

Patella graphica is founded on a single specimen. Should a common specific name be required for this section of *P. rugosa*, it is evident that *P. tenuistriata*, Deslong., must take precedence.

EXPLANATION OF PLATE IV.

- FIG. 1. *Pleurotomaria depressa*, Phil. Oxford Clay, Scarborough. York Museum. Apical view. Flattened specimen.
 „ 2. *Pleurotomaria depressa*, Phil. Kelloway Rock, Scarborough. Leckenby Collection. TYPE of *Pl. striata*, Leckenby, REFIGURED. Apical view. 2a. portion enlarged.
 „ 3. *Pleurotomaria guttata*, Phil. Kelloway Rock, Scarborough. Bean Collection, British Museum. TYPE of *Pl. arenosa*, Leckenby, REFIGURED. 3a. portion enlarged.
 „ 4. *Pleurotomaria guttata*, Phil. Kelloway Rock, Scarborough. Leckenby Collection. Back view.
 „ 5. *Pleurotomaria* near to *anglica*, Sow. Dogger, Blue Wyke. York Museum.
 „ 6, 6a, 6b. *Trochotoma calix*, Phil. Dogger, Blue Wyke. Back, apical, and basal views.
 „ 7. *Patella graphica*, Leck. Kelloway Rock, Scarborough. Bean Coll. British Museum. Apical view. 7a. portion enlarged.

(To be continued.)

IV.—CANADIAN ARCHÆAN OR PRE-CAMBRIAN ROCKS AND THE IRISH METAMORPHIC ROCKS.

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[Read before the Royal Geological Society of Ireland.]

AS introductory to the subject of this paper, some observations made in Ireland on foliation, or the structure induced by metamorphism, with other phenomena connected therewith, will be submitted.

Students of Petrology and Lithology seem now in general to allow that there are three kinds of metamorphism, namely Regional and Contact, for which I have proposed respectively the terms *Metapepsis* and *Paroptesis*,¹ and Chemical change, to which King of Galway gave the name *Methylosis*, while more recently the Americans called it *Paramorphosis*. At the present time it is not intended to refer to the latter, as these preliminary remarks refer specially to the others.

In one and the same area Paroptesis or Contact metamorphism must necessarily occur at a different time to Metapepsis or Regional metamorphism; and the first may take place either before or after the other; or possibly there may have been two or more successive actions which affected the rock or rocks of one area; as, for instance, first in places there may have been Paroptesis, while subsequently these altered rocks were included in a Metapepsis area, while afterwards in portions, or the whole of the area Paroptesis or Metapepsis may again have taken place; because, as long ago pointed out by Lyell, vulcanicity often occurs over and over again, even with ages between, in one place or one area. In places the present structure of some of the Canadian Archæans would suggest that they were subjected to a succession of periods of alteration, some due to Paroptesis, others to Metapepsis; to this subject we will hereafter return.

¹ Geology of Ireland, p. 175.

The south-east of Ireland is very instructive, as on both sides of the rib of granite of the Leinster range there are bands of Paroptesis rocks; but while those to westward of the rib, with some peculiar exceptions hereafter mentioned, retain their Paroptesis form, those in the band to the eastward of the rib have been changed into gneiss and schist by the Metapepsis that subsequently invaded those portions of the counties of Dublin, Wicklow and Wexford. Therefore we have as a *general rule* to the westward of the granite rib a band of “baked rocks” (due to Paroptesis), while eastward of the rib there is a band of gneiss and schist (due to Paroptesis and subsequent Metapepsis), outside of which are sub-metamorphic rocks. The metapeptic action that invaded the latter area seems to have been most intense in lines running about E.N.E. and W.S.W., so that if we traverse the county from south to north, we cross over zones of “submetamorphic rocks” and of rocks belonging to the “Schist Series;”¹ that is, if we ignore other metamorphic actions now to be mentioned.

