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1909.

488TH ORDINARY GENERAL MEETING.

MONDAY, DECEMBER 7TH, 1908.

GENERAL J. G. HALLIDAY IN THE CHAIR.

The Minutes of the previous Meeting were read and confirmed and the election of the following candidates confirmed :—

MEMBERS.—E. W. Maunder, F.R.A.S., Superintendent of the Solar Department, Royal Observatory, Greenwich; the Rev. Father John Gerard, S.J., F.L.S., B.A.; H. Charlewood Turner, Esq., M.A. (Camb.), Secretary.

LIFE ASSOCIATE.—A. W. Oke, Esq., B.A., LL.M., F.G.S., F.L.S.

ASSOCIATES.—F. Gilbertson, Esq., B.A. (Camb.); J. C. McMurdo Given, Esq., M.D., M.R.C.P.; Mrs. J. E. Hendley; Miss A. M. Hodgkin.

The following paper was read by the Author :—

*GENEVA AND CHAMOUNIX HALF A CENTURY
AGO AND TO-DAY. (Notes of a Recent Visit.)* By
Professor EDWARD HULL, LL.D., F.R.S. (Vice-President).

(With lantern views.)

INTRODUCTION.—*Visit to Geneva, 1852.*—It is about half a century since I first stood on the banks of the Mer de Glace at Chamounix and had a view of Mont Blanc. Early in my college days I had become acquainted with the glories of the Alps, and was fired with ambition to visit Switzerland and its wonderful snowy mountains and glaciers. I had read and studied that charming book, *Norway and its Glaciers*, by Professor James Forbes, as also the explorations of Agassiz, Charpentier and De Saussure amongst the Alpine Glaciers as related by Lyell; but it was to Forbes that I was chiefly indebted for what I know of the structure and movement of glacier ice, as it is to his observations conducted on the Mer de Glace of Chamounix through several successive seasons, with the aid of his faithful attendant and guide, Auguste Balmat, that we are acquainted with the laws which regulate the motion of glacier ice; observations which were afterwards repeated by Tyndall.

Therefore, on the first opportunity that presented itself after my appointment to the staff of the Geological Survey of Great

Britain, and having scraped together sufficient funds, which with great self-denial were sufficient to carry me through my journey—that I left England for Switzerland. I crossed over to Paris, where I stayed only one night, and next day took the train for Dôle, beyond which the railway did not then extend. Arriving at Dôle by midnight, I left the train and presented myself at the office of the diligence demanding a seat for Geneva. What was my consternation when I was informed that the coach was “full up,” as all the seats had been booked beforehand in Paris! I was told that I must wait for the coach next day; but might not that coach be just as full as the one about to start? In this dilemma I appealed to the conductor to get me through somehow, and he agreed for the sum of 20 francs, and at the risk of dismissal if discovered, to make me a den on the coach top amidst the luggage, where I could lie covered over by the tarpaulin, but open in front.

First view of the Alps.—To this proposal I had to assent, and in this position I made the journey to Geneva, of about nine or ten hours, as part of the baggage. I need hardly say the position was not quite as comfortable as that of a first-class compartment of a railway train at the present day!

But I was not without a reward which is denied to persons so travelling to-day. After crossing several beautiful hills and valleys of the Jura range, we at length came to a point in the road where all the passengers were allowed to descend and remain for some minutes. It was the summit of a ridge from which the road commenced to descend into the great Valley of Geneva. From this point the view commanded the valley and the Lake of Geneva stretching from end to end; beyond which was seen the range of the Alps rising in three successive tiers. First, that of the forests, green with verdure. Above this extended the dark band consisting of naked rock, contrasting with that of the forest below and with that of the snows above; and surmounting this region was that of the snowy Alps, its lower limit clearly marked off as seen from my point of vantage, and rising high into the pure vault of heaven; so pure and ethereal as to give the idea that it was a celestial vision rather than as part of the terrestrial world; and finally, rising from the centre was the white dome of Mont Blanc, the highest point of Europe. This magnificent range of mountain scenery stretched from end to end a distance of over fifty miles.

This first view of the High Alps has remained impressed on my memory ever since, and for the time the discomforts of my journey were forgotten. Needless to say, the view is now

seldom seen by travellers, as the coach has given place to the railway, from which only slight glimpses of the High Alps are to be obtained.

First visit to the Mer de Glace.—Arriving at the beautiful city of Geneva, I did not remain there more than two or three days. My goal was the Mer de Glace and Chamounix, and to that I pushed on by diligence. At that time there was no railway; it is otherwise now, and after a long day's journey I found myself in the little village at the foot of Mont Blanc. Next day I ascended the pine-clad slopes to the chalet of Montanvert, and at length stood on the edge of the great glacier. A wonderful and beauteous sea of ice, fissured by crevasses, and bounded by lofty cliffs terminating often in sharp peaks, and lying at their feet were huge moraines of broken rock and *débris* fallen from the cliffs above. It was a weird and awful sight, as no living creature was visible from where I stood. But I was not alone. I sat down on a boulder to eat the little store of biscuits and fruit I had brought with me, and presently I was joined by a noble hound—possibly a St. Bernard—who made up to my side in a friendly way, and I returned his civility by sharing with him my lunch. How he came to be there or whence he came I never discovered, but he remained with me for the rest of the day, and having accompanied me down to Chamounix in the evening he then disappeared, doubtless satisfied with having fulfilled his friendly office of guide, companion, and protector.

