14. *On the LLANDOVERY and ASSOCIATED ROCKS of CONWAY (NORTH WALES).* By Miss G. L. ELLES and Miss E. M. R. WOOD, Bathurst Students, Newnham College, Cambridge. (Communicated by J. E. MARR, Esq., M.A., F.R.S., Sec. G.S. Read January 8th, 1896.)

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I. INTRODUCTION, AND DESCRIPTION OF AREA.

THE Geological Survey Map (Sheet 78 N.E.) of the district lying immediately south of the town of Conway reveals an outcrop of Tarannon Shales, which is curious as regards its relation to the associated formations, since the Tarannon Shales are represented as being both underlain and overlain by rocks of Wenlock age. This circumstance led us to examine this special area; and our attention having already been directed to the occurrence of graptolitic shales below the Tarannons in other parts of Wales, we thought it possible that they might also be present in the Conway district.

Our observations in that district have extended over a fairly wide region, including the greater part of the valley of the Afon Gyffin between Conway and Y-Ro; but the only area which we have mapped in anything like detail lies immediately south of the town of Conway itself, and occupies the hill opposite Conway Castle and the railway. This area is bounded on the east by the River Conway, and on the west by a fault ('boundary-fault,' as we term it in the following pages) which brings a calcareous grit of Bala age against Silurian beds.

The northern limit of the area is formed by the Afon Gyffin, a tributary stream of the River Conway, which it joins just below the Castle. The southern limit has been taken, for convenience, at the beginning of the dense woods belonging to Benarth Asylum. In other places higher up the valley, where we hoped to find a similar succession, the ground was low-lying and all rock-exposures were concealed beneath a tract of alluvium.

The geological structure of the area is fairly simple, though the beds are faulted and give indications of having been disturbed, the cleavage in many cases being in a direction at right angles to that of the plane of bedding. There is no great variation in the lithological characters of the beds; they are all of the general type known as 'greywacke,' and graduate locally from thick-bedded gritstones, through smooth flagstones, and thin-bedded hard grey shales down to fine-grained graptolitic mudstones. The only fossils with which we have to deal are graptolites, and their value for purposes of stratigraphical correlation is now too well known to need comment.

II. LITERATURE.

The succession of rocks at Conway has received but little attention at the hands of geologists, and the literature is in consequence somewhat scanty. In the second edition of the Geological Survey Memoir on North Wales (1881) the succession at Conway is given as follows :—

Wenlock Shale.	} Wenlock Beds.
Denbighshire Grit.	
Tarannon Shale.	
(Upper and Lower Llandovery Beds absent.)	
Caradoc or Bala Beds.	

It is also suggested that the absence of Llandovery rocks between Conway and the country east of Bala Lake may possibly be due to the overlap of the Tarannon Shales, which are said to rest on Lower Silurian rocks at about the horizon of the Bala Limestone.

The Tarannon Shales form a narrow band at the base of the Denbighshire Grits extending from Conway to Llanbedr, about 5 miles to the south, being interrupted only by three small faults with a downthrow to the east.

On the hill immediately south of Conway the base of the grits, resting on a narrow band of Tarannon Shales, strikes towards Gyffin and, dipping east at an angle between 10° and 30°, passes south by Y-Ro to Caerhun, where the western boundary is lost in the alluvium of the River Conway. It is also stated that the grits pass up into the Wenlock Shale, but no mention is made of the considerable thickness of Wenlock Shale which we have found below the lowest grit-band in this district.

Prof. Lapworth, in his classical work on the 'Distribution of the Rhabdophora' (Ann. & Mag. Nat. Hist. ser. 5, vols. v. & vi. 1880, pp. 45, etc.), records the occurrence of many graptolites in the Tarannon Shales of Conway. On palæontological grounds he concludes that the Tarannon Shales of Conway correspond to the lowest portion of the Gala Group of Southern Scotland, that is, with the zone of *Monograptus exiguus*.

Our work necessitates a modification of the views of the earlier Surveyors, though we are in complete agreement with Prof. Lapworth's suggestion as to the horizon of the Tarannon Shales of this district.

III. GENERAL SEQUENCE.

In this area we believe that we have a succession of graptolitic mudstones representing beds of Llandovery, Tarannon, and Wenlock ages, and we hope to show that the omission of Llandovery Beds in the Conway succession of the earlier surveyors was erroneous. We consider that the general sequence in descending order is as follows:—

5. Denbighshire Grits and Flags.
4. Wenlock Shales.
3. Tarannon Shales.
2. Upper Llandovery Beds.
1. Bala Beds.

The junction between the Bala and Llandovery rocks is nowhere visible. The former do not come to the surface south of the Afon Gyffin, but at the time of our first visit drainage-operations were in progress along the road passing the timber-yard on the way to Benarth, and at a few feet below the level of the road black graptolitic shales containing *Diplograptus foliaceus* (Murch.) and *Climacograptus bicornis* (Hall) were seen, apparently *in situ*, underlying the Tarannon Shales. If this be really the case, the Lower Tarannon rests unconformably on rocks of Bala Limestone age, and the succession is here different from that seen on the other side of the fault (F. 2 in map, p. 274), where Llandovery rocks occur, but it is unlikely that the Birkhill Shales have been overlapped in this short distance.

