The Lower Waipara Gorge.

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INTRODUCTION.

THE Waipara River, like the Hurunui and Waiau-ua, flows across a series of sub-parallel topographic barriers in its easterly course to the sea. High-standing ridges and intervening valley lowlands are aligned in a general N.E.–S.W. direction and are the most striking features of the North Canterbury landscape. The major streams flow across the grain of the country, cutting deep channels or gorges across the successive topographic barriers.

The object of this paper is to examine the relation of the Waipara River to the topographic barrier across which its lower gorge is cut in the vicinity of Amberley. The problem of accounting for this lower gorge was discussed by Speight (1912, pp. 225–6), when he expressed the view that both the Waipara and Hurunui Rivers afforded examples of superimposed drainage. Later, however (1915, pp. 336-53) he reviewed the whole question of the structure of North Canterbury and the relation of the drainage pattern to it, and stated his general agreement with Cotton's idea of differential movement of crust-blocks proceeding into late geologic time. It is implied that the rivers are antecedent with respect to the topographic barriers. The hypothesis of antecedence is more fully presented by Speight in a still later paper discussing the special case of the Hurunui River (1918, pp. 93-105).

In discussing the relation of North Canterbury rivers to topographic barriers, Cotton (1922, p. 243) uses the term "anteconsequent." According to their genesis streams are classified as consequent, subsequent, resequent, obsequent, or insequent. According to their relation to a topographic barrier they are classified as antecedent or superimposed. The two bases of classification are entirely different. In the present writer's opinion the above terms are adequate for statement of the relation of river valleys to the land surfaces on which they are developed, and he does not now use the term "anteconsequent." Therefore the object of this paper is to discuss whether the Waipara River is antecedent or superimposed with respect to the topographic barrier that it crosses near Amberley.

The writer's study of the river has been incidental to his study of the neighbouring coast, because interpretation of the shoreline history has involved consideration of the later geologic history of the landmass. The relation of the river to the topographic barrier has,

therefore, assumed a special importance. In connection with the shoreline study the following interesting components of the country adjacent to the lower Waipara River were examined in some detail:—

1. A wide strand-plain—the Amberley strand-plain.
2. A large terrace about 150 feet above sea-level—the Amberley terrace.
3. A large river terrace with a downstream slope slightly steeper than the present floor of the river valley—the Teviotdale terrace.

Each of these will be discussed briefly and this will involve discussion of the whole matter of the mode of origin of the lower Waipara Gorge.

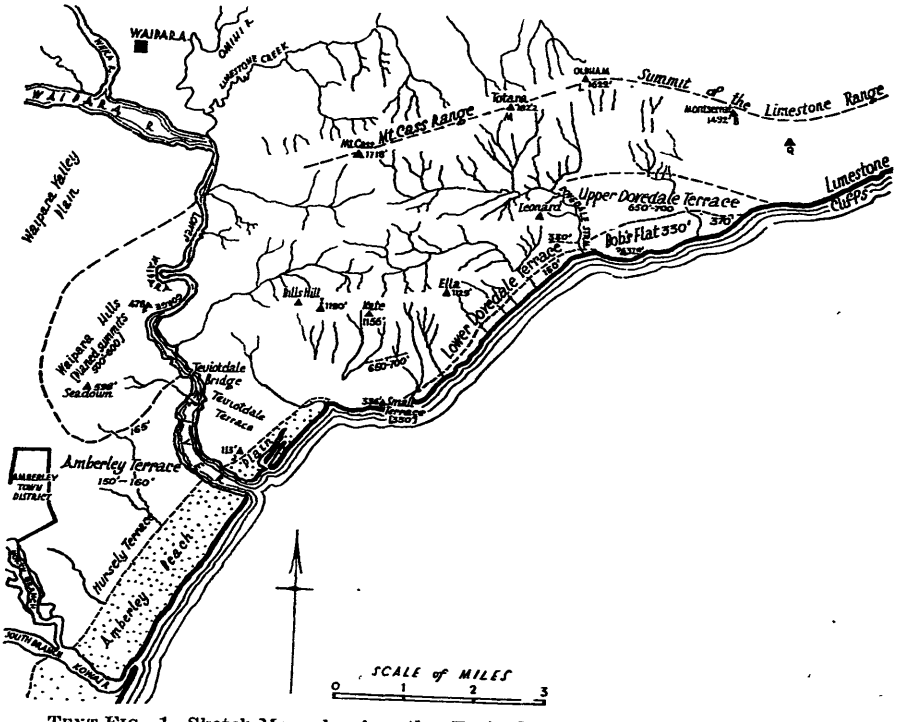
1. The Amberley Strand-plain.