In this region, besides the intrusion of the normal Leinster granite (Haughton's type), which is supposed to have taken place in Post Cambro-Silurian time, there were also newer intrusions that may have occurred in Devono-Silurian² times; and as the latter were accompanied by Paroptesis, the rocks in connection with them are additionally altered; the “baked rocks” to the westward of the rib being changed into schists, while to the eastward of the rib they have had the metamorphism intensified. There is also to be considered what may have been the effect of the granitic roots (the laccoliths of Gilbert) of the eruptive rocks contemporaneous with the Cambro-Silurians, as these also seem to have had Paroptesis in connection with them, and this necessarily was prior to the Metapepsis of the district. Although the effect of this Paroptesis is not now very conspicuous, yet it should be mentioned, as it shows how many different times the same rocks may be subjected to metamorphic action of some kind or another.

There is also in this area a peculiarity in the metamorphism. Years ago Jukes pointed out that the younger or Cambro-Silurian rocks were more altered than the older Cambrians; and suggested that it might be more apparent than real, as none of the Cambrians in contact with the granite were exposed. But down in the south-east of the Co. Wexford, away from the granite rib, the same thing occurs; as nearly invariably along the boundary between the Cambrians and the Cambro-Silurians the last are more altered than the first.³ To the north-west and westward of Rathdrum, Co.

¹ *Ibid*, Chapter x. page 175.

² In the old world the terms Lower Silurian, Upper Silurian, Devonian and Lower Old Red Sandstone are used so indiscriminately that it is hard to know exactly what rocks are meant. In this paper Selwyn will be followed and to indicate Lower Silurians Phillips's term *Cambro-Silurian* will be used, while all the others will be included under the term *Devono-Silurian*.

³ In connection with this metamorphism of adjoining rocks, it may be mentioned that in the Belvoir section (Cambro-Silurian), Co. Clare, there are some beds in the fossiliferous strata altered apparently for no particular reason.

Wicklow, there are rocks that Wyley considered to be metamorphosed Cambrian, but Jukes put them in the Cambro-Silurians. As has been mentioned in my description of the Irish rocks, I believe Wyley was right, and that Jukes was mistaken by supposing that nowhere in the county were Cambrian rocks so much altered. This confusion due to different kinds and times of metamorphism, will be referred to hereafter when speaking of the Canadian rocks.

The Cambrians of the Carnsore district (S.E. Wexford) illustrate some peculiar phases in metamorphism. If you follow the rocks northward from Carnsore by Carne to Greenore, there are; first, oligoclastic porphyritic granite, then oligoclastic porphyritic granitoid gneiss or gneissic granite, that graduates through gneiss into schists. Go, however, a short distance westward, and on the Saltees Island are found orthoclastic gneissic granites, usually fine-grained, in which are a few subordinate hornblendites (hornblende-schist), while on the mainland at Forlone Point (Kilmore Pier) there are at the south hornblendites, that by an alternation of beds graduates into a considerable thickness of orthoclastic fine granitoid gneiss; the last, to the north, has a hard boundary, outside of which are hornblendites and other schists. This sudden change in lithological characters is important.

In the Mourn Mountain district, Co. Down, there are two distinct intrusions of granite, the first, "Slieve Croob granite," probably at the close of the Cambro-Silurian period, and the second at the close of the Carboniferous period. The Cambro-Silurian rocks of the country are altered (sub-metamorphic) by Metapepsis, probably an adjunct of the genesis of the older granite; but subsequently a new metamorphic action invaded the rocks in the vicinity of the boundary between the granite and sub-metamorphic rocks, changing the latter into gneiss and developing a foliation in the granite, the rocks now occurring in the following order:—

- | | |
|---------------------|--------------------------------------|
| 1. Granite | } The original granite intrusion. |
| 2. Gneissic granite | |
| 3. Hard boundary. | |
| 4. Gneiss | } The original submetamorphic rocks. |
| 5. Schists | |

The newer granite (Post-Carboniferous?) has not to any great extent altered the adjoining strata; but at the same time more or less signs of Paroptesis are apparent.

