Palæozoic Formations in the Light of the Pulsation Theory

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II. THE MIDDLE CAMBRIAN OR ALBERTAN PULSATION.

The second pulsation recognizable in the marine Palæozoic Series covers the Middle Cambrian period of the accepted classification. The generally adopted standard of succession of the Middle Cambrian is that of the Scandinavian succession which has furnished a number of subdivisions based on palæontological zones. The thickness of these sections is however so slight, that they can only be regarded as representing a fragmentary portion of the entire succession of the Middle Cambrian.

The same thing is true for the Atlantic region of North America for although the section here is often more extensive than that of Europe, it must still be regarded as an entirely inadequate representation of Middle Cambrian sedimentation. Nevertheless, it has very generally been adopted as at least the American type of the Middle Cambrian and the name Acadian, derived from the Nova Scotia—New Brunswick region, is generally applied to the Middle Cambrian of the Atlantic Province *i. e.* the Caledonian geosyncline, and has also been used in European literature.

As pointed out by Resser however, a far more satisfactory standard for the Middle Cambrian is that of the Cordilleran province or geosyncline of Western North America, where the formations of this system have an almost unprecedented development, both as regards their thickness and their fossil content, and where moreover they are almost exclusively developed in calcareous facies.

Resser has suggested the House Range section of Utah as perhaps the most satisfactory standard, as it is also one of the earliest sections studied in detail. But with all due deference to the patriotic feelings which may, in part at least, have prompted the selection of this example from the United States, I believe that even a better representation is found in the Canadian Cordillerans, especially the celebrated Mount Bosworth section on the Alberta-British-Columbia Divide. Thanks to the work, through many years, of Walcott on these sections, and more recently, the able contributions by Resser himself, as well as by a number of other geologists of the younger generation, we have a most complete knowledge of the succession of the formations and their fossil content. Nowhere in the world has the Middle Cambrian furnished such wonderfully preserved fossils, as those unearthed by the labours of Walcott in the remarkable Burgess and Ogygopsis shales of the Stephen formation in these sections, and this fact alone should entitle these sections to rank as the standard for Middle Cambrian stratigraphy.

If any general term for the Middle Cambrian as a whole is desirable, and in view of the fact that it represents a distinct pulsation, I believe that such a term will be serviceable, the name ALBERTAN which I proposed in 1921[1] seems the most serviceable and descriptive and I have adopted this name for the Middle Cambrian Pulsation.

We may follow the same order of procedure that has

1 Text-book of Geology. Vol II, p. 243 Foot Note.

been adopted in the discussion of the Lower Cambrian, taking first the Appalachian Province or geosyncline, with its extension over Mississippia, then the Palæo-Cordilleran geosyncline, and after that the Caledonian and Indo-Chinese geosynclines. The map Pl. II, will give the general outline of the seas during the maximum transgression in each of these geosynclines, but it should again be emphasized that from the method of projection adopted, there is of necessity much distortion which progressively increases towards lower latitudes.

THE APPALACHIAN GEOSYNCLINE.

This geosyncline has essentially the location which it had in Lower Cambrian time, except that the Southern and Northern Appalachians had little or nothing in common, being separated even at the period of maximum transgression, by the persistent Albany axis of elevation. The northern part of the geosyncline probably was an extension of the Siberian seas, while the greater part, that is the southern portion of the geosyncline, was invaded by the waters from the region of the present South Pacific, or the *Crepicephalus Sea* of the period. There was one further modification, and this was the extension of the waters, both in Middle and Upper Cambrian time, across the great marginal plain of the geosyncline i e, Mississippia, where these formations are represented by relatively thin mostly clastic members, which probably exemplify a succession of minor floodings and retreats, during the general period of the Middle Cambrian transgression.

There is at present considerable diversity of opinion regarding the formations referable to the Middle Cambrian within the southern Appalachian Province. In his great monograph, on the Cambrian Brachiopoda published in

1912, Walcott referred all the strata between the Rome formation and the base of the Knox dolomite, or its equivalent, to the Middle Cambrian. This group in the southern states of Alabama, Georgia and southern Tennessee is generally known as the CONASAUGA FORMATION, while in the Knoxville region of Tennessee and further north, 4 divisions are recognized which are as follows in descending order.

4. Nolichucky Shale.
3. Maryville Limestone.
2. Rogersville Shale.
1. Rutledge Limestone.

In some sections, the upper 3 divisions are represented by the Honaker limestone. To this series has been added at the base a part of the Rome formation, that is a group of sandstones and shales, resembling the Rome, but containing typical Middle Cambrian fossils, and without doubt respresenting the reworked products of erosion of the older Rome, by the re-advancing Middle Cambrian Sea, after the long period of exposure due to the retreat of the Lower Cambrian Sea, at the end of the first Pulsation.

Ulrich, who does not apparently consider this possibility, would refer the entire Rome to the Middle Cambrian, and in this he has been followed by some of the younger men. Such reference is of course entirely inadmissable, since the typical Rome carries the Lower Cambrian *Olenellus* fauna.

The unity of the series of formations thus referred to the Middle Cambrian has recently been questioned, and the Conasauga group has been divided, partly into Middle and partly into Upper Cambrian. The advocates of this new classification have even persuaded Walcott to adopt their views in his later publications. Thus, while it is still recognized that the Conasauga formation of the Coosa valley of Alabama is in part at least of Middle Cambrian age as indicated by its fossils, the greater portion and sometimes the whole of it in other sections, is referred by Ulrich and Butts to the Upper Cambrian.

The obvious reason for this change in classification is the introduction by Ulrich of his Ozarkian system, and his very able defence of the unity and distinctness of the group of strata which he includes therein, based as it is on his remarkable knowledge of the field relations of these formations, as well as their fossils. The Ozarkian is intended to represent a distinct system, between the Cambrian and Lower Ordovician, which latter is by Ulrich generally spoken of as Canadian, and which corresponds essentially to the Beekmantown group of the older classification. The Ozarkian system is almost exclusively developed in the Southern Appalachian geosyncline and its extension over Mississippia, though more recently Walcott, in his revision of the Cordilleran sections, has recognized representatives of Ulrich's Ozarkian above the typical Upper Cambrian of that province.

Officially, the Ozarkian is not recognized by the U. S. Geological Survey, the beds so designated by Ulrich being referred to the Upper Cambrian, a position which I believe is eminently correct. Despite such a reference however, the upper portion of the Conasauga group and its equivalents are still included in the Upper Cambrian, in the more recent Survey publications.

While it is my intention, so far as possible to present both sides of the question, I may here state my long-held conviction that the Ozarkian of Ulrich though distinctive in faunal character because of the source of origin of the faunas, is nevertheless of Upper Cambrian age, at least so far as the transgressive portion is concerned, and to this I may add the conviction now arrived at that all the formations in the Southern Appalachians, below the base of the Knox dolomite of Tennessee, or the earlier dolomites of the Alabama region, and the top of the true Rome, below the reworked upper portion, are referable to the Middle Cambrian; that is, the entire Conasauga and the 4 members which represent it in northern Tennessee, as previously noted, belong to the Middle Cambrian[1].

We may now proceed to a discussion of the several formations of the southern Appalachians, beginning with the Rome, the upper portion of which, in some localities, is referable to the Middle Cambrian. But this part is separated from the true Rome by a pronounced hiatus and disconformity, which may however be masked. This division therefore requires a distinctive name.

The Rome formation has been described at some length in the article on the Lower Cambrian, but it may be repeated here, that it consists in large part of a heterogeneous aggregation of red shale, red sandstone, green shale and fine-grained calcareous ferruginous sandstone, with some beds of coarse bluish dolomite, in beds as much as 100 ft in thickness, and here and there a bed of pure blue-banded limestone up to 50 ft.

From Pennsylvania to Roanoke Virginia, the name Waynesboro is applied to this formation, but south of

1 This is contrary to my statements on page 15 (p. *41* of the Science Quarterly, Vol. IV) of part I of these articles, where I adopted the classification in current usage. Further study of the problem has however, convinced me that the whole of the Conasauga and equivalent formations must be placed in the Middle Cambrian, where it was put by Walcott in 1912.

Roanoke, the name Rome is generally used, though in the eastern belt of outcrops, the name Watauga is applied.

In some sections, especially in Alabama, *Olenellus* has been found in the highest beds of the Rome formation, but in some other sections, beds of the general character of the Rome, and generally regarded as forming the upper 100 or 200 ft of this formation, have furnished Middle Cambrian brachiopods and trilobites. It is highly probable that we are here concerned with a misidentification of the horizons, and that although these beds have the appearance of the Rome formation, they are really to be separated as a distinct division and placed at the base of the Middle Cambrian.

As has been shown in the earlier paper, the Rome clearly represents the regressional phase of the Lower Cambrian pulsation. That this was followed by a prolonged period of exposure and a certain amount of erosion can hardly be questioned, though the actual amount of the older formation removed by this erosion may have been slight because of low relief. The transgressing Middle Cambrian Sea would most certainly find a quantity of debris of the Lower Cambrian rocks available, out of which the basal beds of the Middle Cambrian series were formed. If the country was low and the exposed rocks subject only to weathering, it is expectable that fragments at least of Lower Cambrian fossils were left strewn over the surface after the manner so commonly met with on weathered surfaces of fossiliferous formations today. Such fragments would then be included in the basal Middle Cambrian beds, along with the remains of the fauna of the early Middle Cambrian Sea, thus giving the appearance of a mixed fauna and suggesting the idea of a transition formation.

Among the characteristic Middle Cambrian trilobites obtained in beds referred to the Upper Rome of Tennessee are *Bathyuriscus bantius* Walcott, *Dolichometopus productus* (Hall & Whitfield), *Coosia robusta,* and *Coosia superba* Walcott. The last of these has also been obtained from the Lower Conasauga shales of Alabama. Besides these trilobites some 18 species of brachiopods have been listed from these beds of which 9 or half the number also occur in the Lower Conasauga shales of Alabama.

Only one of these, *Westonia ella* is also known from the Lower Cambrian of the Palæo-Cordilleran geosyncline. It is however also characteristic of the Middle Cambrian of that province.

In North Central Alabama,[1] the Rome or Montevallo formation, with a typical Olenellus fauna including *Olenellus thompsoni,* is succeeded disconformably by the Conasauga formation, which in this region is very largely a thin-bedded limestone with partings of shale, which latter does not exceed one tenth of the mass. This formation, approximating 1,900 ft in thickness, contains a fairly rich fauna of brachiopods and trilobites. Most of the former also occur in the so-called Upper Rome beds of Tennessee. The trilobites however, *Norwoodia* 3 species, *Agnostus* 3 or 4 species, and *Crepicephalus* 3 species, including *C. texanus* Shumard, were regarded by Walcott and Ulrich as Upper Cambrian, and Butts refers the formation to this horizon. In the area southeast of the Cahaba coal-field in Alabama however, the Conasauga carries Middle Cambrian fossils, and Butts concedes that all of it may be of Middle Cambrian age. The Conasauga of the Birmingham Valley how-

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1 Charles Butts, Bessemer and Vandiver quadrangles U. S. Geol Altas Folio. 221.

ever, he regards as equivalent to the Nolychucky shale of Tennessee and perhaps the Maryville limestone as well. Butts indicates a distinct disconformity between the Conasauga and the Rome in the Shades Valley section, and this is emphasized by the fact that in the Cahaba Valley the entire Conasauga is absent, the Ketona dolomite resting directly upon the Montevallo formations, this dolomite elsewhere over-lying the Conasauga.

In Tennessee[1] the Rome is succeeded by the so-called Upper Rome already referred to as characterized by Middle Cambrian fossils, and probably representing in part at least reworked Rome debris. This is a sandy shale 250 ft thick in Bay's Mountain. It is succeeded by the Rutledge limestones which are massive and range in colour from blue to black and gray, with many beds of green and yellow calcareous shale towards the base. North of Knoxville, it is almost wholly a calcareous shale, indistinguishable from the Conasauga and Rogersville. The thickness is 450 ft in the northeastern region, diminishing to 350 ft in the southwestern area. At the base of the Rutledge, the characteristic mid-Cambrian trilobite *Dolichometopus productus* occurs, and *Zancanthoides* and other trilobites are common in other parts.

Overlying the Rutledge is the Rogersville shale, a yellowish gray to bluish gray, rather soft fissile shale, with a few thin sandy layers. In the Knoxville quadrangle, its thickness ranges from 180 to 220 ft.

The Maryville limestone rests with apparent conformity upon the Rogersville. It is a thick-bedded blue limestone, much like the Rutledge below, but rather more profusely and finely banded. Its thickness is approximately 500 ft.

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1 Knoxville Folio, etc.

From it a number of trilobites, all of new genera have been obtained. These will be referred to a little later. In the Knoxville quadrangle, the thickness ranges from 150 ft north of Knoxville, to 350-400 ft near Maryville and 500-550 ft on Dumpling Creek.

The Nolichucky shale succeeds the Maryville limestone conformably. It consists of calcareous shales and shaly limestones, with beds of massive hlue limestone in the upper portion. In weathering the colours of the limestone generally change to yellow, brown or red. Northeast along Bay's Mountain, the limestone begins to be more prominent and the shales more highly coloured. The thickness in the Knoxville region remains fairly constant from 450-500 ft. *Crepicephalue texanus* and *Dicellomus politus* are its most characteristic fossils.

The Nolichucky is succeeded by the Knox dolomite with a fairly constant thickness of 3,500 ft.

As already noted there has been considerable diversity of opinion regarding the age of the 4 formations just described. Formerly Walcott[1] placed then all in the Middle Cambrian. Subsequently, after the study of the trilobites from the Maryville and the Nolichucky he decided on an Upper Cambrian age for these two formations, and in this he has been generally following by the later workers in these formations. The Middle Cambrian age of the Rutledge limestone is conceded by all, while the Rogersville is referred to as probably Middle Cambrian by Butts and Stose, though Resser and Bridge in their correlation table Pl. I put it in the Upper Cambrian, separating it from the Rutledge by a pronounced hiatus. This hiatus is not indicated, so far as the literature shows, by any physical

1 Cambrian Brachiopoda Mon 51 U. S. Geol. Surv. 1912, p. 147

disconformity, and it is purely a concomitant of the classification adopted. The continuity of the 3 upper formations is conceded and the discontinuity between the Rutledge and the higher beds is not established by any physical criterion. On the contrary it is recognized that throughout a large part of the southern Appalachians, the Honaker limestone, a thick-bedded bluish dolomite indistinguishable lithologically from the higher dolomites, represents the combined Rutledge and Maryville limestone, where the intervening Rogersville shale has thinned out. Unless then a disconformity can be established in the Middle of the Honaker limestone, the continuity of the entire series must remain established. This difficully is circumvented by some by referring all the formations to the Upper Cambrian.

That the series is a formational unit is further indicated by the brachiopod fauna, many of the species ranging throughout and characterizing the upper part of the Nolichucky shale as well. This in Walcott's classification was first placed at the base of the Knox dolomite, but it has since been recognized as distinct and is without doubt referable to the upper Nolichucky. Of the 11 species of brachiopods found in the Nolichucky, only 2 *Lingulepis acuminata* and *Dicellomus politus* are unknown in the Rutledge or older beds. Both of these occur in horizons which are included by Walcott as basal Knox dolomite though the former is associated with species wide-spread in, and characteristic of the lower formations. These are the only 2 recognized Upper Cambrian species.

The Conasauga formation represents these 4 formations in the Southern Appalachians and like these appears to be a continuous depositional unit, although the much disturbed character of these formations would make the location of breaks a difficult, if not an impossible task.

In the Bessemer-Vandiver region, the thickness of the Conasauga is estimated at 1,900 ft, while in northeastern Alabama, its range is given as 1,600-2,000 ft. For the most part it is a rather thin-bedded gray, finely crystalline limestone, interbedded with soft shale, the proportion of the shale varying in different sections. The Middle Cambrian age of the lower part is conceded and indicated by the occurrence of *Dolychometopus productus.* The greater part of the formation however is commonly referred to the Upper Cambrian and correlated with the Maryville and Nolichucky, a correlation borne out by the occurrence of identical species of trilobites. Resser and Bridge even make the Conasauga cover the hiatus, which they assume between the Rutledge and Rogersville, and thus give adherence to the theory of formational continuity. That the Nolichucky and Upper Conasauga are separated from the over-lying Knox dolomite by a pronounced disconformity is conceded by all, and is indeed indicated by the striking change in the fauna of the higher series. Ulrich refers these overlying beds to his Ozarkian, a division which by many Is regarded as essentially equivalent to the Upper Cambrian.

If it is conceded that the Conasauga group and the 4 members representing it in the Knoxville region, form a continuous depositional unit, bounded above and below by a hiatus and disconformity, it is clear that they are referable to a single pulsation. According to Ulrich and his followers, this covers the Middle and Upper Cambrian in the Southern Appalachians. The next transgressional unit i. e. the positive half of the succeeding pulsation is recorded in the series of rocks included by Ulrich in his Ozarkian division, which he makes a distinct systematic unit in the lower Palæozoic. This system he defines as follows.[1]

"Under the term Ozarkian, I include all the formations of the Appalachian Valley, that can be shown to be younger than: (1), The top of the Upper Cambrian Nolichucky shale, in Northeastern Tennessee and (2) the top of the Conasauga shale in Southeastern Tennessee, Northwestern Georgia and Northeastern Alabama, and which are older than the base of the Stonehenge limestone of the Canadian system[2] in Southern and Central Pennsylvania."

According to Ulrich's interpretation of the section, we have in the Southern Appalachians a depositional unit in the Lower Cambrian, a 2nd comprising the Middle and Upper Cambrian, and a 3rd represented by the Ozarkian and the Canadian or Beekmantown, though the actual continuity of the latter with the Ozarkian, is not conceded by Ulrich.

Interpreted in terms of the Pulsation Theory, this would imply 1, a Lower Cambrian pulsation, 2 a pulsation including both Middle and Upper Cambrian, and 3 a pulsation covering the new Ozarkian system as a transgressive and the Beekmantown, as a regressional phase.

When we compare this with the pulsations of the Atlantic-Caledonian province, we find a pronounced discrepancy. The Lower Cambrian agrees in representing a single pulsation as already discussed at length. The Middle Cambrian however, forms a single pulsation unit, separated stratigraphically as well as faunally from the underlying Lower Cambrian, and the over-lying Upper Cambrian (*vide infra*). The Upper Cambrian, together with the Tremadoc,

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1 Ulrich E. O. Revision of the Palæozoic System. Bull. Geol. Soc. of America. Vol. 22, pp. 281-680, 1911.

2 The Beekmantown Group of current usage.

which European geologists generally regard as continuous formations, represent the transgressive series of the 3rd marine pulsation, of which the Arenig represents the regressive series. It would probably be difficult to convince British geologists that there is a peristent hiatus between the higher Upper Cambrian and the Tremadoc, though such a hiatus is suggested by the followers of Ulrich who would insert the entire Ozarkian system at this horizon. (see Resser-Bridge Correlation table) Again it might be rather difficult (though perhaps not impossible) to convince British geologists of the occurrence of a hiatus between the Tremadoc and Arenig, as is suggested by the correlation tables of the Ulrichian school. We shall discuss the relationship of these formations and their faunas in a later section. For the present it may suffice to say that these suggested gaps in the section are assumed to satisfy the correlation, which is based entirely upon palæontological grounds, and the belief in the continuity of palæontological zones from one geosyncline to another.

Whether we accept or reject the Upper Cambrian Tremadoc-Arenig depositional continuity, the classification as developed by Ulrich and his school implies that Middle and Upper Cambrian together form a single pulsation in the Southern Appalachians, whereas in the Caledonian province and the Cordilleran as well, they form 2 pulsations. Again, the Ozarkian represents the transgressive portion of a new pulsation in the Southern Appalachians, but in the Caledonian and Cordilleran geosynclines, the transgression began with the Upper Cambrian and continued into the base of the Ordovician, *i. e.*, the Tremadoc, which indeed should form a complete pulsation, if the assumed disconformity between it and the Arenig is a reality. No one has yet positively recognized Ozarkian in Europe, although the attempt to find a representative has been earnestly made. If then Ulrich's correlations are correct, we must discard the Pulsation theory in favour of the Oscillation theory for the later Cambrian and the earlier Ordovician.

But! is Ulrich's classification correct or even plausible, or is there another interpretation of the facts? There can be no dissent from the general thesis of Ulrich that the Ozarkian is a distinct sedimentary unit in the Southern Appalachians, characterized by a fauna heretofore unknown at least in its major aspects. But it is another question whether this sedimentary and faunal unit represents a distinct system, which is to be intercalated between the older Cambrian and Ordovician systems, and which in most other parts of the world is represented by a hiatus. I would submit that the Ozarkian group of formations is the South Appalachian equivalent of the Upper Cambrian and its succeeding transitional series found in other parts of the world, that indeed the Ozarkian in point of time is Upper Cambrian, although its fauna is so different from the known Upper Cambrian of the other geosynclines. This difference is one that can readily be explained by the fact that the southern Appalachian geosyncline was opened to the central American portion of the old Pan-Pacific, and that its fauna was wholly supplied from that source, there being no connection with the Caledonian geosyncline or even with the Northern Appalachian geosyncline. If any portion of the Palæo-Cordilleran geosyncline was fed by waters from the same source, that part would be characterized by a fauna of similar character, though of selected types.