This is a strip of land along the coast that has been already described by Speight (1912, p. 222) and by the present writer as a plain of recent emergence. It has a maximum width of 1½ miles near Leithfield, and from its inner edge rises a cliff which is still well preserved, and extends southward for several miles, decreasing steadily in height. Speight (1912, p. 224) records the height of this terrace as 50 feet, and the present writer (1926, p. 226) notes that near the Waipara River it is 120 feet. It is obvious that these results have been obtained from measurement at two different points, and that neither observation has any special significance.

In January, 1934, the writer re-examined the plain very closely, and, assisted by Mr S. A. Cooper, took a series of careful levels across it to the summit of the cliff behind it. Talus from this cliff and fan-like deposits of gravel, spread out from the mouths of gullies cut in the upper terrace, mask the inner edge of the plain in many places. Apart from these superimposed features, however, the inner edge of the strand-plain is, in several swampy hollows, actually at a lower level than normal high-water mark. The strand-plain is composed of a set of beach-ridges, from the crests of which the land surface slopes gently back to swampy hollows, those on the north side of the river being generally full of water after any heavy rain. The beach-ridges are very well defined on the road to Amberley Beach and as far south as Leithfield. From this latter point the strand-plain is covered with irregular dunes of blown sand, and its characteristic structure thereby obscured.

That the sea cut the cliff behind the plain seems abundantly clear, but there is no need to demand vertical movement of land or sea-level to account for retreat of the shoreline. The plain was built out from the base of the cliff by a normal process of progradation, and the several beach-ridges represent its "lines of growth." Speight (1912, p. 224) suggested that a slight vertical uplift was responsible for the emergence of the plain from the sea, and the present writer had concurred in this view. The nature of the beach-ridges and the low elevations of the inner edge suggest, however, that all its features can be accounted for without assuming any vertical upward movement of the land relative to the sea at all.

A satisfactory geomorphic history of the strand-plain might, therefore, be stated somewhat as follows. In a cycle of retrogradation an older levelled surface—the Amberley terrace—was cut back by the sea. As a direct result of this cliffing of its front, the Waipara and Kowai Rivers were entrenched in it. Then ensued locally a cycle of progradation, in which the strand-plain was built out from the base of the cliff as a beach-ridge foreland. The rivers have extended their courses across it and are now planing out a new surface below that on which they once flowed. The whole sequence of events might have occurred on a steadily sinking landmass just as well as on one undergoing elevation. Indeed, it might be suggested that the extensive cutting back of the land by the sea and the fairly rapid deepening of the water off the present shore seem to favour an hypothesis of late subsidence rather than one of elevation. In any case the recent entrenchment of the Waipara and Kowai Rivers in the Amberley terrace does not *prove* recent land uplift.



TEXT-FIG. 1. Sketch-Map showing the Teviotdale-Waipara coast and lower Waipara Gorge.

On the coast immediately north of the Amberley strand-plain resistant conglomerates have delayed retrogradation, causing the pronounced salient shown on the accompanying map (Fig. 1). This salient would be even more prominent before the strand-plain was formed by the purely local accumulation of waste in the vicinity of the mouths of the Waipara and Kowai Rivers.

2. The Amberley Terrace.

This terrace represents the northern extremity of that great stream-planed surface known as the Canterbury Plain. Behind the topographic barrier through which the lower Waipara Gorge is cut it merges into the valley-lowland plain of Omihi. Between the Amberley township and the Teviotdale bridge its inner edge is about 160 feet above sea-level, and from this inner edge the Waipara Hills, i.e., the topographic barrier across the river, rise to a maximum height of 598 feet. Amberley township stands on this terrace at a height of 150 feet, and the terrace ends seaward in the cliff (Hurseley Terrace on the map) behind the strand-plain just described. When this Amberley Terrace is viewed as a whole from the summit of the Waipara Hills, it appears to have the form of a large and very gently sloping alluvial fan laid about the base of the hills, and overspread near its inner edge by secondary fans, the Seadown Homestead standing near the apex of a specially large one. A section showing the structure of the terrace is best displayed in the south bank of the Waipara River below the gorge. The relatively soft upper members of the local sequence of Tertiary beds have been very neatly bevelled, and a cover of loose sandy gravels and sandy clays spread over the planed surface. The angular to sub-angular nature of these superficial gravels and the complete absence of fossils suggest that these are entirely of fluvial origin.

