EXCURSION TO THE WESTERN PENNINES.

(Organised by the N.E. Lancs. Group.)

SATURDAY, JULY 24TH, TO TUESDAY, AUGUST 3RD, INCLUSIVE.

REPORT BY THE DIRECTORS AND EXCURSION SECRETARY.

SATURDAY, JULY 24TH, 1926.

THE party was met at Clitheroe by members of the N.E. Lancs. Local Group and proceeded to headquarters at the Swan and Royal Hotel.

After tea a lantern lecture was given at the Royal Grammar School, on "The Geology of the Western Pennines," by Mr. J. Ranson, A.M.I.M.E., F.G.S., Prof. S. H. Reynolds, D.Sc., presiding.

MALHAM.

SUNDAY, JULY 25TH, 1926.

Director, J. RANSON, A.M.I.M.E., F.G.S.

THE object of this excursion was to enable the party to note the differences between the stratigraphy, tectonics and scenery of the Craven highlands north of the Middle Craven Fault and the features to be studied in the Pendle area and the Bowland Fells ; also to examine the Bowland Shales north of the above fault and correlate them with the Shales of Pendle Hill.

The party, numbering about 40, travelled to Malham by motor. Here attention was drawn to the knoll-reef limestones (upper D.*), from which Cawden and Wedber Knolls have been dissected.

These massive folded limestones were examined on the banks of Gordale Beck between the knolls, but they yielded no fossils. Mr. John Holmes, however, exhibited *G. crenistria* from beds farther down stream.

The beck was followed to Janet's Foss, a picturesque waterfall on an outgrowth of moss-grown tufa resting on bedded limestones.

The Middle Craven Fault was crossed by Gordale Bridge and the impressive cliffs of Gordale Scar dominated the view. The massive limestones of the escarpment with their gentle northerly dip were contrasted with the folded limestones south of the fault in Gordale Beck. This appears to be due to the presence of a core of older palæozoic (Silurian and Ordovician) rocks which enabled this highland block to resist folding (as

* See maps by Prof. E. J. Garwood and Miss E. Goodyear, *Quart. Journ. Geol. Soc.*, lxxx (1924).

pointed out by Prof. Marr), while the rocks to the south yielded readily to post-Carboniferous movements.

The magnificent cliffs at Gordale Scar are due to the massive sheets of D_1 limestone overlying beds in which vertical joints give rise to columnar structure at the base of the cliff.

The D_1 limestones are thrown down to the south by the Middle Craven Fault and cut back by Gordale Beck north of the fault, which, at the same time, has prevented the accumulation of cliff débris in its course, and so accounts for the great wall of rock rising vertically to a height of 300 ft.

Owing to the heavy rain overnight Gordale Beck was in flood and made a pleasing picture at the fall, while the springs below spouted vigorously from the ground in contrast to their usual limpid flow.

The ascent to Gordale was made over a mass of stalagmitic tufa evidently accumulated in a cavern when the great overhanging walls of rock met above at a time not very remote. It took a considerable time for the large party to ascend the fall, but while waiting their turn, the great cliffs, the canopy of cloud, the roaring fall and dripping rocks made an impression not readily forgotten.

Mr. Cosmo Johns very kindly took charge of those who did not care to attempt the climb and proceeded *via* Malham Cove to meet the party later in the day.

A halt was made for lunch in Gordale. Here it was pointed out that the springs below the Scar are fed by water swallowed on the floor of this valley, and the considerable head of water in the flooded beck accounted for the vigour with which they spouted from the ground that morning. In very dry seasons what little there is of Gordale Beck disappears before reaching the fall at the Scar. It is clear, therefore, that Gordale is in process of becoming a dry valley, like its neighbour, which terminates at the Cove.

After lunch the journey was resumed to Upper Gordale over the deeply fissured pavements of D_1 limestone; the fissures —widened joints—were observed to be inhabited by a rich flora. These limestones were contrasted with their time-equivalents in the Clitheroe area. On the way to Upper Gordale the party met Mr. W. H. Dalton, formerly of H.M. Geological Survey. Mr. Dalton, who surveyed a portion of this district several decades ago, was warmly welcomed and accompanied the party to the patch of Silurian rocks stretching from Upper Gordale to west of the Tarn. Mr. Dalton gave a short talk, which was much appreciated, on these rocks.

The Director pointed out the position of the North Craven Fault in Gordale Beck, and said that along the line of that Fault to the north lay a considerable area of the older palæozoic rocks of Silurian and Ordovician age. These ancient rocks

had been folded and cleaved by Caledonian movements and formed high land throughout the greater part of Devonian time. During that time the total thickness of Silurians as developed in this area had been removed by denudation and the Ordovician rocks exposed in several places. Although the total exposed area of these ancient rocks was small, there could be no doubt that they underlay the Pennines over a wide area, and had been responsible for the provision of a stable crustal block which had resisted and prevented the intense folding suffered by the rocks south of the great faults.

Submergence of the remains of this Devonian land (the pre-Pennines) was not effected until rather late in Carboniferous Limestone time, beginning in C, and completed in S, times, as shown by Prof. Garwood and Miss Goodyear.

Malham Tarn was next visited and accounted for by the presence of drift-covered Silurian rocks and a ridge of glacial drift to the south of it. A large stream flowed out of Tarn Foot.

To the south-west, Smelt Mill was to be seen. There the galena mined among these hills was formerly smelted. Later it was used as a school, but now only a ruin remains.

By the ruin are the Smelt Mill Sinks where the stream from near Capon Hall disappears at a pool after heavy rains, but sinks along the stream course to the west in dry weather.

The water from the Smelt Mill Sinks reappears in the spring at Malham Cove, but only forms a small proportion of the water emerging there.*

The overflow from Malham Tarn was then followed to the Tarn Sinks along the course of a small depression. Here the stream, after flowing over the Silurian rocks, and then for about a quarter of a mile over drift-covered limestone, was seen to disappear at the " Sink," a boulder-strewn spot. This water subsequently reappears at Aire Head Springs below Malham Village, and in times of heavy rain it contributes slightly to the spring at the foot of the Cove.

A suggestion had recently been made by the Rev. C. L. Tweedale that the dry valley should be made water-tight and the stream allowed to fall over Malham Cove again as it did in former times, but this was considered to be not practicable and undesirable in any case.

The party then traversed the dry valley from the Sink to the top of Malham Cove, passing through a rocky defile and by the cliff at Comb Scar down to the green turf which made easy walking to the Cove. The valley gave one the impression of not having been long deserted by the stream which made it.

At the foot of Malham Cove the effects of a rock-fall from the cliffs above were noted. This occurred during the winter

* The Underground Waters of N.W. Yorkshire, *Proc. York Geol. Soc.* (1900).

of 1925. A large bare patch on the right of the cliff marks the place from which the fall occurred. The huge mass of limestone fell on to the scree below and then broke into many smaller blocks which bounded considerable distances and now rest about the stream emerging from the Cove.

After tea at the Buck Hotel, Aire Head Springs were visited and observed to be flowing vigorously, as was to be expected from the large overflow from Malham Tarn.