If however, we classify the Ozarkian as Upper Cambrian, then not only the Rogersville and Rutledge but also the Nolichucky and Maryville of Tennessee and the whole of the Conasauga further south, must be referred to the Middle Cambrian. We have already seen that these formations are one depositional unit and the product of a single advance and retreat of the sea. We have also seen that the brachiopod fauna which characterizes them, extends essentially throughout the entire series, and that it is largely if not wholly restricted to this series and locality. None of the species occur in the Caledonian geosyncline though the Palæo-Cordilleran geosyncline, which apparently also had communication with the southern sea carried some of them.

It is the trilobite fauna, which has given rise to the change in the classification from Middle to Upper Cambrian in so far as this is based on palæontological evidence, and so it behoves us to consider this fauna somewhat more at length. The total number of species described from these shales and referred to the Upper Cambrian is 33, though 3 of these are not identified specifically. These 30 fully identified species are classed in 12 genera, to wit.

Norwoodia Walcott 4 species.
Acrocephalites Wallerius 1 species
Lonchocephalus Owen 1 species
Saratogia Walcott 2 species
Crepicephalus Owen 6 species and 2 specifically unidentified.
Asaphiscus ? Meek 2 species and one specifically unidentified; (generic identification questioned)
Blountia Walcott 7 species
Maryvillia Walcott 2 species
Lisania Walcott 1 species

Armonia Walcott 1 species
Cidaria Walcott 2 species
Kingstonia Walcott 1 species

At the outset, it should be noted that all but one of the species described from these formations are new and unknown elsewhere. The excepted one *Crepicephalus texanus*, was originally described from Burnet Co. in Texas. The genus *Norwoodia* Walcott belongs to the Order Proparia, having its genal spines attached to the fixed checks. The cranidium has a *Ptychoparia*-like glabella, generally ending forward in a long spine. The pygidium is relatively large. The 4 species from the Southern Appalachians are found in the upper Conasauga of Alabama and Georgia, and in the Nolichucky shale of Tennessee. One other species, *N. tenera* Walcott, occurs in the Week's formation of the House Range, Utah, horizons 1b and 1c of the section.

This formation was formerly classed by Walcott as the top of the Middle Cambrian, but in 1916 he proposed to change its stratigraphic position from the top of the Middle to the base of the Upper Cambrian[1]. He says the reference to the Middle Cambrian was originally made on account of the presence of *Crepicephalus texanus* in the Week's formation, but that his recent studies of *C. texanus* and its stratigraphic and geographic range have led him to the conclusion that it is an Upper Cambrian species, and that the formations containing it should be referred to the Upper Cambrian. As a matter of fact *Crepicephalus texanus* does not occur in the Week's nor the Orr formation, for the trilobite of these formations formerly identified as *C. texanus* was referred by Walcott in the same paper (p. 206) to *Crepicephalus coria* Walcott, a new species.

1 Cambrian Geol. and Pal. Vol. III No. 3, p. 161

The fact that *Norwoodia* belongs to the Proparia might strengthen the argument for its Upper Cambrian age, were it not for the fact that a very typical and remarkable genus of this order *Burlingia* Walcott, is confined to the Middle Cambrian *Ogygopsis* shale of the Stephen formation.

The genus *Acrocephalus* has one species in the Lower Cambrian, 6 species in the Middle Cambrian, 1 in the Upper Conasauga formation, one in the Meagher limestone of Montana, which succeeds the Wolsey Shale, and which Resser and Bridge still class with the Middle Cambrian, though Walcott in his description of the species calls it Upper Cambrian. Finally 1 species *A.? glomeratus*, has been described from dark reddish-brown sandstone from Rawlins, Carbon Co, Wyoming, in horizon referred by Walcott to the Upper Cambrian. With the exception of this one species then, all the others occur in the Middle Cambrian or earlier or in formations of questionable horizon. Thus the species of this genus, favour a Middle rather than an Upper Cambrian age, for the Southern Appalachian species.

The genus *Lonchocephalus* Owen, was based on specimens from the late Cambrian sandstones of Minnesota and Wisconsin. 4 species occur in these Wisconsin formations[1] and one in the Potsdam sandstone of New York and all these may therefore be regarded as of southern origin. Two others occur in the Week's formation of Utah and one *L. appalachia* occurs in the Maryville limestone of Tennessee and the Upper Conasauga formation of Alabama. Even if all the species from the Weeks and the Potsdam

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1 All of these 4 occur in the Franconia formation which is referable to the Middle rather than the Upper Cambrian as I shall demonstrate below.

are regarded as Upper Cambrian in age the southern source of all of them can hardly be questioned and it is therefore not difficult to conceive that they may have Middle Cambrian forerunners from the same center of origin.

The genus *Saratogia* Walcott, is based on *Conocephalites calciferus* from the Hoyt limestone of the Potsdam, a horizon belonging in Ulrich's Ozarkian Series. 4 other species occur in the Eauclaire and Franconia sandstones of Wisconsin (which I refer to the Middle Cambrian as Walcott formerly did) and this clearly shows the southern origin of this generic type. Two other species, *S. arses* Walcott and *S. aruno* Walcott occur, the former in the Nolichucky of northeastern and the latter in the upper Conasauga of southeastern Tennessee. Here again, though one of the other species (or 5 if we follow the classification of Ulrich) are referred to the Upper Cambrian or even later horizons, there is nothing to forbid us to regard these Tennessee species as Middle Cambrian fore-runners from the same center of origin. Walcott has described 1 species, *Saratogia tenellus,* from the Middle Cambrian Kiulung group of Shantung, China. It remains to be seen whether this species is strictly congeneric with the American species. If it is, then further evidence is furnished for the existence of the genus in Middle Cambrian time.

The genus *Asaphiscus* has its genotype *A wheeleri* Meek, in the Middle Cambrian Wheeler formation of Utah, and in the Marjum formation as well, 1,500 ft. below the Upper Cambrian. 7 other species are known from strata of unquestioned Middle Cambrian age, 3 from the Wolsey shale of Montana, one from the Middle Cambrian of China (Fouchou formation) and one from the arenaceous shale of Wolf Creek, 6 miles below Rocky Gap, Bland Co. Va, a horizon referred to the Middle Cambrian by Walcott. 3

species and a specifically unidentified form were obtained from the Weeks formation, 1 unidentified species was obtained from the Middle Cambrian. The Kittatinny limestone of Pensylvania has furnished 4 species questionably referred to this genus, one of which also occurs in the Maryville limestone of Tennessee, from which horizon a specifically unidentified form was also obtained. The subgenus *Blainia,* has 4 species, all of which were obtained from a single horizon in the Middle Cambrian part of the Conasauga shale, of Alabama and Tennessee. *Blountia* Walcott, has 7 species, all confined to the Maryville limestone of Tennessee, to which *Maryvillia* Walcott, with 2 species is also confined. Finally the genus *Lisania* characteristic of the Middle Cambrian of China, appears to be represented in the Maryville limestone of Tennessee.

The genus *Armonia* is based on the single species, *A pelops* Walcott, from the Conasauga. It is related to the Middle Cambrian genus *Elrathia* (genotype *Ptychoparia kingi* Meek) of the Marjum and Wheeler formations, and to the genus *Chancia,* also confined to the Middle Cambrian (Spence shale) of Idaho (2 species). *Cedaria* has two species, one the genotype from the Conasauga the other from the Nolichucky. A third species (*C. woosteri* Whitfield) comes from the so-called Upper Cambrian of Wisconsin.

Finally *Kingstonia* is based on *K. apion* Walc. of the Maryville formation, though Walcott says "*Kingstonia* occurs in the Upper Cambrian formations of the southern Appalachians, central Pennsylvania, and throughout the Rocky Mountains, *Kingstonia* appears in faunas of Atlantic and Arctic waters."[1] So far these other species have not been

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1 Walcott. Camb. Geol. and Pal. Vol. V, pt. 3 (Smiths. Miscell. Coll., Vol. 75) p. 103, 1925.

described, and their generic relation to the Maryville species is still open to question.

So far then, none of the species have furnished indubitable evidence for the Upper Cambrian age of these Appalachian formations. There remains only the genus *Crepicephalus* to be considered.

Of the 18 species or varieties described, 6 or one third occur in the Maryville or the Conasauga, or the equivalent Honaker limestone. In addition to this, there are two others not specifically determined which occur in these strata. Only one of these, *Crepicephalus texanus* is identified from other formations. Of the remaining 12, 2 have been described from the Lower Cambrian, 1 from the Middle Cambrian of China, 2 from the Weeks and Orr formations of the Palæo-Cordilleran geosyncline, and 4 species have been described from the Eauclaire of Wisconsin, a formation, incorrectly placed in the Upper Cambrian. One of these also occurs in the much lower Dresbach. The Gallatin limestone (including the Grosventre) of the Yellowstone region in Montana contains 5 species, one of them identified as *C. texanus*.[1] The Gallatin limestone is correlated by Resser and Bridge, with the Upper part of the Middle Cambrian and most of the Upper, its base being within the horizon of the Meagher limestone of the Helena and Little Belt regions, the Wheeler and Marjum formations of the Central Cordilleran and the Stephen and the Eldon formations of the northern Cordilleran, all of which are of unquestioned Middle Cambrian age.

Crepicephalus texanus (Schumard) was originally described from Clear Creek, Burnet, Co. Texas. The type has been destroyed by fire, but Walcott reasons that as

1 This occurs in the lower or Grosventre division.

the head waters of Clear Creek drain an area on its western side, where the Cap Mountain formation occurs, it is from this formation that the type specimen undoubtedly came.[1] Other material has since been obtained from this formation. The Cap Mountain Formation[2] consists of about 90 ft. of limestones and sandstone, both more or less glauconitic. The green grains of glauconite are especially abundant in cross-bedded standstones which constitute the top of the formation. The material representing *Crepicephalus texanus* from this formation and illustrated by Walcott (III, Pl, XXX) is recorded under locality 67a.

The Cap Mountain formation rests on the Hickory sandstone, which is the lowest Cambrian formation of the region and ranges in thickness from a few to 350 ft. It begins with a basal conglomerate, which frequently contains pebbles and boulders of the underlying pre-Cambrian rocks, and their intrusives. Page describes it as grading upward into the Cap Mountain limestone, from which it is not separated by any trenchantly marked limit (*Loc. cit*).

The Cap Mountain formation is succeeded by the Wilberns formation, the lower two-thirds of which consist of thin-bedded limestones, while the upper third consists of shales with some limestones in the upper part, and with interbedded small conglomeritic layers. The greatest recorded thickness of the Wilberns is 220 ft.

It is in turn overlain by the Ellenburger limestone, probably 1,000 ft in thickness. This is a crystalline dolomite of somewhat variable texture and contains much white and yellow chert. The bedding planes are generally

1 Walcott III, p. 210

2 J. A. Udden. L. C. Baker and Emil Böse Review of the Geology of Texas. Bull. Univ. of Texas. No. 44. 1916. p. 34.

not well-marked and in the upper 100 or 200 ft, the formation is more calcareous than in the lower part. Oolitic layers are present and there are calcareous conglomerates in its lowermost and its top layers. The upper part of the series is believed to be of Ordovician age, but the lower part is Upper Cambrian. The fact that the Ellenburger limestone is conglomeritic near the base, while the underlying Wilberns formation carries conglomeritic layers in its upper part, suggest that the two are separated by a disconformity and a hiatus, and if so, it is possible that this represents the Middle-Upper Cambrian hiatus, and places the Wilberns and Cap Mountain formations and the Hickory sandstone in the Middle Cambrian. Resser and Bridge put these formations in the Upper Cambrian and the Ellenburger in the Ozarkian, separating the series by a disconformity and hiatus, while Ulrich, in his unpublished correlation table, makes the upper part of the Ellenburger Canadian.

It would thus appear that we have here the same problem that we have in the Southern Appalachians, apparently the lower 3 formations represent one transgression and retreat, though the cross-bedding at the top of the Cap Mountain might suggest a hiatus between it and the Wilberns. The Ellenburger limestone represents the Ozarkian (Upper Cambrian) transgression and is separated by a hiatus from the preceding formation. Whether the Wilberns belongs to the lower or the higher series, remains to be seen. It thus becomes again a question of the classification of the Ozarkian. If that is a phase of the Upper Cambrian, as I believe it to be, the Cap Mountain formation, with its *Crepicephalus texanus*, belongs to the Middle and not to the Upper Cambrian.

Crepicephalus texanus is again reported from the Abrigo limestone in the Bisbee district of Arizona. (Walcott. Loc. 358c) The Abrigo is conformably underlain by 430 ft. of Bolsa quartzite, which rests with a basal conglomerate on the pre-Cambrian crystallines. The Abrigo 770 ft. thick, consists of slabby limestones with interbedded layers of chert. At the top the limestone grades into a white quartzite 8 ft. in thickness, and is disconformably succeeded by the Martin Limestone of Devonian age (See below).

Recently Dr. Ruedemann has described 3 species of graptolites from the Conasauga beds or their equivalent the "Elbrook" or Honaker—Nolichucky formation of Eastern Tennessee[1]. These are as follows with their distribution.

	Loc, 107a	Loc 119	Loc 126a
1. *Haplograptus vermiformis* Ruedemann	—	—	×
2. *Dendrograptus edwardsi* var. *major* Rued.	×	×	×
3. *Callograptus antiquus* Ruedemann	—	×	—

Loc. 107a is in the "Elbrook" (Honaker-Nolichuky) formation of Morristown Tennessee.

1 Bulletin of the Public Museum of the City of Milwaukee, Wisconsin, Vol. 12 No. 3, 1933

Loc. 119 is in the Conasauga formation 10 miles northwest of Knoxville Tennessee

Loc. 126a, is in the Conasauga 10 miles east of Knoxville Tennessee

Dr. Ruedemann follows Ulrich in calling these beds Upper Cambrian, but as we have seen they really represent Middle Cambrian. He also describes *Dictyonema schucherti* from the Colchester (Lower Cambrian) of Highgate Vermont, and a number of other graptolites from higher Cambrian formations. These will be considered later.

This early occurrence of graptolites bears out my suggestion that graptolites originated in Cambrian if not Sinian time in the Pacific, and that if these older forms are preserved they should be looked for in Cambrian strata deposited in embayments from the Pacific. The strata in which these and the later Cambrian graptolites are found certainly conform to this requirement.[1]

The Northward Extension of the Southern Appalachian Geosyncline

In Virginia, Maryland and Pennsylvania, the Middle Cambrian is represented by the Elbrook limestone or dolomite. This lies disconformably upon the Waynesboro which is the more northerly representative of the Rome. The Waynesboro carries *Olenellus* and is clearly the retreatal phase of the Lower Cambrian, to which it indubitably belongs. Ulrich it is true, wants to place it in the Middle Cambrian, because in some of the sections further south, Middle Cambrian fossils have been found in a formation of

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1 A. W. Grabau, Origin, distribution and mode of preservation of the Graptolites. Memoirs of the Institute of Geology, Academia Sinica Vol. VII, pp. 1-52 1929

this lithologic type. As we have seen however, this can only be regarded as the reworked debris of the older Rome, formed during the period of exposure, before the readvance of the sea in Middle Cambrian time. Arthur Beven,[1] correlates the Elbrook of Northern Virginia, with the Honaker and Nolichucky of Tennessee. In Maryland and southern Pennsylvania, the Elbrook is 1000 ft. thick, and as in Virginia, is succeeded disconformably by the Upper Cambrian Conococheague limestone. (Ozarkian of Ulrich).

In South-central Pennsylvania, the Elbrook formation has a thickness of 3000 ft. and consists of limestones and dolomites, with some shaly beds. It is followed disconformably by the Conococheague, which begins with a basal conglomerate of rounded limestone pebbles 1 inch or more in size, with a matrix of coarse-grained vitreous quartz. This is followed by edge-wise conglomerates indicating shallow water conditions.[2] About 100 miles farther east,[3] the Elbrook has an estimated thickness of only about 300 ft. and consists of finely laminated fine-grained marble, in part dolomite, in part limestone. It lies disconformably upon the Ledger dolomite of Lower Cambrian age and is disconformably succeeded by the Conistoga limestone apparently of Chazy age. The intervening beds, if formerly present, have been removed by pre-Chazy erosion. Here too, the overlying beds begin with basal conglomerates containing pebbles with large masses of granular, white to

1 State Geologist of Virginia, Guide-book 11, 16th International Geol. Congress.

2 Mercersburg—Chambersburg Folio No. 170, U. S. Geol. Survey Atlas.

3 F. Bascom and G. W. Stose. Coatsville-West-Chester Folio. No. 223 U. S. Geol. Survey Atlas.

gray marble in a gray limestone matrix. Formerly, these as well as some of the Lower Cambrian and the over-lying Lower Ordovician limestones were included in the general term Shenandoah limestone in Central Pennsylvania, and Kittatinny limestone in Northeastern Pennsylvania. Farther north in central Pennsylvania, the following succession is found in descending order.[1]

LOWER ORDOVICIAN			
Beekmantown Group			
Bellefonte Dolomite			1000-1900 ft.
Axemann limestone			100- 480 ft.
Nittany Dolomite			1000-1200 ft.
Stonehenge limestone			290- 702 ft.
Disconformity (?)			
Ozarkian of Ulrich (Lower Canadian of Chart; our Upper Cambrian)			
Larke Dolomite			0- 250 ft.
Mines Dolomite			150- 250 ft.
Gatesburg Formation			800-1750 ft.
	4. Unnamed bed	500 ± ft.	
	3. Ore Hill limestone member	100 ± ft.	
	2. Unnamed bed	600 ± ft.	
	1. Stacy Dolomite member	500 ft.	
(*Probable Hiatus and Disconformity.*)			
UPPER CAMBRIAN (of correlation chart, our Middle Cambrian)			
Warrior Limestone (= Buffallo-Run limestones)			690-1250 ft.
Pleasant Hill limestone			500- 600 ft.

1 U. S. Geol. Survey, Correlation chart 1928. Revised classification added in parentheses

Hiatus and Disconformity

LOWER AND MIDDLE? CAMBRIAN. (Our Lower Cambrian)

Waynesboro Formation 300 + ft.

The classification here given is that of the correlation chart, but it is probable that it is subject to modification. The Stonehenge member, which in the Mercersburg—Chambersburg area, overlies the Conococheague, is generally regarded as the base of the Beekmantown horizon. Accordingly the limestones which separate it from the Warrior or Buffalo-Run limestone must represent the Upper Cambrian of our classification *i. e.* the Ozarkian of Ulrich. This would place the Warrior limestone and the underlying Pleasant Hill, not in the Upper but in the Middle Cambrian, as the equivalent of the Elbrook limestone further south. Among the trilobites of the Warrior is *Millardia avitas* Walcott, a genus represented by *M. optata* (Hall) in the Eauclaire of the Upper Mississippi Valley and by *M. semele* Walc. in the Weeks formation of Utah. Both of these are probably Middle Cambrian. As in the more southerly region, these limestones rest disconformably upon the Waynesboro, which is Lower Cambrian, except where some re-worked disintegration product of the Waynesboro may be included in the overlying basal part of the Middle Cambrian.

In his unpublished correlation chart of 1933, Ulrich makes the Stonehenge of Central Pennsylvania the base of the Lower Canadian, *i. e.* Beekmantown. The Larke and Mines, he refers to the Upper Ozarkian and the Gatesburg to the Lower Ozarkian. The Warrior or Buffalo Run, he refers to the Upper Cambrian, while he makes the Pleasant Hill and underlying Waynesboro Middle Cambrian, correlating the former with the Elbrook of Southeastern Pennsylvania. The Warrior is correlated with the Maryville and Nolichucky and the Gatesburg with the Conococheague and in part, the Copper Ridge.

It remains to be determined whether the palæontological evidence will bear out this correlation and if so, the dividing line, between the Upper and Middle Cambrian as here adopted, is drawn at the top of the Warrior limestone. In general then, I accept Ulrich's correlation, except that I call his Ozarkian Upper Cambrian, and his Upper and Middle Cambrian, Middle Cambrian, excluding however from this the Waynesboro, which belongs to the Lower Cambrian.

The northern end of the Southern Appalachian geosyncline is formed by the Albany axis, which passes westward into the borders of the southern Adirondacks. Here the formations begin with the Potsdam sandstone, followed by the Hoyt limestone and this by the Little Falls dolomite. The lower two divisions are generally referred to the Ozarkian of Ulrich and represent the over-lapping margins of the transgressing Upper Cambrian sea, while the Little Falls dolomite may be regarded as the basal deposit of the retreating Lower Ordovician or Beekmantown sea. Farther east, on the axis itself, near Albany, these formations are represented by the mud-flat deltas of the Schaghticoke with *Dictyonema*, and the Deepkill shales, with the lowest Ordovician graptolites.[1]

Extension of the Middle Cambrian over the Marginal plain of Mississippia

We shall leave until a later part of this paper, the

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1 A. W. Grabau. Origin, Distribution and mode of preservation of the Graptolites. Memoirs of the Geol Institute of the Academica Sinica Vol. VII 1929, page 38.

discussion of the Middle Cambrian of the northern Appalachians, since this is entirely distinct and more closely related to the Caledonian province. Unlike the Lower Cambrian however, the Middle Cambrian sea, in its transgression in the southern Appalachian geosyncline, also submerged a considerable portion of the flat marginal plain of Mississippia, from Burnet Co. in Texas, on the southwest, to the Ozark regions of Missouri on the east, and the upper Mississippi Valley region of Wisconsin and Minnesota on the north.

