41. *NOTES on the STRUCTURE of the PALÆOZOIC DISTRICTS of WEST SOMERSET.* By A. CHAMPERNOWNE, Esq., M.A., F.G.S., and W. A. E. USSHER, Esq., F.G.S. (Read May 14, 1879.)

INTRODUCTION.

IN the following account of traverses made during the past autumn across some of the classical ground of West Somerset and its confines, we do not aim at any extensive alteration in principle of the work wrought by the master hand of De la Beche, and given to the scientific world forty years ago*.

Notwithstanding the encyclopædic paper of Mr. Etheridge†, wherein both the physical and palæontological relations of the North-Devon rocks are so ably worked out, instances of unbelief will occur where ocular evidence is wanting, prompted perhaps by a hankering after the apparently simple version of the structure of North Devon put forward by the late lamented Prof. Jukes‡. Although the ground has been carefully gone over in Mr. Etheridge's paper, such a confirmation of his views as the infilling of minor stratigraphical details affords may not be altogether unworthy of attention.

The classification which De la Beche's unequalled description of the North-Devon rocks suggests was put into form by the late Prof. Phillips, who, however, included the unfossiliferous grits and slates of Pickwell Down with the slates of Morteheo as one division§. Although these divisions were similarly treated by Mr. Hall in 1865 and 1867||, a more detailed description mitigated an error of classification which that gentleman has since abandoned. Mr. Hall informed us that the term Pickwell-Down Sandstone was applied to that division by Prof. Jukes, acting on his suggestion. To Mr. Hall belongs the credit of inaugurating the present more complete classification, which rightly distinguishes the position of the Lower Pilton, or Baggy Beds in the upper part of the series¶. This classification was, with some slight modifications, retained by Mr. Etheridge, and has been adopted by us. With this introduction, we shall commence with our westernmost traverses.

* Report on Geol. of Cornw. & Dev. ch. 3, &c.

† Q. J. G. S. vol. xxiii. p. 568.

‡ Q. J. G. S. vol. xxxii. p. 320, and additional Notes, &c.

§ Pal. Foss. Devon, Cornwall, and W. Somerset, pp. 183-193.

|| Lecture to Exeter Naturalists' Club, Sept. 23, 1865; and Q. J. G. S. vol. xxiii. p. 372.

¶ It should be mentioned that Mr. Hall has abandoned the term conglomerate as applicable to any of the N. Devon Devonian rocks, the concretionary structure in the Pickwell Down division to which it was applied being too insignificant to merit the designation.

FROM DULVERTON STATION TO DUNSTER (fig. 1).

Dulverton Station is situated upon the junction between the Culm-measures and Pilton slates. Towards Brushford, Pilton fossils were obtained in nearly vertical slates, passing insensibly into the Culm-measures in the railway-cuttings. The well-marked feature of Hulverton Hill (to the south of the railway) is formed by the characteristic Culm-measure rocks, which, along a line nearly east and west from Coddon Hill (south of Barnstaple) form here and there bold hog-backed or conical hills, notably at Swimbridge. These beds are easily distinguishable by their baked appearance, whitish, buff, or dark-grey colour, and frequent chertoid texture; they consist of thick shales or thin fine-grained grits in tabular layers, so intersected by even joints as to afford a valuable road-metal without further fracture. In a quarry on Hulverton Hill the Coddon beds dip S. 10 E. at 80°. To the north of the railway, to the east of Brushford, grey Pilton slates, vertical, and striking as at Hulverton Hill, are exposed in a quarry, from which Prof. Phillips obtained many of his best specimens.

By the highroad to Dulverton, at a mile from the station, bluish-grey slates, with thin even beds of limestone and grit, containing quartz, dip S. at from 45° to 65°. In Pixton Park a southerly dip of 45° was obtained near the gatehouse, where the grey slates strike parallel with the Culm rocks of Hulverton Hill. A little northward of Combe Farm, so far as meagre surface evidence may be relied upon, a band of buff or brownish grits, either belonging to the *Cucullæa*-zone or occurring above it in the Pilton beds, crosses the highroad, forming the crest of an anticline; for towards Dulverton the Pilton beds dip N. at 75°, and near the bridge across the Barle N. 30° W. at 20°.

