



**JAMES
GEIKIE**

***FRAGMENTS
OF EARTH LORE:
SKETCHES &
ADDRESSES
GEOLOGICAL AND
GEOGRAPHICAL***

James Geikie

Fragments of Earth Lore: Sketches & Addresses Geological and Geographical

EAN 8596547339373

DigiCat, 2022

Contact: DigiCat@okpublishing.info



Table of Contents

[Cover](#)

[Titlepage](#)

[Text](#)

II.

The Physical Features of Scotland.^[B]

^[B] *Scottish Geographical Magazine*, vol. i., 1885.

Scotland, like “all Gaul,” is divided into three parts, namely, the Highlands, the Central Lowlands, and the Southern Uplands. These, as a correctly drawn map will show, are natural divisions, for they are in accordance not only with the actual configuration of the surface, but with the geological structure of the country. The boundaries of these principal districts are well defined. Thus, an approximately straight or gently undulating line taken from Stonehaven, in a south-west direction, along the northern outskirts of Strathmore to Glen Artney, and thence through the lower reaches of Loch Lomond to the Firth of Clyde at Kilcreggan, marks out with precision the southern limits of the Highland area and the northern boundary of the Central Lowlands. The line that separates the Central Lowlands from the Southern Uplands is hardly so prominently marked throughout its entire course, but it follows precisely the same north-east and south-west trend, and may be traced from Dunbar along the base of the Lammermoor and Moorfoot Hills, the Lowthers, and the hills of Galloway and Carrick, to Girvan. In each of the two mountain-tracts—the Highlands and the Southern Uplands—areas of low-lying land occur, while in the intermediate Central Lowlands isolated prominences and certain well-defined belts of hilly ground make their appearance. The statement, so frequently repeated in class-books and manuals of geography, that the mountains of Scotland consist of three (some writers say five) “ranges” is erroneous and

misleading. The original author of this strange statement probably derived his ignorance of the physical features of the country from a study of those antiquated maps upon which the mountains of poor Scotland are represented as sprawling and wriggling about like so many inebriated centipedes and convulsed caterpillars. Properly speaking, there is not a true mountain-range in the country. If we take this term, which has been very loosely used, to signify a linear belt of mountains—that is, an elevated ridge notched by cols or “passes” and traversed by transverse valleys—then in place of “three” or “five” such ranges we might just as well enumerate fifty or sixty, or more, in the Highlands and Southern Uplands. Or, should any number of such dominant ridges be included under the term “mountain-range,” there seems no reason why all the mountains of the country should not be massed under one head and styled the “Scottish Range.” A mountain-range, properly so called, is a belt of high ground which has been ridged up by earth-movements. It is a fold, pucker, or wrinkle in the earth’s crust, and its general external form coincides more or less closely with the structure or arrangement of the rock-masses of which it is composed. A mountain-range of this characteristic type, however, seldom occurs singly, but is usually associated with other parallel ranges of the same kind—the whole forming together what is called a “mountain-chain,” of which the Alps may be taken as an example. That chain consists of a vast succession of various kinds of rocks, which at one time were disposed in horizontal layers or strata. But during subsequent earth-movements those horizontal beds were compressed laterally, squeezed, crumpled, contorted, and thrown, as it were, into gigantic undulations and sharper folds and plications. And, notwithstanding the enormous erosion or denudation to which the long parallel ridges or ranges have been subjected, we can yet see that the general contour of these corresponds in large measure to the plications or

foldings of the strata. This is well shown in the Jura, the parallel ranges and intermediate hollows of which are formed by undulations of the folded strata—the tops of the long hills coinciding more or less closely with the arches, and the intervening hollows with the troughs. Now folded, crumpled, and contorted rock-masses are common enough in the mountainous parts of Scotland, but the configuration of the surface rarely or never coincides with the inclination of the underlying strata. The mountain-crests, so far from being formed by the tops of great folds of the strata, frequently show precisely the opposite kind of structure. In other words, the rocks, instead of being inclined away from the hill-tops like the roof of a house from its central ridge, often dip into the mountains. When they do so on opposite sides the strata of which the mountains are built up seem arranged like a pile of saucers, one within another.

There is yet another feature which brings out clearly the fact that the slopes of the surface have not been determined by the inclination of the strata. The main water-parting that separates the drainage-system of the west from that of the east of Scotland does not coincide with any axis of elevation. It is not formed by an anticlinal fold or “saddleback.” In point of fact it traverses the strata at all angles to their inclination. But this would not have been the case had the Scottish mountains consisted of a chain of true mountain-ranges. Our mountains, therefore, are merely monuments of denudation, they are the relics of elevated plateaux which have been deeply furrowed and trenched by running water and other agents of erosion. A short sketch of the leading features presented by the three divisions of the country will serve to make this plain.

THE HIGHLANDS.—The southern boundary of this, the most extensive of the three divisions, has already been defined.

