Mr. CARRUTHERS said that as the rhizome, whether it was that of *Aspidium* or *Osmunda*, was an aërial, and not a subterraneous rhizome, it must have been carried to its present position; and it consequently indicated, as Col. Lane Fox had pointed out, the direction of the stream.

Mr. FLOWER regarded Col. Lane Fox's memoir as of great interest, as affording an additional instance of that perfect similarity of these deposits, whether in France or England, which in places so wide apart might reasonably be taken to indicate a common origin. It was indeed generally assumed that these deposits were brought down by rivers; but this, according to his view, was by no means certain. Col. Lane Fox had described the valley as 4½ miles wide; but there was at Croydon, 12 miles distant, a deposit of gravel capped with loess, containing elephant-remains, and exactly resembling the Thames-valley gravels, and communicating with them. This evidently formed part of the Thames-valley system, whatever that system might be taken to be; and if so, he thought it incredible that the loess should have been distributed by river-action over an area 12 or 15 miles in width. In conclusion, he was quite content to adhere to the opinion held by the French geologists, and formerly by several of our own most able writers, that the distribution of these superficial drifts was in the first instance diluvial rather than fluvial.

Col. A. LANE FOX, in reply, pointed out the artificial character of the implements, and the manner in which the mammalian remains occurred. He thought that some part of the brick-earth of the lower terraces might have been deposited at the bottom of a lake.

Mr. BUSK, in proof of the animal-remains not having been brought from a distance, showed that remains of the same animal were found in close proximity to each other.

Prof. RAMSAY made some remarks on the undoubtedly artificial character of the implements, and on their position at the base of the gravels. The origin of the Thames valley he had already maintained to be of Postmiocene age; and though there was at present no evidence of man's existence at that time, it was still possible. Of the extreme antiquity of the human race there could, however, be no doubt.

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4. *On the* EVIDENCE *for the* ICE-SHEET *in* NORTH LANCASHIRE *and adjacent parts of* YORKSHIRE *and* WESTMORELAND. By R. H. TIDDEMAN, Esq., M.A. Oxon., F.G.S., of the Geological Survey of England and Wales.

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[PLATE XXX.]

INTRODUCTION.

THE materials on which the remarks are founded which I now have the honour of submitting to the Society, have been collected by me

for several years past whilst carrying on the work of the Geological Survey. The process has been necessarily slow; for the direct evidences do not generally obtrude themselves upon one's notice, and they are so sparingly scattered over the ground, and so affected by the form of the ground and other local causes, that any generalization from a mere partial examination of the district would be worthless. It has been my privilege to go over the greater part of the area acre by acre; and although objects of more practical utility have been the chief aim of this examination, I have always been on the look-out for any records of the Glacial period which are graven on the rocks themselves. I believe that very few such which are exposed have escaped my notice; and those found I have endeavoured to register impartially, leaning as little as may be towards one theory or another.

I intend, first, very briefly to describe the physical features of the district.

The region lies between latitude 53° 38′ and 54° 18′, and extends from the great watershed of England on the east to Morecambe Bay and the Irish Sea on the west. To the N.N.W. are the Lake mountains, and to the south the plains of Cheshire and South Lancashire. The accompanying map (Pl. XXX.) will explain better than words the features of the country. It is on the scale of $\frac{1}{3}$ inch to a mile, and is coloured to represent elevations. The contours of one half of it have been reduced from the Ordnance 1-inch contoured maps, the remainder from the 6-inch scale. The levels which I have used are those of 200, 500, 1000, 1500, 2000 feet. The great watershed is traced in lozenge-shaped dots.

On the west, next the sea is a great plain, a continuation of that of South Lancashire and Cheshire. It consists chiefly of Trias and Permian much covered and almost entirely concealed by Glacial drift and alluvium. This all lies below the 200-feet contour, and is in some places more than 12 miles broad. Its extent is rudely represented by the main mass left white on the west margin of the map.

With the exception of a small portion in the north-west corner of the map forming the estuary of the river Kent, the rest of the district west of the watershed consists of the drainage-systems of the Ribble and the Lune. The whole of the Ribble-basin is contained in the district, and a great portion of that of the Lune. The main direction of these rivers is from the north-east.

The Ribble-basin is bounded on the south-east by a chain of moorlands running north-easterly from Chorley, called by Mr. Hull the Rossendale Anticlinal. They rise to heights of from 1000 to 1500 feet, one summit only attaining the latter elevation. Their southern flanks drain into the Irwell, and thence by Manchester into the Mersey. On the north of them is a long valley containing the valuable coal-field of Burnley and Blackburn. This country drains north by the rivers Calder and Darwen, which pass through narrow defiles in the long Pendle range of hills into the valley of the Ribble.

The Pendle chain of hills is a strongly marked feature in the

district. It consists of the entire thickness of the Millstone-grit and Yoredale series, and runs with a tolerably straight course from near Chorley on the sea-side plain to and beyond the great watershed; its highest point is Pendle Hill, 1831 feet. The rocks of which it is formed dip, for the greater part of their course, at very high angles to the south-east. To this I shall again refer.

The Ribble runs along an anticlinal valley excavated in carboniferous shales and limestones, which, from the alternations of hard and soft rocks, crumble away quickly under denuding forces.

Between the Ribble and the Lune lies a great rudely circular patch of high moorlands intersected by small radiating valleys, which, as it has no general name, I will call for the purposes of this paper the Central Fells. It is about 18 miles in diameter, and consists of the Yoredale and Millstone Grits, dipping gently north. The highest point is Ward's Stone, 1836 feet, 5 feet higher than Pendle; but several of the Fells rise to nearly 1800 feet. Indeed, looking from the hill-summits, one cannot but be struck by the apparently uniform level to which all these Fell-tops rise, suggesting most vividly a very old "plain of marine denudation." The summits show here and there mounds of loosened rock in the last stages of disintegration. Sometimes scars of grit occur, but only where some valley-slope in close proximity has eaten into the foundation of the rock which forms it. Generally the tops are rounded and void of any sharp features, and for the most part clothed in peat-moss from 1 to 15 feet or more in thickness; and they form a wild bleak country, tenanted only by sheep and grouse, the plover and the curlew. North of this tract the grits of which it is composed dip beneath the comparatively low district of the Ingleton coal-field; it is between the 200- and 500-feet levels in the basin of the Lune. To the west of this is the Lune, running south-west by Lancaster; and again west, separated by a low tract, lies the estuary of the Kent.

The north-east corner of the map contains a high tract of country, constituting one of the principal parts of the Pennine chain of hills. On its south-east border lie the well-known hills of Ingleborough, Pennigent, and Fountains Fell, rising respectively to the heights of 2373, 2231, and 2191 feet above the sea; and on the north, Whernside 2414, Gragreth 2250, Widdale Fell 2203, &c. This high country is separated from that west and south-west by a broad valley, which runs along the Craven Faults. This may have been at some former time a continuous line of drainage, but is now crossed by the watersheds between the Lune and the Ribble and the latter and the Aire; and portions of it are now drained by all three of these rivers. It has been already mentioned that the general course of the Lune and Ribble is to the south-west; but the former, when running alongside, and the latter through, this high tract, have a southerly direction. The fact remains that over the greater part of this district these rivers and their tributaries, and consequently the valleys, run to the south-west.

