in the lobe of the fin itself there is a series of four well-defined, hourglass-shaped supports. Of these bones the anterior three are much elongated, and nearly equally slender, while the fourth is much more robust and expanded at its distal end. The four elements radiate from the anterior half of the base of the fin; and it seems very probable that some smaller cartilage behind and near the distal border of the lobe have disappeared from lack of ossification. The fin-rays gradually increase in length from the anterior border to the middle of the lobe, whence they decrease again backwards, and finally become extremely delicate."

In my collection there is a specimen of *Cœlacanthus tingleyensis*, Davis, from the Cannel Coal, Middle Coal-measures, Tingley, Yorkshire, crushed vertically, which exhibits the pectoral fins, and one, the left, shows characters very similar to those given by Dr. Smith Woodward. The clavicle is well shown and springing from a point about its centre; and opposite to the process which is usually seen on these bones there are six basal supports, of which the anterior four are elongated and more or less uniform in thickness, the fifth is more nearly hourglass-shaped, and the sixth (fourth of Dr. Woodward ?) is more robust and widely expanded distally. No supports are seen posteriorly to the sixth, but as the dermal rays extend some distance behind this point, and as the lobe of the fin has here suffered somewhat from crushing, it seems highly probable that there were two, if not three, supports posterior to the sixth, but that they have in the specimen been destroyed during fossilization. At their distal extremities each support is opposed to two or more of the dermal rays, which, as pointed out by Dr. Woodward, "increase in length from the anterior border to the middle of the lobe, whence they decrease backwards, and finally become extremely fine." All the rays are closely articulated distally.

From the above it will at once be seen, as pointed out by Dr. Woodward, that the pectoral fin of *Cœlacanthus* is a striking contrast to that of the existing Crossopterygian *Polypterus*, the basalia more closely approaching that of the Actinopterygii.

NOTICES OF MEMOIRS.

I.—The Movements of Underground Waters of Craven.[1]—First Report of the Committee, consisting of Professor W. W. Watts (Chairman), Mr. A. R. Dwerryhouse (Secretary), Professor A. Smithells, Rev. E. Jones, Mr. Walter Morrison, M.P., Mr. G. Bray, Rev. W. Lower Carter, Mr. W. Fairley, Mr. P. F. Kendall, and Mr. J. E. Marr. (Drawn up by the Secretary.)

THE Committee is carrying out the investigation in conjunction with a Committee of the Yorkshire Geological and Polytechnic Society. The present is merely an interim report, as the work is still in progress.

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

It was decided that the first piece of work should consist of an investigation of the underground flow of water in Ingleborough. This hill forms with its neighbour, Simon's Fell, a detached massif, which is peculiarly suitable for investigations of this nature. The summit of the group is formed of Millstone Grit, then follow Yoredale Shales and Sandstones, the whole resting on a plateau of Carboniferous Limestone. Many streams rise on the upper slopes of the hills and flow over the Yoredales, but without exception their waters are swallowed directly they pass on to the Carboniferous Limestone, to reappear as springs in the valleys which trench the plateau.

The Committee first turned its attention to tracing the water which flows into Gaping Ghyll hole. It was generally believed that the water issued at a large spring immediately above the bridge at Clapham Beck Head and immediately below the entrance to Ingleborough Cavern. On April 28 specimens of the water from this spring were taken for analysis before the introduction of any test. Two cwt. of ammonium sulphate was then put into the water flowing into Gaping Ghyll, and at the same time the amount of the water was gauged and found to be equivalent to 251,856 gallons per diem. A few hours later a second quantity of 2 cwt. of the same substance was introduced. On the same day 1½ lb. of fluorescein in alkaline solution was put into a pot-hole known as Long Kin East, about 1,300 yards north-east of Gaping Ghyll.

In view of the important influence which the direction of the joints in the limestone had been found to exercise over the flow of underground water,[1] the direction of the joints in the limestone clints in the neighbourhood of Long Kin East was taken, and was found to be N.N.W. to S.S.E., and to run in such a direction as to lead to the probability that the water would reappear at the springs at the head of Austwick Beck, and these were consequently watched.

