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JOURNAL OF

THE TRANSACTIONS

OF

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OR,

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1908.

ORDINARY GENERAL MEETING.

WAS HELD IN THE ROOMS OF THE INSTITUTE, ON MONDAY, FEBRUARY 3RD, 1908.

LIEUT.-COLONEL MACKINLAY, IN THE CHAIR.

The Minutes of the previous Meeting were read and confirmed.

ELECTION :—Rev. G. T. Manley, M.A. (Camb.), was elected Associate.

The following paper was then read by the Secretary in the absence of the author :—

ON THE GLACIERS, PAST AND PRESENT, IN THE SOUTH ISLAND OF NEW ZEALAND, TOGETHER WITH THE GREAT VERTICAL MOVEMENTS OF THE GROUND. By C. DILLWORTH FOX, Esq. (Associate Member).

THE South Island of New Zealand presents to even the uninstructed eye, the eye of the merely casual observer, many interesting problems; one of the most interesting being that, in a climate quite as warm as the extreme South of England, there is a glacier system superior to any of the others in temperate climes; that though the mountains are much lower than those in Central Europe (Mount Cook, the highest peak of the range being 12,345 feet high), the ice-work required to ascend them is much greater than in Switzerland, even though the sea, with its warmth and equable temperature, almost washes the foot of the range on the west.

To those specially interested in glacial action, there are many points worthy of observation, for here can be studied, as nowhere else in temperate climates, such great ice-filled valleys nearly level, receiving on both sides secondary glaciers equal in size to the largest Swiss. According to Von Lendenfeld, the Tasman Glacier has a fall of less than 1,400 mètres in 20 miles of actual length, and the lower portion from the foot of Mount De la Bèche 650 mètres in 12 miles. Here, too, can be observed the effects of prehistoric glaciation, which was on a vast scale, and is apparently more modern, or, at any rate, more strongly marked and more easily distinguishable than the European.

Now, to our tourist, the road to Mount Cook has many points of interest. When he arrives at Lyttelton, the port of Christchurch, he finds himself in the crater of a gigantic extinct volcano, through the side of which a tunnel has been made—a notable undertaking in the early days of the Colony. On emerging he sees before him a vast alluvial plain, the great Canterbury Plains, celebrated nowadays for mutton and lamb (frozen). Arrived at Timaru, a pretty seaport in the downs at the southern extremity of the plains, he turns inland, and after following a river and its gorge for 30 miles, goes over a low saddle into a valley that has been "closed" by the elevation of the land on the east—a phenomenon quite common on this side of the island—and arrives at Fairlie, the terminus of the railway westwards. From Fairlie you coach or motor the remaining 95 miles, first following the river in its windings through the folds of the hills, and go over Burke's Pass into the Mackenzie Country, a plain of considerable extent, from 1,000 to 2,000 feet above sea level, surrounded entirely by the ranges which form the watershed of the great Waitaki River, very barren, and covered with water-worn shingle. In this plain the three great lakes—Tekapo, Pukaki and Ohau—are situated all of which present the same features in that they are all of great depth, and are blocked by a vast morainic deposit consisting of great boulders, from the size of a large hay-stack downwards, embedded in a cream-coloured clay which is eagerly licked by all kinds of stock, and through which the rivers from the lakes have cut their way. You get your first glimpse of the big peaks when nearing Lake Tekapo, but from the foot of Lake Pukaki, 20 miles further on, there is a marvellous panoramic view of the great main range 40 to 60 miles distant. All the way thence to the Hermitage—a comfortable hotel nestling under the southern lateral moraine of the Mueller Glacier, just between Mount Cook and Mount Sefton—the glorious view is unfolding and expanding with every turn of the road. You follow at first the lake, then close under the Ben Ohau Range and Mount Sealey, crossing *en route* innumerable shingle fans, and getting glimpses of blue ice high up on the left. Right in front towering the tent-like peak of Mount Cook, with Mount Stokes and Mount Tasman on either hand; then Mount Haidinger with its square top, and the three-peaked Mount De la Bèche at the turn of the Tasman Glacier; to the right Malte Brun, with its red rock precipices and great ice fields, and the shingle slips of the Nun's Veil (known locally as Rotten Tommy) complete the view. From the turn of the road westwards, after passing Birch Hill sheep station, you face Mount Sefton, with its great overhanging glaciers, which keep up a thundering of avalanches day and night, and the view from the front door of the "Hermitage" of Mount Sefton reflected in the little lake is a sight never to be forgotten.