Just above Dulverton church the grey slates suddenly give place to lilac-red slates and grits, so characteristic of the upper part of the Pickwell Down division, which is further evidenced by features and surface indications as far north as Court Down. This junction is evidently a fault, both from dissimilarity in amount and direction exhibited by the dips on either side of it, and from the absence of the *Cucullæa*-grits and olive slates (forming together the Baggy Beds, or Lower part of the Pilton series). Proceeding eastward to Hele Bridge, further evidence of the fault is furnished by a developed continuation of the grit band before noticed near Combe Farm. The beds are exposed in Pixton Park, near a gate-house, and dip N.W. at 55°. Immediately on the north of the highroad they end off sharply against the Pickwell Down division. From Hele Bridge northward to Barlynch Abbey, where it is exposed in quarries, the Pickwell* series is amply evidenced by characteristic surface-stones, vegetation, and form of ground. To the north of the Abbey a quarry about 25 feet in height exposes light grey or greenish and faint reddish grits with red markings in places, dipping S. 15° E., with undulations, at an average angle of 45°. A cleavage structure

* We omit the fuller title for the sake of brevity.

is here and there developed in directions parallel to the joints; in places the undulating surfaces of the joint-planes resemble the adjacent markings by the road, attributed by Prof. Jukes to ice mamillation. In the vicinity of this spot the Pickwell beds seem to form a syncline, as northerly dips are met with near the Abbey on the south.

Near Oxgrove an appearance of northerly dip is probably occasioned by joints in the direction of the cleavage. At a quarter of a mile north of Oxgrove we appear to cross the junction between the Pickwell series and underlying division of greenish and grey slates of Morte and Ilfracombe (called after the typical localities in which their upper unfossiliferous and lower fossiliferous beds are respectively developed). Greyish schistose or irregular slates near Oatway are apparently intersected by joint-planes dipping N. at 70° , whilst the bedding seems to follow the direction of the cleavage, dipping S. 10° E. at 70° . In places the slaty laminæ thicken into impersistent lenticular gritty bands. At Chilly Bridge characteristic Morte slates are exposed. Due east of Kent's Mill the slates dip E. 20° S. at about 50° ; a few chains to the north grey uneven or schistose slates, with vertical cleavage, seem to dip N. 20° W. at from 60° to 70° . At about one third of a mile north from the above a northerly dip is exhibited.

At the junction of the Ordnance map sheets 20 and 21, grey grits and purplish slates are associated with greenish and bluish grey slates, proving a repetition of the Pickwell series, in a syncline, aided by fault. From the occurrence of Pickwell beds to the north and north-west, we have little hesitation in saying that the Morte slates of Chilly Bridge form an anticline, throwing off the Pickwell beds on the north and south, and passing under them on the west towards Drayton Farm.

At Clammer irregular or schistose slates and slaty grits, with vertical cleavage, and in colour more allied to the Morte than the Pickwell beds*, seem to dip S. to S. 20° E. at 50° . A contrary dip, N. 20° W. at 70° , is suggested by divisional planes, apparently joints. Near Clammer bedding and cleavage-planes appear to run in the same direction, but the joints seem to be vertical. From Clammer to Bridgetown slaty lilac or purplish grits and slates are associated with grey slates, and undoubtedly belong to the lower part of the Pickwell series, from evidence obtained to the west of the Exe valley. Near Bridgetown lilac or purplish and grey slates, uniformly coated with lichen, and presenting a grey weathered surface, are finely exposed in the road-cutting. The cleavage-planes, inclined southward at 60° to 70° , are intersected by two or three impersistent lines, apparently bedding-planes, giving a southerly dip of 13° .

At Bridgetown the dip is S. at about 65° ; and the lower parts of the Pickwell-Down series, forming a passage into the Morte slates, rest upon them in strict conformity, the junction-line having been

* Compare greenish grits and slaty beds near Drayton and Slade Farms in Pickwell series, Barle Valley, two miles above Dulverton.

traced westward from the bank of the Barle (opposite Bridgetown), where Morte slates are shown normally dipping under the Pickwell beds.

From Exton to Cutcombe no further evidence of the Pickwell series is obtainable by the highroad, although, to the south of Winsford, a strip of the lowest part of that series, represented by intercalations of purplish, buff, and greenish slates, appears to be brought down by fault or undulation between Yellowcombe and Winsford, but in insufficient force to permit of their extension eastward to Widlake, where a dip of 50° to the S. was obtained in Morte slates.

Near Lock Yard the slates dip as at Widlake. West of Lower Quarum they are stained reddish, and exhibit a tendency to slaty grit. From Lower Quarum to Whiten Farm the slates have a steady southerly dip at 40° to 50° where exposed. The bedding seems to follow the direction of the cleavage at right angles to the joints eastward of Hoe Farm. It is impossible to distinguish the Morte and Ilfracombe varieties of this great series of slates by any definite boundary; a provisional line might be dotted through Eyeson Hill or Lower Quarum. At the Mill, between Whiten Farm and Luckwell Bridge, the Wheddon-Cross limestone-beds mentioned by Mr. Etheridge are well exposed; they consist of about 30 feet of dark bluish-grey limestone, partaking in every respect of the cleavage, which is here in the same plane with the bedding. The laminae are frequently coated with films of dark grey shimmering shale. Faint traces of crinoids and corals were noticed on the bedding- or cleavage-surfaces. At about 15 feet from the top of the section the laminae have, in places, coalesced to form even beds of limestone 2 or 3 inches in thickness. The dip is S. 10° E. at 45° .

