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The Glacial Catastrophe in Savoy

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the site of Ptolemy Pheron, mentioned by Strabo, as he records that near there was a large island where olives grew; this may be Bahdur, than which, with the exception of Er-ri, also lying off this part of the coast, there is no island of any size nearer than the Massawa group. In both islands there are very old cisterns arched over, and in Er-ri two stones (basalt, which must have come from the mountains inland) were found bearing inscriptions in ancient Arabic.

Fourteen sub-tribes of the Beni Amer are enumerated, with their former headquarters, but the country is now deserted except at Akik-el-Soghier and Adobena. Two years ago the mountain district was prosperous, but the dervishes have driven the inhabitants south towards Senhet. The Beni Amer are all cattle-owners, and there is little agriculture, any suitable spots on the small mountain plateau being invariably used for cemeteries.

The Glacial Catastrophe in Savoy.

MOUNTAIN regions are subject to many sorts of sudden disasters, but the terrible catastrophe in the Haute Savoie, which has lately caused so lamentable a loss of life at the Baths of St. Gervais, is of a kind happily rare, even among snow-clad ranges. It was brought about by an inundation, which, however, must not be confused with the inundations, similar in nature and effect, but not in origin, which are caused when a glacier advances from a lateral glen across a main valley, dams its stream, and thus creates a lake, which eventually bursts. Such accidents have occurred among the Alps in the Val de Bagnes (Glacier de Getroz), in 1595 and 1818, and in the Oetzthal (Vernagt Glacier) several times both in the last and present centuries (see Ball's 'Alpine Guides'), and more than once in the Valley of the Indus (see Drew's 'Jummoo and Kashmir'). From such catastrophes the recent outbreak was quite distinct. Mr. Ball writes:—"Comparatively small glaciers, lying on a steep rocky slope, have been known, in a few rare instances, to detach themselves wholly or partially from their beds, and to fall into some lower valley." And he instances the destruction of Randa, in the Zermatt Valley, by the Bies Glacier in 1819. This is, apparently, what happened in the chain of Mont Blanc, with the addition that the fall was accompanied by a flood of water capable of carrying the mischief to a great distance. The nearest parallel, probably, may be found in the Caucasus, in the disastrous floods which have several times swept out of the Devdorak glen, under the north-eastern face of Kasbek, and destroyed, after a course of several miles, the high road in the Dariel gorge. These the Russians have described as "the avalanches of Kasbek," and I well recollect Sir Roderick Murchison's interest and surprise when I was, in 1868, able to describe to him the locality and the true character of the sudden outburst of ice and water.

The recent catastrophe may most exactly be described as the explosion of a glacier by the stoppage of the sub-glacial water-channels which drain it. All glacier explorers are well aware that the ice does not melt only at its lower extremity; strong streams flow along the surface of the upper névés, and tumble down the shafts known as moulins, to the rocky floor on which the ice rests. Their volume is sometimes proved by a great waterfall bursting out of the side of the ice, as the Arveiron once did below the Montanvers; or, as may be seen often, the drainage of a large lateral glacier is buried, after a short course under the open sky, in

the ice-stream of the main valley. These sub-glacial streams are busy at work eroding deep and narrow channels. Examples may be examined where the ice has recently retreated, *e.g.*, on the Eiger Glacier, close to the Wengern Alp, or at the Rosenlauri Glacier. This fact—the erosion by water going on under glaciers—has been little noticed by travellers, or in scientific handbooks and treatises.

It stands to reason that when the bulk of frozen matter descending the mountain-side is confined by narrowing slopes, when it has to pass through a funnel, there is a greater risk of these sub-glacial vaults and channels being stopped or choked. This risk will be further heightened when the bulk of descending ice is on the increase. It may be remembered that last year (see 'Proc. R. G. S.,' vol. xiii., p. 683) I pointed out that the névés on Mont Blanc were swelling, and that to an extent that renders the ordinary route across the Petit Plateau dangerous on account of avalanches from the Dôme du Gouter.

