has been noticed. In that rock, however, felspar is present, described as plagioclase and idiomorphic. In the boulder, the dusty-looking or opaque white substance clearly is interstitial, and is now steatite, a decomposition product of a rhombic pyroxene. The specimen appears to be nearest to the group of the picrites, to the form of that rock not containing felspar. It is somewhat intermediate between the typical augite-picrite and the variety distinguished by Professor Bonney as hornblende-picrite, and it has a likeness to the Penarfynydd rock.¹ So far as I am aware, it has not been recognized *in situ* in the Zmutt district, and it will be interesting if any climber in that neighbourhood should track it to its home. The boulder being large, it most probably came directly from some of the neighbouring heights, possibly from the western side of the Matterhorn, gabbro, according to the Swiss map, occurring from the watershed down at intervals to the neighbourhood of the Zmutt glacier. This hornblende-picrite is interesting as another variety of the basic igneous rocks, varying from serpentine to gabbros, which form a widespread group, extending at least from the Saas Valley to the Val d'Hérens.

IV.—ON THE SUBDIVISIONS OF THE CARBONIFEROUS SERIES IN GREAT BRITAIN, AND THE TRUE POSITION OF THE BEDS MAPPED AS THE YOREDAL SERIES.

By WHEELTON HIND, M.D., B.S.Lond., F.R.C.S., F.G.S.

(Concluded from the April Number, p. 169.)

THE earlier part of this paper is devoted to a short epitome of the stratigraphical evidence that the Yoredale rocks of Wensleydale are only the equivalents of the upper part of the Carboniferous Limestone, and that the so-called Yoredale Beds of South Yorkshire, Lancashire, and Derbyshire are an entirely different series, which occupy a position above the Carboniferous Limestone. After all, the important point is the palæontological evidence, which, to my mind, is absolutely conclusive.

On comparing the Molluscan fauna of the limestones and shales of the Yoredale Rocks of Professor Phillips with that of the Carboniferous Limestone of Derbyshire, it is at once seen that they are practically identical. In the list of fossils given in the Appendix to the Geological Survey Memoir on the country round Mallerstang,² 110 named species of corals, echinoderms, annelids, crustaceans, polyzoa, and mollusca are enumerated, the great majority of which are common to the Yoredale Series and Great Scar Limestone. But no species occur which are peculiar to the upper beds, and which do not occur in the mass of Carboniferous Limestone in one locality or another. On palæontological grounds, therefore, no distinction can be drawn between the Yoredale Series of Wensleydale and the main mass of Carboniferous Limestone, though it would not have been surprising, considering the differences of lithological character

¹ Cf. T. G. Bonney in GEOL. MAG. 1880, p. 208. A. Harker, loc. cit.

² Explanation of Sheet 40, Geological Survey.

in the deposit, if such had been the case. Not only do the Yoredale Rocks of the Wensleydale area contain no distinctive fossils peculiar to themselves, but many species recur again and again in beds separated from each other by many feet of different strata, in which often plant beds occur and at times well-marked seams of coal, proving that terrestrial conditions obtained between deposits containing a similar fauna. There is no possibility, thanks to the nature of the ground, that the series of limestones are only one bed, repeated by a succession of folds; and the only alternative is, that owing to an unsuitable environment the fauna migrated and lived on in an outside area, ready to return when suitable conditions obtained. This was, of course, Barrande's theory for his "colonies," for the truth of which it would appear that the Carboniferous rocks afford abundant evidence, and the series of Carboniferous rocks in Scotland give a good example.

In Scotland, beneath the Coal-measures, there is a long series of alternating beds of sandstones, shales, limestones, and coals as an upper division, and the Calciferous Sandstone Series as a lower division, consisting of shaly clays and argillaceous limestones, oil shales and sandstones. The fossils characteristic of the Carboniferous Limestone of England are found throughout the upper series in those beds which are of marine origin, and occasionally in thin bands in the Lower or Calciferous Sandstone Series. In the beds of this series on the Fifeshire coast, Mr. J. W. Kirkby, of Leven, has enumerated no less than eighteen such marine horizons distributed chiefly in the upper and lower portions of 4000 feet of strata ("On the Zones of Marine Fossils in the Calciferous Sandstone Series of Fife": Quart. Journ. Geol. Soc. 1880, vol. xxxvi, p. 559). One hundred and fifty-two species are enumerated, of which only seven appear to be new and therefore, as far as is known at present, peculiar to the series; but a few others belong to fresh- or brackish-water beds.