The ammonium sulphate put in at Gaping Ghyll reappeared at the large spring at Clapham Beck Head on the morning of May 3, and continued to flow until the evening of May 6, when the water again became normal. Thus the time occupied by the ammonium sulphate in travelling from Gaping Ghyll to Clapham Beck Head, a distance of one mile, was about five days. No ammonium sulphate was found in any of the other springs in Clapdale. This result proved beyond doubt that Gaping Ghyll was connected with Clapham Beck Head.

The fluorescein put in at Long Kin East showed itself at Austwick Beck Head, but not at any of the neighbouring springs, on May 11, having taken over thirteen days to travel, the delay being probably due to the small amount of water flowing at the time of the experiments.

These results are of considerable importance, as they definitely reveal two lines of divergent movement of these underground waters, and indicate a subterranean watershed of much interest.

[1] See previous investigations of the Yorks. Geol. and Polyt. Soc. Committee.

The influence of the master-joints of the Carboniferous Limestone in determining the direction of flow of these underground waters was also, as at Malham, clearly shown.

The next set of experiments was carried out by the joint Committee on June 8 and following days.

In order to confirm the results in connection with the Gaping Ghyll to Clapham Beck Head flow, and further to ascertain more definitely if there existed any connection between Gaping Ghyll and the smaller springs in Clapdale, 10 cwt. of common salt was put into the waters of Gaping Ghyll on June 4, and a further 10 cwt. on June 5, samples of the water from each of the springs being taken several times a day until June 25.

One pound of fluorescein in alkaline solution was introduced into the stream flowing through Ingleborough Cave on June 8 at 10 p.m., at the point where the water plunges down a hole in the floor of the cave, and marked 'Abyss' in the 6-inch Ordnance map. Five cwt. of ammonium sulphate was introduced into a sink on the allotment, about 500 yards north-east of Long Kin East, on June 9, at 3 p.m.; and at 3·15 p.m. on the same day 1 lb. of fluorescein in alkaline solution was poured into the stream which flows past the shooting-box on the allotment and sinks near the Bench Mark 1320·1.

The fluorescein introduced into the abyss came out of Clapham Beck Head, and possibly at Moses Well and other springs in Clapdale, but this point requires further investigation, the evidence being as yet somewhat unsatisfactory. The salt from Gaping Ghyll appeared at Clapham Beck Head on June 15, 16, 17, 18, 19, 20, and 21, being at its maximum on June 18, but not at any of the other springs.

The ammonium sulphate put into the sink on the allotment appeared at Austwick Beck Head on June 22, the other springs in the neighbourhood being unaffected on that day; but on the 24th and 25th there were slight increases in the amount of ammonia in two small springs in Clapdale, viz., the small spring below Clapdale Farm and Cat Hole Sike. As one of these streams is close to the farmyard, and the other was at the time nearly dry and flowing through pasture land, no importance is attached to these slight increases. Of the fluorescein put in below the shooting-box no trace has since been found, and the same is the case with ½ lb. of methylene blue introduced into Grey Wife Sike, above Newby Cote.

Several most interesting problems still await solution in this area, one of them being the relations of the Silurian floor which underlies the Carboniferous Limestone of the plateau to the flow of underground water. The two sinks Gaping Ghyll and Long Kin East are only about 1,300 yards apart, and yet the waters of the one take a direction quite distinct from those of the other, and eventually emerge in a separate valley, the distance between the springs being 1½ miles apart, the great mass of Carboniferous Limestone known as Norber, a hill upwards of 1,300 feet in height, lying between the two valleys. In Crummack Dale it is seen that the Silurian rocks

form a ridge running in an approximately north-west and south-east direction, and unconformably overlain by the Carboniferous Limestone. If this line be continued it separates the Gaping Ghyll to Clapham Beck Head flow from that of Long Kin East to Austwick Beck Head. Thus it appears that this ridge of Silurian rocks forms an underground water-parting, which the Committee hopes to be able to trace for a considerable distance across the area.

The magnitude of this undertaking will be to some extent realized when it is stated that upwards of 400 samples of water have been tested for common salt, ammonium, and fluorescein, making in all upwards of 1,200 tests. The whole of the grant of £40 has been spent upon the investigation, and a small sum in addition. The experiments which have been carried out have indicated which are the most suitable reagents for use in different cases, and it is consequently hoped that future investigations will be carried out at rather less cost than has been the case up to the present. The Committee ask to be reappointed, with a grant of £50.