Second visit to Chamounix and the Mer de Glace, 1908.—Having now finished the narrative of my first visit, I proceed to make some observations on the Mer de Glace of to-day, in order to illustrate the changes which have occurred within the past half century. Chamounix itself has greatly changed. Instead of a hamlet in the upper Rhone valley with, perhaps, two or three hotels, it is now a good sized town with numerous hotels, and shops exhibiting photographs of the scenery around, some of the coloured ones being remarkable examples of high art. A handsome English church raises its spire in the centre of the town, and was well filled by a congregation on the Sunday I was there. Instead of the toilsome climb of about 3,000 feet to Montanvert,* a newly-opened narrow gauge railway, worked by steam locomotives, ascends by a winding

* The "Hôtel d'Angleterre" at Chamounix, at which I stayed, has an elevation of 1,000 mètres (3,280 feet) above the level of the sea, and lies at the base of Mont Blanc, the summit of which is conspicuous from the front of the building.

path through the forest of pines which clothes the side of the mountain; and as several trains ascend and descend during the day, one may see from below two trains slowly wending their way, one far above the other on the side of the mountain, either in the same or opposite direction. The upper end of the line approaching Montanvert is still incomplete, and will scarcely be ready for another year; so the traveller has to climb some distance on foot in order to reach the platform on which is built the huge, unsightly hotel of Montanvert, from which, however, a fine view of the Mer de Glace in the valley below is obtained.*

The Mer de Glace as seen to-day.—On coming in sight of the Mer de Glace from my commanding position, which included the whole of the central portion from the base of Takul downwards almost to the extremity of the glacier, I was surprised and not a little disconcerted by its aspect.† As compared with its appearance on my first visit (judging, of course, from memory) the whole mass of the glacier seemed to have shrunk in volume, and its surface to be defaced by a promiscuous covering of dust, gravel and boulders, causing it to appear very different from the generally clear and clean surface of the ice, with a well-defined central moraine of large blocks of granite ranging down from the cliffs of Takul above. This shrinkage was very perceptible along the sides of the glacier, where the edge of the ice had shrunk away from the lateral moraines which marked its former limits. The lower end of the glacier seemed also to have receded to a higher level than that at which it stood at my first visit, when it stretched farther downwards towards the Arveiron Valley. The result of all this was disappointment, not entirely dissipated by the spectacle of hundreds of visitors scrambling over the ice, in contrast to the solitude which attended my first visit. Aware, however, that appearances are sometimes deceptive, I resolved to make further enquiry on my return to Chamounix regarding the supposed shrinkage of the Mer de Glace.

Visit to Mons. J. Vallot.—On returning to Chamounix I was advised to consult Mons. J. Vallot, the Director of the observatory of Mont Blanc, and on my calling at his house a day or two

* Here a flat slab of porcelain has been set up by the Club Alpin Français, on which is engraved, Altitude 1,909 mètres, lat. N. 51° 03' 72" long. E. 5° 09'.

† Takul is the name given to the lofty cliffs which rise from the glacier at the point where the two arms of the Mer de Glace unite (see fig. p. 22).

after, I was most kindly received, and furnished with details extending over twenty-five years of observation, which completely verified my conclusions regarding the shrinkage, not only of the Mer de Glace, but of all the glaciers of the Alps of Savoy.

Mons. J. Vallot's observations of the rate of motion of the ice of the Mer de Glace.—This may be the place to give some account of the results arrived at by this authority from his observations conducted systematically for several years regarding the movement of the ice of the Mer de Glace.* These observations were conducted between the years 1891 and 1899 in an elaborate manner by using the blocks of rock lying on the surface of the ice or placed in position. Taking a straight line across from side to side at four stations in the following order—