Indeed it is not improbable that this flooding extended northwestward, to the Deadwood region of South Dakota, and there it may even have become confluent with the Montana Wyoming extension of the Palæo-Cordilleran geosyncline.

It is true that the early Palæozoic formations throughout this region are now almost universally referred to the Upper Cambrian, but this is the result of Ulrich's influence on American stratigraphic thought. Before Ulrich established his Ozarkian system as a formation between the Cambrian and Lower Ordovician or Canadian, the lower beds throughout this region were classed as Middle Cambrian, which if there is a distinct Ozarkian system, left only a very insignificant portion for the Upper Cambrian. To remedy this, the whole series was referred to Upper Cambrian overlap, just as the pre-Knoxville post-Rome formations, of the southern Appalachians with which those of Missisippia are still largely correlated, had been transferred from the Middle to the Upper Cambrian.

If however, we refer the Ozarkian, not to a distinct system, but recognize it for what it is, *i.e.* the south-Pacific representative of the Upper Cambrian, we are free to return to the earlier classification in so far as stratigraphic and palæontologic correlation with the formations in the Southern Appalachians warrants it. Thus, whether we can recognize the disconformity and hiatus between the Middle and Upper Cambrian in the Mississippi Valley region or not, nevertheless those formations, which we can correlate with the Conasauga of Alabama and Southern Tennessee and its four representative divisions of the Knoxville region, have a sure basis for their classification as Middle Cambrian, since the pronounced disconformity between the Conasauga and Knoxville or the Nolichucky and Knoxville, clearly marks the upper boundary of the Middle Cambrian formation.

It is however, imperative, that we do not forget the all important fact, that in a prevailingly sandy series, such as that in the Upper Mississippi Valley, a disconformity and a stratigraphic break, even of considerable magnitude, may be entirely masked and scarcely or not at all indicated by physical evidence.

On the retreat of the sea at the end of Middle Cambrian time, the sandy clayey sediments which become exposed, are subject to extensive disintegration, especially if, as is almost certain to be the case in view of the growing land expanse, the climate becomes more arid. The results of such exposure then, would be the formation of a general covering layer of coarse and fine sands and dust, mingled with the more or less broken fragments of the fossils of these Middle Cambrian formations, from the disintegration of which the sand is derived. Some of the more resistant organic remains may of course remain unbroken, strewing the surface freed from matrix, after the manner familiar to anyone visiting a surface of weathered fossiliferous rocks.

The readvancing sea finds this material ready for consumption, and by reworking it, incorporates it in the much later formation deposited in it, and of which these disintegration products form the chief clastic source. It is thus easy to see that in many places the contact between the two divisions may be entirely obscured and appear transitional, though in others there may be physical evidence of the break, especially where mechanical erosion has supplemented disintegration of the underlying formation. Moreover, the possibility is always present, that there may be a commingling of the weathered-out fossils of the earlier formation, either entire or in broken fragments, with the organisms of the later, so that the palæontological break will not appear a sharp one at the contact, though distinct enough between higher and lower formations.

With these principles in mind, we may now discuss the several divisions in the different sections.

A. *The Central Texas region*

The succession in this region has already been given on p. 180 (p. *346*) but the further subdivisions of the formations made by Ulrich, may now be added.[1]

SUPERFORMATION Lower Mississippian

Great hiatus and disconformity

CAMBRO-ORDOVICIAN [Cambrovician]

Ellenburger limestone

Cotter zone	200 ± ft.
Calathium zone	100 ± ft.
Lecanospira zone	200 ± ft.

1 Ulrich. Correlation table, 1933. unpublished

(These three zones are referred by Ulrich to the Canadian.)

Gasconade Upper & Middle zones (referred by Ulrich to the Upper Ozarkian)	
Gasconade Lower zone	
Royer zone	100 ± ft.
Eminence zone	150 ft.
Potosi zone	50 ft.

(These four divisions are referred to the Lower Ozarkian by Ulrich.)

Fort Sill limestone (also referred to L. Ozarkian by Ulrich)	100 ft.
Wilberns Formation	220 ft.
Cap Mountain Formation	90 ft.
Hickory sandstone	350 ft.

(The last 3 divisions are referred by Ulrich to the Upper Cambrian.)

Hiatus and Unconformity

PRE-CAMBRIAN FORMATIONS.

The Hickory and Cap Mountain Formations and perhaps the Wilberns as well, may represent Middle instead of Upper Cambrian, if as is likely the Ozarkian portion of the Ellenburger and the Fort Sill are referable to the Upper Cambrian.

B. *The Arbuckle Mountains.*

This uplift lies in Eastern Oklahoma, approximate Longitude 97° W. Latitude 34°30′ N. The two chief divisions are the Arbuckle limestone above and the Reagan sandstone below, with the Honey Creek shaly beds between the two. Walcott in 1912, referred the Upper Arbuckle to the Ordovician and the lower 50 ft. or so, (Honey

Creek shale) as well as the Reagan sandstone beneath to the Upper Cambrian. Ulrich has subdivided the former extensively the following being his latest division.

Superformation. Simpson limestone (Chazyan)

Hiatus and Disconformity

Upper Arbuckle limestone		5,000 ft.
Upper Canadian portion	3,300 ft.	
Middle Canadian portion	1,250	
Lower Canadian portion	450	
Lower Arbuckle limestone		3,010 ft.
Upper Ozarkian portion	350 ft.	
Middle Ozarkian portion (Chapman Ranch)	350	
2. Van Buren limestone formation		
1. Proctor Dolomite.		
Lower Ozarkian portion		2,110 ft.
Limestone (unnamed)	478 ft.	
Royer Dolomite	706	
Signal Mountain Beds	105	
Unnamed Dolomite	673	
Fort Sill Limestone	98-148	

Probable Hiatus and Disconformity

Upper Cambrian		252-452
Honey Creek shale	52	
Reagan sandstone	200-400	

Hiatus and Unconformity

Granite or other crystallines.

Ulrich correlates the Reagan sandstone with the Hickory sandstone of Central Texas, and the La Motte of the Ozark region. The Honey Creek beds, he correlates with the Wilberns of Texas and the Bonneterre of the Ozark region.[1]

If as I believe, the Ozarkian portion of the *Arbuckle limestone* is referable to the Upper Cambrian, then the Honey Creek and Reagan beds, must probably be referred to the Middle Cambrian. The classification of the Fort Sill is more of a problem. 45 to 50 feet above its base (at Loc. 12g of Comanche Co. Oklahoma) the following fossils have been obtained.

Dikellocephalus texanus Walcott.
Saukiella? junia Walcott.

The former of these has also been found in the Wilberns formation of Texas. Walcott gave the following subdivision of the Reagan and immediately overlying beds.

BASAL ARBUCKLE of the Springer section, probably *Honey Creek* of Ulrich (with horizon as numbered by him) 52 ft.

4. Heavy-bedded compact, gray limestone 4 ft.
5. Thin-bedded shaly limestone 4 ft.
   The fauna (12 m) includes the following
   Obolus tetonensis ninus (Walcott) (also St. Charles)
   Lingulella similis (Walcott)
   Eoorthis remnicha texana Walcott

1 It must be remembered that these correlations, though printed, have not actually been published, and that they therefore represent a tentative expression of Ulrich's opinion, subject to change if necessary after further consideration. It is by Dr. Ulrich's kind permission, that I refer here to his correlation as others have referred to it elsewhere.

Correlated with it are the faunas 9z and from other localities, 12j, with
Eoorthis wichitaensis (also Nunkoweap) and
Calvinella rustica Walcott (12j).

6. Heavy-bedded compact gray limestone 4 ft.
7. Thin-bedded shaly and clayey limetone often yellow, with some limestone conglomerate, no fossils. 0-40 ft.

REAGAN SANDSTONE 245 ft.

Div. 1. Highly calcareous sandstone, with numerous pure crystalline limestone layers and layers containing fossils. 4 distinct zones have been recognized as follows. 176 ft.

d. 125 ft. above the base; contains fauna (9u) comprising
Obolus tetonensis ninus Walc.
Lingulella similis (Walc.)
Eoorthis iudianola Walc.
E. wichitaensis Walc.
Syntrophia primordialis (Whitfied)

In other localities, (9q, 9s, 9w, 12n, 12p?) these same species have been found and the following in addition.
Lingulella ora (9q)
Lingulepis acuminatus Conr. (9q, 9s, 12n, 12p)
Linnarssonella girtyi Walcott (9q, 12p)

Acrotreta curvata Walcott (12p)
Acrotreta microscopica (Shumard) (12n, 12p)
Acrotreta ulrichi Walcott (12p)
Eoorthis remnicha (Winchell) (12n, 12p)
Eoorthis remnicha texana Walc. (12n)
Eoorthis wichitaensis laeviusculus Walc. (12n, 12p)

c. The next lower fossiliferous zone in this division is 100 ft. above its base. It contains fauna (9t) with the following species.
Obolus matinalis (Hall)
Obolus tetonensis ninus Walc.
Lingulella similis (Walc.)
Acrotreta microscopica (Shumard)
Eoorthis indianola Walc.

All except the first have also been found in Loc. 12k, where the following additional species were obtained.
Eoorthis wichitaensis Walc.
Eoorthis wichitaensis laeviusculus Walc.

b. The next zone is 10 ft. lower or 90 ft. above the base of the division. It contains the fauna (9p) with the following species.
Obolus tetonensis ninus Walc.
Lingulella ora Walc.
Linnarssonella girtyi Walc.

Locality 9x, which has been correlated with it, contains only *Dicellomus politus*.

a. The next fossiliferous zone is 45 ft. below *b*, or the same distance above the base of the division.

The fauna (12,s) at this point, contains to brachiopods, but undescribed trilobites. Locality 9v, which is questionably correlated with this horizon has furnished.

Lingulepis acuminata Conrad
Linnarssonella girtyi Walcott

Div. 2. Massive calcareous sandstone, which has become leached into laminar favose masses **25 ft.**

At the base of this division and immediately above the underlying division is a fossiliferous zone (9r) with the following species.

Obolus tetonensis ninus Walcott
Lingulella similis (Walcott)
Linnarssonella girtyi Walcott
Acrotreta microscopica (Shumard)

Div. 3. Whitish crystaline limestone, almost made up of fragments of large crystids. With the limestones, small lenses and layers of glauconitic sandstone are interpolated. **24 ft.**

Div. 4. Basal beds of glauconitic grit, containing several layers of porphyry pebbles **20 ft.**

Hiatus and Unconformity

PRE-CAMBRIAN PORPHYRY.

It will be seen that the fauna on the whole is a unit. Most of its species are widely distributed as shown in Table V. Many if not the great majority it must be confessed, occur elsewhere in undoubted Upper Cambrian beds. This may mean that the entire series is referable to the Upper Cambrian, the Middle Cambrian being here unrepresented. This question must for the present be left in abeyance.

C. *The Ozark Region*

The Ozark uplift or dome is a low elevation on the west of the Mississippi River, in Southern Missouri and Northern Arkansas, from which the later Palæozoic strata have been removed by erosion thus exposing the earlier beds. This is the region from which Ulrich has named his Ozarkian system, although the development here is less complete in some respects than in the Arbuckles or in the Southern Appalachians. The most recent studies in this region comprise the survey of the Potosi and Edge Hill quadrangles by C. L. Dake.[1] the region lying in general to the south of the city of Potosi Mo. (approximately Longitude 90° 47′ W. and Latitude 37° 56′ N) The succession in this section is as follows, the classification in sqare brackets, being that adopted in this paper.

Superformation Lower Pennsylvanian

Great hiatus & Disconformity

Ozarkian [Upper Cambrian]

Roubidoux formation 0-100 ft.

1 Missouri Bureau of Geology & Mines, 2nd Series, Vol. XXIII. 1930

	Disconformity [?]	
Gasconade Formation		150-200 ft.
	Disconformity [?]	
Eminence Formation		0-200 ft.
Potosi dolomite		0-300
	Disconformity & Hiatus	
Upper Cambrian [Middle Cambrian]		
Derby-Doerun Formation	Eminence Formation	0-110
Davis Formation		0-180
Bonneterre Formation		0-300
La Motte sandstone		0-100
	Great Hiatus and Unconformity	
Pre-Cambrian crystallines.		

The most pronounced hiatus und disconformity is at the base of the Potosi and this is made the base of Ulrich's Ozarkian. Those who accept Ulrich's Ozarkian as a separate geological system, younger than the Cambrian, must of necessity refer the beds underlying it to the Upper Cambrian, as they are not thick enough to represent both Middle and Upper Cambrian time. To those of us however, who hold that Ulrich's Ozarkian is merely the southern and central Usonian phase of the Upper Cambrian, the underlying beds become naturally referable to the Middle Cambrian, at least in so far as they are distinct physically and faunally from the Ozarkian beds. This classification is quite in harmony with that adopted for the Southern Appalachians, for the correspondance of these earlier Missouri beds with the Conasauga series of the Southern Appalachians is generally recognized. The detailed characteristics of these formations for the Potosi region are as follows summarized from Dake's work.

La Motte sandstone. This rests upon the very uneven erosion surface of the old porphyry and hence its thickness varies from place to place, the greatest exposure being 100 ft. although drilling has disclosed as much as 223 ft. The formation is essentially a quartz sandstone, varying from light-gray to reddish brown, with clay layers common throughout. The upper layers generally show transition into the overlying Bonne-terre formation, through an interval of 10-20 ft. of alternating sandy and dolomitic layers. Microscopic study has shown that the grains of quartz are moderately rounded with their surfaces etched, this rounding being exceptionally perfect in the upper part, where the rock is also freer from clay. Other minerals are usually wanting, but the quartz grains often show secondary enlargement.

Along the line of contact with the porphyry, there is also a basal conglomerate, and there is no break between it and the overlying rocks, although sometimes there may be a fine conglomeratic bed or coarse grit near the top of the Lamotte sandstone. In some sections, a few fossils have been reported from the Lamotte, these including *Obolus lamborni* and some imperfect trilobite remains. Ulrich correlated this formation with the base of the Conasauga shale of Tennessee and with the Rogersville.[1]

Bonneterre Dolomite. This marks the progressive advance and deepening of the sea as is shown by the continuity with the underlying Lamotte. The basal beds of the Bonneterre are usually sandy, and there is an alternation of sandy and dolomitic layers in the lower portion. The upper part of the formation is crystalline and at intervals shaly layers are found. The greatest thickness of the

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1 Revision of the Palæozoic systems

formation obtained from a bore hole is 278 ft, but according to Dake, this probably does not include the transition zone at the contact with the Lamotte.

This formation has furnished a considerable fauna, most of the species having been obtained from the lower part. The brachiopods abound in *Obolus*, *Lingulella*, and *Dicellomus*, and the trilobites are especially characterized by *Crepicephalus* (*C. texanus*, *C. comus* and *C. thoosa* as well as others) and by *Norwoodia* and *Kingstonia*.

The discovery of a rich new fauna of 63 species including 4 new genera and 24 new species from the basal part of the Bonneterre dolomite of southeastern Missouri has just been announced by Christina Lochman.[1]

"This fauna, comprising trilobites, brachiopods, pteropods, cystids and merostomes, represents a typical assembly of the *Crepicephalus* zone."

Miss Lochman's study of the ecology of the Bonneterre fauna, has led her to the conclusion that it was a typical benthonic group and obviously the fauna must be regarded as of littoral type.[2]

So far as the species have been published the fauna is listed in Table V.

The age of this formation was for many years regarded as Middle Cambrian, to which division it was formerly assigned by Bain and Ulrich. In his monograph on the Cambrian Brachiopoda, Walcott also places this formation

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1 Preliminary list of titles and abstracts of papers to be offered at the 46th annual meeting of the Geol. Soc. of America, December 1933, p. 70.

2 I use the term Littoral as defined in my Principles of Stratigraphy and Text-book of Geology, including in it both the Shore and Neritic Belts.

in the Middle Cambrian, though in a footnote he suggests a possible younger age. When Ulrich created his Ozarkian system from the higher formations of this region, it necessitated the shifting of all formations below to a higher level, and he therefore assigned this, together with the Lamotte, to the Upper Cambrian. In this he has generally been followed by most later students. If however, as we believe, the Ozarkian represents Upper Cambrian, we may confidently return to the old classification and refer all the beds of this region below the Potosi to the Middle Cambrian. Ulrich's later correlation with the Appalachian succession makes it the equivalent of the Upper Maryville and the Upper Conasauga, and he correlates it further with the Cap Mountain of Central Texas and the Eauclaire of Wisconsion. All of these horizons are here regarded as of Middle Cambrian age, although Ulrich and his followers place them all in the Upper Cambrian. Again recently discovered faunas indicate equivalency with the lower Deadwood formation of South Dakota.

The Davis Formation. This is a more or less shaly series, with intercalated thin magnesian limestones, which overlies the Bonneterre. Its thickness varies from 160-170 ft, but often it is entirely removed by the erosion which followed the exposure at the end of Middle Cambrian, time, and before the transgression of the Ozarkian or Upper Cambrian Sea, so that the Potosi dolomite, the basal member of that series, sometimes rests directly on the Bonneterre. "This is particularly true over much of the southeast portion of the Edge Hill quadrangle."[1] Locally, also the Davis overlaps the Bonneterre and rests with a basal conglomerate upon the old porphyry. It is in perfectly

1 Dake *Loc. cit.* p. 79.

conformable contact with the overlying Derby formation and in many cases the name Elvins is used to cover both horizons.

A fauna with *Hyolithes primordialis*, *Lingulella acutangulus*, *L. similis*, *Linnarssonella girtyi*, *Acrotreta microscopica missouriensis*, *Billingsella coloradoensis*, and *Eoorthis wichitaensis* besides others, characterizes this formation. Also, according to Dake, it is from this horizon that Beecher's famous Eurypterid *Strabops thatcheri* apparently came. But perhaps the most significant fauna, for purposes of correlation, is that of the gastropods, especially the genus *Hypseloconus* the species being those described by Berkey from the Upper Dresbach (Lower Franconia according to Resser.). The following species are listed by Dake as identified by Professor Bridge.

Hypseloconus capuloides Berkey
Hypseloconus cornutiformis Berkey
Hypseloconus cylindrica Berkey
Hypseloconus franconiensis Berkey
Hypseloconus recurvus (Whitfield)
Hypseloconus recurvus attenuatus Berkey
Hypseloconus recurvus erectus Berkey
Hypseloconus marginatus Berkey

Also other species related to *Triblydium* and a trilobite related to *Maryvillia arion*.

The brachiopods *Eoorthis remnicha* and *Billingsella coloradoensis* often characterize certain horizons in great abundance and sometimes these form very persistent beds.

In his revision of the Palæozoic systems Ulrich correlates the Elvins (combined Davis and Derby-Doerun) as a whole with the Nolichucky of Virginia and Tennessee and with the upper Conasauga of Alabama. In his latest unpublished correlation table, he suggests correlation with the Dresbach and Franconia, which is indeed strongly indicated by the *Hypseloconus* fauna of the Upper Mississippi Valley. Ulrich also correlates it with the Upper Cap Mountain and all of the Wilberns of Texas, and the Honey Creek of Oklahoma.

Dake reports the finding, in the upper thin-bedded member of the Gallatin limestone of North-western Wyoming, of a closely related fauna, interbedded with edgewise conglomerates. This lies "above the typical scarp of the lower massive Gallatin limestone and just below a typical flat-pebble conglomerate.........in a considerable thickness of greenish shale and conglomeratic limestone." In this *Billingsella coloradoensis* (Shumard) was identified by Kirk. This species and *Eoorthis desmopleura* Meek, are also found in a 50 ft. bed of interbedded limestone-conglomerate and green shales, above the scarp of the massive Gallatin limestones in Clark Fork Canyon. The same brachiopod fauna, also occurs in the Wilberns of Texas.

Derby-Doerun Formations. These were formerly included with the Davis and classed together with it as the Elvins formations. They consist of a slight thickness, 60 to 80 ft. of massive non-cherty dolomites, which often show conspicuous cross-bedding of the eolian type, and it is suggested that these beds belong to the retreatal phase of the Middle Cambrian Sea, representing in part at least the disintegrated material reworked by wind activity. (See Pl. XII b in Dake's report). Fossils are rare or absent, and often represented by broken fragments only, though near the base of the formation species of *Obolus* seem to be abundant and from some beds of the Doerun *Finkelnburgia osceola* has been reported.

This forms the upper portion of Ulrich's Elvins formation, which he classes as Upper Cambrian, because he makes the succeeding beds typical Ozarkian. From what has however been repeatedly said, this marks the terminal horizon of the Middle Cambrian in this region, and as we have seen, it is separated by a great hiatus and disconformity from the succeeding Upper Cambrian of the Ozarkian type. The basal member of this higher series, the Potosi, rests disconformably on the Derby-Doerun, or where that has been removed by post Mid-Cambrian erosion on the Davis or even on the Bonneterre.