In the Counties Galway and Mayo different phases of metamorphism can also be studied. At first the metamorphism may appear to follow general rules, but when details are entered into, here as elsewhere, peculiarities hard to be explained are found.

If a traverse is made northward from Furbogh, west of Galway town, to Oughterard across the strike of the rocks, you start from a tract of porphyritic oligoclastic granite that merges into porphyritic oligoclastic gneissic granite, while the latter graduates through gneiss into schists; still further north in the Co. Mayo these schists merge into unaltered Cambro-Silurian rocks. Although across the strike

the gneissic granite generally graduates into gneiss, yet in some places, there is a hard boundary between them.

If the rocks, however, are followed westward along the strike of the rocks, the change is not so gradual, as there are rather sudden jumps from granitic to schistose rocks; while in the latter are found outliers, either having a nucleus of porphyritic oligoclasic granite, or being entirely gneissic granite. These usually are suddenly replaced by schists, as if they were small tracts which had been subjected to an extra action, prior to the time of the regional metamorphism.

But if we go southward from the mass of the porphyritic oligoclasic granite, there is a complete change in the character of the metamorphism; as here in places margining it are gneissic granites often orthoclastic and fine-grained, but having associated, and alternating with them, coarse-grained and oligoclasic beds. While to the S.E., at Galway town, there is a complete change of rocks, principally hornblendites, that come in against the granite, and in a few small patches on it. This small area of schist apparently in such close proximity to the mass of the oligoclasic porphyritic granite seems peculiar. This, however, might perhaps be explained by phenomena that can be studied to the westward near Roundstone and Slyne Head; but as it would take some time, and the rocks are not of interest in the present inquiry, it appears sufficient to have recorded their presence.

In the Co. Galway the oligoclasic porphyritic gneissic granite, especially across the strike of the rocks, is a portion of the general graduation from the oligoclasic porphyritic granite into the schists and unaltered rocks: but in the Castlebar district, Co. Mayo, there are courses and masses of it that evidently were intruded into their present positions. These Mayo rocks are very interesting, because among the Laurentians of Canada we find somewhat similar gneissic granite as intruded masses (called Labradorians and Norians by the Canadian geologists and marked La on Selwyn's map).

From the published writing in connection with the oligoclasic granite and associated rocks of the Co. Donegal, it is evident that the sequences are somewhat similar to those in the Counties Galway and Wexford; there being granite that in places graduates through gneiss into schist; while in other places, as at the south of the Galway, porphyritic granite, different groups of gneissic rocks, comes in. At the same time, however, as a general rule, the margin of the granitoid rocks is here more marked than in either Galway or Wexford.

It is unnecessary to further individualize the Irish localities; but to certain traits of metamorphism I would draw attention. Years ago I pointed out¹ that in the West Galway and Mayo districts, rocks in the "Second Stage"² of metamorphism followed the planes of the most conspicuous structures in the original rocks; let this structure be lamination, cleavage, fine jointing, oblique lamination, spheroidal structure, concretionary structure, or any of the wavy

GEOL. MAG. 1871, Vol. VIII. pp. 263-268. ² *Geology of Ireland*, chapter x.

structures peculiar to some calcareous or allied rocks; while in the typical gneissic granite or granitoid gneiss, all the original structural lines are obliterated; they or any subsequent foliation being replaced by a nearly perpendicular one; but the strata of this new foliation seem to follow the strike of the original stratification.