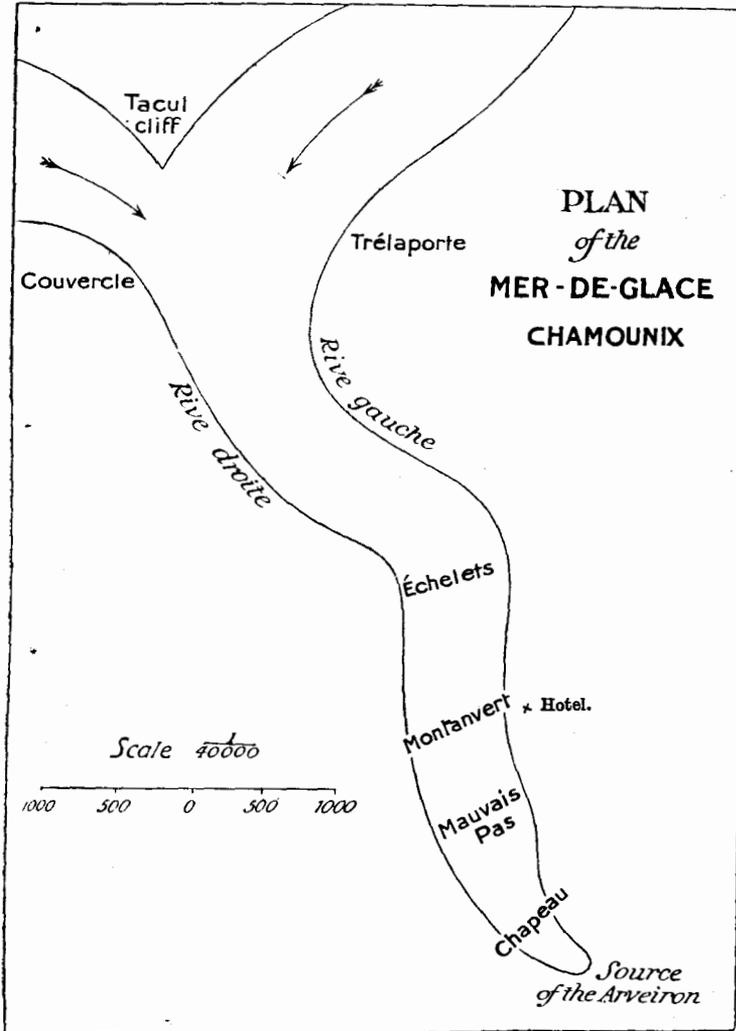
- No. 1, Echelets, the highest of the stations,
- „ 2, Montanvert, about 1,000 mètres lower,
- „ 3, Mauvais-Pas, next lower down,
- „ 4, Chapeau, near the lower end,

M. Vallot selected, or placed in position, a line of stones on which to paint the numbers 1, 2, 3, etc., from side to side; and by visiting the glacier from time to time, and measuring the positions of each stone as it had advanced from the starting point marked on the plan, he was able to determine its rate of motion downwards and its relative rate as regards those of its neighbours. This laborious process was somewhat different from that adopted by Professor James Forbes with the assistance of his able assistant, Auguste Balmat, many years previously. But the same general result regarding the rate of motion of the glacier was arrived at in both cases; that is to say, the motion is similar to that of a river flowing down its bed, which is most rapid at the centre and least at the sides.† Mons. Vallot holds that the difference in the rate of movement at different points is caused by the difference in the form of the bed of the glacier, also its breadth, depth and its inclination. This is considerable when it was found that between two points one kilomètre‡ distant from each other, namely, between Mauvais-Pas and Chapeau, the rate varied from 34·2 to 43·4 mètres during the year 1893. The following table gives the results of the observations during nine years:—

* *Annales de L'Observatoire Météorologique du Mont Blanc.* By J. Vallot, tomes iv, v (Paris, 1900).

† Similar results were arrived at by Agassiz from observations on the Unteraar Glacier.

‡ 1,093·6 yards.



(From a plate by Mons. Vallot.)

Rate of motion of the Mer de Glace.
(Speed in centimètres.)

YEARS.	ÉCHELETS.		MONTANVERT.		MAUVAIS-PAS.		CHAPEAU.	
	Rate.	Slope.	Rate.	Slope.	Rate.	Slope.	Rate.	Slope.
1891-2	39·0	6·2	44·0	11·5	36·0	8·4	—	—
1892-3	39·3	5·5	44·1	15·1	35·5	12·4	—	—
1893-4	38·1	2·7	40·6	14·5	34·2	14·6	43·4	50
1894-5	34·0	8·5	32·9	15·2	30·7	10·8	—	—
1895-6	31·7	10·0	28·9	10·7	30·8	38·7	—	—
1896-7	32·6	10·8	28·3	9·7	30·8	38·7	—	—
1897-8	33·5	7·3	27·7	11·6	31·0	39·6	—	—
1898-9	34·4	7·2	26·3	10·2	—	—	—	—

Amongst other results arrived at by this observer were that the rate of motion of the ice is greatest in summer and least in winter. This is true of all the Alpine glaciers, and has been determined by Streenstrap even regarding the ice of Greenland.