Since the foregoing excursion provided a full day's work, a small party desiring to examine the Bowland Shales north of the Middle Craven Fault (more thoroughly than could have been done after the round described) spent the day about Bordley's. They were successful in obtaining *Homoceras malhamense*. The small party then visited exposures on the opposite side of the stream from Aire Head Springs. Mr. Holmes showed beds in the limestone containing *G. crenistria*, and almost immediately above these the strata contained *Numismoceras spirobis*, specimens of which were found. This is interesting in view of the fact that a similar sequence is found in the Bowland Shales at Dinckley, in Swardean Clough above Pendleton and in Little Mearly Clough.

The party returned to Clitheroe by motor.

HORTON-IN-RIBBLESDALE.

MONDAY, JULY 26TH, 1926.

Director, J. HOLMES.

THE journey to the pre-Carboniferous tract at Horton was made by motor-coach, along the valley of the Ribble, with the rolling country of the Craven Lowlands on the east, and the grit-capped fells of Bowland on the west. Beyond Hellifield, Millstone Grit and Shales were seen thrown down against Great Scar Limestone by the southern branch of the Craven Fault, which was crossed at Settle. Between the faults, the route lay between limestone scars to Stainforth, where pre-Carboniferous rocks are brought up by the northern fault, and occupy the valley to beyond Horton, where they disappear beneath glacial drift. From the bridge at Horton, the party had a fine view of Penyghent, the contours of the Great Scar, Yoredales, and Millstone Grit standing out boldly against the sky-line, while to the north-west the summits of Ingleborough and Whernside were clearly seen. North of the Craven Faults, the Carboniferous rocks have been trenched to their base by the parallel streams of the Ribble and Austwick Beck, leaving the limestone tongue of Moughton Fell projecting between them. The main object of this excursion was to examine the sections exposed on both sides of Moughton and on the west side of

Crummockdale, but, owing to the late arrival of the party at Horton, the latter part of the programme had to be abandoned, and many interesting sections along the route followed had to be hurriedly passed over.

The first beds to claim attention at Horton were the Ingletonian rocks, a series of sediments derived from a volcanic area, and laid down in Ordovician times, or possibly earlier. It was noticed that the beds seen in the bank of the Ribble at Row End were formed of coarser materials than those seen in Delaney's quarries, where they are worked for road material to a considerable depth below the surface of the ground. The Great Scar limestone (S beds) which rests unconformably upon the Ingletonians, is also extensively worked here, but the junction is not seen. At Gillet Brae, a few hundred yards south of the quarries, the unconformity was seen in a stream section, the limestone with several feet of conglomerate at its base resting upon the upturned edges of the older rocks. At Garth House, Austwick Grits and Flags were seen in a double synclinal fold with a broken anticline between them near Horton Wood.

At Crag Hill, Bala Limestones and Shales, with characteristic fossils, were seen in an anticline, with the base of the Silurians folded over them.

A stiff climb brought the party to the fine unconformity at Areo Wood, where the Horton Flags have been quarried back level with the face of the limestone cliff, which rests upon their highly inclined beds with little or no conglomerate between.

The unconformity was seen almost continuously along the southern end of Moughton, and up the east side of Crummackdale, being only hidden in places by limestone screes.

Bala beds brought up by the northern fault were examined near the hamlet of Wharf, and in the journey up Crummackdale the succession seen in Ribblesdale was crossed in reverse order. the beds striking in a south-easterly direction under the limestones of Moughton.

Time did not permit the interesting sections at Norber Brow and Austwick Beck Head to be visited, and the famous Norber erratics were only seen from a distance. Dr. Lovett, of Clapham, kindly pointed out a fossiliferous section in the Bala Shales opposite to Austwick Beck Head.

In the north-east corner of Crummackdale an exposure was seen of a fine grained rock which has had some local repute as a whetstone. The rock is greenish-grey in colour, but infiltration from the joint surfaces has produced successive bands of a reddish hue, which become rounded at the corners, and towards the centre form a concentric or oval pattern.

Returning over the weathered limestone plateau of Moughton, the party had a fine view of the surrounding country, and of

the glacial deposits occupying the valley above Horton ; a suite of drumlins with axes pointing north-and-south indicating the direction of the ice-flow.

RISHTON, WHALLEY BANKS AND BLACK HILL.

TUESDAY, JULY 27TH, 1926.

Directors, J. SPENCER, J. RANSON, F.G.S., AND V. DEAN.

AFTER leaving the motor near Whitebirk, where they were joined by members of the local Group, the party walked to Side Beet, on the Rishton hillside. Here the Director (J. S.) gave an account of the geological structure of the district, pointing out that the Rishton Range was a continuation of that of Pendle and consisted of beds of Millstone Grit and Lower Coal Measures, forming the S.E. flank of the Clitheroe anticline and dipping steeply under the beds of the Burnley Basin.

The party then examined the outcrops on the hillside, commencing with the Upper Foot Coal or ' Bullion Mine,' so called on account of the occurrence of ' bullions ' in the roof-shale overlying the coal. These bullions contain Goniatites and occasional plant petrifactions. In the coal itself are also found ' coal balls,' composed entirely of plant remains, petrified by calcium and magnesium-carbonates.

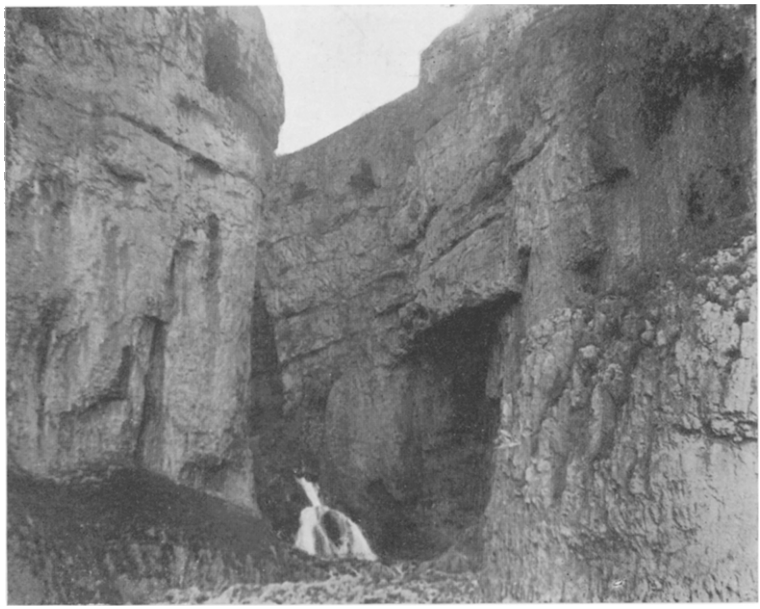
Next, the positions of the Lower Mountain Mine and Bassey Mine were noted, along with the underlying Woodhead Hill Rock, a bed of coarse sandstone nearly at the base of the Lower Coal Measures. At this spot the rock affords evidence of ice action and drift bedding. In the old quarry excavated in the shales underlying the Woodhead Hill Rock is an exposure of exceptional geological interest. A thin seam of coal known as the Six Inch Mine here forms the base of the Lower Coal Measures and the roof-shale of the coal contains bullions, whilst in the coal occur coal balls. These are similar to those associated with the Upper Foot Coal or Bullion Mine already noted.

It had always been considered previous to the work of Stopes and Watson* that these bullions and coal balls only occurred in association with the Upper Foot Coal of the Lower Coal Measures, and this had led to much confusion in correlating the coal-seams of different districts.

The discovery by the Director of the occurrence of bullions at this place confirms the views of the above writers.

