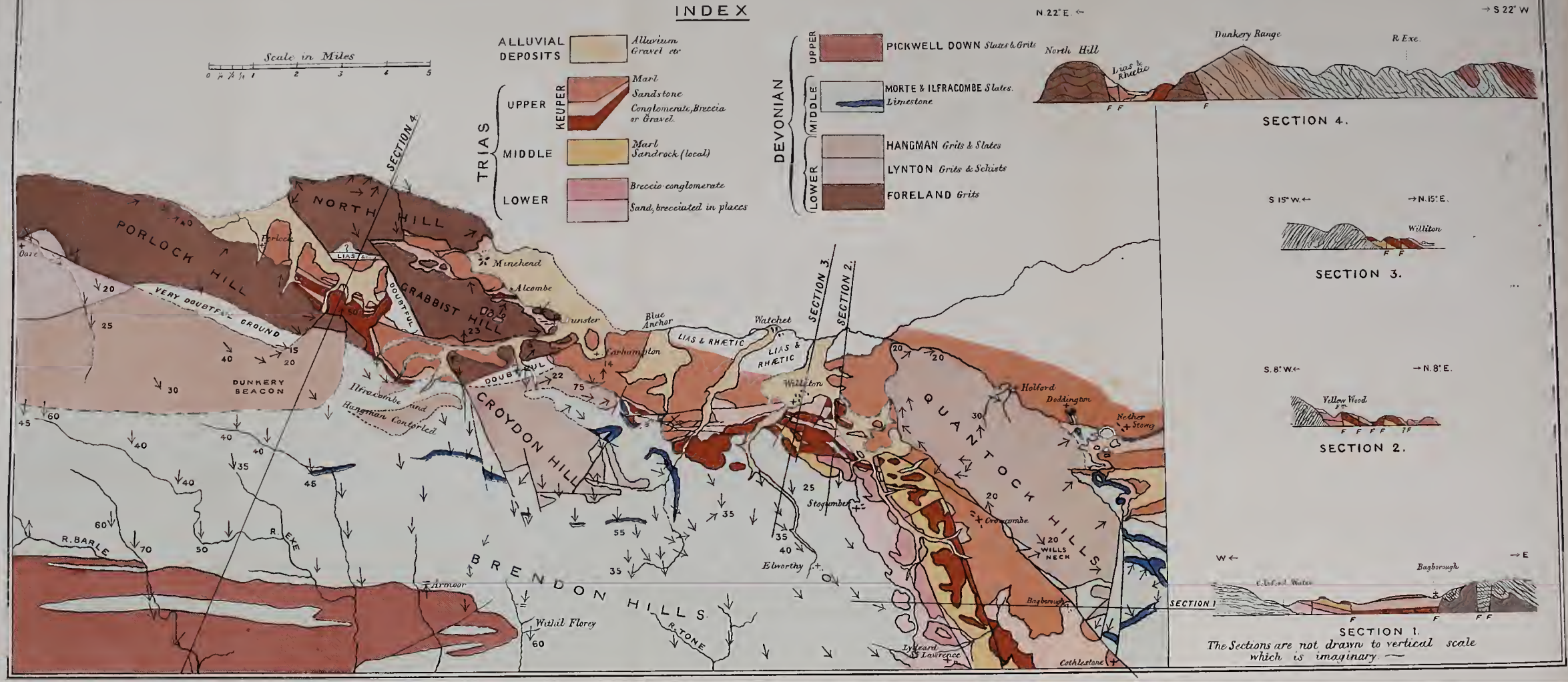
GEOLOGICAL MAP OF WEST SOMERSET,

SHEWING THE RELATIONS OF THE TRIASSIC AND DEVONIAN ROCKS,

BY W. A. E. USSHER.



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The Triassic Rocks of West Somerset and the Devonian Rocks on their borders.

(By permission of the Director General of the Geological Survey.)

BY W. A. E. USSHER.

PREFACE.

IN April, 1875,[1] I first published an account of the "Subdivisions of the Triassic Rocks between the Coast of West Somerset and the South Coast of Devon;" and subsequently, in 1876, communicated to the Geological Society of London a fuller account,[2] in which a section of the beds between the Quantock and Brendon Hills was correctly given, but reference is made to the occurrence of the lowest division of the Trias in the neighbourhood of Washford, Dunster, Minehead, and Selworthy, and also to the presence of Lower Marls (Middle Trias) in these districts. This northerly extension of the Lower and Middle Trias beds was inferred from an examination of the Triassic area around Williton, and thence to Minehead and Porlock, made by Mr. H. B. Woodward and myself, in 1874. Our identifications of Sandstones and Breccias

[1] *Geol. Mag.*, Dec. 2nd, vol. xi, no. 4.
[2] *Quart. Journ. Geol. Soc.*, vol. xxxii, p. 386, and p. 378, 379.

in that area as Lower Trias, and consequent belief in the occurrence of Middle Trias Marls in it also, was based on lithological resemblance amounting to identity of character, and we considered this sufficiently strong to warrant the inference that a Fault intersected the Marl districts between Williton and Minehead, cutting out the Lower Keuper Sandstone and its basal Conglomerate, and throwing Keuper against Middle Trias Marls: of this Fault we could obtain no further proof, and as we were unacquainted with the Devonian rocks, our brief inspection left the matter in complete uncertainty.

In 1877,[3] I stated that west of Williton the "presence" of the Lower Marls "or representation by equivalent deposition cannot be proved."

In a paper "On the Chronological Value of the Triassic Strata of the South-Western Counties," communicated to the Geological Society in 1878,[4] I mentioned, "Between Watchet, Williton, and Porlock, the probability of large Faults bringing together the Upper and Lower Marls;" but, further on in the same paragraph, the uncertainty I felt is shown by the following reservation — "the occurrence of beds bearing strong lithological affinities to the Lowest Triassic division at Minehead, and in the valleys between Dunster and Porlock, notably at Luckham; rendering the identification of beds subjacent to the Conglomerate division very uncertain, and affording strong probability that the Keuper is alone represented, this area having been dry land during the deposition of the lower beds; and owing to local causes the basement beds of the Keuper in this locality betray a strong similarity to the basement Breccias (presumably of Bunter age)." In 1879, having through the kind permission of my late chief, Sir Andrew Ramsay, had opportunities of studying the Devonian rocks of North Devon, I returned to West Somerset

[3] *Trans. Dev. Assoc.*, 1877: "A Classification of the Triassic Rocks, etc."

[4] *Quart. Journ. Geol. Soc.* for August, 1878, p. 460; paragraph *(d)* under Fourth proposition.

and made a careful survey of the Devonian rocks, as well as the Trias from Porlock to the Quantocks. The results of this survey are very briefly set forth in this paper, which therefore forms a necessary sequel to my previous papers on the Trias of the South-western Counties.

In 1874, "the strong probability" above quoted was not entertained; a wider acquaintance with the Devonshire Trias suggested it, and the survey of 1879 confirmed it.

INTRODUCTION.

The area of which this paper treats is included in sheet 20 of the Ordnance Map; it is bounded on the north by the Bristol Channel and the Liassic strata of Watchet and Blue Anchor; on the west and south by the margin of the map, and on the east by the Triassic districts of Bridgewater. Within these limits attention is confined to the Triassic and Devonian rocks. Part I being devoted to a consideration of the relations of the former; Part II furnishing a brief description of the latter; as it was only by a survey of the Devonian rocks on their borders that it was possible to account satisfactorily for the obscure relations of the Triassic beds, more especially in the areas west of Williton.

The strata mentioned are given in descending sequence in the following table:—

- TRIAS ...
  - Keuper, or Upper Trias,
    - Upper—Marls; marginal Sands and Breccias.
    - Lower
      - Sandstones, local intercalation with Marl at base.
      - Conglomerate, Breccia, Gravel.
  - Middle Trias,
    - Marls.
    - Sandstone (local) at base.
  - Lower Trias,
    - Breccio-conglomerate and Breccia.
    - Sand, more or less brecciated in places.