From Wheddon Cross the features of the underlying series, the Hangman grits, are well shown in the range of hills of which Dunkery Beacon forms the highest point.

The junction of the Morte and Ilfracombe slates with the underlying Hangman grits takes place near the bend in the highroad north of Cutcombe, where slaty beds rest upon coarse thin even-bedded slaty grits, resting on red and brownish, rather coarse, thick-bedded grits, with an occasional tendency to schistose structure, and dipping S. 30° E. at from 10° to 13° . The strike changes slightly, but the angle of dip remains constant, in the three quarries by the highroad. From this point to Timberscombe, grits with shales intercalated prevail. A quarry by the highroad N.W. of Oaktrow shows a most remarkable unisynclinal curve, rough-cleaved greyish and reddish grits folding back upon themselves, as shown in the sketch (fig. 2), the cleavage beautifully converging upon the axis of the curve. The height of the section is about 20 feet.

By the lane leading southward to Oaktrow from the highroad grey and reddish slaty shales and schists are associated with reddish-brown grits, apparently undulating, in which a northerly dip of 7° was obtained. A quarry on the east side of Timberscombe exposes dark chocolate-brown, red, and greyish grits, in places quartzose,

split off by numerous irregular joints, sometimes glazed with hæmatite, and approximating to a slaty structure in places; bands of chocolate-coloured clayey shale are occasionally interstratified. The beds dip S. at 5° .

Fig. 2.—*Unisynclinal Curve in Hangman Beds, near Oaktrow.*
(Height of section 20–25 feet.)

From here to Dunster grits are evidenced by surface-stones, but no sections were observed. If the Timberscombe grits belong to the Foreland group (as similar beds are exposed near Porlock), a fault between Bickham and Withycombe must bring the Hangman and Foreland groups into juxtaposition, cutting out the intermediate Lynton beds; and this we hope to prove by the next traverse.

FROM DUNSTER TO THE FORELAND.

As in the previous traverse no beds equivalent to the even grey grits and fossiliferous schists of Lynton were crossed, Mr. Etheridge having clearly shown the mantling of the Ilfracombe slates and associated limestones round the east end of the Croydon-Hill anticlinal, formed of Hangman grits, and as in our traverse from Wilton to Cannington, hereafter to be described, we were unable to trace the Lynton division, it was of the utmost importance to account for its disappearance, and for the great breadth of grits occupying the area from Cutcombe, on the south, to North Hill, near Minehead, on the north.

The south side of Grabbist Hill consists of reddish-brown grits, in which no reliable dips were obtainable till we reached Slatcombe, near Wooton Courtney, where the beds dip N. 15° E. at from 5° to 20° . On the western flanks of Grabbist Hill, near Lower Knoll, hard reddish-brown siliceous grits with numerous irregular joints, and

slaty beds intercalated, dip E. at from 5° to 20° , and at Tivington N.E. at 30° .

The valley between Grabbist Hill and Luckham is occupied by red sands, breccias, and marls of the Triassic series, in part concealed by alluvia. The relations of the Triassic beds in an area in which they may be expected to present much local lithological variation, and where they would naturally attenuate, notwithstanding very high dips, throw hardly any light upon the disturbances affecting the older rocks; but a much more careful study of the latter than we were able to make would no doubt clear up much that is ambiguous in the relations of the Trias, and show whether beds of Pre-Keuper age had been deposited in the area to the west of Williton, as lithological similarities seem to suggest.

From Luckham to Stoke Pero the surface is strewn with fragments of grit. At about half a mile east from Cloutsham coarse red and lilac quartzose grits are exposed, dipping E. 25° S. at 10° .

In the stream between Cloutsham and Bagley siliceous grits dip eastward at 20° . Near Cloutsham and Brackslade no dips are obtainable; red and brown grit-stones are scattered over the surface. Near Stoke Pero a south-easterly dip of 23° was obtained in red and brown grits. The grits in this neighbourhood approach rather to the Hangman than the Foreland type; so that the sharp bend in the stream to the north of Cloutsham may be due to a dislocation bringing up Foreland beds to the north.

By the road from Stoke Pero towards Bendles Barrows siliceous grit-stones of the Hangman type are strewn over the surface.

