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ON THE FORMS OF THE STRATIFIED ALPS OF SAVOY

(1863)

[*Bibliographical Note.*—This was a lecture given by Ruskin at the weekly evening meeting of the Royal Institution (Sir Henry Holland, Bart., in the Chair), June 5, 1863.

An abstract of the lecture, drawn up by Ruskin and here given (pp. 3–11), was published in the *Proceedings of the Royal Institution* (vol. iv. part ii., No. 38, pp. 142–146).

The abstract was reprinted separately with the following title :—

> Royal Institution of Great Britain. | Weekly Evening Meeting, Friday, June 5, 1863. | Sir Henry Holland, Bart., M.D., D.C.L., F.R.S., Vice-President, | in the Chair. | John Ruskin, Esq. | On the Forms of the Stratified Alps of Savoy.

Octavo, pp. 4. The title occupies the upper portion of p. 1. Issued stitched and without wrappers; there is no imprint, and there are no headlines, the pages being numbered centrally.

The abstract was next reprinted in the *Geologist* for July 1863, vol. vi., No. 67, pp. 256–259.

It was included in *On the Old Road*, 1885, vol. i. pp. 721–727 (§§ 581–588); and again in the second edition of that book, 1899, vol. ii. pp. 359–366 (§§ 290–297). The sections are here renumbered.

A full report of the lecture, in the preparation of which the reporter clearly had access to Ruskin's MS., appeared in the *London Review* of June 13, 1863. As this report often reproduces Ruskin's own words, it is here appended (pp. 12–17).

An account of the lecture, for the most part translated from the *London Review*, appeared in French in the feuilleton of the *Journal de Genève* of September 2, 1863. The translation was made by Madame Adèle Roch, wife of a jeweller at Geneva.

In the *Geologist* for September 1863 (pp. 321–327), the editor (S. J. Mackie, F.G.S., F.S.A.) had an article on the lecture, with which were printed two woodcuts from diagrams shown by Ruskin; these are here reproduced (Plates I. and III., pp. 6, 14). The article quotes several passages from the lecture; these are here given in footnotes on pp. 3, 4, 5, 7, 9.]

ON THE FORMS OF THE STRATIFIED ALPS OF SAVOY

1. THE purpose of the discourse was to trace some of the influences which have produced the present external forms of the stratified mountains of Savoy, and the probable extent and results of the future operation of such influences.[1]

The subject was arranged under three heads:—

(I.) The Materials of the Savoy Alps.
(II.) The Mode of their Formation.
(III.) The Mode of their subsequent Sculpture.

2. (I.) *Their Materials.*—The investigation was limited to those Alps which consist, in whole or in part, either of Jura limestone, of Neocomian beds, or of the Hippurite limestone, and include no important masses of other formations. All these rocks are marine deposits; and the first question to be considered with respect to the development of mountains out of them is the kind of change they must undergo in being dried. Whether prolonged through vast periods of time, or hastened by heat and pressure, the drying and solidification of such rocks involved their contraction, and usually, in consequence, their being traversed throughout by minute fissures. Under certain conditions of pressure, these fissures take the aspect of slaty cleavage; under others, they become irregular cracks, dividing all the substance of the stone. If these are not

[1] ["'Geology,'" remarked Mr. Ruskin in his opening words, 'properly divides itself into two branches,—the study, first, of the materials and chronology of deposits; and, secondly, of their present forms'" (report in the *Geologist*, September 1863, p. 321).]

filled, the rock would become a mere heap of débris, and be incapable of establishing itself in any bold form. This is provided against by a metamorphic action, which either arranges the particles of the rock, throughout, in new and more crystalline conditions, or else causes some of them to separate from the rest, to traverse the body of the rock, and arrange themselves in its fissures; thus forming a cement, usually of finer and purer substance than the rest of the stone. In either case the action tends continually to the purification and segregation of the elements of the stone. The energy of such action depends on accidental circumstances: first, on the attractions of the component elements among themselves; secondly, on every change of external temperature and relation. So that mountains are at different periods in different stages of health (so to call it) or disease. We have mountains of a languid temperament, mountains with checked circulations, mountains in nervous fevers, mountains in atrophy and decline.

