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plentiful in "Ice Fiord," the seams coming to the water's edge; the Norwegian sealers often call here to fill up with it. There is very little game, as the reindeer has been nearly shot out. The fishing is poor, and the blue and white fox are very scarce. Gulls and sea-birds abound during the short summer. On the rubbly spit of land at the entrance to the bay is seen the small cemetery where those who have died far from home are buried, and the remains of two huts that have in years past sheltered shipwrecked crews who have had to pass the winter in this scene of desolation. The intense stillness of the spot seems almost to numb one's senses, and produces a peculiarly restful feeling of the body and nervous system.

Our stay here was short, and after a very stormy passage, we were, I believe, all glad to be once more inside the Tyne, and feel that no accident had happened, and that all who left with the ship had returned safely.

THE RIVER SPEY.

By LIONEL W. HINXMAN, B.A., of H.M. Geological Survey.

THE physiography and geological history of the river Spey present several points of interest which, as far as I am aware, have not been discussed by previous writers on the Physical Geography of Scotland.

It is unnecessary in the case of so well-known a river as the Spey to enter into any geographical details as to watershed and course that can be followed on any good map. It will be sufficient to state that the drainage basin of the river—that is, the area from which it derives its waters and the rock-waste which it carries to the sea—is approximately 1300 square miles in extent. The upper portion of the basin includes a wide tract of high mountainous ground, that in its greatest breadth measures 25 miles from north to south. The length of the river, measured along its windings from Loch Spey to the sea, is 97 miles, or almost exactly that of the Tweed.

On looking at a map of the drainage basin of the Spey one is at once struck by the fact that the river does not occupy the centre of the area, but lies considerably nearer to the northern than to the southern boundary. It will also be noticed that the southern tributaries are more numerous and important than those flowing in on the northern bank, and that the former have a course more or less at right angles to the main stream. The only northern tributaries of any size, the Dulnan and Calder, flow for the greater part of their course through longitudinal valleys, parallel to that of the Spey. The southern side of the basin includes a large extent of mountainous country, most of which has a greater mean elevation than the ground north of the river. This implies a greater fall for the streams flowing in from the south, as well as a greater rainfall. Hence they have been able to cut a long way back into the original high-level plateau, and thus drain a larger area than those on the north side.

The upper course of the Feshie, one of the largest tributaries of the

Spey, presents an excellent example of the shifting of a watershed, and the capture of the head-waters of a stream belonging to another river-system.

For the first six miles of its course the Feshie flows to the east, but at the point where it touches the boundary between the counties of Aberdeen and Inverness, it bends suddenly round, and runs in a directly opposite direction on the further side of Sron na Ban Righ. The watershed at this bend is only a few feet above the bed of the stream, and on the eastern side a wide peat-filled valley, now only occupied by an insignificant burn, runs eastward to the Geldie, following the same line as the course of the Feshie above the bend.

It is evident that the river Eidart, which joins the Feshie a mile below the bend, was once the head-stream of that river, but that the Feshie has gradually cut back its bed to the county march and captured

the upper part of the Geldie. Thus the former head-waters of the Geldie are now those of the Feshie, and the watershed between the basins of the Spey and the Dee has been shifted more than six miles to the eastwards.

It is a common belief that the Spey is the swiftest river in Scotland. But this statement, which will be found in almost every school geography and guide-book, is not according to the facts. The total fall of the Spey, from source to mouth, is 1142 feet, and less than that of either the Dee or Tay; and is, moreover, very unequally distributed over its course. The lower portion is certainly swifter than that of either of the above two rivers; but a large section of its middle course is comparatively slow, and in places even sluggish in character.

The large rivers of north-eastern Scotland have also been recently described as orthodox in their course—that is, as exhibiting the three regular phases of upper or torrential track, middle or valley track, and lower or plain track.

That this is not the case with the Spey will, I think, appear from a consideration of the following facts:—

PROFILE OF THE COURSE OF THE SPEY

FALL OF THE SPEY.

Feet.		Feet.		Miles.
From 1142	to	1000	in	6 $\frac{1}{2}$
„ 1000	„	900	„	2 $\frac{1}{4}$
„ 900	„	800	„	12
„ 800	„	700	„	14 $\frac{1}{2}$
„ 700	„	600	„	21 $\frac{1}{4}$
„ 600	„	500	„	7
„ 500	„	400	„	6
„ 400	„	300	„	6 $\frac{1}{2}$
„ 300	„	200	„	7
„ 200	„	100	„	7
„ 100	„	Sea-level	„	6 $\frac{1}{4}$

Fig. 3 represents a vertical section or profile of the course of the Spey, and it will be seen at once how much this line departs from the smooth parabolic curve shown in Fig. 2, which represents the course of an orthodox and mature river.