- DEVONIAN,
  - UPPER ... Pickwell Down Beds: Purple Slates.
  - MIDDLE ...
    - Morthoe type: Pale greenish Slates, with quartz, unfossiliferous.
    - Ilfracombe type: Grey Slates, with Limestone (local) and Grit beds near the base.
  - LOWER ...
    - Hangman Grits: Grits and Slates.
    - Lynton Beds: Even Grits and uneven, partly calcareous, Slates.
    - Foreland Grits: Quartzose Grits, with occasional slaty intercalations.

PART I.

THE TRIASSIC ROCKS OF WEST SOMERSET.

In no part of the West Somerset area do the subdivisions of the Trias display an unbroken sequence; they are constantly disturbed by Faults. The principal Faults exhibit a rough parallelism to the old coast line formed by the steep slopes of the Devonian highlands of the Brendon Hills and the Exmoor range. In addition to structural difficulty, we have also to encounter in this area many obstacles of a purely lithological nature, due to the variability of the Devonian rocks from which the strata were derived, and to the narrow channels in which the accumulating sediments were pent up. Thus we have in the districts west of Williton, Keuper beds, thrown down under analogous conditions to those under which the Lower Trias Breccias and Sands of the Tiverton valley and its vicinity were formed; and as a consequence the base of the Keuper frequently consists of rubbly Breccia and Gravel, associated with Sand, identical in character with some local typical varieties of Lower Trias Breccias. Between the Quantocks and Brendons the basement beds of the Keuper

are often represented by an incoherent grit Gravel, resembling the Lower Trias of the Tiverton outliers.

Adequately to describe the district under consideration would be impossible in the necessarily circumscribed limits of a paper. I purpose, therefore, to treat the three main divisions of the Trias—viz., Lower (Breccia and Sand), Middle (Marls), Upper or Keuper (Gravels, Breccias and Conglomerate, Sand, Sandstone and Marls)—and the areas they occupy, seriatim.

The Lower Trias.

This division consists of Breccia and Breccio-conglomerate, Sand and brecciated Sand and Loam. The coarser beds occur at the top of the series, but they are frequently interstratified with beds of Sand; and the Sands, especially at and near their junctions with the Older rocks, are constantly brecciated.

From Lydeard St. Lawrence to Lower Vexford the Lower Trias beds are Faulted against the Middle Trias Marls, and against the passage beds forming the base of that series; the absence of the coarser beds, constituting the upper part of the Lower Trias, at Lydeard St. Lawrence and on the north of Westowe, is due to this Fault.

The upper beds of the Lower Trias are well exposed in the railway cuttings at Stogumber station, and north and east of it; they consist of red-brown rubbly Breccia, containing angular and sub-angular fragments of Middle Devonian Grit, Slate, and Quartz, and occasional Quartz pebbles in a matrix of loamy Sand, irregularly consolidated, and containing impersistent beds of Sandstone. Near Stogumber station the Breccia seems to give place to irregular beds of Sand and sandy Loam.

At Chiddencombe Farm a small patch of Lower Trias is visible; it is cut off by Fault on the south, against Middle Trias Marls. A short distance south of Higher Vellow, north

of Stogumber, the upper beds of the Lower Trias, consisting of brecciated Sands, hard Breccia, and well worn Gravel and Conglomerate beds, conformably overlap the lower and more sandy portion, and rest directly upon the Older rocks; but they soon pass under Middle Trias Marls, and are cut off on the north by Fault against Keuper Conglomerates and Sandstones. This Fault, which runs from Newton Farm, through Vellow, bounds the most northerly exposure of Lower Trias beds in the South-western Counties. A small patch of Sand and Gravel in the Middle Devonian area at Elworthy suggests the former extension of the Lower Trias from Tolland in that direction; but there is otherwise no reason to conclude that the Lower Trias beds of this area extended very much further upon the Devonian area than their present limits.

The Middle Trias.

As in the districts to the south, the Middle Trias consists of Red Marls, exhibiting here and there a downward passage into the underlying series.

Near Lydeard St. Lawrence, beds of Sandstone, probably intercalated with Clay, occur at the base of the Middle Trias, and are cut off against the Lower Trias by Fault. From Lower Vexford to Newton Farm, Sandstones form the base of the Middle Trias; they are probably representative of the passage series of Sandstones and Marls developed at Polehill and near Thorn St. Margarets, in the map to the south (sheet 21). At Yard Farm the passage beds at the base of the Marls seem to consist of Sandstone and brecciated Clay.

The Middle Trias Marls form the central portion of the Triassic valley, extending from Coombe Wood, near Lydeard St. Lawrence, northward, to the southern end of the village of Bicknoller, where they are cut off against Keuper Marls on the north; their mass being terminated in an apex made by the junction of two Faults. In the district between Coombe Wood and Heddon Oak they pass under Lower Keuper Con-

glomerate and Gravel; but from Heddon Oak northward, the Lower Keuper Gravels form outlying patches, and are faulted against Keuper Marls on the north and north-east, and at Newton Farm they are cut off on the west, against Lower Keuper Sandstone and Conglomerate, by a dislocation, terminating or shifting the Vellow Fault before alluded to. Following the Vellow Fault westward from Newton Farm, we find a patch of Middle Trias Marls upon Higher Vellow Hill, resting on Lower Trias, which is cut off against Lower Keuper. At Vellow the Middle Trias is cut out by the Fault, but it reappears where the Fault crosses the lane to Monksilver, and extends along the margin of the Older rocks toward Escott, where it rests on the Lower Trias. This patch of Middle Trias continues along the margin of the older rocks to a point rather more than a mile west of Vellow, where a cross Fault brings on Keuper basement beds upon the Older rock and at Aller Farm; but Middle Trias Marls form the valley cut through the Lower Keuper, and extend to Orchard Wyndham, on the east of which place they are again faulted; they finally disappear beneath the Alluvium of the Higher Stream and Orchard Wyndham Valley; and on crossing the Alluvial tract we find Keuper Gravels resting directly on the Older rocks, and no further evidence of Middle Trias to the westward.

Middle and Lower Trias.—The above is a brief general description of the superficial extension of the Lower and Middle Trias beds; and although I had, when working out the area, more than once despaired of obtaining a solution, I have no hesitation in regarding it as strictly correct. How far these beds may have extended into the Bristol Channel area is a mere matter of speculation; it is not unlikely that the Dolomitic Conglomerate and Marl of South Wales would occupy much of the interval; and even if Infra-Keuper beds were thrown down in the intervening area, it is most improbable that there ever was a transport way in that direction

for the materials in the coarser Triassic beds of South Devon, as these materials in the Keuper and Lower Trias of the Stogumber area are of entirely local derivation.

In a paper entitled "Notes upon the Physical Structure of the Watchett Area, and the Relation of the Secondary Rocks to the Devonian Series of West Somerset," read before the Cottswold Naturalists' Field Club, in 1873, by Mr. Etheridge, it is stated that Bunter occurs, and that the Stogumber "valley is deeply paved with the Dolomitic (Tipnoller) Conglomerate." As the relations of the Triassic subdivisions were then unknown, and the chief object of the paper was to describe the Lias and Rhætic beds of the area, it is unnecessary to allude to it further in this place.

Upper Trias or Keuper.

The Keuper beds of the West Somerset area present the usual sequence, viz., Marls on Sandstones, succeeded by Conglomerates or Gravels; but owing to the proximity of the shore lines, and the narrow channels in which the waters of the period were confined, we find the Lower Keuper Sandstone decreasing in thickness, whilst the basal coarser beds are more largely developed and more varied than is the case in the districts to the south.

Basement Beds.—The basement beds of the Keuper consist of massive Conglomerates, loose earthy Gravels, Breccia, and brecciated Sand and Loam. We find the Conglomerate in the south part of the Map, near Coombe Wood; at Vellow; Tor Weston Hill; and in masses in the less indurated and non-calcareous materials in the cuttings at Newton Farm, and at Minehead. At Capton, Orchard Wyndham, and Aller Farm, the basement beds of the Keuper consist of rubbly brecciated Sandstone and loamy Sand, fine Conglomerate, and irregular masses of coarse Conglomerate.