The Glacier de Bionasset, the main source of the stream, down the bed of which the destroying flood recently poured on St. Gervais, flows from the horseshoe under the northern cliffs of the Aiguille, of the same name, and the Aiguille du Gouter. It was by its flanks that De Saussure and Boutrif made their early attempts to ascend Mont Blanc, and their tracks are now followed by climbers who take what is known as the St. Gervais route. Otherwise the glacier is little visited. It has a steep and rapid course in its upper portion, falling some 3000 feet from the base of the Aiguilles to a comparatively level pasture, on which its lower extremity rests. On its right, or north bank, it is confined by a flat-topped, rocky ridge—La Tête Rousse (*circa* 9000 feet). North of this ridge lies a small glacier, which no one that I know of—since De Saussure—has thought worthy of mention. Flowing from under the ridge that divides the Bionasset basin from the Valley of Chamonix, it gives birth to a small torrent—easily stepped over by a child even on a warm afternoon—which falls very rapidly down steep rocky slopes and sheep pastures into the Bionasset Glacier. De Saussure, who bivouacked at its base, speaks ('Voyages,' vol. ii.) of this little glacier—now distinguished as the Glacier de la Tête Rousse—as "a small glacier covered with snow, from which issues a clear and fresh stream, which served all the needs of my party." Its torrent does not enter the Chamonix Valley, but turned west by the ridge of the Prarion falls for three miles through a steep glen to join the Bonnant, or Contamines stream, at Bionnay (3200 feet). The Bonnant then flows through meadows, and gradually sinks into a wooded cleft as it approaches the village of St. Gervais. It is crossed above the village, which stands safe and high on the hillside 600 feet above the Baths (which are 2060 feet above sea-level), by a bridge of a single arch, at a very great height above the water. This has escaped injury. Below this is, or was, the broken arch of the old bridge, which carried the track used from ancient times until quite recently as one of the accesses from lower Savoy to the Valley of Chamonix. A Roman boundary-stone has been found close by on the Forclaz. At this point, by a sudden plunge of about 500 feet, the Bonnant reaches the bottom of a deep, narrow dell, which half a mile lower down, some six miles from the end of the Bionasset Glacier, opens into the valley of the Arve. Close to the foot of the fall, beside the torrent, stand the Baths, established in the first decade of the present century. The village of Le Fayet (1950 feet), the halting-place of the Chamonix diligences, lies in the open valley of the Arve, at the mouth of the glen, which is exceedingly narrow in its upper portion—not 100 yards wide at the Baths. Part of the building stood immediately above the water.

This insignificant glacier of the Tête Rousse proves to have been the source of the outbreak. The only first-hand account of it as yet received is that given by the Sous-Guide-Chef of Chamonix, who went with two comrades to visit the spot, a three

hours walk from the well-known "Pavillon de Bellevue." The following is the guide's official report:—"The avalanche of ice and water proceeded from a lake formed under the Glacier de la Tête Rousse, at the foot of the Aiguille du Gouter. The front of the glacier is something over 330 feet in width, and 100 in height; it has been broken off perpendicularly by the pressure of the water. There is now under the ice a cave some 115 feet in breadth, and 50 in height. We were unable to ascertain its extent. Close to the mouth of the cavern we found snow lying. This led us to suppose that the water had been thrown out with such force as to form an immense cascade, leaping over the rock (?). There is no further danger at present on the St. Gervais side, and a ridge of rocks protects the Valley of Chamonix."

This note is not as clear as could be wished on all points; but it makes the source of the disaster certain, if not all the peculiarities that made it so fatal. The agent of devastation was, in fact, an avalanche riding on a flood. The fronts of many small glaciers give way and fall, but their impetus does not take them beyond at worst the shepherds' huts; this swept unchecked for at least 6 miles. The question which is difficult to answer is, how did a force of water sufficient to act as carrier to so much solid matter accumulate beneath so small an ice-field? Its own drainage is insignificant, and if bottled up by movements of the ice in one place, would almost certainly find another exit. Is it possible that the "clear water" issuing from the ice, mentioned by De Saussure, points to some sub-glacial spring or reservoir, which may have been pent up? This, however, must be regarded rather as an ingenious conjecture than as a solid hypothesis. But the theory put forward by the distinguished naturalist, M. Forel, that the heat generated by the first fall of the ice down the slope of 3000 feet to the plain on which the lower portion of the Bionnasset Glacier rests, was sufficient to turn it into water, is contrary to experience, and cannot be accepted. The Bies Glacier did not turn to water in its fall, nor do the avalanches that fall an equal height on the cliffs of the Wetterhorn. The ice is, in fact, broken into fragments, which reconsolidate, when they reach level ground, into a solid bank. It is very much to be desired that some traveller, with a practical and scientific knowledge of glaciers and their behaviour, should as soon as possible carefully examine the spot.