3. This change in the structure of existing rocks is traceable through continuous gradations, so that a black mud or calcareous slime is imperceptibly modified into a magnificently hard and crystalline substance, enclosing nests of beryl, topaz, and sapphire, and veined with gold. But it cannot be determined how far, or in what localities, these changes are yet arrested; in the plurality of instances they are evidently yet in progress.[1] It appears rational to suppose that as each rock approaches to its perfect type

[1] [The report in the *Geologist*, September 1863, p. 322, gives here some of Ruskin's words:—

"'Through the whole body of the mountain there runs, from moment to moment, year to year, age to age, a power which, as it were, makes its flesh to creep; which draws it together into narrower limits, and in the drawing, in the very act, supplies to every fissure its film, and to every pore its crystal.'

"And in this change the imaginative mind of Mr. Ruskin saw, perhaps with prophetic distinctness, how all terrestrial things were purifying themselves for some greater end, some more beautiful condition. All is advance, from disorder to system, from infection to purity; nor can any of us know at what point this ascent will cease. We can already trace the transformation from a grey flaky dust, which a rain-shower washes into black pollution, to a rock whose substance is of crystal, and which is

the change becomes slower; its perfection being continually neared, but never reached; its change being liable also to interruption or reversal by new geological phenomena. In the process of this change, rocks expand or contract; and, in portions, their multitudinous fissures give them a ductility or viscosity like that of glacier-ice on a larger scale. So that many formations are best to be conceived as glaciers, or frozen fields of crag, whose depth is to be measured in miles instead of fathoms, whose crevasses are filled with solvent flame, with vapour, with gelatinous flint, or with crystallizing elements of mingled natures; the whole mass changing its dimensions and flowing into new channels, though by gradations which cannot be measured, and in periods of time of which human life forms no appreciable unit.

4. (II.) *Formation.*—Mountains are to be arranged, with respect to their structure, under two great classes—those which are cut out of the beds of which they are composed, and those which are formed by the convolution or contortion of the beds themselves.[1] The Savoy mountains

starred with nests of beryl and sapphire. But we do not know if the change is yet arrested, even in its apparently final results. We know in its earlier stages it is yet in progress; but have we in any case seen its end?"]

[1] [Here, again, the *Geologist*, pp. 323–324, gives some of the lecturer's words:—"There is the mountain which is cut by streams or by more violent forces out of a mass of elevated land, just as you cut a pattern in thick velvet or cloth; and there is the mountain produced by the wrinkling or folding of the land itself, as the more picturesque masses of drapery are produced by its folds. Be clear in separating these two conditions. There are two ways in which this folding of the hills may be effected. You may have folds suspended or folds compressed. If underneath, a mass comes up which sustains the folds,—a pendant wave; but if the force be lateral, you have a compressed wave. And observe this further distinction:—if a portion be raised by a force from beneath, unless the beds be as tenacious as they are ductile, they will be simply torn up and dragged out of shape at that place, and on each side the country will be undisturbed. But if they are pushed laterally into shape, the force of the thrust must be communicated through them to beds beyond; nay, the rock which immediately receives the shock may, if harder than those beyond it, show little alteration of form, but pass on the force to weaker beds at its side, and thus affect a much larger space of country than the elevatory convulsion. Now the fact is that in the Alps both these actions have taken place, and have taken place repeatedly, so that you have evidence both of enormous lateral thrusts which have affected the country

are chiefly of this latter class. When stratified formations are contorted, it is usually either by pressure from below, which raises one part of the formation above the rest, or by lateral pressure, which reduces the whole formation into a series of waves. The ascending pressure may be limited in its sphere of operation; the lateral one necessarily affects extensive tracts of country, and the eminences it produces vanish only by degrees, like the waves left in the wake of a ship. The Savoy mountains have undergone both these kinds of violence in very complex modes and at different periods, so that it becomes almost impossible to trace separately and completely the operation of any given force at a given point.