The most prevalent type is Gravel or Breccia of local materials, usually very rubbly, and not unfrequently earthy.

The massive Conglomerate of the Thorn St. Margarets type, when traced northward, passes horizontally into rubbly Gravel near Nethercot and Cooksley Farm, the change first affecting the base. These Gravels, generally consisting of fragments of Devonian grits, more or less worn, are very similar to some Lower Trias Gravels in the Tiverton district. They occur on the Middle Trias Marl, capping the highest ground in the district occupied by that formation, and making distinct escarpment features south-east of Heddon Oak, and east of Vexford and Rexon. These Keuper Gravels are often so loose and earthy that they resemble superficial deposits.

About Beggearn Huish and Higher Stream the basement Keuper beds consist of rubbly Gravel of Middle Devonian fragments, often very little worn; but, toward their junction with the overlying Sandstones, they contain beds of Breccia and brecciated Sandstone. Between Beggearn Huish and Minehead the coarser beds of the Keuper are only exposed in places on the margin of the Devonian rocks, and they appear to occupy a much higher horizon in the Lower Keuper than the basement beds of that division to the south of Williton, as the overlying Sandstones are much attenuated.

At Sandhill Farm a marginal strip of Conglomerate rests on the Older rocks. At Alcombe a calcareous Conglomerate (Dolomitic) underlies the Sandstone, and at Minehead Sandstones occur at the eastern end of North Hill, on and in Breccia, with a small mass of Conglomerate.

In the Porlock Valley, between Wotton Courtney and Horner, the marginal deposits consist of brecciated Sand and Breccia; containing beds of Sand and Sandstone, and overlain by Sandstones, containing beds of Breccia. At Luckham the Breccia has been worked for Hæmatite in the hill on the east of the village. In the Breccia between Luckham and Horner there is a bed of well worn pebbles of Devonian grit.

Keuper Sandstones.—The Keuper Sandstones of Bishop's Lydeard, in sheet 21, are very calcareous, and they maintain

this character in the south part of sheet 20; the beds often merit the designation of Marlstone, and are of a grey color, somewhat similar to the Marlstones of Lestre, described in my paper on the Triassic rocks of Normandy (*Q.J.G.S.* for May, 1879, p. 250). At Bagborough, near Shopnoller, and between Riches Holford and Cooksley Farm, these calcareous beds are burnt for lime. This exceptional character displayed by the Keuper Sandstones led my colleague, Mr. J. H. Blake, who surveyed the Lias of Watchet (when I was beginning my survey of the Triassic rocks at Wellington, in sheet 21), to infer that he had found in them the representative of the Muschelkalk.

On the south of Washford and Williton the Sandstones are often calcareous, and also near Crowcombe Heathfield; but in a much lesser degree than in the district between Riches Holford and Cothelstone; and in the last named district the calcareous beds do not extend to the top and base of the subdivision, being rather of the nature of an irregular lenticular mass in it.

Between Williton and Sampford Brett a Conglomeratic bed occurs in the Sandstones; they exhibit false bedding in places, and buff mottling, as also at Minehead. A Waterstone series, consisting of red sandy Marl and Loam, with thin, even beds of Sandstone, separates the Sandstones from the underlying Conglomerate at Sampford Brett. This local Waterstone parting is also noticeable on the same horizon at Fitzhead and near Milverton, in sheet 21. It does not appear to be continuous between these places, or to extend to the westward.

Between Dunster and Alcombe the Keuper Sandstones form a marginal deposit, and are brecciated in places.

Upper Keuper.—The Keuper Marls in the area do not call for any special mention.

Relations of Keuper Subdivisions.

The Keuper Sandstones attain their greatest superficial

breadth between Cothelstone and Riches Holford. They are Faulted against the Middle Devonian rocks of the Quantocks at Bagborough, being overlain by patches of Keuper Marl, also cut off by the Fault, at Cothelstone and at East Bagborough. From Bagborough the Keuper Marls extend northward, at the foot of the Quantocks, continuously to the coast. A Fault running northward from Coombe Wood by Cooksley Farm, Heathfield, and Lawford to Thorncombe and Ford Farm, near Bicknoller, cuts out the Keuper Sandstone near Riches Holford, throwing Keuper Marl against Keuper basement Gravels, nearly as far as Robbuck Farm, where Sandstones reappear, dipping under the Keuper Marls of Crowcombe. From the north part of Lawford, to Ford Farm, the Lower Keuper Sandstones and the coarser beds at their base are cut out by the Fault which separates Middle Trias Marls with Lower Keuper Gravel outliers from the Keuper Marls. At Lower Halfway and Thorncombe, the area occupied by the Keuper Marls between the Fault and the Quantocks is very narrow. The Lower Keuper beds are again visible at Newton Farm, Woolston Moor, and Tor Weston Farm, whence they extend westward, by Williton, to the Washford Valley. In this area they are partly bounded on the south by the Vellow Fault, and cut out and repeated by lesser Faults, too numerous to particularize. West of the Washford Valley, between Dragon and Goldsoncot, there are numerous patches of Sandstone, exhibiting faulted relations. In one spot, about twenty feet of whitish Sandstones (resembling a Freestone) are exposed in a quarry; the basement Breccias are apparently conformably overlapped on the margin of the Older rocks. A marginal belt of Conglomerate occurs at Sandhill Farm, overlain by a thin strip of Sandstones, which are continuous along the older rock margin to Withycombe.

From Withycombe to Dunster, marginal Sandstones are only visible in one place, in Dunster Park; the Keuper Marls elsewhere extending up to the Older rocks.

From Dunster to Alcombe, marginal Sandstones, Breccia, and Conglomerate form a narrow fringe to the Older rock margin, and, as before mentioned, they also occur at Minehead.

The Minehead Breccia and Sandstone appear to be simply a marginal fringe, as between Alcombe and Dunster.

The narrow valley between Dunster and Timberscombe connects the Trias of the main area with that of the Porlock Valley. West of Minehead the deposits were also, no doubt, continuous in late Keuper times; but it is not improbable that an earlier channel of communication existed on the north side of North Hill.

Sandstones and Sands underlie the Marls near Bratton and Perryton, and extend in a narrow tongue by Hinon, toward Selworthy. A strip of Sandstone occurs at Wydon, Faulted against Marls on the south.

Between Venniford and Brandy Street, Lias and Rhætic beds occur on the South of Selworthy, at a lesser elevation than the tongue of Trias Sand near Hinon; the relative levels have no doubt been determined by a Fault running between East Lynch Farm and Little Heydon, by Heydon Down to Slatcombe, near Wotton Courtney. In the valley between Dunster and Timberscombe, Marl is evidenced near Avil, and sandy brecciated marginal deposits at Totterdown and Kitswall Farms. From Timberscombe to Brockwell, Sandstones and Sands, more or less brecciated, form a marginal band, developing into the Breccias of Huntsgate, Old Ball, and Luckham; these Breccias almost entirely represent the coarser beds of the Trias, the Sandstones being confined to beds interstratified with them, and to a thin band containing Breccia, which separates them from the overlying Marls near Knoll Farms and Luckham.

At Doverhay and Porlock, marginal patches of Sandstone occur.

The Porlock Valley is also much affected by Faults, and an extensive flat of alluvial Gravel between Heydon Down and

Porlock Quay conceals the Keuper, which, from its exposure on the borders of the alluvial tract, appears to consist of Marl.

Some tiny outliers of Keuper Sand and Loam occur in the valleys south of Alcombe; but there is nothing to lead one to suppose that the Triassic beds of the Porlock Valley were of any considerable thickness; nor is there anything to show that the lower beds may not be of later date than the normal Lower Keuper Sandstones; the probability being that the coarser beds of the Keuper ran higher and higher in the series, from Williton westward, as progressive subsidence led to the continuation of marginal deposition.

OUTLIERS.

The Devonian areas have been searched with sufficient minuteness to ascertain the absence within their limits of Secondary rock outliers, except in the vicinity of the Triassic boundary, and in old valleys.