It is curious to note that between 500 and 2280 feet no marine bands have as yet been discovered, and only four occur in the first 600 feet; the 1780 feet of intervening beds being composed of repeated alternations of sandstones of various colours, shales, marls, and ironstone bands, in several of which, but chiefly in the argillaceous beds, plant-remains are fairly plentiful.

It is evident, too, that the Carboniferous Limestone fauna did not die out with the close of that period, even as expressed in the rocks of the Derbyshire-Yorkshire area; for, although absent from the strata for intervals of time represented by many hundred feet of deposit, there are occasional recurrences of certain typical fossils of that fauna in certain widely separated localities at different horizons.

Mr. J. Ward has shown three bands with a marine fauna to exist high up in the North Staffordshire Coalfield, two of which contain several well-known Carboniferous Limestone species, the third only *Lingula squamiformis*. I make no mention of the marine bands containing *Goniatites Listeri* and *Aviculopecten papyraceus*, as these

shells do not belong to the fauna contained in the limestones. At Coalbrookdale *Spirifer bisulcatus* and *Productus scabriculus* occur with other marine shells in the Penneystone Ironstone of the Coal-measures, which, however, do not occur in the Carboniferous Limestone.

In a bed of shale containing calcareous bullions, situated above a gannister-like sandstone, some little distance below the third bed of Millstone Grit on Congleton Edge, is a fairly rich fauna, containing, amongst others, *Productus* (four species), *Spirifer*, *Athyris*, *Orthis*, *Streptorhynchus*, *Chonetes*, *Terebratula*, *Discina*, and *Lingula*, all of which are found in the limestone, but are absent in all the intervening beds. It is difficult to arrive at any satisfactory conclusion as to the whereabouts of this Carboniferous sea in which the limestone fauna survived, and it is questionable if a discussion of the matter would be productive of any benefit.

The proper fauna of the beds between the Millstone Grits and the Carboniferous Limestone in the Yorkshire-Derbyshire area is a very typical one, though not peculiar, in any particular, to this horizon; in fact, it is identical with the fauna which is found in the marine beds of the Gannister Series of the Lower Coal-measures. The evidence for this fact has been lately much increased by the collections of Messrs. Holroyd and Barnes, in the beds exposed below the Millstone Grits in the valleys round Marsden and Saddleworth, and from the beds passed through in the London and North-Western Railway tunnel under Standedge Moor. I have been over the ground with these gentlemen, and have had the opportunity of gathering the fossils myself as well as of studying the fine series that they have collected during the last few years. The fauna is, taken as a whole, very similar to that which has always been considered characteristic of the Gannister Series of Lancashire, several species being identical with those found in the nodules of the roof of the Bullion Coal. Very few species, indeed, if any, are common to it and the Mountain Limestone fauna; but the three genera *Carbonicola*, *Anthracomya*, and *Naiadites*, which are so frequent in the Coal-measures, are all represented, the former by at least four well-marked species; and the shells themselves cannot be in any way distinguished from those occurring in the Coal-measures. It may be therefore emphatically stated, that the fauna of the shales which are situated below the Millstone Grit in South Yorkshire is totally distinct from that which characterizes the shales and limestones of Wensleydale.

