nature of the surface motion at an earthquake observatory. But this of itself tells us nothing of the speed and direction of transit of the disturbance, particulars which are only to be learnt by connected observations made at several stations. Any one earthquake, as a whole, lasts far too long and begins too gradually to admit of the measurement of time-intervals between its arrival at different points, but if we can identify any single vibration in the records given at several stations—spread over a moderate area, and connected telegraphically with each other—the problem admits of a fairly easy solution. A recording seismograph at each station will give a complete record of the earthquake as it appears there, and if, during its progress, time signals be sent from one station and marked on all the revolving plates, it will be possible to

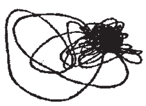

FIG. 10.

determine the differences in time of arrival of *the same phase of the same wave* at the successive stations in the group. From this, if the stations be sufficiently numerous, the speed and direction of transit, and even the origin of the disturbance, may be found with more or less precision. But all this depends on our being able to recognise at the various stations some one wave out of the complex records deposited at each, and, especially in view of the curvilinear nature of the motion, it would be hazardous to say without trial whether this can be done. To ascertain whether it can be done, and if so to organise groups of connected stations to carry out the scheme roughly sketched above, should be the next step in observational seismology.

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NOTES ON A FEW OF THE GLACIERS IN THE MAIN STRAIT OF MAGELLAN MADE DURING THE SUMMERS OF 1882-83 IN H.M.S. "SYLVIA"

THE western part of the main Strait of Magellan, to which my remarks are confined, lies between rugged and abrupt mountains, of rock mainly crystalline, but in parts of slate.

The highest peaks are not over 4500 feet high, and the height of the snow-line is about 2700 feet. The land is cut up into small areas by numerous and tortuous channels, and, on the southern side certainly, no large masses of land exist. The mountain ridges are mostly sharp and steep, and afford but little area for snow to lie in quantities, but wherever a mountain slope is moderate, there it accumulates, and forms *névé*, which may or may not descend to lower levels.

From this it will be seen that the glaciers spoken of are small, only one snow-field, the "Northbrook," being of any size. Much larger glaciers of course exist in these regions, but were not in my beat, lying either to the south about Mount Darwin and Mount Sarmiento, 7000 feet high, or to the north on the mainland bordering the western channels.

Some ice-masses are ridiculously small, one I remarked, at the end of summer, on a ledge a little below a very sharp ridge 2700 feet high, was not probably larger than 10,000 tons. It lay entirely bare of snow on the southern or shady side of the ridge, and was of blue ice.

It is evident that it is the enormous amount of the supply of material which accounts for the existence of glaciers from such small origins, and in fact the deposition of snow is going on all the year round for the majority of hours out of the twenty-four. The winds are eternally from the western quarter, are usually fresh, and, arriving moist from the Pacific against the rampart of mountains, rush up their western slopes into the colder regions, where constant condensation takes place. During my stay—about eight months—the summits of the higher snow-fields (3500 to 4500 feet) were only seen twice or thrice, so continually are the mists around them.

The daily duration of rain at the water-level during the *Sylvia's* stay of about eight months west of Cape Froward was eleven hours out of every twenty-four. The quantity corresponded to a yearly fall of 180 inches.

Though the mean temperature for the year is low, the range, summer and winter, is very small, so that flowering plants which grow on the borders of the glaciers and on exposed hills perish in England, from inability to withstand the sudden changes and lowness of the winter temperature.

The inference would seem to be that a Glacial period need not so much depend upon extreme cold as on an unlimited condensation with an equable temperature, low enough at moderate altitudes to form snow.

The glaciers are nearly entirely devoid of erratic blocks or surface moraines. Coming, as they do, over everything, down a hill-side, there is seldom an overhanging mountain to discharge blocks; where there is, the rock is so solid that the very slight changes of temperature (for the sun has no power here) is not sufficient to disintegrate it. Even the glaciers therefore that descend nearly to the sea are quite clean and spotless to the very end.

I could never make out any raised beaches, nor other signs of former lower level of the land; all the evidence is the other way. No beaches exist at the water-level of the present day. There is not enough sea in these confined channels to wash away the land, even if it was of a softer nature. The steep rocky mountain-sides dip clean into the water nearly everywhere. Thick moss covers the hill-sides wherever it can get a hold, so that it is not easy to see the true contours of them, and a more experienced eye than mine might perhaps detect a raised beach where I have failed to do so.

Glacier from Mount Wharton

Mount Wharton, 4400 feet high, on the south shores of Long Reach, sends down what I consider a rather remarkable glacier, despite its small size.