Certain features of this terrace are of special interest. The inner edge as seen just above the Teviotdale Bridge is very thinly veneered with gravel, but farther up, near the entrance to the gorge, the cover disappears altogether, leaving a bare surface cut in the basement rock. This cut surface has a slope definitely steeper than the slope of the cut platform out on the seaward margin of the terrace. Out towards this seaward margin the thickness of the gravel cover increases to a total of well over 50 feet. In the immediate vicinity of the Waipara River the covering material is almost entirely composed of angular gravel. Elsewhere, especially near Leithfield, sections in the old sea-cliff show that the terrace is covered with a fine clay, either spread over the upper surface of the gravel or interbedded with it. Speight (1912, p. 222) suggested that this clay "resembles the loess of the south-eastern portion of the South Island." The present writer regards this clay merely as fine water-spread silt such as might be expected in an outer zone of deposition by a stream spreading over such a structure as the Amberley terrace. In the old sea-cliff just north of the Waipara River sections show a layer of well-rolled uniformly graded small greywacke pebbles resting directly on the surface of the cut platform. This looks like marine gravel, but it is overlain by more angular gravel and beds of sandy clay bearing no resemblance to beach material. Since the well-rolled gravel is often a characteristic deposit on the bevelled surface of a stream-planed bench, there is no single feature of the terrace which may be cited confidently as evidence of its being a wave-levelled form.

Therefore, the Amberley terrace may be regarded simply as an old surface over which the Waipara River used to flow on its emerg-

ence from a canyon cut across the Waipara Hills. All that has happened is that the river has become entrenched in this old surface, and this downcutting may not necessarily be connected in any way with the late land uplift. It is probably a direct result of the cutting back of the land by the sea to form the cliffs, from the base of which the beach-ridge foreland, i.e., the Amberley strand-plain, has but lately been built. The energy of the river is now directed to widening its channel and planing out a new surface below the level of that on which it formerly flowed, and its course has been extended across the beach-ridge foreland.

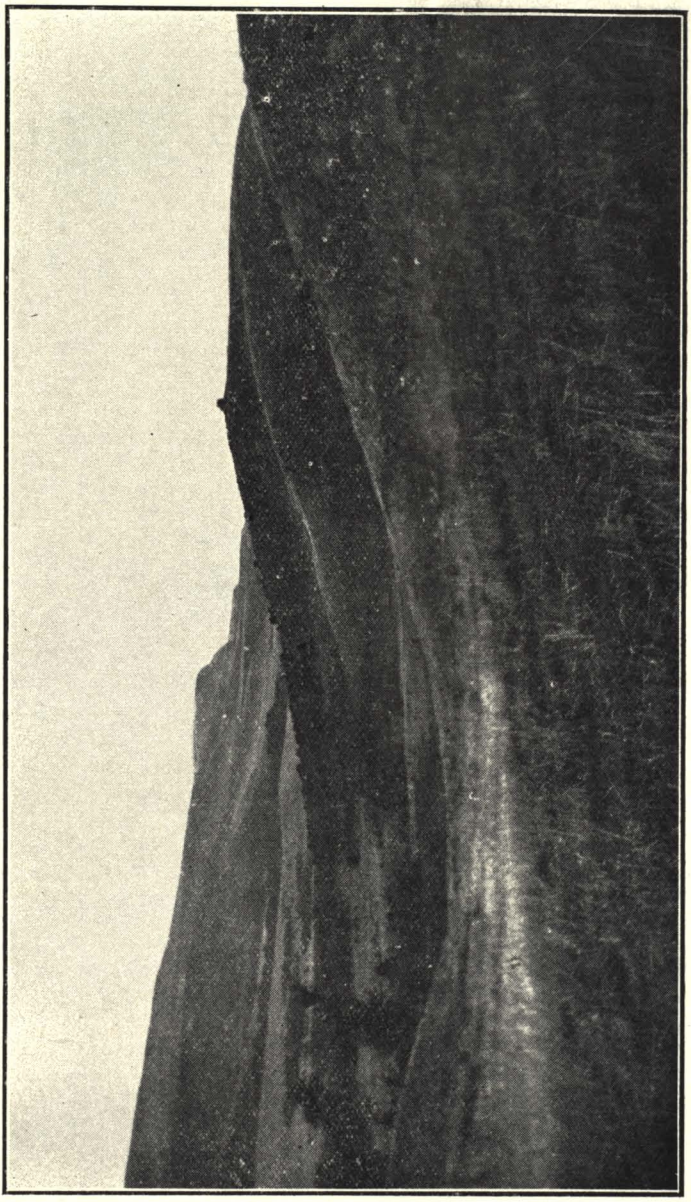
3. THE TEVIOTDALE TERRACE.

