case of the Harper, so that this movement has extended far inland into

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* R. Speight, The Physiography of the Cass District, *Trans. N.Z. Inst.* vol. 48, 1916, p. 148.

† A. McKay, On the Geology of Marlborough and South-east Nelson, *Rep. Geol. Explor. dur. 1890–91*, 1892, pp. 1–28.

‡ C. A. Cotton, The Structure and Later Geological History of New Zealand, *Geol. Mag.*, 1916, p. 248 *et seq.*

the mountain region of the Southern Alps. It is therefore evident that the relative height of the central portions of that range compared with the parts to the east was at one time greater than it is now, unless there are faults of whose existence nothing is known at present which worked in the other direction.

This is not the only instance that the locality furnishes of a valley determined in all probability by structural movements, for some five miles to the south-east there is an exactly analogous valley in the Upper Porter leading to Coleridge Pass, a low saddle in the Craigieburn Range; and on the Lake Coleridge side of the pass there is a marked break in the parallel ridges which are such characteristic features of that part of the Rakaia region I have been informed that pieces of coal have been found in this locality, but have never been able to come across any myself, though it is not at all improbable that it exists, and that another small outlier of the Tertiary series exists in that part of the lake-basin. If this is really so it would explain, just as the Harper fault explains, the existence of the isolated blocks into which these parallel ridges are cut However, many glaciated regions show the presence of such isolated remnants of ridges, and it is hardly safe to explain the Rakaia phenomena in this way without further evidence It may be noted that Gregory in his book, *The Nature and Origin of Fiords*, notes in numerous places the frequent occurrence of isolated mountain blocks in glaciated regions, and explains them as the result of cross-fractures and not as a product of glacier erosion.

The question of the age of the Harper River fault is a matter of some interest In its initial stages it is certainly of pre-glacial origin, since the valley has been glaciated An overflow from the Waimakariri basin came in from the neighbourhood of the Bealey, and came down the unnamed tributary referred to previously, and left traces all down the valley to the junction with the Avoca, where it merged into the great ice-streams which have so profoundly modified the landscape of this region. The result of glacial action on a valley of fault origin will, of course, be considerably different from that in a normal stream-eroded valley In the former there will be no overlapping spurs, and therefore there will be, after glaciation, no truncated or semi-truncated ends, no beehive forms, but the valley-walls will exhibit complete alignment, a feature well exemplified in the Harper and Cass Valleys Unless the formation of the valley has ante-dated the glaciation by a long period there will be little sign of the development of tributaries, so that hanging valleys will be absent. Further, if the sides have all irregularities removed, the flat faces left when the glacier retreats will be stable under the action of erosion agents, and will be preserved much longer than those valley-sides on which the stream-valleys are already organized.

The Cass Valley exhibits a well-developed system of overlapping spurs on its floor, but these are no doubt due to the overdeepening of the flat floor of the glaciated trough by stream erosion after the retreat of the ice; and the same remark applies to the Upper Harper, but to a more limited extent.

Although the fault formation of the valley must be pre-glacial, there is evidence of disturbance of drainage in the case of Lake Coleridge which may be attributable to recent movements along the same line of fracture The circumstances are as follows: Round Lake Coleridge there is a well-developed old shore-line about 60 ft. above the present level of the lake.

This is to be seen very clearly in the neighbourhood of the intake for the tunnel in connection with the power-station, but clearest of all in the sheltered bays on what is called "the Peninsula," about half-way along the eastern side of the lake. These show clearly that the water within comparatively recent times was 60 ft. higher. The lake now drains out at its northern end towards the Harper and Wilberforce Rivers, but there is a clearly defined old river-channel, with terraces and everything complete, leading from near Messrs Murchison's station buildings towards the Acheron at the other end of the lake, the road following the bed of this old stream for about a mile. The highest point of this outflow channel above the lake is about 60 ft., so that if the lake were filled up to the level of its old shoreline it would discharge in the opposite direction to what it does at present. The cause of this reversal is attributable to a lowering of the barrier at the northern end. What this barrier was is not clear; it may have been the front of the retreating glacier of the Wilberforce, for if that acted as a ponding agent it would be effective as long as its terminal was below the upper end of the lake, but when the ice retreated farther it would allow the outflow of water in the direction of the Wilberforce. This would no doubt account for the phenomenon, especially as the change in direction of drainage appears to have taken place suddenly, and not by the slow removal of a rock barrier by water erosion.

The other explanation suggested is that the movements on the line of fault had not ceased when the lake discharged normally from its southern end, but that a sudden lowering of the country north-west of the line of the Harper River allowed of escape of water in a northern direction The slumped character of the sides of the Upper Harper Valley suggest recent earth-movements Further, if the line of the Upper Harper be continued to the south-west it will pass close to two other Tertiary outliers, one near Glenthorne, at the mouth of the Harper,* and the other near the Mount Algidus Station, across the Wilberforce; and it is possible that their preservation may be associated in some way with the same set of circumstances that have accounted for the occurrence of a Tertiary remnant in the Upper Harper Valley. By suggesting this continuation of the fracture-line across the Wilberforce it is not intended to endorse McKay's extended system of fault-lines as indicated in his map. Although this writer did great service towards the proper interpretation of the structural features of the mountain area of Canterbury, he probably erred in carrying his hypothesis too far. There is no evidence that I am aware of pointing to the extension of this line of fracture farther to the south-west

*J. VON HAAST, *Geology of Canterbury and Westland*, 1879, geological map facing p 370.