In the vicinity of the Trias the following outliers occur:—Keuper Gravel on the east side of Lodhuish, north of Nettlecombe: two patches of Lower Trias Sand between Whitemoor Farm and Plash, separated from the main mass by the erosion of the small stream valley of Coleford Water: two tiny patches of Keuper Sand and Gravel near Holford, on the border of the Quantocks.

The outliers in old valleys are:—Four small patches of Keuper Sand and Gravel, south of Alcombe, on the northern slopes of Grabbist Hill; a small patch of Lower Trias Sand on the south of Elworthy, at about a mile from the nearest part of the main mass.

Although the presence of Lias on the south of Selworthy, and that not of a marginal character, proves that a very considerable thickness of Secondary rocks has been denuded from the flanks of the Devonian highlands, and renders it probable that the connecting ridge of Little Heydon, between

North Hill and Grabbist Hill, was at one time buried beneath Liassic and perhaps Keuper beds; still there is nothing to warrant the belief that Secondary sediments were thrown down over the higher Devonian hills, or that they encroached far beyond their present limits, except up creeks and other indentations of the old coast line, from which they would the more readily be swept away in the ordinary processes of drainage.

Mr. Etheridge, in the paper before referred to (Cotteswold Naturalists' Field Club, in 1873), alludes to the "probable island-like condition of the Exmoor and Quantock Hills at the time of the deposition of the New Red and Lias series;" and to the absence of proof "that the Lias ever covered these elevated ranges." The statement that New Red rocks occur nowhere west of Porlock is evidently due to an oversight, as two patches shown on the old Geological Survey Map, sheet 26, occur at Portledge Mouth and Peppercombe, between Bideford and Clovelly.

PART II.

DEVONIAN ROCKS OF WEST SOMERSET ON THE BORDERS OF THE TRIAS.

Introductory.

The Devonian rocks of West Somerset belong to the North Devon type of that formation, of which they form the easterly prolongation. As is natural in tracing great divisions of rock formations along their strike, we find modifications in their character, due to local causes, either dependent on the geography of the period, or on chemical or mechanical agencies which may locally have prevailed with more or less intensity. These modifications, however, are of very little moment, never

leading to the obliteration of those characteristics by which the main divisions of the Devonian system in North Devon are severally recognizeable.

The Devonian rocks of this northern area are separated from those of South Devon by a great expanse of Culm measures, or by the Carbonaceous system, as it was called by the old writers.

The general structure of the Older rocks of Devon and Somerset is, therefore, a great trough or basin, the Devonian formation emerging from beneath the newer Culm rocks on the north and south, and being continuous beneath them. Notwithstanding this continuity, the types of the Devonian system in the northern and southern region are quite distinct, although there are, of course some points of similarity.

Again, when we extend the comparison to the Continent of Europe, we find in South Devon a much greater similarity to the Devonian rocks of the Ardennes and of Germany than is displayed by North Devon and West Somerset. This similarity amounts in places to identity of lithological character, and shows the occurrence of corresponding Faunas marking certain horizons. The northern area, on the contrary, though exhibiting lithological and palæontological affinities to the Devonian rocks of France and Germany, would appear in a sense to bear relations to them somewhat akin to those presented by the Devonian rocks of Livland, Kurland, Novgorod, and Petersburg, to those of Petschoraland and the Urals.[5] That is to say, we have a much greater development of Sandstones in the West Somerset and North Devon region, both in the higher and lower beds, than in South Devon or in Germany; but in this respect our district furnishes analogy to parts of the French and Belgian area.

The Middle Devonian of France and Germany is char-

[5] See *Materialien zur Kentniss der Devonischen Ablagerungen in Russland*, by Th. Tschernyschew, Mem. du. Comité Geologique, St. Petersburg, vol. i, no. 3, p. 81.

acterised by a thick bed of Limestone, which is locally well represented in South Devon, in the Torquay, Brixham, and Plymouth districts, but which is feebly and impersistently indicated in North Devon, and also in the Brendon range, as at Treborough, Roadwater, Cutcombe, etc.; its best representation in the northern area being on the Quantocks, near Holwell and Asholt, where the Limestones resemble types of South Devon Middle Devonian Limestone, and, even taking exaggeration in thickness by contortion and overfolding into account, they make a very respectable show for this region. The Upper Devonian Limestones and characteristic Fauna of the Frasnian are conspicuous in our northern district by their absence; so that we have really no actually defined boundary between the Upper and Middle Devonian, except that marked by lithological change, which may well have occurred at a different stage in the accumulation of the beds from that which is elsewhere marked by a distinction in the Fauna, not always accompanied by a corresponding change in the character of the sediments.

Last October I had the advantage of paying a flying visit both to North and South Devon, in company with several eminent foreign geologists, who had made the Devonian rocks of the Continent their especial study. Seeing this formation in our northern and southern districts for the first time under my auspices, they pointed out any striking resemblences either in lithological character or fossil horizons which the rocks presented to those in the countries with which they were acquainted. Professor Gosselet, of Lille, rendered me valuable assistance in the suggestion of explanations to account for the absence of correlative horizons, and in kindly identifying some specimens sent to him from South Devon. Professor Kayser, of Marburg, in a paper recently published, drew a comparison between the rocks he had seen on the excursion, and the divisions of the Devonian system in Germany. Thanks to these eminent exponents of the Devonian rocks of France and

General Classification of Devonian Rocks.

	France and Belgium.	N. Devon and W. Somerset.	South Devon.	Germany.[7]	
Upper Devonian.	Fammenien ... ... (Slates and Psammites)	Pilton Beds ... Baggy Beds ...	Red & Grey Slates Slates with Calcareous Nodules and Nodular Limestone (*Clymenia*).	Fucus Sandstone ... Knollen Kalk ... Cypridinien Schiefer ... Iberger Kalk ...	*Upper.*
	Frasnian ... ... (Slates & Limestones)	Pickwell Down Grits and Slates Morte Slates.	Limestone (local) Slates & Mudstones Limestone (Chudleigh).	Adorfer Goniatite Kalk Budesheim Slate ...	
Middle Devonian.	Calcaire de Givet ...	Ilfracombe Slates, with Limestone	Limestone locally replaced by Slate & Volcanic rocks	Stringocephalen Kalk ... Nassau Schalstem	*Middle.*
Lower Devonian.	Eifelian ... ... Limestones and Slates (Calceola)	Basement part of Ilfracombe Slates.	Thin Limestones and Slates. Grey Slates ...	Calceola Kalk ... Calceola Schiefer ...	
	Grauwacke d'Hierges, etc. (*Spirifer cultrijugatus.*)	Hangman Grits ... (*Natica, Myalina*).	Cockington, Lincombe, & Warberry Grits (*Sp. cultrijugatus.*)	Ober Coblenz Stufe ...	*Lower.*
	Gedinnien (Slates, Quartzite)	Lynton Beds ... Foreland Grits.	Meadfoot Slates... ? Dartmouth Slates	Unter Coblenz Stufe ...	

[7] See Kayser, "Ueber das Devon in Devonshire und in Boulonnais;" *Neu Jahrbuch für Mineralogie, etc.*, 1889, vol. i.

Germany, and to a detailed examination of the complicated Devonian area between Totnes and Torquay, I am enabled to put forward the following general classification.[6] It will be seen that the German classification brackets Limestones and Slates with the Middle Devonian, which are in the French and Belgian area included in the Lower.

The Devonian rocks of France and Germany are characterised by groups of fossils, showing a distinct succession, and marking out divisions to which we find in South Devon very strong local resemblances; but from the distortion the fossils have undergone, the local prevalence of volcanic rocks, and the partial occurrence of characteristic fossil localities, as well as owing to an apparent interblending of typical forms, it is not possible to trace out minor horizons with absolute certainty.

The disappearance of the Middle Devonian Limestone in Cornwall, and the prevalence of slates, almost to the exclusion of the other lithological representatives of the series, renders it probable that a careful study of that county from north to south might explain to some extent the changes the divisions of West Somerset and North Devon have undergone to produce the divergence in character exhibited by them in South Devon.