Observations on the "ablation" of the Mer de Glace.—Mons. Vallot has also contributed an interesting "note" to the French Academy on the "ablation" or lowering of the surface of the Mer de Glace during two definite periods, namely, 15 and 57 years, at stages given in the above table:—

(The figures are given in mètres.)*

	Altitude.	Years.	Exact mean.	Approximate in 57 years.
At Échelets ...	1,920	15	11·0	54
„ Montanvert...	1,843	14	13·4	55
„ Mauvais-Pas	1,705	13	19·8	49
„ Chapeau ...	1,550	13	29·5	74

Thus at Échelets, the highest of these stages, the lowering of the surface has been in 15 years 36·08 feet, and in 57 years 177·12 feet; while at Chapeau, the lowest of the stages, the fall

* Dated June 22nd, 1908 ; the figures are in mètres

has been in 13 years 96·76 and in 57 years 242·72 feet. These are the alterations of level since 1850 within the memory of the present inhabitants. But Mons. Vallot goes a step farther back and compares the present levels with those of the period of maximum high level of the Glacial period, showing enormous shrinkage since that epoch. He has observed the glaciated rocks at the foot of the Aiguille du Dru and at the head of Trélaporte, positions higher up than those above-named on the side of the Mer de Glace. There can be no doubt the ice reached these glaciated rocks, and has left its well-recognized marks and polished surface, and these he finds to be 400 mètres (1,312 feet) higher than the actual moraines now at the base of the cliffs. At this altitude the glacier has left no lateral moraines analogous to those of the present day, and he concludes that the Glacial Epoch does not present so long a period of equilibrium as is generally supposed. He infers, on the contrary, that the rise and fall of the ice was comparatively rapid, not allowing time for the formation of a lateral moraine, which can only be accumulated during a prolonged period of tranquillity.

On the above facts M. Vallot remarks:—"When we consider that the life of a man has sufficed to see the *ablation* of 50 mètres of a glacier (that is to say, of one-eighth of the total thickness of 400 mètres) disappear since the Glacial Epoch, one asks if all that has been said regarding the length of that period has not been considerably exaggerated?" But here I would observe that we must recollect that whatever the length of that period may have been it was sufficient to allow of the bed of the Atlantic Ocean being raised to a height of over 6,000 feet above its present level, and the extension of the continental river valleys to that depth below the present surface, and the subsequent subsidence of the sea-bed to about its existing level.*

VISIT TO THE GLACIER DES BOSSENS.—My next visit was to the Glacier des Bossons, which descends from the snows of Mont Blanc and is easily visible from Chamounix. Its valley is clothed in forests of pine, and its lower end disappears beneath the trees, leading one to suppose that it is easily accessible on

* This is on the assumption that the cold of the Glacial Period has been brought about by physical changes such as the elevation of the sea-bed, and adjoining continents, and the consequent diversion of the Gulf Stream, all of which I have endeavoured to show took place in my essay, "Another possible cause of the Glacial Epoch." *Trans. Victoria Institute*, vol. xxxi, p. 141 (1805).

foot from the Clamounix valley, a supposition which is dissipated on trial. There is, in fact, a stiff climb of about 2,000 feet in order to reach the Chalet, where a good view of the glacier is obtained together with needful rest and refreshment. I will not stop to describe this glacier further than to observe that a brief survey of its lateral moraine shows that the ice has here retreated to a considerable extent (perhaps 200 feet) from its former level. Along the top of the moraine large boulders are perched, ready to fall from the slightest movement. These were left when the ice reached that level; but the moraine itself is bare and destitute of vegetation, which apparently has not had time to grow upon its surface since the ice retreated; evidence of the recentness of the shrinkage. On descending towards the valley of the Arve we passed some huge blocks of granite, left by the glacier when it reached far below its present limits. Some of these must have weighed 100 tons, and are being quarried for building.

Remarkable appearance of Mont Blanc, August 17th, 1908.—Mont Blanc under the setting sun.—When approaching Chamounix the day of our arrival we were favoured by a scene of wondrous beauty which ought not to pass unrecorded. The train was passing about sunset along the Valley of the Rhone bounded on either hand by mountainous heights, when someone exclaimed, "Look at Mont Blanc!" and casting our eyes upwards in the direction indicated we beheld a scene never to be forgotten. The great mountain dome, with some of the adjoining heights and bordering snowfields, seemed to have been converted into a mass of burnished gold, owing to the declining rays of the setting sun which were flooding the heights with their light, but were quite out of sight to us, being intercepted by the intervening heights. This gorgeous scene was fortunately visible from the railway for several minutes, so that we had time to realize its supreme beauty, which words fail to describe. The white fields of snow lit up by the setting sun reflected in all their rich beauty their own resplendent colouring. It was a rare coincidence—the splendour of the sunset, the reflection from the snows, and our own position as observers!

Geneva revisited, 1908.—We may now go back to Geneva, and note the changes which have taken place in this celebrated city within the last half-century. They have been indeed remarkable. At the time of my first visit to the city of Calvin there were no railways, nor, if I recollect, steamboats on its great lake, the only ships being the pretty double-winged

sailing boats; no tram lines through the streets, no turbines for supplying the inhabitants with water and with power for driving tramcars and turning machinery.