I now propose, first, to give a description of the scratches found upon the solid rocks, distinguishing, where possible, between those

which may have been the result of local glaciers and those which, from their position or other circumstances, must be memorials of the great Ice-sheet at the period of its maximum development.

I will then, secondly, give an account of other indications at the surfaces of the rocks which seem to point to the movement of ice over them.

Thirdly, I will endeavour to show the inferences to be derived from a study of the Till in connexion with the other phenomena; and

Lastly, the general conclusions as to the Ice-sheet to be derived from a study of this district, and the inferences which may be drawn by correlating the observed phenomena of this district with those of others surrounding it.

I. Ice-scratches.

The whole of the rocks of this country, wherever the Till or Lower Boulder-Clay now exists, or may reasonably be supposed to have not long been removed, show a *moutonnée* and usually striated surface. Wherever the rocks have been hard enough to resist the weather, or the overlying Till stiff enough to protect the scratches, they still remain. There is hardly a quarry or rock-exposure in the district where you have a hard line between the top of the rock and the overlying Till where you may not find scratches. Of course where you have soft shales or sandstones or rapid alternations of hard and soft rocks under the Till, the two are much confused and no such direct indications exist.

It is only where subsequent rain or river denudation in the valleys has removed the glacial surface of the ground, or high up on the Fells where no stiff drift has remained to act as a shield, that you cannot find *moutonnée* surfaces. Finding the ice-mouldings so general in places suited for their preservation, it is almost impossible to avoid the conclusion that the whole country has been at one time one vast ice-covered *roche moutonnée*.

In placing upon the map (Pl. XXX.) the observations which have been made on this subject, I have merely given the line of the direction of the travelling mass, and not the quarter from which in each case the ice may be supposed to have come. I have done this because I have been afraid lest I should appear by any personal bias to distort the facts and so affect the main question. I have preferred to lay before the Society the scratches, which do not admit of controversy, and leave them to be judges in each case of the probable direction in which the ice moved along those scratches.

I need scarcely say that the sign employed on the map does not indicate in each case the distance over which the scratches are seen, but the centre of each sign is the point at which the observation has been made. It must not be supposed that the absence of scratches in three corners of the mass indicates their non-existence, but merely that no observations have been made, those portions being beyond my district.

My thanks are due to my friend Mr. T. McK. Hughes for notice of several scratches in the extreme north of the map, and also for some

in the neighbourhood of Ingleborough. I may state that throughout this district at each locality the striæ are tolerably regular and parallel. Some few do, of course, cross the others obliquely; but there is seldom any difficulty in seeing which is the main direction. Such slight and unsystematic deviations may easily have been made by stones falling into crevasses, which would not necessarily at first have their principal axis in the direction of the movement of the ice. Such rotation as would be produced in accommodating their axes to the direction of least resistance would cause any projecting points to form scratches oblique to those produced by stones which had already assumed that direction.

The Scratches of the Lune District.—There appears to be a greater harmony of arrangement along parallel curved lines here than in any other part of the district. It will be seen that near the north edge of the map, about Killington Common, they have a south-south-westerly direction; a few miles further south they are a little more westerly, whereas about Lancaster and south of Morecambe Bay they curve again to the south. It is not easy to describe the parallelism of curvature; but the map renders it at once apparent to the eye.

Now, can these be accounted for by a local glacier? Those on Killington Common are on one of the highest parts of the ridge between the valleys of the Lune and Kent, and run along its crest, not across it. They are about 600 feet above the adjoining valleys. Those further south are not on quite such high ground; but they are considerably above the lowest line of drainage which would be taken by a glacier at several miles distance from high gathering-grounds.

The scratches on Claughton Moor, a semidetached hill on the north side of the Central Fells group, are very interesting. They harmonize most thoroughly with the curved arrangement of the others in the Lune district, and were evidently formed in the same way and by the same agent. Yet, unless we are prepared to admit that the direction of the main mass of ice was north and towards the higher ground of the Lake-district rather than south and away from it, we must allow that they were formed by ice pushing uphill at the rate of 800 feet or more in two miles. This view is confirmed by the higher Fells S.S.W. of this, lying in the same line of direction, being completely *moutonnées* over a very large surface, and to a height of at any rate 1500 feet.

I had the benefit of Professor Ramsay's opinion on this matter; and he quite agreed with me that the ice producing these effects must have come from the north, and not from the south. It is clear that local glaciers going downhill have not made them; for in this case the ice has not been travelling in the direction of the greatest fall, but considerably across it. Nor can they have been produced by icebergs grounding, as might be suggested; for then there would be some indication of coasting, whereas these markings are all nearly parallel and going up the hill instead of along it. Nor will an ice-foot explain it; for then we should have scratches radiating from the higher ground. In short, I can conceive of no arrangement but that of land-

ice pushed up over this hill by pressure from behind, and obliged to maintain a definite course by ice to the right and left of it.

Now let us look at the set of north-and-south scratches on the north flank of the Central Fells.

It might be suggested that they are due to the shedding of ice to the north from those Fells; but, on the other hand, they are close to the valley of the Wenning, a river which runs from the east to join the Lune, and which would under a system of separate glaciers drain the ice of a considerable part of the high ground about Ingleborough, as well as the northern flank of the central moorlands. Such a valley-glacier would require a considerable width for its channel; and the ice in that would proceed exactly at right angles to the path indicated by these striæ; and they show no signs of turning to run into the Wenning glacier. They cannot be clearly explained by the grounding of icebergs; for icebergs we know are governed in their course more by currents than by winds, and it is improbable that a current five miles broad would impinge upon land without giving some signs of its being deflected. Upon the whole I incline to the opinion that these scratches also belong to the same system as the remainder of the Lune scratches, and that they represent the passage of ice over the Central Fells by a movement from the north—a supposition which is somewhat strengthened by the great smoothing to which these Fells up to their summits have been subjected, all the ordinary stratigraphical features having been obliterated.

Ingleborough District.—Another very interesting set of scratches has been found by Mr. Hughes and myself on the east flank of Ingleborough; they are running in a curved line, pointing to one another, and rising as they proceed from north to south. They curve from S. 10° W. to W. 40° S., and in so curving rise from 1225 feet to 1350 feet. The curve taken by them seems to be caused by the ice rounding Simon's Fell, the east shoulder of Ingleborough. They are on the edge of a long moraine-like mound, which takes the same direction as the scratches. I confess I have some difficulty in seeing at what portion of the glacial period these were made. That they were made by a glacier is very probable; but if so, the glacier which formed them must have been at least four miles in breadth. They certainly do not show any signs of having been formed by any small local glaciers which had their birth on Ingleborough; for they are transverse to the course of any such glaciers. It is possible that the moraine-like mound may have been what was left of the till of the ice-sheet between the scour produced by the dwindling glacier of the Ribble valley and a small glacier descending from the hollow on the south side of the summit. In that case they may still be memorials of the great ice-sheet.

On the large limestone plateau south-east of Ingleborough, rudely coextensive with the portion between the 1000- and 1500-feet levels on the map, are many signs of ice-action. They exist chiefly under isolated large boulders supported on little pedestals of limestone rock, in many respects similar to glacier tables; for the boulder has preserved from weather the scratched surface on which it rested, whilst all around the limestone has wasted away to the depth of

eighteen inches or two feet. Most remarkable examples of this, to which Mr. Hughes first called my attention*, occur on Norber; and the Silurian boulders there, some of which must have been brought from lower levels in the country north of them, appear to have a rude arrangement along lines which coincide with the direction of the scratches and the line in which they must have travelled from the parent rock.

