tive appearance of the scales when found in an isolated, or detached condition.

Geological Position and Locality.—In the Blackband Ironstone of the Middle Carboniferous Limestone Series, worked at Borough Lee, near Edinburgh.

VI.—THE METAMORPHIC AND ASSOCIATED ROCKS SOUTH OF WEXFORD.

By C. CALLAWAY, M.A., D.Sc. Lond., F.G.S.

IRISH land, which has so long puzzled our statesmen, proves to be equally perplexing to our geologists. The metamorphic rocks have excited much controversy, and new problems are emerging. Prof. Hull¹ claims to have found Laurentians in Donegal, Galway, and intermediate localities, while Mr. Kinahan, in this *MAGAZINE*,² sums up the evidence for the old opinions. As I have recently studied one of the areas referred to by the latter, I submit a few comments on a part of his paper. I am much indebted to him for the very kind and courteous manner in which he abridged my work by indicating the most important sections, and regret that I must ungratefully repay the obligation by differing widely from his conclusions.

Mr. Kinahan utters a very just caution against attaching undue importance to lithological characters. Lithology must undoubtedly be subordinate to petrology. But the Archæan geologists are quite justified in accepting, with due precautions, the guidance of lithology, when petrology is not available.

The paragraph (p. 427) in Mr. Kinahan's paper which I venture to criticize runs thus :—"The rocks of the Carnsore or S.E. Wexford district I have very carefully worked out, and to me it appears that northward and westward they gradually merge into unmetamorphic rocks; and in the latter are found *Oldhamia*, a Cambrian fossil." These words call for special comment, because, as it appears to me, they express a fallacy of observation which has led to very erroneous conclusions. The argument mainly runs upon the words "gradually merge." I shall endeavour to show that the facts of the case can only be met by inserting "do not" before "gradually."

It has been frequently assumed that, if a metamorphic rock lies near unaltered beds whose age is determined by fossils, the former must be an altered portion of the latter series. The possibility that the two rocks were brought together by faults has not received due attention. In the Survey Map of Anglesey, as I have shown in this *MAGAZINE* and elsewhere, the same beds are in one place coloured "Cambrian" and in another "Silurian," simply because they were locally associated with those groups; whereas, on a closer examination, the junctions between the altered and unaltered series were invariably seen to be faults. I contend that the same oversight has vitiated the published work on the geology of Wexford.

The Survey Map of the Carnsore area represents three parallel

¹ British Association, 1881; and previously in *Nature*.

² September, 1881; also British Association, 1881.

bands striking to the west-south-west, and respectively consisting, taking them from south to north, of (1) granite, (2) metamorphic schist, and (3) unaltered Ordovician. This arrangement, if accepted, would seem to lend some support to Mr. Kinahan's opinion of a gradual passage between the granite and the Ordovician, or, according to his more recent view, Cambrian. But the three unbroken strips of colour do not truly represent the facts. It would be more correct to describe the district as a mosaic of irregular fragments. The ground is scored with faults, some of them so close together that, within an acre, at least three formations sometimes crop to the surface. The broken nature of the district is, indeed, recognized by Mr. Kinahan in the "Survey Memoir," and in his "Geology of Ireland;" but he nevertheless maintains that there is a passage between the metamorphic and the unaltered rocks, though no clear case of transition is recorded in his works, and all the facts I observed in the field were inconsistent with such a supposition. But some details must be given.

CARNSORE GRANITE.—There are two points to be considered here. First, is the rock metamorphic or igneous? Mr. Kinahan affirms that it is metamorphic, with igneous intrusions. Of the former point I could find no proof. I searched the coast section from Carnsore Point to the most northerly limit of the granite band, as indicated on the map, and could detect no trace of anything but undoubted igneous granite. I examined the ground for some distance inland, and searched dozens of stone walls, but the result was the same. The rock is perfectly crystalline, and is, indeed, porphyritic, large prisms of felspar being thickly scattered through the matrix. If metamorphic granite occurs in mass, it is singular that in so limited an area it should be so difficult of detection, especially as I searched all the localities in which Mr. Kinahan states that foliation occurs. There is, however, plenty of parallel jointing, which may have been taken for bedding.