On ascending the opposite slope of the valley to the west of Stoke Pero a thick head of brown grit-stones conceals the rock. At the head of a stream-gorge, at about half a mile south of Wilmotsham, buff slaty grit gives a surface-dip S. 30° E. at about 15° . By the road southward from Pool, where the bend is shown on the map (to the N.E. of Bendles Barrows), a section 5 feet deep exposes greenish slaty grits or thick slates, apparently vertical and striking N.E., terminally curved.

Westward of Bendles Barrows, in and by the road over Lucott Hill, at a few chains south of the stream, grey slaty beds are intercalated in red and coarse brown grits, dipping S.W. at from 20° to 40° . As their strike coincides in direction with that of the greenish slates on the other side of Bendles Barrows before mentioned, we have here the evidence of intercalation of slaty materials with grits of the Hangman series which is so well shown in the cliff-face of the Little Hangman Hill, on the North-Devon coast.

On the southern slope of Lucott Hill a northerly surface-dip was obtained in slaty grits; at the road-junction on the hill greenish and red grits and slaty beds seem to dip S. 10° W.

From Lucott Hill (fig. 3) we struck into the East-Lynn valley at a point due west of the bottom of the word "*Lucott*" on the map, where we observed hard thick-bedded greyish siliceous grits of the Hangman series dipping southward at from 20° to 25° . Proceeding down the valley, at about ten chains from the above, a south-easterly dip of

35° was obtained. At about ten chains further on Hangman grits, containing raddled grey schistose beds, dip southward at 20°, and S. 20° E. at 30°, and rest in strict conformity upon the characteristic

Fig. 3.—Section North and South through Culbone.

warm-grey, evenly bedded fine grits and grey schists of the Lynton division, which form a low crag or ridge feature in the valley, dipping S. 25° E. at 25°. At about 15 chains from this junction a tributary streamlet joins the East Lynn; proceeding along it, we observed the same even flaggy Lynton grits dipping S. 15° E. at 20°, at a point about 15 chains from the main stream.

Having thus terminated the Lynton beds in the East-Lynn valley by a conformable junction with the Hangman grits, we will retrace our steps, and, starting from Porlock to Countesbury, and then to Oareford, endeavour to show that the absence of the Lynton beds on Lucott Hill, and to the east of it, is due to a fault following the general trend of the East-Lynn valley. On ascending Porlock Hill from Porlock, chocolate-grits, resembling those of Timberscombe (as before stated), with irregular schistose beds, dip E. 12° S. at 50°, and N. 30° E. at 70°, the change in dip being apparently due to a fault. A little further on they dip N. 30° E. at from 60° to 65°.

The evidence on Porlock Hill is confined to surface-stones till we come to a section about 10 chains east from the turning to West Porlock shown on the map, but now no longer in existence; here the grey, buff, and red fissile grits so characteristic of the Foreland group are apparently horizontal. The present road to West Porlock joins the main road at a point on the map where the letter *W* of the words *White Stones* touches it. By this road, near West Porlock on the north-west of Whitestone Park, red grits dip N. 10° W. at 55°. Midway between this observation and Westacot similar red grits (rather fine-grained) exhibited a northerly dip of 20° and a doubtful southerly dip of 50°, which may be along joint-surfaces. South of Westacot an easterly dip of 55° was furnished by greenish-grey and reddish fine fissile grits, in which we obtained several casts of small bivalves. About halfway between this section and the main road, on Porlock Hill, similar beds afforded a dip E. 20° S. at 25°.

From White Stones to Countesbury, in the adjoining map (sheet 27), no pits deep enough to afford reliable dips were observed from

the highroad; the surface-stones everywhere consist of red, buff, brownish, whitish, greenish, or grey fissile or flaggy fine-grained grits, generally of sombre tints.

By the road from Porlock and Oare Hills to Oareford grey and purplish or red fine-grained flaggy grits are evidenced by numerous surface-stones. At a bend in the road, not shown in the map, just above the East Lynn Valley, dark grey and red fine-grained grits and schistose beds of the Foreland group exhibit contrary dips of about W. 10° S. and S. 20° E., at angles apparently conforming to the slope of the hill. In the valley below the above observation, dark grey Lynton grits, even-bedded and evenly jointed, with occasional grey schistose intercalations, are exposed by the East Lynn, and in little hills or crags of a somewhat conical shape, which are so characteristic of the Lynton grits, and, as before stated, occur near their junction with the Hangman group in this valley. By the stream and in the crags the Lynton beds dip S.E. and E.S.E., generally at an angle of 55° . At Oareford houses grey schists strike S. 20° W., apparently dipping E. 20° S. at from 30° to 50° . Near Withycombe Farm purplish-grey Lynton grits strike in a north-easterly direction. North of Withycombe Farm bluish schistose grits dip E. 40° S. at 40° .