North, south, and west of Settle many scratches are to be found. They have nearly all a general north-and-south direction. Some of them may have been produced by later glaciers, lying as they do along the bottom of the valley; but others are at elevations up to 1300 feet, and, taken with the scratches on Ingleborough, on the other side of the Ribble valley, would imply a glacier eight miles broad and 750 feet deep. A point worthy of notice is that these scratches are taking a course parallel to the general direction of the watershed, which is not two miles to the east of them.

Bowland Knotts.—From the Central Fells south of Ingleborough a long ridge dividing the Lune and Ribble drainage strikes east towards the Ribble valley near Settle. It is composed of the lowest bed of the Millstone Grits, dipping gently north. Along its edge are many bold and picturesque bastions of rock, forming a fine foreground to the beautiful panorama of the Pennine chain which is seen from here. Close to the highest point, which is crossed by a mountain-road running from Clapham to Slaidburn, on a prominent bluff of conglomerate, I found the most remarkable evidences of ice-action in the whole district. Scratches were seen under drift at an elevation of 1400 feet; the direction was S. 15° E. across the ridge. On another rocky eminence, one third of a mile south-east of the first are more scratches, on the southern side of the ridge; their direction is S. 5° E., and the elevation is about 1325 feet.

If these were produced by a local glacier, what were its gathering-grounds? Not the Fells immediately west; for then the scratches would be at right angles to their present course. Looking along them to the north, the nearest ground even *equalling* this in height is a portion of Ingleborough seven and a half miles distant; and between this and that lies a broad valley excavated to the depth of about 1000 feet. Ingleborough, with its 900 feet only of additional height, could hardly fill up that valley and make itself felt at that distance. If we look south again along the scratches, there is no ground of equal height to help us nearer than Pendle Hill, at *twelve* miles distance, and across *two* broad valleys. The height at which these scratches occur across this ridge is greater than the height of some of the passes across the Fells to the west of it. There can be very little doubt that the ice-stream passed entirely over these Fells.

In the broad valley between Ingleborough and Bowland Knotts, to which I have just alluded, are two distinct sets of scratches at right angles to one another. One runs south-east, the other south-west. The south-east set were probably made when the ice-sheet was not at its maximum, *i. e.* when there was not sufficient lateral pressure or "shouldering" to thrust the ice over Bowland Knotts, and when

* "Notes on the Geology of parts of Yorkshire and Westmoreland," Proc. Geol. and Polyt. Soc. of the West Riding, 1867.

it had to go round, these south-east scratches being generally on lower levels than those to the south-west. They would therefore probably be made at the earlier or later part of the ice-sheet period—most likely the latter; for the ice at its maximum would obliterate the effects of its earlier development. The south-west scratches seem to lead on from those on the high ground north of the valley, and may belong to the same set as those on Bowland Knotts, the change in direction being accounted for by the form of the ground. On the other hand, it is possible that they may be the result of a local glacier later on, finding its way to the valley.

These scratches running in directions transverse to one another call to mind a suggestion which Professor Ramsay made to me some two or three years ago, that it is possible that there may have been undercurrents, so to speak, in the ice-sheet, caused by the form of the ground. That this occurs on a small scale, at any rate in glaciers, I am pretty well convinced. I saw an instance of it on the Zardezan glacier at the head of the Val Pellina in the summer of 1869. A small glacier debouching from a higher level on to the main ice-stream spread so far across it that the median moraine resulting from the junction of the two swept round in a curve nearly to the opposite bank of the main glacier, which was very far from being a narrow one. There could be no doubt that two bodies of ice were moving in different directions, one above the other, for some distance; but I should feel inclined to hesitate before applying the principle on so great a scale to explain the opposing scratches in so broad a valley, especially as they may be explained by better-known phenomena, as I have already shown.

Leading on from Bowland Knotts is another scratch, on the opposite side of the Hodder valley; it trends across the valley and across the ridge on which it lies.

On the Watershed.—About seven miles west of Skipton lies the Great Watershed, here on comparatively very low ground. It runs along a range of hillocks rising to about 700 feet. They are composed chiefly of drift; but in some parts the underlying limestone rises to the surface. Here is the only scratched surface which I have yet found which shows glaciation from west to east. This is not to be wondered at. It lies between the basins of the Ribble and the Aire, at one of the lowest passes in the Pennine range across the watershed of England. Granted such a development of ice as I have already indicated, it is quite impossible that some of the ice should not have been discharged in this direction. I am aware of the difficulties that are raised about the east side of the Pennine chain being so free from drift: but all geologists agree that some, at any rate, does exist; and the patches that are left cannot be considered to have been dropped just as they are, in isolation. The difficulty lies rather in the question, how has the mass of it been removed? That is a question which I cannot undertake in this paper; I do not know the ground sufficiently to hazard an opinion; nor, indeed, does the matter come within the scope of this inquiry.

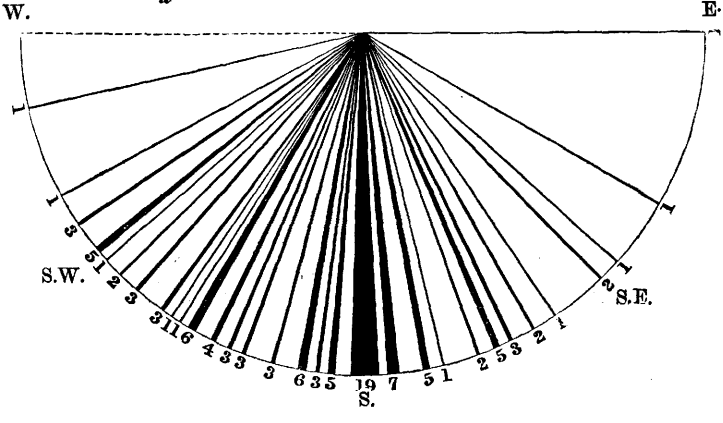
Other scratches seem to run in the direction of East Yorkshire and across the watershed, as about Gisburn, Gledstone, and Barnoldswick.

Clitheroe District.—These last have a general agreement with a scratched "roche moutonnée" on Twiston Moor, on the north-easterly extension of the ridge which culminates in Pendle Hill. It is a complete parallel to those on Bowland Knotts before mentioned; for the scratches are running across the range and not from the summit of Pendle, the highest ground in the neighbourhood. Also the scratches here and those on Bowland Knotts are almost in the same straight line. A proof will be given under the next head that these scratches were formed by ice coming from the north rather than from the south.

In the gorge of the Calder, which cuts across the Pendle range at Whalley, is a very fine large "roche moutonnée" well scratched. It shows pretty clearly by its form that the ice was going up the course of the present river (or southward), not down it (or northward). This rock, as shown by the drift sections on both sides of the ravine, was well covered up by a good thicknesss of Till, and above that again by forty feet of the "middle sands and gravel;" so that it must have been worked by the ice of the land-ice period, not by icebergs, coast-ice, or ice-foot—nor yet by later glaciers; for in that case those later deposits would have been ploughed out. It will be seen, if we put together the scratches in the neighbourhood of Pendle, that to the north of it they appear to be deflected by that eminence, and that to the south they would seem to be coalescing again. I can conceive its being quite possible that the ice-sheet went quite over Pendle; but even then the base of the ice-stream would be influenced in its course by the slopes of the ground, and some such effect as that noticed would be produced.