D. *The Upper Mississippi Region.*

The Upper Mississippi Valley of southern Wisconsin and Minnesota has long been noted for its fossiliferous Cambrian formations, which have been collectively classed as the St. Croix Series. Formerly the lower part of this series was regarded as Middle Cambrian while the upper part has always been referred to the Upper Cambrian. Since the promulgation of the Ozarkian doctrine however, the whole of this series has been lifted into the Upper Cambrian and has recently been made the type for the Upper Cambrian of North America by Resser.

I however, venture to dissent from this almost universal acceptance, and to return to the older position, which makes the lower part of this series Middle Cambrian. The following table gives the subdivision of the entire series, with my classification added.[1]

1 See the table given by Resser, in Bull. Geol. Soc. of America Vol. XLIV, No. 4, p. 738 and Ulrich's table in the Transactions of the Wisconsin Academy of Sciences, Arts and Letters, Vol. XXI, 1924, pp. 82 and 83. Also his more recent table in the Bull. of the Public Museum of the City of Milwaukee, Vol. XII, 1933, p. 135.

SUPERFORMATION		
St. Peter sandstone		
CAMBROVICIAN		
Beekmantown (Canadian of Ulrich)		
Shakopee dolomite		10-100 ft.
Upper Cambrian (Ozarkian in part of Ulrich)		
Oneota dolomite		0-200 ft.
Madison sandstone, including Mendota dolomite		50 ft.
Jordan sandstone		60-80 ft.
Trempealeau Formation		125 ft.
3. Norwalk sandstone member	50 ft.	
2. Lodi shale member	50 ft.	
1. St. Laurence dolomite member	25 + ft.	
Mazomanie Formation		100-150 ft.
Hiatus and Disconformity		
MIDDLE CAMBRIAN		
Franconia Formation with Ironton sandstone at base		120-170 ft.
(Usually absent in Western Wisconsin:—Ulrich)		
Dresbach sandstone		40-250 ft.
Eauclaire shale		200-350 ft.
Mount Simon sandstone		225-235 ft.
Hiatus and Unconformity		
SINIAN Keweenawan (or Pre-Cambrian crystalline).		

The hiatus and disconformity between the Middle and Upper portion of the section is shown by the frequent absence according to Ulrich, of the Franconia in Eastern Wisconsin, when the Mazomanie sandstone rests upon the Dresbach, and by the absence of the Mazomanie in Western Wisconsin.[1]

It is also shown by the very striking faunal change between the Franconia and the succeeding beds.

The following are the characters in brief of the formations here referred to the Middle Cambrian.

The Mount Simon Sandstone. This represents the accumulation of residual sand during early Cambrian and Sinian time upon the exposed Old Land surface, and which was reworked by the advancing Cambrian Sea. The fact that this old residual sand is for the most part pure, indicates that the old residual soil was extensively worked over by the wind, which removed much of the finer material while at the same time, the sand grains were subject to wear, this resulting in the production of more or less rounded grains. The continuous wind activity, also resulted in a sorting of the grains, more or less according to size.[2] It is safe to say, that probably the great mass of quartz sand which goes to make up the early Palæozoic formations over the region of the Mississippian low land, is this old residual sand, which has been repeatedly reworked by the sea, and reincorporated in successive deposits. If the material were the product of wave erosion along the shore, it would hardly show the purity of grain that is so commonly found in these formations, but would rather consist of a mixture of sand and clay, or else sand followed by clay instead of by limestones. Of course these basal sandstones are not everywhere pure quartz, for there are

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1 Ulrich 1924

2 See Grabau. Text-book of Geology, Vol. II, page 186

clay beds interbedded in some of the sections. But the amount of clayey material is in no wise commensurate with that to be expected if these beds were entirely the product of marine and river erosion, or the utilization of the weathered material of the land, which had not previously been sorted and purified by wind activity. And above all, the remarkable relationship so commonly met with *i.e.* the gradation between the sandstones and the succeeding limestones or dolomitic rock could not have developed, if there were much clay material furnished to the waves of the transgressing sea. For in such a case we would have the limestones and sandstone of a single depositional cycle separated by clay deposits, instead of the transition from sandstones into the succeeding limestones or dolomites which is so commonly met with in these formations.

That basal conglomerates are occasionally present in this series is of course to be expected, especially where the old rocks are porphyries or other cryptocrystalline igneous rocks. But the remarkable fact is that the basal conglomerates are as a rule of very slight thickness and on the whole negligible, and this would imply that torrential rivers were essentially wanting in this region during the period of sea transgression, while wave activity as a whole was not very pronounced. All of this would indicate a flat low land surface across which the sea trangressed.

It is of course perfectly well known that in some sections cliffs existed, representing old erosion-remnants or monadnocks on the peneplane surface. Along the base of such monadnocks, coarse debris would of course accumulate and here the basal beds would consist of conglomerates or even of boulder beds.[1] But even in such cases wave activity seems to have been almost negligible, as is shown by the fact that the rich gastropod fauna with *Hypseloconus* and *Triblidium* described by Berkey from the upper Dresbach or lower Franconia was obtained from the matrix of a conglomerate in the neighbourhood of old diabase monadnocks. The broken shells etc so ofter cited as evidence of strong wave activity can perhaps be explained better as due to exposure to subaerial agencies. (See below).

Despite the occasional conglomerates, the fact remains that over most of the area covered by the early Cambrian sediments, the basal sandstone as well as those succeeding it consist primarily of quartz grains, except of course where calcareous material is mingled with these grains.

It has been repeatedly emphasized that the lithological composition of these Cambrian beds "is maintained without appreciable modification over remarkably great distances."[2]

The Eauclaire Formation. This consists mostly of thin-bedded, in part shaly sandstones, becoming coarse, white, friable sandstones towards the base. Fossils are abundant and generally distributed in two marked zones. The lower one is characterized by the trilobite *Cidaria*, which is also represented in the upper Conasauga and the Nolichucky shale of the Northern Appalachians and serves approximately to correlate these horizons. In the higher part the fossil zones are characterized by *Crepicephalus*, and this again is a wide-spread horizon in the Cambrian deposits of this region. *Crepicephalus* is especially characteristic of the Maryville and Nolichucky horizons of the Southern Appala-

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1 Sec the illustrations in Grabau, Text-book of Geology, Vol II, p. 185

2 Resser 1933, loc. cit. page 752.

chians and is equally characteristic of the Cordilleran region, where many of the Cambrian sections terminate with the *Crepicephalus* beds. (Resser)

The fauna of the Eauclaire is given in Table V, Col. 17.

Dresbach Sandstone. This is a massive-bedded rather coarse-grained sandstone, with a thin bed of shale at the base, and shaly sandstones near the middle (Walcott). Resser calls it a "beach-dune deposit, which probably becomes fossiliferous immediately west of the present Mississippi River, away from the old shore line." The fossils in the top and basal portion of the series consist almost entirely of the shells of *Dicellomus* and *Lingulella.*

Berkey[1] describes at length the lithological character of these formations in the St. Croix Dalles. He divides the Dresbach into two divisions, an upper Dresbach (A) and a lower Dresbach (B). The lower, of which about 50 ft. are exposed in the region described by him, consists of sandy shales, loose clayey shales and calcareous shales in which thin layers of limestone 1 to 3 inches thick occur. Finally there are pyritiferous shales in which secondary iron sulphide in little pellets and grains make up almost 1/3 of the mass. Fossils are abundant in individuals, though meagre in variety and they are most numerous in the calcareous shales. The pyritiferous shales also carry a few fossils which are generally replaced by the iron sulphide, but the other beds of the formation are almost devoid of fossils. The upper Dresbach (A) has a persistent shaly development in its uppermost and lowest members, between which is a greensand bed, which is coarsely arenaceous. The

1 American Geologist. Vol. XX, 1897, p. 373, *et. seq.*

typical section according to Berkey is as follows in descending order.

3.	Shaly sandstone	10 ft.
2.	Green-sand	20 ft.
1.	Gray shale	40 ft. (Exposed)

The green-sand is a glauconitic mixture with broken fragments of Linguloid shells which are abundant, though other fossils are not common. Cross-bedding characterizes this bed at Franconia and the quartz grains are comparatively large and well-rounded. The shells are mostly broken, but undecomposed. Occasionally large pebbles of quartz occur, and near the old projecting ridges of igneous rock a basal conglomerate is found. It is from such a conglomerate that Berkey has obtained the rich fauna of gastropods (*Tribli-dium*, *Hypseloconus* etc.) already referred to, and which is listed in Table V Col 18. The horizon is the upper Dresbach or lower Franconia.

These fossils correlate this horizon with the Davis formation of the Missouri region.

The Franconia Formation. This was named by Berkey from the village of Franconia in Minnesota, where it is exceptionally well exposed. Here it consists of an incoherent fine sand at the top, preceded by more compact and thick-bedded layers in which thin seams of green shale occasionally appear. There is a general lack of calcareous matter and the fossils are mostly molds, from which the original shell has been dissolved. The usual exposure is about 100 ft, but Ulrich gives 125+ as the maximum in Minnesota, 120-170 in Western Wisconsin, while he reports it as usually absent in Eastern Wisconsin. In Western Wisconsin Ulrich divides it into the following zones in descending order.

5.	Upper Green-sand	54-70 ft.
4.	Yellow sandstone	40-50 ft.
3.	Lower Green-sand	40 ft.
2.	Micaceous shale	15 ft.
1.	Ironton sandstone member	2-12 ft.

The Ironton sandstone is now more often made a distinct division and though it only ranges from 2 to 12 ft. in thickness, it contains 2 distinct fossiliferous zones, a lower with the trilobite *Camaraspis convexus* (Whitfield) (formerly referred to *Arionellus* or *Agraulus*), and a second one characterized by the trilobite *Elvinia roemeri* (Shumard), (formerly referred to *Dicellocephalus* and later to *Ptychoparia*).

The Ironton formation is remarkable in that in Southwestern Wisconsin it is composed mainly "of reworked, washed and relatively coarse residual grains of Dresbach sandstones, the surface of which has previously been subjected to subaërial bleaching and wear."[1]

Ulrich considers that there is a distinct break between the Dresbach and Ironton, marked by an undulating plain, above which washing and sorting of the loose quartz grains of the underlying formation is first indicated.

The Franconia proper as now recognized, is divided according to Resser into the following divisions and zones.

C. *Ptychaspis beds.*
 2. Saukaspis zone
 1. Ellipsocephalus curtus zone

B. *Conaspis Beds.*
 4. Wilbernia zone
 3. Taenicephalus zone

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1 Ulrich, Transactions of the Wisconsin Academy of Science Arts and Letters Vol. XXI, 1924, p. 93.

2. Unnamed zone
1. Unnamed zone

A. *Eoorthis beds*
2. Eoorthis remnicha zone
1. Hypseloconus zone

As has already been noted, there is a widespread zone with *Eoorthis remnicha* in a persistent bed of the Elvins or Davis formation of Missouri, occurring approximately about 100 ft. above the top of the Bonneterre. On the other hand the *Hypseloconus* zone of the Elvins occurs about 10 ft. above the top of the Bonneterre. Although these localities are some 400 miles apart, the zones appear to be persistent, and this would suggest the equivalency of these two formations and the essential uniformity of the area of deposition. The question may be raised as to the classification of these beds, for the lower zone was originally placed below Berkey's typical Franconian and included in the Dresbach series. It is possible that no very great weight is to be attached to the break between the Dresbach and the Ironton, although a certain period of exposure of the former seems to have preceded the formation of the latter. If may be one of those zonal breaks, which as we shall see later, are so characteristic of the marginal plain of the Caledonian Geosyncline.

The *Eoorthis* beds are followed by the *Conaspis* beds, which in Western Wisconsin comprise 10-40 ft. of yellowish platy sandstones, some of which are filled with highly characteristic remains of trilobites. Here in the upper part occurs a zone characterized by *Taenicephalus shumardi* (Hall) Ulrich and Resser, first described as a *Conocephalites* and later as a *Conaspis*. The latter genus comprises a number of species formerly referred to *Conocephalites*.[1] Two unnamed zones of the Conaspis beds occur below the *Taenicephalus* zone, while above it occurs the *Wilbernia* zone with *Wilbernia diademata*, originally described as *Ptychoparia diademata*.

The "*Ptychaspis*" beds consist of 50 to 70 ft. of green-sands with *Ellipsocephalus curtis* and *Chariocephalus whitfieldi* as the characteristic trilobites.

In Western Wisconsin, the upper green-sand is succeeded by the basal sand of the Trempealeau formation, of which some 20 ft. underlie the St. Laurence dolomite. In Eastern Wisconsin on the other hand the Mazomanie sandstone 100-150 ft. thick, lies below the Trempealeau. In this region, the Franconia is usually absent and the Mazomanie rests directly upon the Dresbach. Faunally, the Mazomanie is entirely distinct from the underlying beds and to some extent more nearly related to the succeeding Trempealeau. So far as the trilobites are concerned, the species found in this formation are confined to it. This is of course to be expected considering the extreme detailed discriminations to which Ulrich and Resser have subjected the trilobites of these various formations. But generically, the Mazomanie has both relationship with the overlying and underlying formations.

Thus of the 27 specifically named species of *Prosaukia*, 8 occur in the Franconia, and 3 in the Trempealeau, while 18 are confined to the Mazomanie. On the other hand, of the 17 identified species of *Saukiella*, 3 occur in the Mazomanie and the remainder in the higher beds. The same thing is true of the brachiopods. Out of 23 species in the lower formations (Franconia, Dresbach and Eau-

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1 See Walcott II, p. 357.

claire) 10 also occur in the higher beds, but it must be remembered that the brachiopods have not been subjected to the rigid stratigraphic analysis accorded the trilobites. It is a matter of general agreement however, that the most important break in the entire series is located between the Franconia and the overlying Mazomanie-Trempealeau, and this together with the usual absence of the Franconia in Eastern Wisconsin may be taken as evidence of a marked disconformity and hiatus at this horizon. It is here that Hall and Sardeson[1] drew their dividing line between the Upper and Middle Cambrian, and it is here I would also place the dividing line.

E. *The Deadwood Section of South Dakota*

In the Black Hills region of South Dakota and the adjoining area of Eastern Wyoming, the Palæozoic section begins with the *Deadwood Formation*, which rests directly upon the Pre-Palæozoic crystallines. This formation ranges from 40 ft. or less in the southeastern part of the Black Hills, to 500 ft. or more in the northern part.

Three main divisions are readily recognized in the Deadwood formation, a lower brownish or buff coarse quartzitic sandstone or quartzite, conglomeratic at the base; a middle, less indurated portion, made up chiefly of thin-

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1 C. W. Hall and F. W. Sardeson. The Magnesian Series of the Northwestern States. Bulletin of the Geol. Soc. of America Vol. VI, 1895, pp. 167 (170) Ulrich makes Hall and Sardeson include the Franconia in their St. Lawrence series which would place their faunal break below the latter. As a matter of fact however, the term Dresbach as used in 1895 included the Franconia as the upper Dresbach, and this original upper Dresbach was raised to the rank of an independent formation by Berkey in 1898 and given the name Franconia.

bedded, sandy, glauconitic shales or limy beds, that are in places more or less filled with flat calcareous pebbles; and an upper massive, buff or reddish sandstone which like the lower member is locally quartzitic. In places the upper sandstone is overlain by several feet of thin greenish shales, at the top of which there appears here and there a local sandstone. Above this follows disconformably the Whitewood limestone of Ordovician age.[1]

Near the town of Deadwood, in the Northern Black Hills, the type locality, the basal member averages about 40 ft. + in thickness, the Middle member more than 300 ft. and the upper member 50 ft. Fossils are abundant and well preserved in many places and occur at many horizons.

According to a preliminary announcement,[2] a collection made in 1932 by a Smith College Field party, at the type locality on Whitewood Creek, has disclosed the presence of a *Crepicephalus* zone, 48 ft. above the contact of the Deadwood, with the pre-Cambrian schists "The bed is moderately fossiliferous but the specimens have been broken and exhibit the effects of rough treatment in agitated water."

The following species are given by Myerhoff and Lochman, as identified from this stratum.

Dicellomus fiestus Lochman
Dicellomus pectenoides (Whitfield)

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1 C. C. O'Hara. Guide-book, 25, 16th International Geol. Congress 1932, p. 12.

2 Preliminary list of titles and abracts of papers to be offered at the 42nd annual meeting of the Geological Society of America December 1933, p. 36. Howard A. Myerhoff and Christina Lochman.

Dicellomus politus (Hall)
Hyolithes primordialis (Hall)
Pseudagnostus dakotensis Myerhoff & Lochman
Paracrepicephalus thoosa (Walcott)
Anomocarella modesta Myerhoff & Lochman
Kingstonia convexa Lochman.
Lonchocephalus minor? (Shumard)

In addition to this are unnamed species of *Litagnostus*, *Crepicephalus?*, *Paracrepicephalus*, *Coosia etc.*

According to the authors, the presence of *Paracrepicephalus thoosa* (Walcott) indicates the equivalency with the widely distributed *Crepicephalus* zone which the authors, in accordance with general usage, refer to the early Upper Cambrian.

This species is characteristic of the Upper Conasauga, Honaker and Maryville formations of the Southern Appalachians and these according to the classification here advocated represent typical Middle Cambrian, and it is doubtless to this horizon that the lower part of the Deadwood must again be referred. This has been its position prior to the promulgation of the Ozarkian doctrine.

The character and mode of preservation of the fossils in this horizon appears to have considerable significance. According to the authors the specimens were broken and they refer this to treatment in rough water. It may however be questioned, if on a flat sandy surface, such as that which characterized the entire region of St. Croix deposition in Cambrian time, wave activity could have played such a prominent part. It is a well-known fact, that on flat sandy shores, the most delicate shells can be picked up unbroken after even a heavy storm which has cast them ashore. Along steep shore lines, shells are of coarse often ground into unrecognizable fragments, but on shelving shores they are merely worn by the drifting sands and seldom broken. Moreover, they are mingled with the sand and so protected from contact with one another, and if there are no pebbles or boulders which can serve as tools for the waves to pound up the shells with, there is little likelihood of their being broken into fragments. Often where shells of one species accumulate in masses, as may be seen frequently on many shelving shores, they are seldom broken, although by mutual attrition, they may be more or less worn. Even on moderately steep shores, the shell-sand, accumulating near the level of high tide, contains an abundance of unbroken and often unworn young shells, and here indeed we find the protoconchs of young gastropods as a rule, perfectly preserved.

Although there are few observations on record regarding the occurrence of the exoskeletons of horse-shoe crabs (*Limulus*) which may be regarded as the nearest analogue of the shed exoskeletons of trilobites, those that are available, supplemented by my own observations, point rather to a prevailingly complete preservation of these structures. for they are readily buried in the shifting sands and thus preserved from any grinding action, unless they happen to be in the zone of agitated pebble beaches.

Without attempting to stress the point unduly, it may at least be remarked that caution should be used before referring such beds of broken organisms to the effect of wave activities. It appears to me that we have here rather an indication of subsequent exposure to subaerial activity, of an extended sand area enclosing organic remains. If these deposits represent the sediments of the northern margin of the Middle Cambrian shallow sea, they would on the retreat of this sea, remain exposed for perhaps millions of years before the returning Upper Cambrian sea would resubmerge them. During this long interval the shifting of these sands and their subjection to the vicissitudes of a more or less arid climate, would result in the fragmentation, though not necessarily the complete destruction of the shells and trilobite exoskeletions, and this to an extent over vast areas which no wave activities would accomplish. For if the destructive effect of the waves were so comprehensive, it would be difficult to understand how organisms could continue to exist in such waters. The Upper Cambrian sea would assemble the scattered fragments and by gravitative selection arrange them in a more or less continuous fossil bed. With this may easily be included Upper Cambrian species.

Even temporary exposures, for a few months or years, such as may readily have occurred a number of times, during the deposition of a single formation, might account for the broken character of the shells in certain localities, whereas to attribute the breaking of many shells, no more than one fourth of an inch in diameter, largely if not wholly to wave activity, would require a confidence in the power of the waves that can only be based on more widespread observations of modern examples, than are at present available.

If on further examination of these beds of fragmentary fossils, it becomes established that such fragmentation is due chiefly to subaerial exposure of the unconsolidated sediments, they may serve as a suitable guide for the location of the disconformity between the Middle and the Upper Cambrian portions of these widespread early Palæozic sandstone formations.

MIDDLE CAMBRIAN OF THE PALÆO-CORDILLERAN GEOSYNCLINE

It is generally recognized that nowhere is there such a complete development of the Middle Cambrian as in the Cordilleran region of Alberta and British Columbia. It is on this account that I have suggested the name *Albertan* for the Middle Cambrian pulsation, which is here seen to be more complete than elsewhere though because of the prevailing calcareous character of the formation, it is difficult to differentiate the transgressive from the retreatal portion. As one of the best known and standard sections, we may take that of Mount Bosworth on the Continental Divide between Alberta and British Columbia. The mountain lies directly north of the head of Kicking Horse River on the main crest of the ranges, and some 10 or 11 miles North-west of Field station on the Canadian Pacific Railroad (approximate Longitude 116° W.; Latitude 51°30′ N). Other important sections in the immediate vicinity are those of Mount Stephen, Mount Whyte, and Fossil Mountain. Walcott says of Mount Bosworth "It contains one of the largest and most complete Cambrian sections in the Canadian Rockies. North of Mount Bosworth the sequence and character of the formations as expressed throughout the Bow Range, begin to change and the section loses its completeness"[1] As in most of the Canadian Rockies, the strata are little disturbed, being only gently inclined and unmetamorphosed. The entire succession in Mount Bosworth is as follows in descending order.