Second, does the Carnsore granite pass into the schistose band? Of this no proof is even adduced. No sections are given or localities named. We have nothing but the general statement that the granite graduates through schist and "submetamorphic" rocks into unaltered Cambrian. Very few exposures occur near the line of junction, but I found, about 200 yards north of the line, south-east of Lady's Well, a thin-bedded dark gneiss with garnets, a rock which certainly bore no signs of a character intermediate between porphyritic granite and the schists of the second band. Indeed, this gneiss is far less granitoid than some beds which occur much further from the granite. The granite of the Saltee Islands, which I did not examine, is also said to be metamorphic, but, as it lies several miles south of the second or schistose zone, it is obvious that it is of no use for our purpose.

METAMORPHIC BAND.—This zone is about one mile wide, striking west-south-west to Crossfarnoge Point. The rock is typically a greenish chloritic gneiss, spotted with grains of felspar. It sometimes varies into chlorite schist, and is often interfoliated with

felspathic or quartzo-felspathic seams. The chlorite variety is sometimes so fine-grained as to resemble a slate, but, even under the pocket-lens, it is seen to be a true foliated schist.

According to hypothesis, these schists should graduate into the "submetamorphic" rocks, but of this passage there is no satisfactory proof. In the immediate Carnsore district there are no junction sections. The Survey Map, indeed, represents the two groups in contact north-east of Ballytrent House; but, after a careful examination of the section, I could find no trace of the less altered series. The rocks are here very clearly exposed in the shore for about half a mile, the junction being placed on the Map in about the middle of the section. The facts do not justify this separation. The whole series is truly metamorphic, consisting of the types I have described. The green slaty-looking bands, which are frequently intercalated with gneissose beds, have apparently been mistaken for the rocks of the "submetamorphic" group, from which they widely differ in their degree of metamorphism. These green rocks are thoroughly, though minutely, crystalline; whereas the "submetamorphic" group is typically a felspathic slate in which metamorphism does not advance beyond the incipient stage.

Seven miles to the west-south-west, near Tom Haggard, we find the two series in contact, but there are no signs of a passage, and the junction has all the appearances of a fault. North of the junction, we find nothing but pale-green slates, with here and there some gritty bands. I traced the succession for about two miles across the "submetamorphic" zone. Sometimes the rocks bore slight traces of foliation, but the alteration occurred at irregular intervals, and did not increase towards the junction with the metamorphic series. The slates stopped abruptly on the north side of a slight depression, and, immediately to the south of the hollow, we come to gneiss and chlorite schist, with no trace of the slate series.

Both types are well seen on the shore north of Greenore Point with their ordinary lithological characters. Masses of gneiss and of green slate lie side by side, but in no case could I find a passage between the two. In one spot, near the Point, they occur on exactly the same strike, the beds of the slate seeming to be a continuation of the gneiss; but there is no merging of the one into the other, and the junction is clearly a fault. In another place, a mass of red sandstone is let in between two areas of gneiss and slate lying on the same strike.

I was so satisfied in the Carnsore district that the two formations were brought together by faults, that I thought it unnecessary to examine the section at Crossfarnoge Point, especially as Mr. Du Noyer's Map quite bears out my views. At the north end of this Map is an area of "submetamorphic rocks," bounded on the south by a "gabbro dyke." South of the dyke, Mr. Du Noyer represents "gneiss alternating with schist," "granitoid gneiss," and "gneiss, with some schist bands," a description which agrees very well with what I saw on the same strike near Ballytrent House. Mr. Kinahan, indeed, represents the case somewhat differently. Mr. Du Noyer's

"schists" he calls "argillites," and he supposes they are the same as the "submetamorphic rocks" north of the dyke; but as he himself describes his "argillites" as "principally talcose and hornblendic," it is obvious that they cannot be identical with the slates of the "submetamorphic" series, which, though sometimes slightly talcose (or chloritic), are never hornblendic.

"LOWER SILURIAN" ZONE.—This band (*b* 2) occupies the country between the metamorphic zone, and the Carboniferous band south of Wexford. From Mr. Kinahan's later works, I understand he has modified his original opinion, and has adopted a Cambrian age for the rocks. I believe it will be found that four distinct formations are represented within the area.

(1) *Ordovician*.—Grey shale, grit, and conglomerate, near Tagcoat, with *Orthis Actoniæ* and *O. testudinaria*. Black and grey shales at Bannow. These, the ordinary types of the district, show their affinity with the Bala series, not only in their fossils, but by their close lithological resemblance.

