GENESIS OF HIGHLAND SCENERY.

By Rev. D. C. Mackay.

The first time that we ascend one of our higher mountains on a fairly clear day and look around, we are inevitably struck with astonishment at the wonderful sight that presents itself. We may have listened to realistic accounts and read graphic descriptions of all this, but in spite of the fidelity of these verbal testimonies, nothing short of personal observation can succeed in bringing this wild scene home to our imaginations. When looking from the plain, one is apt to imagine that there are at least certain lines or ranges of hills more or less defined, but when we reach a commanding mountain top this illusion is soon dispelled. There is really no attempt at lines or order of any kind—there is only a jumble of hills and mountains of all sizes and shapes. On recovering from the first sensation of astonishment, the least inquisitive will be inclined to ask whence comes all this variety of feature. In the old days of faith, people did not trouble about these things, or, if they did, they were apt to put it all down to the particular fancy of the Creator on the morn of creation; but in these days when science arrogates every domain to itself, we are of a more enquiring turn of mind, and must have the why and the wherefore of everything.

Why, then, and wherefore these hills of the Highlands?

For an answer to this we must turn to Geology. This comparatively youthful science is simply the offspring of nature fertilised by observation, so that every man may be a geologist to a certain extent, given a little aptitude and opportunity. With regard to the genesis of our scenery, then, geology tells us that the chief agents at work were the following:—

(1) Upheavals of the soil by some subterranean force, producing corrugations, undulations, faults, etc., on the surface. (2) Rain, frost and the elements in general, resulting in a constant denudation of the surface. (3) Water deposit-

ing sediment, marine, lacustrine or alluvial. (4) Ice in the glacial age depositing in one place what it had carved out in another. (5) Volcanoes bringing new elements to the surface. No doubt most of these agents have been at work from the beginning; but as real, practical science does not pretend to say just what that beginning was, we cannot exactly study these agents setting out to work; it will, however, be quite sufficient for our purpose if we watch them actually at work, or if we examine the general results they are producing.

(1) The first, and, probably the greatest of these agencies is upheavals of the surface. We cannot explain the cause of these, as we have not had opportunities for studying the forces at work under the earth's crust, but we may form some idea of their magnitude from the terrific violence of some of the volcanic eruptions. But, whatever the cause, the effect of these forces is evident enough, and is also extremely varied, these upheavals (under which head we must understand also the corresponding antithesis, which is subsidences of the soil) being sufficient of themselves to produce a great diversity of scenery. A few lines of rough drawing will explain my meaning better than many lines of print. Let us suppose then that we start with a plain composed of various kinds of rock and soil lying in horizontal layers one above the other as represented in section in (Fig 1.) So far it is an ordinary, undiversified

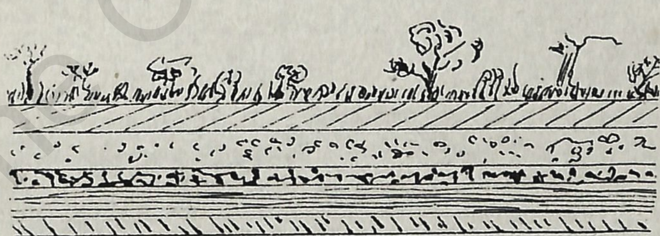

Fig. 1. Horizontal section of (imaginary) rock with perfectly regular strata.

plain. Presently the labouring heat in the centre of the earth, or some other cause or causes unknown, sets to work upon it, and, in the course of many years, produces a little hill in the middle of our plain. It is to be noticed also that in this operation the courses of rock lose their horizontal position (Fig. 2.) There we have already got a hill. But suppose, as very often happens, that this elevation of the

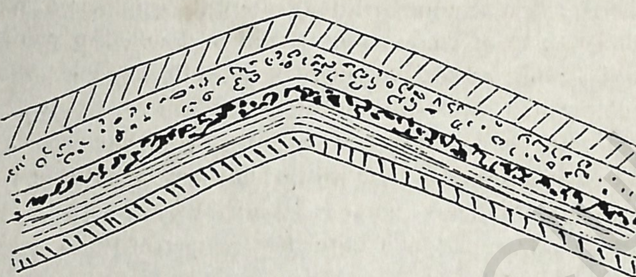

Fig. 2. The same after upheaval (omitting superficial vegetation.)

soil had taken place, not merely in a broad plain, but in a valley through which a stream was running (Fig. 3.) The

Fig. 3. Similar strata worn away by water.

result would be that as the bed of the valley was gradually raised up, the stream would be dammed back and its waters would have to keep rising apace with the obstacle before they could surmount it and continue their way to the sea. Thus we have a loch. And supposing further that this loch eventually attained an area of several square miles, and that