Since there is no junction visible between the Bala and Llandovery rocks, we are unable to determine definitely whether the Lower Llandovery rocks are absent or not in the district.

Note on the Bala Rocks of the Conway District.—On the other side of the River Conway, in a quarry of Bala rocks on the hill above Deganway, we have found remains of several large trilobites. Many seem referable to the species *Phacops appendiculatus* (Salt.) (= *P. eucentra*, Ang.?). This would tend to show that we have here representatives of the Ashgill Shale fauna of the Lake District. If this be the case, there exists in this part of North Wales a higher series of Ordovician rocks than has hitherto been supposed, and hence the break between Ordovician and Silurian rocks is less than was formerly believed to be the case.

The Upper Llandovery rocks pass up conformably into the Tarannons; but on palæontological grounds we believe that the latter are overlapped by the Wenlock Shales, and that the highest beds—that is, the zone of *Cyrtograptus Grayæ* (Lapw.)—are not present here.

The best section of the Wenlock Shales is to be seen on the shore below Benarth, and here we approximately determined the upper limit of these beds, on lithological grounds, at a point where the beds become more flaggy in character and contain bands of grit.

The exposures on the side of the hill were not sufficiently good to enable us to determine the upward limit with certainty.

There are two main faults in this district: one (F. 1), as has been mentioned above, forms our boundary-line to the W. and strikes 10° W. of N.; while a second one (F. 2), striking 30° S. of W. and

Fig. 1.

SECTION THROUGH A.B

Fig. 2.

SECTION THROUGH C.D.

with a downthrow to the E., brings the Upper Llandovery and Tarannon beds against the Wenlock Shales. We believe that the occurrence of Upper Llandovery Beds is dependent in a great measure on this second fault.

IV. DETAILED DESCRIPTION OF THE BEDS.

1. The Llandovery Rocks.

Rocks which are undoubtedly of Llandovery age occur on the right bank of the Afon Gyffin, from opposite Neckarmount House to the timber-yard buildings. Farther W. they are concealed beneath the alluvium of the river. They strike 10° N. of W., and dip 10° W. of S. at an angle of about 55° . Continuing on this strike, they are again seen in vertical section in the high bank opposite the fork formed by the junction of the Benarth and Gyffin roads; here they occur slightly below the level of the road, and probably occupy the whole of the marshy ground lying between the road and the bank.

(a) *Stream-section*.—The beds seen in section near the stream are capable of the following subdivisions, in descending order:—

7. Hard grey bed.
6. Black shale-band, with *Rastrites maximus*.
5. Grey flagstones.
4. Black shale-band, with graptolites.
3. Grey flagstones.
2. Black shale-band, with graptolites.
1. Very tough flagstones.

1. *Tough Grey Flagstones*.—Little need be said of the unfossiliferous beds forming the base of the section. They consist of tough grey flagstones, and are well exhibited in the bed of the

stream. They call to mind strongly the so-called Barren Mudstones of Moffat (Lapworth, Quart. Journ. Geol. Soc. vol. xxxiv. 1878, p. 240) and other areas. They are about 4 feet thick, but their base is not visible.

2. *Black Shale-band*.—This band is composed of typical black mudstones; it is only a few inches thick, and is much weathered, so that large blocks are not obtainable. We identified the following graptolites:—

<i>Rastrites peregrinus</i> (Barr.).	<i>Monograptus gregarius</i> , Lapw. C.
<i>Monograptus Hisingeri</i> , var. <i>nudus</i> (Lapw.).	<i>Diplograptus tamariscus</i> (Nich.) C.
— <i>Hisingeri</i> , var. <i>jaculum</i> (Lapw.).	<i>Climacograptus normalis</i> (Lapw.).

(C=very common. c=common. R=rare.)

3. *Grey Flags*.—The black fossiliferous band No. 2 is separated from the band No. 4 by a foot of grey flagstones, very similar in character to those found at the base of the section.

4. *Black Shale-band*.—Very similar to band No. 2, but fossils are rather more abundant. This band is also of inconsiderable thickness. We have found in it the following fossils:—

<i>Monograptus concinnus</i> (Lapw.).	<i>Diplograptus sinuatus</i> (Nich.) C.
— <i>Hisingeri</i> , var. <i>nudus</i> , Lapw.	— <i>Hughesii</i> (Nich.).
— —, var. <i>jaculum</i> (Lapw.).	— <i>tamariscus</i> (Nich.) C.
— <i>gregarius</i> ? (Lapw.).	<i>Climacograptus normalis</i> (Lapw.).
— <i>lobiferus</i> (M'Coy).	C.