The profile-line of the Spey is divided into three well-marked sections of unequal length. The upper section has a fairly steep but uneven slope; the middle section is gently inclined throughout, and at three several points is for some distance almost horizontal; the lower section falls steeply and evenly to the sea.

A closer examination of the levels at various points serves to emphasise these three divisions.

In the first part of its course, from Loch Spey to Laggan Bridge, the Spey falls 327 feet in 14 miles, or at the rate of 23 feet per mile. In the middle portion, between Laggan Bridge and Grantown, 215 feet in 40 miles, or 5·3 feet per mile. From Grantown to the sea, 600 feet in 43 miles, or at the rate of 14 feet per mile. The fall per mile in the lowest section is thus nearly three times as great as in the middle section. Nor is this large fall due to any sudden steep descent or series of rapids. It is evenly distributed over the whole distance of 43 miles (as will be seen by a reference to the table), and represents a slope of about 1 in 378.

Before seeking for an explanation of this striking departure from the normal, it will be advisable to return to the higher parts of the river, and examine its course in greater detail.

I have said that the middle section contains three nearly horizontal portions. These indicate the position of three basins formerly occupied by lakes, but now drained by the gradual lowering of the barriers which retained the water.

The first of these basins extends from near Dalcholly, above Laggan Bridge, to a point a quarter of a mile above the confluence of the Truim with the Spey, and forms an alluvial flat six miles in length, with an average breadth of half a mile. Through this flat the river winds with a sinuous course, cutting deeply into the sand and fine silt which at an earlier period it laid down on the floor of the loch. The numerous "cut-offs" or curving pools, such as the Sean Amar (Old Channel), above Laggan Bridge, show the method in which the river is always straightening its course, by cutting through the necks of the loops as it winds from side to side of the valley. The barrier which produced this

basin is found a short distance above the mouth of the Truim, where the rocks of Torr na Truime and of Creag Dubh approach one another on either side of the valley.

The next basin extends from Kingussie to the foot of Loch Insh, which represents but a small remnant of the ancient lake whose waters covered an area seven miles in length and nearly a mile in breadth. The barrier of the Kingussie basin is not so obvious as that of Invertruim; and in this case there is no constriction of the valley. An explanation must be sought in the river Feshie, which flows at right angles into the Spey, a short distance below Loch Insh. This river, which drains a wide area of high mountain ground, and flows with a rapid fall through a steep-sided valley, carries down a vast amount of rock-waste, which is spread out in a large alluvial fan between Feshie Bridge and the foot of Loch Insh. In times of heavy spate the tributary will bring down more coarse material than the main river can carry away; the fan of alluvium grows and pushes the latter against the further side of the valley, and has undercut the steep northern bank below Kinraig. A further increase in the alluvial deposit of the Feshie at an earlier period may have partially held up the waters of the Spey, and caused them to spread out in a shallow lake above the fan, for even at the present time it is a common sight to see timber, brought down by the flooded Feshie, floating *up* the Spey towards Loch Insh.

Large sums have been expended in protecting the meadows of Insh and Kingussie by embankments that are destroyed by every exceptional flood, while the same money devoted to causing the Feshie to flow with an oblique course into the Spey half a mile further down, and to deepening the Spey channel below the island at Kinraig, would drain the upper part of Loch Insh, and convert the marshy meadows above, that are now flooded for half the year, into fertile, arable land.

The wide stretch of alluvium that extends for about three miles above and below Nethy Bridge points to the existence of two former lake-basins, the one between Gartenmore and Broomhill, the other between Broomhill and Balliefurth. A damming-back action of the Nethy, similar to that ascribed to the Feshie, may possibly account for the upper basin; while there are indications of a rock-barrier at Revack Hill that may have held back the waters of the lower loch.

But in addition to these ancient lakes, whose position and extent can be estimated with tolerable accuracy, we are confronted with the fact that nearly the whole of the middle section of the course of the Spey is a waste-filled basin.

Between a point two miles above Kingussie and Grantown, no rock is seen in place anywhere along the river-bed. Throughout the whole of this distance of twenty-seven miles, the river is now engaged in cutting through a flood-plain composed of the materials deposited at former periods, when the amount of waste brought down by the Spey and its upper tributaries was greater than the river below could carry away.

It has already been said that the last forty miles of the Spey present a steep and regular slope. Over the greater part of this distance the river is flowing through solid rock, and is still engaged in deepening its bed.

So great a departure from the normal course of a large river indicates that this portion of the Spey is of more recent origin than the middle section above Grantown, where it has long ceased to deepen its original bed, while the fact that the river is still cutting back also shows that the slope between Grantown and the sea must have been increased at some period later than that of the excavation of the upper part of its course.

The effect of an uplift or elevation of the land along an axis running north and south somewhere about Grantown would be to diminish the slope of the river valley on the upper or south side of the axis, and to increase the slope below, and such an uplift may therefore be suggested as the possible cause of both the long waste-filled basin above Grantown, and the rapid fall between that place and the sea.