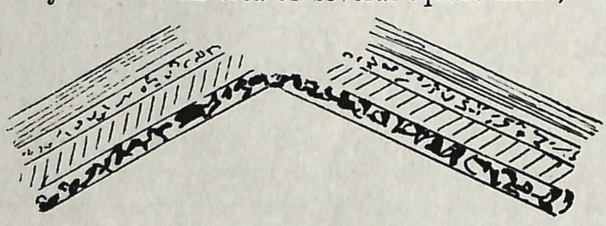

Fig. 4. The same upheaved under river bed, producing a lake.

another upheaval took place in its centre, the result would naturally be "an islet in an inland sea." Thus it is evident that these upheavals may be capable of producing practically any variety of scenery. I have here indicated merely the main lines, but a little reflection will readily suggest a great many details that may result from the process of evolutions described. For instance, it may happen that some rocks, especially if they lie at some distance from the point of upheaval, may not be sufficiently pliable to yield to the upward thrust, with the result that they will crack, the portion that is more directly under the influence of the upheaval continuing to rise, while the other portion remains *in situ*, thus producing what is technically known as a fault. (Fig. 5.) Again if this happened during the process of

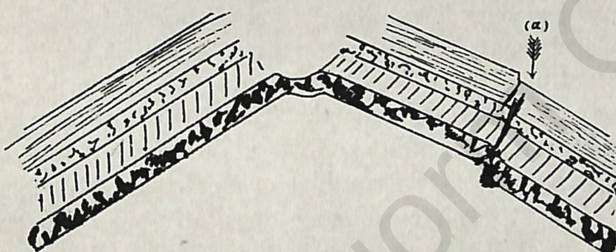

Fig. 5. On further pressure the rock to the right refusing to yield more produces the fault at (a), through which the stream may find a new exit.

damming up a stream, the latter would naturally find a new course for itself where the fault had occurred.

It is not to be supposed that these or any similar changes will be likely to take place in the course of a few years. In fact geology does not deal with years. A century would be almost a microscopic unit of time for this science, as any event worthy of its notice can scarcely be said really to have taken place in such a short period, unless in the case of some sudden cataclysm. Bearing this in mind, we can easily understand that these upheavals may be taking place around us, or even under our very feet, quite in the normal way, without being in the least appreciable to us during the relatively short span of our lives. These forces move like the short hand of a clock—we cannot actually see them moving, but from time to time we can ascertain, without any doubt, that they have moved. It is also quite easy to ascertain that these upheavals I have been speaking of have been taking place quite recently. The east coast between Aberdeen and Arbroath shows this definitely, for in every other cove we find a crescent of marshy soil or gravel lying between the highest water-mark of the present day and the cliffs that have obviously been carved out by the waves at no very distant date. There are other parts of the world, such as some portions of the coast of Sweden and some of the shores of South America, where this rising is still more pronounced, while, on the other hand, the west coast of Greenland is gradually subsiding. It is chiefly to this cause that we owe the general elevation of the Highlands as well as a good many of their picturesque features.

(2) Probably the next most important agent in the formation of scenery is the denudation of the soil by rain and the other elements. Unlike the first, which is apt to be intermittent and casual in its incidence, this action may be said to be permanent and general. The effects of this process may be very plainly seen in our valleys. They are manifestly carved out by the slow corroding of the rivers which run through them, these rivers being practically the rains that have fallen within that river-basin assembling on their way to the sea. At first glance, it might seem that that quiet river murmuring on so peacefully would be totally inadequate to produce some of the results that we find, for our straths sometimes measure miles across, especially if estimated from top to top of the hills that have been sundered in their formation. We must remember, however, that there is really no limit to the ultimate effect of a persistent cause, given sufficient time. It is not, however, on the quiet, tranquil days of its life that the river does the most of its serious work, besides it is powerfully assisted by every flood and by every frost in widening the valley which it has once begun to fashion. Anyone who has any misgivings as to the corrosive power of water may easily put them to rest by a very innocent experiment with which I have amused myself lately. All that is necessary is to make a rough map of Scotland—or, for that matter, of any other place—with clays and soils of various degrees of cohesion to represent the varying toughness of different kinds of rock. This may be merely a ground plan without any elevations. Next get a watering can and let the rains fall *ad lib.* Presently there will be any number of burns, streams and rivers, all busy