5. *Grey Flagstones*.—These differ in no particular from those already described.

6. *Black Shale-band*.—This, the uppermost black shale-band that occurs in the section, is by far the most important. It is exposed about 3 yards from the top of the bank, below the uppermost bed of grey flagstones. The bed weathers very deeply, and has a curious rough fracture which renders it easily recognizable. The band is richly fossiliferous, and has yielded the following graptolites:—

<i>Rastrites maximus</i> (Carr.) C.	<i>Monograptus lobiferus</i> (M'Coy).
— <i>gemmatus</i> (Barr.).	— <i>spinigerus</i> (Nich.).
— <i>distans</i> (Lapw.).	— <i>turriculatus</i> (Barr.) R.
<i>Monograptus argutus</i> (Lapw.).	<i>Petalograptus ovatus</i> (Barr.).
— <i>Barrandii</i> (?) (Suess).	— <i>palmus</i> (Barr.).
— <i>concinnus</i> (Lapw.).	<i>Diplograptus sinuatus</i> (Nich.) C.
— <i>gregarius</i> (Lapw.) R.	— <i>tamariscus</i> (Nich.) C.
— <i>galaensis</i> (Lapw.) R.	— <i>Hughesii</i> (Nich.) C.
— <i>Hisingeri</i> , var. <i>nudus</i> (Lapw.).	<i>Climacograptus normalis</i> (Lapw.).
— —, var. <i>jaculum</i> (Lapw.) c.	c.

(b) *Marsh-section*.—The beds seen in section in the bank of the marsh are, as before mentioned, a continuation of those seen by the stream, and here, as before, they dip steadily in towards the hill. The marsh, which occupies the space between the road and the bank, lies about 3 feet below the level of the road, but the ground rises somewhat towards the bank. Were it not for this depression, no Llandovery Beds would be seen here, as the band with *Rastrites*

maximus is found almost at the level of the road, and the black band No. 4 is only just visible at the foot of the bank. This band disappears almost at once when traced east or west, and the zone of *Rastrites maximus* is also lost at the level of the road on either side of the depression.

The section is, however, very interesting as affording an opportunity of studying the passage from the Llandovery rocks into the Tarannon Shales. There occurs in this place a graptolitic band above the zone of *Rastrites maximus*. This must be, from its position, either a passage-zone or the lowest bed of the Tarannon Shales. From the character of the fauna presently to be described, we prefer to regard it as a true passage-bed.

The following is the section seen at this locality, the strata being enumerated in descending order:—

	Ft.	In.
9. Spotted grey flagstones to summit.		
8. Black graptolitic band (probably passage-zone)	0	6
7. Grey flagstones, with hard gritty band about 1 inch wide at base	1	8
6. Shale band; zone of <i>Rastrites maximus</i>	1	0
5. Grey flagstones, unfossiliferous	1	0
4. Black shale-band, just visible.		

(The beds are numbered to correspond with those of the stream-section.)

From the nature of the exposure of No. 4, we scarcely expected to find any fossils. We succeeded, however, in obtaining a few graptolites, but these were too fragmentary for specific determination.

Zone of R. maximus, Band No. 6.—This band is easily recognizable by its characteristic fracture and mode of weathering. It has yielded the following graptolites:—

<i>Rastrites maximus</i> (Carr.). C.	<i>Monograptus gregarius</i> (Lapw.).
<i>Monograptus concinnus</i> (Lapw.).	R.
— <i>spinigerus</i> (Nich.)?	— <i>crassus</i> (Lapw.).
— <i>Hisingeri</i> , var. <i>nudus</i> , Lapw.	— <i>involutus</i> (Lapw.)?
C.	— <i>turriculatus</i> (Barr.). R.
— —, var. <i>jaculum</i> (Lapw.).	<i>Petalograptus ovatus</i> (Barr.).
C.	— <i>palmeus</i> (Barr.).
— <i>cyphus</i> (Lapw.).	<i>Diplograptus tamariscus</i> (Nich.). C.
— <i>galaensis</i> (Lapw.). R.	— <i>Hughesii</i> (Nich.). C.

It will be observed that in this locality and in the stream-section the zone of *Rastrites maximus* is characterized by the abundance of *Diplograptus* belonging to the species *Hughesii* (Nich.), *tamariscus* (Nich.), *ovatus* (Barr.), and *palmeus* (Barr.). The first two are by far the most numerous.

The upper limit of the Llandovery Beds appears to be well defined by the hard gritty band occurring at the base of No. 7.

8. Fossiliferous Band.—This differs somewhat in lithological characters from the lower graptolitic bands. It is not so black, nor is it so soft, being of a more gritty nature. It yielded the following fossils:—

Monograptus Hisingeri (Carr.).
* — *crispus* (Lapw.).
* — cf. *sartorius* (Tullb.).
* — cf. *speciosus* (Tullb.).
* — *runcinatus* (Lapw.).

