The single example of *D. caduceus* is the large form which in Victoria is not found associated with *D. bifidus*, but occurs in higher beds. It has, I think, been included by mistake. *D. bifidus* is very common, and juvenile and well-grown specimens occur. *Tetragraptus serra* agrees with the figures of the form which J. Hall refers to Brongniart's species, and which has been renamed by Miss Elles and Miss Woods *T. amii*. *T. harti* resembles *T. quadribrachiatus* J. Hall, but has only one theca in the primary branch, and is much more slender. The sicula is well shown in the two examples present. *Phyllograptus* cf. *typus* comprises several specimens of lanceolate forms of various sizes.

AGE OF THE BEDS.

Judging by the Victorian standards, and eliminating the two specimens that I regard as intruders, the beds may be arranged in the order given above. They represent the middle and lower series of the Castlemainian. The Bendigonian, characterized by *Tetragraptus fruticosus*, is with us usually only a few feet below the beds corresponding with those of Butcher's Gully, and it would be of interest to see whether this series is not represented in the locality which has yielded the present series of fossils. The presence of Lancefieldian has been proved at Preservation, as shown by a previous paper to the Institute.

For convenience, the Victorian divisions of the Ordovician are here given, especially as a recent work on geology coming from a faulty source gives them wrongly :—

Upper Ordovician.

Lower Ordovician { Darriwillian. / Castlemainian. / Bendigonian. / Lancefieldian.

ART. XLVI.—*Notes on the Soils of the Wairau Plain, Marlborough.*

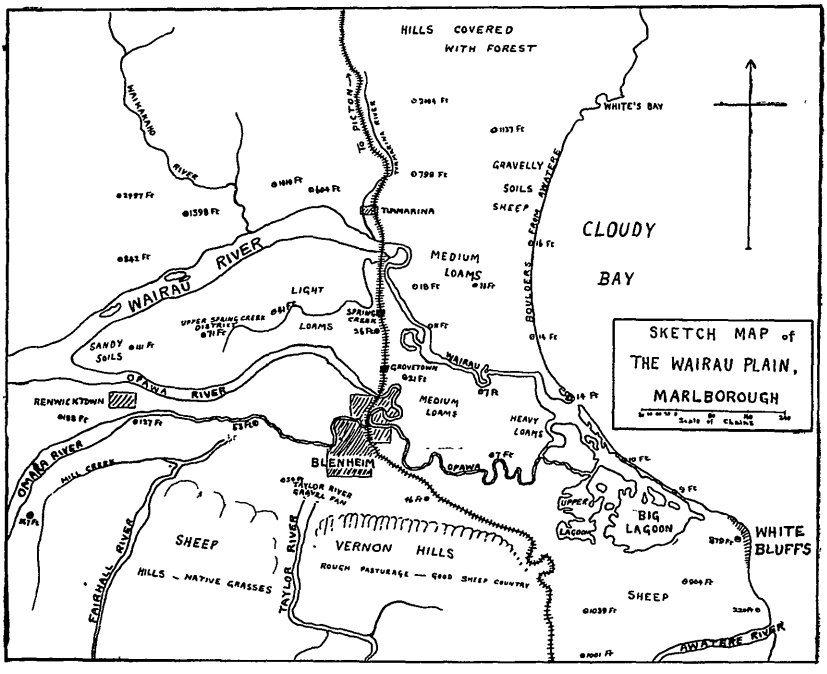
By LEONARD J. WILD, M.A., F.G.S.

[*Read before the Wanganui Philosophical Society, 26th October, 1914.*]

THE district herein described is about 60,000 acres in extent, and includes some of the richest alluvial soils in the Dominion. The Wairau Plain probably owes its formation to the filling-up of a lagoon by the sediments brought down by the Wairau River. There is no doubt that at a geologically recent period this district was at a lower level than it is at present, and what is now a fertile plain was then an arm of the sea extending up the valley for twelve or fourteen miles from the present coast-line. The neighbouring Awatere Valley was also at a lower level, but was nevertheless a land surface, and the Awatere River discharged large quantities of sediment into the sea. A portion of this material, the heavier gravels deposited near the shore, was gradually drifted up the coast, across the mouth of the Wairau arm, and piled up against the cliffs at Cloudy Bay, thus enclosing a lagoon. In this lagoon the sediments of the Wairau River and its present tributaries have been deposited, and even yet the process of filling in is not completed, for in the south-east corner of the district there still remains a portion some

thousand acres in extent, most of it permanently under water, and separated from the sea by a narrow boulder-bank 8 ft. to 16 ft. above sea-level. All the material in this boulder-bank is from the Awatere River, and includes large quantities of the volcanic rocks brought down by the tributaries from the dykes in the Kaikoura Mountains described by McKay, and more recently by Thomson.* The Wairau River, indeed, has not yet carried any gravel to the sea, the limit to which it has so far carried any being just below the railway bridge, which is several miles from the shore-line.