In the classification it will be seen that the Morte Slates, which occupy a large area, might be included in either the Upper or Middle Devonian. This is due to the fact that these beds have yielded no fossils whatever. Their boundary with the Pickwell Down series is distinctly marked by color in West Somerset, the basement beds of the overlying series being purple Slates, lithologically identical with them: moreover, they pass quite insensibly downward into the grey Slates of the Ilfracombe series, from which they can only be distinguished by a more or less hypothetical geological boundary line. The Ilfracombe beds are often with difficulty dis-

[6] See table.

tinguishable from the underlying Hangman Grit series, into which they may be said to pass downward by intercalation with Grit beds; so that here again we have a rather indefinite boundary line.

Professor Kayser, in the paper before referred to, alludes to the exceptional character of the North Devon and West Somerset Devonian type as follows:—"The preponderance of Sand formations in the Devonian of North Devonshire shows a greater shallowness of that part of the Devonian sea, and therewith also the greater proximity of the coast. It is not also to be forgotten that the North Devon coast directly bounds the Bristol Channel, to the north of which the Devonian makes its appearance in a still more anomalous and peculiar formation, namely, as Old Red" (Sandstone).

Professor Hull (*Q.J.G.S.*, May, 1880), correlated the Red or Yellow Sandstone and Conglomerate on the north of the Bristol Channel with the lower part of the Upper Devonian (Pickwell Down Sandstones), and considered the Sandstones and Marls with "cornstones" of that area equivalent to the Morte and Ilfracombe Slates, the Hangman Grits, and Lynton beds, and of estuarine origin, physically connected with the beds of North Devon, which were being deposited in the open sea. (*Report on Carboniferous, Devonian, and Old Red.* Internat. Geol. Congress, Table 4.)

In the classification I have given above, the Hangman Grits are bracketed with the Lower Devonian. Apart from questions of correlation with the Continent, I think this alteration is borne out by the character of the beds, their typical red speckled horizon being almost identically reproduced in part of the Lincombe and Warberry beds of the Torquay district, which are undoubtedly Lower Devonian.

In a paper "On the Geology of parts of Devon and West Somerset North of South Moulton and Dulverton," communicated to this Society, and published in the year 1879, I discussed the relations of the Upper and Middle Devonian,

and in accordance with precedent classified the Hangman Grits with the latter, an idea which recent researches in South Devon have led me to abandon, and to regard them as the Upper Division of the Lower Devonian.

I shall now proceed briefly to indicate the extension and locality of the Devonian Divisions in the area under consideration. Owing to the absence of boundary between the upper part of the great Slate series, of the Morte or Morthoe type, and the Lower, or Ilfracombe type, these must for purposes of description be included in the same series. The general relations and structure of the divisions will then be briefly treated of in the Quantock and Brendon area, with special reference to the derivation of the newer strata, and to the dislocations in the older rocks, and their effects. Finally, the relations of the Hangman and Foreland Grits will be separately treated.

Lower Devonian.

Foreland Grits.—These consist mainly of reddish, purple, and grey fine Quartzose Grits, with occasional slaty masses; they are feebly conglomeratic in places, and contain Fucoid-like markings. These beds form Oare Hill, Porlock Hill, North Hill, and Grabbist Hill, and occur at Timberscombe, and in the north part of Dunster Park. In this area, with the exception of two or three miles between Timberscombe on the east, and Brockwell on the west, they form the borders of the Porlock and Minehead Trias. Beyond these limits, with the doubtful exception of the northern termination of the Quantocks, where rocks resembling them were observed, the Foreland Grits are nowhere exposed.

Lynton Beds.—These beds consist of uneven grey Slates, with interstratified, even bedded, fine grained, grey Grits. Their presence in sheet 20 is confined to the western margin, from the northern end of Luccot Hill, where they are cut out by Fault, westward. Their relations will be discussed in the

last part of this paper. It is quite possible, bearing in mind the changes that may take place in a formation along its strike, that Lynton beds may be brought up by Faults or folds on the Quantocks, but there is no reliable proof of such being the case.

Hangman Grits.—These beds consist of coarse Quartzose Grits, fine Grits, and intercalated reddish and grey Slates and Slaty Grits. The typical coarse Quartzose, red speckled rock forms a comparatively small part of this variable series. The Hangman beds form three considerable masses. The westernmost constitutes the Dunkery range, Bendles Barrow, and Black Barrow Down; the central mass forms the high land on the west of Withycombe and Croydon Hill; the easternmost, from Bagborough northward, is the nucleus and back bone of the Quantocks. The greatest elevations in West Somerset, Dunkery Beacon and Wills Neck, are composed of Hangman beds.

The Lower Devonian in the area under consideration occupies a superficies of about 60 square miles, of which the Hangman alone covers 40, and the Lynton beds only three.

Morte and Ilfracombe Slates.

These Slates occupy an area of about 90 square miles in sheet 20. There is even less distinction between the upper and lower portions than in the typical districts from which their names are derived. The upper part is less evenly fissile than in North Devon, and does not maintain so uniformly its pale green-grey tint. The lower beds are distinguished, as a whole, by the presence of Grits and masses of Limestone, and by greater variety of color and texture. The distinction between the types is, broadly speaking, about the latitude of the following places from west to east—Exford, Lype Hill, Hazery, and Elworthy. The Hæmatite of Eyeson Hill and the Brendon Mines occurs in the upper part of this great Slate series. In the lower part, Limestone bands, impersistent, and

of no great thickness, are met with in the vicinity of Cutcombe, Couple Cross, Luxborough, and Treborough. On the east of Croydon Hill, at Rodhuish, Escot Farm, Goldsoncot, and Higher Roadwater, they exhibit some local development, but only form an important factor in the series on the Quantocks, from Buncombe Hill, northward, to Doddington.

Traces of the so-called 'Bittadon Felsite' occur in the Middle Devonian Slate series at Armoor, south of Lype Hill, and at Farmers, near Withil Florey, apparently at or near the same horizon as at Bittadon.

Pickwell Down Beds.

The red Slates and red and grey Grits of this series are confined to the south-western margin of sheet 20, from Blagdon Hill westward, over an area of 12 or 13 square miles, in which they are thrown into long inverted synclinal folds, marked by considerable inlying strips of the subjacent Morte Slates.

THE QUANTOCKS.

Chocolate, lilac, and grey grits, interstratified with slates in places, form the more elevated northern part of this range. These beds belong to the Hangman Grit series, which extends southward to Bagborough and Cockercombe. At their southern extremity inliers of the Hangman series occur in the Middle Devonian Slates, near Bagborough, their relations being complicated by Faults.

The Middle Devonian Slates and their associated Limestones extend eastward from a Fault junction with the Hangman series running from near East Bagborough to Cockercombe. From Cockercombe to Doddington Middle Devonian Slates form the flank of the Quantocks, being faulted against the Hangman series near Adscombe, where Trap Ash occurs at the junction. The Middle Devonian beds (Ilfracombe

series) also occur in Faulted patches on the western margin of the Quantocks, nearly as far north as Crowcombe. The Limestones of this series are conspicuous about Great Holwell and Asholt, also further north, between Plainsfield and Over Stowey, near Walford's Gibbet, and at Doddington. Thin beds of Limestone and calcareous Slate also occur in Cothelstone Park, on Buncombe Hill, and on the north of Lydeard Cross. The distribution of the Limestones shows to what an amount of disturbance the strata have been subjected by contortion and dislocation. Although there are several irregular masses and bands north of Buncombe Hill, it is quite possible that these may be repetitions of the same horizon by Faults and folds, and that the irregularities in its thickness may not be altogether due to lenticular occurrence, but in some cases be occasioned by contortion or overfolding.

The association of Grits, and their local prevalence in the lower part of the Ilfracombe Slate series of the Quantocks is worthy of note, as we find many of the Devonian inliers in the Triassic area east of the Quantocks composed of fine red micaceous Grits and sandy mudstones, which may represent the shoreward prolongation of this division.

Derivation of Trias from Devonian Rocks.

