

EARTH-SCULPTURE*

AMONG the questions which may be treated as matters of strict science, and which yet cannot be wholly divested of the strong human, one might almost say personal, interest which belongs to them, is the birth of mountains and valleys. The familiar outlines of his dwelling-place have fixed the attention of man from the infancy of the race up to the present day. Long before science arose to deal with them they had become inwoven with his history, his habits, and his creed. The great mountains had been to him emblems of majesty and eternity, lifting up their fronts to heaven as they had done from the beginning, and would no doubt do to the end. They rose before him as monuments of the power of that great Being who had heaved them out of chaos. It was enough for him in that early time to feel their mighty influences; he had then no questions or doubts as to how or when they first appeared upon the earth.

Happily, in spite of questioning, exacting Science, these first natural and instinctive feelings are not yet dead within us. A knowledge even of all the laws of mountain-making cannot, if our minds are healthy and our hearts beat true, deprive us wholly of that first genuine child-like awe and wonder in presence of noble mountains,—crag and cliff sweeping in rugged and colossal massiveness above dark waves of pine, far into the keen and clear blue air;—the vast mantle of snow, so cloud-like in its brightness, yet thrown in many a solid fold over crest and shoulder; the dark spires and splintered peaks, half snow, half stone, rising into the sky, like very pillars of heaven; and then the verdure of the valleys below, the dash of waterfalls, the plenteous gush of springs, the laugh and dance of brook and river as they one and all hurry down to the plains—who can see these things for the first time, nay, for the hundredth time, without at least some sparkle of the simple child-like emotion of the olden time, or without appreciating, even if he cannot fully share, the feeling of the poet to whom they bring “dim eyes suffused with tears”?

These great dominant features of the land must indeed ever rivet our imagination, and yet when the questioning spirit of modern science asks to know how they came into being, we are no longer permitted to content ourselves with the early belief that they were but parts of the primæval outlines of the earth. The progress of inquiry and knowledge has destroyed that belief. We find, too, that both labour and patience are needed ere we can understand what has been put in its place. But the task of learning this is well repaid. However grandly the mountains rose when they were gazed at only in awe and wonder, they gain an added sublimity when the eyes which look upon them can trace some of the steps whereby their grim magnificence has been achieved.

We naturally associate the more lofty and rugged parts of the land with the operations of former earthquakes and convulsions by which the solid earth has been broken and ridged into these picturesque forms. This obvious inference was early adopted in geology, and though in many cases a mere belief rather than a legitimate deduction from observation, and springing from a conviction of what ought to be, rather than what has been proved to be the case, it has sturdily maintained its hold alike on the popular mind, and also to a very considerable extent in the orthodox geological creed.

Towards the end of last century, however, Hutton and Playfair, names never to be mentioned in Edinburgh without gratitude and pride, proclaimed views of a very different character. They maintained that the rocks of the land, originally accumulated under the sea, have been upheaved by underground movements, and without pretending to know in what external forms these

rocks first appeared above the sea, they contended that the present contours of the land had arisen mainly from a process of sculpture,—the valleys having been carved out by rains, streams, and other superficial agents, while the hills were left standing up as ridges between. So satisfied were these bold and clear-sighted men that their idea was essentially true, that they gave themselves no concern in gathering detailed proofs in its support. They were content with general appeals to the face of nature everywhere as their best and irrefragable witness. But, as events proved, they were in advance of their time. The views which they promulgated on this subject were first opposed, then laid aside and forgotten. In the subsequent literature of the science for fully half a century they almost wholly disappear. An occasional reference to them may be met with, where, however, they are cited only to be dismissed, as if the writer seemed hardly able to restrain some expression of his wonder that men could ever have been found so Quixotic as to vent such notions, or that others could have been so gullible as to believe them.

Apart altogether from the truth or error of the Huttonian teaching regarding the origin of the earth's superficial features, no one who has the progress of geology at heart can regard without regret this almost contemptuous dismissal of the question from the range of scientific inquiry. For together with that teaching went all interest in, and even all intelligent appreciation of, the problem which Hutton had set himself to solve. Men turned back to vague notions about cataclysms, earthquakes, subterranean convulsions and fractures, of which they spoke, and sometimes still speak, with a boldness in inverse proportion to their knowledge of the actual conditions of the problem. They studied with praiseworthy assiduity and success the working of the various natural agents whereby the surface of the land is affected, but it was with the view rather of showing how the materials of new continents are gathered together, than of learning how the outlines of existing continents have been produced. The study of the origin of mountain and valley went out of fashion, and from the time of Playfair's Illustrations, published at the beginning of this century, received in this country but scant and haphazard attention until in recent years the subject has gradually revived, and has become one of the most prominent and interesting subjects of geological research.