This terrace is of especial interest to the present paper, because explanation of its peculiar features involves examination of the mode of origin of the lower Waipara Gorge. The terrace extends across the summit of the Waipara Hills that form the topographic barrier through which the gorge is cut, and two alternative hypotheses may be advanced to account for it. The first hypothesis would demand that the Waipara River is antecedent to the topographic barrier, while the second would assume that the river is superimposed with respect to this barrier. The first has hitherto been generally accepted by recent writers on Canterbury physiography. The terrace is best developed on the north side of the Waipara River, extending from the gorge to the present shore, where it ends abruptly in a bold cliff about 300 feet high. It is a river-terrace standing at a considerably higher level than the Amberley terrace just described, and displays a slightly steeper downstream slope. When this surface slope is projected inland it is found to extend over the summit of the Waipara Hills, i.e., the topographic barrier that attains a maximum height of 598 feet in Seadown. Moreover, the cap of angular and sub-angular gravel may be traced from the summit of the sea-cliff to the summit of the Waipara Hills above the gorge. The terrace has, however, been partially destroyed by a small stream, in the upper valley of which the Teviotdale homestead stands. Inland, behind the barrier of the Waipara Hills, is a broad valley-lowland opening out southward on to the Amberley terrace described above.

To an observer viewing the present landscape from the interior lowland valley it would seem that a normal course for the river to have taken would have been around the end of the topographic barrier rather than across it by way of the deep, steep-walled gorge. Therefore, the possibility immediately presents itself that the river is antecedent to the barrier. This would imply that the Waipara Hills represent part of a differentially elevated crust-block or slab, raised as a barrier across the course of the stream. In this case a former stream-bed, represented by the Teviotdale terrace, would have been dislocated by a fault and raised to its present situation as part of the independently moving crust-block. Such a crust-block would be expected to acquire a more or less steep tilt in the process. The Teviotdale terrace, however, shows that no such tilting has taken

TEXT-FIG. 2. Sketch of lower Waipara Gorge from a point on the Teviotdale terrace on the north side of the river near the Teviotdale bridge. The sketch shows a portion of each of the three levels of stream-planation, viz., the Teviotdale terrace; the Amberley terrace (inner edge); and the wide bed now being planed out by the river. (Sketch by R. W. Hamlyn.)

place; its slope is only very slightly greater than that of the present bed of the river. Therefore, to preserve an hypothesis of differential upward movement of a crust-block to form a topographic barrier across the stream it would seem necessary to suppose the existence of two faults, one defining the general direction of the inland lowland valley, the other somewhere offshore parallel to the present coast. In these rather unlikely circumstances the barrier might conceivably have been raised to its present situation without greatly disturbing the slope of the Teviotdale terrace, which merely represents a portion of a former bed of the present river. There is, however, no evidence that any such faulting has occurred, except for the dislocation of the covering-beds connected with the formation of the big crust-block of the Mt. Cass Range. The steep face of this range, standing out boldly above the Omihi valley-lowland, has usually been described as a fault-scarp, but no actual fault-plane has been located or described. It is at least just as likely that the scarp is a fault-line scarp revealed by erosion of infaulted weak beds, and that the scarp has retreated a long way from the plane of the ancient fault. The hypothesis of a late differential movement of a crust-block across the course of the river is simple and attractive, but no single point can be cited as



A portion of the inner edge of the Teviotdale terrace where it is dissected by a small stream rising near the Teviotdale homestead. The terraces on the coast are th refore remnants of stream-planed forms. Downcutting by streams is probably due to retrogradation of the coast.

