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ORIGINAL ARTICLES.

I. NOTES ON THE SHAPE AND STRUCTURE OF SOME PARTS OF
THE ALPS, WITH REFERENCE TO DENUDATION.—PART II.

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(Plate VI.)

AT the extremity of my sketch, fig. 1, p. 52, which by the printer's inadvertence is marked *y* instead of *x*, the beds appear to turn suddenly downwards. They are actually more inclined at this spot; but the principal cause of their apparent increase in steepness is a change in their strike. Generally parallel to the precipice, it here turns westwards (*i.e.* towards the spectator); and, holding myself bound in candour to note, as I proceed, every circumstance appearing to make for the modern glacial theories, I must admit that, as the beds at this extremity of the cliff turn outwards from the Alps, it might not inaptly be concluded that the great Chamouni Glacier, which by its friction filed the mountain two thousand feet down at the top, by its pressure turned the end of it several points of the compass round at the bottom!

This change in the strike of beds, though over a very limited space, yet perfects the Salève as a typical example, entirely simple in its terms, of a wave of the undulatory district of the Savoy Alps. I call it the 'undulatory' district, because, in common with a great belt of limestone ranges extending on the north side of the gneissose Alps as far as the Valley of the Rhine, it is composed of masses of rock which have bent like leather under the forces affecting them, instead of breaking like ice; and their planes of elevation are therefore all, more or less, curved.

This is one of the points on which I want help. I have hitherto met with no clear statement of the supposed or

supposable differences between the mountains which rise bending, and those which rise rigid. The conglomerates of Central Switzerland, for instance, are raised always, I think, in rectilinear masses, league heaped on league of continuous slope, like tilted planks or tables. But the subjacent limestones of Altorf and Lauterbrunnen are thrown into fantastic curves. The gneissitic schists of Chamouni are all rectilinear; those of Val d'Aoste and the Black Forest are coiled like knots of passionate snakes. Is this difference caused by difference in the characters of the applied forces, or by differences in the state of the materials submitted to them? If by difference in the materials, it is not easy to understand how forces which could twist limestone-beds a thousand feet thick, as a laundress wrings linen, could have left conglomerates in any other state than that of unintelligible heaps of shingle and dust. But if the difference is in the manner of the agency, we have instantly a point of evidence of no small value respecting the date and sphere of any given elevatory force. But I have not yet seen any attempt to distinguish, among the several known periods of elevation in the Alps, those during which the action was accompanied by coiling pressures from those, if any, during which we have only evidence of direct heave. And the question is rendered both more intricate and interesting by the existence of the same structural distinction on a small scale. The metamorphic series, passing from gravel into gneiss, through the infinitely various 'poudingues,' is far more interesting than the transition from mud to gneiss through the schists, except only in this one particular, that the conglomerates, as far as I know them, do not distinctly coil. Their pebbles are wrenched, shattered, softened, pressed into each other; then veined and laminated; and at last they become crystalline with their paste: but they neither coil, nor wholly lose trace, under whatever pressure, of the consistent couching on their broad sides, which first directed Saussure's attention to the inclined position of their beds; whereas limestones in the same transitional relation to the gneiss (those under the Castle of Martigny, for example) wrinkle themselves as if Falstaff's wit had vexed, or pleased, them, and made their faces 'like a wet cloak ill laid up.'

It is true that where the conglomerates begin to take the aspect of shattered breccias, like those which accompany great faults, some aspect of coiling introduces itself also. I have not examined the conglomerate-junctions as I have the calcareous ones, because the mountain-forms of the breccias are so inferior (for my own special purposes of art) to those of the schists,

that I never stay long in the breccia districts. But a few hours of study by the shores of the Reuss or Limmat are enough to show the general differences in aspect of compression between metamorphic schists and conglomerates; and the distinction on a large scale is everywhere notable; but complicated by this fact, which I have not until lately ascertained positively, that through even the most contorted beds of the limestones there run strange, long, rectilinear cleavages, extending in consistent slopes for leagues,—giving the mountain-mass, seen at right angles to their direction, an aspect of quite even stratification and elevation, with a strike entirely independent of its true beds and minor cleavages, and traversing them all.