Underlying the Six Inch Coal is the First Millstone Grit, a coarse sandstone divided into two portions by the Sand Rock Coal, the upper bed of rock being only eight feet in thickness in this locality, whilst the lower one is of the normal thickness of fifty feet. This First Millstone Grit, with its dividing coal, forms a feature in many parts of N.E. Lancashire.

* On the Occurrence and Origin of Coal Balls, etc., *Proc. Roy. Society* (1908).



A.—GORDALE BECK (see p. 169).



[*Photos by J. Ranson.*

B.—VIEW OF WHITENDALE IN FOREST OF BOWLAND, LOOKING NORTH.

[*To face p.* 174.

The party next visited Cunliffe Quarry in the Second Millstone Grit. This is a fine hard grey sandstone quite unlike the other beds of Millstone Grit. Its extreme durability renders it suitable for the paving and flagging of roads and streets, and it is used for those purposes in the large towns.

Some of the beds of rock in the quarry are laminated and split readily into flags, whilst other beds contain no laminations and are quarried for paving setts, kerbs, etc.

The Director pointed out the connection of these beds with those of Rossendale, where they attain their maximum thickness, and then the party walked farther along the hillside to Close Brow Quarry, in the same series of beds. This quarry, however, is not in the same line of strike, a fault of about eighty yards throw separating the two quarries.

The Second Millstone Grit or Haslingden Flagrock of Close Brow Quarry is of special interest, ripple-marking, rain-pittings, jointing, etc., being well illustrated ; and, at the farther end of the quarry, the large fault already mentioned is very well shown. Some time was spent in the examination of these features and in the search for the species of fresh water fossils occurring in the shales on the opposite side of the fault.

After lunch the back portion of the quarry was examined and the glacial features pointed out, the boulder clay overlying the rocks of the quarry containing erratics of Lake District and Ribblesdale origin ; whilst the overturning of the edges of the highly inclined beds of rock (terminal curvature) bears testimony to the force exerted by the ice-sheet during its passage over this part of the country.* (plate 11A).

The shales underlying the Haslingden Flags in the ' back kitchen ' of the quarry belong to the Holcombe Brook Series and *Gastrioceras cancellatum* (Bisat) was obtained by the energetic members of the party. Proceeding up the road, the party examined a continuation of the sequence from the Holcombe Brook Series through the Brooksbottom Beds, exposed in the stream and in Harper Clough Quarry. The shales and sandstones belong to the Third Millstone Grit, a mutation of *Reticuloceras reticulatum* (Bisat) occurring in the shales.

The large *Stigmaria* on the face of the rock in the quarry attracted the attention of the party.

Passing over a line of fault and Smalley Quarry (which is in the First Millstone Grit), the party proceeded along the hillside to Cliff Quarry near Great Harwood. This quarry is in the Fourth or Kinderscout Grit and the Director gave an explanation of the renaming of these lower beds of grit, due to the new zonal work of Bisat.

After looking at the area covered by the glacial sands and

* The Ice Sheet in N. Lancashire, etc., R. H. Tiddeman, *Quart. Journ. Geol. Soc.* (1872). The Glaciation of N.E. Lancashire, A. Jowett, *Quart. Journ. Geol. Soc.*, (1914).

gravel near Bowley Hill, a feature of the Fourth Grit, with a strike fault, was noticed and the position of the drift-covered beds of Sabden Valley Shales indicated.

On leaving Bowley Hill the party came in sight of the R. Calder, which here cuts through the twin hills of the Pendle Range and enters the R. Ribble at Hacking Ferry near Whalley.

This was considered by the Director (J. R.) to be the most important physical feature of the district, first described, so far as he knew, by the late Mr. J. Lomas, A.R.C.Sc., who, in a popular account of river work, published three sketch maps to show how the R. Ribble had captured the R. Calder and Hodder.

The party were reminded that Mr. Spencer had called attention to the large dale of Calderdale, as seen from the hillside above Rishton, and that the lower part of that dale was now deserted by the river responsible for its existence. The Calder had been beheaded by a tributary of the R. Ribble, S.W. of Altham.

The present drainage system of the district probably dated from early Tertiary time when the Ribble, Hodder and Calder flowed independently in a south-westerly direction to the sea. The R. Ribble developed tributaries which cut back through the gritstone hills of Longridge and Waddington Fell to the N.W. until the R. Hodder was captured. The River Loud is obviously a misfit in the ancient valley of the Hodder, as would be seen on the excursion to Whitewell.

On the other hand a second feeder of the R. Ribble cut back through the escarpment of the lower Millstone Grit of the Pendle range at Whalley until it received the drainage from the Sabden Valley Shales along whose strike Sabden Brook and Dean Brook developed.

Thus augmented, this stream deepened its bed more rapidly and attacked the next ridge of upper grits and ultimately beheaded the R. Calder.*

That the capture of the Calder was accomplished in pre-glacial times is evident from the fact that it flows through a drift-covered gap with glaciated grits at the Whalley end at Turn Hill.

At Whalley Banks the drift is conglomeratic and large slipped masses of this deposit lie on the side of the river, and one large block and several smaller ones in the river itself. This conglomerate consists chiefly of well-rounded boulders of limestone, grit, sandstone, chert, etc. This is ' Ribblesdale Drift ' cemented by the solution of its calcareous boulders.

Sabden Brook had been diverted out of its pre-glacial course by a great ridge of drift and now entered the Calder at Cock Bridge.

This Calder Gap contrasts strongly with the gorge at

* See report on Excursion of N.E. Lancs. Group, *Proc. Geol. Assoc.*, xxxvi. p. 185 (1925).

Hoghton, which is a post-glacial gorge as indicated by its vertical walls and pot-holed bed, where corrasion is still proceeding in flood-time. The pre-glacial gap of the Darwen at Hoghton is blocked by a thick mass of glacial drift, chiefly sands and gravels, between Hoghton and Pleasington.

Under the direction of Mr. V. Dean, the party then proceeded rapidly down to the sharp bend of the river, where a view of the Calder Gap was obtained. Continuing up stream to Cock Bridge and thence by Read Hall, the party soon arrived at Whin Lane on the S.E. slope of Black Hill. Here, by the kind permission of Mr. Kemp, of Sawley, the first of a number of quarries which line this road was visited. With one exception (p. 179), these quarries are all excavated in the Woodhead Hill Sandstone, which is rather coarse in texture and has a thickness of from sixty to seventy feet. It is the lowest sandstone member in the Lower Coal Measures. The beds dip south-eastwards at an angle of from forty to fifty degrees. They are traversed by minor bedding planes which cut the beds obliquely and make angles of from twenty to thirty degrees with the major bedding. As seen on the large dip-joint face in the quarry visited, they make angles of from ten to fifteen degrees with the horizontal, the apparent dip being towards the south-east. The exceptional development of this structure enables the rock to be split into very thin flags and for about a mile along Whin Lane it has been quarried at intervals for flags and roofing slates. The structure has long been the subject of discussion among local geologists. Some believed it to be of mechanical origin and suggested that it represented a peculiar form of cleavage or faulting which had its origin during the Permo-Carboniferous upheaval. Others, though convinced that they were confronted with some form of current-bedding, were unable to account for its unusual regularity. Both schools seem to have assumed that the structure is confined to the Woodhead Hill Rock along this part of Black Hill, and it is not improbable that this supposition was directly responsible for most of the misunderstanding which has existed with respect to its origin.