The straightness of that boundary is due to the fact that it coincides with a great line of fracture of the earth's crust—on the north or Highland side of which occur slates, schists, and various other hard and tough rocks, while on the south side the prevailing strata are sandstones, etc., which are not of so durable a character. The latter, in consequence of the comparative ease with which they yield to the attacks of the eroding agents—rain and rivers, frost and ice—have been worn away to a greater extent than the former, and hence the Highlands, along their southern margin, abut more or less abruptly upon the Lowlands. Looking across Strathmore from the Sidlaws or the Ochils, the mountains seem to spring suddenly from the low grounds at their base, and to extend north-east and south-west, as a great wall-like rampart. The whole area north and west of this line may be said to be mountainous, its average elevation being probably not less than 1500 feet above the sea.

A glance at the contoured or the shaded sheets of the Ordnance Survey's map of Scotland will show better than any verbal description the manner in which our Highland mountains are grouped. It will be at once seen that to apply the term "range" to any particular area of those high grounds is simply a misuse of terms. Not only are the mountains not formed by plications and folds, but they do not even trend in linear directions. It is true that a well-trained eye can detect certain differences in the form and often in the colouring of the mountains when these are traversed from south-east to north-west. Such differences correspond to changes in the composition and structure of the rock-masses, which are disposed or arranged in a series of broad belts and narrower bands, running from south-west to north-east across the whole breadth of the Highlands. Each particular kind of rock gives rise to a special configuration, or to certain characteristic features. Thus, the mountains that occur within a belt of slate, often show a

sharply cut outline, with more or less pointed peaks and somewhat serrated ridges—the Aberuchill Hills, near Comrie, are an example. In regions of gneiss and granite the mountains are usually rounded and lumpy in form. Amongst the schists, again, the outlines are generally more angular. Quartz-rock often shows peaked and jagged outlines; while each variety of rock has its own particular colour, and this in certain states of the atmosphere is very marked. The mode in which the various rocks yield to the “weather”—the forms of their cliffs and corries—these and many other features strike a geologist at once; and therefore, if we are to subdivide the Highland mountains into “ranges,” a geological classification seems the only natural arrangement that can be followed. Unfortunately, however, our geological lines, separating one belt or “range” from another, often run across the very heart of great mountain-masses. Our “ranges” are distinguished from each other simply by superficial differences of feature and structure. No long parallel hollows separate a “range” of schist-mountains from the succeeding “ranges” of quartz-rock, gneiss, or granite. And no degree of careful contouring could succeed in expressing the niceties of configuration just referred to, unless the maps were on a very large scale indeed. A geological classification or grouping of the mountains into linear belts cannot therefore be shown upon any ordinary orographical map. Such a map can present only the relative heights and disposition of the mountain-masses, and these last, in the case of the Highlands, as we have seen, cannot be called “ranges” without straining the use of that term. Any wide tract of the Highlands, when viewed from a commanding position, looks like a tumbled ocean in which the waves appear to be moving in all directions. One is also impressed with the fact that the undulations of the surface, however interrupted they may be, are broad—the mountains, however they may vary in detail according to the character of the rocks, are massive, and generally

round-shouldered and often somewhat flat-topped, while there is no great disparity of height amongst the dominant points of any individual group. Let us take, for example, the knot of mountains between Loch Maree and Loch Torridon. There we have a cluster of eight pyramidal mountain-masses, the summits of which do not differ much in elevation. Thus in Liathach two points reach 3358 feet and 3486 feet; in Beinn Alligin there are also two points reaching 3021 feet and 3232 feet respectively; in Beinn Dearg we have a height of 2995 feet; in Beinn Eighe are three dominant points—3188 feet, 3217 feet, and 3309 feet. The four pyramids to the north are somewhat lower—their elevations being 2860 feet, 2801 feet, 2370 feet, and 2892 feet. The mountains of Lochaber and the Monadhliath Mountains exhibit similar relationships; and the same holds good with all the mountain-masses of the Highlands. No geologist can doubt that such relationship is the result of denudation. The mountains are monuments of erosion—they are the wreck of an old table-land—the upper surface and original inclination of which are approximately indicated by the summits of the various mountain-masses and the direction of the principal water-flows. If we in imagination fill up the valleys with the rock-material which formerly occupied their place, we shall in some measure restore the general aspect of the Highland area before its mountains began to be shaped out by Nature's saws and chisels.

It will be observed that while streams descend from the various mountains to every point in the compass, their courses having often been determined by geological structure, etc., their waters yet tend eventually to collect and flow as large rivers in certain definite directions. These large rivers flow in the direction of the average slope of the ancient table-land, while the main water-partings that separate the more extensive drainage-areas of the country mark out, in like manner, the dominant portions of the same

old land-surface. The water-parting of the North-west Highlands runs nearly north and south, keeping quite close to the western shore, so that nearly all the drainage of that region flows inland. The general inclination of the North-west Highlands is therefore easterly towards Glenmore and the Moray Firth. In the region lying east of Glenmore the average slopes of the land are indicated by the directions of the rivers Spey, Don, and Tay. These two regions—the North-west and South-east Highlands—are clearly separated by the remarkable depression of Glenmore, which extends through Loch Linnhe, Loch Lochy, and Loch Ness, and the further extension of which towards the north-east is indicated by the straight coast-line of the Moray Firth as far as Tarbat Ness. Now, this long depression marks a line of fracture and displacement of very great geological antiquity. The old plateau of the Highlands was fissured and split in two—that portion which lay to the north-west sinking along the line of fissure to a great but at present unascertained depth. Thus the waters that flowed down the slopes of the north-west portion of the broken plateau were dammed by the long wall of rock on the “up-cast,” or south-east side of the fissure, and compelled to flow off to north-east and south-west along the line of breakage. The erosion thus induced sufficed in the course of time to hollow out Glenmore and all the mountain-valleys that open upon it from the west.