Putting these gigantic cleavages (of the origin of which, even if I could guess any reason, I would still say nothing so long as I could do no more than guess) for the present out of the question, the mass of the Savoy limestones forms a series of surges, retreating from the Alps, undulatory in two directions at least, as at fig. 1, A, Pl. VI., and traversed by fissures usually at right angles to the strike of the longitudinal surge. When that strike varies consistently at the same time, we may get conditions of radiant curve and fracture, B; and the undulations themselves are seldom simple, as at *a*, but either complicated by successive emergence of beds, *b*, or more frequently by successive faults, *c*, farther modified by denudation of upper beds, *d*, and, locally, by reversals of their entire series, *e*.

All these complex phenomena will be produced by one consistent agency of elevatory or compressive force. Any number of such tides of force may of course succeed each other at different epochs, each traversing the series of beds in new directions,—intersecting the forms already produced, and giving maxima and minima of elevation and depression where its own maxima and minima coincide with those resultant from previous forces.

Now, by every such passage of force, a new series of cleavages is produced in the rocks, which I shall for the present call ‘passive cleavages,’ as opposed to ‘native cleavages.’ I do not care about the names; anybody is welcome to give them what names they choose; but it is necessary to understand and accept the distinction. I call a cleavage ‘native’ which is produced by changes in the relation of the constituent particles of a rock while the mass of it is in repose. I call a cleavage ‘passive’ which is produced by the motion of the entire mass under given pressures or strains. Only I do not call the mere contraction and expansion of the rock *motion*; though, in large formations, such changes in bulk may involve motion

over leagues. But I call every cleavage 'native' which has been produced by contraction, expansion, segregation, or crystallization, whatever the space over which the rock may be moved by its structural change; and I only call a cleavage 'passive' which has been caused by a strain on the rock under external force. Practically, the two cleavages, or rather the two groups of cleavages, mingle with and modify each other; but the 'native' cleavage is universal;—the 'passive' is local, and has more direct relations with the mountain-form.

In the range, for instance, of which the Aiguille de Varens forms the salient point, of which the rough outline is given in the same plate, fig. 2, seen in front, and in fig. 4, seen in profile, the real beds dip in the direction *a b*, fig. 4, being conspicuous in every aspect of the mountain in its profile: they are seen again on the opposite side of the valley (of Maglans) at *c d*. On the face of the mass, fig. 2, they are seen to be contorted and wrinkled, on the left reversed in complete zigzags;* but through all these a native cleavage develops itself in the direction *e f*, accompanied by an elaborate network of diagonal veining with calcareous spar.

This cleavage directs the entire system of the descending streams, which, by help of it, cut the steps of precipice into oblique prisms, curved more and more steeply downwards, as the sweep of the torrent gains in power; so that, seen from a point a little farther to the right, the mountain seems composed of vast vertical beds, more or less curved in contour, fig. 3. But the face of the precipice itself is hewn into steps and walls, with intermediate slopes, by a grand vertical passive cleavage, *g h*, fig. 4, to which the direction and disposition of the entire Valley of Maglans are originally owing.

And thus in any given mountain-mass, before we can touch the question of denudation, we have to determine the position it occupies in the wave-system of the country,—the connections of its cleavages with those of neighbouring masses,—and the probable points of maxima elevation which directed the original courses of glacier and stream. Then come the yet more intricate questions respecting the state of the materials at each successive elevation, and during the action of the successively destructive atmospheric influences.

I have no pretension to state more than a few of the main facts bearing on such questions in the Savoy districts of the Lower Chalk, which I will endeavour to do briefly in one or two following papers.

* This contortion is an important one, existing on both sides of the valley; but it is in reality farther to the left. I have crowded it in to complete the typical figure.