In disposing of the theory of mechanical origin, the Director drew attention to the occurrence of several thin bands of evenly-bedded sandstone which are intercalated with the thick beds of obliquely bedded strata. It is thus impossible to believe that the latter is a result of earth-movement, while the former exhibits no trace whatever of the effect of such movements. If further evidence were needed to date the planes in question, it is afforded by a ripple-like feature which sometimes occurs on the upper surface of the thicker beds of rock. Seen at a distance, it would easily be mistaken for true ripple-marking. A closer inspection, however, shows that it is a simple series of

straight ridges that have about the same width as an ordinary sand-ripple. Each one represents the outcrop edge of a minor band on the surface of the main bed and the intervening hollows are obviously the result of erosion along lines of weakness provided by the planes themselves. Thus we can only conclude that the planes of one bed were already in existence before the material of the next was laid down upon it.

A study of the distribution and direction of the planes in the Woodhead Hill Rock along both margins of the Burnley Coalfield has enabled the director to put forward a suggestion respecting their mode of origin. The infrequent exposures at this horizon along the north-western margin of the coalfield leave no doubt that current-bedding of the type under notice has a much wider distribution than was formerly supposed. In the outcrops to the W.S.W. and E.N.E. of a mile-and-a-half strip in the Whin Lane area the beds are for the most part evenly-bedded, the current-bedded type being restricted to a few feet only of the total thickness. Moreover, the relative positions of the two types of deposit do not seem to remain constant in the several exposures, the latter type being present sometimes at the top, sometimes in the middle, and sometimes at the base. In some cases it occurs in two of these positions, but in the areas named, it is always subordinate in importance to the evenly-bedded type. Another interesting difference between the current-bedding of these areas and that of Whin Lane is that it always makes a much smaller angle with the main bedding in the former than in the latter locality. For example, at the former localities it usually varies from five to twenty degrees, whereas at Whin Lane it is generally from twenty to thirty degrees. Allowance being made for the dip due to folding, the true dip of the minor bedding planes in all the areas just described was found to vary from W.N.W. to N.N.W.

The other margin of the coalfield above referred to is formed by the monoclinal uplift which gives rise to the local Pennines. It runs in a general north-and-south direction, and along the western slopes of the range the Woodhead Hill Rock is again brought to the surface. From Colne, near the apex of the basin, to the Long Causeway north of the Cliviger Gorge, only two undoubted exposures of the rock have been examined. They suggest that here the beds are similar to those E.N.E. of the Whin Lane type. From Cartridge Clough, near Portsmouth, to Gorpley Clough, east of Bacup, there are numerous excellent exposures of the rock. Here the beds are strongly current-bedded, like those of Whin Lane, and it should be noted that the two areas have the same approximate distances from the apex of the basin. South of Gorpley the beds have not been examined, and it remains to be seen whether the similarity between the two lines of outcrop will continue to hold good.

It is significant that the true dip of the current-bedding along the western margin should be in a direction approximately at right angles to those already described. The direction here varies from W.S.W. to S.S.W. In the Rossendale and Darwen areas, which lie to the south and south-west of the main coalfield, the Lower Coal Measures and underlying grits are again brought to the surface, and one or two exposures of the Woodhead Hill Rock have been examined. These indicate that the current-bedding is in a direction intermediate between those noted above. The Director suggested that these facts point to a deltaic origin for the Woodhead Hill Rock, the beds described representing a minor cone of a large delta, the remainder of which has been destroyed by subsequent folding and denudation. The direction of the current-bedding shows that it has been produced by currents flowing from N.E. to S.W. The repeated succession of current-bedded layers indicates that the material was accumulated in a slowly

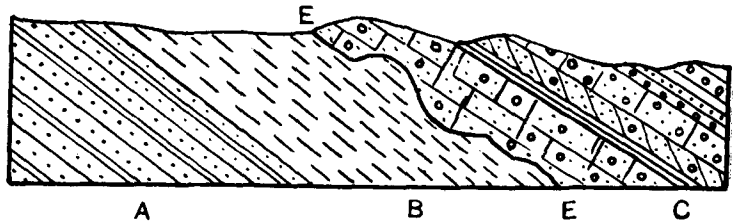


FIG. 20.—CONTEMPORANEOUS EROSION BELOW THE "ROUGH ROCK," QUARRY IN WHIN LANE, READ.

A—Haslingden Flags (2nd. Millstone Grit.)
B—Sandy Shales.
C—"Rough Rock" (1st. Millstone Grit.)
E—Eroded Surface.

subsiding area. The regular direction of the current-bedding planes was attributed to regular currents drifting the heavier portions of their loads along the upper surface of a delta-cone. When this material reached the steep front of the cone it would roll down it since the current was unable to carry it in suspension. The Director then referred to the work of the late Dr. Sorby, who had demonstrated that the angle of rest of such material was determined by the size of the grains, the larger the grain, the greater being the angle of repose. Moreover, Dr. Sorby had named the structure "drift-bedding" to distinguish it from ordinary current or irregular bedding. (plate 11B).

The party then visited another quarry farther up the hillside. Here a splendid example of contemporaneous erosion on the surface of the shale below the First Millstone Grit was

examined (fig. 20.) Specimens of *Carbonicola* were found in these shales by Mr. W. H. Bennett.

At this juncture the party adjourned for tea at a cottage by the roadside, and after tea a second quarry in the Woodhead Hill Rock was visited. In a quarry on the summit of Black Hill, a fifteen-inch coal-seam with a hard ganister seating (worked for road metal) was seen.

Proceeding westwards by "Fairy Holes," Crow Bridge, and Easterly Hall, the party soon reached Moreton Hall Lodge, where motors were waiting to convey them back to headquarters.

WORSAW AND PENDLE.

WEDNESDAY, JULY 28TH.

Director, D. PARKINSON, Ph.D., F.G.S.

Report by the Excursion Secretary, with additional notes.

THE party took the bus to Chatburn and proceeded to walk across the outcrops of Clitheroe Limestone to Worsaw Knoll. Overlying the knoll limestone are the Worston Shales (Shales-with-limestones) which contain *Prolecanites compressus* beds at the base. The low ground between Worsaw and Pendle consists of Worston Shales, and the party had a good view of the concave slope on the side of Pendle above the Pendleside Limestone. Proceeding up Burst Clough a halt was called at the *Beyrichoceras hodderense* band. The limestone in this is a peculiar one, and forms a marked feature along the side of Pendle. The zone-goniatite was rather difficult to find, for, unless one is armed with a sledge hammer, only small chips of the rock can be removed. However, a few specimens were obtained. The *Lithostrotion arachnoideum* bed was not well exposed, but examples of the type coral were found.

The party then proceeded across to the next clough, at the top of Little Mearley Wood. Here were seen the *Emmonsia parasitica* beds which form the top of the Pendleside Limestone.

Proceeding up the clough a fairly complete series of the Bowland Shales was seen. A bullion was extracted from the shales, and, on breaking, yielded two specimens of a variety of *G. crenistria*. The more energetic members followed the director up the clough and obtained specimens of the zonal goniatites.

The Bowland Shales and Millstone Grit.