The inclination of that portion of the fissured plateau which lay to the south-east is indicated, as already remarked, by the trend of the principal rivers. It was north-east in the Spey district, nearly due east in the area drained by the Don, east and south-east in that traversed by the Tay and its affluents, westerly and south-westerly in the district lying east of Loch Linnhe.^[C] Thus, a line drawn from Ben Nevis through the Cairngorm and Ben Muich Dhui Mountains to Kinnaird Point passes through the highest land in the

South-east Highlands, and probably indicates approximately the dominant portion of the ancient plateau. North of that line the drainage is towards the Moray Firth; east of it the rivers discharge to the North Sea; while an irregular winding line, drawn from Ben Nevis eastward through the Moor of Rannoch and southward to Ben Lomond, forms the water-parting between the North Sea and the Atlantic, and doubtless marks another dominant area of the old table-land.

[C] The geological reader hardly requires to be reminded that many of the minor streams would have their courses determined, or greatly modified, by the geological structure of the ground. Thus, such streams often flow along the “strike” and other “lines of weakness,” and similar causes, doubtless, influenced the main rivers during the gradual excavation of their valleys.

That the valleys which discharge their water-flow north and east to the Moray Firth and the North Sea have been excavated by rivers and the allied agents of erosion, is sufficiently evident. All the large rivers of that wide region are typical. They show the orthodox three courses—namely, a torrential or mountain-track, a middle or valley-track, and a lower or plain-track. The same is the case with some of the rivers that flow east from the great north-and-south water-parting of the North-west Highlands, as, for example, those that enter the heads of Beaully Firth, Cromarty Firth, and Dornoch Firth. Those, however, which descend to Loch Lochy and Loch Linnhe, and the sea-lochs of Argyllshire, have no lower or plain-track. When we cross the north-and-south water-parting of the North-west Highlands, we find that many of the streams are destitute of even a middle or valley-track. The majority are mere mountain-torrents when they reach the sea. Again, on the eastern watershed of the same region, a large number of the valleys contain lakes in their upper and middle reaches, and this is the case also with not a few of the valleys that open upon the Atlantic. More frequently, however, the waters flowing west pass through no lakes, but enter the sea at the heads of long sea-lochs or fiords. This striking contrast between the east and west is not due to any difference in the origin of the valleys. The western valleys are as much the result of erosion as those of the east. The present contrast, in fact, is more apparent than real, and arises from the fact that the land area on the Atlantic side has been greatly reduced in extent by subsidence. The western fiords are merely submerged

land-valleys. Formerly the Inner and Outer Hebrides were united to themselves and the mainland, the country of which they formed a part stretching west into the Atlantic, as far probably as the present 100 fathoms line. Were that drowned land to be re-elevated, each of the great sea-lochs would appear as a deep mountain-valley containing one or more lake-basins of precisely the same character as those that occur in so many valleys on the eastern watershed. Thus we must consider all the islands lying off the west coast of the Highlands, including the major portions of Arran and Bute, as forming part and parcel of the Highland division of Scotland. The presence of the sea is a mere accident; the old lands now submerged were above its level during a very recent geological period—a period well within the lifetime of the existing fauna and flora.

The old table-land of which the Highlands and Islands are the denuded and unsubmerged relics, is of vast geological antiquity. It was certainly in existence, and had even undergone very considerable erosion, before the Old Red Sandstone period, as is proved by the fact that large tracts of the Old Red Sandstone formation are found occupying hollows in its surface. Glenmore had already been excavated when the conglomerates of the Old Red Sandstone began to be laid down. Some of the low-lying maritime tracts of the Highland area in Caithness, and the borders of the Moray Firth, are covered with the sandstones of that age; and there is evidence to show that these strata formerly extended over wide regions, from which they have since been removed by erosion. The fact that the Old Red Sandstone deposits still occupy such extensive areas in the north-east of the mainland, and in Orkney, shows that the old table-land shelved away gradually to north and east, and the same conclusion may be drawn, as we have seen, from the direction followed by the main lines of the existing drainage-system. We see, in short, in the table-land of the

Highlands, one of the oldest elevated regions of Europe—a region which has been again and again submerged either in whole or in part, and covered with the deposits of ancient seas and lakes, only to be re-elevated, time after time, and thus to have those deposits in large measure swept away from its surface by the long-continued action of running water and other agents of denudation.