Now all is changed except the splendid scenery of the landscape viewed from the banks of Lake Lemman, some fine hotels and houses with the cathedral, occupying a commanding position in the upper part of the town. On visiting this church, severely plain and destitute of R.C. decoration, I was startled by seeing the name of John Knox conspicuously posted on a slab in the wall, reminding the visitor that the Scotch Reformer had during those stormy times visited Geneva, and occupied for a while Calvin's pulpit; and in memory of this brotherly visit a very beautiful annex called "the Macchabees" has been erected on the south side, where Presbyterians meet to worship on the Sabbath, according to a ritual closely resembling, if not identical with, that of the Church of Scotland at the present day. "Calvin's Chair," of plain hard oak, stands beneath the elaborately carved pulpit, which replaces the original one of the sixteenth century. The chair is regarded with veneration as a monument of the Reformer. What times of religious fervour were those when the images and ornaments of the Roman worship were pulled down and destroyed, and the bishops and priests were given the choice of accepting the Protestant faith or of quitting their sanctuary for an asylum in France or Italy. In these days of "passive resistance" it is difficult to picture to ourselves the perfervid religious convictions by which Switzerland was swayed from end to end, and which resulted in bringing over to the Protestant faith the cities of Geneva, Lausanne, Zurich, Basle and Berne. But Lucerne and the seven Forest Cantons retained their attachment to the papacy—after a severe struggle between their opposing forces and those of Berne.

The great turbine installation of the Rhone.—When at my first visit I stood by the banks of the Rhone below Geneva, there was probably nothing to intercept the course of the stream as it issued forth from the lake; a pure, ever-flowing sheet of water, which had entered at the upper end of the lake brown and turgid with glacier mud. This mud had subsided in the still waters, and has within the Christian era added an extensive tract of flat alluvial soil as shown by the remains of a Roman fort which once stood on the banks of the lake about a mile above the present margin in the valley of the upper Rhone above Villeneuve. Now, however, half the volume of the river is utilized for turning a grand installation of powerful

machinery in the form of turbines, twenty in number, and each 1,000 h.p., by which the city is supplied with water, electric light and motive power, all in almost unlimited quantity.

There had existed since the year 1837 successive attempts to utilize the waters of the Lower Rhone, but from various causes they were insufficient to supply the demands of an increasing population and prosperous community. But at length, in 1882, a concession was granted by the city of Geneva to the enterprising engineers, MM. Merle d'Aubigny and Turretini, to construct the present powerful works. These turbines were specially designed for the works at Geneva, and were manufactured at Zurich, the great centre of mechanical appliances in Switzerland, by the firm of MM. Escher, Wyss and Co. The force thus obtained operates a proportionate number of powerful dynamos, and is distributed for industrial motive power, as also for lighting and for water supply by centrifugal pumps capable of throwing the water to a height of about 270 feet in the air above the surface of the lake. The total cost of these works to December, 1905, reached 9,964,728 francs (nearly £400,000), a very large sum for a population of about 106,000 souls; but having been once carried out is almost automatic, and is certainly inexpensive to keep going. Nature has given compensation to Switzerland for the absence of coal. Coal-fields are exhaustible, but the supply of water from the snowfields can never fail as long as the present order of nature lasts.

Junction of the Rhone and Arve.—A convenient causeway has been constructed by which the visitor is enabled to stand just over the spot where the pure waters of the Rhone, issuing from the Lake of Geneva, come in contact with the turgid waters of the Arve—a most impressive sight! Between lofty banks of stratified gravel, once the bed of a vast lake of post-Glacial times, these two fine streams move majestically onwards; yet do not their waters commingle. They run side by side for a long distance; but the level of those of the Rhone being somewhat higher than those of the Arve, and their force and velocity greater, the Rhone gradually pushes the Arve towards the opposite bank, and gains the mastery. The difference of level above the junction is shown by the fact that at several places the somewhat open material of which the causeway is formed allows the water of the Rhone to percolate underneath and invade that of the Arve. May we not in this case of the rivers find an illustration of the two great principles which govern mankind and which Scripture clearly unfolds to us, for instance,

in the parable of the wheat and the tares, the principles of good and evil? Like the waters of the Rhone and the Arve they move along side by side, but they refuse to commingle. They are, in fact, constantly at war, each striving for the mastery; but the forces of good and that "make for righteousness" are gaining on those of evil through the spread of Christian light throughout the world, and as we believe will ultimately prevail, when the "knowledge of the glory of the Lord will cover the earth as the waters do the sea."

Literary coincidence between the English and Swiss "Lake Districts."—It is a somewhat curious coincidence that the City and Lake of Geneva has, like the Lake District of England, been the favourite residence of distinguished men of letters. Naturally, men of high intellectual capacity congregate where the beauties of the landscape, the mountains, the lakes and the fruitful vales tend to tranquillize their minds and inspire them with poetic imagery; and in following up this thought the names which suggest themselves at once for the English Lakes are those of Wordsworth, Southey, Ruskin, Harriet Martineau and De Quincey, and for those of Geneva, Calvin, Farel, Beza, Voltaire, Rousseau, Necker, Charpentier, De Saussure, Agassiz, Gibbon, D'Aubigny and others; names which for good or for evil have left their memory for all time. Calvin's greatest work, *Christianæ Religionis Institutio*, "which has shed undying lustre on his name," though issued in Basel (1535) is associated with Geneva, and to the Academy founded by Calvin in 1559 learned French, Italian, German and English emigrants flocked and rendered the city illustrious for learning. Amongst the English we find the names of Spencer, Coxe, Chambers, Bishop Hooper and other divines.*