The rivers that cross the plain afford further evidence as to the manner of its formation. The largest, the Wairau, meanders over a wide stretch of country, and provides two very fine examples of an ox-bow curve and one of an ox-bow cut-off. The first curve occurs a little below the point where the Blenheim–Picton Railway line crosses the river, the cut-off is about a mile and a half lower down the river, and the other curve is



about a mile and a half lower down again. The next-largest river, and the most important, in that it makes the Town of Blenheim accessible to small steamers, is the Opawa. This is a distributary of the Wairau, and the two enclose the greater part of the delta formed when the Wairau entered the still waters of the lagoon. The Opawa is a perfect example of a meandering river. The shortest course possible to it from Blenheim to the point where it rejoins the Wairau near the sea is four miles and a half long; the actual course taken by the river in its windings between these two points is over nine miles and a half in length.

These and other facts contribute to an understanding of the geological history of the area. The whole plain is a flat surface slightly tilted towards

* Trans., N.Z. Inst., vol. 45, 1913, p. 308.

the sea. Until the early settlers had considerably increased by artificial means the height of the natural levées bordering the rivers the whole district was subject to periodical floods. Even yet the district is not immune: in December, 1914, a large area was inundated by a Wairau flood, and hundreds of pounds' worth of crops just ready for harvesting were destroyed. Indirectly the floods are useful, for they are active agents in renewing the soil and in building up the plain. Cases have been brought to the notice of the writer of fences built by the settlers of fifty or sixty years ago which are now completely buried by the flood-deposits of less than half a century.

We now have the key to the nature of the soils. Examination in the field and mechanical analysis in the laboratory show that all grades are represented, from gravelly and sandy soils in the inner area to fine-grained silts near the coast. If grouped according to their physical properties, the soils fall roughly into bands parallel to the present coast-line, but there are two notable exceptions to this arrangement. One is the alluvial fan of the Taylor River south of Blenheim, some hundreds of acres in extent. The soil here is gravelly, yet very fertile, and has proved itself capable of maintaining excellent lucerne-fields, and this is no doubt largely due to the excellent drainage and water-supply provided by the widely spreading underground channels of the Taylor River, and to the fact that the area lies well to the sun. The other exceptional area is in the north-east corner of the district, where the band of gravel from the Awatere River already referred to is much wider, as, indeed, it would be expected to be from geological considerations. Here the soils are extremely gravelly, and ploughing has not yet been attempted, but sheep do very well there.

Chemical analyses show that the soils are well stocked with plant-food in an available form, and this is in accord with the remarkable crops they bear. Large yields of excellent malting barley are still obtained, though the yields are not now equal to those obtained by the last generation of farmers. This is generally ascribed to continuous cropping without manures; thorough cultivation is the usual preparation for the crop, and the traditional practice is to "plough three times." The most important crops taken at the present time are oats, barley, peas, clover, lucerne, and such forage crops as rape, mangels, maize, &c., together with a small area of potatoes. The area devoted to roots is necessarily restricted by the scarcity and expense of labour. The fertilizer most commonly used is superphosphate, which even on clovers gives better results than basic slag, notwithstanding that there is not an excess of lime in the soil. The superiority of superphosphate is probably due to its stimulation of root-growth, for the district is one of low rainfall. Nitrogenous and potash manures have been found to produce no appreciable effect.

The Wairau Plain is widely and favourably known for the production of seed of great vitality and high germination-capacity. Thousands of bushels of garden peas are annually exported for seed, and the lucerne seed that gives best results in New Zealand is that grown in Marlborough. A considerable quantity of red clover and cowgrass seed of excellent quality is also harvested, and small areas are given up for the raising of mangel, carrot, and flower seeds. Seed-raising is for the most part done on the contract system, the farmer supplying the land and labour, and the other party, usually one of the large seed-merchants, providing the seed and taking over the produce at a specified price.

Soil-analyses.

Chemical.

No.	Phosphoric Anhydride (P_2O_5).		Dipotassic Oxide (K_2O).		Nitrogen.
	Citric-acid Extract.	HCl Extract.	Citric-acid Extract.	HCl Extract.	
1	0·1050	0·2090	0·093	0·323	0·290
2 .. .	0·0370	0·1540	0·064	0·470	0·191
3	0·0358	0·1930	0·046	0·426	0·114
4	0·0810	0·1613	0·044	0·415	0·281
5	0·0990	0·1660	0·072	0·515	0·272
6	0·0970	0·1620	0·036	0·340	0·300

Mechanical.

No.	Moisture.	Loss on Ignition.	Clay.	Fine Silt.	Silt.	Fine Sand.	Coarse Sand.	Gravel.
1	2·10	7·90	12·7	45·4	18·2	12·4	1·70	..
2	1·90	4·50	1·7	24·3	25·3	23·0	11·70	7·26
3	2·15	5·78	4·6	29·2	25·5	28·0	5·70	..
4	1·85	3·85	10·8	20·2	23·7	35·5	5·30	..
5	3·12	6·80	5·7	31·4	31·2	17·8	4·35	..
6	2·00	4·13	9·8	24·1	26·3	23·6	10·10	..

Reference.

1. At confluence of Wairau and Opawa Rivers.
2. From Renwicktown.
3. From Blenheim.
4. From Spring Creek, east of railway-line.
5. From Upper Spring Creek.
6. From Upper Spring Creek, west of No. 5.

These analyses were made by the conventional methods of British agricultural chemists. The nitrogen determinations were made by Kjeldahl's method, and the mechanical analyses by the sedimentation process.