Your first trip is naturally to the Mueller Glacier close by, and your first remark is on the shockingly dirty state of the glacier, for no clear ice is to be seen for some miles above its snout, it is so entirely covered with *débris*. At the mouth, however, you see that is on the surface only; that, though such a vast quantity of moraine is carried on its back little or none is to be seen in its heart;—it does not bring along underneath it the "digging tools" one reads about.* This glacier, of all the larger glaciers on the eastern side, would be the one that might be expected to excavate; because it descends at a fairly steep angle, perhaps eighteen to twenty degrees; whereas the Tasman never in its lower portion exceeds five degrees. But the river at the mouth of the Mueller flows out quietly and without any special rush, while, on the other hand, the Tasman River generally bursts up with considerable violence, sometimes to a height of as much as 15 feet, from the pressure of the superincumbent ice. (Not many years ago I can remember when the Mueller Glacier had pushed its ice completely across the valley, and butted right into the spur of Mount Cook, and the Hooker River, which now just washes at the foot of the ice cliffs, flowed right under it.) The Tasman Glacier is also completely covered with *débris* at its lower end, and it is some 3 miles up before you can find a crevasse to sound. The depth confirms what you have surmised, that the bottom of the glacier is much below the level of the river at its source; but this is no evidence of digging, the simple

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* By "digging tools" the author doubtless means angular blocks and stones which by scoring the bed-rock leave behind grooves and hollows commonly seen where the ice has been moving.—ED.

explanation being that the matter carried down by the glacier is so enormous as completely to fill up the bottom of the Tasman Valley as the glacier slowly retreats, which can plainly be seen by the successive heaps of terminal moraine all down the valley. The *débris* brought down by the Mueller Glacier is immediately washed away by the Hooker River; there is no room in this valley for its deposition.

In the ice age, or glacial period, of New Zealand, which is placed by Capt. Hutton in the older Pliocene, this glacier with its tributaries, the Hooker and Mueller, combined on the west, and the Murchison and Jollie on the east, was over 40 miles longer than it is at present, and its terminus was at the southern end of Lake Pukaki. All down the sides of the Valley of the Tasman you can see the lateral moraines in several series, the largest and highest being quite 200 feet above the present level of the lake; while the great terminal moraine, though perhaps not quite so high as that at Tekapo, represents a far greater accumulation, for the Pukaki Lake is much the deeper. Now this is exactly the same phenomenon on a larger scale presented by the present terminus of the glacier—a hole blocked with morainic deposit brought forward by the glacier and dropped at the snout. Nor is there here any rock-basin; nothing but the considerable slope of the Mackenzie Plains to the gorge of the Waitaki 14 miles distant, where the three rivers, Tekapo, Pukaki and Ohau, unite. Now I understand that this great hole, the Pukaki Lake, does not show a depth below the level of the rock bottom of the Waitaki; and were it so, though the weight of the ice must have been enormous, and far above computation, still I think it open to question whether ice descending at such a small angle (not more than one degree from the *névé* even were the mountains double their present height) could have possibly dug these great holes, supposing the ice to be armed with the so-called "digging tools," which I maintain are non-existent, or at any rate extremely problematical.