II.—The Underground Waters of North-West Yorkshire.[1]

By Rev. W. Lower Carter, M.A., F.G.S., Hon. Sec. Underground Waters Committee, Yorkshire Geological and Polytechnic Society.

Part I. The Sources of the Aire.

THE Silurian and Carboniferous rocks between Malham Tarn and Malham are traversed by two branches of the Craven Fault with the downthrow to the south. Malham Tarn lies on Silurian, and its overflow sinks in the limestone directly the northern fault is crossed. The drainage of the area to the west of the Tarn disappears at the Smelt Mill Sink. The drainage of the area east of the Tarn is carried off by Gordale Beck, along the course of which some water sinks into the jointed limestone. To these three sinks correspond three principal outlets, the stream at Malham Cove, Aire Head Springs, and the springs at the bottom of Gordale.

The history of previous investigations is then given. From the centre of Malham Cove a dry limestone gorge runs in a northerly direction to the Tarn. Up to the beginning of this century flood-waters were known to traverse this valley and discharge over the Cove. There are several sinks along the line of this dry valley. Now all the overflow is taken by three sinks south of the Tarn.

Various efforts have been made to trace the connection between the sinks and outlets. Flushes of water from the Tarn have been shown to affect Aire Head before Malham Cove. Experiments by introducing chaff, bran, magenta, and uranin into the sinks failed to show any traces at the outlets.

The present investigation was carried out during 1899, by a Committee of Engineers, Chemists, and Geologists, appointed by the Yorkshire Geological and Polytechnic Society. Flushes of water were sent down from the Tarn to the Tarn Water Sinks.

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

Aire Head Springs responded in two hours. With large flushes a rise in Malham Beck was also observed.

The chemical investigations were as follows:—

Ammonium sulphate was put in below the Malham Tarn Sluice on June 22, and appeared at Aire Head from July 4 to 11. Distinct traces were also found at Malham Cove on the same dates.

Common salt and fluorescein, put in at the Smelt Mill Sink between June 22 and 28, appeared at Malham Cove from July 4 to 11.

Fluorescein, put in at Tranlands Beck on June 22, appeared at Scalegill Mill on June 23.

Ammonium sulphate, put into upper Gordale Beck on August 26, appeared at the springs below Gordale Scar on September 7.

Common salt, put into Cawden 'Burst' on September 18, appeared at Mire's Barn from September 23 to 27.

Fluorescein put into the bottom of Grey Gill Cave was not traced.

A geological investigation of the area showed that the limestone is traversed by two sets of prominent joints, of which the master-joints, which run in a north-west to south-east direction, are very well developed. These master-joints are found to largely determine the flow of the underground waters. The direction of these master-joints unites the Smelt Mill Sinks and Malham Cove directly, and that may be taken as the direction of flow. A parallel line from Malham Tarn Sinks would bring the water from them to Grey Gill, a dry valley in the escarpment to the east of Malham Cove. No evidences of moving water were found there.

To the south of the Mid-Craven Fault the jointing of the limestone is found to be variable; but prominent joints were found bearing in a north-east and south-west direction. If the Tarn water followed these joints on crossing the fault it would traverse a direction almost at right angles to its previous course, and following the limestone in its bend underneath a synclinal of Yoredale shale, would be likely to reappear at Aire Head Springs, which is the nearest point for re-emergence on the southern side of the anticlinal.

The master-joints north of the Mid-Craven Fault would similarly carry the water which sinks into the bed of Gordale Beck south-eastward into the limestone, and if, as it nears the fault, it followed a set of joints running at right angles to the previous set, it would come out at the springs at the foot of Gordale Scar, which was found to be the case by the chemical tests. Gordale itself turns in this direction from some cause.

The conclusions of the Committee are:—

1. That Malham Cove Spring discharges the water from Smelt Mill Sink and the limestone area west of the dry valley; and under certain conditions some of the Tarn water.