In some places there is a hard boundary between the gneissic granite and the gneiss; or the latter may be absent, the granite being margined by schist. This seems to suggest that it is possible the coarse foliation of the gneissic granite may be due to a second Metapepsis of a more limited extent; that while it affected them and developed the leaves of foliation, it did not invade the adjoining strata. We will now proceed to the metamorphic rocks of Canada.¹

A feature that strikes a stranger is the massive coarseness of the foliation in some of the Laurentian gneiss. This appears to me, as mentioned in connection with the Irish rocks, to be due not to excessive metamorphism at one and the same time; but to stages, the rocks having been invaded two, three, or even many more times by successive but independent periods of metamorphism; thus developing but not obliterating the leaves due to the earlier metamorphisms.²

This coarse foliation is very conspicuous in the previously mentioned gneissic granite called Labradorian by the Canadian geologists. Of it we have no exact representatives among the Irish rocks; the nearest approach in structure being the gneissic granites of Carnsore, co. Wexford; of the barony of Moycullen, co. Galway; of the Erris district, co. Mayo; and of the Castlebar district, also in Mayo. The latter being an intrusion, is in this respect more like the Canadian rocks than the others, which were originally stratified rocks.³

¹ It appears remarkable that metamorphism seems to be so restricted to the older rocks in Canada. Is it possible, that in the areas called Archæan, from their lithological character, there may be newer rocks included? If not, why should metamorphism be so confined to them, when in a little spot like Ireland we have metamorphosed Cambrians, Cambro-Silurians, Devono-Silurians, Carboniferous (?) and Lias.

² Excessive metamorphic action in a portion of an area will change rocks into granite; but if a milder metamorphism invades rocks at different successive times, it ought to more and more develop the plates or leaves without obliterating them. This can be seen on a small scale in different places in Ireland, the best perhaps being along the before-mentioned boundary of the older, or "Slieve Croob" granite of the Mourne Mountain district. In general in Irish localities the additional metamorphism seems due to Metapepsis, succeeding Paroptesis, or *vice versa*; but in some places one period of Metapepsis seems to have been followed by another. As the Canadian rocks are so ancient, we may suppose that at least three or four times they have been covered by a sufficient depth of strata to develop metamorphic action, but not sufficient to convert them into typical granite. It appears to me an interesting problem, why in such vast areas we should have gneiss without its being, in part, converted into granite of metamorphic origin? Unless we suppose that some of the rocks that are now gneiss were at one time granite, but by subsequent metamorphic action foliation was developed in it, and thus by degrees it was changed into gneiss. Such a change can take place; because if the "Slieve Croob granite" ~~was~~ covered up by a sufficient depth of strata, it would be entirely converted into gneiss.

³ Mixed up, either as strata or small intrusions, with these rocks of Wexford, Galway, and Mayo, are eruptive rocks; that, however, were portions of the geological groups (Cambrians and Cambro-Silurians) and not subsequent intrusions, as was the case in respect to the Castlebar district porphyritic gneiss.

Some of the varieties of granite are also remarkable for the massive character of their crystallization, more especially the pegmatites. This, among others, is very conspicuous in the white mica pegmatite of the Vale of the Du Leivre, the felspar being in considerable masses, while the plates of the white mica are in places over nine inches across.

These pegmatites belong to Sterry Hunt's "Endogenous rocks"; he suggesting that the minerals crystallized out of solution. Such a supposition can be easily understood when pegmatite is found in small masses or in lenticular veins; but it is not so easily conceived when we have to treat with large masses.¹ Still, however, it is possible, if not probable, that Sterry Hunt may be right; as in great thicknesses of rocks there is no reason why there should not be vast vugs filled with mineral solutions; and when the minerals crystallized out, they would fill such cavities, thus forming masses of pegmatite or other rocks that had a similar genesis. In the Aughowle district, co. Wicklow, there is a pegmatite locally called "Bastard Granite," a variety of which is the "Plumose Granite" of Jukes. This rock occupies a considerable area, and is somewhat like the Canadian pegmatite, although not as coarsely crystalline. From it I would suggest, that it is probable the coarse crystallization of pegmatite may be original structure and not due to subsequent metamorphism; the mass of this Wicklow pegmatite is newer than the normal Leinster Granite (Haughton's type), and consequently ought to be younger than the time of the Regional Metamorphism; as there is no newer metamorphism recorded in its vicinity that might have affected it. At the same time, the Canadian rocks are so much older, it is quite possible that their crystallization may have been augmented by metamorphism.