As the Older rocks of the Brendon Hills, Nettlecombe, Monksilver, and Elworthy, etc., consist of Middle Devonian Slates, bounding the Trias from Lydeard St. Lawrence, by Stogumber, to Withycombe; and as the associated Limestones are confined to the vicinity of the Hangman beds of Croydon Hill, it is safe to infer that the Triassic valley between Williton and Lydeard St. Lawrence was eroded in the lower Slates and gritty beds, with associated Limestones of the Middle Devonian. Derivation from these and from the Grits of the Hangman series on their eastern border would account for the variability of the Triassic subdivisons. Take for instance the Keuper Conglomerate with Limestone pebbles passing into a

Conglomerate and Breccia of Grit fragments, and these into an incoherent rubbly Gravel.

THE BRENDON AND DUNKERY RANGES.

The Limestones of Goldsoncot and Rodhuish resemble those of Asholt in their irregular mode of occurrence, showing Faults and flexures. The flexures of the Limestone are well shown on a small scale in a quarry near Escott Farm, where the rock is in one part surmounted by Keuper Breccia.

The relations of the Middle Devonian and Hangman beds of Croydon Hill are much complicated by Faults. The most important of these cuts off the Hangman beds between Luxborough and Timberscombe, and crossing the valley near Wotton Courtney, follows the trend of the crest of Heydon Down, cutting off the Liassic patch of Selworthy on the west, and the Hinon Triassic band on the east. This Fault I will call the Luxborough and Timberscombe Fault, as I shall have occasion to refer to it. The Hangman beds of Croydon Hill are faulted against Foreland Grits on the north; the exact position of the Fault is not definable, but the uncertainty is confined to comparatively narrow limits, as the characteristic features of the Foreland Grits are well shown near Bonniton, and the beds are exposed in Dunster Park and near Timberscombe. This Fault is shifted northward by the Timberscombe and Luxborough dislocation (concealed by Triassic beds not affected by it) to somewhere near Wotton Courtney, whence it runs to Brockwell. From Brockwell westward to Luccot Hill, the position of the Fault is very uncertain, and it is probably shifted by cross dislocations. From Luccot Hill, westward, the intervention of the Lynton beds between the two great Grit divisions renders the position of the Fault certain.

The Hangman Grits of the Dunkery range pass regularly

beneath Middle Devonian Slates on the south; but they are probably cut off by Fault on the east of Luckham Barrows, against faulted and folded passage beds, partly Hangman, partly Middle Devonian basement beds, which extend to the borders of the Trias on the north of Cutcombe and Stowey Ball. The contortions of the strata in the last named district made it impossible in the limited time at my disposal adequately to represent their mode of occurrence on the one inch scale. Some idea of the nature of these contortions may be gleaned from the curve at Oaktrow, figured in a joint paper "On the Palæozoic Districts of West Somerset," by the late Mr. Champernowne and myself (*Q.J.G.S.* for August, 1879, p. 537). A more detailed examination, subsequent to the traverses described in this paper, gave me the satisfaction of verifying the conclusions expressed in it in every respect; which is the more gratifying, as it entitles the name of my lamented friend to a place among the exponents of Somersetshire Geology in that formation with which his long and successful labours in South Devon will ever be associated.

Derivation of Trias from Devonian Rocks.

The chocolate-brown, grey, and lilac beds of the Foreland division, and the Grits and Slates of the Hangman and Middle Devonian series, between Brockwell and Timberscombe amply account for the sources of supply from which the Keuper Gravel and Breccia of Luckham, Old Ball, and Higher and Lower Knoll Farms were derived.

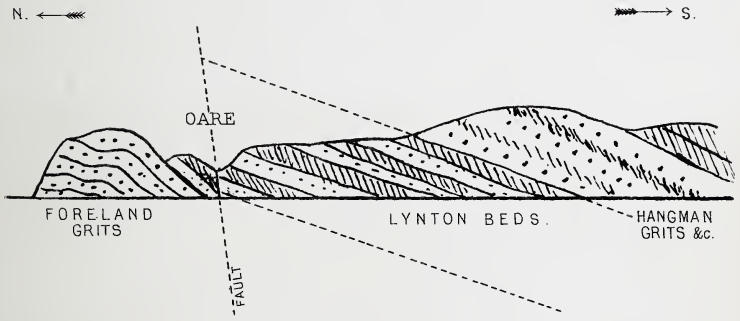
FAULTS AND EARTH MOVEMENTS.

Faults are more easily detected in the Triassic rocks than in the Devonian area; the comparatively thin divisions of the former, and their distinctive characters, which by careful study can be followed through all their lithological variations, often render Faults of slight magnitude recognizable, whereas the

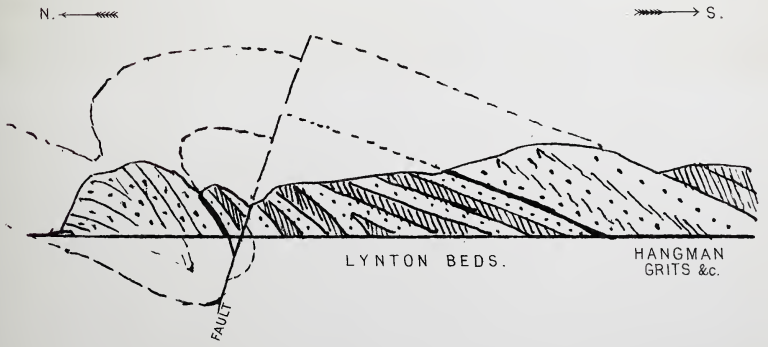
DIAGRAMMATIC SECTIONS

Showing alternative explanations of the relations of the LOWER DEVONIAN at OARE.

SECTION. 1.



SECTION. 2.



J. Akerman, Photo-lith. London.

absence of persistent horizons in the vastly thicker divisions of the Devonian might frequently cause Faults of considerable magnitude, but only affecting individual divisions, to be overlooked.

Where seen in section; justified by the behaviour or character of beds visible in contiguous exposures; or affecting the relations of beds of different character, as those of the Middle and Lower Devonian, or the Limestones associated with the former, it is possible to detect Fault boundaries with more or less certainty. On the other hand, when divisions—as in the case of the Foreland and Hangman Grits—of similar general character, and containing varieties of rock common to both, are brought in contact, it is very difficult to find the actual line of junction. This difficulty is shown on the map by the spaces left uncolored near Wilmotsham, Cloutsham, Stoke Pero, and in Dunster Park.

The principal Faults throughout the area approximate more or less nearly to the direction of the axes of elevation, and we may therefore reasonably infer that they were due to the unequal strain experienced by the strata in yielding to the successive earth movements to which for long ages this area was subjected. The earliest of these movements appears to be that to which the synclinal structure of the Palæozoic rocks of West Somerset and Devon is due, and by it the general east and west strike and southerly dip was imparted to the Devonian strata of Exmoor. Subsequently, movements of contraction obliquely across the former, in directions north, north-west, to south, south-east, seem to have taken place, and to them I would refer the trend of Croydon Hill and Heydon Down, and of the Quantocks. Still later, a further elevation of the high lands, apparently more or less irregular, partly approximating to the direction of the earlier, partly to that of the later movements, effected numerous displacements in the Secondary strata, and caused them to dip more or less steeply off the borders of the Older rocks.

From the foregoing it is manifest that we should expect to find dislocations of different ages, corresponding to the movements above described. To attempt to classify or instance at length the numerous Faults known to occur in the district would be beyond the scope of this paper, I shall therefore take two or three examples.

First. The Fault which crosses the Oare Valley, and, cutting out the Lynton beds, throws the Hangman Grits on the south against the Foreland rocks on the north. This Fault is parallel to the general strike of the Devonian rocks, and to the trend of Oare, Porlock, and Grabbist Hills. It enters the Triassic valley near Brockwell, without in any way affecting that formation, and it would normally follow the valley to Dunster, were it not stepped or shifted to the south by the Timberscombe and Luxborough Fault.