* *Monograptus pandus* (Lapw.).
— *lobiferus* (M'Coy).
* — cf. *nodifer* (Tullb.).
Diplograptus Hughesii (Nich.).
Climacograptus normalis (Lapw.).

It is this fauna which leads us to believe that the zone is a passage-zone, as the fossils marked with an asterisk are characteristic Tarannon forms, while the other species are common in the Llandovery Beds.

2. The Tarannon Shales.

(a) *Marsh-section*.—Unfortunately the lowest beds of the Tarannon Shales in this district are not very fossiliferous—at least in places which are accessible, for much of the section is obscured by buildings and lumber from the adjoining timber-yard.

At the corner of the road, however, we succeeded in obtaining two slabs on which were seen a number of badly preserved Monograptids. Many of these were too obscure for identification, but we have determined *M. pandus* (Lapw.), *M. Hisingeri*, var. *nudus* (Lapw.), *Cyrtograptus Lapworthi* (Tullb.), and *C. (?) spiralis* (Gein.).

These beds were almost immediately faulted out against the Wenlock Shales.

(b) *Section opposite the Forge*.—The section of Tarannon Shales seen opposite the forge is by far the best in the district, and contains a rich graptolitic fauna. It was from these beds that Prof. Lapworth obtained the fossils recorded by him in his 'Distribution of the Rhabdophora' (Ann. & Mag. Nat. Hist. 1880, ser. 5, vols. v. & vi.). The strike of the beds does not appear to have been affected by the fault, and they dip 10° W. of S. at a fairly constant angle of about 55°.

The beds consist of alternations of hard grey unfossiliferous flagstones, with softer black shale-bands containing graptolites. They are quite different in character from the Llandovery rocks, and are not so fissile.

The following is the complete section seen; the lowest beds occur exactly at the corner by the forge, while higher beds come on along the road in either direction:—

	Ft. In.
13. Soil and loose shale	4 0
12. Bands of hard grey flags, with softer seams. Unfossiliferous...	2 6
11. Black shale-band, with graptolites. Very ferruginous and deeply weathered	1 6
10. Grey flagstones	0 9
9. Black shale-band, with graptolites. Very soft, and stained yellow	1 0
8. Grey flagstones	0 9
7. Soft black graptolitic shale	0 6
6. Grey flags, with narrow band of hard yellow grit: all very ferruginous	0 5
5. Soft black shale, with graptolites	0 9
4. Unfossiliferous grey flags	0 7
3. Black shale, with graptolites	0 9½
2. Grey flags	1 0
1. Grey, sandy, graptolitic band; iron-stained above.	

(Base not seen.)

Band No. 1.—Lithologically this band differs from any of the other graptolite-bearing bands seen in this section. It may be roughly separated into two divisions :—

- (a) Lower. Sandy grey bed.
- (b) Upper. Flaggy bed, stained bright red.

In the lower of these two divisions the graptolites are very numerous but fragmentary, and for the most part very badly preserved; those in the upper division are more easily determinable. We obtained the following fossils :—

<i>Monograptus pandus</i> (Lapw.). C.	<i>Monograptus speciosus</i> (Tullb.).
— <i>runcinatus</i> , var. (Lapw.).	— <i>crispus</i> (Lapw.).
— <i>exiguus</i> (Nich.). C.	— <i>turriculatus</i> (Barr.).
— <i>nodifer</i> (Tullb.).	— <i>Becki</i> (Barr.)?
— <i>Hisingeri</i> , var. <i>nudus</i> (Lapw.).	— ? <i>urceolus</i> (Richter).
— —, var. <i>jaculum</i> (Lapw.).	<i>Petalograptus palmeus</i> (Barr.).
— <i>broughtonensis</i> (Nich.).	<i>Diplograptus tamariscus</i> (Nich.).

The unfossiliferous flagstones are very similar throughout; they consist of pale grey flaggy beds, occasionally somewhat gritty, and are often very hard. Some of the upper beds are speckled.

Band No. 3.—This soft mudstone-band has yielded the following forms :—

<i>Monograptus pandus</i> (Lapw.).	<i>Monograptus</i> ? <i>urceolus</i> (Richter).
— <i>runcinatus</i> , var. (Lapw.).	— cf. <i>flexuosus</i> (Tullb.).
— <i>exiguus</i> (Nich.). C.	— <i>capillaceus</i> (Tullb.).
— <i>turriculatus</i> (Barr.). C.	<i>Petalograptus palmeus</i> (Barr.).
— cf. <i>cygneus</i> (Törnq.).	

