IX.—*Observations on the Higher Summits of the Pentland Hills.*

By ALEXANDER SOMERVAIL.

(Read 23d January 1879.)

The Pentland range, although one of the smallest in our country, is more diversified in its geological structure than any other, not even excluding the great chain of the Grampian Mountains. The Pentland Hills belong to three well defined geological periods or systems. One portion of the range is referable to the Silurian, another to the Old Red Sandstone, and another to the Carboniferous formation. The composition of the rocks which make up each individual hill is quite as varied. Some hills are composed entirely of the old lavas we now designate felstones and porphyrites, others are made up of sedimentary strata and consist of various slates, conglomerates, and sandstones. The range in its vital aspect is quite as much diversified, especially with regard to its vegetable covering. Some hills are from top to bottom covered with a smooth green turf, some with bent, and others with heather, while on many of the hills all exist more or less, and appear to struggle with each other for possession. The vegetable covering has in some cases given a name to the hills, such as Green Law and the Black Hill, the former being covered with grass, the latter with heather, which when not in bloom has from a distance quite a black aspect.

The object of this paper is not, however, to describe the vital phenomena of the range, nor even its geological structure, but is entirely confined to certain changes the hills have undergone during and subsequent to the Glacial Period, or to what may be termed the superficial geology. Yet it is necessary to make a few more preliminary remarks before citing my own observations, so as to give a complete idea of the whole subject.

The Pentlands may be said to commence almost within our own city, running in a south-west direction, and terminating partly in the counties of Peebles and Lanark. The age or elevation of the greater portion of the range has with good reason been referred to the Old Red Sandstone period, and we likewise know for certain that a part is much older than that period, and also that another part is much newer. The oldest hills, as I have already mentioned, are composed of Silurian strata which are almost vertical. The newest, or most recent,

hills are those which are formed of sandstones of Lower Carboniferous age—as the Cairn Hills, to which I shall afterwards draw your special attention. The intermediate hills, or those of Old Red age, form now the principal summits of the range, and consist of the old lavas which burst through and overflowed the surface of the Old Red Sandstones. They form the north-eastern, or that portion of the range which is nearest to Edinburgh, running by Penicuik and Carlops.

The greatest altitude is Scald Law, which is 1898 feet, or 8 feet higher than Carnethy, which, in spite of the measurement of the Ordnance Survey, is yet regarded by the inhabitants of the district as the highest summit. This no doubt arises from the well defined form which Carnethy assumes, its fine conical shape giving it certainly the most imposing appearance of any hill in the range. The other principal heights belonging to this group are Allermuir Hill, Capelaw Hill, Castletaw Hill, North Black Hill, South Black Hill, East and West Kip Hills, all ranging between 1500 and 1800 feet. The south-western portion of the range runs in the direction of Mid Calder, and forms the East and West Cairn Hills. Those hills are from base to top made up of fine conglomerates, grits, and sandstones of Lower Carboniferous age, so little disturbed since their formation that the beds lie almost horizontally from top to bottom. The Cairns are fine specimens of hills cut and carved out of the solid by the action of erosive agencies, without the help of any apparent volcanic upheaval, which many are so prone to associate with the formation of mountains.

It is an impressive sight to stand on the apex of the East Cairn Hill and look down its southern slope upon the huge fragments of sandstone which thickly strew its surface, and amid which you have wended your way to the top. The scene is like the wreck of a miniature world, which the vulgar by cataclysms or convulsions of nature would most likely seek to explain. The origin of this chaos is, however, simple. None of the numerous masses of rock have been carried or brought from a distance, they all belong to the hill itself. From the edges of the strata which pile up the hill and which protrude through the turf, immense blocks have become separated by the action of frosts and other atmospheric causes, assisted by the natural jointage of the rock. Other forces, such as marine denudation, have doubtless in the past been active, but to the former causes are referable, I think, the loose masses which cover the surface of East Cairn Hill.

Another object of interest which attracts the eye of the observer is the great gap between him and the West Cairn Hill known as the “Cauld Stane Slap.” This old and popular name is completely and scientifically correct, the Scotch term *Slap*

meaning gap or breach. That the ends of the strata which form the East and West Cairn Hills -were once united, and that through those once persistent beds of sandstone was driven the present narrow defile, no one can doubt who has given the ground even the most superficial examination.