In the Province of Ontario and the neighbouring portion of the Province of Quebec, the Archæan rocks are divided up into Huronians and Laurentians. Selwyn has pointed out, that these divisions, although lithological, have not been proved to be petrological; while as far as I can learn, Logan has not stated that he had found any proofs of their being petrological groups. On the other hand, however, Dawson (Sir J. W.), Sterry Hunt, and others seem to insist that they are not only lithological, but also petrological groups.

A rock that appears to be considered a typical Ontario Laurentian is a pinkish or flesh-coloured fine-grained gneiss. Hand-specimens of this gneiss are undistinguishable from some of the rocks of the Cambrians of the Saltees and Forlorn, S.E. Wexford, of the Cambro-Silurians, counties Wexford and Wicklow, of the Cambro-Silurians, co. Galway, of the Cambrian (?) of Erris, co. Mayo, and of the Cambro-Silurians and Cambrians (?) of the co. Donegal. Some of these metamorphic rocks, as for instance those at Forlorn, were evidently originally felspathic and probably tuffose stratified rocks; this probably was also the case in many places where similar gneiss occurs in the counties Galway, Mayo, and Donegal; but there are also in those places, and in the co. Wicklow, similar gneisses that evidently were originally intrusions of felstone or felsite. In the high ground called Chelsea Mountains, Ottawa county, there is a

granitoid gneiss very like some of those of Galway, Mayo, and Donegal; this is a rock intermediate in structure between those just mentioned in Ontario and the coarse gneissic granite of Chicoutimi,¹ Mont Calm, etc., of the province of Quebec; these rocks apparently all being more or less similar in their constituents, but having been subjected to different degrees or periods of metamorphism.

Here in connection with the Chelsea district may be mentioned the schistose rocks between the highland and Chelsea settlement; as with them there are calcareous and allied rocks exactly similar to rocks in the "Ophiolite and Dolomite series" of the Twelve Pins or Bennabeola district, co. Galway.² These Irish rocks have been suggested by William King, Galway, to be of Cambrian age, while my examination of the district seems to go to confirm this opinion.³

Before proceeding further, it appears necessary to mention some peculiar Irish calcareous rocks. These are found at the base of the Lower Carboniferous Sandstone, Co. Clare, at or near the base of the Devon-Silurian rocks of Mayo and Galway, and at different horizons in the Cambro-Silurians and Cambrians of Donegal, Sligo, Mayo, Galway, Waterford, Wexford, and Wicklow. These calcareous rocks are more or less intimately connected with basic eruptive rocks and to me appear to be adjuncts of vulcanicity.⁴ In the township of Buckingham and elsewhere in Ottawa county there are apatites (phosphate of lime), that make very like the above-mentioned Irish Cambro-Silurian and Cambrian (?) limestones as they are associated and more or less intimately connected or entangled with the basic eruptive rocks. In connection with these, it may perhaps be allowable to suggest, that originally they possibly were carbonates; but that in some way, not yet explained, but at the same time being an adjunct of metamorphism, they were changed into the phosphate.

The rocks which par excellence are classed as Laurentians belong to the lithological groups for which I have proposed the names "Gneissic Granite or Granitoid Gneiss" and "Gneiss series"; while the Huronian rocks par excellence belong to the group called "Schist series" and "Sub-Metamorphic rocks."⁵ In these general classifications, however, there are exceptions; because, as in Ottawa county, there are included in the tracts at the present time mapped

¹ Some of these rocks I learn from Dr. George Dawson, during last summer's explorations, have been proved to belong to the Laurentians and not a separate group.