2. That Aire Head Springs discharge the main portion of the water disappearing down Malham Tarn Water Sinks.

3. That Gordale Beck Springs discharge the water sinking in Upper Gordale.

4. That chemicals put into Cawden 'Burst' appeared at Mire's Barn.

5. That Tranlands Beck Sinks discharge at Scalegill Mill.

6. The investigations show that within the area the main direction of underground flow is along the master-joints of the limestone.

III. — The Caves and Pot-holes of Ingleborough and the District.[1] By S. W. Cuttriss.

THE portion of Yorkshire to which this paper refers is contained in Sheets 49, 50, and 60 (New Series) of the 1-inch Ordnance Survey. The great Craven Faults which traverse it in a north-west to south-east direction have produced a difference of level of the strata of several thousands of feet; the limestones on the south side of the Faults being far below the surface.

The Silurian slates and grits form the basement beds, and are exposed in several of the valleys. On these rests the Carboniferous Limestone, which has a thickness of about 500 feet from the base to the present exposed surface on Ingleborough. The name Carboniferous Limestone is here applied only to distinguish a particular bed of rock in the district. Above this are a series of thinner limestones, shales, and sandstones (the Yoredales of Professor Phillips), capped by Millstone Grit.

Towards the west the Carboniferous Limestone has been cut off by the Dent Fault, while the Craven Faults determine its extension towards the south. The main line of fault passes through Ingleton, Clapham, and Austwick to Settle, then eastwards by Malham. North of this is another fault, near the first at Austwick, but about 1½ miles apart at Malham. Further north the most interesting caves and pot-holes are found in an area comprising the Leck Fells, Kingsdale, Chapel-le-Dale, Ribblesdale, and around Ingleborough.

The whole area may be divided into three sections :—

1. The Yoredales, comprising the rocks of that name. These limestones being comparatively thin, and intercalated with beds of shale and sandstone, the caves are small and obstructed with earth, through which the water percolates. They are at an elevation of from 1,300 to 1,600 feet, and do not materially affect the drainage of the ground.

2. The Southern Carboniferous, including the Carboniferous Limestone between the two Craven Faults. Although part of the same formation as the Carboniferous Limestone north of the Fault, yet the caves in the two sections differ entirely in their characteristics. Here they are distinguished by an absence of running water, the walls are covered with a considerable thickness of calcareous deposit, and their entrances are blocked with clay and rock débris. The well-known Victoria and Attermire Caves are included in this section. A further characteristic is the entire absence of pot-holes—vertical chasms in the ground caused by falling water enlarging the rock fissures.

3. The Main Carboniferous, which includes the remainder of the Carboniferous Limestone within the area defined. Here there are no

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

dry caves, all being active drainage channels. Pot-holes also are very abundant. In the Leck Fell and Kingsdale districts the caves are almost without exception those of engulfment, while in Chapel-le-Dale and Ribblesdale they are chiefly caves of débouchure. The first-named are usually low at the entrance. The passages then increase in height to 20 feet or more, but rarely exceed 6 feet in width, usually much narrower. Some may be traversed a quarter of a mile or more, such as Lost John's Cave, which terminates in a subterranean pot-hole over 100 feet deep. The caves of débouchure are much more numerous. The mouth is generally wide and shallow, with a flat roof. A cascade or waterfall is usually found some little distance in, beyond which the passage is a simple water-worn channel, gradually shallowing and broadening until too low to permit of further progress.

The pot-holes occur at or near the top of the limestone, at between 1,100 and 1,300 feet elevation, and always where there are surface streams, which fall into the chasms. Over thirty have been named, nearly all of which have been descended by the writer and friends, members of the Yorkshire Ramblers Club, many of them for the first time. Half the number are over 100 feet deep. Gaping Ghyll, on Ingleborough, attains a depth of 350 feet, and was first descended by Monsieur E. A. Martel, in 1895. Rowten Pot, in Kingsdale, was conquered in 1897, and found to be 365 feet deep, thus being the deepest known pot-hole in the country.

No evidence of the presence of the Silurian rocks has been found, the lowest observable rock being either light or black limestone. The average Summer temperature in both caves and pot-holes is 48° Fahr.