5. The speaker's intention was to have analysed, as far as possible, the action of the forming forces in one wave of simple elevation,[1] the Mont Salève, and in another of lateral compression, the Mont Brezon: but the investigation of the Mont Salève had presented unexpected difficulty. Its façade had been always considered to be formed by vertical beds, raised into that position during the tertiary periods; the speaker's investigations had, on the contrary, led him to conclude that the appearance of vertical beds was owing to a peculiarly sharp and distinct cleavage, at right angles with the beds, but nearly parallel to their strike, elsewhere similarly manifested in the Jurassic series of Savoy, and showing itself on the fronts of most of the

> for hundreds of miles, and of local elevations independently operating through them, and breaking their continuity of action. * * * The ripple of a streamlet rises, glances, sighs, and is gone. An Atlantic wave advances with the slow threatening of a cloud, and breaks with the prolonged murmur of its thunder. Imagine that substance to be not of water, but of ductile rock, and to nod towards its fall over a thousand vertical fathoms instead of one, and you will see that we cannot assert, perhaps cannot conceive, with what slowness of march or of decline the mountain-wave may rise or rest. But whatever the slowness of process, the analogy of action is the same. Only remember that this has taken place through rocks of every various degree of consistence and elasticity, and as the force thrills and swells from crag to crag, it is itself rent again and again into variously recoiling, quenched, or contracted energy, and divides itself against itself with destructive contradiction."

The asterisks are in the *Geologist*, apparently marking where the report omits a passage in the lecturer's MS.]

[1] [For the Salève "wave," see also, below, p. 29.]

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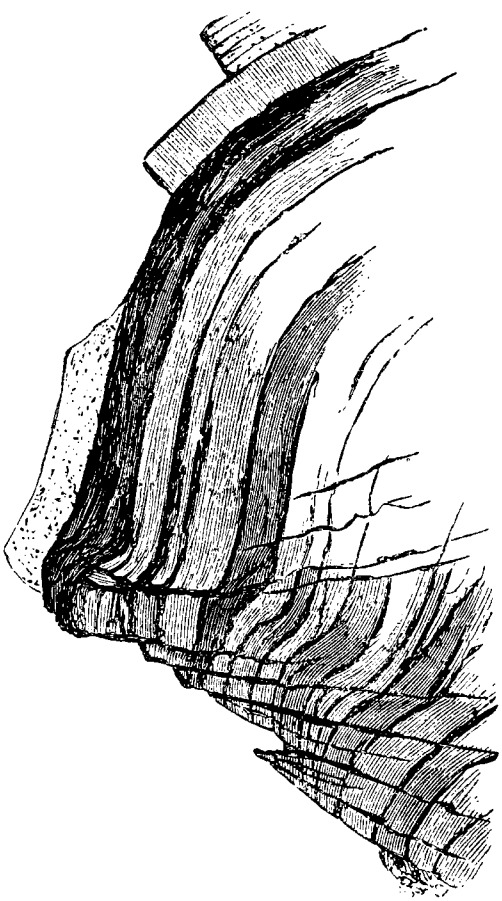

Ideal Section of the Salève

precipices formed of that rock. The attention of geologists was invited to the determination of this question.[1]

The compressed wave of the Brezon,[2] more complex in arrangement, was more clearly defined. A section of it was given[3] showing the reversed position of the Hippurite limestone in the summit and lower precipices. This limestone wave was shown to be one of a great series, running parallel with the Alps, and constituting an undulatory district, chiefly composed of chalk beds, separated from the higher limestone district of the Jura and lias by a long

[1] [The report of this part of the lecture is as follows in the *Geologist* (pp. 324–325):—

"Saussure, Studer, and Favre, leading or copying each other perhaps, as geologists very often do, represent the face of the hill towards Geneva to be formed by vertical beds; but Mr. Ruskin's impression is

> "'that these perpendicular plates of crag, clear and conspicuous though they are, are entirely owing to cleavage,—that is to say, to the splitting of the rock in consequence of the pressure undergone in its elevation; and that the true beds curve into the body of the hill. I dare not,' he adds, 'speak with any confidence in opposition to these great geologists, but I earnestly invite some renewed attention to the question, which is of no small importance in determining the nature of the shock which raised the walls of the Alps round the valley of Geneva.'"