The clear-water deposits of the early Carboniferous age were followed by coarse detrital deposits of the Millstone Grit and Coal Measures times. The zoning of the Carboniferous Limestone by the coral-brachiopod fauna has been carried out successfully by Vaughan in the Bristol area and by Garwood around Settle, but the succeeding deposits have presented many difficulties.

With the oncoming deltaic conditions the corals and brachiopods passed and Wheelton Hind attempted to zone the grits by means of lamellibranchs, but the vertical range of each of the species was, in general, too great for anything but zoning in a very broad sense. The goniatite fauna showed better promise and was used in part by Hind, but the lack of good material made this method not too successful in his hands. However, his pioneer work did much to keep the interest alive in the matter and to stimulate further work.

This was taken up seriously in 1919 by Bisat, who, with untiring energy and patient investigation, has not only laid the foundation for further work, but has described many species of goniatites from the North of England, and has proved their value for detailed zoning. This work has been of great service to the Geological Survey in Lancashire and in Yorkshire.

One of the great difficulties has been to correlate the higher limestones formed in the Carboniferous Sea with the lower of the deltaic deposits, which were probably encroaching on and gradually overlying the limestone.

Succeeding the limestone of the age of that round Clitheroe is, in Wensleydale, the Yoredale Series, whereas in this district there is a great series of shales, so well developed on the slopes of Pendle Hill that Hind proposed the term Pendleside Group for them. He first stated that this series included all the beds between the limestone-massif and the Pendle Grit, but finally reduced it to the beds above the Pendleside Limestone. Thus narrowed down the Pendleside Group is anticipated by the Bowland Shales of Phillips, so that Bisat sees no reason for the retention of Hind's term.

The Bowland Shales are well developed on the northern and north-westerly slopes of Pendle Hill and, including the Pendleside Grit, have a thickness of 1,300 ft. at Little Mearley Clough. They sweep along the hillside to the west of Pendle and meet the River Ribble at Dinckley.

The main zones are :—

5. Pendle Top Grit.
4. *Eumorphoceras pseudo-bilingue.*
3. *Goniatites spiralis.*
2. *Goniatites sphærico-striatus.*
1. *Goniatites crenistria.*

The zone of *G. spiralis* includes the Pendleside Grit.

G. crenistria and some varieties are the chief cephalopods in the *crenistria* zone. In the lowest beds visible at Dinckley are bullions containing *Dimorphoceras gilbertsoni*, and, a little above this, a band of small bullions containing typical *G. crenistria* and *Beyrichoceratoides truncatum.*

The *G. sphærico-striatus* zone contains abundant specimens, crushed in shale, but there is also one band of small bullions

where solid specimens may be obtained. The Dinckley section is here drift-covered until the entry of *G. spiralis*. Phillips' type *G. spiralis* was founded on crushed specimens, but from the *spiralis* zone several spirally striated species have been obtained.

The shales following at Dinckley contain crushed specimens of *E. pseudo-bilingue*. The only exposure in the Bowland shales on Pendle visited during the excursion was at Little Mearley Clough. The section here is somewhat similar to that at Dinckley, but just above the incoming of *spiralis* is a thick bed of sandstone, the Pendleside Grit. This is thick on Pendle itself, but thins out in a south-westerly direction and has not been observed at Wiswell, about three miles from Little Mearley Clough.

There is an interesting section at Light Clough, Wiswell. Just above the *spiralis* zone and below *pseudo-bilingue* occurs the much discussed and undescribed form '*leion*.' Until recently sufficient material was not available for its specific description.

E. pseudo-bilingue does not continue right up to the Pendle Top Grit, but in the 40 ft. of shale immediately underlying the grit is another form, *Homoceras* c.f. *malhamense*, a form which has been confused with *leion*.

Posidonomya becheri occurs in the lower part of the Bowland Shales and *P. membranacea* in the upper.

The bed of sandstone, the Pendle Top Grip, that forms the thick capping of Pendle Hill, marks the incoming of the Millstone Grit. This grit caps the ridge leading from Pendle to above Whalley and is exposed in the River Ribble between Dinckley and Sales Wheel.

Only a small bed of unfossiliferous shale separates this from another thick bed of grit the Wilpshire Grit, so named from its development at Wilpshire near Blackburn. Above this is a well developed shale series, the Sabden Shales. These can be traced from near Colne to the south of Pendle at Roughlee, along the Sabden valley and on to the River Darwen near Salmesbury. Some of the lower beds have been recognised in the shales above the Pendle Top Grit at Sales Wheel. The best exposure in the lower Sabden Shales is at Gill Beck near Colne.*

Here the zones of *Eumorphoceras bisulcatum* and *Nuculoceras nuculum* can be distinguished in the lower part. These are followed by bullions containing a globose variety of *Homoceras striolatum*. Above this should occur the *H. diadema* zone, but this form has not been found *in situ* at Gill Beck, although a few pieces of limestone containing *diadema* have been found in the stream.

The Upper beds of the Sabden Shales are well exposed at Roughlee. The following zones can be made out :—

*Eray, *Proc. of Manchester Geol. Assoc.*, vol. 1, pt. 1 p. 44.



[*Photo by J. Ranson.*

"GRIKES" IN D_1–LIMESTONE OF MALHAM.

[*To face p.* 182.

5. *Reticuloceras reticulatum* (type).
4. *R. inconstans.*
3. *Homoceratoides prereticulatum.*
2. *Homoceras striolatum.*
1. *H. proteum* (with a late form of *diadema*).

The beds are seen about 50 yards downstream from the bridge at Roughlee. They consist for the most part of shales, containing a few bullions, with thin limestones intercalated. From the bullions solid specimens may be obtained.

The section on the River Darwen at Salmesbury Bottoms has not yet been fully investigated, but it seems to promise an almost complete succession of beds in these shales. *H. diadema* has been found there just a little below *H. proteum*, showing that the Roughlee succession fits on to that at Gill Beck. Unfortunately the lowest beds at Salmesbury are almost inaccessible unless the river is very low, but *Anthracoceras glabrum*, a form which comes above *E. bisulcatum* has been found there.

The beds above the Sabden Shales contain the Kinderscout Grit and the Upper Grits of Yorkshire and Lancashire, and are interesting in showing the evolutionary development of *R. reticulatum*. Bisat has recognised three principal mutations, the latest occurring at the top of these beds. During the excursion the various mutations were collected near Portsmouth and the variations noted. The last appearance is in the shales beneath the Lower Haslingden Flags, where it occurs with *Gastrioceras cancellatum*.

The grits above this marine band are well developed in the neighbourhood of Haslingden and are named after that town. There are two bands of sandstone—the Lower and the Upper Haslingden Flags—separated by a band of shale containing *G. cumbriense*. On the top of the Upper Haslingden Flags, and separated from them by sandy shales, is the Rough Rock. This is a coarse, pebbly grit and is remarkable for containing a seam of coal, the Sandrock Coal, in the middle of it.

GREAT HAMELDON.

THURSDAY, JULY 29TH.

Director, Dr. R. L. SHERLOCK.

THE party met at the Griffin's Head, Huncoat, and proceeded up hill to the claypit near Close Plantation. This pit shows almost the whole of the Accrington Mudstones in a face about 90 ft. high. At the bottom the worthless black shale underlying the mudstone forms the floor, while above the pit reaches almost to the top of the strata ; the Old Lawrence Flags (locally called the Hameldon Scout Rock) appearing in old quarries a little above. The mudstone is greenish-grey and grades into the

flags, themselves of a greenish-yellow colour. The mudstone and flags indicate deposition in a delta, the former being deposited rapidly at the junction of fresh and salt waters.