At about half a mile north of Withycombe Farm (fig. 4) the character of the ground alters, being marshy and much lower about Oare. This change is due to a great fault crossing the Oareford road below the contrary dips (exhibited by the Foreland grits, as before stated), and probably continuing along the valley to the north of Cloutsham, and thence by Bickham to Withycombe. Continuing this line westward to the coast at a point north of the camp (between Countisbury and Lynmouth), where evidences of fault are conspicuous in the cliffs, we find that it separates Foreland grits on the north from Lynton beds (with tolerably steady southerly dip) on the south, the straight boundary line between the divisions being apparently only broken in two places by fringing masses of Lynton beds thrust up with the Foreland grits on which they rest—viz. for more than a mile near Combe Farm (sheet 27), and eastward of Oare. The conformable superposition of the Lynton beds on the Foreland group is best seen near Oare. By the farmyard on the north bank of the East Lynn at Oare, hard lilac, buff, and grey fine-grained grits with reddish markings, and jointed in all directions, are exposed in a quarry, and dip S.E. at 30° . From this quarry northward to the highroad, by the gully which usurps the place of the path shown on the map, Foreland grits are evidenced by a thick head of characteristic stones.

At about five chains eastward of the farmhouse fine-grained grey even-bedded Lynton grits and grey schists dip S.E. at 40° by the stream, and are shown further on preserving the same direction of dip at increasing angles. This upcast mass of Lynton beds makes a marked feature at its junction with the Foreland grits on which it rests, forming a steep ridge that trends N.E. to about ten chains from the main road, whence the boundary deflects with a minor fea-

ture along the slope of Oare Hill to the fault which cuts it off somewhere near the road to Oareford.

From the foregoing evidences we have no hesitation in saying that the absence of the Lynton beds from Lucott Hill eastward is due to a great fault which extends from the point whence the coast deflects N.N.E. to the Foreland, following the East-Lynn valley (but cutting across the bends in the stream) as far as Oareford, whence skirting the north of Lucott Hill it appears to pass by Cloutsham Ball (name not on the map), and probably runs through Bickham to Withycombe on the north of Croydon Hill. This fault appears to be Pre-Triassic; but of this we cannot be certain without carefully examining the Triassic districts of Luckham, Wooton Courtney, and Withycombe.

Mr. Etheridge advocates the existence of a fault from the Foreland to Minehead*, and also suggests that the lowest beds are obscured by "an extensive fault affecting the Foreland Sandstones"†. The correctness of the latter suggestion we have endeavoured to prove; but we confine the anticlinal structure (also said to obscure the relations of the beds) to the higher ground composed of Foreland grits between Countesbury and Porlock, as we have failed to detect any signs of such structure in the East-Lynn valley. Of the fault between the Foreland and Minehead we could obtain no direct evidence in the limited area gone over, but, judging from slight indications, think the existence of such a fault, obscuring the relations of the grits of the Foreland group *inter se*, by no means improbable.

THE TORRE VALLEY (fig. 5).

The village of Ashbrittle is situated on dark bluish slates or thick shaly beds of the Coddon-Hill type, and exhibiting its characteristic features in adjacent hill-summits to the west of the village. The Culm beds are exposed near Trace Bridge, dipping S.E. at 45°.

Whatever cleavage may at times be developed in the argillaceous parts of this upper series of Devon and Cornwall, it here at least coincides with the bedding. A line south of Coalman's Mill, passing between Chequeridge and Pitt Farms, divides the Culm-shales (which near Pitt Farm are nearly horizontal) from the light-grey slates of the Pilton series. Near Coalman's Mill *Spirifera Urii* occurred in bluish-grey slates which dip S.E. At Stawley the strike has altered, giving a S.S.W. and S.W. dip; and north of Stawley Parsonage, between that and Hagley Bridge, a marked feature is caused by reddish, greyish, and greenish grits and slaty beds: occasional red-brown sandy seams suggested a decomposed limestone.

These beds were noticed by De la Beche (Geol. Report, Cornwall, Devon, &c., pp. 53 and 104); they contain many fossils (*Spirifera disjuncta*, *Streptorhynchus*, a Pilton Crinoid, &c.). Mr. Hall com-

* Quart. Journ. Geol. Soc. vol. xxiii. p. 595.

† Ibid. p. 694.

parens this local development of grit in the Pilton series with similar fossiliferous grits near Braunton. The beds dip S.S.W. and S.W. at from 32° to 34° , and at Kittisford Barton S. at 37° .