THE CENTRAL LOWLANDS.—The belt of low-lying ground that separates the Highlands from the Southern Uplands is, as we have seen, very well defined. In many places the Uplands rise along its southern margin as abruptly as the Highlands in the north. The southern margin coincides, in fact, for a considerable distance (from Girvan to the base of the Moorfoots) with a great fracture that runs in the same direction as the bounding fracture or fault of the Highlands. The Central Lowlands may be described, in a word, as a broad depression between two table-lands. A glance at the map will show that the principal features of the Lowlands have a north-easterly trend—the same trend, in fact, as the bounding lines of the division. To this arrangement there are some exceptions, the principal being the belt of hilly ground that extends from the neighbourhood of Paisley, south-east through the borders of Renfrewshire and Ayrshire, to the vicinity of Muirkirk. The major part of the Lowlands is under 500 feet in height, but some considerable portions exceed an elevation of 1000 feet, while here and there the hills approach a height of 2000 feet—the two highest points (2352 and 2335 feet) being attained in Ben Cleugh, one of the Ochils, and in Tinto. Probably the average elevation of the Lowland division does not exceed 350 or 400 feet. Speaking generally, the belts of hilly ground, and the more or less isolated prominences, are formed of more durable rocks than are met with in the adjacent lower-lying tracts. Thus the Sidlaws, the Ochil Hills, and the heights in

Renfrewshire and Ayrshire, are composed chiefly of more or less hard and tough volcanic rocks; and when sandstones enter into the formation of a line of hills, as in the Sidlaws, they generally owe their preservation to the presence of the volcanic rocks with which they are associated. This is well illustrated by the Lomond Hills in Fifeshire, the basal and larger portion of which consists chiefly of somewhat soft sandstones, which have been protected from erosion by an overlying sheet of hard basalt-rock. All the isolated hills in the basin of the Forth are formed of knobs, bosses, and sheets of various kinds of igneous rock, which are more durable than the sandstones, shales, and other sedimentary strata by which they are surrounded. Hence it is very evident that the configuration of the Lowland tracts of Central Scotland is due to denudation. The softer and more readily disintegrated rocks have been worn away to a greater extent than the harder and less yielding masses.

Only in a few cases do the slopes of the hill-belts coincide with folds of the strata. Thus, the northern flanks of the Sidlaws and the Ochils slope towards the north-west, and this also is the general inclination of the old lavas and other rocks of which those hills are composed. The southern flanks of the same hill-belt slope in Fifeshire towards the south-east—this being also the dip or inclination of the rocks. The crest of the Ochils coincides, therefore, more or less closely, with an anticlinal arch or fold of the strata. But when we follow the axis of this arch towards the north-east into the Sidlaws, we find it broken through by the Tay valley—the axial line running down through the Carse of Gowrie to the north of Dundee. From the fact that many similar anticlinal axes occur throughout the Lowlands, which yet give rise to no corresponding features at the surface, we may conclude that the partial preservation of the anticline of the Ochils and Sidlaws is simply owing to the greater durability of the materials of which those hills consist. Had the arch been

composed of sandstones and shales it would most probably have given rise to no such prominent features as are now visible.

Another hilly belt, which at first sight appears to correspond roughly to an anticlinal axis, is that broad tract of igneous rocks which separates the Kilmarnock coal-field from the coal-fields of the Clyde basin. But although the old lavas of that hilly tract slope north-east and south-west, with the same general inclination as the surface, yet examination shows that the hills do not form a true anticline. They are built up of a great variety of ancient lavas and fragmental tuffs or "ashes," which are inclined in many different directions. In short, we have in those hills the degraded and sorely denuded fragments of an ancient volcanic bank, formed by eruptions that began upon the bottom of a shallow sea in early Carboniferous times, and subsequently became sub-aërial. And there is evidence to show that after the eruptions ceased the volcanic bank was slowly submerged, and eventually buried beneath the accumulating sediments of later Carboniferous times. The exposure of the ancient volcanic bank at the surface has been accomplished by the denudation of the stratified masses which formerly covered it, and its existence as a dominant elevation at the present day is solely due to the fact that it is built up of more resistant materials than occur in the adjacent low-lying areas. The Ochils and the Sidlaws are of greater antiquity, but have a somewhat similar history. Into this, however, it is not necessary to go.

The principal hills of the Lowlands form two interrupted belts, extending north-east and south-west, one of them, which we may call the Northern Heights, facing the Highlands, and the other, which may in like manner be termed the Southern Heights, flanking the great Uplands of the south. The former of these two belts is represented by

the Garvock Hills, lying between Stonehaven and the valley of the North Esk; the Sidlaws, extending from the neighbourhood of Montrose to the valley of the Tay at Perth; the Ochil Hills, stretching along the south side of the Firth of Tay to the valley of the Forth at Bridge-of-Allan; the Lennox Hills, ranging from the neighbourhood of Stirling to Dumbarton; the Kilbarchan Hills, lying between Greenock and Ardrossan; the Cumbrae Islands and the southern half of Arran; and the same line of heights reappears in the south end of Kintyre. A well-marked hollow, trough, or undulating plain of variable width, separates these Northern Heights from the Highlands, and may be followed all the way from near Stonehaven, through Strathmore, to Crieff and Auchterarder. Between the valleys of the Earn and Teith this plain attains an abnormal height (the Braes of Doune); but from the Teith, south-west by Flanders Moss and the lower end of Loch Lomond to the Clyde at Helensburgh, it resumes its characteristic features. It will be observed also that a hollow separates the southern portion of Arran from the much loftier northern or Highland area. The tract known as the Braes of Doune, extending from Glen Artney south-east to Strath Allan, although abutting upon the Highlands, is clearly marked off from that great division by geological composition and structure, by elevation and configuration. It is simply a less deeply eroded portion of the long trough or hollow.