The party then followed a path leading to Hameldon Scout, where the flags form a plateau at about 1,000 ft. O.D., trenched by a deep ravine exposing also the mudstone below. The top of the plateau is covered by thin peat resting on boulder-clay and behind it Great Hameldon rises to 1343 ft. Approaching the hill one passes over the shales covering the Old Lawrence Flags, then the Riddlescout Sandstone and more shales, all hidden by Drift. At the foot of the hill the Arley Mine Coal, the base of the Middle Coal Measures, crops out and its position is indicated by a line of outcrop workings. A little more shale follows, and then the Dandy Rock forms the top of the hill. It is noticeable that Drift formerly covered the hill, for fragments of Millstone Grit were found. On the plateau and on Great Hameldon itself considerable numbers of pigmy flint implements have been found and one flake was picked up.

Passing over a down-faulted trough of Middle Coal Measures, the party reached large old quarries in the Crutchman Sandstone, where lunch was taken and then, passing over a considerable spread of this rock, the Crutchman Quarry was reached. Here an adjacent fault has thrown the sandstone into high dips, the maximum being 60 degrees. A fault, hidden by quarry spoil, brings the sandstone against the Warmden Sandstone exposed in the Warmden Quarry. While the Crutchman Sandstones are here flags with silvery micaceous surfaces, the Warmden Sandstone is thicker-bedded and shows large spheroidal concretionary masses. The Crutchman Sandstone is the rock beneath the Pasture Mine Coal, and it rests on shale, here cut out by the last-named fault. Below the shale comes the Warmden Sandstone between the Upper Mountain Mine Coal above and the Inch Mine Coal beneath. The latter is visible in the valley below the quarry, but was not visited. About 35 ft. of shale beneath the Inch Mine Coal brings us to the Great Arc Sandstone covered by the Upper Foot Mine Coal with a marine band above it. The sandstone gives rise to a waterfall and small ravine. It was pointed out that in this district the streams flow in ravines ending upstream in small waterfalls, above which are wider valleys. This evidently indicates post-glacial erosion.

A walk across much-faulted ground brought the party to Stone Fold, where the First Millstone Grit (Rough Rock) was seen in small quarries. The grit is cut off by a fault, which is of interest as bearing small quantities of lead and barytes. Across the fault the 2nd Grit (Haslingden Flags) comes in and was seen in a quarry at Cribden Side. This 'grit' is really a flaggy sandstone with harder bands that make valuable setts (so-called granite). The Accrington-Haslingden road lies in a valley

below the flags and for a mile follows a peat-filled glacial overflow channel. On the east is solid rock, while on the west a feature no less bold is composed of morainic material. The excursion ended here and the party returned by motor to Clitheroe.

This evening the members of the N.E. Lancs. Local Group were entertained to dinner by the Association visitors, Prof. S. H. Reynolds, D.Sc. (representing the President) presiding at one table, and Mr. J. Ranson, A.M.I.M.E., F.G.S., President of the Local Group, at the other. The latter, in returning thanks for the visitors' hospitality, expressed the hope that the N.E. Lancs. Local Group would prove itself a worthy " chip of the old block."

CLIVIGER GORGE.

FRIDAY, JULY 30TH, 1926.

Director, W. LLOYD, B.Sc.

THE party met at Portsmouth station.

An examination was first made of the Millstone Grit series exposed in Green's Clough, immediately south of the station. The lowest bed exposed is the Gorpley, or Main Third Grit, which forms a waterfall at the foot of the clough. The grit is coarse and massive, and some 70 ft. of it are visible, the base not being exposed. Proceeding upstream the party were able to examine the various sub-divisions of the Middle Grits, including the Helmshore Grit, the ' Blackrock ' underlying the *Gastrioceras? sigma* marine band, and the Holcombe Brook Series. *Gastrioceras cancellatum* and other fossils were collected from the marine band which lies 30 ft. above the highest coal seam of the series. During the return down the side of the clough distinct features of geological importance and the observable effects of the Cliviger Valley fault were pointed out from several vantage points overlooking the main valley.

The party then took the main road to Cornholme, and reached Paul Clough *via* Redwater and Pudsey Cloughs. The junction of the Millstone Grit and the Lower Coal Measures is well exposed at the top of Redwater Clough, the shales underlying the current-bedded Woodhead Hill Rock resting on the Six Inch Mine Coal which caps the Rough Rock (the highest member of the Millstone Grit Series). The Rough Rock occupies the stream bed all the way up Pudsey Clough, and is characterised by a series of well marked potholes. At the commencement of Paul Clough, which is a continuation of Pudsey Clough, the Sandrock Mine Coal has been exposed by outcrop diggings in a quarry, and was seen to be about 1 ft. thick.

Paul Clough afforded an unbroken succession of the Millstone

Grit Series, from the Rough Rock to the Kinderscout Grit, in the following descending order* :—

Rough Rock (1st Grit).
Shales with Upper Haslingden Flags.
Grey mudstone.
Dark shales, with *Gastrioceras crenulatum*, etc.
Lower Haslingden Flags (2nd Grit).
Shales with *G. cancellatum*.
Holcombe Brook Coal and Grit.
Shales with *Lingula* near base.
Hazel Greave Grit.
Shales.
Gorpley (Main Third) Grit.
Shales with *Reticuloceras reticulatum* mut. *beta*.
Sandy shales and flags.
Shales with *R. reticulatum* late mut. *alpha*.
Upper Kinderscout Grit.
Sandy shales.
Kinderscout Grit.

The conglomerate nature of the Kinderscout Grit was well seen in the stream at the head of the clough.

The party returned to Cornholme *via* the Long Causeway and Shore, from which points good visibility afforded unusually clear views of geological features over a wide area on both sides of the Cliviger Valley.

THE CRACOE KNOLLS.

SATURDAY, JULY 31ST, 1926.

Directors, R. G. S. HUDSON, M.Sc., F.G.S., AND MISS K. BOOKER.

THE village of Rylstone was the starting point of this excursion. From close to Rylstone a fine view was seen, both of the Cracoe Knolls with a background of the Craven Highlands, and of the low rounded hills of the Craven Lowlands with a background of Pendle Hill. The first exposure visited was that of the Rylstone Limestones—unfossiliferous D_1 limestones—in the railway-cutting. From here the party crossed Calton Gill to the Limekiln Quarry and collected corals from the Zaphrentid bed at the base of the Skelterton Limestone and *Goniatites crenistria* from the black limestones in the stream-section. The distant view of Clints Quarry was an excellent demonstration of the shifting of the outcrop of the Skelterton Limestone by the Winterburn Fault. Some time was spent in Clints Quarry; fossils were collected from the Zaphrentid band, the *Lithostrotion arachnoideum* beds and the *Michelinia* bed and there was some

* See section, p. 50, Summary of Progress for 1922. *Mem. Geol. Surv.*, 1923.

discussion about the brecciated nature of the limestone of the *L. arachnoideum* beds. After collecting from the exposure of the *Goniatites spiralis* zone, the party rapidly examined the "crenistriatoid" beds in Upper Washfold Beck.