It is not my purpose to give any historical sketch of the progress of inquiry on this question, although I ought not even to refer to it without an allusion to the names of Scrope, Ramsay, Jukes, Ruskin, Dana, Topley, Whitaker, Greenwood, the Duke of Argyll, Mackintosh, and others, who, though often differing widely in their views, have done so much to renew an interest in what will probably always prove one of the most alluring aspects of geology. Thoroughly convinced of the essential truth on which the Huttonian doctrines were based I wish, on the present occasion, first to define and illustrate some of the leading features of these doctrines as I hold them myself, and as I believe them to be held by the great body of active field geologists in Britain, and secondly, to review certain objections which have recently been reiterated against them.

At the outset it is necessary to ascertain what relation the internal arrangements of the rocks bear to the external forms of the land, in other words, the influence of what is called Geological Structure. It is obvious, as Hutton showed, that since the rocks have been formed as a whole under the sea, they must have been raised out of that original position into land, so that the first point we settle beyond dispute is that the mass of the land owes its existence to upheaval from below. But though we fix securely enough this starting point in our inquiry, it by no means follows that we thereby settle what was the original outline of the land so upheaved. The non-

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recognition of this fact has involved not a few of the writers on this subject in great confusion and error.

Among the geologists of the present day there is a growing conviction that upheaval and subsidence are concomitant phenomena, and that viewed broadly they both arise from the effects of the secular cooling and consequent contraction of the mass of the earth. The contraction has not been uniform, as if the globe had been a cooling ball of solid iron. On the contrary, owing to great differences in the nature and condition of the various parts of our planet and perhaps to features of the interior with which we are yet but imperfectly acquainted, some portions have sunk much more than others. These, having to accommodate themselves into smaller dimensions would undergo vast compression and exert an enormous pressure on the more stable tracts which bounded them. It could not but happen that after long intervals of strain, some portions of the squeezed crust would at length find relief from this pressure by rising to a greater or less height, according to their extent and the amount of force from which they sought to escape. These upraised areas would no doubt tend to occur in bands or lines across the direction of the pressure, much as the folds we produce in the sheets of an unbound book are more or less nearly parallel with the two sides from which we squeeze the paper. They would sometimes be broad folds—huge wide swellings of the earth's surface. At other times they might be long, lofty, and comparatively sharp ridges. In the one case they would give rise to high plateaux or table-lands, in the other they would be recognised as mountain-chains.

This is a rough-and-ready statement of what seems the probable explanation of the origin of the elevated tracts upon the earth's surface. It is evident that the pressure would be vastly greater a few hundreds or thousands of feet underground than at the surface, and hence that though the rocks deep down might be squeezed and crumpled, as we could crumple brown paper, yet that at the surface they might show little or no contortion. Certainly without further proof we could never affirm that a contorted mass of rock which now forms the surface of the ground rose as part of the surface during the time of upheaval and contortion. Intensely crumpled rocks would rather suggest a deeper position, with the subsequent removal of the rocks under which they originally lay.

As the earth has been cooling and contracting ever since it had a separate existence as a planet, its surface must have been exposed to a long series of such shrinkage movements as those we are considering. Apart, therefore, from local evidence, we should expect that ridges and depressions must have been impressed upon that surface in a long succession from the earliest periods downwards, and hence that the present mountain-chains and basins of the earth must be of many different ages. We cannot tell what the first mountains were made of, nor where they lay, although some of the existing ridges of the earth's surface are undoubtedly, even in a geological sense, very old. In not a few cases the same mountain-chain can be shown from its internal structure to be of many successive dates, as if it lay along a line of weakness which had served again and again as a line of relief from the severe earth-pressure.

These questions have been treated with much ability by Constant Prevost, Dana, Mallet, and others, to whose writings I refer for details. In stating them in this general way my object is to show that those geologists who, like myself, believe in the truth of the Huttonian doctrines of denudation, are most unfairly represented when they are said to ignore the influence of subterranean forces upon the exterior of the earth. None can recognise more clearly than they do how entirely have the great surface outlines of the globe been dependent upon the action of these forces, that is, upon the results which

flow from the contraction of the planet and from the reaction of the heated interior upon the surface.