Though not known to be so rich in species, the shales of Derbyshire and North Staffordshire contain a similar fauna, several species of *Goniates*, amongst which *G. reticulatus* is conspicuous, *Aviculopecten papyraceus*, and *Posidoniella laevis* occurring at several horizons. In Cheshire, however, on Congleton Edge, situated some 200 feet below the base of the Millstone Grit, here represented by the third, Rivelin or Roaches grit, is a bed of black shales in which are layers of calcareous nodules, which overlies a hard, fine, gannister-like quartzose rock. These concretions contain a rich

fauna, which, although peculiar with regard to its Lamellibranchs and Gasteropods, has a plentiful Brachiopod fauna, consisting of typical Carboniferous Limestone forms. The following species have been collected in this quarry by myself:—

<i>Terebratula hastata</i> .	<i>Productus semireticulatus</i> .
<i>Spirifer glaber</i> .	„ <i>longispinus</i> .
„ <i>bisulcatus</i> .	„ <i>cora</i> .
<i>Athyris planosulcata</i> .	„ <i>scabriculus</i> .
„ <i>ambigua</i> .	<i>Chonetes Lagueissiana</i> .
<i>Orthis resupinata</i> .	<i>Discina nitida</i> .
<i>Streptorhynchus crenistria</i> .	<i>Lingula mytiloides</i> .

LAMELLIBRANCHS.

<i>Myalina peralata</i> .	<i>Edmondia</i> , sp.
<i>Modiola transversa</i> (Hind).	<i>Sanguinolites</i> , sp.
<i>Nucula gibbosa</i> .	<i>Posidoniella semisulcata</i> (Hind).
„ <i>æqualis</i> .	

There are also several forms of *Goniatites*, *Nautilus*, *Orthoceras*, with Gasteropoda and Crustacean remains, including *Dithyrocaris testudineus*. It is to be noted that, although the Brachiopoda are Lower Carboniferous forms, the Lamellibranchs are peculiar.

Many fossils have been obtained from the shales in the neighbourhood of Todmorden, several of which are to be seen in the Manchester Museum, Owens College. This fauna is a very singular one, and remarkable for the number of species.

The nomenclature and lists given by authors are, however, not to be trusted, most of the forms having been named by Captain Brown, and the vast number of the names are only synonyms. Still, several forms of *Posidoniella* are present, of which, after an examination of all the types, fortunately preserved at Owens College, I recognize *Posidoniella lævis* (Brown), *P. minor* (Brown), *P. Kirkmani* (Brown), *P. variabilis* (Brown), *P. subquadrata*, sp. nov., *Aviculopecten papyraceus*, Sow., *A. fibrillosus*, Salter, *Nucula gibbosa*, Fleming, *N. æqualis*, Sow., *Goniatites reticulatus*, *G. stenolotus*, *G. carbonarius*, *G. Listeri*, and at least two new species.

J. W. Davis quotes (“West Yorkshire”) four species of *Nautilus*, ten species of *Goniatites*, fourteen species of *Orthoceras*, together with a very rich Gasteropod fauna, from the same bed. I am not well enough acquainted with these groups to say anything as to the value of the large number of species here enumerated, but the common Mountain Limestone species are all conspicuously absent.

With regard to the Brachiopods, only three are mentioned by authors—*Orthis resupinata*, *Productus Martini*, and *P. antiquatus*, Gibson; but I have not seen these specimens, and from the curious nomenclature nothing can be said at present as to what species occur at Todmorden; still, the essential fact remains that, on the whole, Brachiopoda are conspicuously absent.

The shales of Flasby are credited with a long list of *Goniatites*, among which are *G. Listeri*, *G. Longthorni*, and *G. reticulatus*, all of which occur in the Gannister Series of the Lower Coal-measures.

Viewing, therefore, as a whole the fauna of these shales, it cannot

but be noted that it is totally different from that of the Mountain Limestone, and also of the Yoredale Series of Wensleydale; and the question at once arises as to the correctness of applying the term Yoredale to them, seeing that they differ so essentially, both lithologically and palæontologically, from those beds to which the term was originally applied. There is in these beds an absence of the limestones which are so characteristic of the series in Wensleydale, and this may at first sight appear to account for the difference in the faunas; but, as a matter of fact, some of the shales in Wensleydale are far richer in organic remains than the limestones, and these remains are typically those which occur in the great mass of limestone.