Northward from Hagley Bridge the Pilton beds are represented by slates in which grits were observed in the lane north of Surridge, dipping from S.E. to S. at from 40° to 60° . Whether this change in strike may be natural or the effect of a fault bounding the northern slopes of Stawley Parsonage hill, we must, without further investigation, leave as conjectural.

In the railway-cutting to the west of Pouch Bridge rather dark grey slates, tough grey grits, and films of limestone dip S. 20° E. at 43° . They embrace some brown arenaceous beds, due, as Mr. Hall thinks, to decomposition of limestone. Mr. Hall found Pilton fossils in these beds.

In the cuttings east of Pouch Bridge slates are exposed changing abruptly from dark bluish-grey to light grey. Blue-black slates have been turned out of the tunnel near Hellings, and yielded (so-called) *Petraia celtica*. The occurrence of similar beds at Venn-Cross station, where they contain *Septaria*, induced us to think that a strip of Culm-measures had been brought down by an E. and W. fault; but as the Pilton beds are often dark-coloured, we have abandoned this idea. In the lane north of Pouch-Bridge viaduct light-grey argillaceous slates dipping southward contain *Petraia celtica* &c.

Pilton slates with unreliable surface-dips are visible as far north as Rockhouse Inn, where a large quarry, by the turning to Bibor's Hill, exposes dark-grey raddled grits and slaty beds, containing Pilton fossils, and occasionally brown seams (decomposed limestones) with organic remains. The beds dip from S. 15° E. to S.E. at angles of from 65° to 75° .

On the southern slope of Bibor's Hill very hard irregularly jointed grey grits and slaty beds dip N. 30° W. at 55° , thus proving the structure to be a natural or faulted anticlinal. From their breadth of outcrop in this district the components of the Pilton beds appear to be repeated both by fault and flexure; and from lithological similarity, we are inclined to regard the Bibor's-Hill beds as a repetition of those on Stawley Parsonage hill, probably by a fault running in an easterly and westerly direction, not far north of Pouch-Bridge viaduct. As the Bibor's-Hill beds do not appear to outcrop north of Iron Hill, the grey slates which continue thence to the farmhouses south of Wadding were probably dislocated by the continuation of a fault shown in the railway-cutting (north of Bathealton), where it throws down Trias on the south. This view is strengthened by contrary dips, S.S.E. at 60° and N. 15° W. at 60° , respectively obtained on the hill-slope and by the lane to Chipstable (to the east of Trow-Hill Farm).

In a small section at the farm, south of Wadding, Mr. Hall fixed the junction between the grey Pilton slates with limestone bands and the olive slates, which in this district form the upper part of the Baggy beds. The beds dip S. 15° E. at 70° . In these greenish

slates Mr. Hall obtained a *Lingula*. An even conformable junction trending W. 20° S. and E. 20° N. separates them from lilac and reddish grits and slaty beds shown in a quarry a few chains north of Wadding Farm, dipping S. 15° E. at 35°. Mr. Hall identified these beds as *Cucullæa*-grits; lithologically we should have been unable to distinguish them from the Pickwell grits and slaty beds, upon which they rest conformably, forming a narrow zone about twelve chains in width along the southern flanks of the Pickwell range, and scarcely distinguishable by feature. In this zone, S. of Challich Farm, south-easterly dips of 50° to 55° were obtained, and casts of *Cucullæa* were found by Mr. Hall.

In the Tone valley, at a few chains north of the *Cucullæa*-zone, a dip S. 15° E. at 50° was obtained in Pickwell beds; thence to Washbottle Mills the characteristic features and vegetation of the Pickwell series, constituting the high land of Heydon and Main Downs, are unmistakable; but the exposures of rock were too slight to afford reliable dips. A fault with a southerly downthrow, of which evidence has been obtained near Wiveliscombe, may cross the Tone valley near Challich Farm.

On emerging from the narrow river-gorge (of the Tone) which intersects the Pickwellian range, we have the clearest evidence of perfect conformity between this series and the underlying Morte slates at Washbottle Mills, by a slight deflection of the junction in accordance with the physical features, a character distinctly exhibited in its prolongation westwards. There are no conglomerates to be seen, nor any thing to indicate a lapse of time between these two subdivisions in North Devon or West Somerset.

Morte slates are shown immediately above the junction on the road to Huish Champflower. The boundary follows the road from the Mill eastward to Higher Raddon, and is concealed by Triassic rocks near Langley. Along this line the character of the grits* is exhibited in three small quarries on the northern slope of Main Down and at Higher Raddon, where the beds show S.S.-easterly dips of from 35° to 45°.