Now Mr. Alexander McKay, F.G.S., Geologist to the New Zealand Government, firmly maintains that, in New Zealand at least, these lake basins are due not to the digging power of ice, but to great earth movements. This South Island is crossed by three great geological faults. In the north-east of the island are the great Kaikouras nearly 10,000 feet high, separated into two ranges by the cleft through which the Clarence River runs. Here one can plainly trace two great faults, one on each side of the mountains, one up the River Awatere, and the other up the gorge of the Clarence, while a third minor fault goes from the mouth of the Clarence on the south side of the range in the direction of the Hanmer River. These can clearly be followed for many miles, both by surface indications of displacement—miles of tumbled earth in a straight line—which in recent times have marked the "road of the earthquakes," and also by the numerous geological sections to be obtained along the course of the various small rivers draining from the mountains, which show that enormous vertical displacement has taken place. Mr. McKay thinks the whole mass of the Kaikouras was raised to the present height from a moderately elevated plateau since the commencement of Pliocene times; and points out that the general direction of the northernmost of these two faults (they apparently cross at Hanmer Plains where are hot springs, and where the seismic disturbances were at their worst a few years ago) would touch the curious succession of glacial lakes all following one another in a direct line—Sumner, Pearson, Coleridge, Tekapo, Pukaki, Ohau, Hawea, Wanaka, Wakatipu. The country has not as yet been geologically surveyed in detail, except in portions, but traces of the fault have been recognised in many places. Those who have gone overland from Christchurch to Hokitika will doubtless remember the great mass of Mount Torlesse which has been pushed up through the white limestone rocks at Castle Hill. Further south, the fault may be seen crossing the Rangitata at Mesopotamia, and following Forrest Creek to Fox Peak in the Two Thumbs Range. On Simons Hill, south-east of Lake Pukaki, the glacial clay is found 500 feet and more above the plain, as shown by the sheep licks—I mentioned before how fond stock are of this clay, said to contain some form of magnesium—then again at the Ohau, in the elevation of Ben More, and perhaps between Ben Lomond and the Remarkables at Queenstown on Lake Wakatipu.

The third great fault in this island runs nearly north and south from Te Wae Wae Bay in the south west, following the course of the Waiau River, through the length of Lake Te Anau, and down Lake McKerrow to Martin's Bay (Hutton). The whole country to the west of this line is a tangled mass of mountains, so steep and broken as to be very difficult of access, and is densely covered with vegetation, owing doubtless to the excessive rainfall, which averages an inch a day at Puysegur Point. The soundings in Lakes Te Anau and Manapouri show them to be of great depth; while the well-known West Coast Sounds, which have been so graphically described by

Mr. Maclaren in *Vict. Inst. Trans.*, vol. xxxiv, present similar features. This is the oldest geological formation in New Zealand, and is exceptionally rich in minerals. Little, however, has been done to exploit it, except in the case of gold, of which a considerable quantity is now being obtained. There is every reason to believe that all this broken country was once at a much higher elevation (Bell), that the Sounds are simply drowned river valleys, and though they were in the ice-age filled with glaciers, as shown by the smoothings on the rock sides, and by the bar at the mouth of each—due primarily to moraine deposit, not tidal action—it may yet be shown that even in this case the valley is continued out to sea, as is the case in the similar Norwegian fjords. Further north there are several lakes—Lakes McKerow, Mapourika, Kanieri and others—which have terminal moraines and great depth, so that here is a parallelism going far to corroborate the opinions of Mr. McKay, the late Captain Hutton, F.G.S., and Mr. J. McBell of the Department Mines, N.Z., that this closure of the sunken river valleys is mainly due to the deposition of morainic *débris*.

In conclusion, I only venture to suggest that other causes than the excavating power of glaciers may account for the great depths in lakes and fjords, as it is well known that there have been great earth movements in time past. Neither the Kaikouras nor the Spencer Mountains in the north, both ranges close on 10,000 feet, show any sign of glacial action (Hutton)—evidence that they have been uplifted since the glacial period—and since that time there has been a period of great subsidence and denudation followed by a general uplift, which apparently still continues, at least on the east coast; I could instance many closed valleys caused by the rising of the coast line. At Amuri Bluff, 100 miles north of Christchurch, there is a terrace with modern sea shells 500 feet above high water mark (McKay); at Motunau, 50 miles north, a raised beach with similar shells 150 feet above the sea (Hutton). A deposit of silt occurs on Banks' Peninsula to a height of 800 feet (Hutton); and there is every reason to believe that Captain Cook sailed inside Banks' Peninsula, *i.e.*, over the present site of Christchurch; and, either from the deposition of shingle and other matter brought down by the great rivers—as some maintain—or from the gradual uplifting of the eastern side of the Island, there is no doubt that within the period of my observation (the last thirty-five years), the high water mark on the Canterbury coast has markedly receded.