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1 Walcott Cambrian Geol. and Pal. Vol. V (Smithsonian Miscell. collection, Vol. 75, No. 5,) pp. 308-309, Pl. LXVII

I. Mount Bosworth Section

Upper Cambriam		3590 ft.
Sherbrook Formation	1375 ft.	
Paget Formation	360 ft.+	
Bosworth Formation	1587 ft.	
Arctomys Formation	268 ft.	
Middle Cambrian		4580 ft.
Eldon Formation	2728 ft.	
Stephen Formation	640 ft.	
Cathedral Formation } Ptarmigan Formation }	1212 ft.	
Lower Cambrian		1453 ft.
Mount Whyte Formation	350 ft.	
St. Piran Formation[1]	503 ft.	
Fort Mountain Formation	600 ft.	

The equally famous MOUNT STEPHEN section lies 7 miles west-south-west of the Mount Bosworth section, and here the thicknesses of the formations are very nearly the same. Several other important sections occur within a radius of 5 to 10 miles.

In this paper we shall discuss only the Middle Cambrian beds, referring to the Upper and Lower Cambrian only so far as their limiting relations are concerned.

Characteristics of the Middle Cambrian Formations

The Ptarmigan Formation. This is named from Ptarmigan Peak Massif, where it is exposed at the base of the

1 In the Lakes Agnes and Louise region, about 5 miles S. E. of Mount Bosworth, the total thickness of the St. Piran is 2705 ft. which is assumed to be its maximum. (Walcott, *loc. cit.* p. 314)

section 4.75 miles N.N.E. of Lake Louise Station, on the Canadian Pacific Railway. In both the Mount Bosworth and Mount Stephen sections it has not been differentiated from the Cathedral formation, but its presence there is indicated by the characteristic fauna in the lower part of this formation. In character, it is more or less arenaceous gray limestone with interbedded bands of thinner-bedded, dark-bluish black limestone and some interbedded beds of shale. The most important of these shales is the *Ross Lake Shale,* typically exposed in the Ross Lake section, on the south side of the Canadian Pacific Railway, 1 mile S. S. W. of Mount Stephen Station on the Continental Divide. This shale is greenish and dark-gray, compact and siliceous and has a thickness of 7 feet. It contains an abundant fauna in which the trilobite *Albertella* is the dominant one (63j)[1]. In this section, the base of the shale is 509 ft. above the top of the Mount Whyte Formation.

On the slope of Mount Bosworth, the shale is somewhat thicker and contains nearly the same fauna. The following are the thicknesses of the Ptarmigan formation in a number of important sections.

A.	(II)	Ptarmigan Peak about 10 miles E.N.E. of Mount Stephen	516 ft.
B.	(III)	Bow Lake 20 miles N.W. of Ptarmigan Peak	534 ft.
C.	(IV)	Ross Lake 8.5 miles W.S. W. of Ptarmigan Peak	664 ft.

1 These are Walcott's locality numbers, and are cited for ready reperences to the original articles.

D. (VI) Castle Mountain[1] in Bow Valley about 23.5 miles S. E. of Mt. Stephen. 272 ft.

E. (VII) Ghost River on Rocky Mountain Front, 55 miles E of Mt Stephen 1122 ft.

A (II[2]) *Ptarmigan Peak* At Ptarmigan Peak the subdivision of the formation is as follows (Walcott V, p. 278)

Super Formation: Cathedral limestone

Ptarmigan Formation 516 ft.

1a. Thin-bedded fine-grained, hard, dark, gray to grayish black arenaceous limestone 46 ft.

The fauna (63b) includes

Zacanthoides cimon Walcott

Neolenus constans Walcott

1b. Finely arenaceous limestone in thick alternating bands of a light-gray and dark lead-gray colour. The lower 20 ft. light-gray, finely arenaceous laminated limestone 270 ft.

The fauna comprises trails and annelid borings which occur abundantly within the layers and on their surfaces. The *Ross Lake* shale (not exposed) occurs probably about 100 ft. below the top of the section.

1c. Massive-bedded, bluish-gray more or less finely arenaceous limestone, with many dark layers of oolitic limestone, the ooliths varying from 5 to 25 mm in diameter. 110 ft.

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1 About 15 miles in an air line W.N.W. of Banff Station Alberta Canada.

2 Section numbers used in the text and diagrams.

Only a few minute fragments of trilobite tests were seen.

Subformation Mount Whyte (L. Cambrian)

There is no recognized disconformity between the Ptarmigan and Mount Whyte, but as discussed in the preceding article, there is much indirect evidence for its existence, Not only is the variability in thickness of the two formations pronounced, but above all, there is the abrupt change of the fauna.

B(III) *Bow Lake.* At Bow Lake, the subdivision of the Ptarmigan is as follows. (Walcott V, p. 324)

Superformation, Cathedral limestone.

Ptarmigan Formation			534 ft.
1.	Bluish gray, thin layers in massive beds The fauna consists of fragments of *Neolenus*	108 ft.	
2.	Ross Lake shale. Dark siliceous shale with the *Albertella* fauna.	6 ft.	
3.	Thin layers of bluish gray limestone in massive beds breaking down on slopes but quickly becoming more massive-bedded and cliff-forming, and passing below into gray rocks.	154 ft.	
4.	Deep bluish-gray, massive-bedded coarse limestone, more or less mottled on weathered surfaces	144 ft.	
5.	Light-gray, more or less mottled, rough weathering limestone in massive layers 6-50 ft. (The fossils are annelid borings.)	122 ft.	
Subformation Mount Whyte. (L. Cambrian)			762 ft.

Again, there is no recognized physical break. The upper bed of the Mount Whyte, is thin-bedded rough-surfaced, bluish gray limestone, passing into coarser magnesian, thin-bedded limestone. The annelid borings in the lowest bed of the Ptarmigan (No. 5) indicate shallow water and therefore support the idea of a hiatus and disconformity.

The Mount Whyte in this section has a total thickness of 762 ft. which is twice its thickness in the Mount Bosworth and Ptarmigan Peak sections, and more than 3 times its thickness in the Castle Mountain and Ross Lake sections. In addition to that we have the abrupt change in fauna.

C(IV). *Ross-Lake section.* Here the detailed section is as follows (Walcott V, p. 306)

Superformation Cathedral limestone.

Ptarmigan formation 664 ft.

1.	Thin-bedded, more or less arenaceous and mottled limestone	155 ft.
1a.	Bluish gray limestone in thin irregular layers, interbedded in a greenish siliceous shale.	3 ft.
2.	*Ross Lake shale.* Greenish and dark gray compact siliceous shale, weathering to light gray when long exposed, when the solid hard layers become shaly. This shale is characterized by an abundance of the *Albertella* fauna,	7 ft.
3.	Massive-bedded, gray and mottled, rough weathering arenaceous limestone	160 ft.

4.	Compact, dove-gray-coloured limestone in thin layers	12 ft.
5.	Massive-bedded, dirty-gray coloured rough-weathered calcareous sandstone	275 ft.
6.	Alternating layers of bluish black and steel-gray hard limestone	52 ft.

Subformation Mount Whyte Formation. 248 ft.

Again no indications of a physical disconformity are recorded, but such probably exists. The upper bed of the Mount Whyte consists of 43 ft. of gray to grayish black, thin-bedded oolitic limestone with many small fragments of trilobites and is preceded by a 5-foot bed of sandstone and arenaceous limestone. The total thickness of the Mount Whyte here is only 248 ft. and the total thickness of the Ptarmigan is 664. In the Castle Mountain section, where the Mount Whyte is also 248 ft, the Ptarmigan is only 272 ft, or almost 1/3 the thickness of that at Ross Lake. If the dividing lines are correctly drawn, these differences in thickness cannot be without marked significance.

D(VI) *Castle Mountain Section.* The lower part of the Middle Cambrian at Castle Mountain shows the following divisions (Walcott V. p. 276)

Superformation Cathedral formation
Ptarmigan Formation 272 ft.

1a.	Bluish-black fossiliferous limestone	12 ft.

This contains a fauna peculiar for the small size of the individuals, this suggesting adverse conditions and the production of dwarf faunas. The genera *Albertella* and *Dorypyge* are characteristic, and this suggests that we are dealing here with the *Albertella* zone.

1b. Gray arenaceous limestone In nearly every bed; this is marked by large irregular dark annelid borings. About 75 ft. from the base, the limestone passes into gray quartzite sandstone. 260 ft.

Subformation. Mount Whyte. (L. Cambrian) 248 ft.

This consists of 136 ft. of limestones with indeterminate fossils, though in the upper 40 ft. there are some undescribed trilobites (horizon 58d). Below this in 1c, which consists of 22 ft. of dirty-brown sandstone, the typical upper Mount Whyte fauna is found. No evidence, of a physical disconformity between the Mount Whyte and the Ptarmigan is recorded but it probably exists.

E(VII) *Ghost River Section,* on the Rocky Mountain front.

This section is 55 miles east of Mount Stephen, and the characters according to Walcott are as follows (Walcott V, p. 62).

Superformation Devonian Ghost River Series

Hiatus and Disconformity

Upper and Middle Cambrian 1122 ft.

1. Thin-bedded gray limestone, with abundant annelid trails on weathered surfaces 252 ft.

2.	Gray and bluish-gray thin-bedded limestone shelf or terrace-forming	40 ft.
3.	Massive bedded cliff-forming gray limestone weathering into thin layers	830 ft.

Subformation Lower Cambrian.

The fauna obtained from the 3 divisions above listed, include that of the Ptarmigan horizon with *Albertella,* the Stephen horizon, with *Glossopleura,* and apparently also Upper Cambrian, with *Ptychaspis.* Considering the fact that the total series is only 1122 ft, it would seem that there is at least one hiatus or more,-one of them at the base of the Ptarmigan, the other between the Stephen and the Upper Cambrian. Walcott holds that it is probable that, "the Cambrian section of the Front Range, between the South Fork of Ghost River and the South Fork of Panther River, and probably still farther northwest, includes the St. Piran and Mount Whyte formations of the Lower Cambrian, and the Ptarmigan formation of the Middle Cambrian, with which the section terminates at a plane of disconformity resulting from the non-deposition in this region of the Middle and Upper Cambrian and later formations up to the Devonian."[1]

In view of the faunas above referred to it is possible that this opinion needs revision.

I *Mount Bosworth.* (Walcott V, p. 312) Returning to the Mount Bosworth section we must note that the Ptarmigan has not been differentiated from the Cathedral, but that its presence is shown by the occurrence of the *Albertella* fauna in the drift on the south slope of Mount

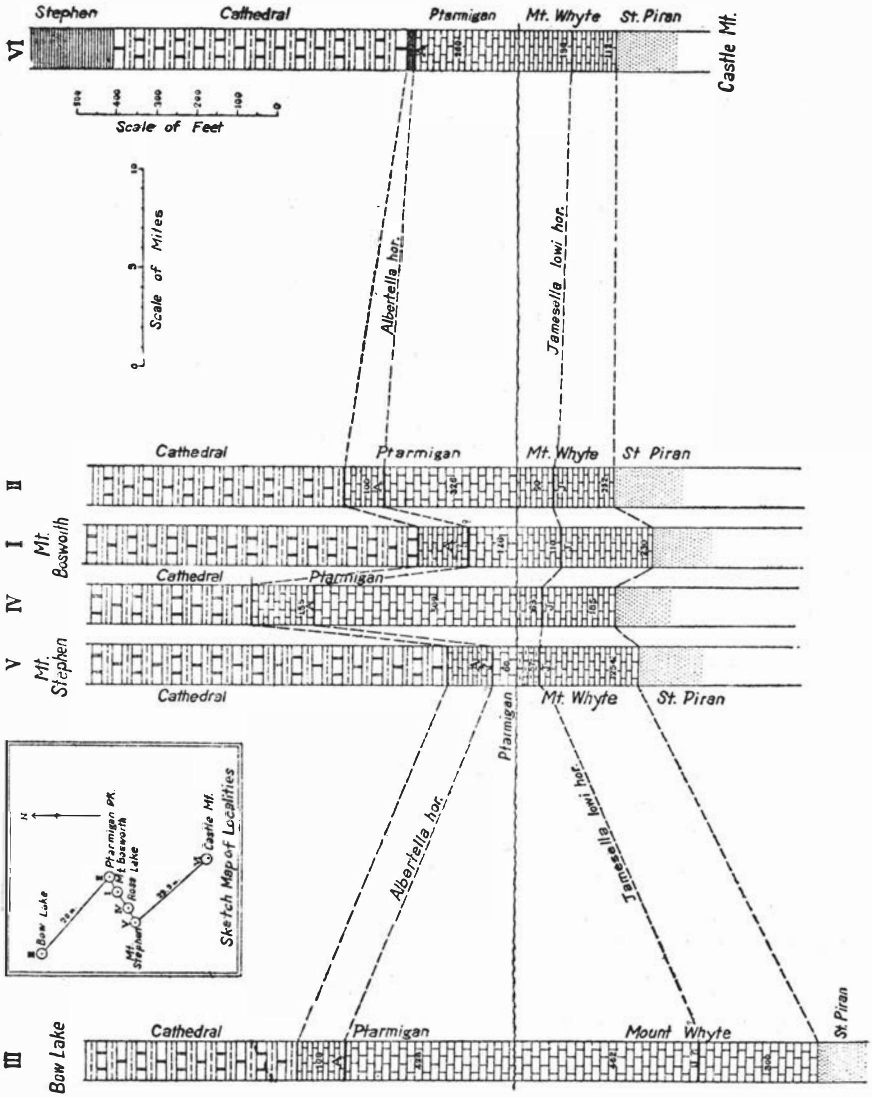
1 Walcott, *Loc. cit.* p. 263.

Bosworth. The lowest division of the Cathedral consists of 126 ft. of thin-bedded arenaceous limestone, with annelid borings and trails in some of the layers, and this is succeeded by 682 ft. of massive arenaceous limestone. Since the total thickness of the Cathedral and Ptarmigan is only 1212 ft. and it is followed by the Stephen, it is probable that the Ptarmigan portion is of slight thickness, and that the *Albertella* zone occurs either near or at the base of the lowest 126 ft. (division 1c) or immediately above it. The underlying Mount Whyte formation which here has a thickness of 390 ft. has a typical *Jamesella lowi* zone 160 ft. below the top of the Mount Whyte. The upper 120 ft. are also arenaceous limestones, with annelid trails and borings. As already outlined in the earlier article, there are a number of typical fossiliferous zones at lower horizons.

V. *Mount Stephen* (Walcott V, p. 316) In this section too, the Ptarmigan has not been differentiated. The thickness of the Cathedral formation, which probably includes it is 1680 ft. to the base of the Stephen formation, though that thickness is estimated rather than measured. The lower 60 ft. consists of massive-bedded arenaceous dolomitic limestone, which rests upon the Mount Whyte, which itself has a thickness of 315 ft. and contains 7 fossiliferous zones (see article 1). The highest of these with *Jamesella lowi* etc, lies at the very top of the Mount Whyte, and if we are permitted to judge by thicknesses, appears to be unrepresented in the other sections.

Summary of the sections on the Canadian Pacific.
Text-Fig. 4.

It is perhaps dangerous in sections of this type to judge of the relationships of the formations by the occur-



Text—Fig. 4. Sections in the Canadian Rockies (Northern Palæocordilleran Geosyncline) showing the variation in the position of the *Albertella*-zone of the Ptarmigan Formation (Lowest Middle Cambrian) and of the *Jamesella lowi* zone of the Mt. Whyte Formation (Highest Lower Cambrian) as évidence for a disconformity between the two. The sections are: I, Mt. Bosworth. II, Ptarmigan Peak. III, Bow Lake IV, Ross Lake; V, Mt. Stephen; VI, Castle Mt. (For location see small inset map and text) rence of similar fossiliferous zones, because the possibility that other still undiscovered zones may occur at other horizons, cannot be excluded. Nevertheless, it may be worth while to summarize what is known of the occurrence of these zones.

The three best determined sections form almost an isoseles triangle, (See Text-Fig. 4) the base of which is formed by Ptarmigan Peak (II) on the northeast and Ross Lake (IV) on the southwest, with a distance between the two points of 8.5 miles, while the apex of the triangle is formed by Bow Lake (III) on the Northwest, distant about 20 miles from each of the other points. At Bow Lake (III) the Ross Lake shale with the *Albertella* fauna, lies 108 ft. below the top of the Ptarmigan. Twenty miles S.S.E. at Ross Lake, (IV) the same horizon lies 155 ft. below the top, while at Ptarmigan Peak, (II) the northeastern end of the base line of the triangle, its position is given as approximately 100 ft. below the top, though the actual outcrop has not been observed. This same horizon in the 3 sections lies at the following distances above the top of the Mount Whyte.

Bow Lake (III)	426 ft.
Ross Lake (IV)	509 ft.
Ptarmigan Peak (II)	326 ft.

This variation in thickness may of course be due to local variation in sediments, but it also is possible that it represents variation due to overlap. Taking the same sections, we have the following thicknesses of the underlying Mount Whyte, which in each case rests upon the St. Piran sandstone.

At Bow Lake (III)	762 ft.
At Ross Lake (IV)	248 ft.
At Ptarmigan Peak (II)	342 ft.

This is a much more pronounced variation and suggests irregularity of off-lap or of erosion before the advent of the Ptarmigan, rather than inequality of deposition.

If we now take account of Mount Bosworth and Mount Stephen, both of which lie on the base line or its extension (Mount Bosworth lies almost mid-way between the two end sections, and Mount Stephen 1½ miles or 2 miles southwest from Ross Lake) we meet with even more striking difference in the Ptarmigan, *provided our interpretation of the position of the Albertella zone is correct*, for in Mount Bosworth (I) it lies 126 ft. or less above the base and in Mount Stephen (V) 60 ft. or less.

Equally striking is the variation in the underlying Mount Whyte formation. This will be brought out if we correlate, the lowest zone in which *Jamesella lowi* makes its appearance in the Mount Whyte formation. Thus taking the sections in the order from Southwest to Northeast along a distance of not more than 10 or 11 miles, we have the following positions of this zone.

	Elavation above base of Mount Whyte	Position below top of Mount Whyte
Mount Stephen (V)	258	57
Ross Lake (IV)	185	63
Mount Bosworth (I)	230	160
Ptarmigan Peak (II)	253	90

In Castle mountain 23.5 miles southeast of Mount Stephen, a bed with a typical upper Mount Whytc fauna and presumably including *Jamesella lowi*, lies 112 ft. above the base and 136 ft. below the top. In this section, the Ptarmigan has a thickness of 272 ft. with the *Albertella* fauna in the upper 12 ft. or 260 ft. above the base.

Again in the Bow Lake section, 20 miles N. N. W. of Mount Stephen, the *Jamesella lowi* horizon has not been located, but if we assume it to be in a horizon approximately 250 or 300 ft. above the base, as in the other sections, it would lie more than 460 ft below the summit of the Mount Whyte. (See Text-Fig. 4).

While not considering them as absolutely conclusive, we may at least hold that these figures are suggestive of a disconformity between the Mount Whyte and the Ptarmigan, and this interpretation is supported by the general shallow water character of the early Ptarmigan, and often the late Mount Whyte, on either side of the disconformity, and enormously strengthened by the fact that there is a complete change of fauna as already brought out in our tables in the preceding article.

Section VIII. The Siffleur River Section

(About 46 miles north of Mount Bosworth)
(Walcott V. p. 337)

Here we find the Mount Whyte formation only 140 ft. thick and carrying the *Olenellus* and *Bonnia* fauna characteristic of the lower part of the formation farther south. The Ptarmigan formation which overlies it has a thickness of 306 ft., and carries the *Albertella* fauna, though the exact level of this has not been recorded. It should however, be noted that Walcott suggests the possibility that beds 2b, 2c, and 2d of the overlying Cathedral Formation, with a combined thickness of 370 ft, may have to be referred to the Ptarmigan. Including these beds however, the thickness of the Cathedral is only 1240 ft. to the base of the Stephen (here called Murchison formation) so that from the point of thickness alone, it is probably more likely that the whole is referable to the Cathedral.

Section IX. The Robson Peak Section

(Walcott V, p. 360)

This section which is about 200 miles north of Mount Bosworth is remarkable in that here too, the *Albertella* fauna is found in the lower member of the Middle Cambrian. This is the Chetang formation 900 ft. in thickness. It consists of bluish gray thin-bedded limestones, with *Albertella bosworthi* at a horizon 350 ft. below the summit, or 550 ft. above the base. 100 ft. below the summit or 800 ft. above the base is a fauna with *Zacanthoides* sp, *Bathyuriscus* sp. and *Nisusia* sp. The formation is succeeded by 3000 ft. of higher Middle Cambrian strata, and rests upon the Hota formation of Lower Cambrian age, which, 300 ft. below the summit, carries the *Olenellus canadensis* fauna and at a lower horizon the *Callavia-Wanneria* fauna already discussed (See article 1).