Following the boundary of the Trias and the Morte slates, the character of the latter is well shown in Oakhampton House slate-quarries, where the characteristic grey slates are somewhat raddled in places, the cleavage and bedding being apparently coincident, and dipping S. 15°–20° E. at 70°: by the highroad to Pitsford Hill the same southerly dip has been noticed. We did not continue this traverse into sheet 20, but obtained good evidence of the undulations in the greenish quartz-veined slates of the Morte series which are shown in the accompanying section (fig. 5).

ACROSS THE QUANTOCKS TO CANNINGTON PARK.

At Staple Hill foot, near West Quantocks Head, the boundary of the older rocks is sharply defined. Purplish grits in broken condition are seen at the cottages; and on reaching the open ground a

* Lilac, red, and purplish-grey grits and slaty beds.

quarry exposes red-brown and lilac grits and splintery shales, which dip N. 15° W. at 25° , and are much cut up with irregular joints. The spot is about a quarter of a mile due south of West Quantocks Head.

To the south of the above, in the gully east of Weacombe, a quarry is opened in similar grits, fine-grained, and partly greenish, dipping N. 35° W. at 20° . A quarter of a mile further up the valley grits with schistose intercalations dip N. 10° W. at from 40° to 50° . From here across the summit of the range the surface-stones (the only evidence obtainable) are generally of coarse siliceous grit, reminding one of the upper beds of the Great Hangman *; but where the paths to Hutsham and Holford divide, the rock shown in the path is *in situ*, and apparently horizontal.

At the foot of the hills at Holford is a large quarry of grits and clay shale, which dip N.E. at angles varying from 15° to 30° . The beds in the upper part are thin quartzose red-speckled grey grits, associated with greenish-grey shale, and resting irregularly upon a boss of similar grit (fig. 6), thick-bedded, into which the shales dove-

Fig. 6.—*Boss of Grit in Shales with thin-bedded Grits, Holford Quarry.* (Vertical scale, 1 in. = 40 feet.)

tail in one or two places, showing a lenticular character in the beds. At a bend in the highroad, just south of Holford, quartzose grits, with some even-bedded finer-grained beds and redder in tint, show dips changing from E. 30° N. at 40° to E. at 25° . From Holford, following the turnpike road to Nether Stowey, a quarry by Sherwage Wood shows red-brown grits, with general dip N. 30° E. at 10° . At turning to Doddington, Triassic rocks cross the road; at turn to Perry Mill Farm, reddish grits and shales dip E. 35° N. at 40° .

From Nether Stowey to Cannington and Bridgewater the Palæozoic rocks occur as inliers only, here and there amidst the Triassic sediments. Of these we have only occasion to refer to that of Radlet Farm on the south of the road, and those of Ashford Mill and Cannington on the north. The inlier at Radlet consists of fine reddish grits and shales. Padnoller beds are similar grits and shales, affected by an east and west fault, which bounds the last-mentioned inlier on the north.

Immediately to the north of Cannington an E. and W. ridge, two miles long, consists of purplish-grey arenaceous mudstones, finely

* See Symonds's 'Records of the Rocks,' p. 264.

micaceous and sectile. In the roads north from Cannington to Cannington Park the surface-dip seems to be southward, with undulations. An exposure in an adjacent field showed red-brown shales with occasional greenish mottling, under red Triassic sand, near the northern margin of the patch. With the conditions under which these inliers present themselves there is such a constant chance of raddling from Trias, that the colours of these soft arenaceous mudstones cannot be considered of much value, and they may be of almost any age, from the Culm-measures downwards.

Their relations with the Cannington-Park limestones are obscured by Triassic sands occupying the valley between the inliers. Large E. and W. faults prevail in the Bridgewater area, notably one on the south of Fiddington, with downthrow on the south: and this, if continuous, would make the Cannington inlier above the limestone; but the frequency of these Post-Triassic disturbances along E. and W. lines would justify a belief in precedent lines of fracture in similar directions concealed by the Trias; so that in the absence of any evidence of relations between the Cannington and Cannington-Park inliers, it seems not unreasonable to regard their junction as a pre-Triassic fault, probably of great magnitude.

The limestone is well bedded, and intersected by numerous irregular joints. As far as evidence goes, the dips in the quarry by the road on the south side of the park would make the strike of the limestone at right angles to the trend of the adjacent inlier, *i.e.* the reverse of what would happen were their relations normal. On the N.W. side of the quarry the dips range from W. 42° S. at 20° to S. 25° W. at 25° ; and on the N.E. face the beds dip E. 30° S. at 40° . A similar change of dip is observable on the south side of the quarry. In the S.W. corner, near the entrance, the beds dip W. at 70° , and W. 15° S. at 55° , whilst on the S.E. a dip E. 20° N. at 38° is observable, also S. 42° E. at 20° . The beds therefore form an anticline, the axis of which trends in a N. and S. direction. In one part of the southern face two fissures filled with Triassic sand were observed.