The hour of the catastrophe confirms a conclusion I have drawn from much experience—that the coldest as well as the hottest moments of the twenty-four hours are those when most avalanches fall. The cause is obvious. The destructive force of melting is fully equalled by the splitting caused by the freezing of water in the ice-veins.

It is obvious that both Bionnay and the Baths occupied the worst positions possible, where the flood would have its greatest velocity and be most concentrated. Le Fayet was exposed by another cause—the relative height of the bed of the stream, raised on ancient detritus, above the houses on its left bank. But much that has been written in newspapers with regard to the recklessness of building on such sites is mere after-the-event wisdom. The Bonnant is a friendly stream: its banks fringed with foliage bear witness to its usually quiet habits. No similar catastrophe is recorded to its discredit. For ninety years the Bath-house had never been in peril. A Paris journal suggests that an Inspector-General of Glaciers should be appointed, to prevent similar catastrophes in future. He will have his work cut out in seeing to every out-of-the-way glacier of the French Alps! Such a proposal shows to what an extent belief in State regulation extends among our neighbours. Another newspaper suggests that there need be no fear of a frequent recurrence of such disasters as the Government have taken in hand the re-afforesting of the French Alps! Such are the dangers of a little knowledge. The practical lesson to be drawn from the catastrophe is, that

in mountain regions the mildest-mannered torrent should not be made too close a neighbour.—[D. W. F.]

Postscript.—The Chamonix guide and traveller, François Dévouassoud, sends the following account of the result of a visit just made by M. Vallot—well known for his scientific researches on Mont Blanc, and as the originator of the observatory named after him near the top of the mountain—to the scene of the outbreak :—“On the little Glacier de la Tête Rousse M. Vallot found that two basins of water had formed, the upper being the larger. The upper basin first gave way, and its contents poured into the lower, which then broke through a barrier of ice 130 feet thick, forming an opening of 130 feet, a sort of gorge or cave. According to M. Vallot’s estimates the avalanche contained 3,600,000 cubic feet of water, 300,000 cubic feet of ice, and collected in its descent 11,000,000 cubic feet of débris. Its depth is put at 20 feet, width 160 feet, and length 3300 feet. It fell first, not on to the Glacier de Bionasset, but down the bed of the little torrent of the Glacier de la Tête Rousse, on to that pretty level meadow you know well.

“It is reported that the little torrent had been dry for two months; but as no one had climbed Mont Blanc by the Aiguille du Gouter this year, the lakes on the glacier had not been noticed, and no steps were taken to drain them. Everyone says no similar disaster has ever been heard of.”

Except that it is not yet made quite certain whether the lakes were on or under the surface of the glacier, this account is clear and definite. M. Vallot’s full report will be awaited with interest. M. Tairraz will photograph the spot as soon as the weather permits, and send copies to the Society.—[D. W. F.]

GEOGRAPHICAL NOTES.

Admission of Ladies as Members.—The Council has resolved on a step that has been for some time under its consideration—to throw open the Fellowship of the Society on the same terms and conditions to both sexes. The increasing number of ladies, eminent as travellers, and contributors to the stock of geographical knowledge, and the number of women now interested as students, or teachers, in our branch of science, coupled with the evidence brought forward of a desire among both classes to enjoy the practical privileges conferred by our Fellowship, were, in the opinion of the Council, sufficient reasons for at once making the proposed extension, which will, it is believed, be to the advantage of the Society, and meet with general approval among the Fellows.

Death of Miss Cracroft.*—In the death of Miss Sophia Cracroft, which occurred on June 20th, Arctic authorities of all nationalities will recognise that a striking personality has been removed from among them. The niece of Sir John Franklin, she was brought up from

* By Admiral Sir George H. Richards, K.C.B.