(2) *Cambrian (Longmynd)*.—The prevailing types are pale-green, red, and purple clay-slates. They are well seen on the shore at Bannow, and are said to contain *Oldhamia*. They are true argillaceous deposits, and are easily distinguishable from the felspathic slates of the "submetamorphic" group. Considering the great distance between the two areas, their resemblance to the Salopian types is very striking. In an examination of the localities where they are said to pass into "submetamorphic" rocks, I failed to find the slightest foundation for such a conclusion. The Cambrian is as unaltered as in the Longmynd Hills, while the felspathic series usually exhibits a slight glaze indicative of incipient metamorphism, and sometimes contains beds of hornstone.

(3) *Hypometamorphic series*.—As these rocks are everywhere faulted against other formations, petrology furnishes us with no proof of their age. They are quite unlike Ordovician and Cambrian, both in mineral characters and state of alteration. At the same time, their resemblance in both points to the Pebidian rocks of Anglesey is very marked. It is difficult to present the full force of this argument on paper, but after several months' close study of the Welsh types, my examination of the Wexford rocks produced a very strong opinion of the identity of the two series. The prevailing rock in both areas is the pale-green altered felspathic slate. Similar grits and hornstones also occur. Bands of quartzite, which are not usual in Pebidian rocks in England and South Wales, are found in Anglesey, and more conspicuously in the Wexford district. Any inference from the strong lithological affinities here indicated could not, of course, withstand clear stratigraphical evidence, but, as such proof is wanting, lithology affords a high probability of contemporaneity.

(4) *Metamorphic series*.—Here also petrology is of little service, and lithology is again almost the only available guide. Comparing these rocks with our known gneissic formations, the Lewisian and the Anglesey group, presumably Dimetian, the resemblance to the

latter is much the closer. The green chlorite schists, which are so marked a feature in Anglesey, are almost equally conspicuous in the Carnsore area; while the gneissose and granitoid types are also similar in both localities. In Anglesey, however, granitoid rock forms a thick band at the summit of the series, while, in Wexford, granitoid seams, usually of no great thickness, are intercalated with the green schists. It is also to be observed that if the strike of the Anglesey schist were produced to the south-west, it would pass through the Carnsore district. The massive, highly crystalline character of the Lewisian gneiss, together with the predominance of hornblende and micaceous constituents, strongly distinguishes it from the Carnsore schists.

These four types, Ordovician, Cambrian, Pebidian, and (?) Dimetian, are represented in this narrow band. All the groups have a prevailing strike to the west-south-west, but wherever observed, and sections described as critical were selected, there were no indications of a passage between any two of the formations.

I have recognized the Pebidians in other parts of Leinster, but their description lies beyond the scope of the present paper. It may perhaps be hoped that the discovery of this new series in Ireland will clear up some difficulties. The lithology of these rocks has obviously perplexed Irish geologists, and they have been referred to more than one formation. Their distinct mineral characters should, however, enable their distribution to be determined.

I had not intended to publish anything on Irish Archæan geology until I had visited other districts, but Mr. Kinahan's challenge seemed to call for reply, and I have ventured to contribute from my notes such facts as bear upon his views.

VII.—NOTE ON THE GENERIC DISTINCTNESS OF *PURPUROIDEA* AND *PURPURA*, WITH REMARKS UPON THE PURPUROID SHELLS FIGURED IN THE GEOL. MAG. PLATE VIII. DECADE II. VOL. VII. 1880.

By JOHN LYCETT, L.R.C.P.E., and M.R.C.S. Engl.

THE genus *Purpuroides* was described by me in 1848 from three species in the Great Oolite of Gloucestershire, and published in the Annals and Magazine of Natural History, accompanied by woodcuts representing one of the species. Before that period M. Buignier had described and figured three species of the same genus from the Coral Rag of France, Mem. Soc. Philomath. Verdun, 1843, accompanied by plates illustrating the species, which he assigned to the genus *Purpura*; these figures were for the most part insufficient for the purposes of generic discrimination, and founded upon specimens more or less imperfect; one of them was believed by me to be identical with the species figured in my woodcut, and was accordingly named by me *Purpuroides nodulata*, the name of the species having been adopted from the *Murex nodulatus* of Young and Bird, which was also believed to be identical with the Gloucestershire species. At the period in question (1848) only one other Jurassic species attributed to the genus was known, viz. the *Murex tuberosus* of Sowerby's Mineral Conchology, tab. 578,