The highest summit of this group of hills is West Cairn, which is 1844 feet, East Cairn being a few feet lower, or 1839 feet, so that the highest point of the Cairns is 54 feet below the level of the top of Scald Law, and 46 feet below that of Carnethy. These facts with regard to levels it is necessary to bear in mind, as they have an important bearing on the subject, and one to which I shall afterwards have occasion to refer.

Let us now confine our attention to the felstone or porphyrite group of hills and observe the nature of the deposits which cover their tops. In this respect they differ considerably. Some of them are covered with verdure to their summits, others have their tops bare and rocky, others are partially broken up and disintegrated into a sort of soil with embedded fragments of rock; others again are thickly covered with deposits of peat, resting immediately on the surface of the rock without any parting of clay or soil.

The peat is always in strong force on those hills which have flat and extensive tops, where the rain is not rapidly drained off but accumulates in pools, and in its turn produces a strong growth of peat-forming vegetation. Its rate of growth on the tops of hills of such an elevation must be very slow, as it has a severe struggle for possession of the surface, as heavy rains descending and running as miniature streams wash it away sometimes as quickly as it can grow. The summit of the North Black Hill, which is very flat and has a more extensive area than any other hill in the whole range, is covered with peat to a depth of 5 or 6 feet. Scald Law, the highest of the Pentlands, another flat-topped hill, has a thickness of 6 feet of peat resting at an elevation of about 1600 feet, which gradually thins away as it reaches the top. Peat also occurs on the slopes of Carnethy, but almost disappears as we near the apex, as it does on all the other hills which partake of a conical form.

Near the tops of many of the hills are found numerous small stones or boulders resting on the surface of the peat, and also embedded in it sometimes to a considerable depth. This is especially the case on the North Black Hill where they occur in great abundance. These loose pieces of rock must not, however, be regarded as being of more recent origin as to position than the peat on which they rest or in which they are slightly embedded, as will be seen from the following reason. The pools of rain water and the small streams already-referred to cut through to the bottom of the peat in many directions, and scatter the *debris* of

rock which lies beneath it over its surface at lower levels, also leaving portions entirely bare with nothing but an accumulation of loose fragments of rock. This continued action of growth, destruction, and deposit has led to the peat in some places being mixed up with small boulders or stones, as if they had been deposited during the formation of the peat. The boulders which occur below the peat on some of the hill tops also occur on the summits, where it is nearly or entirely absent. Those fragments of rock and small boulders are not confined in composition to the mass which forms the hills on which they are found, but embrace a variety of rocks which are altogether foreign to them. On the tops of Scald Law and Carnethy are many pieces of quartz ranging from the size of a marble to larger than a man's fist, also small boulders of greenstone and a variety of felstones and porphyrites which are different from those composing the hills on which they are found. The same remark holds good more or less with regard to Castle Law, Cape Law, Allermuir, and many others of the range. There is, however, another class of boulders, much more numerous and much larger in size. They consist of fine conglomerates, grits, and sandstones of a reddish or yellow colour passing into white; some of them are well rounded and others more angular in shape, and all of them are soft and friable from long exposure to the elements. They rest on the very highest points of Scald Law and Carnethy. On the latter hill these sandstone boulders are common, but on the former they are more so. On the North Black Hill they are more numerous still. They appear to diminish in numbers as we reach the hills in the neighbourhood of Edinburgh, and are in great force on those on the south-western side in the locality of the hill just mentioned. They also occur below the 6 feet of peat which rests near the top of Scald Law, from which I have dug them along with boulders of felstone and other rocks.

After a careful examination of the sandstone boulders with regard to colour, mineral composition, and texture, I think there can be no doubt that their source is the sandstones of the Cairn Hills, which they resemble and agree with in every respect.

The question now arises, What inference are we to draw from the multitude of these masses of sandstone, now resting at elevations much higher than their source? Are we to infer that the valleys and the highest summits of the Pentlands were at one time filled up, and covered over by such an enormous mass as the Cairn Hill Sandstones? This question is, I believe, one altogether apart, and is in no way connected with the fragments of sandstone which cover the hill tops. It is one which I do not mean to discuss. This opinion has been formed from

the total absence of any scrap of these sandstones occurring *in situ* on any of the hills, either on their summits, slopes, or in their valleys; also from the fact that the loose pieces resting on Carnethy, the North and South Black Hills, Scald Law, and others are intermixed with other boulders of rocks entirely different, yet all apparently having the same origin, and carried and deposited by the same agent.