Section XIII. The Gordon Mountain Section

This is situated in Powell County Montana, about 285 miles south of Kicking Horse Pass, *i.e.* Mount Bosworth. The succession of formations here is as given on the next page: in descending order. (Walcott IV p. 16)

The thicknesses in other Montana sections are added.

The decrease in the thickness of the Flathead sandstone is regular eastward from Helena but northeast of Helena the thickness is unusually high. On the other hand 60 miles northwest of Helena at Gordon Mountain it is again thinner than at Helena. The Wolsey shale, also varies very greatly in thickness from west to east. In Gordon Moun-

	Gordon Mt. Montana XIII	Helena Montana XIV	15-20 Miles N.E. of Helena Montana XV	Little Belt Mt. 60-70 Miles E. of Helena XVI	Big Snowy Mts. 60 miles E. of Belt Mt. XVII
Upper Cambrian					
7 Yogo limestone	835	170-450	—	130	—
Middle Cambrian					
6 Dry Creek Shale	64	40	—	40	—
5 Pilgrim Limestone	545	317	340	97	—
4 Park shale	47	150	290	800	—
3 Meagher limestone	145	450	720	100+	300
2 Gordon shale	284	420[1]	695[1]	150[1]	750[1]
1 Flathead sandstone	125	300	640	160	75
Total, Formations 1-5	1146	1637	2685	1307	1123+

Hiatus and Disconformity

SUB-FORMATION: *Belt Terrane* (*Sinian*). In all sections.

tain, where the formation is called the Gordon shale, it has the following subdivision in descending order. (Walcott IV p. 17).

6a. Chocolate or purple argillaceous sandy shale 64 ft.
Fragments of the fauna from the next lower bed occur here.

1 In these sections the name Wolsey is used instead of Gordon. They may or may not be exact equivalents.

6b.	Dark greenish argillaceous shale, weathering a dark green. (A brachiopod and trilobite fauna (4q) was found here but without *Albertella*).	35 ft.
6c.	Layers of impure limestone, separated by dark greenish shale	21 ft.
6d.	Greenish and gray shales, with interbedded sandy shales and sandstones. 82 ft. above the base, *Albertella* is found in a thin layer of sandstone, and between 75 and 90 ft. above the base occurs a rich *Albertella* fauna (Loc. 4 v).	164 ft.

The Flathead ? sandstone, underlying it with a total thickness of 125 ft, shows the following subdivisions.

7a.	Thin-bedded, greenish and brown sandstone, with shaly sandstone partings. Characterized by annelid borings and trails, by mud-cracks and ripple-marks.	43 ft.
7b.	Gray sandstone in thick beds, some of which have quartz conglomerates, with pebbles up to ½ of an inch in diameter.	82 ft.

In a thin arenaceous layer 20 ft. above the base, fragments of *Albertella* were found.

Twelve miles northeast of Gordon Mountain, on the Continental Divide, the *Albertella* fauna occurs in a thin-bedded shaly brownish sandstone, believed to represent 7a of the preceding section. The thickness of all the formations is greatest in Section XV N. E. of Helena and so is that of the entire Middle Cambrian exclusive of the thin

Dry Creek shale at the top. From this section the decrease is in all directions.

From Gordon mountain east to Big Snowy mountain the Middle Cambrian beds rest by overlap disconformably on the Belt Terrane of Sinian age. This overlap indicates transgression at the beginning of Middle Cambrian time, since beds with the *Albertella* fauna are the first beds formed here, and this transgression itself is an evidence for the independence of the Middle Cambrian pulsation. It serves as a corroboration of the assumption previously expressed, that the *Albertella*-bearing beds form a transgressive series over the more or less eroded surface, of the Lower Cambrian Mount Whyte or older formation.

The higher Middle Cambrian Formations

The Mount Bosworth Section. The following succession is recognized in descending order in this standard section.

Superformation Upper Cambrian	
Arctomys Formation	268 ft.
Middle Cambrian	
Eldon Formation	2728 ft.
Stephen Formation	640 ft.
Cathedral Formation (including Ptarmigan)	1212 ft.

Hiatus and Disconformity.

Lower Cambrian. Mount Whyte Formation.

As already noted, the beds immediately succeeding the Mount Whyte formation in this section, consists of 126 ft. of thin-bedded gray arenaceous limestone, with annelid borings and trails in some of the layers. The latter indicate shallow water and are to be regarded as a feature of the Middle Cambrian transgression. Although as previously stated, the *Albertella* fauna of the Ptarmigan formation has been found in the drift, it is not known whether the whole of this lower series or even a larger portion is to be referred to the Ptarmigan.

The succeeding beds (1b) are massive bedded, light-gray arenaceous limestones with thinner layers at various horizons, and irregular lentils of darker coloured beds. The thickness in this division is 682 ft.

It is succeeded by (1a), 404 ft. of thin-bedded gray arenaceous limestones, like those overlying the Mount Whyte. No fossils have been found in these higher beds.

In the nearby *Mount Stephen section*, the Cathedral, including the Ptarmigan, has a thickness of 1,680 ft. and begins with 60 ft. of massive-bedded arenaceous dolomitic limestone. This is succeeded by 1,560 ft. of massive-bedded, arenaceous, siliceous dolomite, with thinner beds at certain horizons and with annelid borings and trails at a few levels. Otherwise this emormous series has furnished no fossils, though as before noted, the basal portion somewhere may contain the *Albertella* fauna. The series is terminated by 60 ft. of dark gray arenaceous limestone.

The Stephen Formation. This is one of the most interesting of the Middle Cambrian formations of the Canadian Rockies, for it has furnished the most extensive series as well as the most marvellously preserved of organic remains.

In the Mount Bosworth section, it is only 640 ft. thick, but in the Mount Stephen section seven miles away, it reaches a thickness of 902 ft. The following are the subdivisions in descending order.

Stephen Formation

1.	Thin-bedded, dark-gray and bluish-black limestone	315 ft.
	The fauna (57c) includes the following	
	Micromitra zenobia Walcott	
	Obolus mcconnelli (Walcott)	
	Nisusia alberta (Walcott)	
	Hyolithes carinatus Matthew	
2a.	Greenish siliceous shales	23 ft.
	Contains (57y)	
	Westonia ella (Hall & Whitfield)	
2b.	Thick-bedded, bluish-gray limestone	22 ft.
	Contains (57z)	
	Micromitra zenobia Walcott	
	Nisusia alberta Walcott	
2c.	Greenish siliceous shale	70 ft.
2d.	Alternating bluish gray compact limestone, with siliceous and arenaceous shale in the Lower part.	210 ft.
	The fauna (57g) comprises	
	Cruziana sp.	
	Iphidella pannula (White)	
	Westonia ella (Hall & Whitfield)	
	Glossopleura boccar (Walcott)	
	besides *Hyolithes* and *Ptychoparia*.	

In the Mount Stephen section, the Stephen Formation, has the following succession in descending order.

Subdivision of the Stephen Formation of Mount Stephen.

1a.	Bluish gray limestone, with bands of dark siliceous shale in lower portion.	190 ft.

Fossils poorly preserved, (57n) and incompletely identified specifically.

1b. The *Ogygopsis* shale. 150 ft.

Calcareous and siliceous shales, and in its best development, carries immense numbers of trilobites especially

Ogygopsis klotzi (Rominger)
Bathyuriscus rotundatus (Rominger)
Neolenus serratus (Rominger)
Zacanthoides spinosus (Walcott)

The fauna is given in Table VI. col. 5†.

2a. Thin-bedded, bluish-black limestone 325 ft.

In the Upper portion of this series just beneath the *Ogygopsis* shale, a bluish-black shaly limestone has furnished (58r)

Obolus mcconnelli (Walcott)
Acrotreta depressa (Walcott)
Hyolithes annulatus Matthew
Neolenus serratus Rominger
Ogygopsis klotzi (Rominger)

At locality 57 j, just east of the great fossil bed, the following additional forms were collected.

Nisusia alberta Walcott
Bathyuriscus rotundatus Rominger

2b. Massive bedded gray limestone 57 ft.

3a. Alternating gray and greenish siliceous shale, with gray oolitic limestones 200 ft.

About 50 feet from the base this contains *Iphidella pannula* (White), *Nisusia alberta?* Walcott, besides *Hyolithes* and *Microdiscus*.

On Mount Field and Mount Wapta, the remarkable BURGESS SHALE member is found in the Mount Stephen Formation, from which the wonderfully preserved Middle Cambrian fossils have been obtained, which have made this region famous. The succession here, beneath the Elgin Formation is as follows.

1.	Greenish argillaceous shale with annelid trails	6 ft.
2.	Gray arenaceous limestone	3.6 ft.
3.	Bluish-black and gray, finely arenaceous shales and thin layers of gray, rough sandstone in massive layers	24.6 ft.
4.	Gray, arenaceous magnesian limestone, in massive beds, with fragments of fossils, also shales	22 ft.
5.	Coarse arenaceous limestone	4 ft.
6a.	Gray, siliceous shales, in beds 2-4 ft. thick with fragments of trilobites	42 ft.
6b.	Finer grained shales than 6a, in thin layers of siliceous, slightly calcareous shale, with *Micromitra* sp., *Sertularian* sp., *Hyolithes* cf. *billingsi*	80 ft.
6c.	Bluish-gray, exceedingly fine-grained strong siliceous shales, becoming darker downward, with the lower 12 ft; a black shale	228 ft.
	Total thickness of the Burgess shale formation	410 ft.

Between 30 and 40 ft. from the base of this formation, the Phyllopod fauna occurs in great abundance. The prolific *Marella splendens* layer, consists of 7 ft, 7 inches of shales, which are mostly bluish gray in colour but also have layers of dirty-gray shales. The most important of the fossil-bearing layers is only 1 ft. and 4 inches thick. The fossils are given below.

Fossils of the Burgess Shale

Algæ

Cyanophyceæ (Blue-Green Algæ)

1 Morania confluens Walc.
2 Morania costellifera Walc.
3 Morania elongata Walc.
4 Morania fragmenta Walc.
5 Morania ? frondosa Walc.
6 Morania ? globosa Walc.
7 Morania parasitica Walc.
8 Morania ? reticulata Walc.
9 Marpolia spissa Walc.

Chlorophyceæ (Green Algæ)

10 Yuknessia simplex Walc.

Rhodophyceæ (Red Algæ)

11 Waputikia ramosa Walc.
12 Dalyia racemata Walc.
13 Dalyia nitens Walc.
14 Wahpia mimica Walc.
15 Wahpia virgata Walc.
16 Bosworthia simulans Walc.
17 Bosworthia gyges Walc.

Calcareous algæ

18 Sphaerocodium ? præcursor Walc.
19 Sphaerocodium ? cambria Walc.

Spongiæ

Silicispongiæ

1 Halichondrites elissa Walc.
2 Tuponia lineata Walc.
3 Tuponia flexilis Walc.
4 Tuponia flexilis intermedia Walc.
5 Takakkawia lineata Walc.
6 Wapkia grandis Walc.
7 Hazelia palmata Walc.
8 Hazelia conferta Walc.
9 Hazelia delicatula Walc.
10 Hazelia mammillata Walc.
11 Hazelia nodulifera Walc.
12 Hazelia obscura Walc.
13 Corralia undulata Walc.
14 Choia carteri Walc.
15 Choia ridleyi Walc.
16 Hampronia bowerbanki Walc.
17 Pirania muricata Walc.

Hexactinellidæ

18 Protospongia hicksi Hinde
19 Diagoniella hindii Walc.
20 Vauxia gracilenta Walc.
21 Vauxia bellula Walc.
22 Vauxia densa Walc.
23 Vauxia dignata Walc.
24 Vauxia ? venata Walc.
25 Eiffelia globosa Walc.
26 Chancelloria eros Walc.

Holothurioidea

1 Eldonia ludwigi Walc.
2 Laggania cambria Walc.

3 Louisella pedunculata Walc.
4 Mackenzia costalis Walc.

Scyphomedusæ

1 Peytoia nathorsti Walc.

Annelida

Chætognatha

1 Amiskwia sagittiformis Walc.

Chætopoda

2 Miskoia preciosa Walc.
3 Aysheaia pedunculata Walc.
4 Canadia spinosa Walc.
5 Canadia setigera Walc.
6 Canadia sparsa Walc.
7 Canadia dubia Walc.
8 Canadia irregularis Walc.
9 Selkirkia major (Walc.)
10 Selkirkia gracilis Walc.
11 Wiwaxia corugata (Matthew)
12 Pollingeria grandis Walc.
13 Worthenella cambria Walc.

Gephyrea

14 Ottoia prolifica Walc.
15 Ottoia minor Walc.
16 Ottoia tenuis Walc.
17 Banffia constricta Walc.
18 Pikaia gracilens Walc.
19 Oesia disjuncta Walc.

Crustacea

Branchiopoda

1 Opabinia regalis Walc.
2 Opabinia ? media Walc.

3 Leanchoilia superlata Walc.
4 Yohoia tenuis Walc.
5 Yohoia plena Walc.
6 Bidentia difficilis Walc.
7 Naraoia compacta Walc.
8 Burgessia bella Walc.
9 Anomalocaris gigantea Walc.
10 Waptia fieldensis Walc.

Malacostraca

11 Hymenocaris perfecta Walc.
12 Hymenocaris ? circularis Walc.
13 Hymenocaris obliqua Walc.
14 Hymenocaris oralis Walc.
15 Hymenocaris ? parva Walc.
16 Hurdia victoria Walc.
17 Hurdia triangulata Walc.
18 Tuzoia retifera Walc.
19 Odaraia alata Walc.
20 Fieldia lanceolata Walc.
21 Carnavonia venosa Walc.

Trilobita

22 Marella splendens Walc.
23 Nathorstia transitans Walc.
24 Mollisonia gracilis Walc.
25 Mollisonia? rara Walc.

Merostomata

26 Molaria spinifera Walc.
27 Habelia optata Walc.
28 Emeraldella brocki Walc.
29 Emeraldella micrura Walc.

The Eldon Formation. This is the highest of the divisions of the Middle Cambrian in the Canadian Rockies.

In the Mount Bosworth section, it has a thickness of 2728 ft. and nearly the whole of this (2700 ft.) is exposed in Mount Stephen, where however it forms the summit of the mountain. The following is the character and sub-division in detail.

1a.	Irregular bedded, gray, siliceous and arenaceous limestone, thick-bedded above and thin-bedded below	410 ft.
	A fossiliferous limestone, with *Agnostus*, *Ptychoparia*, and *Bathyuriscus* occurs 192 ft. above the base (57 x)	
1b.	Gray-thin-bedded arenaceous limestone	110. ft.
1c.	Massive-bedded, siliceous, fine-grained compact limestone with *Billingsella?* and a *Neolenus*-like pygidium near the summit (57 w)	197 ft.
1d.	Massive-bedded limestone like preceding	71 ft.
2.	Thin-bedded, bluish-gray limestone with stringers of dolomitic limestone	95 ft.
	24 ft. from the base, a 2 ft. bed of shaly siliceous limestone contains *Obolus mcconnelli* Walcott. *Obolus membranaceous* Walcott *Isoxys* cf. *argentea* (Walcott) *Elrathia* sp. etc.	
3.	Massive-bedded, dark-gray arenaceous limestone	190 ft.
4.	Massive-bedded, cliff forming limestone	1655 ft.

The Middle Upper Cambrian Contact
Text-Fig. 5.

The irregular-bedded siliceous and arenaceous limestones, which form the summit of the Eldon formation are covered by the *Arctomys* formation, 268 ft. thick. This is a variable series of arenaceous shales, with alternating bands of colour ranging from greenish to deep-red, buff, yellow and gray. Numerous mud-cracks and ripple marks occur on many of the layers and a few casts of salt crystals have been observed on some of the buff-coloured arenaceous shaly layers.

There can be little question that these beds mark a pronounced disconformity between the Middle and the Upper Cambrian. Whether some of these beds are to be regarded as belonging to the retreatal phase of the Middle Cambrian Sea, or represent the sediments of the advancing Upper Cambrian Sea, is of little significance. They are succeeded by the calcareous beds of the Upper Cambrian Bosworth formation.

These beds are not preserved in the Mount Stephen section, but they are again found in the Castle Mountain section 23.5 miles southeast of Mount Stephen. Here the Arctomys Formation with a total thickness of 218 ft, consists of an upper portion (1a), 158 ft. thick, of arenaceous and calcareous shale, purple and gray coloured with thin intercalated buff-weathering calcareous layers. Mud-cracks, ripple-marks and the pseudomorphs of large salt crystals occur in the arenaceous beds. They are underlain by (1b) 60 ft. of thin-bedded compact drab-coloured, limestone and overlain by siliceous fine-grained limestone, which forms the base of the Bosworth Formation.

The underlying *Eldon Formation,* which here has a thickness of 1905 ft, consists mostly of thin-bedded siliceous limestones in the upper part and more massive-bedded, cliff-forming siliceous limestones in the lower part. The most characteristic organic remains are large and small annelid trails and borings, indicating comparatively shallow water. These are also found at various horizons in the massive limestones. A few trilobites have also been recorded from the upper beds.

The Stephen formation, in this section is only 366 ft. thick and comprises fossiliferous shales and thin limestone beds. A *Glossopleura* fauna occurrs in the lower part and *Obolus mcconnelli* is most common in the higher.

While the Arctomys beds, which mark the period of emergence, rest upon the Eldon Formation in these southern sections of the Canadian Cordilleran, a remarkable difference is seen in sections farther north. Thus in the Glacier Lake section, 42 miles north-northwest of Mount Bosworth, the Eldon Formation is entirely absent, the Arctomys series lying directly upon the *Murchison Formation* which is the northern equivalent of the Stephen. (See Text-Fig. 5)

In this section, some 220 ft. of the Murchison are exposed. The lower half consists of bluish gray, thin, irregular-bedded limestones and the upper half of massive-bedded limestones with fragments of trilobites in some of the beds. The Arctomys formation in this section has a total thickness of 1386 ft. and consists of the following succession in descending order.

1a.	Bluish gray irregularly laminated limestones with some few small fragments of trilobites	520 ft.
2a.	Purplish-colored siliceous shale	18 ft.

2b.	Thick layers of compact, finely laminated dove-coloured limestone	73 ft.
2c.	Gray and dove-colored massive bedded limestone, with much arenaceous matter	155 ft.
2d.	Purplish siliceous shales, passing downward into hard limestones and containing a small *Obolus* and *Lingulella isse*, besides fragments of a small trilobite in the upper portion	90 ft.
2e.	Compact limestone, with ferruginous arenaceous beds in the upper part	136 ft.
2f-2l.	Alternating limestones and shales, the latter with mud-cracks. The former sometimes with fragments of trilobites and *Obolus*.	161 ft.
2m.	Thick layer of dove-coloured, compact, finely laminated limestone	12 ft.

Walcott says that this limestone and similar bands above, appear to have been formed from a calcareous slime or mud spread in thin layers, rather slowly and evenly. "It suggests a glacial mud precipitated from the mud derived from a glacial stream"[1]

2n.	Greenish drab and gray siliceous and partly argillaceous shales with interbedded hard compact, thin layers of gray limestone near the base. The upper 200 ft. purplish colored and siliceous.	221 ft.

Of the formation as a whole, Walcott says that it "appears to represent the period of deposition of a series of shallow fresh water deposit, alternating with brachish-

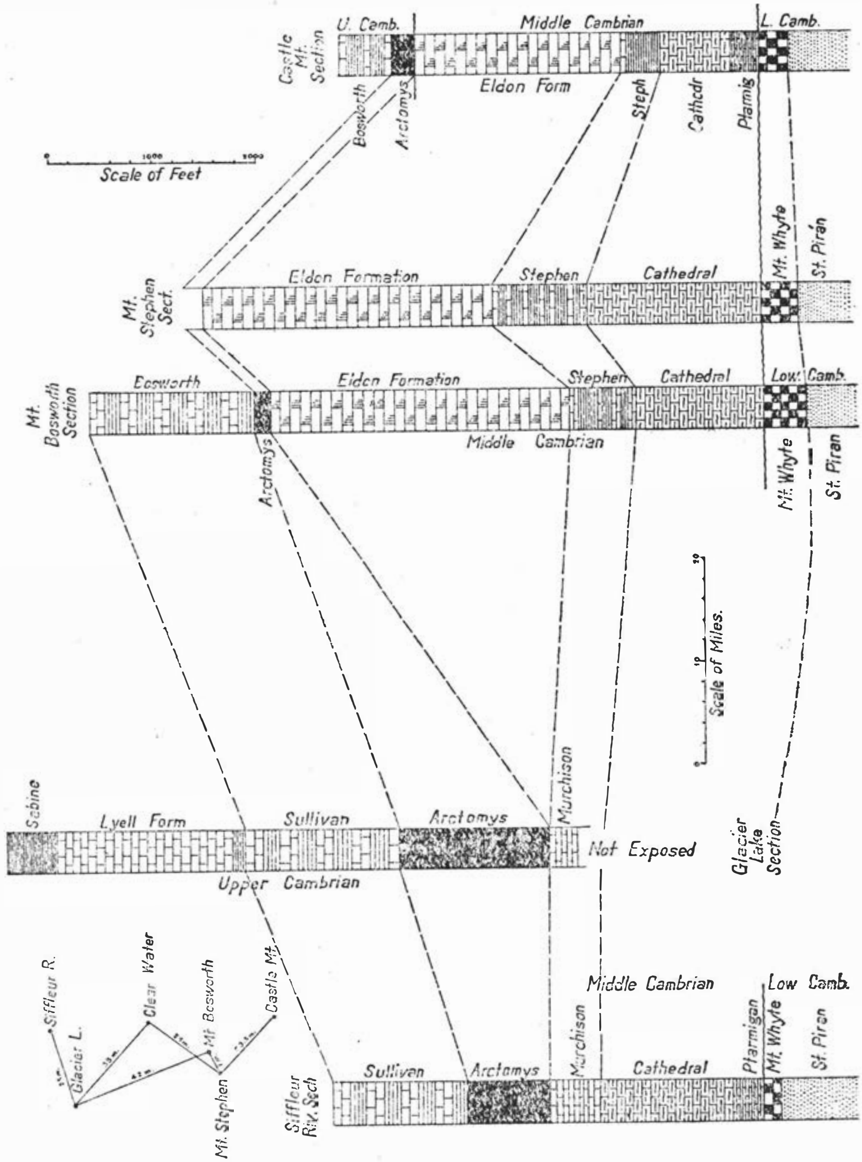
1 Walcott V, p. 347

water and marine sediments, such as would occur in a shallow sea, near the mouth of a large river bringing fine sand, mud, and slime derived from glacial streams, originating some distance from the shore line. These fine shales and sandstones, alternate with more or less thin calcareous and arenaceous layers and have on their surfaces, ripple marks, mud-cracks and casts of salt crystals .... The Eldon is absent by non-deposition and the Arctomys is immediately superjacent to the Murchison limestones that represent the Middle Cambrian of the Bow Valley Section."