Close to the south bank of the Ribble, at the junction of Starling Brook, about two miles above Ribchester, are some scratches trending

Fig. 1.—*Diagram showing the proportion of Ice-scratches running in different directions in North Lancashire &c.*



S. 8° W., whereas the valley is running W.S.W. I do not think these can be referred to later glaciers; they would rather seem to

belong to the system which crossed over the shoulder of Pendle Hill and went up the Calder valley. One scratched "roche moutonnée" occurs under Mellor Beacon; its direction is W. 13° S., one of the very few instances of scratches with so much of west and so little of south in them, and its direction is probably due to local causes.

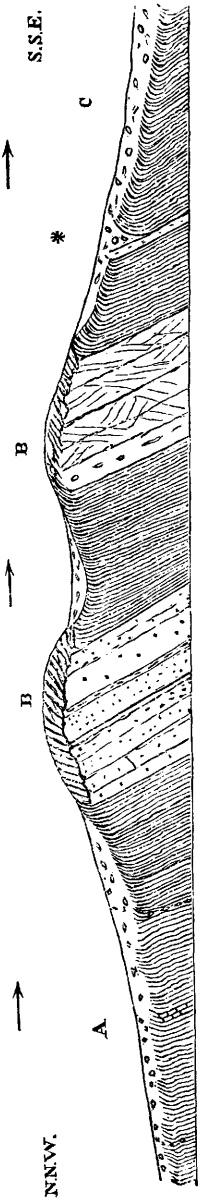
The scratches along the coast are not many, the greater part being well covered with drift; but those which do occur seem to agree well in their direction, giving one the idea of a great ice-stream coming to the S.S.E. from the Lake-district, and so damming up the whole of the ice-drainage of the district as to compel it to work across the hills and valleys towards the south, instead of between and along them to the south-west.

The diagram (fig. 1) gives a summary of the ice-scratches observed, reduced to a common centre. The radii show by their thickness the proportional frequency of ice-scratches in each direction; and the numbers are appended. It is a fact worthy of note that 20 per cent. of the whole are running due south.

II. Other Indications of Ice-movement.

I will now proceed to describe other appearances on the surface of the rocks which seem to point to the passage of ice over them.

The range of the Pendle chain which runs from near Chorley on the western plain to Skipton forms the southern side of the great compound anticlinal to which I have already referred as that in which the Ribble valley south of the Pennine chain is excavated. Its general range is E.N.E.; and therefore its general dip will be S.S.E. But this dip, for the greater part of its length, is at very high angles, from 30° to 60°, and sometimes more. Along the southern flank of these hills you find over wide areas the different laminæ of the beds *at the surface* so turned over in a downhill direction, *i. e.* south, that the angle of dip is either considerably increased, or even reversed, to a depth of one or two feet or more (fig. 2). It is obvious that this is not due to any internal movements of the crust; for it does not penetrate below the surface. I am aware that this phenomenon has been before noticed, and often referred to a sub-aërial "drag" or "trail" of soft beds to a lower level by reason of gravitation under the softening and loosening influences of rain and frost; but we also get it on the tops of the hills as well as on the slopes, and here gravity would have very little or no field for action. In this position it has been referred to the agency of icebergs grounding on ridges of rock and thrusting the projecting edges of the beds over by the shock. Granting that this is possible, we must yet allow that if an iceberg floating from the north grounded on the top of a ridge, the very fact of its so doing would prevent its exerting this power on the southern flank, which would be in deeper water, and so protected from the abrading power of any floating body of sufficiently light draft to pass over the top of the ridge without hindrance. And any iceberg grounding on the ridge would have to be reduced in bulk by melting, or by breaking itself upon the rock before passing, and would not run



A. Edges pushed up hill.
B. Edges pushed across the hill.
C. Edges pushed down hill.

* Till forced in between two beds. The arrows indicate the direction of the movement of the ice.

Fig. 2.—*Diagram Section to show the effects of the Ice-sheet on highly inclined rocks along the Pendle Range.*

A. Grey Rocks; *a*. Grey Till from the same.
B. Red Rocks; *b*. Red Till from the same.
C. Grey Rocks; *c*. Grey Till from the same.
The arrow indicates the direction of the ice-flow.

Fig. 3.—*Sketch Section illustrating the passage of the Ice-sheet as shown in the colouring of the Till by the rocks traversed.*

aground again until it came to a reef of less, or at any rate equal depth from the surface of the sea.

But there is yet another position in which this effect is observed; and that is, on the north side of a hill where the dip is into the hill or south (A in the diagram, fig. 2). Here the edges of the beds have been pushed up hill instead of down, though still in the same direction. This cannot in any case be referred to subaërial "drag" or "trail," but exists in spite of it. Again, this might be thought the result of a thrust from an iceberg floating against the ridge; but in so soft a rock as shale, in which this usually though not exclusively occurs, it seems probable that the berg in recoiling would detach the material already loosened by the first forward thrust, and so tend to deface its own work. Can we suppose that in this case the beds have been thrust up hill by an ice-foot fringing the shore, and raised higher at every tide by the accumulation of fresh ice at its base? It seems plausible. Yet, if we admit it, we shall have to allow that whereas on the northern beaches of narrow islets the ice-foot was forcing the edges of the beds upwards and inland, on the southern shores it was dragging them downwards beneath the sea—an hypothesis which cannot be maintained for an instant.

The question then comes to this. Shall we attribute the same effect at A (in the diagram, fig. 2) to an ice-foot, at B to icebergs, and at C to subaërial "drag?" or shall we recognize at both A and B the effects of icebergs, and at C the work of subaërial agents? for no one of these is in itself sufficient to account for all three cases. Such explanations, taking all the facts together, would seem, to say the least of it, to be rather forced and unnatural.

On the other hand, if we can find an agent which will consistently account for this identical effect in all the positions in which it occurs, and also give a solution to several other groups of kindred facts which cannot be readily explained in other ways, we should accept it without hesitation. And such an agent is the great ice-sheet pushing on from its northern gathering-grounds, recruited by the greater elevations on its course, but overriding the lesser, grinding down and smoothing by its weight and friction rocks presenting but a gentle incline, tearing up and turning over the basset edges confronting its approach. For, be it noted, it is only on the southern side of the anticlinal, where the outcrops face the north, that these appearances are to be found; throughout the whole of the northern part of the district, all about the Central Fells, where the beds are dipping north or lying at gentle inclines, nothing of the sort is to be seen. The reason is clear. Where the beds dip north they succeed each other in relation to any force coming from the north, as do the tiles of a roof to the rain; but where dipping south the arrangement is just the reverse. To use a homely illustration, in one case the brushing was with the nap, in the other against it. These superficial movements are common, so far as I have seen, all along the Pendle range. I have seen them some distance south-west of Blackburn. Between the Calder and Pendle Hill, more particularly about Padiham Heights, they are very frequent. Mr. Hull and I, in surveying this ground, found them in nearly every quarry-,