Band No. 5.—From this band we have identified

<i>Monograptus turriculatus</i> (Barr.).	<i>Monograptus galaensis</i> (Lapw.).
— <i>pandus</i> (Lapw.).	— <i>Flemingii</i> (Salter).
— <i>runcinatus</i> , var. (Lapw.).	— ? <i>urceolus</i> (Richter).
— <i>Hisingeri</i> , var. <i>nudus</i> (Lapw.).	— <i>Proteus</i> (Barr.).
— <i>exiguus</i> (Nich.).	<i>Petalograptus palmeus</i> (Barr.).
— <i>crispus</i> ? (Lapw.).	— <i>ovatus</i> (Barr.).

Band No. 7.—This contains

<i>Monograptus turriculatus</i> (Barr.). C.	<i>Monograptus speciosus</i> (Tullb.).
— <i>exiguus</i> (Nich.).	— <i>retroflexus</i> ? (Tullb.).
— <i>Hisingeri</i> , var. <i>nudus</i> (Lapw.).	<i>Diplograptus tamariscus</i> (Nich.).
— <i>pandus</i> (Lapw.).	

Band No. 9.—This bed is peculiar, because of its being stained bright yellow; it has yielded

<i>Monograptus pandus</i> (Lapw.).	<i>Monograptus Hisingeri</i> , var. <i>jaculum</i> (Lapw.).
— <i>turriculatus</i> (Barr.).	<i>Petalograptus ovatus</i> (Barr.?). C.
— <i>crispus</i> (Lapw.).	— <i>palmeus</i> (Barr.). C.
— <i>exiguus</i> (Nich.).	<i>Retiolites Geintzianus</i> (Barr.).
— <i>prionon</i> (Bronn.).	
— <i>Hisingeri</i> , var. <i>nudus</i> ? (Lapw.).	

Band No. 11. This band consists of black flaggy mudstones, deeply weathered and often iron-stained. It breaks characteristically into

lath-shaped fragments with a splintery fracture. We have obtained from it the following :—

<i>Monograptus pandus</i> (Lapw.). C.	<i>Monograptus speciosus</i> (Tullb.).
— <i>runcinatus</i> , var. (Lapw.). C.	— cf. <i>cygneus</i> (Törnq.).
— <i>exiguus</i> (Nich.). C.	— <i>pridon</i> (Bronn).
— <i>attenuatus</i> (Hopk.).	— <i>concinus</i> (?). Lapw.
— <i>crispus</i> (Lapw.).	— ? <i>urceolus</i> (Richter).
— <i>broughtonensis</i> (Nich.).	<i>Petalograptus ovatus</i> (Barr.).
— <i>turriculatus</i> (Barr.). C.	— <i>palmeus</i> (Barr.). C.
— <i>riccartonensis</i> (Lapw.).	<i>Diplograptus tamariscus</i> (Nich.).
—, sp. nov.	— <i>Hughesii</i> (Nich.).
— <i>Hisingeri</i> , var. <i>nudus</i> (Lapw.).	<i>Retiolites Geinitzianus</i> (Barr.).
—, var. <i>jaculum</i> (Lapw.).	— <i>obesus</i> (Lapw.).
— <i>galaensis</i> (Lapw.).	

Strictly speaking, this band might be divided as follows :—

- (a) Graptolitic Shale.
- (b) Unfossiliferous Flags.
- (c) Graptolitic Shale.

But (b) is of such insignificant thickness that for practical purposes it seems better to group the three as one bed.

It will be evident from these lists that several species of graptolites are common to all the bands: for example, *Monograptus exiguus* (Nich.) and *M. turriculatus* (Barr.) range throughout, and have been found on the same slab; *M. pandus*, Lapw., and *M. runcinatus* var., Lapw., are also commonly associated with these.

(c) *Shore-section*.—The only other place where we found a workable section was that seen at low tide on the shore between the timber-yard and the lodge belonging to the Benarth Lunatic Asylum. The section commenced just at the old landing-stage.

The dip and strike remain constant as before, but, owing to the fact that beds are denuded along their dip, they are exposed somewhat farther to the south than is the case in the road. Unfortunately, where we hoped to find the highest beds the section was obscured by sand and shingle, and the rocks next visible were certainly of Wenlock age, since they contained *Monograptus pridon* (Bronn), *M. vomerinus* (Nich.), etc.

We believe that there is a continuous outcrop of Tarannon Shales from the fault (F. 2) to F. 1, the boundary-fault; but there are no good exposures, as the ground is chiefly a grassy slope. The presence of these beds was therefore in most cases inferred by the disappearance of the feature invariably formed by the Wenlock Shales.

3. The Wenlock Shales.

A considerable thickness of Wenlock Shale underlies the lowest band of Denbighshire Grit in this district. The outcrop assumes a curious form to the west, owing to the presence of the fault (F. 1) and to the configuration of the ground.