Geneva as an asylum for persecuted Reformers.—Geneva has had the honour of offering an asylum to the persecuted Reformers of France and other countries during the troublous period of the sixteenth and seventeenth centuries, when in the time of Cromwell, the Duke of Savoy, at the instigation of the Pope, endeavoured to exterminate the Vaudois of the High Alps, which called forth the lines of Milton:—

"Avenge, O Lord, thy martyred saints,

Whose bones lie scattered on the Alpine mountains cold."

and caused the Lord Protector to threaten the Duke of Savoy with his vengeance, by "sending his ships across the Alps"

* *History of the Nations, supra cit.*, p. 287.

unless he withdrew his hand, which he, the Duke, did! And the next important occasion was the massacre of St. Bartholomew's Day in 1572, when thousands of Protestants were ruthlessly murdered in cold blood or had to fly for their lives into Geneva, Zurich and other friendly Swiss towns on the one hand, or to England and Ireland on the other. We are fortunate in now having the details of this foul tragedy laid bare by the researches of a Roman Catholic historian of undisputed eminence. I refer to Lord Acton, late Professor of History to the University of Cambridge,* because I learn there are persons so ashamed of this event that they are inclined to deny that it ever happened; and from the efforts (related by Lord Acton) which were made by the Catholic writers of France to destroy all documents relating to this event, it is clear that they would have gladly blotted out that record from the page of history. The destruction of a million of France's most God-fearing and industrious inhabitants was a loss she has never recovered, and a gain to those countries who opened their doors to the refugees. Retribution was sure to follow, and has followed. Through Zwingli's efforts Switzerland extended the *droit d'asile* to all, and she henceforth followed out her mission as a neutral power. It is the protection so freely given to refugees by Geneva, Zurich, and other Swiss cities that brightens the history of the gloomy reaction period towards the close of the sixteenth century after the death of Calvin, and during the Marian persecution refugees from England found a friendly asylum in these prosperous cities.†

Such were the scenes and impressions which presented themselves during my visit to Switzerland a few weeks since, and about half a century previously. I have not included the beautiful City of Lausanne, which was the point of arrival and departure for our tour; nor the Hotel Gibbon, where the historian is said to have composed his great history of the *Decline and Fall of the Roman Empire*, a work which is in itself a library of information regarding the times to which it refers—to have done so would have unduly extended this paper.

* "The Massacre of St. Bartholomew," in *The History of Freedom*, by Lord Acton (1907), MacMillan and Co. The Pope Gregory XIII. on hearing of the massacre, exclaimed "that it was more agreeable to him than fifty victories of Lepanto, and with his cardinals attended a *Te Deum* in the nearest church in Rome," p. 133-4.

† An admirable account of these times will be found in the volume "Switzerland" of *The Story of the Nations*, by Lina Hug and Richard Stead (Fisher Unwin, 1890). Also, in *The Huguenots*, by S. Smiles (John Murray, 1869).

DISCUSSION.

The CHAIRMAN, in expressing the pleasure with which he and all those present had had in listening to Professor Hull's interesting paper, said that his recollections went back a great deal further even than those of the reader of the paper. In his opinion the modern traveller by railway sustained an enormous loss in missing the view obtained by the old traveller by diligence from the crest of the Jura at such a place as the Col de la Faucile.

Mr. W. H. HUDLESTON, F.R.S., said that the paper was extremely interesting to him, not only because it was in accordance with his own views, but also because it served to remind him of his experiences in Switzerland, which coincided to the very year with these of the author.

Now it so happened that he (the speaker) towards the end of January, 1852, arrived at Geneva in the banquette of a diligence (*summa diligentia*, as they used to say in those days), but clouds and darkness had prevented him from enjoying that famous view. Nevertheless, as he was spending the remainder of the winter at Geneva, there were plenty of opportunities, and he chose one bright frosty day for the ascent of the Col de la Faucile. Surely there is no grander view in Europe. From the snowy foreground of the Jura you look down upon the broad vale of Switzerland with its cities and villages, and above all, its glorious lake, the whole bounded on the opposite side by the still more snowy ranges of the Alps, ever increasing in height until they culminate in the chain of Mont Blanc. Professor Hull had estimated the extent of this view at 50 miles, but he (the speaker) thought that it might possibly be even longer. The only view which could compare with this one is the view from the heights above Baramula, looking across the Vale of Kashmer, with the Wular lake in the middle towards the chain of the central Himalayas. There is considerable analogy between these two celebrated views, and he thought that the Alpine one would lose nothing by comparison with the Himalayan.

He was much interested in the contrast drawn by Professor Hull between the Geneva of to-day and the Geneva of fifty or sixty years ago. From an æsthetic point of view the change was by no means an advantage. In the early fifties Geneva was a very picturesque old town, symmetrical, and for the most part within its fortifications.