But a block of marble is not a statue, nor would a part of the earth's crust heaved up into land form at once such a surface of ridge, and valley, and nicely adjusted water system as any country of which we know anything on the face of the globe. In each case it is a process of sculpture, and the result varies not only with the tools but with the materials on which they are used. You would not expect the same kind of carving upon granite as upon marble. And so, too, in the great process of earth-sculpture, each chief class of rock has its own characteristic style. The tools by which this great work has been done are of the simplest and most everyday order—the air, rain, frost, springs, brooks, rivers, glaciers, icebergs, and the sea. These tools have been at work from the earliest times of which any geological record has been preserved. Indeed, it is out of the accumulated chips and dust which they have made, afterwards hardened into solid rock and upheaved, that the very framework of our continents has been formed. The thickness of these consolidated materials is to be measured, not by feet merely, but by miles. If the removed materials are so thick, they show what a vast mass of rock must have been carved away. And even before knowing anything of the way in which the various tools are used, we should be justified in holding it to be, at the least, extremely improbable that any land surface would long retain its original contour or even any trace of it.

But when we come to watch with attention how the tools really do their work, this improbability increases enormously. Adopting a method of inquiry suggested by Mr. Croll, I have elsewhere shown that even at their present state of progress the amount of geological change which they would accomplish in a comparatively small number of ages is almost incredible. On a moderate computation they would reduce the general mass of the British Islands down to the level of the sea in five or six millions of years, and might carve out valleys a thousand feet deep in a fourth part of that time. It is evident that though the upheaval of some parts of the continents may go back into the remotest geological antiquity, the forms of the present surface must be, comparatively speaking, modern.

There is reason to believe that many, if not most, of the great mountain chains of the globe are, in a geological sense, of recent origin. The Alps, for example, though they may have undergone many earlier movements, were ridged up into their existing mass long after the soft clays were laid down which cover so large an area of the low lands in the south of England, and on which London is built. It would require far more detailed work than has ever been bestowed upon these mountains to enable us even to approximate to what was the original form of the surface just after the upheaval, and before the array of sculpture-tools began their busy and ceaseless task upon these great masses of rock. We may believe that a series of huge parallel folds of curved and broken rock rose for thousands of feet into the air, that when, after the earth-throes had ceased, rain and snow and frost first laid their fingers on the new-born summits, these agents of destruction would have a most uneven surface to work upon, and would necessarily be guided by it in their working; and hence that some, at least, of the dominant earliest ridges and hollows would be perpetuated. Such a belief would carry probability in its favour, but it would certainly not amount to a proof of the supposed perpetuation. That would require to be corroborated by the internal and external evidence of the mountains themselves. In some tracts, as, for instance, among the singularly symmetrical ridges and furrows of the Jura, it would not be difficult to restore the original outline, and to fix exactly how far the subterranean movements had determined the present external forms of the ground,

though even there, where this connection is so clear, we should see at the same time how greatly the tops and sides of the long saddle-shaped arches of rock have suffered from subsequent waste. But among the contorted, inverted, and broken rocks of the Central Alps the task would be infinitely more difficult.

We could not advance far, however, in such a quest before observing that one feature stands out conspicuously enough among the mountains, viz., that whatever might have been their original outlines, these were most certainly not the same as those which we see to-day. No part of the history of the ground can be made more self-evident than that, since the birth of these mountains, millions upon millions of cubic yards of rock have been worn off their crests and ridges, and carved out of their sides. There is not a cliff, crag, or valley along the whole chain of the Alps which does not bear witness to this great truth.

If then, even when dealing with the young Alps, we cannot be quite sure what were their first or infant features, how impossible must it be to decide as to the early outlines of such immensely more ancient uplands as those which date from palæozoic times! For, evidently, the higher their antiquity, and the longer, therefore, their exposure to ceaseless waste, the more must these outlines be changed. The general mass of land might still remain land, but trenched and furrowed and worn down, as the Alps are now suffering, until not a single vestige or indication of its first contour survived, the remaining portions being, as it were, merely the stump or base of what once was.