cutting out miniature glens and valleys and producing great deltas of alluvial deposit beyond the original coast line. I do not say that this experiment will result in reproducing a model of the actual river system of country, but it is certainly wonderful how many of the rivers may be identified with the help of a little imagination, and the more faithfully one observes the actual structure of the country in the original cast, so much the more accurately will the rivers reproduce the details. Thus I fouud that a Moray Firth in the original always elicited a river Ness when the rains began. I do not pretend to attach any scientific importance to this little amusement, but it certainly illustrates very faithfully the play of running water on the surface of the earth. First of all the water will gather wherever there is a little depression in the soil, and, as soon as it has filled it up, will leave by the lowest point in its contour and pass on to repeat the same process with the next available depression. But as the water flows over the edge of these depressions it will gradually wear it down, until, instead of a succession of depressions, it forms one longitudinal cavity which we call a glen. The same process will be going on all round, and as all the rills are making for an identical objective—viz., a lower level—many of them are bound eventually to strike out in identical directions. So the various streamlets, each cutting out its own little glen, by uniting their efforts, are able as a full-fledged stream to carve out a broad strath and a valley that goes widening onward to the sea.

But, as I have said, there are other elements that play an important part in the formation of the valleys. Probably the most powerful of these is frost. Wherever there is a little crack or rent in the soil or in the rocks, there the frost will introduce its powerful lever. First of all, in wet weather these fissures will be filled with water, but some evening the clouds will roll away, the air will be clear and keen and all the stars quivering with scintillation; the homeward-bound, in greeting each other, will not fail to remark that it is "going to be frosty to-night," and so it will be. Then all the water that is caught napping in the clefts will insist on more elbow-room as it dilates into ice. Thus, on the slopes, huge masses of earth will be dislocated and would be precipitated down the incline, were it not for the grip of the frost. And so with the rocks, huge portions of which may lose their equilibrium by being forced a few inches from a position of equipose. While the frost lasts all will be held together by the very force that is working for disintegration. But when the thaw comes there will be many a miniature landslip along the glens, and many a chip and block of stone will leave its native cliff for ever. Then when the rain comes again it sets to work at once, wearing down all the asperities left by the action of the frost. The tendency of the river is simply to cut out a channel for itself, and, if left alone, it would naturally produce a cañon or a narrow gorge with perpendicular sides. But the sharp edges resulting from this formation, being exposed on two or more sides, cannot long resist the disintegrating agencies that are ever ready to set them free to follow the law of gravitation that is constantly summoning them downwards. The detritus is carried away by the river according to its strength, and is used as an instrument for the further carving out of the channel, just as diamonds are polished with diamond dust. It is to the same process that we are indebted for the corries among the mountains, which constitute such a prominent feature in Highland scenery. They are simply the enlarged channels which the streamlets, wielding a power in proportion to their impetuosity, have cut out of the mountain-side. Strange as the statement may seem, it is to these excavations made by running water that the existence of our mountains is due. Were there no sun there could be no shadow, and there could be no mountains without the intervening hollows, but the whole surface would be one great table-land, whatever its elevation might be above sea-level.

(3) The next process which we have to consider is the deposition of sediment, which may take place in the sea, in lakes or in river beds. This sediment is merely the result of the denudation that we have been considering. All the matter that has been torn from the land in the formation of the valleys must be deposited somewhere. A great proportion of it is borne to the sea, where it eventually settles

to the bottom. The effect of this is the gradual deposition of soft material in regular strata, which, in the course of ages, will harden into rock, which, at some future time, may be again raised above the level of the sea to undergo a repetition of the same process all over again. On the other hand, when a river flows into a shallow sea, it often succeeds in filling up the latter with the sediment which subsequently emerges in the form of low flats of mud and ooze, which thereafter depend for their augmentation on the river which overflows them in flood, or adds to them at the edges especially in the case of deltas. Thus we obtain those level flats that are so often to be seen near the mouth of a river. The same thing may happen when the sediment is deposited in lakes; in fact lakes often disappear altogether in this manner, the cavities which held them being filled up by the sediment. Again the river may deposit the sediment in its own bed. This happens mostly in the lower stretches where the water has succeeded in carving its channel almost to the level of the sea. There it flows so gently that the solid materials get time to settle either at the sides or in the bottom. The result is those flat alluvial plains which often lie along the lower reaches of a river and so enhance the landscape with the products of their fertility.

