

here; and not only in New Zealand, but on the shores of the Commonwealth of Australia. It has been shown that the secular movements are so quiet and slow as to produce no appreciable alteration from day to day or year to year. They often require a lapse of several generations to be capable of proof by careful measurement; hence the sooner the marks are erected the earlier will the data be available in the future.

The proofs of upheaval and subsidence are sometimes obtainable over wide continental areas, but generally are marked by a local and variable character; hence, marks should be erected on the shores of all our harbours, on the headlands and outlying projections of land. The work has a high scientific and economic importance, and would naturally fall to the State Department of Lands and Surveys. It could, perhaps, be most conveniently carried on simultaneously with the magnetic survey of the colony now in progress. The marking of the coasts of Australia should be undertaken by the Federal Government, so as to obtain uniformity in the method of determining a mean sea-level datum. Up till now no serious attempt has yet been made to determine the relation of sea-level to the land in New Zealand on a scientific basis, and for this reason the marking of the coast-line with stones, whose position has been accurately determined with respect to sea-level, would further supply a much-needed datum of verification for the officers of the Lands and Survey Department for their more exact geodetic and hydrographical surveys.

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ART. XLIII.—*Notes on some Glacier Moraines in the Leith Valley, Dunedin.*

By Professor JAMES PARK, F.G.S., Director, Otago University School of Mines.

[Read before the Otago Institute, 12th November, 1901.]

Plates XXVII.—XXVIII.

THE glaciers of New Zealand are reputed to be the largest in existence outside the polar regions, with perhaps the exception of some in the higher Himalayas. They are found clinging to both flanks of the "main divide" of the South Island, their greatest development being within the Province of Canterbury. On the West Coast they descend to within 750 ft. of sea-level, into the midst of the evergreen forest. On the east side, where the slope is more gradual and the

annual precipitation less, the terminal face of the glacier ice is seldom found below 2,500 ft.

An examination of the present physical features of the country affords abundant evidence that the present glaciers are but mere remnants of ice-masses that once covered hundreds of square miles, in many places reaching even to the sea.

In Nelson we have the great tumbled moraines blocking the lower ends of Lakes Rotoroa and Rotoiti; in Canterbury, the marvellous ice-cut terraces on the mountains north of Lake Ohau, and the well-preserved terminal moraines on the plains south of the same lake; and, in Otago, the strikingly beautiful rounded or billowy ice-worn foot-hills of the Matukituki, in the Upper Wanaka, the gigantic moraine blocking the old outlet of Lake Wakatipu at Kingston, and the great ice-shorn plateau of Central Otago, through which the Taieri has cut its narrow tortuous course.

Naturally enough, the most abundant and most obvious evidences of former glaciation are to be found in the vicinity of the present-day glaciers, on the ground the glaciers have passed over twice, once in advancing and once in retreating.

On the other hand, there is nothing to show that New Zealand ever experienced a glacial period corresponding to the Ice Age of the Northern Hemisphere. The evidences of glacier action just mentioned show clearly enough that ice-masses of huge size must have occupied a very large portion of southern Otago and Southland in Pliocene or Pleistocene times; and it seems equally clear that an extension of the present glaciers seaward would explain the origin and source of these ice-masses.

Up to the present time no traces of glaciation have been found in the North Island. The continuous and widespread series of older and newer Pliocene strata in the Wanganui, Wellington, and Hawke's Bay districts, with their rich assemblage of marine forms, proves the existence of long-continued sedimentation in shallow seas, teeming with life, at a period when the great ice-plough was scooping out the valleys of Otago. The circumstance that probably 98 per cent. of this varied fauna is represented by living forms shows that the climate in Pliocene times was neither warmer nor colder than at present.

I do not propose to minutely discuss the causes which led to the refrigeration necessary to permit the great extension of the glaciers of Otago in Pliocene times. This subject has already been exhaustively dealt with by Sir James Hector, Captain Hutton, and others. It will be sufficient to state that the former believed, as the result of his explorations among the West Coast Sounds of Otago in 1863, that an

elevation of 2,000 ft., together with the greater extent of land then existing, but since removed by ice erosion, would be sufficient to extend the glaciers to their former limits.