After lunch the party divided; the energetic members of the party accompanied Miss Booker to Skelterton Beck *via* the *pseudo-bilingue* beds of Fell Gill, where they found abundant specimens of the zone fossil; the others took the easier route along the road and saw Hall Haw Quarry—a quarry in the Hetton Limestones and on the axis of the anticline. The most prolific exposures in the Skelterton Beck section were those in the *Goniatites falcatus* band and the *Michelinia* beds, where large masses of silicified *M. tenuisepta* and *Emmonsia parasitica* were weathered out and easily obtainable. After some delay due to the abundance of fossils in the wall close to the beck—the wall here contains limestone-blocks practically all *Lithostrotion affine-phillipsi*—the party walked along the crest of Skelterton Knoll and noted the change in the lithology and thickness of the limestone when compared with that of the same horizon in Skelterton Beck and Clints Quarry. Lack of time necessitated the shortening of the programme and the party crossed the valley to Swinden Knoll. The proximity of the inn where tea had been arranged reduced the numbers of the party. The remaining members spent some time in Swinden Quarry. The dip of the reef limestone, the rarity of fossils, the fine fragmental nature of the limestone, the absence of bryozoa in the tufa layers were points discussed with the aid of the field evidence.

After tea the journey to Clitheroe was broken by a visit to Bull Lane at Hetton. The finest view of the knolls that the district provides was seen here. Bull Lane Quarry in the Hetton Limestones was examined and *Caninia cylindrica* collected.

THE CLITHEROE LIMESTONE.

SUNDAY, AUGUST 1ST, 1926.

Director, Dr. D. PARKINSON.

Report by the Excursion Secretary, E. W. J. Moore, B.Sc., A.I.C., with notes.

IN the Survey Memoir on the Burnley Coalfield, published in 1875, the deposits in this district were thus classified :—

Upper Yoredale Grit Bowland Shales Lower Yoredale Grit	}	= Yoredale Series (of Phillips)
Pendleside Limestone Shales with Limestone Clitheroe Limestone	}	= Great Scar Limestone

In 1889 Tiddeman substituted the terms Pendle Grit and Pendleside Grit for the Upper and Lower Yoredale Grits respectively, because the true Yoredale beds do not occur south of the Craven Faults. At the same time he expressed his opinion that the reef knolls were reefs, growing in a slowly sinking sea.

The lowest member of the Limestone Series seen in this district is the black Chatburn Limestone, whose base is never seen, but which is of Z and C_1 age.

The Avonian facies is different in detail from that of both the South-Western and the North-Western Provinces, and it has been found difficult to correlate the deposits with the zones formulated by Vaughan and by Garwood. The district has been the subject of a recent paper by Parkinson (*Quart. Journ. Geol. Soc.*, vol. lxxxii., part 2). He finds that the Limestone falls naturally into two divisions; the lower, well-bedded limestones he calls the Chatburn Limestone after the village two miles north-east of Clitheroe, where they are well developed, and an upper series of Knoll Limestones. He has abandoned the term 'Shales-with-Limestones,' as this has been applied to beds of different ages in different parts of the country and the local name, Worston Shale Series, is suggested as an alternative.

According to Parkinson the succession is :—

D_2 and some D_1	Pendleside Limestone Series	
D_1 ?	Worston Shale Series	
S	Salt Hill—Worsaw Knoll Series	Clitheroe Limestone
C	Coplow Knoll Series	
Z — C_1	Chatburn Limestone	

The Chatburn Limestone consists of grey to black well-bedded limestones, with occasional shale beds, 1 or 2 ft. thick. One shale band, about 4 ft. thick, occurs persistently and is called the Four-foot Shale. Some of the upper beds are dolomitic, and were considered by Vaughan as typical *laminosa* dolomites.

This limestone is succeeded by the Coplow Knoll Series, the lower of the two knoll horizons. These knolls occur in an almost west-and-east line from Waddow Knoll in the west to just beyond Twiston in the east. The commonest coral is *Amplexus coralloides*, while the most abundant brachiopod is *Spirifer coplowensis*, a new species described by Parkinson. The type section is at Coplow Quarry, about one mile north-east of Clitheroe.

At a higher horizon a second line of knolls occurs, the Salt Hill–Worsaw Knoll Series. The lithology is, in general, similar to that of the underlying series. Many fossils are common to both, but at least 65 species have been recorded from Salt Hill which have not been found in the Coplow Series. *A. coralloides*, which is remarkably common at Coplow, is rare in the higher series.

The Worston Shale Series, which includes the greater part

of the Shales-with-Limestone of Tiddeman, forms the valley between the Worsaw Knoll Series and Pendle. The fauna is scanty, and consists mainly of crushed cephalopods and lamellibranchs. The most abundant forms are *Prolecanites compressus* and *Pterinopecten* sp.

The Pendleside Limestone includes the beds between the Worston Shales and the Bowland Shales. There are three sub-zones. The lowest band, characterised by *Beyrichoceras hodderense*, consists of a grey impure limestone, with blue to green blotches, and with goniatite fragments projecting from its weathered surfaces. It constitutes a conspicuous horizon on the sides of Pendle.

The *Lithostrotion arachnoideum* sub-zone follows and constitutes the greater part of the Pendleside Limestone. The best exposures are in Burst Clough.

The uppermost 30–40 feet of this series is made up of the Ravensholme Limestone, characterised by the coral *Emmonsia parasitica*. It is interesting to note that in the upper part of this sub-zone the goniatite, *G. crenistria*, makes its appearance.

The party walked to Brungerly Bridge and thence by Knunck Knowles to Coplow Quarry at Pimlico. This quarry shows the remains of a once large knoll in the lower Knoll Series, most of the hill having been removed by quarrying. The fossils were plentiful and varied, and the energetic members were able to fill their bags. *A. coralloides* and *Spirifer coplowensis* were found as well as echinoid plates.

The Director led the way across the road to the Chatburn Limestone exposed in Horrocksford Quarry. Specimens of *Syringopora* and *Zaphrentis* were obtained.

At the Bold Venture Quarry the Chatburn Limestone was again seen, but the most interesting feature of this exposure was the evidence of ice-action. The top of the beds, where the drift had been cleared, was hummocky and showed very fine glacial striations.

The small Peach Quarry showed many specimens of *P. humerosus* on weathered surfaces, but it was disappointing trying to extract them. This limestone underlies that of Salt Hill, which was next visited. Typical specimens were readily obtained, and the thick crinoidal capping yielded the blastoid, *Orbitremites*.

BANK HALL COLLIERY AND ROUGHLEE.

MONDAY, AUGUST 2ND, 1926.

Director, EDW. W. J. MOORE, B.Sc., A.I.C.

THE party visited Bank Hall Colliery, Burnley, where the workings were explained by the manager, Mr. Walton, who

then accompanied them down the pit. Some particularly fine specimens of *G. carbonarium* and *G. listeri* were on view in the office.

The party left the colliery and proceeded by tram to Barrowford, from which place a walk across the fields brought them to Roughlee. The shales were examined and a plentiful supply of zonal forms was collected, but the only solid ones obtained were small specimens of *R. reticulatum* and one of *H. striolatum*.

WHITEWELL, WHITENDALE AND SLAIDBURN.

TUESDAY, AUGUST 3RD, 1926.

Director, J. RANSON, A.M.I.M.E., F.G.S.