Passing now to the Southern Heights of the Lowlands, we find that these form a still more interrupted belt than the Northern Heights, and that they are less clearly separated by an intermediate depression from the great Uplands which they flank. They begin in the north-east with the isolated Garleton Hills, between which and the Lammermoors a narrow low-lying trough or hollow appears. A considerable width of low ground now intervenes before we reach the Pentland Hills, which are in like manner separated from the

Southern Uplands by a broad low-lying tract. At their southern extremity, however, the Pentlands merge more or less gradually into a somewhat broken and interrupted group of hills which abut abruptly on the Southern Uplands, in the same manner as the Braes of Doune abut upon the slate hills of the Highland borders. In this region the greatest heights reached are in Tinto (2335 feet), and Cairntable (1844 feet), and, at the same time, the hills broaden out towards north-west, where they are continued by the belt of volcanic rocks already described as extending between the coal-fields of the Clyde and Kilmarnock. Although the Southern Heights abut so closely upon the Uplands lying to the south, there is no difficulty in drawing a firm line of demarcation between the two areas—geologically and physically they are readily distinguished. No one with any eye for form, no matter how ignorant he may be of geology, can fail to see how strongly contrasted are such hills as Tinto and Cairntable with those of the Uplands, which they face. The Southern Heights are again interrupted towards the south-east by the valleys of the Ayr and the Doon, but they reappear in the hills that extend from the Heads of Ayr to the valley of the Girvan.

Betwixt the Northern and Southern Heights spread the broad Lowland tracts that drain towards the Forth, together with the lower reaches of the Clyde valley, and the wide moors that form the water-parting between that river and the estuary of the Forth. The hills that occur within this inner region of the Central Lowlands are usually more or less isolated, and are invariably formed by outcrops of igneous rock. Their outline and general aspect vary according to the geological character of the rocks of which they are composed—some forming more or less prominent escarpments like those of the Bathgate Hills and the heights behind Burntisland and Kinghorn, others showing a soft rounded contour like the Saline Hills in the west of Fifeshire.

Of the same general character as this inner Lowland region is the similar tract watered by the Irvine, the Ayr, and the Doon. This tract, as we have seen, is separated from the larger inner region lying to the east by the volcanic hills that extend from the Southern Heights north-west into Renfrewshire.

The largest rivers that traverse the Central Lowlands take their rise, as might be expected, in the mountainous tablelands to the north and south. Of these the principal are the North and South Esks, the Tay and the Isla, the Earn, and the Forth, all of which, with numerous tributaries, descend from the Highlands. And it will be observed that they have breached the line of the Northern Heights in three places—namely, in the neighbourhood of Montrose, Perth, and Stirling.

The only streams of importance coming north from the Southern Uplands are the Clyde and the Doon, both of which in like manner have broken through the Southern Heights. Now, just as the main water-flows of the Highlands indicate the average slope of the ancient land-surface before it was trenched and furrowed by the innumerable valleys that now intersect it, so the direction followed by the greater rivers that traverse the Lowlands mark out the primeval slopes of that area. One sees at a glance, then, that the present configuration of this latter division has been brought about by the erosive action of the principal rivers and their countless affluents, aided by the sub-aërial agents generally—rain, frost, ice, etc. The hills rise above the average level of the ground, not because they have been ridged up from below, but simply owing to the more durable nature of their component rocks. That the Northern and Southern Heights are breached only shows that the low grounds, now separating those heights from the adjacent Highlands and Southern Uplands, formerly stood at a higher level, and so

allowed the rivers to make their way more or less directly to the sea. Thus, for example, the long trough of Strathmore has been excavated out of sandstones, the upper surface of which once reached a much greater height, and sloped outwards from the Highlands across what is now the ridge of the Sidlaw Hills. Here then, in the Central Lowlands, as in the Highlands, true mountain- or hill-ranges are absent. But if we are permitted to term any well-marked line or belt of high ground a "range," then the Northern and Southern Heights of the Lowlands are better entitled to be so designated than any series of mountains in the Highlands.

THE SOUTHERN UPLANDS.—The northern margin of this wide division having already been defined, we may now proceed to examine the distribution of its mountain-masses. Before doing so, however, it may be as well to point out that considerable tracts in Tweeddale, Teviotdale, and Liddesdale, together with the Cheviot Hills, do not properly belong to the Southern Uplands. In fact, the Cheviots bear the same relation to those Uplands as the Northern Heights do to the Highlands. Like them they are separated by a broad hollow from the Uplands, which they face—a hollow that reaches its greatest extent in Tweeddale, and rapidly wedges out to south-west, where the Cheviots abut abruptly on the Uplands. Even where this abrupt contact takes place, however, the different configuration of the two regions would enable any geologist to separate the one set of mountains from the other. But for geographical purposes we may conveniently disregard these geological contrasts, and include within the Southern Uplands all the area lying between the Central Lowlands and the English Border.