On the motion of the SECRETARY, the thanks of the Society were accorded to the author for his interesting communication, and also to the High Commissioner for New Zealand for the loan of the lantern slides by which the paper was illustrated. The evidences adduced of enormous vertical movements of the land in recent times were of a most striking character, especially those of the Kaikouras and Spencer Mountains.

NOTE ON MR. C. DILLWORTH FOX'S PAPER, BY REV. A. IRVING, D.Sc.

In a paper full of original observations Mr. Fox has made a useful contribution to the science of Glaciation as a subordinate branch of the larger science of Geology. He notes the downward extension of the glaciers of South Island as something abnormal. May not the explanation be found in the proximity of the feeding-ground of the high altitudes (the regions of snowfield and *névé*) to the ocean, and the extraordinary amount of precipitation over that area as indicated by the excessive rainfall noted by him (p. 108) at Puysegur Point, averaging an inch per day? This, with the more rapid downward movement of the New Zealand glaciers (owing probably to their "dirtiness" as noted long ago by Dr. Hector) accounts for what appears at first sight an anomaly. The causes being differently proportioned in Nature, the *quantitative results* differ from those with which we are acquainted in the Alps and other European glaciated regions.

The most interesting point of Mr. Fox's observations is the extent to which they tend inferentially to negative the idea that glaciers have a digging or excavating power. Many geologists have fallen into this error owing to their incomplete conception of the *differential movement of glaciers.* (See A. Irving, on "The Mechanics of Glaciers," *Quart. Jour. Geol. Society*, February, 1883; with a supplementary paper on "Solar Radiation and Glacier Motion," by the same, in *Nature*, vol. xxvii, April 12th, 1883; and a criticism of Nansen, *Ibid.*, vol. xliii, p. 541.)

Mr. Fox's observations on the damming-up of valleys by glacial and other detritus also go to confirm what I have observed and written in former years (see A. Irving, on "The Origin of Valley-Lakes," *Quart. Jour. Geol. Society*, *loc. supra cit.*, supplemented by a summary of Heim's monograph on "Bergstürze," *Geol. Mag.*, March, 1883). Two marked instances of this, from my own Alpine observations, may here be cited: (i) that of the Rosegg in the Engadine, where the retreating glacier at the head of the Rosegg Thal has left exposed the gravel-strewn bed of the quondam intra-morainic lake, as the overflow of that lake has sawn its way down, so as to cut a gorge of 300 to 400 feet deep through the terminal moraine, since Quaternary times; (ii) the case of the Achensee in the Tyrol, where the present lake occupies a faulted valley to a depth of over 2,000 feet, the drainage having been reversed during the Quaternary Period, by the damming-up with glacial detritus of the ancient valley at Maurach, cutting off the waters from the Gorge of Jenbach and the Innthal, and diverting their flow to the north by the Achenthal into the Isar. Such damming-up on a grand scale was described years ago by Professor J. W. Spencer, as the origin of the Niagara overflow from Lake Erie, and was known to the German geologists as the true cause of the overflow of the Bodensee at the Falls of Schaffhausen.

In the face of such evidence and of further facts and reasonings contained in my paper, "On the Work of Glaciers," which appeared in *Natural Science* some sixteen years ago, one may be justified in accepting Mr. Fox's conclusions as sound to Science, and in demurring to the proposition, that the late Sir Andrew Ramsay's theory "has not been seriously undermined," as has been recently asserted in a paper entitled "Ice or Water?" read before the Victoria Institute last year.