Lithologically, the beds differ markedly from the underlying

Tarannon Shales; they are generally harder, of a lighter, often speckled colour, and in places very shivery. The fossils are fairly well preserved, but, owing to the direction of the cleavage, are often difficult to obtain. The beds change their strike somewhat as they approach the faults, being in each case bent up towards them; this is especially well marked in the case of the fault which forms the boundary of the Silurian rocks to the west. We were fortunate in having several workable exposures on the hillside, and these we will proceed to describe in some detail.

(i.) Sections West of Fault (F. 2).

(α) *Section S.W. of Rose Mill Farm.*—The sections exposed near Rose Mill Farm are of small extent. They are chiefly interesting as showing the alteration in the strike of the beds as these approach the fault. Here the strike is 20° N. of W., while as a general rule it is 10° N. of W. The fossils here are for the most part but poorly preserved, but we have identified *Monograptus personatus*, Tullb., *M. vomerinus*, Nich., *M. broughtonensis* (Nich.), and *Cyrtograptus Murchisoni*, Carr. At Rose Mill Farm itself the shales are very shivery, and from the nature of the rock no fossils were obtainable. Here and south of the farm the strike is 15° N. of W.

(β) *Neckarmount.*—An exceedingly good section is exposed along the rough cart-track which leads up from the road, past Neckarmount House, to the farm.

The beds appear to come on about 160 yards above Gyffin Road; they dip steadily into the hill to the S.S.W. at a high angle of about 50° , and maintain a constant strike 10° N. of W. The shales do not appear to be equally fossiliferous throughout. In some bands graptolites are abundant, while others appear to be quite unfossiliferous. The fossiliferous bands yielded *Monograptus priodon*, Bronn, *M. vomerinus*, Nich., *M. personatus*, Tullb., *M. flexuosus*, Tullb., *M. Hisingeri*, var. *rigidus* (?), Lapw., and *Cyrtograptus* sp.

East of Neckarmount the harder unfossiliferous bands are exposed, at the top of a sudden rise of ground. Here the direction of strike changes to 20° N. of W. This is evidently due to the presence of the fault (F. 2), which is at this place in close proximity.

(ii.) Sections East of Fault (F. 2).

(α) *Road-section.*—As mentioned above, the Wenlock Shales are faulted against the Tarannon Shales to the west. Unfortunately the beds here are so deeply weathered that fossils are exceedingly rare, but the change in the character of the rocks, in addition to palæontological evidence, enables us to affirm with some certainty that the beds are of Wenlock age. The only graptolites obtainable were *Monograptus vomerinus*, Nich. (1 specimen), *M. flexuosus*, Tullb. (1 specimen), and *Cyrtograptus* ? (1 specimen).

(β) *Hillside-sections*.—On the hillside, immediately above, the exposures yielded several graptolites, belonging, however, to but few species: *Monograptus priodon*, Bronn, *M. personatus*, Tullb., *M. vomerinus*, Nich., and *M. flexuosus*, Tullb.

This exposure was traceable, with interruptions, round the hill to above the lodge leading to Benarth Asylum.

(γ) *Shore-section*.—The section of Wenlock Shales exposed on the shore at low tide is very complete. These beds first appear just below the end of the lodge garden, and continue for some distance along the shore. The lower beds are very shivery in character, but as higher beds are reached they become more compact and finally pass up into the hard flagstones with intercalated grit-bands belonging to the series of Denbighshire Grits and Flags. The following fossils were obtained:—*Monograptus priodon*, Bronn; *M. personatus*, Tullb.; *M. vomerinus*, Nich.

4. The Denbighshire Grits and Flags.

The boundary-line between the Wenlock Shales and the Denbighshire Grits and Flags east of the fault (F. 2) is approximately correct; but between this fault and the western limit exposures are rare, and the boundary cannot be fixed with any accuracy. Quite near the western fault exposures are more abundant, and the alteration of strike near the line of disturbance is perfectly evident.

V. CORRELATION WITH OTHER AREAS.

1. The Llandovery Rocks.

The general character of the graptolites found on the bank of the stream and in the road-section shows that the beds are nearly related to the Upper Birkhill Shales of Southern Scotland, and also to similar beds occurring in the Lake District and elsewhere.

We do not think that it is possible to trace at Conway all the minuter subdivisions recognized at Moffat, but certainly our highest band (No. 6 of the stream-section) corresponds with the uppermost zone of the Birkhill Shales, namely with the zone of *Rastrites maximus*. The bands below (Nos. 2 and 4) may subsequently be found to be the equivalents of lower zones, but in the present state of our knowledge it is wisest to say only that the beds contain an Upper Birkhill fauna. The following table shows the species common to the beds in various areas:—