Indeed, if my contention be correct, that the Yoredale Series of Wensleydale is the homotaxial equivalent and also the chronological representative of the massif of limestone so typical of Derbyshire, then the black shales of North Staffordshire, Derbyshire, and South Yorkshire belong altogether to a higher horizon and are not in any way the equivalents of any beds of the Yoredale Series. If stratigraphical division be necessary, the only reliable data, in the absence of unconformity or some well-marked change of lithological character, are of a palæontological nature; and this evidence points undoubtedly to a closer biological connection between the so-called Yoredale Beds of Derbyshire with those above, and the Yoredale Beds of North-West Yorkshire with those below. It appears to me that the so-called Yoredale Beds of Derbyshire and Yorkshire should really be included in the Millstone Grit Series, as they contain a very similar fauna and flora, and, moreover, certain very well developed sandstones, often extremely difficult to separate on lithological grounds from true grits.

There are three very different molluscan faunas in Carboniferous rocks, and I have yet to be convinced that they are actually intermingled in the same bed, though there can be no doubt that they overlap each other somewhat.

- No. 1.—The Coal-measure fauna, rich in fish-remains, with the molluscan genera *Carbonicola*, *Anthracomya*, and *Naiadites*; essentially a fresh-water fauna.
- No. 2.—The Lower Coal-measure and Grit fauna, the Gannister and Grit Series, largely marine, but littoral; *Aviculopecten*, *Posidoniella*, *Goniatites*, *Orthoceras*, *Nautilus*, and peculiar Gasteropoda.
- No. 3.—The Limestone fauna, essentially marine, rich in corals, Polyzoa, very rich in Brachiopods; with *Pecten*, *Avicula*, *Edmondia*, *Sanguinolites*, and many other genera of Lamelli-branches, Gasteropods (*Euomphalus*, *Pleurotomaria*, *Murchisonia*, *Loxonema*, etc.), and Cephalopoda. Corals, Crinoids, and Fish-remains, many of these being peculiar to certain beds.

In a few localities, as at Congleton Edge (vide p. 207), we find a curious fauna, which would appear to be a mixture of a few of the Brachiopoda of the Limestone with a fauna on the whole

somewhat approaching that which obtained in the middle of the Carboniferous Series; but here, as at Coalbrookdale, it is only the Brachiopoda of the lower beds which are present, and this family appears to have comprised the hardest and most able of all forms of life to assimilate themselves to altered conditions.

These differences are due to bathymetric conditions, and the overlapping of the faunas to a return to conditions suitable for each group of organisms.

In the North Midlands the fossil flora is abundantly present, with the first fauna: present only in the sense of occurring in beds intercalated with the molluscan-bearing beds, except in the roof of the Bullion Coal, where there is drifted woody material in abundance. The flora is practically absent in the beds containing the lower fauna.

In Northumberland and Scotland the peculiar fauna characteristic of those shales which occur below the Millstone Grit in South Yorkshire is absent, although one or two species are quoted, but no reliance can be placed on the nomenclature of the *Goniatites* at present.

Aviculopecten papyraceus, so characteristic of these beds, is quoted by John Young ("The Carb. Foss. of the West of Scotland," p. 47) as rare, and it is noted by the Palæontologists of the Survey as occurring in shales some distance above the Ell coal (Wishaw district), and in the shale above the Calderwood cement-stone (E. Kilbride district: Mem. Geol. Surv. Scotland, Explanation of Sheet 23) is very much lower down, but in neither case do the other members of the fauna occur. This species is said to occur in the Carboniferous Slate of Clonakilty, co. Cork (Bailey), and in Carboniferous Limestone near Harrogate and Bolland (Phillips); but there is the gravest doubt in my mind as to the correctness of this specific determination, for according to my own observations this species is never found in the Carboniferous Limestone, but is characteristic of the Lower Coal-measures and Millstone grits and the shales below them.