These, no doubt, were out of date in a military sense, but added much to the picturesqueness of a compact town, which, as yet, was innocent of tramlines and disfiguring suburbs. Unfortunately, most of the large continental towns had outgrown their pristine symmetry, and presented, nowadays, a somewhat formless mass of buildings—useful, no doubt, but many of them very ugly. The once beautiful city of Naples was a case in point. The great turbine installation of the Rhone, on the other hand, is a real improvement. As regards the junction of the Rhone and the Arve, if Professor Hull had gone a few miles further down he would have found that this union of waters serves to illustrate the saying “that evil communications corrupt manners,” since the mixture ultimately becomes turbid and not unlike green pea soup.

As regards the extension of railway accommodation to Chamounix, no doubt the modern traveller might obtain some increase of comfort, but he would miss many fine points in the valley of the Arve, and especially that magnificent bend of the river in the neighbourhood of the Pont Pélissier, which exceeds in beauty anything to be seen at Chamounix itself. The Savoyards had been somewhat behind the Swiss in constructing Alpine railways, but in order to make up for lost time there had been a talk of a railway up Mont Blanc itself, of which the line to the Montanvert might be regarded as a very small instalment.

When we come to regard the scientific aspects of the paper, we are presented with facts of great interest and value, more especially in respect of the shrinkage of the Mer de Glace. From the observations of Mons. Vallot it would appear that the actual *ablation* amounts to a little short of 200 feet in fifty-seven years at the Montanvert, where the glacier admits of very accurate measurements, as it there runs in a deep rock channel. The shrinkage of the Glacier des Bossons can only be inferred from the present position of the terminal ice with reference to its moraine. It would, however, be somewhat out of place to attempt any comparison with the Glacial Period, when all the valleys were completely filled with ice, and even the great vale of Switzerland so full that the granite of the Alps was deposited on the limestones of the Jura. Rather it would appear that the changes indicated by the shrinkage of the Mer de Glace and other Alpine glaciers may be regarded as forming part of an alternate rise and fall which has

been going on for several centuries. Numerous writers have testified to the remarkable desiccation which has been going on of late in Central Asia, yet it appears from historic records that there were times when the reverse was the case. Nevertheless, on the whole, it does seem that a dry period has set in throughout these regions, and this has affected the glaciers in the Himalayas to a certain extent. The Geological Survey of India has lately been engaged in a preliminary survey, and it has been found that, while the glaciers of the Karakorum ranges give somewhat varying results, those of the Ganges basin in Kumade show very decided signs of shrinkage. If we are inclined, as regards Switzerland, to speculate on the causes which produce this apparent rise and fall the question becomes one of meteorology. We may believe there has been a deficient rainfall in the Alps during the last sixty years, or, secondly, that there has been a slight increase in temperature, especially in summer. It is for the meteorologists of Geneva and elsewhere to help us to solve this problem.

Some notes contributed by Professor Roget of Geneva were then read by the SECRETARY : these notes are printed at the end of the discussion.

Professor ORCHARD remarked that probably many present had little idea when they came to the meeting how very interesting the subject of geology can be made when treated in the way in which it had been treated that afternoon. In this connection the name of W. H. Hudleston should be coupled with that of Professor Hull in their vote of thanks.

After the discussion a series of lantern slides was exhibited, in illustration of the paper.

The meeting terminated with votes of thanks to Professor Hull, the reader of the paper and to the Chairman, General J. G. Halliday.

NOTES ON THE PAPER BY PROFESSOR ROGET OF GENEVA.

Page 17. It is very difficult to connect with any particular name the first correct notions or experiments upon the motion of glacier ice. At the village of Bagnes or Châbles, in canton Valars, may be seen a memorial tablet claiming for one Perraudin the *originality* of

the experiments, observations and analysis thereof later attributed to Charpentier, Agassiz, Tyndall, etc.

Page 20. The quick relative or comparative shrinkage of the Mer de Glace and other glaciers is an effect of the comparatively greater mass and volume of the Mont Blanc range. The inner temperature of a mountain or mountain-group *grows* in some proportion to its mass and volume. So general causes of shrinkage must tell most upon the Mont Blanc range, the factor of greater internal heat being super-added. The principal cause of shrinkage is the increasing dryness of the atmosphere consequent upon 300 years of general Alpine deforestation. An air loaded with moisture deposits its moisture in the shape of ice crystals and prisms upon any surface the temperature of which is under freezing point, and if those surfaces are conveniently situated to preserve those icicles which are atmosphere-born and grow day by day to be acral reefs, the foundation is laid for a glacier.

Page 21. Glaciers move at a quicker rate along their centre-line because the ice along this line is pressed down by lateral pressure, the result of the gravity of side masses, and of the resistance of the rock-bed which these masses cannot press back outwardly, ice being an elastic body.