If there are no mountains in the Highlands so grouped and arranged as to be properly termed "ranges," this is not less true of the Southern Uplands. Perhaps it is the

appearance which those Uplands present when viewed from the Central Lowlands that first suggested the notion that they were ranges. They seem to rise like a wall out of the low grounds at their base, and extend far as eye can reach in an approximately straight line. It seems more probable, however, that our earlier cartographers merely meant, by their conventional hill-shading, to mark out definitely the water-partings. But to do so in this manner now, when the large contour maps of the Ordnance Survey may be in any one's hands, is inexcusable. A study of those maps, or, better still, a visit to the tops of a few of the dominant points in the area under review, will effectually dispel the idea that the Southern Uplands consist of a series of ridges zigzagging across the country. Like the Highlands, the area of the Southern Uplands is simply an old table-land, furrowed into ravine and valley by the operation of the various agents of erosion.

Beginning our survey of these Uplands in the east, we encounter first the Lammermoor Hills—a broad undulating plateau—the highest elevations of which do not reach 2000 feet. West of this come the Moorfoot Hills and the high grounds lying between the Gala and the Tweed—a tract which averages a somewhat higher elevation—two points exceeding 2000 feet in height. The next group of mountains we meet is that of the Moffat Hills, in which head a number of important rivers—the Tweed, the Yarrow, the Ettrick, and the Annan. Many points in this region exceed 2000 feet, others approach 2500 feet; and some reach nearly 3000 feet, such as Broad Law (2754 feet), and Dollar Law (2680 feet). In the south-west comes the group of the Lowthers, with dominant elevations of more than 2000 feet. Then follow the mountain-masses in which the Nith, the Ken, the Cree, the Doon, and the Girvan take their rise, many of the heights exceeding 2000 feet, and a number reaching and even passing 2500 feet, the dominant point being reached

in the noble mountain-mass of the Merrick (2764 feet). In the extreme south-west the Uplands terminate in a broad undulating plateau, of which the highest point is but little over 1000 feet. All the mountain-groups now referred to are massed along the northern borders of the Southern Uplands. In the south-west the general surface falls more or less gradually away towards the Solway—the 500 feet contour line being reached at fifteen miles, upon an average, from the sea-coast. In the extreme north-east the high grounds descend in like manner into the rich low grounds of the Merse. Between these low grounds and Annandale, however, the Uplands merge, as it were, into the broad elevated moory tract that extends south-east, to unite with the Cheviots—a belt of hills rising along the English Border to heights of 1964 feet (Peel Fell), and 2676 feet (the Cheviot).

The general configuration of the main mass of the Southern Uplands—that is to say, the mountain-groups extending along the northern portion of the area under review, from Loch Ryan to the coast between Dunbar and St. Abb's Head—is somewhat tame and monotonous. The mountains are flat-topped elevations, with broad, rounded shoulders and smooth grassy slopes. Standing on the summits of the Higher hills, one seems to be in the midst of a wide, gently undulating plain, the surface of which is not broken by the appearance of any isolated peaks or eminences. Struggling across the bogs and peat-mosses that cover so many of those flat-topped mountains, the wanderer ever and anon suddenly finds himself on the brink of a deep green dale. He discovers, in short, that he is traversing an elevated undulating table-land, intersected by narrow and broad trench-like valleys that radiate outwards in all directions from the dominant bosses and swellings of the plateau. The mountains, therefore, are merely broad ridges and banks separating contiguous valleys; in a word,

they are, like the mountains of the Highlands, monuments of erosion, which do not run in linear directions, but form irregular groups and masses.

The rocks that enter into the formation of this portion of the Southern Uplands have much the same character throughout. Consequently there is less variety of contour and colour than in the Highlands. The hills are not only flatter atop, but are much smoother in outline, there being a general absence of those beetling crags and precipices which are so common in the Highland regions. Now and again, however, the mountains assume a rougher aspect. This is especially the case with those of Carrick and Galloway, amongst which we encounter a wildness and grandeur which are in striking contrast to the gentle pastoral character of the Lowthers and similar tracts extending along the northern and higher parts of the Southern Uplands. Descending to details, the geologist can observe also modifications of contour even among those monotonous rounded hills. Such modifications are due to differences in the character of the component rocks, but they are rarely so striking as the modifications that arise from the same cause in the Highlands. To the trained eye, however, they are sufficiently manifest, and upon a geologically coloured map, which shows the various belts of rock that traverse the Uplands from south-west to north-east, it will be found that the mountains occurring within each of those separate belts have certain distinctive features. Such features, however, cannot be depicted upon a small orographical map. The separation of those mountains into distinct ranges, by reference to their physical aspect, is even less possible here than in the Highlands. Now and again, bands of certain rocks, which are of a more durable character than the other strata in their neighbourhood, give rise to pronounced ridges and banks, while hollows and valleys occasionally coincide more or less

closely with the outcrops of the more readily eroded strata; but such features are mere minor details in the general configuration of the country. The courses of brooks and streams may have been frequently determined by the nature and arrangement of the rocks, but the general slope of the Uplands and the direction of the main lines of water-flow are at right angles to the trend of the strata, and cannot therefore have been determined in that way. The strata generally are inclined at high angles—they occur, in short, as a series of great anticlinal arches and synclinal curves, but the tops of the grand folds have been planed off, and the axes of the synclinal troughs, so far from coinciding with valleys, very often run along the tops of the highest hills. The foldings and plications do not, in a word, produce any corresponding undulations of the surface.