I have shown (Pal. Soc., vol. xlix, Monograph on *Carbonicola*, *Anthracomya*, and *Naiadites*, pp. 82–145) that the genera *Carbonicola* and *Naiadites* both occur low down in the Calciferous Sandstone Series of Fifeshire, but that the species are different to those occurring in the Coal-measures; and I have pointed out that, similar conditions of deposit being suitable, the same genus returned at several horizons. In the slates of South Yorkshire not only do the same genera occur as obtain in the Coal-measures, but a very large number of the same species are common to the two horizons. These shells must have survived in some outside area, during the deposition of the intervening beds in which they are absent, to return when conditions became again suitable for their migration and survival. This theory demands, not that the beds of one deposit are continuous with other beds at two and more widely separated horizons, but that both beds, containing a practically identical fauna, were the result of one successively continuous series of events. This

argument, of course, applies equally well to those beds which have the typical Carboniferous Limestone fauna.

Now, if carried to its ultimate conclusion, the fact of the presence of these beds containing a Carboniferous Limestone fauna at various horizons in the Black Shales (Congleton Edge), the Millstone Grit (Sawley, near Ripon), the Lower Coal-measures (the roof of the Bullion Coal), and in the Coal-measures themselves (the Penneystone of Coalbrookdale, the roofs of the Gin Mine and Bay Coal, North Staffordshire), emphatically proves Sir Andrew Ramsay's contention that the Carboniferous system was one great succession without a break; because the fauna characteristic of its lowest beds survived during the whole of its duration, a few species probably being preserved into Permian times. But, notwithstanding this unity, there is a well-marked line along which a division can be made into Upper and Lower Carboniferous, for which there are strong grounds, both lithological and palæontological, that is, where limestones of typical marine character ceased to be deposited, and shales and grits with coals took their place, denoting a shallower water and more frequent return to terrestrial conditions, and containing a fauna for which these conditions were suitable.

I have shown in the introduction to my Monograph on the British Carboniferous Lamellibranchiata (Pal. Soc., vol. I, 1895, pp. 10–15) that the Carboniferous series as developed in Great Britain and also in Europe and North America, lend themselves best to a twofold classification, which I have summarized as UPPER CARBONIFEROUS or Anthraciferous, and LOWER CARBONIFEROUS or Calcareous series; and I need not enter further into detail here.

This base line of the upper division would, in Derbyshire, North Staffordshire, and Yorkshire, be at the top of the uppermost thin limestone; for in a few localities the massif of Carboniferous Limestone was succeeded by a short series of passage beds, containing thin limestones with a Carboniferous Limestone fauna, e.g. Butterton Moor, near Leek (Proc. Geol. Assoc., vol. xi, pp. cxxxi, cxxxii); and in the Wensleydale district and Northumberland the topmost bed of limestone would also form the limit, and this line of division is really a palæontological one, and not lithological, because it is at this horizon that the characteristic fauna of the Carboniferous Limestone series ceases to be persistent. The beds above the limestones would then be Upper Carboniferous, and would include the shales below the grits, the grits, and Coal-measures, characterized by faunas No. 1 and No. 2.

There is a great similarity between the deposits of this series, there being several workable coal-seams in the grit series, and many beds of coarse sandstone in the Coal-measures; and in addition, the whole of this series is characterized by an absence, with rare exceptions, of marine conditions. There occur frequent interruptions in deposit due to terrestrial conditions, and, moreover, the palæontology of this series is as a whole very different from that which obtains in the beds below, and is peculiarly characteristic of it.

Some objection may be taken to this division from the fact that

several beds of limestone occur at various horizons in the Coal-measures. But these beds have, as far as is at present known—and I have examined several, and many have been reported upon by officers of the Geological Survey and others—a totally distinct fauna to that which is entombed in the lower limestones; the one difficulty in the Midland area being whether to place the Pendleside limestones in the lower or the upper division. My own view is, that the fossils agree more with the fauna typical of the Carboniferous Limestone than with those above.