The Arctomys formation in this region is succeeded by the Sullivan Formation of shales and limestones.

Twenty-five miles East-northeast of the Glacier Lake section, is that exposed on the *Siffleur River*. Here the Cathedral formation, which rests upon the Ptarmigan with *Albertella*, is 1240 ft. thick, and is followed by 497 ft. of the Murchison Formation which carries the *Glossopleura* fauna in its lower portion and is believed to represent the Stephen formation farther south. This is followed by the Arctomys Formation 725 ft. thick. The Great Eldon limestone (2728 ft. thick) is likewise absent in this section, this clearly marking the great disconformity between the Upper and Middle Cambrian. No fossils are found in the Arctomys Formation and Walcott held that the condition of its deposition were unfavourable for the existence of life.

Although for the most part made up of limestones, and siliceous shales the formation may represent purely continental sediments. Many of the layers, especially in the upper part, "are almost made up of flat concretionary or interformational pebbles, and small round concretions" (Walcott *loc. cit.* p. 335). Here too the Sullivan forma-



Text—Fig. 5. Sections of the Middle Cambrian beds in the Canadian Rockies i. e. northern part of the Palæo-Cordilleran geosyncline, showing the variation in the thickness of these beds between the Arctomys formation, at the base of the Upper Cambrian, and the Mount Whyte formation at the summit of the Lower Cambrian. In the Glacier Lake and the Siffleur River sections, the Arctomys formation rests by overlap upon the Murchison, the quivalent of the Stephen formation, the entire Eldon formation nearly 2300 ft. thick, being missing. The localities are shown in the inset-map and the details are given in the text.

tion of fossiliferous shales and limestones succeeds the Arctomys, with a thickness of 1260 ft.

Robson Peak (Walcott V, p. 358) In Robson Peak 200 miles north of the sections on the Canadian Pacific line, the higher beds comprise the following succession.

CAMBROVICIAN

Robson Formation (Ordovician ? Walcott) 500 ft.
Limestones and dolomites, fossils not collected

Chushina Formation (Ozarkian of Walcott) 1500 ft.
Limestones and shales with several richly fossiliferous zones.

Lynx Formation (Upper Cambrian of Walcott) 3500 ft.
Thin-bedded, bluish-gray limestone with interbedded shales. The lower 100 ft. appear to represent a continental formation and Walcott held that it may be the equivalent of the Arctomis formation of the Glacier Lake section.

"Wherever found, these arenaceous party-coloured shales and shallow water deposits, mark the boundary between the Middle and Upper Cambrian." (Walcott V, p. 360).

Hiatus and Disconformity

MIDDLE CAMBRIAN

Titkana Formation 2200 ft.
Massive bedded, bluish-gray limestone in thin layers, interbedded with gray siliceous buff-weathering limestone in bands 50-100 ft. thick.

In the Upper part occurs a fossiliferous horizon (61 v) from which the following species have been obtained.

Micromitra zenobia Walcott.
Obolus mcconnelli Walcott
Obolus septalis Walcott
Acrotreta cf depressa Walcott
Hyolithes carinatus Matthew
Selkirkia major Walcott
Agnostus montis Walcott
Zacanthoides spinosus Walcott
Dorypype dawsoni (Walcott)

This fauna correlates this horizon with the Stephen Formation of Mount Stephen.

A second fossiliferous horizon (61 l, and 61 m) occurs about 1000 ft. lower. From this fossils of the genera *Acrothele*, *Acrotreta*, *Agnostus*, *Dorypyge* and *Zacanthoides* have been obtained.

Tatei Formation 800 ft.

Thick-bedded gray siliceous and arenaceous limestone. No fossils obtained.

Chetang Formation 900 ft.

Bluish-gray, thin-bedded limestone, cliff-forming. About 100 ft. below the summit *Nisusia* sp, *Zacanthoides* sp. and *Bathyuriscus* sp. were found (61o); about 350 ft. below the summit occurs (at 61p) *Abertella bosworthi* Walcott, while *Abertella levis* Walcott and *Agraulus* sp. have been obtained from a drift block (61 w).

Probable Hiatus and Disconformity

LOWER CAMBRIAN.

The subdivisions have already been given on page 62. (*88*).

The West Greenland Section

In Inglefield Land and Washington Land, on Kane Basin, West Greenland, Middle Cambrian beds overlie disconformably the Lower Cambrian. The latter have already been described on pages 32-35 (*58-61*) and the reference cited. The series in descending order comprises the following formations according to Poulsen, but arranged according to our revised classification.

Cambrovician Series

Nunatami Formation (Upper Canadian of Poulsen)	140	meters
Cape Clay Formation (Upper Ozarkian of Poulsen)	30	,,
Cass Ford Formation (Upper Ozarkian of Poulsen)	400	,,

Hiatus and Disconformity?

Cape Frederick VII Formation (Lower Ozarkian? of Poulsen)		?

Hiatus and Disconformity

Middle Cambrian

Pemmican River Formation (Lower Ozarkian? of Poulsen)		?
Cape Wood Formation (Middle Cambrian of Poulsen)	40-100	,,

Hiatus and Disconformity

Lower Cambrian

Cape Kent Formation	10-20 meters.
Wulff River Formation	20-40 ,,

The Nunatami Formation contains 4 zones, the lowest with *Didymograptus bifidus* Hall, the second with *Phyllograpties angutifolius* Hall. These indicate Lower Beekmantown or Arenig. The bouldery character of the next two zones may have some relation to the retreatal phase of the Cambrovician in this region.

The Cape Clay Formation also has a Beekmantown character and it and the underlying Cass Ford Formation may both belong to the Upper Cambrian transgressive series. The Cass Ford Formation is especially suggestive, since throughout it consists of a series of coarse limestone conglomerates chiefly of intraformational character with thin-interbedded more or less argillaceous limestones, which have furnished 8 fossils, of which only two species of *Histricurus* are specifically determined, both of them new.

The Cape Frederick VII formation is classed by Poulsen as Lower Ozarkian with a query. It is only known from boulders and its exact position has not been located. Moreover the 5 specifically determined species are all new and all belong to new genera as well. Three are referred to the genus *Clavaspidella* Poulsen, which is closely related to *Glossopleura*, a genus characteristic of the Stephen formation of the Middle Cambrian. The second genus is *Protosymphysurus* Poulsen, with one new species *P. kochi*. This also belongs to the general group to which

Glossopleura belongs, showing approach towards *Symphysurus*. Finally, the genus *Ptychoparella* Poulsen, with one species *P. breviana* Poulsen, "seems to be much more closely related to *Ptychoparia* than the great number of North American species which were formerly referred to that genus" (Poulsen). The generic difference is confined to the pygidium.

The classification of this formation must at present remain in doubt and since its position in the section is not known, we have no precise means of placing it. Thus it may represent a part of the retreatal series of the Middle Cambrian or a part of the transgressive series of the Upper Cambrian.

I have placed the Pemmican River formation in the Middle Cambrian, despite the fact that Poulsen refers it with a query to the Lower Ozarkian. It consists of a series of arenaceous calcareous shales, of unknown thickness. These have furnished only one fossil so far *Elrathiella obscura* Poulsen, both the species and genus being new. The genus is closely related to *Elrathia*, the genotype of which is the well known *Ptychoparia kingi*, typical of the Middle Cambrian of the Palæo-Cordilleran geosyncline. The relationship is so close that Poulsen says "It is somewhat questionable if the differences are more than subgeneric." There is thus no palæontological reason, why this division cannot be referred to the Middle Cambrian, and since it evidently lies below the disconformity and appears to be continuous with the Cape Wood Formation, the stratigraphic evidence too seems to favour this classification.

The Cape Wood formation, begins with a conglomerate, "composed of irregular pebbles of yellowish-gray compact limestone, mixed with a dark-green arenaceous mass, consisting of glauconite and quartz grains."

This portion does not exceed 10 meters in thickness and evidently marks the transgressive phase of the Middle Cambrian across the more or less eroded surface of the Lower Cambrian Cape Kent formation. In the pebbles of this limestone conglomerate the following 5 species have been found.

1. *Dorypyge resseri* Poulsen
2. *Glossopleura walcotti* Poulsen (*gen. et. sp.*)
3. *Glossopleura expansa* Poulsen (*gen. et. sp.*)
4. *Solenopleurella ulrichi* Poulsen (*gen. et. sp.*)
5. *Polypleuraspis solitaria* Poulsen (*gen. et. sp.*)

Boulders of the same petrographic character collected on the beach contain Nos. 2 and 3 of the above list, and in addition.

6. *Glossopleura sulcata* Poulsen
7. *Glyphaspis perconcava* Poulsen (*gen. et. sp.*)
8. *Amecephalina mirabilis* Poulsen (*gen. et. sp.*)
9. *Acrocephalops gibber* Poulsen (*gen. et. sp.*)
10. *Dorypyge obliquespina* Poulsen

The upper part of the Cape Wood formation consists of yellowish gray compact limestone, of practically the same petrographical aspect, as the limestone pebbles of the underlying conglomeratic beds.

In addition to the 3 species of *Glossopleura* above listed, the following have been found.

11. *Glossopleura longifrons* Poulsen
12. *Elrathia ? crassilimbata* Poulsen
13. *Elrathia? groenlandica* Poulsen

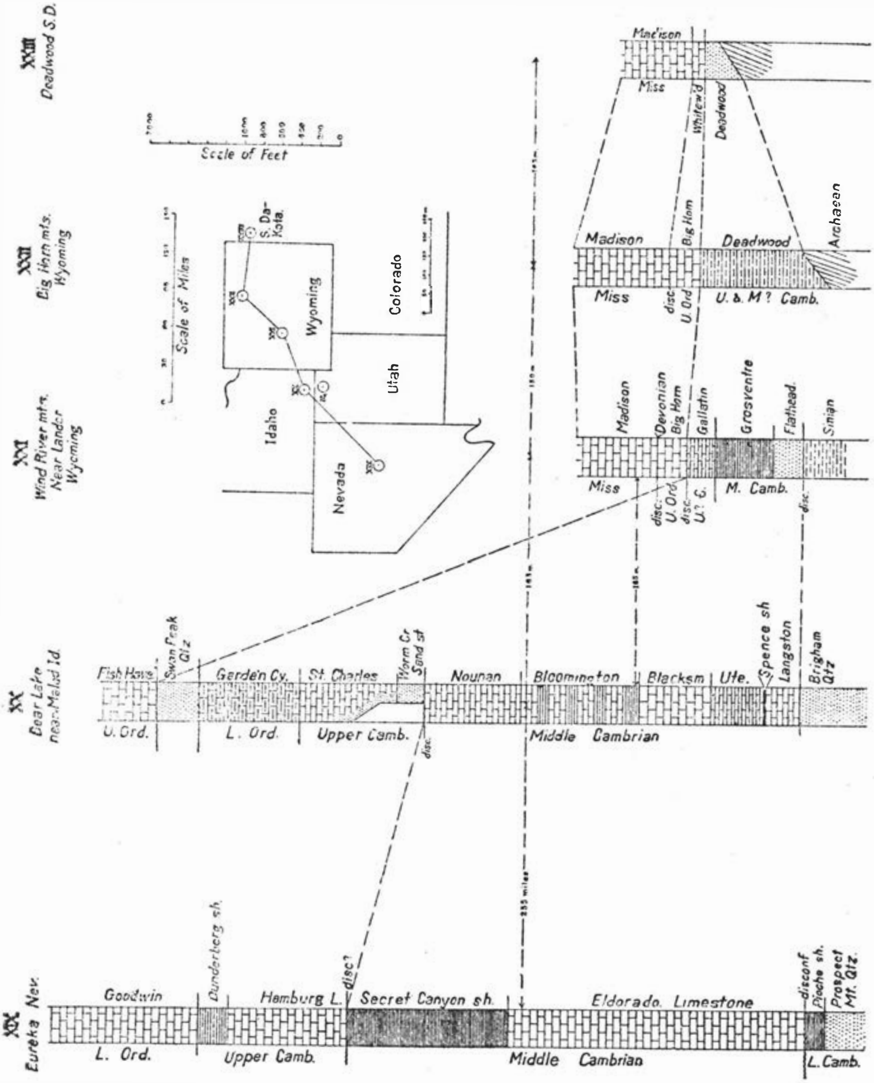
This fauna is a typical Middle Cambrian fauna, although the species are all new. *Glossopleura* is based on *Dolychometopus? boccar* Walcott, of the Stephen formation. *Solenopleurella* differs from *Solenopleura* in having a square glabella, combined with a rim of practically even width. *Polypleuraspis solitaria* is known only from a pygidium. *Amecephalina* is closely related to *Amecephalus* Walcott, of the Spence and Chisholm shales, Middle Cambrian, having a more strongly curved anterior margin and narrower fixed cheeks with a short posterio-lateral limb. *Glyphaspis* is based on *Asaphiscus? capella* Walcott of the Wolsey shale. (Middle Cambrian)

Finally *Acrocephalops* appears to be closely related to *Acrocephalites* Angelin, which has various representatives in the Middle Cambrian of the Palæo-Cordilleran as well as the Caledonian geosynclines.

The Central Cordilleran Sections

(Text Fig. 6.)

Three hundred miles due south from Helena Montana, in southeastern Idaho, lies the city of Malad. From 30 to 40 miles northeast of it, is the Fort Hall Indian reservation and 50-60 miles east of Malad. near the Wyoming border, is the Bannock,-Bear-Lake section. 255 miles southwest of Malad, lies the Eureka mining district of central eastern Nevada. We will consider a group of sections extending from Eureka through Malad and then E.N.E to the region around Landor, Wyoming about 200 miles distant from Malad, to eastern Wyoming, and the Deadwood region of South Dakota, another 300 miles, with the Big Horn region about half way between the two.



Text-Fig. 6. Sections across the Palæo-Cordilleran geosyncline in the Northern United States, showing the relation of the Middle and Upper Cambrian strata to each other and to the Lower Cambrian and the Ordovician, and the overlaps upon the marginal plain. The locations of the sections are shown on the inset map. For details see the text.

A second group of sections (Text Fig. 7.) approximately parallel to the first, begins at the Highland Range in Southern Nevada, 125 miles S. of Eureka. It extends northeast to the Pioche region about 40 miles distant, thence to the House Range of Western Utah, about 100 miles in the same direction, then to the Wasatch Range near Salt Lake, 100-150 miles further Northeast, and then nearly due east for 300 miles to Pikes Peak in the Front Range of Colorado, with the Uinta and Leadville regions between.

A 3rd group of sections approximately parallel to the border of the old geosyncline, extends from Gordon Mountain through Helena Montana, 60 miles southeast, to the Yellowstone about 150 miles further southeast, then to Landor, another 150 miles in the same direction, and on to Pike's Peak 300 miles further southeast. These sections are shown in the diagrams Text-Figs 6-8.

XIX. *The Eureka Section*[1] (Approximate Long. 116° E.; Lat. 39° 30′ N)

SUPERFORMATION. Middle Ordovician, Eureka quartzite — 200-400 ft.

LOWER ORDOVICIAN

Pogonip limestone (restricted) — 1200 ft.

Goodwin Formation (Type Locality) — 1500 ft.

Bluish gray limestone, with Beekmantown fossils.

UPPER CAMBRIAN

Dunderberg shale (Type Locality) — 350 ft.

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1 Mostly from the correlation charts and sections published for the 16th International Geological Congress, with the classification there adopted. Comments by the author added in square brackets.

Yellow argillaceous shale, with layers of chert nodules.

Hamburg limestone (Type Locality) 1200 ft.

Dark-gray granular limestone.

[*Hiatus and Disconformity*]

MIDDLE CAMBRIAN

Secret Canyon shale (Type Locality) 1600 ft.

Shale and thin limestone in the upper 25 to 200 ft, mostly shales blow.

Eldorado limestone (Type Locality) 3050 ft.

Gray compact limestone, lighter-coloured than the Hamburg

[*Hiatus and Disconformity*]

LOWER CAMBRIAN

Pioche shale 0-200 ft.

Absent in most regions.

Prospect Mountain quartzite (Type Locality) 1500 ft.

Bedded brownish-white, ferruginous near the base, with thin layers of argillaceous shale.

Hiatus and Unconformity

ARCHÆAN GRANITES

XX. *Sections in the vicinity of Malad Idaho and Bear Lake N. Utah.*[1]

Superformation. Middle Ordovician, Swan Peak quartzite 500-700 ft.

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1 Guide Book No. 17 for 16th Int. Geol. Congress. 1933. Parts enclosed in square brackets are comments by the author.

LOWER ORDOVICIAN

Garden City limestone (Type in N. W. Utah) 1130-1250

Thick and thin-bedded gray limestone and limestone conglomerates and breccias with Beekmantown fossils. (*Dalmanella pogonipensis* (Hall & Whitf.) *D. hamburgensis* Walcott etc.)

UPPER CAMBRIAN

St. Charles limestone (Type locality) 500-1350 ft.

Gray arenaceous limestone with cherty concretionary layers. At the base lies the *Worm Creek* quartzite 200-300 ft. thick, a white reddish and brownish quartzites.

[This quartzite and the very variable thickness of the St. Charles indicates a disconformity between Upper and Middle Cambrian]

[*Hiatus and Disconformity*]

MIDDLE CAMBRIAN

Nounan limestone (Type locality) 950 ft.

Massive, locally cherty, limestone, with some sandy and coarsely crystallized dolomitic standstones and some shaly layers.

Bloomington Formation. (Type locality) 1300 ft.

Bluish gray limestone, with sandy argillaceous beds, with the Hodges shaly member (300 ft.) near the base.

Blacksmith limestone Thin-bedded pure limestone above, with oolitic bands and arenaceous limestone below.	750 ft.
Ute limestone Light gray greenish or bluish gray limestone with oolitic beds,	480-585 ft.
Spence shale (Type Locality) Fine argillaceous papery shale.	30 ft.
Langston limestone (Type Locality) Massive bedded blue gray to light gray limestone, crystalline or porous, with siderite concretions.	375 ft.
[Probably hiatus and disconformity]	
Brigham quartzite Vitreous quartzite and sandstone, generally purplish or pinkish, also white, red, black etc. some conglomerate layers. Near top locally shaly. Upper part has been classed with Middle Cambrian. Basal part either Lower Cambrian or Beltian. (Sinian). The disconformity at the base of the Middle Cambrian is probably masked by the reworking of the older sands by the transgressing Middle Cambrian Sea.	1000-1600 ft.

The Faunas of the various members are given in Table VI.

XXI. *Section in Wind River Mountains near Landor, Wyoming.*

(About 165 miles E.N.E of Malad)

SUPERFORMATION Upper Ordovician. Bighorn dolomite 100-300 ft.

Hiatus and Disconformity

UPPER CAMBRIAN
Gallatin limestone 200-250 ft.

Hiatus and Disconformity

MIDDLE CAMBRIAN .
Grosventre shales, limestones and conglomerates 450-580 ft.
Flathead sandstone 300 ft.

Hiatus and Disconformity

PRE-CAMBRIAN [Sinian quartzites shales etc.]

The most remarkable thing about this section is the enormous thinning of the formations within such relative short distances, whereas in the even greater distance between Eureka and the Malad districts, the thinnings of the formation is comparatively moderate. This clearly shows that the Landor region marks the border of the geosyncline, probably the marginal shelf. This is further shown by the extensive overlap of these thin wedge-edges for the next 300 miles to the Northeast as shown by the following sections.

XXII. *Section on the east side of Big Horn Mountain*
(150-200 miles northeast of Landor).

SUPERFORMATION. *Upper Ordovician.* Bighorn dolomite. 250-300 ft.