Mention has been made of the elevated moory tracts that serve to connect the Cheviots with the loftier Uplands lying to north-west. The configuration of these moors is tamer even than that of the regions just described, but the same general form prevails from the neighbourhood of the Moffat Hills to the head-waters of the Teviot. There, however, other varieties of rock appear, and produce corresponding changes in the aspect of the high grounds. Not a few of the hills in this district stand out prominently. They are more or less pyramidal and conical in shape, being built up of sandstones often crowned atop with a capping of some crystalline igneous rock, such as basalt. The Maiden Paps, Leap Hill, Needs Law, and others are examples. The heights draining towards Liddesdale and lower reaches of Eskdale, composed chiefly of sandstones, with here and there intercalated sheets of harder igneous rock, frequently show escarpments and terraced outlines, but have a general undulating contour; and similar features are characteristic of the sandstone mountains that form the south-west portion of the Cheviots. Towards the north-east, however, the

sandstones give place to various igneous rocks, so that the hills in the north-east section of the Cheviots differ very much in aspect and configuration from those at the other extremity of the belt. They have a more varied and broken outline, closely resembling many parts of the Ochils and other portions of the Northern and Southern Heights of the Central Lowlands.

The low-lying tracts of Roxburghshire and the Merse, in like manner, present features which are common to the inner region of the Central Lowlands. Occasional ridges of hills rise above the general level of the land, as at Smailholm and Stitchell to the north of Kelso, while isolated knolls and prominences—some bald and abrupt, others smooth and rounded—help to diversify the surface. Bonchester Hill, Rubers Law, the Dunian, Penielheugh, Minto Hills, and the Eildons may be mentioned as examples. All of these are of igneous origin, some being mere caps of basalt resting upon a foundation of sandstone, while others are the stumps of isolated volcanoes.

In the maritime tracts of Galloway the low grounds repeat, on a smaller scale, the configuration of the lofty Uplands behind, for they are composed of the same kinds of rock. Their most remarkable feature is the heavy mountain-mass of Criffel, rising near the mouth of the Nith to a height of 1800 feet.

Everywhere, therefore, throughout the region of the Southern Uplands, in hilly and low-lying tracts alike, we see that the land has been modelled and contoured by the agents of erosion. We are dealing, as in the Highlands, with an old table-land, in which valleys have been excavated by running water and its helpmates. Nowhere do we encounter any linear banks, ridges, or ranges as we find described in the class-books, and represented upon many general maps of the country. In one of those manuals we read that in the

southern district "the principal range of mountains is that known as the Lowther Hills, which springs off from the Cheviots, and, running in a zigzag direction to the south-west, terminates on the west coast near Loch Ryan." This is quite true, according to many common maps, but unfortunately the "range" exists upon those maps and nowhere else. The zigzag line described is not a range of mountains, but a water-parting, which is quite another matter.

The table-land of the Southern Uplands, like that of the Highlands, is of immense antiquity. Long before the Old Red Sandstone period, it had been furrowed and trenched by running water. Of the original contour of its surface, all we can say is that it formed an undulating plateau, the general slope of which was towards south-east. This is shown by the trend of the more important rivers, such as the Nith and the Annan, the Gala and the Leader; and by the distribution of the various strata pertaining to the Old Red Sandstone and later geological periods. Thus, strata of Old Red Sandstone and Carboniferous age occupy the Merse and the lower reaches of Teviotdale, and extend up the valleys of the Whiteadder and the Leader into the heart of the Silurian Uplands. In like manner Permian sandstones are well developed in the ancient hollows of Annandale and Nithsdale. Along the northern borders of the Southern Uplands we meet with similar evidence to show that even as early as Old Red Sandstone times the old plateau, along what is now its northern margin, was penetrated by valleys that drained towards the north. The main drainage, however, then as now, was directed towards south-east.

Many geological facts conspire to show that the Silurian table-land of these Uplands has been submerged, like the Highlands, in whole or in part. This happened at various periods, and each time the land went down it received a

covering of newer accumulations—patches of which still remain to testify to the former extent of the submergences. From the higher portions of the Uplands those accumulations have been almost wholly swept away, but they have not been entirely cleared out of the ancient valleys. They still mantle the borders of the Silurian area, particularly in the north-east, where they attain a great thickness in the moors of Liddesdale and the Cheviot Hills. The details of the evolution of the whole area of the Southern Uplands form an interesting study, but this pertains rather to Geology than to Physical Geography. It is enough, from our present point of view, to be assured that the main features of the country were chalked out, as it were, at a very distant geological period, and that all the infinite variety in the relief of our land has been brought about directly, not by titanic convulsions and earth-movements, but by the long-continued working of rain and rivers—of frost and snow and ice, supplemented from time to time by the action of the sea.