brook-, and road-section. The least-favourable position for their preservation is that at A in the diagram. It is only natural that it should be so; for denudation is greater along escarpments than elsewhere, and the effect of subaërial drag would be to destroy them. A very good example occurs in Twiston Brook (just along the line of the scratches on Twiston Moor), where the overturned beds may be seen for a distance of 150 yards along the brook. It is covered and preserved by the overlying Till; and that shows some evidence here, from its materials, of its being merely the waste product of the rocks passed over, and of the direction in which it was being pushed. Another occurs in shale above Moorside, on the north side of Pendle. My friend and colleague, Mr. W. Gunn, has seen similar overturnings of the surface-edges at different points along the chain between Pendle and Skipton. Perhaps the most interesting example of all is one occurring at Blackburn, a representation of which I have embodied in the diagram at the point marked with an asterisk. My friend Mr. James Eccles, F.G.S., called attention to it in a paper read to the Manchester Geological Society; but as it illustrates so well the subject before us I cannot forbear to mention it. It is seen in a road-cutting in a lane near the public park. Beds of shale, sandy flags, and gritstone are dipping southerly at high angles. In one part a bed of soft shale, resting on some harder rock, has been pushed away from it at the surface; and in the angle between the two lies some Till. It seems pretty clear that ice has pushed away the softer bed to a greater extent than the harder; consequently a vacant space was left; and into that a portion of the "moraine profonde" was forced. I know not any phenomena in connexion with the Glacial period which give so vivid a picture of a resistless force working in an undeviating course over hill and dale across the ordinary drainage-channels of the country as this wreck and ruin of all opposing obstacles.

III. The Evidence of the Till.

In speaking of the Till I have no intention of entering upon its well-known characteristics, its local composition, its boulders scratched but not usually rounded, its absence of bedding, &c. I would merely wish to point to those appearances which seem to indicate the direction in which the ice-sheet which formed it travelled; and when speaking of the Till as the product of the ice-sheet, I must remark that much of what is called Till must have been remodelled by the glaciers which were the direct successors, without interruption, of the ice-sheet; and no distinct line can be drawn in this district between the one and the other.

It is a common practice to speak of the Till as being coloured by the rocks beneath; and to a certain extent this is true; but when it is stated that it is always of the same colour as the rock on which it lies, such a remark must either be founded on insufficiency of observation, or is due to the observations having been made in districts where the differences in the rocks passed over are not sufficiently marked to impress their distinctive colouring &c. on the Till.

There is abundant evidence in this district that it is not coloured by the rocks *on which it lies*, but by the rocks *over which it has been pushed*. Where the ice-sheet has been passing for some distance over grey rocks (fig. 3) you may find grey drift upon them; and if, further south, red rock comes on, you will still find grey drift upon it. But if the red rock continue for some distance southwards, you will see the red drift coming in beneath the grey, and the latter tailing out as the former increases in bulk and importance. If, again, continuing your section south, there is a change from red rock to grey, again you will have the red drift resting upon the grey rock for some distance, until the grey drift rises from the rock and intervenes, and so on, the waste product being always on the lee side of the rock producing it. There are several instances of this in the district. Thus, in the valley of the Lune, north of Kirkby Lonsdale, are two long patches of Old Red Sandstone. Further south, in the direction of the ice-movement in Leck Beck, are Coal-measures consisting for the most part of grey rocks, such little red colouring as they do possess being probably derived from the overlying drift. This is almost as red as the Old Red Sandstone, certainly very much redder than the Coal-measures on which it rests, so that the latter cannot be the source whence its colour was derived. There can be little doubt that this drift has passed over the Old Red Sandstone higher up the valley. Again, the patch of Permian south-east of this has acted in a similar way upon the drift which lies immediately to the south of it.

In the Ribble valley, near Clitheroe, is a patch of red rocks supposed to be of Permian age. It lies about 20 miles to the S.S.E. of the last-mentioned; and no other red rocks exist in the country between; grey Till lies upon it. About half a mile south of its southern boundary is a section in Barrow Brook, showing at the base grey Carboniferous shale; on that is grey Boulder-clay, and above it red clay; over this, again, is grey Boulder-clay, the line between the two being very distinct. It is probable that we have here first the Till from the grey rocks south of the Permian, then that from the Permian, and lastly that from the grey rocks on the other side of the Permian. There is no other red rock which could give the colour but this Permian; the next nearest rock of that colour is some Trias in the Ribble, 7 miles or more to the south-west. All these facts point to the southern movement of the ice-sheet.

Again, on the Trias just mentioned, in the Ribble below Stubbin's Wood, on the left bank is a fine section including Pebble-beds, Till, Middle Sands and Gravel, and Upper Boulder-clay. The Trias is faulted down to the south-west against grey Carboniferous rocks. The Till on this Trias is grey; but further to the south you have grey and yellow Carboniferous rocks with red Till reposing on them. The diagram (fig. 3) is a sketch section embodying these observations.

If we allow, for the sake of argument, that there was at one time an ice-sheet over the whole or nearly the whole of this district, and that it slowly disappeared, we must admit that each piece of ground so covered must at one time have been at the edge of that sheet, and that there would be a time when at any particular spot the ice would be losing strength to such an extent that it could no longer

thrust forward its "moraine profonde." This would accumulate between the ice and the rock in inverse proportion to the weight and power of the ice. This accumulation of the Till would be an effect constantly following the edge of the ice-sheet in its retreat.

If this were so, we should get very much the kind of section shown in the diagram. The edge of the ice would be working up red drift on to the grey rocks south when it had no longer strength to enable it to abrade the grey rocks themselves, and so in retiring succession. And this is just what I have found in this district in the distribution of colour through the Till.

Of course the Till coloured by the red rocks is not entirely made up of their waste. It contains nearly the same boulders as the grey Till; it is only the matrix which has been coloured by an intimate mixture of red sand or clay.

It is obvious that, although strictly speaking these variously coloured beds have a certain sucession about them, it is a succession so rapid and so brought about by the same causes under the same conditions, that to refer them geologically to different ages would be wholly wrong. Any geologist not acquainted with this changeable character of the Till might think when he found drift of one colour resting with a hard line upon drift of another colour, that he had discovered an unconformability in the Boulder-clays, and classify them accordingly. For this reason I cannot but think that such terms as "the Blue Clay, the Grey Clay, the Yellow Clay, the Clay with Chalk and without," when applied to glacial deposits of particular ages, are cumbersome and misleading. Such characteristics can only hold good as a test of time over a *very* limited area; and even that is doubtful. It is quite possible, nay, it is certain, that in some areas you may have Till of totally different appearance, colour, and material deposited side by side, by the same agents, and under the same conditions, at the same time.

As regards the transport of material, it is an interesting fact that over the greater part of this district there are none but local rocks in the Boulder-clay. In the term local I include any rocks which are derived from any part of the drainage-system in which they are found as boulders. Thus you may find Silurian rocks in any part of the Ribble valley, though they become more scarce in proportion to the distance from the parent rock, which lies chiefly in the neighbourhood of Ingleborough and along a line thence to Malham Tarn.