Second. The Timberscombe and Luxborough Fault follows the direction of the range of high ground cut through by the Dunster Valley near Timberscombe, forming Croydon Hill, Heydon Down, and Little Heydon. The effect of this Fault on the Triassic rocks between Timberscombe and Wotton Courtney is very slight; whilst on Little Heydon it is marked, cutting off Lias on low ground, against Foreland Grits, near Venniford, and forming the western boundary of a tongue of Triassic Sand on much higher ground near Hinon. The downthrow of this Fault, to the west, must be very considerable, as Foreland Grits are separated from Middle Devonian Slates at Timberscombe; yet, in the vicinity of this spot it traverses the Keuper Marls of the Wotton Courtney valley without affecting their continuity. At Little Heydon, on the contrary, where the Fault has no appreciable effect on the Foreland Grits, its effect on the Secondary rocks is striking.

From the foregoing facts I infer that the major Faults were pre-Triassic, but that in post-Triassic times further displacements were in many places effected along the old lines of fracture, and numerous new lines of dislocation were formed.

The boundary between the Hangman and Ilfracombe beds of the Quantocks, and the Keuper at Bagborough and Cothelstone, is a Fault, the antiquity of which it is difficult to determine.

To render this paper as complete as I can make it, in the absence of palæontological evidence for which there are no systematic data at my disposal, the following notes are appended with reference to the relations of the Foreland Grits.

THE RELATIONS OF THE LOWER DEVONIAN DIVISIONS IN WEST SOMERSET.

There is only one exception to the clear evidence of succession afforded by the divisions of the Devonian rocks of North Devon, namely, the junction of the Lynton beds with the Foreland Grits. The appearance of opposing dips between the Morthoe Slates and overlying Pickwell Down beds, upon which the late Professor Jukes relied in his interpretation of the structure of the Palæozoic rocks of North Devon,[7] can be, as I have elsewhere shown,[8] simply explained without invoking the aid of a Fault, and when traced along their strike into West Somerset, the conformable succession of these divisions is demonstrated with absolute certainty. With the Foreland Grits, however, the case is different. Their junction with the Lynton beds in the cliffs near Countesbury is an exceedingly obscure Fault, which however can be traced with tolerable certainty across the windings of the East Lynne valley, both by feature and lithological evidence, into West Somerset, and up to the foot of Luccot Hill, where the Lynton beds are cut out by it against Foreland Grits on the north, and pass conformably under the Hangman Grits on the south. As the Lynton beds do not reappear, or are not recognizeable

[7] *Quart. Journ. Geol. Soc.*, March, 1886, p. 321.
[8] *Geol. Mag.*, Dec. 2, vol. viii, no. 10, p. 441 ; Oct., 1881.

to the east of Luccot Hill, the only evidence that we could expect to find of their normal relations to the Foreland Grits would be through the discovery of their lower beds on the north side of the dislocation, or of the upper beds of the Foreland group on the south of it.

The late Mr. Champernowne visited the district with me in 1878,[9] when we were so fortunate as to discover a patch of Lynton beds on the north side of the Fault near Oare, exhibiting by dips clear indications of conformable superposition on the Foreland Grits. In the same neighbourhood, further west, I was subsequently enabled, through partial exposures, to detect rocks similar to the Foreland group, on the south of the Fault.

The evidence obtained by us at Oare satisfied me that previous observers had rightly placed the Foreland Grits at the base of the Devonian series.

It must be admitted, however, that this instance of superposition is exceptional, and that eastward from the point where the Lynton beds disappear, and the Fault separates the Hangman from the Foreland Grits, the meagre evidence of surface fragments and occasional exposures does not enable one to mark its position with any degree of certainty.

It was subsequently suggested to me that the Hangman and Foreland groups might be the same series, and the Lynton beds the lowest in the area; in which case the superposition at Oare would be accounted for by an inversion, and the downthrow of the Fault would be to the north, as shown in the second sketch section, the normal interpretation being given in the first.

This suggestion recurred to me frequently afterward whilst engaged in mapping the Devonian Rocks of West Somerset, and I felt that, if it could be substantiated, many difficulties experienced in mapping the area would cease to exist, and the relations of the rocks would be much simplified. I will there-

[9] *Quart. Journ. Geol. Soc.*, Aug., 1879, p. 541.

fore weigh, as fairly as I can, the balance of evidence, as far as memory enables me, for and against this view. In its favour the following may be taken into account :—

First. The beds underlying the patch of Lynton Slates on the north side of the Fault near Oare, are reddish Grits, somewhat similar to the Hangman Grits which rest on the Lynton beds near Luccot Hill.

Secondly. After their disappearance near Luccot Hill, there is no further evidence of the Lynton beds, although we might reasonably expect that they would be brought up or thrown down somewhere by Fault or flexure in the distance of ten miles, between Luccot Hill and Dunster Park; for in this distance, going by general lithological characters, a Fault between the Hangman and Foreland Grits would be shifted several times by cross dislocations.

Thirdly. Leaving out of consideration the general differences between the Hangman strata south of Luccot Hill, Stoke Pero, and Cloutsham, and the beds of the Foreland group to the north of these places, we find no lithological distinction in the rocks exposed sufficiently marked to fix the position, or even (without corroberative evidence) to justify the existence of a great Fault in the vicinity of these places, which are in line with the direction of the Fault between Luccot Hill and Oare.

Fourthly. In districts which, from the general character of the rocks we would regard as composed of Hangman beds, and similarly in the area occupied by the Foreland Grits, we find exposures of rock resembling the Foreland type in the former, and analogous to varieties of the Hangman group in the latter case.

For example, at a mile south of Stock Mill we encounter massive grey silicious Grits of the Foreland type, and similar to beds exposed in the valley north of Pool and Brackslade. The exposure is at least half a mile south of the spot where the Oare valley Fault should cross the Stock Mill valley.

These beds may, however, really belong to the Foreland group, and owe their abnormal position to displacement of the main Fault by a cross dislocation along the Stock Mill valley.

At the northern extremity of the Quantocks, near Perry Court Farm, Grits resembling those of the Foreland group are exposed, but there is nothing to justify the existence of a great Fault in the neighbourhood.

On Grabbist Hill, in the Foreland Grit area, exposures of rocks resembling varieties of the Hangman group are visible. On the western slope of the hill Hangman beds might actually occur, and be cut off on the east by the Luxborough and Timberscombe Fault.

Fifthly. The strata near Stock Mill, Wilmotsham, and Cloutsham, afford no indications of a Fault, their dips being generally in an easterly direction, such as might be expected, were the Hangman and Foreland groups parts of the same series, and the Lynton beds subjacent to it.

Sixthly. The Oaktrow curve, before alluded to, shows the probability of frequent inversions occurring in the area. We have also several examples of folding, either normal or inverted, of sufficient magnitude to complicate the relations of the Devonian divisions and subdivisions.

For example. The purple slates of the Pickwell Down series are thus complicated by inversions, south of Withypool and Winsford, and on a large scale to the north of Dulverton and Haddon Down.[10] The Pilton beds are troughed in the Pickwell Down series, west of North Molton ridge. Their junction with the Baggy Beds near Stoke Rivers is similarly complicated.

I shall now proceed to test the value of the six reasons above given in favour of the suggested identity of the Hangman and Foreland groups, *seriatim*.

[10] See map accompanying paper by the Author, *Som. Arch and Nat. Hist. Soc. Proc.*, 1879.

The first may be dismissed as trivial, the red Grit at Oare not being distinctive of either group.

The second point is perhaps the strongest. But assuming the identity of the Hangman and Foreland groups, the absence of the Lynton beds east of Luccot Hill would prove that the Faults and folds affecting the rocks are not of sufficient magnitude to bring them to the surface. It is, however, quite possible that small patches of Lynton beds might be brought to the surface by Faults or folds, or have been spared by denudation in sites where the surface evidence is not strong enough to lead to their detection.

The third point, as to the absence of definite indication of the Fault, is met to a great extent by the fact that the exposures in the valley are not continuous and often infrequent; whilst, on the moorland surface, fragments and occasional shallow pits are insufficient to afford reliable evidence. Again, as I have before pointed out, it is quite probable that the Oare valley Fault may be shifted by a cross dislocation along the Stock Mill valley, to a point more than a mile south of Stock Mill.

