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THE EXCAVATION

OF

THE VALLEYS OF THE ALPS.

BY

A. C. RAMSAY, F.R.S.

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**I**N the month of March last I read a memoir to the Geological Society on the Glacial Origin of the Swiss and other Lakes, which has since been published in that Society's Quarterly Journal for August. In that memoir I incidentally alluded (p. 200) to the existence of the chief Alpine valleys *before* the glaciers attained their greatest extension, which valleys were afterwards "*modified* in form by the weight and grinding power of ice in motion."

In a previous memoir, published in 1859, I stated that "it is certain all glaciers must deepen their beds by erosion, and it may be that, when a glacier filled a valley" almost to the brim, "the thickness of the ice was not equal to the present mass added to the superincumbent weight indicated by the signs (striation, &c.) on the slopes above the present surface of the glacier." But though glaciers certainly have a powerful effect in deepening their beds, it has always appeared to me a difficult and perhaps an impossible point to determine to what extent the great Alpine valleys have been eroded by ice—whether, in fact, they have been chiefly scooped out by it, or whether, as I always believed,

their general contours only have been thoroughly moulded and modified. During a late visit to the Alps I obtained, by help of that distinguished geologist, Mr. Gastaldi of Turin, some important evidence on the subject.

No true geologist is likely to assert that these valleys have been mainly scooped out from end to end by ice, for the reason that, *since* the disappearance of the ice, running water, in the formation of gorges, &c., has comparatively effected so little. Given sufficient time, and, as old Ray long ago inferred, any amount of degradation may be produced by rain and running water. The Alpine streams have doubtless flowed in their present channels for long, and, compared with the depth of the valleys, have done but little. *Long*, however, is a comparative term, and in this instance it may represent a very brief period compared either with the length of the great glacial epoch, or with that which, preceding it, came after the disturbance of those Miocene rocks that form so important a portion of the Alps, and the right understanding of which disturbance is an essential element of the question. For obvious reasons (which it would take long to detail, but which every geologist will appreciate) it is evident that the period that has passed between the disappearance of the great glaciers and the present day is trifling compared with that which elapsed between the close of the Miocene and the commencement of the *glacial epoch* of geologists; and also there is good reason for suspecting that the great glacial epoch itself was longer than that which has passed since the climate of the northern hemisphere ameliorated. It is not therefore to be expected that the later modifications of Alpine valleys produced by existing causes should be commensurate to the old, for *time* is wanting. When we go back to the epochs that followed the disturbance of the Swiss Miocene rocks, we have to deal with periods so long, that (if the style of reasoning of the greatest geologists and naturalists is worth anything) the glacial and existing epochs united are trifling compared with it; for during those periods the mammalian life of the world was renewed again and again, and the invertebrata of the seas, though as species far more enduring, were by slow gradations almost all replaced; while since the commencement of the "glacial epoch" it is more than doubtful if a single species of marine mollusca has disappeared. There was therefore, after the disturbance of the Miocene rocks of the Alps, ample time for enormous degradation by any existing cause.

Let any one who doubts the wasting and erosive power of common atmospheric agents aided by running water, visit Auvergne and the countries formed of solid rocks bordering the Rhine and Moselle. Like the Alps, both of these regions have been above the sea, at least, ever since the close of the Miocene epoch. Both



are unaffected by ice; and the valleys in them, which are neither few nor small, have all, in the opinion of the best observers, been scooped out by running water during those immense periods of time the relics of which are partly represented by the subdivisions of the Crag and of other strata still more fragmentary, all of which were deposited before the glacial epoch. During all these periods, and many more, of which few traces remain, the Alps were being wasted; and no geologist acquainted with the evidences of the climate of the times is likely to assert that the great glaciers of the Alps endured during all these changes. The question, therefore, easily arises, to what extent were the Alpine valleys formed during those periods that preceded the "Glacial epoch" *par excellence*, so called from the existence of continental phenomena, both in America and Europe, of which even the old glaciers of the Alps form but a minor part. The evidence is imperfect; but such as it is, it gives much more than a hint that the large valleys were in their main features approximately as deep as now before they were filled with ice. The belief is as old as the writings of Charpentier; and others who entertain the notion have only followed in his wake.

At the mouth of the valley of Aosta, the great moraine of Ivrea, which consists of loose material piled on the plain to a height of about 1600 feet, proves that, where the glacier issued from the valley upon the plain, the ice at the sides was at least of that thickness, and probably still thicker in the middle. Further, when lately south of the Alps, it was proved to me by Mr. Gastaldi\*, that at the mouths of the great Alpine valleys opening on the plain of the Po, there were ancient alluvial fan-shaped masses of gravel quite analogous to those that by the agency of existing torrents have issued from the gorges on either side (for instance) of the valleys of the Rhone or the Dora, or of those that still issue at their mouths. These were deposited on a plain rather lower than the existing one, above Pliocene marine deposits, at a time when the true mountain-valleys—at all events near their mouths—were just about as deep as they are now; for the great glaciers that filled the larger valleys issued out upon and overflowed these low-lying river gravels, and deposited their moraines *above* them, only in part scooping them away, apparently because the glaciers did not endure long enough of sufficient size to complete their destruction.

No better proof could be required that in great part the valleys of the Alps were approximately as deep before the glacial epoch as they are at present; and I believe, with the Italian geologists, that all that the glaciers as a whole effected was only slightly to deepen these valleys and materially to modify their general out-

\* See also memoirs by Mortillet and Omboni.

lines, and, further (a theory I am alone responsible for), to deepen them in parts more considerably when, from various causes, the grinding power of the ice was unusually powerful, especially where, as in the lowlands of Switzerland, the Miocene strata are comparatively soft. But for details on this point I must refer to my memoir in the *Journal of the Geological Society*.