The "ideal section of the Salève" given in Plate I. is from the diagram exhibited by Ruskin. Plate II. is engraved from a drawing by Ruskin at Brantwood, on which he has written:—

> "Salève cliff, looking north, after climbing half-way up between Veyrier and the Grande Gorge; showing the likest part to true vertical stratification. But I believe it is *all* cleavage."

"He is fully aware," continues the *Geologist*, "of the difficulties which attend the verification of the section. All the lower part of the Salève is Jura limestone, as determined by Favre, and that this rises up in a nearly vertical sheet along the whole front, thrusting up the Neocomian and compressing it, Mr. Ruskin admits; 'but there is no doubt,' he contends, 'respecting these frontal clefts.' Neither does he deny that there are raised beds of Neocomian on parts of the mountain, as assigned by Favre; but [he contends] that at the Grande Gorge, where the natural section is clearest, there are the beds all following the curve of the summit, and that the vertical fissures are rather faults or cleavages, or partly both, the business being so complicated that one cannot tell which is which." On this subject see further, below, p. 14; and compare W. G. Collingwood's *Limestone Alps of Savoy*, p. 100.]

[2] [The *Geologist* adds (p. 324): "notable in the dash and curve."]

[3] [That is, in the diagram here reproduced (Plate III., p. 14). In addition to this section, Ruskin must have shown a drawing of the mountain group. The report in the *Geologist* (p. 325) again gives the lecturer's words:—

> "You see the group is composed of an isolated pyramidal mass, of a flat mass behind it which extends at both sides, and lastly, of a distant range of snowy summits, in which Mount Vergi and the Aiguille de Salouvre are conspicuous objects. Now these three masses are merely three parallel ridges of limestone-wave, formed mainly of originally horizontal beds of Rudisten-kalk, approaching you as you stand looking from

trench or moat, filled with members of the tertiary series—chiefly nummulite limestones and flysch. This trench might be followed from Faverges, at the head of the Lake of Annecy, across Savoy. It separated Mont Vergi from the Mont Dorons, and the Dent d'Oche from the Dent du Midi; then entered Switzerland, separating the Moleson from the Diablerets; passed on through the districts of Thun and Brientz, and, dividing itself into two, caused the zigzagged form of the Lake of Lucerne. The principal branch then passed between the High Sentis and the Glarnisch, and broke into confusion in the Tyrol. On the north side of this trench the chalk beds were often vertical, or cast into repeated folds, of which the escarpments were mostly turned away from the Alps; but on the south side of the trench, the Jurassic, Triassic, and Carboniferous beds, though much distorted, showed a prevailing tendency to lean towards the Alps, and turn their escarpments to the central chain.

6. Both these systems of mountains are intersected by transverse valleys, owing their origin, in the first instance, to a series of transverse curvilinear fractures, which affect the forms even of every minor ridge, and produce its principal ravines and boldest rocks, even where no distinctly excavated valleys exist. Thus, the Mont Vergi and the Aiguilles of Salouvre are only fragmentary remains of a range of horizontal beds, once continuous but broken by this transverse system of curvilinear cleavage, and worn or weathered into separate summits.

The means of this ultimate sculpture or weathering were lastly to be considered.

the Salève. Probably, I think, approaching at this moment, driven towards you by the force of the central Alps, the highest ridge broken into jags as it advances, which form the separate summits of Alpine fury and foam; the intermediate one joining both with a long flat swing and trough of sea, and the last, the Brezon, literally and truly breaking over and throwing its summit forward as if to fall upon the shore. There is the section of it (Plate III.); the height from base to summit is 4000 English feet,—the main mass of the façade, formed of vast sheets of Rudisten-kalk, 1000 feet thick,—plunging at last, as you see, in a rounded sweep to the plain."]