In the junction of the Hangman Grits with the Middle Devonian Slates, the presence of Slates in the former, and of Grits in the latter series, often renders boundary lines—especially in a contorted district, such as that between Timberscombe and Cutcombe—very uncertain, and the detection of Faults extremely difficult; yet, in the neighbourhood of Croydon Hill and the Quantocks, dips and general lithological distinctions are sufficiently strong to demonstrate the existence of numerous boundary Faults. In the cases above cited, had the boundaries separated two great Grit groups, with strong general distinctions, but many points of resemblance, many of the Faults shown would in all probability have entirely escaped detection.

The fourth point, as to local similarities between beds presumably belonging to different groups, has already been partly

answered by the probabilities of such cases as south of Stock Mill and at the west end of Grabbist being accounted for by Faults. It must be remembered that in so variable a group as the Hangman, the local occurrence of massive silicious Grit, and of other beds resembling rocks in the Foreland series, would not be extraordinary, bearing in mind the chances of variation in a distance of fourteen miles, from the coast exposure at Trentishoe to the Stock Mill valley, and of twenty-nine miles from Trentishoe to the northern end of the Quantocks. In the paper before cited,[11] an example of variation in the Hangman group at Holford is figured.

Fifthly, as to similarity in direction of dip. This cannot be taken as proof of the absence of Fault; for where the Fault is known to occur, near Oare and Oareford, dips similar in direction and not very different in angle of incline, have frequently been obtained on either side of it.

The sixth point need not be argued, as it only indicates the probability of inversion, and could not be advanced as a reason without entailing some such fallacious syllogistic reasoning as the following:—Divisions of the Devonian strata of North Devon and West Somerset are complicated in their relations by inversions on a large scale. The rocks at Oare are divisions of the Devonian strata of North Devon and West Somerset. Therefore the rocks at Oare are complicated in their relations by inversions on a large scale.

Against the suggestion of the identity of the Hangman and Foreland groups, the following reasons must be taken into consideration.

First. The Hangman group is a variable series, in which slates and slaty beds are largely developed, indicative of intermediate conditions between the Middle Devonian Slate series above, and the intercalated Grits and Slates of the Lynton Beds below. Signs of conglomeratic conditions are, as far as I am aware, entirely absent.

[11] Champernowne and Ussher, *Q.J.G.S.*, Aug., 1879, p. 545.

The Foreland group, on the contrary, is not nearly so variable, much more sparingly associated with slaty Grits, and contains here and there thin bands of fine conglomerate.

Secondly. In the Hangman group, a series of whitish, rather course, red speckled Quartzose Grits, with slaty beds above and below, forms an apparently persistent horizon throughout North Devon and West Somerset. In the Foreland rocks, on the contrary, no such persistent horizon is recognizeable, nor has any similar lithological variety been found. They consist, for the most part, of fine grained grey and purplish, masssive-bedded Quartzose Grits, with irregular red slaty beds, and also contain thinner beds of red and purplish Grit, similar to varieties in the Hangman group.

Thirdly. In the Hangman beds of North Devon, Natica and Myalina have been found. In the Foreland rocks, on the contrary, no Fossils have been detected, except obscure fucoidal markings, which have not been observed in the Hangman beds. In this connection I would wish to call attention to the vast field that is open to the enterprizing palæontologist, in the investigation of these two great Lower Devonian Grit groups. It is a constant wonder to me to notice the avidity with which the average palæontologist explores the spoiled heaps of his predecessors, and visits localities which have been rendered classic by previous discoverers. Give a formation a bad name as to its fossil-producing capacities, and a very brief inspection of it will quite satisfy his conscience as to the correctness of the epithet. I have within the last two years experienced the results of this system of investigation. Lower Devonian rocks were known to occur in the Torquay promontory; fossils had been found in them of types demonstrating their antiquity; but in that neighbourhood there was a limestone quarry, and not far off a little cove, with tiny, well preserved Upper Devonian Goniatites; both these were favourite hunting grounds. Lower Devonian fossils were found hard by the latter spot, but their numbers or state of preservation did not

apparently entice the discoverers to researches further afield. Beyond Torquay, extensive tracts of Grit and Slate, forming the highest grounds in the neighbourhood, were left unexplored. The fiat had gone forth—they were unfossiliferous. So these unhappy rocks were bundled about any way in the matter of classification. They figured as Old Red Sandstone, were exhalted to the highest eminence in the Devonian series, and anon shovelled down to its lower depths. They were named 'Cockington Beds' near Torquay, and 'Staddon Grits' near Plymouth.

In my study of the Torquay district I endeavoured carefully to store away the jumbled fragments of information I could gather from so contorted and faulted a country, so as to bring them up for comparison, should occasion arise. I felt all the horrors of a specialist at fault in unravelling a complicated district by structure alone; the data furnished me by the palæontologists—here a little and there a little—being derived from a few spots, furnished a sum total too little to be of any use. So I then determined to search everwhere for a Fauna by which I might restore order in the shattered rocks, and get at their real succession. In this quest I spent many profitless days in the poor neglected regions aforesaid without finding a trace of a fossil. When that sort of thing was getting monotonous, a fragment of one of the thoracic plates of Homalonotus turned up. I existed on that for a long time, till it seemed an illusion. Then, when the effects of being bent double for so many hours a-day were beginning to tell, a very ordinary and unpromising grit stone revealed to my enraptured gaze a Spirifer, which proved to be *Spirifer hystericus* a Lower Devonian form. Then I knew what to do. Instead of spending hours over the same spots, I would extend my borders, and perhaps succeed in peopling this wilderness with extinct forms, and rescue it from 'wastes of doubt.' After that things came round. I found the cherished Pleurodictyum in several places; sometimes a bit of *Gasteropod*; sometimes a fragment of Homa-

lonotus turned up. But these were in surface fragments. It is true that no body but a very ill-disposed person, or a lunatic, would have suggested that the fossiliferous stones were all brought with manure, and the rest, though of the same composition, were indigenous to the soil. Anyway, I thirsted for a find *in situ*; and this, too, came about in a small quarry, where the same fossils and the same kind of rock I had hammered at on Lincombe Hill, Torquay, were exposed. I found here and there, over a comparatively large district, in fewer hours than I had spent days prior to the faith inspired by the find of *Sp. hystericus*, a Fauna sufficient to establish the Lower Devonian age of the beds, and on that starting point to work in the results of my friend, the late A. Champernowne's excellent studies in the stratigraphy of South Devon, which would probably have been published before his lamented death, had he not always entertained a doubt as to the position of these beds in the series.

I cannot apologise for this seemingly *mal à propos* digression in a paper of dry facts. It was necessary to stir up the enterprizing palæontologist of the future to despair not of finding a Fauna; yea, even in the heart of the massive Foreland Grits, though many great stone hammers perish in the search, and dynamite awake the imprisoned fossils from their sleep of ages, to reflect again the beaming visage of the same old *Sol* that looked down upon their gambols in Lower Devonian seas.

To resume. Fourthly, and lastly. The features made by the Hangman and Foreland groups are very distinct. This, however, may be to a great extent due to the structure and position of their component beds. Dome-shaped or conical features, characteristic of the Foreland group so noticeable in Countesbury Hill, are to a less extent apparent on North Hill and about Bonniton, south of Grabbist Hill. On the other hand, the longer and less abrupt slopes, and less rounded summits of Croydon Hill and the Dunkery range denote the Hangman series.

The reasons above given are, I think, sufficient to negative any suggestion as to the identity of the Hangman and Foreland groups; the points in its favour being too weak to turn the scale against them, as well as in many cases, as I have endeavoured to show, otherwise explainable.

Another hypothesis to account for the absence of the Lynton beds east of Luccot Hill, by an unconformable overlap of the Hangman upon the Foreland group also occurred to me; but in that case we should expect to trace the junction by marginal conditions in the former group, which do not occur in it; and, moreover, there are no persistent divergences of strike, such as we might expect to find in a newer series of rocks lying on the denuded edges of an older.

In the map accompanying this paper, the Liassic districts are left uncolored, as they were not surveyed by me, and do not come within the scope of my subject.