In the first case the decrease in slope would diminish the transporting power of the stream, and the waste material would accumulate until the basin became filled up. Below the axis of upheaval, on the other hand, the increase in slope would enable the river to do an increased amount of work. It would therefore cut back its bed afresh, until the outlet of the flood-plain above was lowered, and the materials, temporarily arrested in their course, resumed their journey to the sea.

The alluvial deposits in the upper part of the basin appear to be of great thickness, and it is possible that this part of the valley may have been deepened by the action of glacier ice. It is certain that much of the alluvium is fluvio-glacial—that is, it has been laid down by water flowing from melting ice-sheets. This point will be referred to later on.

The lowest rock-barrier on the Spey is found in the well-marked constriction of the valley at the Pass of Sourden below Rothes. The quartzite of Ben Aigan here formed a barrier that dammed back the water over what is now the fertile Haugh of Rothes, and the remains of this barrier can still be seen on either side of the river at Aikenway Castle. There are indications that the Sourden barrier was at one time high enough to divert the waters of the Spey through the Glen of Rothes. This glen is flanked on either side by well-marked successive terraces that can be traced southwards by Blackhall and Newton, and merge into the high-level terraces of the Spey between Rothes and Craigellachie. The highest of these is nearly 500 feet above sea-level, and may be correlated with the extensive terraces at Knockando and Phones, higher up the river. They are composed of sand and very fine gravel, which was laid down at a time when the gradient of the river-bed was much less steep than it is at present.

The fall of the Spey over the last few miles of its course is at the rate of 16 feet per mile, and so steep is the slope, that the highest spring-tides do not flow further than half a mile above Speymouth. This rapid fall, so unusual near the mouth of a large river, is probably due to the movement which raised the coast-line some 100 feet above the present sea-level, and laid bare the high-level marine terraces that fringe the coasts of the Moray Firth. The old shore-line can still be traced in the low cliffs of red sandstone that are seen above and below the bridge at Fochabers.

Below this point the river is now cutting rapidly back through the loose shingle deposits of the 100-foot and 50-foot raised beaches. These beaches are more or less covered by the alluvium laid down by the river when it first began to flow over the newly raised surface. This portion of its course is consequently very erratic, and the river has at one time or another flowed over the whole of the wide alluvial plain that extends both westwards and for two miles eastwards over the muir of Dallachy. It has now cut down below the surface of this plain, and flows to the sea through a lower tract of recent alluvium in a wilderness of branching channels that shift with every flood. The actual mouth of the river has also changed its position frequently within recent times, and there is evidence to show that it is now travelling westwards.

The site of a Roman station can still be traced on the east side of the river one and a half miles below Gordon Castle. The camp stands on the edge of the 100-foot terrace looking over a lower alluvial plain; and though there is no direct evidence of any recent depression of the coast-line sufficient to cover this plain with the waters of the sea, we may speculate as to the possible existence of an estuary, the *Tuessis Aestuarium* of Ptolemy, up which the Roman galleys sailed to a port which perhaps occupied the present position of the village of Fochabers.

To conclude with a short account of the geological history of the basin of the Spey.

We know that the courses of many of the rivers of the west coast are not earlier than Miocene times, and the actual channel of the Spey may have undergone many local changes within a comparatively recent geological period. But the valleys through which the river and its principal tributaries flow belong to a very early period in the history of the earth. That they existed before the Old Red Sandstone age we know from the fact that the river Avon at Tomintoul is still cutting down through an outlying patch of the conglomerate of that formation which is filling up the ancient valley. How far this formation extended up the Spey valley we cannot say, but the occurrence of conglomerate in the Findhorn valley at a height of 1100 feet above the sea, points to a wide extension westward of Old Red Sandstone strata.

The rocks throughout the greater part of the Spey valley belong to the Highland Metamorphic series, including different varieties of crystal-line schists, gneisses, and quartzites. The age of these rocks is still an open question, but we are safe in assuming them to be of at least Pre-Silurian age, while they may very possibly be found eventually to belong to the Torridonian or some other formation earlier even than the Cambrian period.

Between Boat of Bridge and Fochabers the river is still cutting through the sandstones and conglomerate of the Old Red Sandstone.

It is possible that certain of the great structural lines of the central Highlands have played some part in the history of the Spey valley. The fault which crosses the Moor of Rannoch and determines the hollows in which lie Loch Laidon and Loch Ericht, is continued down the valley of the Truim and passes into that of the Spey. Its subsequent course is concealed beneath the alluvial deposits, and there is no further

evidence of any dislocation of the rocks; but it is not unlikely that this fault may have to some degree determined the line of the valley at this point. The course of the valley between Craigellachie and Rothes coincides with the line of another fault which runs through the Glen of Rothes and Glen Fiddich, and has shattered and brecciated the quartzite of Beinn Aigan along the river bank at Arndilly.