The ground from which the ice travelled in this district was almost entirely east of the Lake country; consequently you get in the Till none of those granites, porphyries, traps, and ashes which might, did they occur, be so easily traced to their origin. The country from which it passed hither is chiefly a Carboniferous tract; therefore many of the boulders may have travelled a long way overland into the Lune and Ribble valleys and yet appear to be derived from local rocks.

But there is a part of the district which is an exception to this rule. A line might be drawn parallel to the glacial curves along the valley of the Lune and down along the eastern border of the western seaside plain which would roughly represent the boundary of the Lake-country drift.

This direction is rudely represented by the glacial scratches on the rocks beneath. In the northern quarter of the map this boundary may be carried along the Gatebeck Brook, as my friend Mr. Hughes tells me. West of this you find Shap Granite and other Lake-district rocks, but none to the east. The boundary runs thence towards Lancaster. I have found such boulders in Till down the coast by Hest-bank and Bolton-le-Sands. South of Lancaster it probably takes the direction shown by the scratches until past the Central Fells. Here it seems to turn a little more to the east; for foreign boulders may be seen in the neighbourhood of Longridge Fell, although it is possible that they may have been brought thither out of the line by icebergs or coast-ice during the period of the Upper Boulder-clay. At any rate the boundary will go over the western end of the Rossendale anticlinal, and thence to Manchester.

I wish particularly to call attention to the fact that this direction coincides with that of the scratches, and that *it is across the mouths of all the valleys.*

In the part of the district east of Pendle Mr. W. Gunn's observations confirm my own, to the effect that there are no boulders of other than local rocks. He gives only one apparent exception—namely, the existence on the north side of Boulsworth Hill of blocks of quartz rock, a rock which he had seen nowhere in place in the neighbourhood. A rock of this kind, however, I happen to know does occur in Stockdale, near Settle, 18 miles to the N.N.W. of Boulsworth; so that this is no real exception to the rule. Moreover the line of transport coincides with the direction of the ice-sheet's movement as shown by the scratches at high elevation on Bowland Knotts and on Twiston Moor. The scratches at Kingscar in the neighbourhood of the parent rock are not in this direction, but S. 15° W.; as, however, they run along the side of some high scars, this variation is probably local.

It is a point insisted on by some geologists, that wherever either rounded stones or marine shells are found in the Boulder-clay it must be of marine origin. I do not think that either of these supposed characters is infallible. Mr. Croll has shown that the Caithness Till, which contains shells, need not necessarily be marine, but may have been formed by the ice-sheet working over a previous sea-bed and pushing the shells on to the land. In this way shells scratched and broken may be found at very much higher levels than the sea in which they lived and died. They are there as much boulders as the scratched stones along side of them, and are no more evidence of the drift in which they lie having been formed under the sea than Spirifers and Producti found in Limestone River-gravel would be proof of its being marine. In very many places the ice-sheet must have passed over what had previously been the sea-bed; and if its course took it thence inland we should be surprised not to find sea-shells mixed with the drift formed by it. Nor can rolled stones be considered a better test; for under similar circumstances they would be brought up from the old sea-bed on to the land. But rolled stones may be found in abundance in the terminal moraine of any glacier, so that we have their presence most naturally explained. No one who has seen one of those swallow-holes called "moulins" in the ice of a large gla-

cier, and the impetuous swirling torrent which enters it at mid-day hurrying down stones from the surface of the ice, can doubt that *there*, at any rate, is a mill in which rolled pebbles are being manufactured; and such "moulins" must have existed in abundance on the ice-sheet in the times of its decay.

IV. Conclusions.

I have endeavoured to show that in the district with which I am more intimately acquainted, there are proofs of a widespread and almost universal glaciation—that whereas the drainage of this district is to the S.W., the general movement of the ice over it was to the S. or S.S.E. across deep valleys, and over hills of considerable elevation—that this is proved by the scratches on the rocks, the direction and method of transport of the Till, its materials, and their arrangement along lines coinciding with the scratches, as well as by the superficial disturbances of the rocks. I showed that these facts would admit of readier explanation by means of an ice-sheet than by any other glacial agent. But the direction of the movement requires a further explanation. Under ordinary circumstances an ice-sheet would be working down from the watershed to the sea in the direction of the main valleys; but this was not so. There must have been a great barrier along what is now the seaside plain to dam up the mouths of these valleys to a great height and prevent their discharge of ice to the south-west. Just where this barrier should have existed we find evidence of a great stream of ice coming from the Lake-district and bearing with it rock-specimens of that country. This must have been of considerable height and very persistent in its flow to divert the ice-drainage of the basins of the Lune and the Ribble from their natural course; but that it did so is very evident. This barrier was but the line of junction of the ice of the Pennine chain with that from the Lake-district, and to the eye they must have presented only the appearance of one great sea of ice; and this barrier must have been supported or shouldered up by other ice coming from portions of the Lake-district still further west.

After coming to the above conclusions I could not fail to be interested in finding how thoroughly the facts observed by the Rev. J. G. Cumming in the Isle of Man agreed with those which I had met with in North Lancashire and Yorkshire. Mr. Cumming, in his work 'The Isle of Man,' states that the glacial scratches have an almost uniform direction across the island of magnetic east to west, that is from the E.N.E. In speaking of the very local character of the lower portion at least of the Boulder-clay formation, he says (p. 113), "as we proceed westward we shall observe how it changes in composition and tallies in chemical character, as well as in lithological appearance and colour, with that of the subjacent prevailing rock a very little to the eastward of any spot on which we may fix for its examination." Further on, p. 120, he says, "we fall in with pebbles of foreign rocks in the Boulder-clay which must have come from a great distance, from the shores of Cumberland and the south of Scotland;" and this leads him "to the conviction of one great current setting down from the Solway Frith upon these shores and overpowering the effects of local currents caused by the

flux and reflux of the tide." He also speaks of the direction in which blocks have been transported agreeing with the scratches on the rocks beneath. At p. 249, he says, "There are phenomena which point to the probability at least that enormous waves with vast carrying force must have swept over the surface of the island. The general appearance of its eastern, as compared with its western side, described by Swedish naturalists under the term *Stossseite* or weathered side, indicates in some measure that fact, and also the direction of that action. But the evidence which tends most powerfully to the establishment of such a view is to be read in the phenomena presented to us on the western side of South Barrule. We have noticed there on its western side, and even within a hundred feet of its summit, large boulders of the same granite which is developed on its eastern side more than 600 feet below the summit. No simple carrying-action of icebergs can have transported these blocks up the very steep eastern face of the mountain, and so over to the other side; but we can imagine the extraordinary action of great waves acting on masses of ice charged with these granitic blocks and bearing them to a considerable elevation above the then sea-level. We must either grant this, or suppose an elevation of the mountain-chain to the westward of the granitic boss since the deposit of the blocks on the top and western side of South Barrule; but of such elevation no independent evidence has been yet discovered." So far Mr. Cumming. This was published in 1848; and though the conclusions drawn from the facts are a little out of date, there can be no doubt of the accuracy of his observation of the facts; and none of his facts, so far as my knowledge goes, are antagonistic to the former existence of a great ice-sheet filling up what is now the Irish Sea, between the Lake-district and the Isle of Man, and passing over that island.