² Geology of Ireland, chapter i. p. xxi.

³ These rocks were suggested by the late Sir R. I. Murchison to be Laurentians; he however subsequently changed his opinion. In the late proposed classification of the West Galway rocks, these have not been included in the so-called Archæan rocks; that distinction being given to the more metamorphosed, but younger rocks in the country to the southward;—rocks that have been proved by their fossils to be of Cambro-Silurian age.

⁴ Geol. of Ireland, chap. xii. p. 194.

⁵ Geol. Ireland, chap. x. p. 177. As a rule the Huronians seem to belong to the "Schist series," but some of the Huronian limestones and associated rocks between Port Arthur and the Rat Portage belong to the rock called by Indian geologists "Sub-Metamorphic rocks." Some of these limestones are very little altered.

as Laurentians¹ greater or less exposures of schistose rocks; while among the Huronians, gneiss occurs. This is similar to what occurs in the old country; as always in a tract belonging to the "Gneiss series," and even often in the "Gneissic Granite," subordinate schistose rocks appear, while in the "Schist series," and even in some places in the "Sub-Metamorphic rocks," subordinate gneiss occurs. From ocular demonstration it is evident, as has been already mentioned, that the Laurentians and Huronians are lithological groups; but are they also petrological, that is, geological groups? This we have now to consider.

In the Province of Ontario there are numerous junctions of the Laurentians and Huronians. Those that seem most known and have been more generally studied occur more or less in the neighbourhood of the Canadian Pacific Railway, between Port Arthur and Winnipeg; and of these the one to which the greatest attention has been directed is the section at the rapid of the outfall of the Lake of the Woods near Rat Portage. This junction is stated by Sir J. W. Dawson and others to be a "Fault boundary." Such a statement cannot be lightly passed over, especially by an Irish geologist, when he thinks of the intricate boundaries in S.E. Ireland (cos. Dublin, Wicklow, and Wexford) between the Cambrians and the Cambro-Silurians, that were first unravelled by Jukes; especially those in the neighbourhood of Carrick Mountains and Glenealy, co. Wicklow, and at Poulshone and Bannow, co. Wexford. As, from the light supplied by Jukes, I was able to satisfy myself that such intricate unconformities may occur, I should be rash to state that somewhat similar unconformabilities did not occur in Ontario; yet at the same time I may be allowed to make suggestions,—or to say that I could not find any satisfactory reasons for supposing that there is an unconformability between the Huronians and the Laurentians.

Here we may digress and ask what are geological—that is, petrological divisions? Years ago I have heard American geologists state that the European maps are more lithological than geological; and the more the subject is studied, the more reasons appear to believe they are right in this opinion; as the major number of the divisions on these maps partake more of lithological grouping than of being natural petrological, that is, geological, divisions. This is especially the case in reference to the Kainozoic and Mesozoic rocks; as the different groups in them are merely lithological groups; but it is not so much the case in the Palæozoic rocks, as in the latter the groups for the most part have a claim to be petrological; but not always, as the rocks between the Carboniferous and the Cambro-Silurian are still in a higgledy-piggledy condition. The subdivisions, however, are only lithological, as is demonstrated by a comparison of the rocks of Ireland with those of England; the sub-groups that occur in regular succession in the English groups being quite mixed up in the Irish ones.²

¹ Selwyn has specially mentioned, that the present boundaries and mapping of this country is only provisional, and that hereafter there will, probably, be found in it tracts of rocks belonging to the Huronians.

² It has been stated,—palæontological evidence proves these different groups;

This confusion of lithological and petrological groups in the geology of the present time appears to me to be a most important consideration in the present inquiry, because, if such a classification is allowed, the Canadian groups have as much right to be called "geological divisions" as many, so called, in England or rather in Europe.