It may seem a "far cry" from Strathspey to the parallel roads of Glen Roy, yet the conditions which produced these well-known features were at the same time the cause of an important phase in the history of our river.

The terraces of Glen Roy and Glen Spean are now admitted by all competent observers to be ancient lake margins. They mark the successive levels of the water dammed back in these glens by masses of glacier ice moving eastwards from the high mountainous ground around Loch Eil. Three of these distinct terraces can be traced along the sides of Glen Roy, and one at least in Glen Spean. The mean levels of the Glen Roy lakes, as shown by these margins, were respectively 1148, 1067, and 855 feet above the sea—that of the Glen Spean lake, 855 feet, corresponding with the lowest of the Glen Roy terraces. The col, or lowest point of the watershed between the head of Glen Roy and Loch Spey, is 1151 feet above sea-level, while the highest level reached by the highest terrace is 1155 feet. It follows that the waters of the lake corresponding to this terrace, when at their fullest, must have escaped over the col and flowed down into the Spey. It has been objected to this theory that there is no sign of any large body of water flowing eastwards over this col. To this objection we may reply that even at its highest level the lake would only stand four feet above the level of the col, and that the normal outflow would not amount to more than a mere "seiping" through the flat peaty hollow that here crosses the watershed. The drainage and surface areas of this loch were also comparatively small.

All who have taken the charming drive from Kingussie to Loch Laggan will remember the straight level valley through which the road passes between the Mashie Water and the sudden eastward bend of the river Pattack. There can be little doubt that this peaty hollow indicates the channel through which much of the water that now flows westwards into the Atlantic once poured eastwards to swell the volume of the Spey.

The watershed of Scotland crosses the road immediately east of the bend of the Pattack. The height of the col is 848 feet, that is, seven feet lower than the mean height of the terraces corresponding to the Glen Spean and lowest Glen Roy lakes. The drainage area of these lakes must have been very extensive, and their combined waters would form a narrow loch twenty miles in length, but with an average breadth not exceeding one mile. A considerable volume of water must consequently have flowed eastwards down Strath Mashie to the Spey; and in this case there is ample evidence of the position of the old river channel.

There are other features in the valley of the Spey that may be attributed to the later phases of the Glacial Period.

Among these are the high-level terraces so noticeable from the

railway between Glen Truim and Kingussie. They can be traced more or less continuously on either side of the valley from Etteridge and Creag Dhu to Nethy Bridge and Broomhill. Examination of their levels at various points proves that, while they have a slight general inclination down the valley, this is by no means uniform. They are therefore neither ordinary river-terraces, which would slope uniformly; nor lake-margins, that would be horizontal. It seems more probable that they were formed by the deposition of sand and gravel between the edge of a shrinking glacier that occupied the centre of the valley and the hill-sides. The material would be brought down by the streams flowing off the hill-slopes and down the surface of the glacier itself.

The hills around the sources and upper course of the Spey are much lower than the Cairngorm mountains, from which the Feshie and other important tributaries descend. Hence towards the close of the Glacial period, when the ice in Badenoch was dwindling or had even entirely vanished, a large glacier may still have been pouring down Glen Feshie into the Spey valley. This would act as a barrier, or even perhaps send a tongue of ice up the valley towards Kingussie; even as in later times the alluvial fan of the Feshie has partially dammed back the water of Loch Insh. Below Aviemore the high-level gravels stretch completely across the valley and form the flat moorlands around Boat of Garten. This sheet of gravel, together with the thick deposits of similar nature that fill the wide valley of Glen More and cover a large area in the Abernethy forest, are fluvio-glacial in their origin and have been laid down by the great body of water issuing from the melting glaciers of Strathspey as the ice retreated up the side glens and main valley.

The large masses of granite that are seen in the bed of the river at various points between Pityoulish and Boat of Garten, and also occur imbedded in the sand in the cuttings on the Carrbridge railway, further indicate the glacial origin of these sands and gravels. They are far too large to have been brought down by the stream, and have dropped to their present position by the force of gravity, as the glacial deposits in which they were imbedded were washed away.¹

To sum up the conclusions at which we have arrived from the consideration of the facts described in this paper. The Spey is a compound river, composed of two sections of different age and at unequal stages of erosion. The lower section has been rejuvenated by uplift, and, contrary to the normal conditions of an orthodox stream, is at once younger in age and steeper in gradient than the higher portions. The Spey valley for the greater part of its extent may, on the other hand, be regarded as the result of the slow erosion of the river, continued since early Palæozoic times, along a line determined in the first place by some original irregularity of surface, but subsequently modified to some degree by earth movements and glacial action.

¹ See *Annual Summary of the Progress of the Geological Survey for 1897*, pp. 148-150.