We have already seen that the highest point of the Cairn Hills (the source of supply of the sandstone boulders) is 54 feet below the level of Scald Law, on which they are plentifully found. It is, however, to be remarked that the top of the North Black Hill, where they are much larger and much more numerous, is 216 feet below the level of West Cairn Hill.

Another point of importance is the inquiry, How much have the various heights of the Pentland range been reduced by denuding forces during the long interval which must have elapsed between Pre- and Post-Glacial times; and what, prior to the glacial epoch, were the higher hills?

If, in imagination, we slowly submerged the Pentlands as we now see them, and allowed them as slowly to emerge from the wasting agency of the tides and waves, the result which would be produced after such a submergence is evident. We should find, I am quite certain, that the Cairn Hills had suffered terribly, that the waves had made great havoc among their soft and flat-lying sandstones, and that they had been reduced in a much greater ratio than the hard and enduring felstone hills. Even at the present day, with the action of the ordinary atmospheric agents, I believe the Cairn Hills to be more the subjects of waste than those composed of porphyrite rocks.

I am thus inclined to regard the Cairns as having been at one time the highest summits of the range, and that during this period portions of them were scattered over the other hill tops. If the Cairn Hill Sandstones really did at one time extend over all the other heights, as Professor Geikie thinks they must have done, then the Cairns must have been very much higher than they are now in order to have done so. This inference, if it be correct, would relieve us of the difficulty of accounting for rocks being removed from a lower to a higher level,—a difficulty which is not even satisfactorily answered by gigantic glaciers, nor even by ice sheets of enormous thickness.

Regarding the mode by which the foreign matter was carried and deposited on the hill tops, where we now find it, Dr James Croll, Dr James Geikie, and Professor Archibald Geikie assert that its carriage and deposition are due to huge glaciers coming from the Highlands, which filled up the basin of the Forth and overflowed the highest summits of the Pentlands in their course over the surface of the country. From this hypothesis I entirely

dissent, and consider the position quite untenable, as failing to explain the phenomena with which we are dealing.

The same authorities, in support of this hypothesis, mention the fact of boulder-clay existing on the summits of the Pentlands. Dr Croll, in his recent able and learned work on "Climate and Time," minutely describes the occurrence of true till, or boulder-clay, on the top of Allermuir Hill; but I hold that neither on Allermuir, nor yet on the top of any other hill in the whole range, is there such a thing as typical boulder-clay, but only a peaty soil, partly formed by the underlying rock and the decomposition of the boulders themselves, together with the decay of vegetable matter, making up a clayey deposit, but having no connection whatever with boulder-clay.

It is perfectly clear that no glacier of Highland origin can account for the *debris* of the Cairn Hill Sandstones resting on the other hills of the range. Instead of ice moving from the Grampians, there is rather the proof of some force from an opposite direction, viz., from S.W. to N.E., or in a line with the exact trend of the hills, or very near it. There are also other indications which I have observed which would favour and corroborate this seeming movement from S.W. to N.E. In deep excavations made in the boulder-clay at Alnwick Hill, near Liberton, there were exposed many boulders of Old Red Sandstone which must have come from the vicinity of Carlisle. I also saw many large boulders of the same rock, along with others from the Pentland range, dug from cuttings made in the boulder-clay, two years ago at Seafeld, near Leith. So that all the boulders observed must have travelled in a line from S.W. to N.E., or parallel with the range of the Pentlands, from whence they were derived. Mr John Henderson has likewise noted the fact of a large slab of sandstone lying in the gorge of the Bonally Burn, which belongs to beds about half a mile to the S.W., which greatly confirms the view I am inclined to take of some force passing from S.W. to N.E.

With regard to the agent which moved in the direction just indicated, and scattered the fragments of the Cairns over the other hills to the N.E., I believe it to have been drifting ice during that period of the glacial epoch, when much of our country seems to have been submerged below the sea, when ice in the form of berg and floe floated over the sunken valleys, and left the *debris* of one hill upon some other. Previous to this period (as I have already stated), I am strongly inclined to think that the Cairn Hills were the highest of the Pentland range, and that during the submergence of the land they were terribly denuded, and suffered in a much greater ratio than the other hills. Indeed this is, to a great extent, evident from their clean-swept summits, formed of comparatively soft and yielding