(4) For our next point we have to go back many centuries to the time when this country experienced a climate similar to that of Greenland to-day. It is not within my province, and still less is it within my competence, to explain the cause of this strange departure from the normal condition of things. Though we ignore the cause, however, we are none the less certain of the fact. At that time more snow fell on our hills than the climate permitted to melt where it fell, so it accumulated till its weight was sufficient to impel it down the slopes in the form of ice—a form that snow always assumes after lying for a certain length of time. Thus originated the glaciers which slid slowly and imperceptibly down the valleys in place of streams. The glaciers have long since passed away, but the valleys remain to give us a faithful account of what befell when the ice was passing. As these great, solidified streams moved on, everything that became

detached above them, and everything that could be detached from beneath, became imbedded in their mass and were carried off. So they glided on, laden with whatever they could pick up by the way—splintered rocks, rough boulders, gravel, sand, mud, &c. When they reached a zone whose temperature was more than they could bear, those grasping monsters were forced suddenly to disgorge all the booty so assiduously gathered as they came along. To-day we find these piles of promiscuous rubbish just as it was yielded up by the melting ice, outwardly disguised and overgrown no doubt, but constitutionally still the same. It does not require much geological skill to enable one to discriminate between those moraines and the agglomerations of similar matter accumulated by running water. The water bears its plunder along chiefly by rolling, so that all the rough edges of rocks and stones are worn off by friction. The ice, on the other hand, carries things bodily, and so preserves them as it found them, except those materials that happened to form part of its under surface (as an Irishman might express it), which will be polished flat on the under side, and probably scratched by frequent contact with hard, sharp rocks. Another distinguishing feature is that water deposits the detritus in fairly regular strata, whereas a melting glacier must simply let go and allow everything to drop in an indiscriminate conglomeration. These moraines, as we might expect, are generally thrown across the mouth of a valley, and very often give rise to a lake within it, not only on account of the deposited rubbish damming back the water, but also on account of the valley having been more deeply excavated by the ice down to the point of its dissolution.

But the ice was not always allowed to behave in this orderly way. Sometimes, instead of melting on dry land, the glacier would slip down right into the sea. The seaward end would then be buoyed up by the water till severance took place, when it would float away as an iceberg. It would then drop its freight all over the bed of the ocean in proportion as it melted. Now, we have incontrovertible evidence to show that during the prevalence of the ice there was a period when the land as we know it was submerged in the sea to a depth of about 2,000 feet. Consequently the greater part of our present country was then the bed of the ocean, and so received its share of spoils from the dissolving icebergs. This explains the presence of those detached masses of rock, known as erratic blocks, lying stranded far from home and friends. Sometimes great masses of a certain formation are found reposing in splendid isolation, scores of miles from any bed-rock of similar constitution. Such masses often form a prominent feature on hilltops, being frequently connected by popular legend with some lapidating scheme of the Devil's. These might easily be accounted for if we suppose, as seems very reasonable, that a floating iceberg had stranded and melted away on the hill-top which was then an island. If this theory be correct these blocks should generally be found at an elevation approaching 2,000 feet, but as to this I have not succeeded in obtaining any definite information.

Such, then, is a rough outline of the chief features left us as a legacy by the mysterious and highly interesting age when our land experienced all the rigours of an arctic climate. Fortunately there is not much more to add.

(5) Volcanoes sometimes contribute largely to the formation of scenery. The characteristic features may be inferred from the nature of volcanic phenomena. These result from an outbreak of the internal heat of the earth. The pressure of the imprisoned gases forces the rocks upwards until a vent is formed, and the escaping gases often hurl the remaining obstacles with tremendous violence into the air. These and the succeeding streams of lava or molten mineral matter fall around the vent and gradually form a cone. The familiar mole-hill is formed on on the same principle, with this difference that the materials ejected by the mole, lacking the viscosity which the lava imparts, fall around in every direction, not possessing sufficient cohesion to form a perfect cone. The lava and other volcanic matter often overflow these cones, or break out through them, and overrun the adjacent country in vast sheets, completely obliterating the former aspect of the

landscape. At other times the molten matter flows, or is forcibly injected, into fissures of the rocks. This matter may eventually harden so that it is able to resist the denuding agencies that subsequently waste away the rock that formed the mould, thus producing the lava dikes; or again, it may prove to be less durable than the containing rock, in which case the original fissure will gradually reappear, keeping pace with the erosion of the intrusive substance. Instances of all these formations occur in a broad belt of volcanic predominance which stretches across Scotland from Fifeshire to the Firth of Clyde, and still more prominently in the islands of Bute and Arran, as well as in several points of the Hebrides. Sometimes again, the lava, in cooling, crystallises into polygonal columns, producing some very remarkable arrangements. The examples in Staffa and Mull, as also the Giants' Causeway in Ireland, are characteristic of this formation, and are so well known that it is sufficient to cite them in passing by way of illustration.

On the whole, it may be said that though volcanoes have been at times very active in this country they have not contributed what could be called a predominating feature to Scottish scenery.

Such is a rapid, and, I fear, a very rough review of the agencies which have been chiefly instrumental in imparting to our country the outlines which it presents.