The limestone is of light grey and dove-coloured tints, intersected by pinkish veins and strings of calcite. Much is of oolitic structure, identical with that of the Mountain Limestone at Clifton, and also on Broadfield Down, near Yatton. We have never seen oolitic structure in any of the South-Devon limestones. Traces of crinoidal stems and corals we observed on the spot, but nothing that could be identified.

In the Taunton Museum we were shown the following specimens:—(1) *Productus*, of small size, apparently *P. cora*, as it has the wrinkled ears and delicate rounded striæ of that species, labelled "J.H. Payne, Cannington Park Limestone, October 24th, 1851;" (2) *Lithostrotion*, two fine polished specimens of a cæspitose form, apparently *L. Martini*; (3) *Lithostrotion basaltiforme*; the Corals from the Baker Collection. (With regard to No. 3, the identification is open to question.)

The Cannington-Park limestone we should unquestionably consider Carboniferous Limestone*. The South-Devon limestones most resembling it are the great mass north of Dainton Tunnel, traversed by the Great Western Railway, the Connator-Hill limestone adjoining the Totnes and Newton turnpike road, as well as that of Barton, near Torquay. These are all light-coloured, partially dolomitized (the first two scarcely fossiliferous), and with bedding undistinguishable; hence their resemblance cannot be called intimate.

The bedded and usually dark-coloured limestones at Daddyhole Plain, near Torquay, at West Ogwell and Bradley, at Dartington, and other localities too numerous to mention, have, neither in fossils nor lithologically, the slightest resemblance to the Cannington rock; but they have, on the contrary, a decided similarity, which amounts at times to identity, to the limestones of Asholt.

On recrossing the Quantocks to Bishops-Lydeard, we observed on Asholt Common a quarry of uneven dark bluish-grey limestone, often shelly, of a character met with so constantly in South Devon. This seems to overlie red-brown grits, dipping S. 20° E. at from 40° to 60° on the north of Asholt Common. Behind Lower-Asholt schoolhouse the character of the Devonian limestone developed in a horseshoe form, with Merridge as the centre of the curve, is shown at its western extremity to consist of reddish and bluish 'shelly' limestone, full of calcite, and intersected by a small fault. These we agree with previous writers (especially Sir H. De la Beche and Mr. Etheridge) in referring to the Ilfracombe series, of which the southern part of the Quantocks appears to consist.

Another very strong reason for the identification of the Cannington-Park limestone with the Carboniferous Limestone of the Mendips, of which we think it forms the southern margin (the connexion being concealed by intervening Secondary rocks), is the entire absence of shaly structure or associated detrital matter, which are so often characteristic features in the Devonian limestones.

In conclusion, we have to express our thanks to Mr. Hall for the kind assistance he has rendered in the particulars in connexion with which his name has been associated in this paper.

* This view is confirmed by Mr. Tawney in an exhaustive paper on the subject (Proc. Brist. Nat. Soc. vol. i. part 3, p. 380), in which he mentions his discovery *in situ* of *Lithostrotion irregulare* and crushed shells, perhaps *Terebrulata hastata*, or possibly *Athyris*, also a small *Productus elegans*, or young *P. punctatus*, and part of a stem of *Actinocrinus*, obtained by Mr. Winwood. He coincides in Mr. S. G. Perceval's opinion that the limestone is undoubtedly Upper Carboniferous Limestone, and mentions that gentleman's determination of the fossils presented to the Taunton Museum by Mr. Baker—*Lithostrotion Martini*, *L. irregulare*, *L. aranea*, *Clisiophyllum turbinarum*, *Syringopora ramulosa*. He also considers that from this identification of its age "it follows that it is totally disconnected with the Quantock series seen a few hundred yards off." In this unqualified opinion we cannot agree, as it is by no means certain that the adjacent Palæozoic inliers belong to the Quantock series.

Mr. Tawney noticed the anticlinal structure we have described, and says, "The fault spoken of by Sir H. De la Beche must certainly exist."

DISCUSSION.

Prof. SEELEY said he had examined the district some years since, rather carefully, and wished to ask Mr. Ussher a few questions. He himself thought he had made out the sequence and mineral structure of the beds, as he did not think the distinctions already established could be always identified; he also demurred to the faults mentioned by the authors. Fossils are rare in many parts of the series. He wished therefore to know on what authority the authors had made their divisions.

Mr. WINWOOD said he knew the country, and had found many fossils in places where Prof. Seeley said he had not found them. He described various localities and the results of his examination.

Mr. USSHER stated that he had traced the subdivisions, both by feature and by lithological character, over an area exceeding 300 square miles, and that the faults were well founded.