The mistakes that may occur by substituting lithology for petrology I may attempt to illustrate by facts observed in Ireland. For the uppermost group of the Irish Cambro-Silurian the term "Slate series" has been suggested, as in general it consists of argillaceous accumulations, also as in it all the principal veins of roofing slates are found; while for the lowest group of the same formation the term "Black Shale series" has been proposed, the rocks in it being also for the most part argillaceous, but at the same time carbonaceous and of a blackish colour. In both groups, however, in places, thick masses of arenaceous rocks may, often suddenly, cut out the argillaceous rocks. This is the case in the western extension of the Croghan-Kinshella hills to the N.E. of Carnew, Wexford, where in the "Slate series" a considerable thickness of grit suddenly appears in the slates; while in the Erriff Valley, co. Mayo, a mass of lithologically identical grits appears in the "Black Shale series." Now, if the rocks in these two far-apart districts were subjected to exactly the same degree of metamorphism, and under exactly the same conditions, we should have two groups lithologically similar, but petrologically or geologically very different; also in both localities the change from one group to another would be marked, as in both these places the argillaceous rocks are suddenly replaced by arenaceous; therefore, if metamorphosed, in both cases there should be hard boundaries between the metamorphosed grit and metamorphosed slates,—one probably being gneiss and the other schist.

In different places in Ireland there are tracts of gneissic rocks more, or less similar to the Canadian Laurentian, yet evidently they belong to distinct geological groups. Of these, those in S.E. Wexford, Carnrose district, are probably of Cambrian age, while those of north Wexford in the Croghan-Kinshella range undoubtedly belong to the Upper group ("Slate series") of the Cambro-Silurian; while those of the counties of Galway and Donegal may in part belong to the Cambro-Silurian and in part to the Cambrian;¹ in Erris, N.W.

this however does not appear to be proved. The different flora and fauna were developed and flourished under such conditions as were most favourable; and consequently each different group is most conspicuous, in more or less similar groups of strata; and for this reason such strata are said to be of one age. This often is hard to disprove, on account of not being able to trace the rocks from one place to another; but when we are able to do so, as is the case with the Carboniferous rocks of Ireland, it is found that the so-called divisions are only lithological. This can also be seen in the Irish Devonian-Silurian; take, for instance, the Culfín section, co. Galway, where the lowest rocks contain Llandovery and Wenlock fossils, while over them are strata containing Caradoc fossils, which are succeeded by rocks having typical Wenlock and Ludlow fossils, while in the group above them, according to Davidson, the prominent and nearly only fossil is of a Llandovery type.

¹ In both these counties these gneissose and granitic rocks are evidently, at least in part, younger than the associated rocks, which have been proved to be, or are probably, of Cambro-Silurian age.

Mayo, they may be metamorphosed Cambrians; in east Mayo, Sligo, and Tyrone, they are possibly Cambro-Silurians or Upper Cambrians, that is, the representatives of the Arenig rocks of Wales; while in the co. Antrim, in the Ballycastle district, they are either Cambro-Silurians or Cambrians. All these lithologically belong to one group, while petrologically they represent different groups, belonging to different geological ages.

It should be pointed out that, as a general rule, hard well-defined boundaries are characteristic of excessively altered rocks; while partly or unaltered rocks usually graduate into one another by alterations of intermediate kinds of rocks; thus limestones in general graduate into argillaceous rocks, and the latter into arenaceous rocks; while a mass of arenaceous rocks will usually at its margin first alternate with argillaceous rocks, before the latter predominate.

The subject of hard boundaries to metamorphosed rocks has been discussed in Chap. x. of the *Geology of Ireland*, where it is illustrated that, in general, small altered tracts in large unaltered areas have well-marked boundaries; while here I would point out that in large areas of granitoid rocks, like those of Galway and Donegal, there are facts which indicate that the metamorphism which invaded the rocks was long subsequent to their original accumulation; as prior to their metamorphism they were upturned, contorted, displaced by faults and denuded, while subsequently such ruptures and breaks were sealed up by the metamorphic action; as proved by the breaks in the less altered rocks being much more numerous than in the granitoid rocks, while all in the latter are also found in the former.