strata, and the great amount of their waste spread over the slopes and summits of the neighbouring hills. There is, however, the possibility, nay, even the probability, that the *debris* of other rocks resting on the summits of the Pentlands may be of Pre-Glacial age,—an opinion which there is nothing to negative, as far as I am aware. There is a point bearing directly on this statement to which I would invite your attention,—one that has been almost systematically ignored, or perhaps has never before been mooted, or, at all events, has been but little discussed. It has become a customary practice,—a kind of geological dogma,—to refer all boulders that are perched at high altitudes, and those that are foreign to the localities in which they occur, as the special product of the glacial period, as if the entire surface of the country had been bare of any such isolated and travelled blocks before the commencement of that epoch. How many of the huge masses of rock, which rest on and near the tops of our mountains and hills, which we with perfect confidence refer to the glacial period, have been there ages before the age of ice set in, it would be difficult to say; yet it is highly reasonable to suppose that there were not a few. How many of the boulders at present imbedded in the till,—nay, even how much of the *debris* we now term the boulder-clay was in existence, ready for the ice to redistribute and rearrange, is, I think, a question worth consideration. It might assist us, I am inclined to think, better to explain the reason of the boulder-clay partaking both of the colour and composition of the underlying rocks.

In the portion of our country under consideration there is no deposit intervening between the upper coal measures and the boulder-clay. This immense gap represents an interval in the history of its geological sequence which we have no faculty to grasp. Some of the intermediate formations were, most likely, deposited either in whole or in part and afterwards swept away. Yet, even between the latest of these deposits and the dawn of the glacial period, the surface of the country would be operated on by the ordinary wasting and redistributing forces—atmospheric action, tides, waves, and rivers—all producing change and accumulating waste. The greater the interval that elapsed between the latest deposit and the formation of the boulder-clay in its present state, the greater would be the breaking up of the surface by denuding agencies; so that many of the phenomena we with confidence refer to the glacial period may have been really produced ages before. Or if, with Dr Croll, we regard glacial periods as of frequent recurrence at regular and comparatively short intervals, how shall we be able to distinguish and separate the erratic blocks of one epoch from those of another?

It is from considerations such as these, that I would be careful in not referring the whole glacial phenomena of the Pentland range to one special period. If I am able to interpret them aright, I think we have, at least, two well-defined movements from different directions: the one from S.W. to N.E., the other from about N.W. to S.E. The former movement was that which carried, in a line parallel to the trend of the chain, the fragments of the Cairns over the tops of the other hills, and swept masses of the Old Red Conglomerate and Porphyrites in the direction of Seafield. To the latter movement, from the N. or N.W., crossing the hills at right angles or diagonally, I would refer the large boulders of quartz and mica slate resting on the slopes of the Pentlands and "the White stone of Peebles," noted by Mr Ralph Richardson, and described in vol. ii. of our "Transactions," page 397.

With regard to the carriage of those Highland boulders resting on the Pentland slopes and in other localities in our own immediate neighbourhood, much unhealthy scientific, or rather, I should say, unscientific, imagination has been excited by the talk and description of immense glaciers, or a whole ice-sheet, moving from the north, not content with passing down the valley of Forth, but crossing over it and sweeping onwards above the highest of the Pentlands. The explanation of these travelled blocks in their present position by drift ice has nothing outrageous in it, but much to commend it. The valley of the Forth had an existence during the glacial period as well as to-day. Its upper reaches drain a country abounding in rocks *in situ* such as we have just mentioned. During a depression of our country, and that during a period when a rigorous cold prevailed, which is no fancy, but an ascertained fact, ice drifting in the direction of the valley, laden with an occasional boulder from its higher reaches would, naturally enough, strand at various points along its shores or shallows, and leave its burden within the line of the lands submerged.

In concluding this short and imperfect notice of phenomena full of interest and well worthy of much further research, let me again briefly refer to the deposit of peat which we found covering the *debris* resting on the hill tops. We have seen that on and near the summits of the highest elevations it attains in some places a thickness of nearly 6 feet, beneath which rest the boulders referred to. It is a question of importance and one of much interest, What period of time does this thickness of peat represent? If we could arrive at anything like an approximate estimate of its growth, making due allowance for all the vicissitudes under which it has accumulated, it might throw a glimmer of light on the lapse of time between the period when the *debris* ceased to be carried and deposited on the Pentland summits,

ON THE HIGHER SUMMITS OF THE PENTLAND HILLS. 199

and when the hills emerged from the sea and a new set of conditions began to prevail favouring the growth of peat ; between this time, which we term the close of the glacial period, and the appearance which the Pentland Hills present do-day.

To conclude ; let me acknowledge the company, opinion, and advice of Mr T. W. Kilgour in many matters, given during some very pleasant rambles among that delightful range of hills, the Pentlands.