I will now proceed to describe some morainic mounds which I discovered last June in the Leith Valley, near the foot of Waikari. These moraines are situated near the top of the ridge separating the Leith Valley and Ross's Creek, which flows into the city reservoir. They extend from the saddle between the Leith Valley and Ross's Creek southward, running parallel with the Leith Valley and terminating in Mr. Henry Skey's farm, Section No. 74, at a point nearly due north of the upper reservoir. Although near the top of the ridge, they lie on the fall into the Leith. There are two lines of mounds parallel to each other. The upper mound, about 500 ft. above the sea, begins inside Mr. Skey's boundary, crosses the road, and runs in a west-north-west to east-south-east direction for about 5 chains, gradually increasing in height towards the saddle until it suddenly ends in a pile of andesitic rocks. At a point about half its length it is 8 ft. high, presenting a steep face to the south and a long gentle slope to the Leith Valley. Numerous tree-stumps and clumps of native forest around the saddle indicate that the whole ridge was at one time covered with forest. At the present time a rimu (*Dacrydium cupressinum*), 4 ft. in circumference and 50 ft. high, is growing in the depression of the lower mound. The lower mound resembles a line of massive earthwork constructed for defensive purposes. It is cut through by a road, and is seen to be composed, at that point, of fragments of rotten rock now forming compact yellow clays. The composition of this mound is also seen in a recent cutting, 10 ft. long and 4 ft. deep, near its western end and on its lower slope, which exposes a confused mass of andesitic rocks and clay. The rocks are mostly angular, tabular in form, and often of enormous size. The pile of tumbled rocks at the western end of the upper morainic mound was evidently exposed by the removal of the associated clays by recent denudation.

The high-level terraces in the valley of the Leith and the alluvia west of the saddle would tend to show that the Leith, before the excavation of the present rocky gorge, flowed across Ross's Saddle to the back of Maori Hill, and thence westward in the direction of the present Kaikorai Valley. The present deep narrow valley of the Leith, with its precipitous rocky sides, was obviously excavated in comparatively recent times.

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## EXPLANATION OF PLATES XXVII.—XXVIII.

## PLATE XXVII.

View of southern end of lower moraine looking north-west.

## PLATE XXVIII.

View taken in depression between the upper and lower mounds, looking along the depression in a west-north-west direction.

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ART. XLIII.—*On the Septarian Boulders of Moeraki, Otago.*

By A. HAMILTON.

[*Read before the Otago Institute, 12th November, 1901.*]

Plates XXIX—XXXV.

IN the year 1848 Mr. Walter Mantell, as Government Commissioner for the Settlement of Native Land Claims in the South Island, travelled on foot from Kaiapoi to the southern settlements of Otago. An interesting summary of his notes by the way was published by his father, Gideon Algernon Mantell, in the "Proceedings of the Geological Society" for the year 1850 (vol. vi., p. 319).\* On page 320 in that publication is a sketch-map of the geology of the coast-line so far as could be gathered from his daily observations and from information obtained from the natives, who at that time were fairly numerous. Names of rivers and coastal features are given from Kaiapoi to the Molyneux River. On reaching what he calls Onekakara Bay he gives a sketch taken a little south of Hampden, looking to the north, including the coastal features as far as the "White Bluff," and in the foreground is "a group of septarian boulders, called by the whalers 'The Ninepins.'"

Mr. Mantell says, "Midway between the bluff and Moeraki the clay contains layers of septaria varying from 1 ft. to 5 ft. and more in diameter. Hundreds of these nodules, which had been washed out of the undermined clay cliffs by the encroachment of the sea, were scattered along the beach. Some were subglobular, others spherical, many were entire, whilst others were broken and glittered with yellow

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\* "Notice of the Remains of the *Dinornis* and other Birds, and of Forest and Rock Specimens recently collected by Mr. Walter Mantell in the Middle Island of New Zealand, with Additional Notes on the Northern Island, by Gideon Algernon Mantell, Esq., LL.D., F.R.S., G.S., &c. With Note on Fossiliferous Deposits in the Middle Island of New Zealand, by Professor E. Forbes, F.R.S., &c."