Again, it may be asked, why, with three distinct faunas, make a twofold division? and the answer is that, although it would be impossible to draw any line of demarcation between the beds containing faunas No. 2 and 1, which are so much intercalated, the fauna of the lower series is so characteristically different; or, with greater reason, it may be asked why even a twofold division? The reasons for this are, first, that a review of the Carboniferous rocks of the world seems to demand such; and, moreover, the fauna of the limestones, although it did occasionally reappear for a brief period in the upper beds, is so typical of the lower beds; and I claim that the binary division of Carboniferous rocks is therefore based solely on palæontological grounds. Mr. R. Kidston considers that the plants distributed through the Carboniferous rocks “clearly indicate a great twofold division,” and in the main his division is identical with mine, although he does not appear to recognize that the Yoredale Series of Wensleydale is only the equivalent of the upper part of the Carboniferous Limestone; but as he says that he has seen no plants from that series, and had no personal knowledge of that district, he has not based any evidence for his classification on those beds.

Geological science knows no hard and fast lines, and classification, though founded on natural laws, is not a law of nature, but purely utilitarian in purpose; but to be of any service at all, even the classification and division of series of strata must be based on the soundest palæontological evidence.

The recognition of the true place of the series of rocks in Wensleydale, although, of necessity, abolishing the term Yoredale Series as one of the primary divisions of Carboniferous rocks, does not render it obligatory for that term to altogether sink into disuse. The name may very well be used to denote the change of character in the series, due to causes which acted locally, and to represent the Carboniferous Series as it occurs in Wensleydale, Swaledale, Teesdale, and the upper parts of Wharfedale and Ribblesdale. But the use of the term must be restricted to this district, and beds of an altogether higher series, with a totally different fauna, must be no longer confounded with them because they appear to occupy a position between two arbitrary and discontinuous base-lines. Currents, reefs, and the differences in depth of a shelving shore, will account for any of the difficulties of tracing any one bed for a distance; and it must be remembered that much of the deposits must have been extremely local, and that many strictly synchronous

deposits must have differed entirely in their composition and mode of deposition, and that denudation will not account for all the apparent breaks which are discovered on attempting to map a district.

NOTE.—Mr. Morton writes that in the North Wales series, mentioned on p. 165, “the Arenaceous Limestone and Upper Black Limestone are one and the same subdivision.”—W. H., April 15, 1897.

V.—WATER *VERSUS* ICE AS AN EXPLANATION OF THE SURFACE BEDS OF EASTERN ENGLAND.

By Sir HENRY H. HOWORTH, K.C.I.E., M.P., F.R.S., F.G.S.

IN former papers on the surface deposits of Eastern England. I have analyzed the conditions of their occurrence and the character of their contents in view of the current theory which makes them the products of ice during an Ice Age. I have endeavoured to show that, tested by every empirical method, they utterly fail to sustain such a conclusion;—that in every character by which we can test these beds, or their component parts, they clearly and emphatically point to some other origin and cause than that of ice; and, on the other hand, that ice such as it is known to us, either in our laboratories or in Nature’s laboratory, is quite incapable of producing the results demanded from it by the champions of the Glacial School who have discussed the surface geology of Eastern England. This negative conclusion is, of course, a very important one when we consider what a dominating influence this School has at this moment, not only among official geologists, but among the pundits of Burlington House, where Lyell’s followers have pushed their master’s teaching to the most extravagant and outrageous length.

If ice be an impossible cause of the phenomena we wish to explain, and if the teaching of half a century on this question will certainly in great part have to be reversed, whither are we to turn, except to the cause which satisfied the *Patres Conscripti* of our science in the days when, before a man became a geologist, he thought it necessary to have a wide and generous training in other sciences and branches of knowledge, men who were mathematicians and physicists as well as geologists, who were in the habit of verifying the capacity of the causes to which they appealed, and who were not tied to some preposterous scholastic prejudice like the theory of Uniformity. They appealed without doubt or difficulty to Water and not to Ice as the main and the efficient explanation of the phenomena of recent geology. At their feet I learned what I know, and by their creed on this question facts and logic both compel me to abide. Water has this supreme claim over Ice, that, whereas the phenomena to be explained absolutely refuse to conform to the proved qualities of ice, they are all consistent with the qualities and characteristics of water. There is not one of them which is not so. Water can carry as heavy weights as ice, and can carry them as far.