CONWAY.	SCOTLAND.		LAKE DISTRICT.		CENTRAL WALES.
Llandovery Beds.	Zone of <i>Rastrites maximus</i> .	Upper Birkhill.	Middle Skelgill.	Upper Skelgill.	
* <i>Rastrites maximus</i> (Carr.).....	*	*		*	*
— <i>gemmatus</i> (Barr.)			*		
* — <i>distans</i> (Lapw.).....	*	*			
— <i>peregrinus</i> (Barr.).....	*	*	*		*
* <i>Monograptus argutus</i> (Lapw.)		*	*		
— <i>Barrandii</i> (Tullb.)					
* — <i>concinus</i> (Lapw.).....	*	*	*		
* — <i>cyphus</i> (Lapw.).....		*	*		
— <i>crassus</i> (Lapw.).....	*	*		*	
* — <i>gregarius</i> (Lapw.).....	*	*	*	*	
— <i>galaensis</i> (Lapw.)	*	*			
— <i>Hisingeri</i> , var. <i>nudus</i> (Lapw.)					
— <i>involutus</i> (Lapw.)	*	*	*	*	*
* — <i>lobiferus</i> (M'Coy)	*	*	*		*
— <i>runcinatus</i> (Lapw.)		*		*	*
* — <i>spinigerus</i> (Nich.)	*	*			
* — <i>turriculatus</i> (Barr.)	*	*		*	*
— <i>Petalograptus ovatus</i> (Barr.)	*	*			
* <i>Diplograptus Hughesii</i> (Nich.)	*	*	*	*	
* — <i>palmeus</i> (Barr.).....	*	*		*	
— <i>sinuatus</i> (Nich.).....	*	*	*	*	
* — <i>tamariscus</i> (Nich.).....	*	*	*	*	
* <i>Climacograptus normalis</i> (Lapw.)	*	*	*	*	

As shown by this table, the correspondence between the fauna of the Conway beds and that of the Upper Birkhill Shales is very close. As the study of our fossil lists will show, the species are by no means evenly distributed throughout the three bands.

Some forms, which are very rare in the zone of *Rastrites maximus*, are far more characteristic of the Tarannon Shales; such, for instance, as *Monograptus turriculatus*, *M. galaensis*, *M. pandus*, and *M. Barrandii*. Others occur more abundantly in the lower bands (2 and 4), and may indicate the presence of lower zones. *Monograptus gregarius* is fairly common in band No. 2, but we have succeeded in obtaining only one specimen from the zone of *Rastrites maximus*.

Rastrites peregrinus was found only in the lowest band (No. 2). The poverty of the fauna from this lowest band was no doubt in part due to the very small extent of the exposure; had we been enabled to work it better, we probably should have found it possible to definitely determine its age.

2. The Tarannon Shales.

The correlation of the lowest fossiliferous band of the Tarannon Group is a matter of some difficulty. We did not succeed in finding

Monograptus turriculatus; but the fauna, on the whole, shows affinities with the underlying and overlying beds, and we therefore consider that it is of the nature of a passage-bed. We do not know its exact equivalent in other areas.

The main mass of the Tarannon Shales may be correlated with the lower of the two groups into which Prof. Lapworth (Ann. & Mag. Nat. Hist. ser. 5, vols. v. & vi. 1880) has divided the Gala rocks of the Southern Uplands of Scotland—that is, the zone of *Monograptus exiguus*.

It does not seem possible to recognize here the two sub-zones defined by Messrs. Marr and Nicholson (Quart. Journ. Geol. Soc. vol. xliv. 1888, p. 654) in the Lake District. There they found (1) zone of *Monograptus turriculatus* (Barr.) and (2) zone of *M. crispus* (Lapw.). In our beds *M. turriculatus* and *M. exiguus* range together throughout, but it is noticeable that the genus *Retiolites* is confined to the uppermost members of the series.

The following table shows the relation of the Tarannon Shales of Conway to beds of similar age in the Lake District and Southern Scotland:—

CONWAY.	LAKE DISTRICT.	SOUTH SCOTLAND.
Tarannon Shales.	Browgill Shales.	Lower Gala.
* <i>Monograptus Becki</i> (Barr.)		*
— <i>broughtonensis</i> (Nich.)	*	
* — <i>crispus</i> (Lapw.)	*	*
— <i>concinus</i> (Lapw.)		*
* — <i>exiguus</i> (Nich.)	*	*
— <i>Flemingii</i> (Salt.)		*
— <i>galaensis</i> (Lapw.)		*
— <i>Hisingeri</i> , var. <i>nudus</i> (Lapw.)	*	*
— <i>prionon</i> (Bronn)		*
* — <i>pandus</i> (Lapw.)	*	
— <i>runcinatus</i> , var. (Lapw.) ...		*
* <i>Cyrtograptus spiralis</i> (Gein.) ...	*	
<i>Petalograptus ovatus</i> (His.)		*
— <i>palmeus</i> (Barr.)	*	*
<i>Diplograptus tamariscus</i> (Nich.)		*
* <i>Retiolites Geinitzianus</i> (Barr.)...	*	
* — <i>obesus</i> (Lapw.)	*	*

It is interesting to note that several of the graptolites found in the Tarannon Shales of Conway seem to be identical with many Swedish forms of the same age.