Now this is the position in which the question presents itself in Britain. The hills of the Highlands and Southern Uplands of Scotland, of the Lake district, and of Wales, are not mountains in the same sense as the Alps or Pyrenees, or other great continental mountain-chains. However much these long lines of elevated ground may have had their outlines modified by the universal waste of the earth's surface, their linear character, the general parallelism of their component ridges, the undulations of the strata along their flanks, as well as their internal geological structure, bear witness to the fact that they are but huge wrinkles upon the shrivelled globe—tracts which have been thrust up while the neighbouring regions have sunk down. But in Britain these characteristic features are wanting. In all probability there never was any true mountain-chain in our region. There is good reason to believe that in very ancient times, that is to say, previous to the Old Red sandstone, a wide plateau-like mass of land was upraised on the north coast of Europe, surviving portions of it being represented by the detached hilly regions of Britain and the great table-land of Scandinavia. The rocks underlying this upheaved tract underwent, at the time of elevation, enormous compression and consequent contortion. This could not happen without an infinite amount of resistance. The heat thus evolved among the grinding masses may have been amply sufficient even to melt them in part. And no doubt it was during this process that they became crystalline over such wide areas, and were injected with granite and other melted products. But all this had been wholly, or almost wholly, completed before the time of the Old Red sandstone, for the deposits of that geological system are formed out of the older altered rocks, and lie undisturbed upon them. Even now, in spite of all the subsequent denudation, the patches of old red conglomerate which remain show to what an extent the older rocks had been buried under it, for they are found rising here and there to a height of 2,000 or 3,000 ft. above the sea. But they prove further, not only that the contortion of the underlying rocks preceded the Old Red sandstone, but that these rocks had suffered a vast extent of waste at the surface, before even the oldest visible parts of the conglomerate were deposited upon them. This waste has been in progress ever since.

We need not, therefore, hope to discover any vestige of the aboriginal surface. A geological section drawn across any part of the hills proves beyond question that the general surface of the country has had hundreds or even thousands of feet of solid rock worn away from it. Such a section shows moreover that our present valleys are not mere folds due to underground movements, but are really trenches out of which the solid rock has been carried away.

So far, this is a question of simple fact, and not merely of opinion. The language of Hutton may be literally true of Britain:—"The mountains have been formed by the hollowing out of the valleys, and the valleys have been hollowed out by the attrition of hard materials coming from the mountains." Our British hills, unlike the chains of the Jura and the Alps, are simply irregular ridges depending for their shape and trend upon the directions taken by the separating valleys. The varying textures of the rocks, their arrangements with relation to each other, their foldings and fractures, and the other phenomena comprised under what is termed "geological structure," have greatly modified this result, but the process has nevertheless, as I believe, been one of superficial sculpturing, and not of subterranean commotion and upheaval. On the details of this process it is not needful to dwell.

From these cursory statements, which express, I believe, the general concurrent opinions of the modern Huttonian school, it should be clear how far that school must be from ignoring the influence of subterranean forces. Hutton himself never did so, and his followers now know far more of these forces than he did. But on the other hand, they claim for the surface-agents in geology a potency great enough to cut down table-lands into mountain-ridges and glens, to carve out the surface of the land into systems of valleys, and in the end to waste a continent down to the level of the sea.

(To be continued.)

ASTRONOMY AT OXFORD

DR. DE LA RUE having, in the course of last summer, made a munificent offer of several astronomical instruments and apparatus, including a large reflecting telescope, to the University, the subject was brought under the consideration of the delegates of the Museum, who, at their first meeting in this term, appointed a committee to "report on the desirability of accepting the munificent offer of Dr. De La Rue to present to the University his celebrated reflecting telescope, on the probable cost of a building to receive the instrument, and on the precise purposes for which this instrument may be usefully employed, in distinction to the refracting telescope now being set up."

The committee, after full and careful examination of the whole subject, have sent in a report, to which they have unanimously agreed, and which the delegates recommended, with entire confidence, to the favourable consideration of the council. In consequence of this report, the following forms of decree will be submitted to a convocation to be held on Thursday, Nov. 27:—

1. That the reflecting telescope and other apparatus offered to the University by Dr. De La Rue be accepted; and that the Vice-Chancellor be requested to return the thanks of the University to Dr. De La Rue for his munificent gift. And that the curators of the University chest be authorised to pay to the delegates of the University Museum a sum not exceeding 1,500*l.*, to be expended by them on the erection of buildings in the park suitable for the reception and use of the telescope and other apparatus presented by Dr. De La Rue, as also of the instruments at present in the small observatory on the east side of the museum, according to plans and specifications prepared by Mr. Charles Barry, architect, and adjoining the observatory now nearly completed.