The writer has prepared a special map of the district on which are shown all the known caves and pot-holes, with the surface streams. Such a map illustrates in a forcible manner the interesting fact that the entire surface drainage of Ingleborough is swallowed up by the limestone. Not a single stream from the higher levels continues an uninterrupted course into the valley below.

IV.—The Outcrop of the Corallian Limestones of Elsworth and St. Ives.[1] By C. B. Wedd, B.A., F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

THE ferruginous and oolitic limestones known as the Elsworth and St. Ives Rocks are now generally believed to be one and the same, an opinion supported by my own work in that district recently. The limestone in question has long been known to occur at St. Ives in brick-pits, being well exposed to the west of the town. It was known also to occur throughout the village of Elsworth. Mr. Cameron noticed a fossiliferous rock outcropping near Hilton, between Elsworth and St. Ives. No other surface exposures were known, but a similar rock was found in the railway cutting at Bluntisham, north-east of St. Ives, at Swavesey, east of the same

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

place, and Bourn, south of Elsworth, and a few other localities, and like rock was found in Wells.

The outcrop can be traced almost continuously from a mile west of the brickyard at St. Ives, striking eastwards along the northern flank of the Ouse valley, and passing north of St. Ives to Needingworth; here it bends abruptly southwards to Holywell and forms a gentle rise. The southern part of the village of Holywell stands on a gravel-capped escarpment of the rock; a collection of fossils in the Woodwardian Museum, Cambridge, agreeing closely with those of the Elsworth and St. Ives Rocks, was believed to have come from Holywell. East of Holywell the outcrop must cross the Ouse valley; I found traces of the rock in a drain some distance west of Swavesey. From here, south-westwards, it is not seen again till it appears at the surface between Hilton and Conington, where a rock was noted by Mr. Cameron. Southwards from here the outcrop crosses a valley to the rising ground west of Elsworth, through which village a narrow tongue of the rock runs still further south. The main outcrop, however, flanks the northern slope of the drift-capped high ground to the west, and can be traced along the slope through Papworth Everard, westwards to Yelling, following the contour of the ground. At both of these localities there are good and highly fossiliferous exposures in streams. Thence the outcrop disappears southwards under drift, but the rock may be seen again to the south, less than two miles south of Croxton, in a ditch in the valley of the Abbotsley Brook.

To the north, east, and south-east of the line of outcrop of this limestone, the ground is occupied by Ampthill Clay, to the west by Oxford Clay. It will thus be seen that the Elsworth and St. Ives Rocks, besides agreeing closely in their fauna, outcrop along the same line of strike, with Ampthill Clay above and Oxford Clay below. The dip is always small, and the rock at Bluntisham, if it reaches the surface at all, does so probably as an inlier, though it may be directly connected at the surface with the outcrop east of St. Ives.

V.—On Rapid Changes in the Thickness and Character of the Coal-measures of North Staffordshire.[1] By W. Gibson, F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

VARIABILITY in thickness and character of the strata is universal throughout the Carboniferous period, but is nowhere more marked in the Midlands than in the coalfield of the North Staffordshire Potteries.

This important coalfield consists of two portions. On the east the productive measures lie in a well-marked syncline, while on the west the strata rise in a sharp anticline extending from Silverdale to Talke. The two productive areas are separated by a strip of ground two and a half miles broad, composed of barren upper measures.

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

A notable difference in the thickness of the strata and nature of the coal-seams characterizes these structurally distinct areas. In the centre of the syncline, near Shelton, the vertical distance between the highest ironstone, or summit of the productive measures, to the Bullhurst coal, or lowest workable seam, is about 1,300 yards. On the anticline at Apedale only 800 yards of strata separate the same horizons. This makes a remarkable decrease in thickness of 500 yards of strata in a distance of under three miles. The reduction in thickness westward of the productive measures is continued, though in a less degree, in the upper barren series, but owing to the absence of shaft sections the amount cannot be definitely stated. It is known, however, that the red marls forming the lower portion of the upper barren series are more than 1,000 feet thick near Etruria station on the Shelton property, and about 850 feet thick near Silverdale, on the south-eastern limb of the anticline. With the decrease in thickness a change has taken place in the lower coals of the productive series. The seams which are house or steam coals on the east change into gas and coking coals on the west.