Many of the phenomena mentioned as occurring in the Irish rocks may not directly apply to the Canadian, but indirectly they do; as they go to prove that too much reliance must not be placed on merely lithological characters. Furthermore, although there are many varieties of the Canadian Archæan rocks for which there are no equivalents in Ireland, yet there are also many that have. Already the great similarity between the gneiss of the two countries and of the calcareous rocks has been pointed out; while there is even a greater similarity between the metamorphosed basic eruptive rocks, if one set is compared with the other. It was remarkable in the section between Port Arthur and Winnipeg, also in Ottawa County, and other places in the Province of Quebec, the few rocks I saw with which I was not previously acquainted.

To return to the boundaries of the Ontario Laurentians and Huronians. All those I saw strongly suggested that they are more lithological than ~~petrological~~, as in no place does there appear to be a regular or well-marked unconformability or even an overlap of the Huronians on the Laurentians; while at each side of the boundary there are striking similarities in the direction and dip of the beds in both classes of rocks; also all breaks, faults, and such like in the supposed older rocks appear also to occur in the supposed newer rocks. There not even being such marked differences in character between these Laurentians and Huronians, as are common in the Irish Cambro-Silurians, between those altered into schists and those altered into granitoid rocks.

If we compare small things with great, a parallel may be drawn between the section of metamorphosed Cambrian rocks at Forlorn Point, co. Wexford, and the section at the Rapids out of the Lake of the Wood, one being a pocket edition of the other. In the Forlorn Point section going southward, we first meet schists, then a hard boundary, then gneiss, and the latter after a time graduates by alternations into schists. In the Canadian section going northward, first you meet schists, then a hard boundary, ^{South} of which is gneiss; and the latter still further north having in it alternations or subordinate beds of schists: while there is also a bay that seemed to have been denuded into softer strata than the gneiss; of this, however, I could not satisfy myself, as the nature of the country and time did not permit.

I am aware that Sterry Hunt and others have suggested that these older rocks accumulated under circumstances quite different to those of the accumulation of the younger rocks; they in a great measure being more chemical than sedimentary accumulations. Such a supposition, however, now that I have been able to study the Canadian rocks, appears to me unnecessary, as these supposed chemical accumulations have their characters in common with rocks of the old country,—rocks whose characters can be proved by ocular demonstration to be due, not to chemical accumulations, but to metamorphic action,—that took place long subsequent to their original deposition.

Some of the suggestions that I have put forward in this paper may possibly have already been ventilated by American geologists. If this should happen to be the case, I beg leave to assure the originator of the suggestion that his claim has been ignored not purposely, but on account of my being unacquainted with the paper in which it was put forward.

V.—A REVISION OF THE ANTELOPES OF THE SIWALIKS.

By R. LYDEKKER, B.A., F.G.S., etc.

A FEW years ago I described¹ some remains of Antelopes from the Pliocene Siwaliks of India, when I employed the generic term *Antilope* in the wide sense in which it was used by the older zoologists and palæontologists. At a later date² I was enabled to refer two of the species thus designated to two of the genera of Antelopes as at present classed; and at the same time mentioned some other forms. A recent examination of all the remains of this group from the same deposits contained in the British Museum has enabled me to make a more exact determination in the case of another of the species mentioned in my first notice, and also to indicate the existence of other forms closely allied to existing African Antelopes. These new forms I hope to have an opportunity of describing on a future occasion, and, therefore, now content myself with merely giving a list of the species which I can at present recognize. The ill-defined character of some of the

¹ *Palæontologia Indica* (Mem. Geol. Surv. Ind.), ser. 10, vol. i. pp. 154-9 (1878).

² *Ibid.*, vol. iii. pp. 127-8 (1884).