The upper part of the mountain, of a tolerably gentle slope, is of an area of about four square miles. This terminates everywhere in steep precipices, over which in different directions the blue ice, which can be seen lining the edge, tumbles, and forms *glaciers remaniés* in hollows at lower levels in several places. On the south-eastern side only is a steep slope, down which, after a series of ice-falls, a leg of glacier, one-third of a mile wide, and one mile and a half long, extends to within 150 feet of the sea-level, and a quarter of a mile from the shore. At its end it abuts against a hill, and from the fact of the ground sloping away on either side from this glacier leg, it appears that this slope is a ridge, down which the glacier comes, as it were, astride. Where it strikes the hill, it divides, and sends a final short leg towards the sea on either side of the peninsula formed by the hill.

The slope of the lower part of the glacier is 15°, and it is much crevassed, and squeezed into pinnacles and ridges, so that, when tolerably clear of snow, it looks like frozen waves.

There is no moraine on it, and, wherever I could see, it lies on the solid rock, but a few stones are carried along at the bottom of the ice, and, at its end, where it abuts against the hill, the latter is a mass of loose rounded stones (very few angular ones), up to the limit occasionally reached by the glacier, which is well and curiously marked by a narrow belt of trees, growing on the edge of the tumbled stone moraine. Behind them the hill is of solid rock, bare or moss-covered (see illustration).

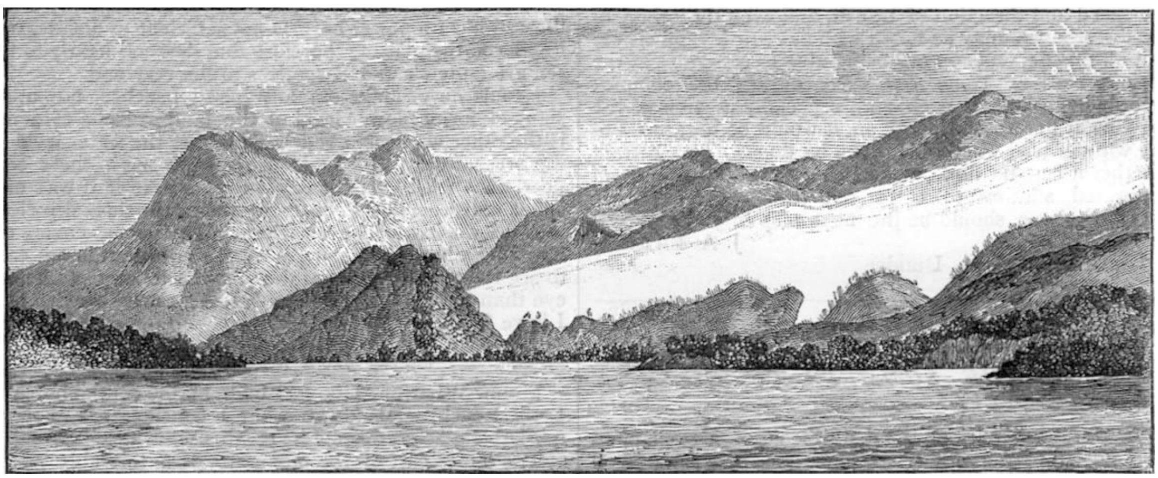
The side limit of the glacier, where it sometimes flows down the slope on its right and left, is also marked by a similar line of trees, the intervening space of about 300 yards being partly strewn with loose stones and coarse gravel, and partly perfectly bare, highly polished, striated rock. This rock has a somewhat remarkable appearance, as it is composed of a fine dark stone (a metamorphosed slate?) with intrusive parallel veins of white crystalline rock. The bands of black and white are very even in width, and there is as much of one rock as the other, so that, as the strike of the veins is in the same direction as the flow of the glacier, they look, at a little distance, like gigantic striæ.

I marked the foot of this glacier in December 1882, and found by March 1883, after the summer, that it had retreated 30 yards. After the winter, I fully expected to find that it had again advanced, but in December 1883 the edge of the ice was 50 yards farther back than in the previous December. They reported a very mild winter at Sandy Point, but I was not prepared to find the glacier retreating throughout the year, as it was manifestly at its full limits not many years ago.

I could not procure any evidence as to its rate of motion. The sides are so broken up, by great pieces falling off and slipping down the slope, that it is almost impossible to get at the main body of the ice to put a mark in.

The head of West Havergal Bay, into which the glacier stream falls, is filled with a level bottom of sand with about 10 fathoms of water over it. This has a very steep edge to the deeper part of the basin. I imagine this to have been the delta formed by the glacier stream, when the land was at a slightly higher level. It is very rare in the Straits of Magellan to have anything but uneven, rocky bottoms to these deep basins, and they are generally steep to the edge of the shore. I have only found these sandy flat bottoms in the vicinity of glaciers, and as a sandy flat always forms around the *embouchure* of the glacier streams, a subsidence of the land would account for the existence of flats under water.