If now we pass on to South Lancashire and Cheshire, we may take the evidence of Mr. Morton as to the glaciation of the basin of the Mersey. In a paper read to the British Association at Liverpool in 1870, he modified his former views as to the scratches which he had discovered being due to a glacier, and having found fresh localities where these existed at some height above the bottom of the valley both on the Cheshire and Lancashire side of the Mersey, attributed them to an ice-sheet working down the Mersey valley to the N.W. The exact direction of the scratches is N. 35 W.; and they are covered by Lake-district débris in Boulder-clay. The scratches Mr. Morton supposes to have been made by the ice-sheet before a submergence, during whch they were covered up by Boulder-clay brought from the north by floating ice.

It will be seen that these scratches were nearly parallel to, only a little more easterly than, those along the Lancashire coast further north, and coincide with the general southern glaciation of North Lancashire. One thing is certain, that if the ice-sheet was working to the S.S.E. in North Lancashire it could not be working to the N.W. in South Lancashire. I would suggest that here too there was a general movement of the ice-sheet *from* the Lake-district, and that the low basin of the Mersey was one of the mouths by which the great ice-basin now represented by the Irish Sea was discharging itself.

If we turn now to Anglesey, Professor Ramsay, to whom my acknowledgments are due, showed many years ago, in 'The Old Glaciers of North Wales,' that the glaciation of that island and the low ground of Caernarvonshire is not in a direction radiating from the mountains, as the highest ground, but that the scratches are from the N.N.E., and that here you get foreign blocks from the hills of Cumberland. On the opposite coast of Ireland the glaciation, as shown by Mr. Close in his Map (Geol. Mag. 1867), is rather along the coast than from the land. Professor Phillips also tells me that he has observed the same at Bray Head, co. Wicklow. Just as the glaciation in Lancashire and Cheshire bore to the east of the mountains of North Wales, so in Anglesey it bore rather to the west, and St. George's Channel was another great outlet on the south for the ice-sheet.

APPENDIX.

TABLE OF ICE-SCRATCHES IN NORTH LANCASHIRE AND ADJACENT PARTS OF YORKSHIRE AND WESTMORELAND.

County.	6-inch Map.	Locality.	Height above the sea in feet*.	Direction.
Lancashire.	19	Above Thwaite Wood, Capernwray Hall...	325	W. 40° S.
	,,	Above Whittington Park	550	S. 32° W.
	,,	New Park, Whittington	525	W. 40° S.
	,,	Long-Field Tarn Pasture..	475	S. 30° W.
	25	Redwell Quarry.....	300	S. 32° W.
	,,	Quarry near Storrs Hall	230	W. 30° S.
	26	Park Lane, near Winnington	313	S. 5° E.
	,,	How Clough, near Winnington	280	S.
	,,	Quarry half a mile W. of Park House, Hindburn	535	S. 15° W.
	29	St. Patrick's Chapel, Heysham.....	35	S.
	,,	Chapel Hill, Heysham	35	S. 10° W.
	,,	Opposite Heysham Lodge.....	40	S. 40° W.
	,,	Money-Close Lane, Heysham	35	S.
	30	N. of Heysham Moss.....	25	S. 5° W.
	,,	W. of Heysham Moss	30	S. 5° E.
	,,	S. of Brown Moss	30	S. 5° E.
	,,	Lancaster Moor	330	S. 5° E.
	31	Claughton Moor	630	S. 25° W.
	,,	Hornby Moor	875	W. 35° S.
	,,	Whitmoor	900	S. 30° W.
	,,	Another on Whitmoor	925	S. 30° W.
	,,	East of Intack House, near Caton	580	S. 10° W.
	,,	S.W. of Intack House, near Caton	510	S. 10° W.
	34	Ellel Crag	325	S.S.E.
	,,	Bazil Point.....	15	S. 5° W.
	46	Wilkinson's Quarry, near Chipping	325	W. 42° S.
	,,	Wilkinson's Quarry, near Chipping	325	S. 30° W.
	47	Chatburn Station, Bold-Venture Quarries	330	S. 30° W.
	,,	Pimlico Quarries	300	S. 20° W.
	48	Twiston Moor	1050	S.S.E.
	54	Bank opposite junction of Starling Brook and Ribble	90	S. 8° W.

* Estimated from the contours on the 6-inch Ordnance Map.

County.	6-inch Map.	Locality.	Height above the sea in feet *.	Direction.
Lancashire.	55	Under Whalley Nab by the Calder	200	S. 10° E. to S. 25° E.
	56	Dole House, Roughlee	775	S. 5° W.
	62	North side of Mellor Beacon, Blackburn	475	W. 13° S.
	77	Euxton Mills, N. bank of Yarrow	100	S.S.E.
	,,	Grey Heights, East of Chorley	.....	S.S.E.
	96	Long Kin, the Allotment, Ingleborough	1350	W. 40° S.
	,, †	Alum Pot Beck, Ingleborough	1225	S. 10° W.
	,,	Under large boulder, Fell Close, Ingleborough	1275	S. 10° W.
	,,	Beck below Shooting House, E. side of Ingleborough	1350	S.S.W.
	,,	Water Swallow, the Allotment, Ingleborough	1375	S. 35° W.
	97	Fair-Bottoms Barn	1100	S. 35° W.
	112	N. of High Bottom	340	S.
	,,	Another	330	S.
	,,	North of Tennant House, High Bentham	510	S.
	113	W. side of Clapham Farm	600	S.E.
	,,	Norber	950	S. 20° W.
	,, †	Wharfe Mill-dam	550	S. 30° E.
	,, †	W.S.W. of Crummack	1150	S.
	,, †	Three quarters of a mile S. of Crummack	800	S.
	,, †	200 yards E. of last	800	S. 10° E.
	,,	Newby Cote, above the Quarries	775	S. 35° E.
	114	Foredale	900?	S. 7° W.
	,,	Helwith-Bridge Slate-quarry	725	S. 5° W.
	,,	John Batty's Wood, Railway-bridge	700	S. 10° W.
	,, †	Tongue Gill, 1 mile N.E. of Stainforth	975	S.S.W.
	,, †	New Close, Silverdale, Stainforth	1220	S. 15° W.
	,, †	Catrigg Beck, Stainforth	1075	S. 25° W.
Yorkshire.	131	Copy House, Cow Gill	540	W. 40° S.
	,,	Kettlesbeck, near Railway-bridge	475	S.E.
	,,	E. of Low-Kettlesbeck House	525	W. 35° S.
	,,	One-third of a mile N. of High Kettlesbeck.	675	S. 40° W.
	,,	Another	675	S.W.
	,,	S.E. of Bridge to High Kettlesbeck	670	S. 40° W.
	,,	North of Lingthwaite, Kettlesbeck	600	S. 20° W.
	,,	One-third of a mile S.S.W. of Blaithwaite	680	S.
	,,	Craven Lane	625	S. 10° E.
	,,	Lawkland-Hall Wood	540	S.
	,,	E. of Sandford Brow	700	S.
	,,	E. of Wham Lane	775	S. 10° E.
	,,	Another	740	S.S.E.
	,,	N. of Cocket Moss	775	S. 10° E.
	,,	In brook N.W. of Lower Sheep Wash	625	E. 30° S.
	,,	On crag, N.W. of Black Hill	1050	S. 25° E.
	,,	Bowland Knotts, E. of gate	1400	S. 15° E.
	,,	One-third of a mile E.S.E. of gate	1325	S. 5° E.
	132	N. of Cocket Moss	760	S.
	,,	E. of Cocket Moss	750	S.
	,,	W. of Hollin-Hall Wood	550	S.
	,,	By Laithes, S.S.E. of Green	535	S.