3. The Wenlock Shales.

The correlation of these beds is matter of no difficulty; they seem to be the equivalents of the Pen-y-glog Slates of the Dee Valley

(Lake, Quart. Journ. Geol. Soc. vol. li. 1895, p. 9), the Brathay Flags of the Lake District (Marr, Geol. Mag. 1892, p. 535), and the Riccarton Flags of Scotland.

CONWAY.	DEE VALLEY.	LAKE DISTRICT.	SCOTLAND.
Wenlock Shale.	Pen-y-glog Slates.	Brathay Flags.	Riccarton Beds.
<i>Monograptus priodon</i> (Bronn).	*	*	*
— <i>vomerinus</i> , Nich.	*	*	*
— <i>personatus</i> (Tullb.).....	*	*	...
<i>Cyrtograptus Murchisoni</i> (Carr.)	*	*	...

There also occurs at Conway *Monograptus flexuosus*, which is a Swedish form of Wenlock Shale age.

4. The Denbighshire Grits and Flags.

The Denbighshire Grits and Flags, from their position above the Wenlock Shales, are in all probability the equivalents of the beds overlying the Pen-y-glog Slates in the Dee Valley, which Mr. Lake has shown (*op. cit.*) to be of Lower Ludlow age.

Approximate Correlation of Beds.

CONWAY.	CENTRAL WALES AND WESTERN ENGLAND.	LAKE DISTRICT.	SCOTLAND.
Denbighshire Grits and Flags.	Denbighshire Grits and Flags. { Nant-Glyn Flags, Moel-Ferna Slates, and Pen-y-glog Grit.	Coldwell Beds.	
Wenlock Shales.	Wenlock Shales (Pen-y-glog Slate).	Brathay Flags.	Riccarton Flags.
(Upper beds absent.) Tarannon Shales.	1. Zone of <i>Retiolites Geinitzianus</i> , <i>C. Grayæ</i> . 2. Zone of <i>Monograptus turriculatus</i> , <i>M. exiguus</i> , etc.	Upper Browgill Beds. Lower Browgill Beds.	Upper Gala Beds. Lower Gala Beds.
Upper Llandovery Beds.	Llandovery Beds of Cardigan and Dee Valley.	Upper Skelgill Shales.	Upper Birkhill Shales.

VI. GENERAL CONCLUSIONS.

From the facts brought forward in the present paper it is evident that rocks of Llandovery age do occur in North Wales, and hence that the stratigraphical break in that region between the Silurian and Ordovician rocks is, at any rate, far less actually than has hitherto been supposed.

The type of Llandovery rocks developed at Conway is more closely related to that of Southern Scotland and Northern England than to that of the typical Welsh Borderland area, and it is interesting to observe that here, at any rate, deep-water conditions prevailed from Upper Llandovery to Wenlock times.

With regard to the Tarannon Shales, Wenlock Shales, and Denbighshire Grits and Flags, they differ in no essential respect from those found in the Dee Valley, which have been recently shown (Lake, Quart. Journ. Geol. Soc. vol. li. 1895, *op. cit.*) to be the normal type, and therefore require no further comment.

Our best thanks are due to Mr. J. E. Marr, F.R.S., and Prof. Charles Lapworth, F.R.S., for much kind help and assistance in our work.

DISCUSSION.

The PRESIDENT said that the Authors of this paper had made an exhaustive survey of a limited area, collecting the fossils and correlating with care the graptolites from each horizon. Such work deserved the Society's praise, as following the example of Prof. Lapworth and other careful workers. Such accurate field-work, coupled with careful palaeontological results, was of the greatest value.

Dr. Hicks said that he had listened with much interest to the paper, and he hoped the Authors would continue their researches into other areas in North Wales, for it is highly important that the fossil-zones in the beds forming the base of the Silurian in that area should be clearly defined. He had not examined the sections referred to by the Authors, but some years ago he found that the sandstones on the eastern side of the Conway valley (towards Llanrwst) contained *Nematophycus* and other fossils characteristic of the Pen-y-glog Beds near Corwen. He would have liked to hear whether the Authors considered that the deep-water beds of Upper Llandovery age at Conway rested directly on the Bala Beds, and whether there was an entire absence of the beds near Bala classed by Mr. Ruddy as Lower Llandovery.

Mr. W. W. WATTS congratulated the Authors on a most admirable piece of work. He pointed out how the Upper Llandovery rocks had been gradually recognized and extended. There was no gap between those of Shropshire and of Conway, for the rocks had been recognized on the Breiddens, near Meifod in Montgomeryshire, and in the Berwyns. There appeared to be no evidence of conformity between the Ordovician and Silurian rocks in the Conway district, in spite of the fact that somewhat deep-sea beds had been found there. He hoped that the Authors would recognize the *Monograptus colonus*- and *M. leintwardinensis*-beds in the Denbighshire Grit.