The physical features more particularly referred to in this paper are of course only the bolder and more prominent contours—those namely which can be expressed with sufficient accuracy upon sheets of such a size as the accompanying orographical map of Scotland (Plate I.). With larger maps considerably more detail can be added, and many characteristic and distinguishing features will appear according to the care with which such maps are drawn. In the case of the Ordnance Survey map, on the scale of 1 inch to a mile, the varying forms of the surface are so faithfully delineated as frequently to indicate to a trained observer the nature of the rocks and the geological structure of the ground. The artists who sketched the hills must indeed have had good eyes for form. So carefully has their work been done, that it is often not difficult to distinguish upon their maps hills formed of such rocks as sandstone from those

that are composed of more durable kinds. The individual characteristics of mountains of schist, of granite, of quartz-rock, of slate, are often well depicted: nay, even the varieties of igneous rock which enter into the formation of the numerous hills and knolls of the Lowlands can frequently be detected by the features which the artists have so intelligently caught. Another set of features which their maps display are those due to glaciation. These are admirably brought out, even down to the smallest details. A glance at such maps as those of Teviotdale and the Merse, for example, shows at once the direction taken by the old *mer de glace*. The long parallel flutings of the hill-slopes, *roches moutonnées*, projecting knolls and hills with their "tails," the great series of banks and ridges of stony clay which trend down the valley of the Tweed—these, and many more details of interest to specialists, are shown upon the maps. All over Scotland similar phenomena are common, and have been reproduced with marvellous skill on the shaded sheets issued by the Ordnance Survey. And yet the artists were not geologists. The present writer is glad of this opportunity of recording his obligations to those gentlemen. Their faithful delineations of physical features have given him many valuable suggestions, and have led up to certain observations which might otherwise not have been made.

III.

Mountains: Their Origin, Growth, and Decay.^[D]

^[D] *Scottish Geographical Magazine*, vol. ii., 1886.

Mountains have long had a fascination for lovers of nature. Time was, however, when most civilised folk looked upon them with feelings akin to horror; and good people, indeed, have written books to show that they are the cursed places of the earth—the ruin and desolation of their gorges and defiles affording indubitable proof of the evils which befell the world when man lapsed from his primitive state of innocence and purity. All this has changed. It is the fashion now to offer a kind of worship to mountains; and every year their solitudes are invaded by devotees—some, according to worthy Meg Dods, “rinning up hill and down dale, knapping the chuckie-stanes to pieces wi’ hammers, like sae many roadmakers run daft—to see, as they say, how the world was made”—others trying to transfer some of the beauty around them to paper or canvas—yet others, and these perhaps not the least wise, content, as old Sir Thomas Browne has it, “to stare about with a gross rusticity,” and humbly thankful that they are beyond the reach of telegrams, and see nothing to remind them of the *fumun et opes strepitumque Romæ*. But if the sentiment with which mountains are regarded has greatly changed, so likewise have the views of scientific men as to their origin and history. Years ago no one doubted that all mountains were simply the result of titanic convulsions. The crust of the earth had been pushed up from below, tossed into great billows, shivered and shattered—the mountains corresponding to the crests of huge earth-waves, the valleys to the intervening depressions, or to gaping fractures and dislocations. This view of the origin of mountains has always appeared reasonable to those who do not know what is meant by geological structure, and in some cases it is pretty near the truth. A true mountain-chain, like that of the Alps, does indeed owe its origin to gigantic disturbances of the earth’s crust, and in such a region the larger features of the surface often correspond more or less closely with the inclination of the underlying rocks. But in many elevated

tracts, composed of highly disturbed and convoluted strata, no such coincidence of surface-features and underground structure can be traced. The mountains do not correspond to great swellings of the crust—the valleys neither lie in trough-shaped strata, nor do they coincide with gaping fractures. Again, many considerable mountains are built up of rocks which have not been convoluted at all, but occur in approximately horizontal beds. Evidently, therefore, some force other than subterranean action must be called upon to explain the origin of many of the most striking surface-features of the land.

Every geologist admits—it is one of the truisms of his science—that corrugations and plications are the result of subterranean action. Nor does any one deny that when a true mountain-chain was first upheaved the greater undulations of the folded strata probably gave rise to similar undulations at the surface. Some of the larger fractures and dislocations might also have appeared at the surface and produced mural precipices. So long a time, however, has elapsed since the elevation of even the youngest mountain-chains of the globe that the sub-aërial agents of erosion—rain, frost, rivers, glaciers, etc.—have been enabled greatly to modify their primeval features. For these mountains, therefore, it is only partially true that their present slopes coincide with those of the underlying strata. Such being the case with so young a chain as the Alps, we need not be surprised to meet with modifications on a still grander scale in mountain-regions of much greater antiquity. In many such tracts the primeval configuration due to subterranean action has been entirely remodelled, so that hills now stand where deep hollows formerly existed, while valleys frequently have replaced mountains. And this newer configuration is the direct result of erosion, guided by the mineralogical composition and structural peculiarities of the rocks.