THE party, twenty-five in number, travelled by motor to Stephen Bridge, near Clitheroe, where red sandstone mapped as Permian by the Geological Survey, was seen to rest with strong unconformity on thinly bedded Carboniferous limestones. Brecciated limestone was included at the base of the red sandstone.

A microscopic examination of this sandstone shows that numerous well-rounded grains are disseminated through it, a considerable portion of these grains being perfectly rounded like millet seed. This is especially notable in the heavy minerals. Some of this material therefore has been wind-blown. Zircons are prominent among the heavy minerals.

In the absence of a good identifiable horizon in these beds, the Director considered that they might be more fittingly and non-commitally designated Permo-Trias.

He had included this exposure in the programme partly to complete the study of the stratigraphy of the district, but more especially to direct attention to the enormous amount of denudation which had taken place towards the close of Palæozoic times. If the beds were really of Permian age, then some 10,000 ft. of Carboniferous strata had been removed during the Permo-Carboniferous interval. This denudation would be first of all marine, as the rocks were lifted from the sea and would take place on the axis of the Clitheroe anticline, which would be planed down somewhat and opened to the attack of consequent drainage and sub-ærial denudation. He presumed that such an enormous amount of work could only have been accomplished in the time involved by a fairly large river. It was a remarkable thing that the Ribble had re-excavated a part of that ancient valley.

The party next visited the Bunter Beds at Bashall Brook above Talbot Bridge. These beds were seen to be soft red sandstones with yellow bands and patches; here and there also were small lenticles of marl. They made an exposure on the stream bank about twelve feet high, and overlay unconformably the lower Millstone Grits, which farther down stream were stained red from the former cover of Bunter Beds.

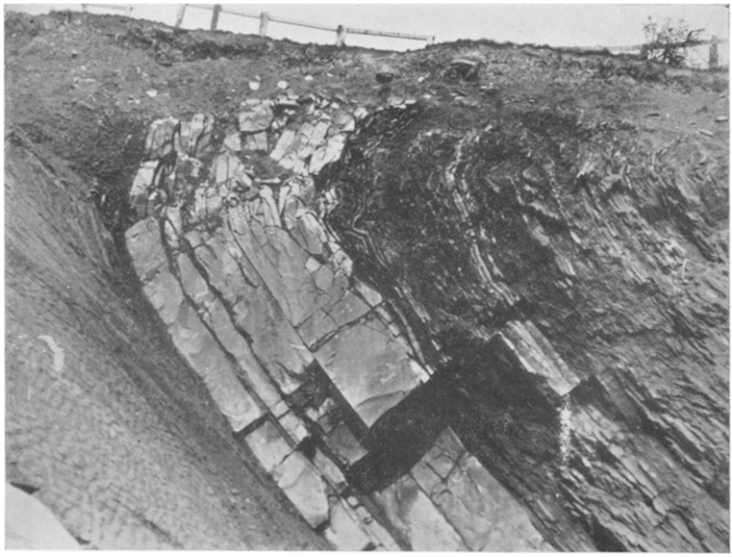


Photo by J. Ranson.

A.—TERMINAL CURVATURE IN HASLINGDEN FLAGS.
Close Brow Quarry, Rishton.



Photo by F. Hughes.

B.—DRIFT-BEDDING IN WOODHEAD HILL SANDSTONE.
Lower Coal Measures. Whin Lane, Read.

[*To face p.* 190.

Mr. E. E. L. Dixon found a few quartzite pebbles in the Bunter Beds here and was inclined to the view that the materials of these beds were of southern origin.

As in the case of the Permo-Trias at Stephen Bridge some of the materials of these Bunter Sandstones show evidence of having been wind-blown, especially in the heavy minerals. The proportion of well-rounded grains, however, was smaller than in the older rocks by Stephen Bridge. Zircons were again conspicuous among the heavy minerals.

The foregoing patches of Permo-Trias owe their preservation to having been thrown down to the south-west by a fault running in a north-westerly direction from near Salford at Clitheroe *via* Braddup Wood to Marl Hill Moor, etc., and probably also to a cover of newer rocks on which the present drainage system was initiated.

The motor was rejoined and the journey resumed to Whitewell and Whitendale to inspect the Blackburn Corporation Waterworks and to examine a section of strata there from the Pendle Grit to the Pendleside Limestone. The party was met and cordially welcomed by representatives of the Blackburn Corporation, including the Mayor, Councillor J. Stanworth, J.P., Sir William Forrest, O.B.E., Aldermen J. T. T. Ramsay, J.P., Deputy-Mayor, J. T. Duckworth (chairman of the Waterworks Committee), and W. Kenyon, Mr. A. T. Gooseman, A.M.I.C.E. (Borough Engineer), and the Rev. A. Boddington.

After lunch, in replying to speeches by the Mayor and Alderman Ramsay, Mr. E. E. L. Dixon, B.Sc., F.G.S., of the Geological Survey, thanked the Corporation for their welcome to the well-chosen source of their water supply, and for their hospitality, and referred appreciatively to the esteem in which the work of geologists, especially of their long-time member, Mr. W. Whitaker, was held by the authorities of that town. In fostering this esteem much credit was due to their leader of that day.

The cordial co-operation between governing bodies of various kinds and workers in geology was necessary. Researches in apparently uneconomic geology were continually found to have economic bearings and, conversely, geologists would find that there were many important economic questions, in the elucidation of which purely geological work was needed.

Mr. A. T. Gooseman, Borough and Water Engineer, suitably acknowledged the vote of thanks, after which the intakes were inspected.

After the waterworks undertaking had been explained by the Borough Engineer and Mr. Ald. Duckworth, and the intakes duly examined, the Director drew attention to the geology of this fine valley, in which a repetition of the rocks displayed in the Clitheroe and Slaidburn anticlines occurs from the Pendleside Limestones (of the Shales-with-Limestones in the Pendle area) through Bowland Shales with Pendleside Grit up to the Pendle Grit.

These rocks are well displayed in both the Whitendale and Brennand valleys along the Sykes anticline, whose axis running N.E. and S.W. is thus roughly parallel to the anticlinal axes of Slaidburn and Clitheroe on the east. As the anticline pitches to the N.E., and the floors of these upland valleys range from 600 to 1250 ft. above O.D. in Whitendale, and 1500 ft. in Sapling Clough at the head of the Brennand Valley, limestones lower than the Pendlesides are not exposed.

Attention was drawn to the section displayed in Calf Clough where the Pendle Grit overlies the Bowland Shales on the steep hillside. The shales were observed to be crowded with large *Posidoniella*, and lower down the sequence, with *Eumorphoceras pseudo-bilingue*.

The valley was then crossed to the western side and a section worked from the Pendleside Limestone to the Pendle Grit. *Goniatites crenistria* was found by Mr. E. E. L. Dixon, followed by *G. spirale* and *Posidonomya becheri* at two horizons.

The party then returned to Bishop's House and were entertained to tea, after which the departure was made to Slaidburn. Here a quarry was visited at Highfield where rolling beds of Pendleside Limestone with *Lithostrotion arachnoideum* in large colonies were well displayed. Lenticular masses of chert were seen to be involved in the folded limestones.

By this time the day was "well spent," and the return was made to Clitheroe *via* Waddington Fell. Atmospheric conditions were good and delightful views were obtained of the Bowland Fells, made famous by Phillips, and thoroughly enjoyed by the party on this brief visit.