* Estimated from the contours on the 6-inch Ordnance Map.

† For these observations I am indebted to my friend and colleague, Mr. T. McK. Hughes.

County.	6-inch Map.	Locality.	Height above the sea in feet*.	Direction.
Yorkshire.	132	S. of Giggleswick Tarn	550	S.
	,,	Under Kingscar, Victoria Cave, Settle	1300	S. 15° W.
	148	Chapel-House Lane, Merrybent	722	S. 30° W.
	,,	Quarry House, Stephen Moor	810	S. 30° E.
	,,	Stephen-Moor House	850	S.
	,,	Tosside Fold	675	S. 20° E.
	165	Limestone Quarry, near Dunnow House	475	S.
	,,	Gravel Pit near Dunnow, further S.W.	450	S.W.
	,,	Baygate	585	W. 35° S.
	,,	Harris's Lathe, Roddel Chapel	640	S. 20° W.
	,,	Sandstone Quarry, near Guy's, Champion	910	S.
	,,	West of Champion House	860	S.S.W.
	,,	Sandstone Quarry E. of Champion	880	S. 5° E.
	,,	Owlet Moss	880	S. 7° W.
	,,	Gill Beck	485	S. 5° E.
	166	Gisburn Toll-bar, Skipton Road	459	S. 25° E.
	,,	Quarry, S.W. of Gladstone	525	E. 42° S.
	,,	Swinden-Moor Head	655	E.
Westmoreland†.	40	Holme Fell, above Jordan Wood	800	S. 35° W.
	43	Killington Common	650	S. 33° W.
	,,	Killington Common	600	S. 25° W.
	,,	Killington Common	800	S. 25° W.
	44	Thirn Gill	885	S. 5° W.
		Thirn Gill	885	S. 20° E.

* Estimated from the contours on the 6-inch Ordnance Map.

† For these observations I am indebted to my friend and colleague, Mr. T. McK. Hughes.

DESCRIPTION OF PLATE XXX.

Map to illustrate the glaciation of North Lancashire, with colours to represent elevations. Levels reduced from the one- and six-inch Ordnance Maps. Scale, 3 miles to 1 inch.

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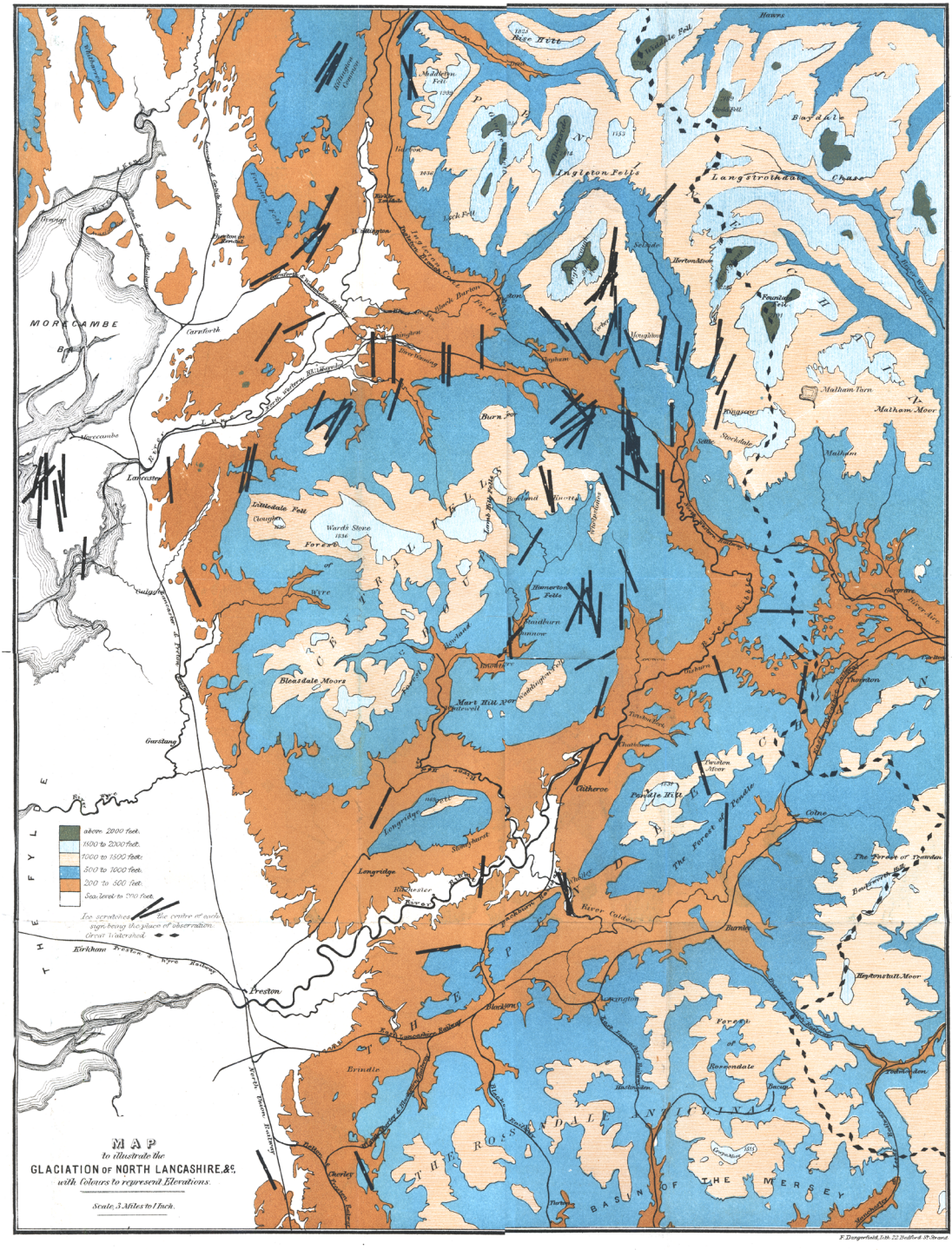
5. *On the* Mammalia *of the* Drift *of* Paris *and its* Outskirts.

By Professor Albert Gaudry, F.C.G.S.

(In a letter to W. Boyd Dawkins, Esq., M.A., F.R.S., F.G.S.)

[Abstract.]

In this paper the author briefly indicated those mammals the remains of which have been discovered in the Pleistocene or Quaternary deposits of Paris and its vicinity. His list includes flint implements as evidences of the existence of man, and bones of the following species:—*Canis lupus*, *Hyæna crocuta* (*spelæa*), *Felis leo* (*spelæa*), *Castor trogontherium* and *fiber*, *Elephas primigenius* and *antiquus*, *Hippopotamus amphibius*, *Rhinoceros tichorhinus* (a Rhinoceros of doubtful species), *Sus scrofa*, *Equus asinus* and *caballus*, *Bos primigenius*, *taurus*?, and *indicus*?, *Bison priscus* and *europæus*, and *Cervus tarandus*, *Belgrandi*, *megaceros*, *canadensis*?, *elaphus*, and a small species.



F. Dangerfield, lith. 22 Bedford St. Strand