The hill-sides around Havergal Bay, where bare, show glaciation to a height of about 700 feet above the present sea-level. I think the land must have been higher when the ice was at this height, as the channel just below some of these marked hills being 60 fathoms deep, it would require the glacier to be 1000 feet thick, which seems to me hardly possible with such a small area for the production of *névé* as there is now, even supposing a greatly increased fall of snow and a much lower average of temperature than at present.



Havergal Bay, Strait of Magellan. End of Glacier from Mount Wharton.

I visited one of the *glaciers remaniés* on the north-west side of Mount Wharton. It lies in a hollow about 1500 feet above the sea, and at the foot of cliffs 1000 feet high or more, and is three-quarters of a mile long by 400 yards wide. It is an excellent example of regelation, as the fragments which form it must be dashed to small pieces in their fall. It was at the end of summer, and only insignificant bits were coming over the cliff from the ice-field above. These fell on the *glacier remanié* broken into minute fragments with a patter as of heavy hail. Larger masses would be similarly broken, and yet the ice-mass was as clear and compact as if it had never been disturbed.

There were signs here on all sides, in the striations and *moutonnée* shape of all the rock above it, that this re-organised mass was once much larger; and 500 feet below, on a tolerably level part of the otherwise steep hill-side, bordering the stream that issues from the glacier, were low lines of moraine that were evidently once at the lower part of its sides.

A snow-field on a flattish mountain 3100 feet high, near Mount Wharton, has no proper glacier, but the ice falls over precipices and forms *glaciers remaniés*.

Glacier from Mount Wyndham

Mount Wyndham, on the opposite side of the Strait to Mount Wharton, sends a glacier down a valley, but has no surface moraine nor blocks. Its length is about two miles and a half, and the width, at the bottom, half a mile. Like others, it is very steep, and its surface is broken into pinnacles with deep crevasses. As I never saw the landward side of Mount Wyndham, I cannot exactly say what other glaciers may take their rise in it, nor what the size of the snow-field may be, but it probably does not exceed more than four or five square miles.

The foot of the glacier is not more than 100 feet above the sea, and is half a mile from the head of Glacier Bay, in a broad flat between the mountain slopes. A thick belt of tangled forest intervenes. This glacier is much shrunk also, a wide space of ground, covered with rounded stones, sand, and gravel, extending all round the foot to the edge of the trees in front, and the hills at the sides.

Signs of glaciation are abundant about this glacier, at far higher levels than it now reaches. Glacier Bay itself has been filled with it. This is a deep basin (70 fathoms deep) with islands stretching across its entrance. Rock Island, the largest of these, is *moutonnée* to the top, 560 feet, and the striæ are plain to see on its smooth precipitous sides. Several perched blocks stand on the mountain-sides about, but as I did not visit these, I cannot say whether they may not have simply come from the heights above, though their precarious positions would indicate not.

Outside Rock Island is another area of even, sandy, and muddy bottom, in from 10 to 6 fathoms water, with a steep edge to the deep water of the Strait, similar to that at the head of Havergal Bay. This, I take it, must have been formed by the glacier stream, and was once its delta when the land was higher.

A sandy flat, mixed with rounded stones, now surrounds the glacier stream where it falls into Glacier Bay, and only wants a subsidence of the land to convert it into a counterpart of Havergal Bay. I do not know how else to account for this flat outside Glacier Bay, which was as unexpected as it was welcome, since it forms one of the best anchorages in the Straits, where even bottoms for the anchors are at a premium.

Northbrook Glacier

A snow-field in King William's Land between Northbrook Sound and Beaufort Bay is the largest in these parts, but I do not know much of it. It lay unfortunately just outside my work, and was so uniformly covered with clouds that I only saw the summit once.

It has probably an area of from fifty to seventy square miles. It is a flattish mountain about 4500 feet high. The ice descends on all sides in a succession of ice-falls, exhibiting lines of blue ice, most beautiful to see, about two or three miles long. Only when within 800 or 1000 feet of the sea is a true glacier formed.

These glaciers at the head of Northbrook Sound reach to within 100 feet or so of the shore level. In Beaufort Bay I rather think they reach the water. In Northbrook Sound the glacier at a mile from the coast, is about a mile and a half wide, but it is shortly after broken by a protruding hill, and divides into two legs, each half a mile wide. This glacier was also much shrunken. It brings down no moraine, and flows over solid rock.