This great variability seems to show that separate areas of deposit were being marked out by local movements of elevation and depression, and thus fulfilling in North Staffordshire the conditions characteristic of the Carboniferous of the Midlands generally, as pointed out by Professor Lapworth.[1]

In North Staffordshire it happens that the areas of maximum and minimum deposit correspond with a syncline and anticline. If this be true generally, and not merely a local coincidence, we may expect the coals in the unexplored coalfield which lies at the surface to the west of the anticline, and which represents the eastern margin of the great synclinal of Coal-measures beneath the Cheshire plain, to be of a different quality from those in the anticline, while the thickness of the measures will be increased.

VI.—On some Fossil Fish from the Millstone Grit Rocks.[2]

By Edgar D. Wellburn, F.G.S.

THE Millstone Grits are naturally grouped into three divisions, viz.: (1) Rough Rock; (2) Middle Grits; (3) Kinder Grits at base. The Middle Grits, consisting of grits, sand, shales, are subdivided into A, B, C, and D beds, A being uppermost. The Pennine Anticline is mostly composed of these rocks, and on the Lancashire side at the head of Calder Valley, on the south side in a quarry at the summit, there is a good exposure of the D shales; in these the majority of fish remains were found; a few occurred at the same horizon at Wadsworth Moor, Sowerby, Kilne House Wood, and Eccup, Yorkshire. The majority are in nodular masses, few in shales, and are associated with a marine fauna. The fish-bearing beds were formed under marine estuarine conditions. They are of great geological and zoological interest, as largely increasing

[1] "A Sketch of the Geology of the Birmingham District": Geol. Assoc., 1898, p. 364.

[2] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

our knowledge of the fish fauna in rocks whose yield of fish remains has hitherto been extremely limited; and zoologically inasmuch as (1) one genus and several species are new; (2) one Lower Old Red Sandstone fish is present; (3) the occurrence of the Lower Carboniferous types, *Orodus*, *Psephodus*, *Pristodus*. The author made some remarks on the fish remains, and exhibited a table of their stratigraphical distribution.

REVIEWS.

I.—The Geology of Central and Western Fife and Kinross. (Memoirs of the Geological Survey of Scotland.) By Sir Archibald Geikie, F.R.S., D.C.L., etc., Director-General. With Appendix of Fossils by B. N. Peach, F.R.S. 8vo, cloth; pp. x, 284. (Glasgow: printed for H.M. Stationery Office, 1900. Price 5*s*. 6*d*.)

THIS well-printed memoir is in the main a description of the geological formations which are represented in Sheet 40 of the Geological Survey map of Scotland, which was published in 1867. The ground was surveyed in part by the author, and in part by Mr. H. H. Howell, Prof. John Young, Prof. J. Geikie, and Mr. B. N. Peach, when Murchison was Director-General. It is not surprising, therefore, that the nomenclature, especially of the igneous rocks, has undergone considerable changes, noticeable when we compare the tablets on the map with the table on p. 13 of the memoir. Much additional information on the coalfields has, however, in recent years been obtained by Mr. J. S. Grant-Wilson, and the Director-General has himself revisited the area from time to time. Consequently every effort has been made to bring the information up to date by personal observation, and with the help of other workers whose publications are listed in the Appendix. It is needless to add that in point of style the memoir bears the most favourable comparison with any previously published by the Geological Survey.

The country described is a highly important one, extending from the Firth of Tay west of Tay bridge to the Firth of Forth at Queensferry. It is composed chiefly of Carboniferous rocks and Old Red Sandstone, with numerous interstratified and intrusive igneous rocks. In the northern part is the Ochil chain, formed mainly of hard lavas of Lower Old Red Sandstone age; the central part, in which lies Loch Leven, is hollowed out of comparatively soft red sandstones forming the plains of Kinross and the Howe of Fife; and in the southern part there is again a belt of hilly ground, more varied and broken than that in the north, and composed mainly of Carboniferous rocks with hard eruptive sheets, which form the Lomond Hills and other prominent heights.

While perusing the very interesting Introductory chapter it would have been useful to the reader to have had a small map depicting the main outlines of the geology and topography, with the names of