Page 22. I connect with this page, which contains a most instructive sketch of the Mer de Glace, a description of the influence of *vegetation* and *climate* upon the growth and the shrinkage of glacier-areas, in the Alps only.

The species of pine, popularly called the *arolle*, has given its name to the famous Alpine resort, Arolla. This tree is now almost extinct and the few remaining forests of *arolles* are as much as possible protected against destruction. At one time these forests extended over extremely vast mountain areas, and if their remains are now so difficult to preserve, it is simply because they have exhausted the soil of the Alps, so far as nourishment suited for that type of pine is concerned.

The *arolle* forest has a luxuriant undergrowth; thick and tall mosses cover a damp and thick layer of soil. There are many shrubs growing out of that moss in thick tangled masses, and the general moisture is such that peaty and marshy patches are most frequent. In prehistoric times—and these practically reach, for Switzerland, down to the days of Julius Cæsar—the Swiss climate was characteristically damp and warm; if only a fraction of a degree, on an average, damper and warmer than nowadays. The forest belt extended from lake and river banks to the height of from six to seven thousand feet upon the Alpine slopes. It constituted, in its protected subsoil, in its mosses, marshes and shrub tangle, in its continuous tree growth, a vast and ever refilled reservoir of rain and snow water. Vapours and fog rose from it in much larger quantities than at present. During the long periods of wind-

stillness which characterize the Alpine climate in winter to the present day, these fogs rested upon the belt of everlasting snow above the forest line, fed it, kept it much broader than it is now, and brought it down much nearer to the forest edge. The quantity of snow-ice thus accumulated during those distant ages was bound to diminish in a ratio proportionate to the reduction of the ancient forest area. What produces glacier-ice is an accumulation of moisture in an atmosphere which is below freezing-point.

Page 23. Glaciers move at a quicker rate in summer because their reaches are then more uniformly subjected to a temperature above freezing-point of the air. That increase of speed appears to be in exact proportion to the shrinkage, and corresponds to a release from pressure all over the mass, a consequence of the melting process (both static and mechanical), non-existent in winter. Any deep sub-glacial melting which may take place in winter is immediately cancelled, as a mechanical agent, by re-freezing on reaching the air.

Page 24. Leaving aside the universal geological agents, it is clear that the shrinkage and growth of glaciers in the Alps is partly the result of man's interference with nature. The observations of M. Vallot, as to the probable speed of glacier shrinkage within historical times, have, for a complement, similar conclusions as to the rapidity of glacier growth. In illustration of this oscillation we have the local tradition, for instance, as to the Theodul pass from Zermatt into Italy. The people say it was open to horse traffic 1,300 years ago. That it had long ceased to be thus open was so evident that the contrary statement became incredible. But, this year, the pendulum has so far swung back, that mules have been led across the iced watershed with success.

I assign that swinging of the pendulum entirely to the action of man. The Alps entered within the area of civilization in the times of Julius Cæsar, 58 B.C. Switzerland was then, from times immemorial, a forest land. A process of systematic deforestation began and developed during 500 years.

The climate, from a comparatively damp climate, became a comparatively dry climate, and as the process progressed, its ratio of effectiveness grew naturally at a much quicker pace. The glacier world shrank enormously, and Italy was laid open to the incursions of northerners. These northerners destroyed civilization in the Alps and elsewhere, as we all know (from the Channel, from the Danube, from the Rhine, to the Mediterranean). From A.D. 500 to A.D. 800 or 900, an enormous spontaneous re-afforestation of the Alps took place, in the absence of man, in the absence of all commerce and industry. The glacier world re-gained the lost ground, and most of the passes were closed up again. The economic history of the Swiss people makes its influence felt next.

From the fifteenth century, they drove back, unceasingly, the

forest. The process is now so complete that *artificial* re-afforestation has become usual. The glacier world, too, has been driven back with the forest to within its limits in the latter centuries of the Roman Empire.

It is quite possible that the Aletsch glacier has not yet shrunk back to its size in the Roman days. There is no reason to deny that at one time the cattle which now cross it on the ice may have passed through a continuous forest from one side of the valley to the other.

REPLY BY THE AUTHOR.

The communications by Mr. Hudleston and Professor Roget form a valuable addition to my paper. I quite agree with the former, that the shrinkage of the glaciers is mainly due to meteorological causes, and these, again, to disafforesting of the mountain slopes. When the surface of the ground has been deprived of the protection of trees, the radiation of heat tends to disperse the clouds and reduce the rainfall; on the other hand the same process causes the rain to flow down rapidly and suddenly to raise the rivers; and it is owing to this cause that in recent times the rivers descending from the Alps have caused inundations of the plains of Northern Italy.

I cannot agree with Professor Roget in his explanation of the differential movement of the central portion of the glacier as compared with that of its sides. The true explanation is, as it seems to me, that like a river flowing along its bed—the friction of the sides of the glacier against its basin retards the motion, whereas along the centre this retarding agency is absent, and the ice drags away from its sides, causing the crevasses to run upwards this is generally recognized.