W. J. L. WHARTON

NOTES

THE Council of the Mathematical Society have awarded the first De Morgan Gold Medal to Prof. Cayley, F.R.S.

M. PASTEUR has been awarded a gold medal by the Société Centrale pour l'Amélioration des Races des Chiens for his work on rabies.

THE jury of the International Horticultural Exhibition at St. Petersburg have awarded a gold medal to Dr. Regel, Director of the St. Petersburg Botanical Garden. The other awards for scientific work were to Dr. Gobi, the Russian algologist, for his remarkable herbarium; to Mr. Hartnack, for his microscope; and to Countess Zichi for her picture representing the *Serapias*. A gold medal was awarded to the Japanese University of Tokio for its collection of fruits.

M. JAMIN has been elected Perpetual Secretary in the Section of Physical Sciences of the Paris Academy in succession to the late M. Dumas.

DR. ADAM PAULSEN has been appointed Director of the Danish Meteorological Institute in succession to the late Dr. Hoffmeyer. Dr. Paulsen was the Chief of the Danish Polar Expedition to Godthaab.

PROF. W. GRYLLS ADAMS, as President of the Society of Telegraph Engineers and Electricians, will hold a *conversazione* in the Museum, Physical Laboratory, and Art Galleries of King's College on Thursday evening, July 3, from nine to twelve o'clock.

BY invitation of the Executive Council of the International Health Exhibition, a conference of the Society of Telegraph Engineers and Electricians will be held in the Conference Room of the Exhibition, South Kensington, on Friday, July 4. The chair will be taken by Prof. W. Grylls Adams, F.R.S., President of the Society, at 11 o'clock a.m., when the following paper will be read and discussed: "On Electric Lighting in Relation to Health," by R. E. Crompton, member. An adjournment for luncheon will take place at 1.30, and at 2.30 the following paper will be read and discussed, viz.: "The Physiological Bearing of Electricity on Health," by W. H. Stone, M.A., M.B. Oxon, F.R.C.P., member.

A LARGE number of guests, including ladies, assembled by invitation of the President of the Royal Society at a *conversazione* held at Burlington House on Wednesday last week.

ARRANGEMENTS have been made by the Council of the Scottish Meteorological Society for the completion this season of the Observatory of Ben Nevis. The first portion of the Observatory was, it may be remembered, opened in October last, and since the observers went into residence continuous hourly observations have been made of the conditions of the atmosphere at the top of the Ben, with special reference to temperature, pressure, humidity, and motion. From the discussion of these, and what were daily made by Mr. Clement L. Wragge in the summers of 1881 and 1882, by the Secretary, Mr. Buchan, the Council have been fully confirmed in the high expectations they had formed concerning the value of a high-level station, both in its bearing upon general meteorological problems, and also with reference to possible forecasts for the British Islands. The problem, however, is great and many-sided, and is one which can only be solved after much patient investigation and labour. The additions to be made to the Observatory will just double its size, and enable the three observers—who during the winter have been considerably cramped in their one apartment—to work under more comfortable conditions. On the south of the present doorway there is to be erected a shelter for tourists. On the north side of the existing building there is to be erected a new sitting room or office, 15 feet by 13 feet, while off this apartment there will be two bed-rooms, each 9 feet by 7 feet. The office will be lighted by two windows; and in each bed-room there will be one window. Opening from the east side of the office is a short passage leading to an octagonal tower, the walls of which will be 6 feet in thickness, and its internal diameter 8 feet. The tower, which will be 25 feet high, will be divided into three apartments, the lower being a dark chamber for photographic purposes, the centre one a spare room, and the upper a depository for observing instruments. The stonework of the tower is carried up to the height of the ceiling of the second chamber. The upper room is a superimposed wooden cabinet, the exposed parts of which are covered with lead. The floor of this apartment is carried out over the stone walls and firmly fixed to the tower below by iron rods, and to the roof above by strong wooden braces, so that it cannot possibly be upset. In the upper chamber are four windows, one facing each of the cardinal points of the compass, and at one of these is a ladder leading down to the roof, so that, should the doorway be blocked by snow, this would form a means of exit for the observers; the ventilating and smoke pipes, which are contained in one casing, are carried up through the roof of the tower, while, rising 6 feet above the ventilator, will be two anemometers, specially constructed by Profs. Chrystal and Crum Brown, for continuously recording the direction and velocity of the wind. These instruments will be self-registering, the apparatus for this purpose being in the chamber below, where it will be accessible at all times. On the eastern face of the tower a door has been left, so as to provide for future extension for magnetic and seismic observations. The estimated cost of the