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evidence that such differential movement has lately taken place. Indeed, the character and situation of the Teviotdale terrace would be very difficult to explain on such an hypothesis.

Therefore, we may present an alternative hypothesis that this high-level terrace has merely been left in its present situation as the result of a process of normal erosion. On this hypothesis the Teviotdale terrace, extending across the summit of the Waipara Hills, is a fragment of an old stream-planed surface on which the river used to flow. The Amberley terrace also represents a stream-planed surface developed below an older one, just as the present bed of the Waipara River represents a still later initial stage of development of a new planed-surface at a lower level still.

There are terrace remnants about the south-eastern base of Mt. Grey, these terraces being neatly bevelled benches cut in gently inclined Tertiary limestones, mudstones, and thick gravel-beds, and capped with fluvial gravel. The possibility presents itself that some of these upper terraces, of undoubted fluvial origin, may be correlated with our Teviotdale terrace, all forming now discontinuous remnants of an old pediment planed out on the relatively soft beds lying in front of the hard rock upland of Mt. Grey. The Waipara River, one of the streams that would have flowed on this old surface and assisted in planing it out, would simply entrench itself and plane out a new surface represented by the present Amberley terrace. Then it has become entrenched in this surface in turn, and is now planing out a new surface at the level of its present bed. The Waipara Hills would therefore be merely a remnant of the old surface into which the Waipara River was entrenched. They would owe their preservation entirely to resistance offered to normal erosion by the relatively hard beds of which they are composed. With respect to the resulting topographic barrier the river would be superimposed in a very simple way. The Omihi valley-lowland would also be a normal result of the erosion thus pictured; it is a weak rock lowland valley developed by subsequent streams, of which the Omihi itself is the most important. In this valley-lowland the Waipara River and its subsequent tributaries are now all entrenched and a new cycle of planation initiated.

SUMMARY.

A sequence of events leading up to the development of the present landscape in the vicinity of the lower Waipara Gorge might be summarized briefly as follows:—

A process of upwarping was accompanied by faulting defining large crust-blocks. This would not be confined to Upper Pliocene or Pleistocene time, as writers on geomorphology have commonly supposed, but would belong to a considerably earlier period. Relief contrasts resulting therefrom would be obliterated, or partially obliterated, by stream-planation. Further uplift of a regional nature would be followed by progressive destruction of the planed surface, with the development of new surfaces at progressively lower levels, a remnant of one of these levels being the Teviotdale terrace. As destruction of the landmass proceeded, hard rock ridges would stand out with

increasing boldness above broad lowland valleys eroded on strips of relatively weak rocks. The Omihi valley-lowland would develop in this way, so that the Waipara River could be regarded as superimposed with respect to the topographic barrier which it crosses by its lower gorge.

The Amberley terrace is the northern extremity of the Canterbury Plain, and represents a surface planed out by streams. That portion of it which extends from the base of the Waipara Hills has the shape of a wide, gently-sloping fan, and is attributable to the Waipara River. A little to the south of it is a similar fan, for which the Kowai River may be regarded as responsible. Both the Waipara and Kowai Rivers have lately become deeply entrenched in the Amberley terrace, and they are widening their channels by lateral cutting. Development of a new planed surface at a lower level has thereby been initiated. The Amberley strand-plain may be regarded as a marine form. It is clearly a beach-ridge foreland built out from the base of an old sea-cliff, and there does not seem to be any necessity to invoke vertical shift of land level relative to the present sea-level to account for it fully.

Finally, it may be suggested that all the recent downcutting by streams into former land surfaces has been a direct result of the cutting back of the land by the sea. The Teviotdale terrace ends at the coast in a fresh cliff over 300 feet high. Evidently the sea has cut away the land to form this cliff, and this would let the river down into the surface on which it used to flow. In any case students of the geomorphology of New Zealand coasts should examine the whole matter of the possible connection between retrogradation and the entrenchment of streams. Many such features usually attributed to vertical uplift of the land may be due to other causes altogether.

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