Hiatus and Disconformity

UPPER CAMBRIAN [Partly Middle Cambrian]
Deadwood Formation 800-1500 ft.

3 Limestone with flat pebble conglomerate	200 ft.
2 Greenish shale and sandstone	200 ft. +
1 Brown sandstone mostly coarse	20-400 ft.

Hiatus and Unconformity

PRE-CAMBRIAN granite.

XXIII. *Section in Northeast Wyoming and Deadwood S. Dakota*

(350-375 miles northeast of Landor.)

SUPERFORMATION *Mississippian* limestones

Hiatus and Disconformity

UPPER ORDOVICIAN.

Whitewood limestone 0-80 ft.

Hiatus and Disconformity

UPPER CAMBRIAN.

Deadwood Formation 50-300 ft.

Green shale, brown sandstone and quartzite, some limestone and breccias.

Hiatus and Unconformity

PRE-PALÆOZOIC schists and granites.

In this section, the Cambrian beds have almost disappeared, for their only representation is in the 50 to 300 ft. of Deadwood sandstones and shales. The type locality for these is in the Black Hills region across the border, where the Deadwood formation ranges from 40 to

500 ft. resting unconformably upon the pre-Palæozoic and disconformably succeeded by the Whitewood Ordovician limestone. (*See* p. 214, (*410*))

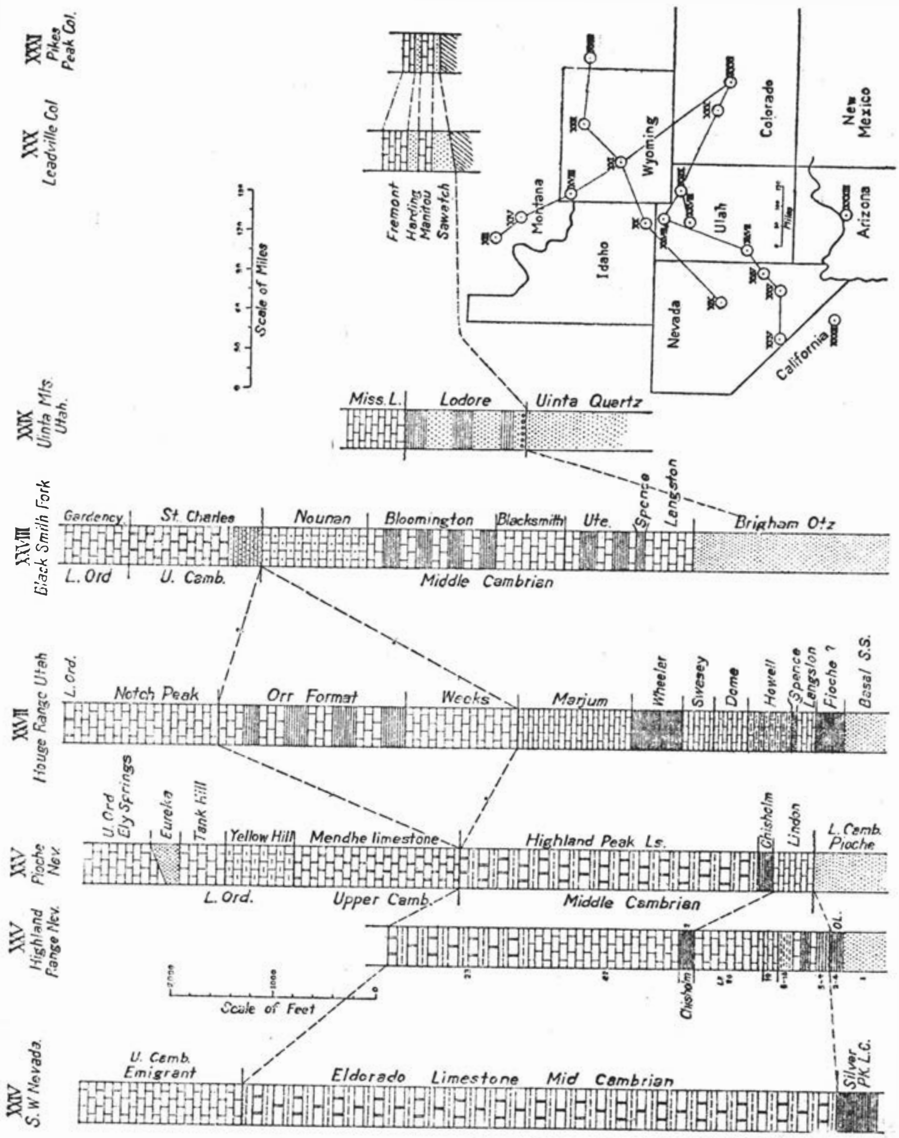
The Deadwood formation, in its maximum development begins with a basal conglomerate from 3 to 40 ft. followed by thin-bedded glauconitic shales and limy beds and terminated by greenish shales and brown or buff sandstones 50 ft or more in thickness.

In this connection, we may note, that there is a strong possibility, even a probability that, as already noted for the type region, some of these overlapping beds may really belong to the Middle Cambrian. As shown by these and other sections, the Middle Cambrian series at the period of maximum transgression (acme of the Middle Cambrian Pulsation) extended far across the marginal plain of the Cordilleran geosyncline, beyond the Landor region (Section XXI) and may easily have reached the Big Horn and become confluent through the Deadwood region with the Upper Mississippi region, i. e. the flooded marginal plain of the Appalachian Geosyncline as already discussed.

Sections froms W. Nevada to Central Colorado
(Text-Fig. 7)

The second line of section passes through the Highland Range Nevada, 125 miles S. of Eureka and extends for a while parallel to the preceding one.

About 125 miles west of the Highland section in Southwest Nevada, Esmeralda and southern part of Nye County, we have the type sections of the Lower Cambrian Silver Peak Group, already discussed in the first article. We may begin the second line of section by completing this southwest Nevada section.



Text-Fig. 7. A series of sections in the southern part of the Palæo-Cordilleran Geosyncline, showing the relations of the Middle Cambrian beds to the Upper and Lower, and the overlaps on the marginal plain. The space between the section is according to the scale of miles given and their vertical scale in feet is indicated. The location of the sections as well as those on Fig. 6 and Fig. 8, are shown on the inset map. For details see the text.

Section XXVI. Esmeralda Co. Nevada

(U.S.G. S. Correlation Tables 1933)

The divisions here recognized are as follows in descending order.

SUPERFORMATION. Middle Ordovician Eureka quartzitie	1200-1500 ft.
LOWER ORDOVICIAN	
Pogonip limestone	2000-4000 ft.
Dark-gray medium grained, with transition beds of limestones, shales and quartzites at the top. (Palmetto Formation of shales and cherts in some sections)	
UPPER CAMBRIAN.	
Emigrant Formation	?
Thin-bedded limestone and reddish shales some layers of black chert.	
[*Hiatus and Disconformity*]	
MIDDLE CAMBRIAN	
Eldorado limestone	5000-6000 ft.
Dark-gray compact, fine grained crystalline limestone.	
[*Hiatus and Disconformity*]	
LOWER CAMBRIAN	
Silver Peak Group, or in its absence the *Prospect Mountain* quartzite.	
(*Hiatus and Disconformity or Unconformity*)	
PRE-CAMBRIAN.	

The details and subdivisions of these formations, except the Silver Peak Group are still very unsatisfactorily known.

In the correlation tables, the Eldorado limestone is made the equivalent of the lower half of the Middle Cambrian only. The Emigrant formation, which is referred to the Upper Cambrian, appears in some sections to lie disconformably on the Silver Peak Group, or with only locally Middle Cambrian beds present. It should be noted however, that in the Type region *i. e.* Eureka Nevada, (Section XIX), the Eldorado limestone 3050 ft thick, rests upon 1500 ft of Prospect Mountain quartzite and is followed by 1600 ft of the typical Secret Canyon shale, which here forms the upper part of the Middle Cambrian, the Upper Cambrian being formed by the Hamburg limestone and Dunderberg shale, which apparently are the equivalents of the Emigrant formation of the more westerly section. The horizon of the Secret Canyon shale is represented either by a hiatus or included in the so-called Eldorado limestone further west.

Section XXV. Highland Range Southern Nevada

This section lies about 125 miles east of the preceding and a similar distance S.S.E. of the Eureka section, with which it is more or less identical.

The highest fossiliferous zone in this horizon appears to be that of the Hamburg limestones of the Eureka section, but whether this belongs in the upper part of the 3000 ft. of limestones overlying the Chisholm shale, (Walcott III p. 409, 1916) or in the limestone immediately overlying bed 23, as given by Walcott in the original Highland section in 1891 (U.S.G.S. Bull 81, p. 318) is not quite clear. The fauna comprises the following species (Loc. 88).

Gastropoda *etc.*

Bellerophon (*Owenella*) *antiquata* Whitfield

Pleurotomaria (*Sinuopea*) 3 undetermined species

Hyolithes attenuatus Walcott
Hyolithes ? corrugatus Walcott
Hyolithes curvatus Walcott

Trilobita

Dicellocephalus cf. *minnesotensis* Owen
Saukiella pepenensis (Owen)
Eurekia disimilis (Walcott)
Conaspis sp
Bowmania americana (Walcott)

Bowmania americana and *Saukiella pepinensis* are both found in the Hamburg limestone of the Eureka district. The latter also occurs in the Lodi and "Gordon" formation of the Upper Mississippi region. *Eurekia disimilis* also occurs in the Secret Canyon shale.

MIDDLE CAMBRIAN

F. Highland Peak limestone 3000 ft.

(b) Upper limestone No. 23 of the original Highland Peak section in Bull. 81 1430 ft.
Bluish black limestone in massive strata. Upward the limestone becomes more siliceous with an occasional shaly bed.

(a) Lower Limestone. No. 22 of Section in Bull. 81 1570 ft.
Massive-bedded siliceous limestone separated into belts 200-300 ft. thick by light-gray, dark gray or bluish black colour bands.

E. Chisholm shales. 125 ft.

Pink-coloured, compact, argillaceous shale, with a few inter-bedded layers of limestone 3-15 feet in thickness. This is No. 21 of the original Highland Peak section. At the Chisholm mine, 2-3 miles N. W. of Pioche the thickness of the shale is about 100 ft. and it contains the following species. (Loc. 31)

Cystoidea

Eocystites ? longidactylis Walcott

Brachiopoda

Iphidella pannula (White)
Westonia ella. (Hall & Whitfield)
Lingulella dubia (Walcott)

Hyolithidae

Hyolithes billingsi Walcott

Trilobita

Zacanthoides typicalis Walcott
Ptychoparia (*Amecephalus*) *piochensis* (Walcott)
Anomocare parvum Walcott
Bathyuriscus howelli Walcott
Dolichometopus productus (Hall & Whitfield)

D. Lyndon ? limestone 606 ft.

Massive-bedded bluish gray limestone with fragments of fossils in the lower third, compact gray siliceous limestone, almost quartzite in places, in the upper, with some evenly bedded limestone at top. (No. 20 of original section).

C. Unnamed Formation (Horizons 5-19 of Walcott's section) 615 ft.

Shales and sandstones, alternating with more or less argillaceous limestone beds from 2-18 ft. and in two cases 50 ft. thick. The basal 40 ft. consist of sandy buff shales with annelid trails and *Cruziana*, apparently indicating a disconformity and shallow water. In an 80 ft. limestone (No. 7) of the section, *Hyolithes billingsi* and *Ptychoparia* (*Amecephalus*) *piochensis* occur, indicating a Middle Cambrian age.

[*Hiatus and Disconformity*]

LOWER CAMBRIAN

B. Shale and limestone series (Beds 2-4 of Walcott's section) 131 ft.

Two beds of limestone, separated by 80 ft. of arenaceous shales, with *Olenellus* (*Mesonacis*) *gilberti*, *O.* (*Peachella*) *iddingsi*. Annelid trails etc. *M. gilberti* also occurs in the lower limestone.

A. Basal quartzite sometimes ripple-marked 350 ft.

The Chisholm shale is made the lowest fossiliferous horizon of the Middle Cambrian in Resser's latest standard sections,[1] although he considers that some of the basal sandstones underlying from 50-1500 ft., may form an earlier member of the overlapping Middle Cambrian series. He moreover expresses the opinion that some of these basal sands may represent the accumulations of the Pre-Cambrian Beltian series (Sinian). However, it appears from this Highland section, that there are at least some 1200 ft. of limestones, shales and sandstones below the Chisholm, which still carry characteristic fossils of the latter formation in the basal portion. Walcott himself states in 1916, (Cambrian Geol. & Pal. III, p. 409) that the Chisholm shale lies about 1200 ft. above the Lower

1 Bull, G. S. A. Vol. 44, No. 1. p. 749, 1933.

Cambrian in the Highland Range Section, which corresponds with the section above given. Walcott further says "The stratigraphic position of the Chisholm shales corresponds in a general way to the Spence shale of the Ute formation of Southern Idaho".[1]

Section XXVI Pioche Nevada.

This section lies close to the Utah border and some 40 miles N.E of the Highland section and 100 miles S.W. of the House Range Section. It shows the following subdivision in descending order. (U.S.G.S. Correlation Tables 1933).

SUPERFORMATION *Eureka quartzite* 150-300 ft.

MIDDLE ORDOVICIAN.

8. *Tank Hill limestone* (Type Locality) 450 ft.

Upper 50 ft. consist of shaly limestones and shales preceded by thicker-bedded limestone and in the lower part a gray, fine grained thin-bedded limestone said to contain Chazy fossils.

[*Hiatus and Disconformity?*]

LOWER ORDOVICIAN

7. *Yellow Hill limestones* (Type Locality) 670 ft.

Fine-grained, gray limestone in beds 2 or 3 inches to 1 ft. thick, with conglomerate layers common in the upper and with medium bedded gray limestone, often conglomeratic, and with conglomerate layers, in the lower part.

UPPER CAMBRIAN

6. *Mendha limestone* (Type Locality) (Upper Cambrian fossils) 1900-2100 ft.

1 Loc cit p. 410

d. Blue-gray thick-bedded, cherty, limestone with layers of flat limestone conglomerate 450 ft.

c. Dark-gray to black dolomitic and cherty limestone 350 ft.

b. Gray heavy-bedded crystalline limestone 500 ft.

a. Gray limestone, thin and thick-bedded, much oolitic and conglomeritic material 800 ft.

[*Hiatus and Disconformity?*]

MIDDLE CAMBRIAN

5. *Highland Peak limestone* 3000 ft.
Light gray to dark gray or black, fine to medium grained recrystallized limestone ; dolomitic limestone and dolomite.

4. *Chisholm shale* 0-180 ft.
Yellow or red-brown argillaceous shale, with limestone layers, abundant Middle Cambrian fossils.

3. *Lyndon limestone* (Type locality no fossils) 400 ft.
Upper half lighter gray and more crystalline, lower half fine-grained dark-gray heavy-bedded.

[*Hiatus and Disconformity?*]

LOWER CAMBRIAN

2. *Pioche shale* (Type Locality) 1120 ft.
Yellow or brown, rarely red argillaceous shales, with thin limestones,

and sandstones, chiefly in middle and upper part. Abundant Lower Cambrian fossils.

1. *Prospect Mountain quartzite* 1500 ft. +
Light to dark-red, vitreous sandstone or quartzite, well bedded with shale partings, thicker bedded at top.

(*Base of section not shown.*)

Comparison of these two sections show a marked difference in the beds which precede the Chisholm shales. If the measurements are reliable, we have about 1220 ft. of limestones shales and sandstones underlying the Chisholm shale in the Highland Range section, with characteristic fossils in the lower beds of this series, while in the Pioche section only 400 ft. of limestone (Lyndon limestone) separate the Middle Cambrian from the Lower Cambrian Pioche shales. This would indicate a rather marked overlap within short distance. In like manner the Lower Cambrian *Olenellus* beds of the Highland Peak section are only 131 ft. thick, preceded by the basal quartzite whereas in the Pioche section, the basal quartzite is succeeded by 1120 ft. of Pioche shales with characteristic Lower Cambrian fossils. This too, if correct is understandable when we recognize the existence of a hiatus with erosion of the older series, followed by overlap of the younger series.

Section XXVII. The House Range in Utah.

The general character of the House Range of Southwestern Utah and its approximate location near Sevier Lake has already been given (Part I page 64 & *Vol. IV* *page 90*[1]). This has come to be one of the best known as well as the most typical sections of the Middle and later Cambrian beds of this part of the Cordilleran region. The lower formations of this section were originally referred to the Prospect Mountain and Pioche shale, though the beds referred to the latter are thin (125 ft.) and contain no characteristic fossils except annelid trails and *Cruziana.* Recently however, Resser (1933 p. 749) has expressed the opinion that the so-called Prospect Mountain quartzite of the House Range is not to be correlated, with the typical formation of that name farther to the southwest, but that it may actually be the overlapping base of the Middle Cambrian, while some of the material may also be of pre-Cambrian (Sinian) age more or less reworked by the advancing Middle Cambrian Sea. According to this view, which has much to commend it, the so-called Pioche shale of the House Range also falls into the Middle Cambrian.

The following is the succession, in descending order, of the formations of the House Range section (Walcott I, p. 173).

LOWER ORDOVICIAN 285 ft.

M. Limestones resting conformably on the Upper Cambrian and characterized by *Westonia notchensis, Eoorthis coloradoensis* etc. Probably referable to the Garden City limestones of more northern sections.

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1 References in italics refer to the volume and page in the Science Quarterly; the others refer to the reprint.

UPPER CAMBRIAN

L. Notch Peak Formation 1490 ft.

1a Gray arenaceous, limestone with irregular nodules of chert, and with thin cherty layers in the lower part. 640 ft.

Among the characteristic fossils are
Lingulella isse (Walcott)
Eoorthis coloradoensis. (Meek)
Schizambon typicalis Walcott, besides trilobites.

1b to 1e. Shaly limestones preceded by siliceous and cherty limestones with occasional shaly beds. 120-150 feet above the base *Obolus leda* Walcott has been obtained 850 ft.

[*Disconformity?*]

The actual existence of a disconformity in this section has not been ascertained, but appears not improbable in comparison with the Blacksmith Fork section of northeastern Utah. The lower beds of the Notch Peak formation when not metamorphosed are thin-bedded limestones with cherty material that occurs as flattened nodules and thin layers that weather dark brown. The contact with the underlying formation appears not to be well shown, for the section has been carried along the strike of the exposed strata 2 miles west of Orr Ridge, where the rocks of the next lower formation are not metamorphosed. In his original description of the section in 1908,[1] Walcott included the Orr formation in

1 Walcott. Cambrian Geol & Pal. I, p. 173

the Upper Cambrian, drawing the line between it and the Weeks formation. More recently however, he has also included the latter in the Upper Cambrian. We shall discuss this more at length below.

UPPER? OR MIDDLE? CAMBRIAN.

K. *Orr Formation* 1825 ft.

1a. Bluish gray to gray compact limestone in layers 1 inch to 2 ft. thick, 200-375 ft.

Only fragments of trilobites have been recorded.

1b. Sandy, siliceous, shales with interbedded limestone layers 6 inches to 2 ft. 84 ft.

Among the fossils in this bed are the following.

Lingulella manticula (White)
Lingulella isse (Walcott)
Obolus rotundatus (Walcott)

1c. Lead-coloured, finely oolitic and arenaceous limestones.—Only fragments of trilobites recorded 91 ft.

1d. Bluish gray, compact limestones in layers 2 inches to 4 ft. thick.— 115 ft.

Near the base, besides fragments of trilobites, the following species are recorded

Linnarssonella modesta Walcott.
Linnarssonella nitens Walcott

1e. Dirty-brown and bluish black arenaceous shales, with thin gray fossiliferous nodules in some horizons and a few limestone layers 4 to 8 inches thick.— 235 ft.

Near the top occur.
Linnarssonella modesta Walc.
Lingulella isse (Walc.) and
Trilobite remains
Near the bottom, the following are found
Paterina crenistria? (Walcott)
Obolus mcconnelli peleus (Walcott)
Lingulella desiderata (Walcott)
Lingulella isse (Walcott)
Linnarssonella transversa Walcott.
Crepicephalus sp.

2a. Gray, slightly arenaceous limestones in layers 2-6 ft. thick.— 590 ft.

At the base and at a point 275 ft. above the base *Crepicephalus coria* Walcott and *C. dis* Walcott were found, species which also occur in the Week's formation. In addition to these the basal beds also contain *Lingulella desiderata* and *Acrotreta idahoensis*.

	2b.	Gray, cherty limestone, the chert in layers	170 ft.	
	2c.	Gray arenaceous limestone	165 ft.	
		Traces of trilobites and brachiopods are found in the lower portion.		
J.	*Weeks Formation*			1390 ft.
	1a.	Thin-bedded limestone (Fragments of trilobites and brachiopods)	245 ft.	
	1b.	Shaly limestone	285 ft.	
	1c.	Shaly bluish gray or dark blue limestone	170 ft.	
		The faunas of these two divisions include: *Lingulella isse* (Walcott) *Obolus (Fordinia) perfectus* Walcott *Acrotreta ophirensis descendens* Walcott *Crepicephalus coria* Walcott *Crepicephalus dis* Walcott *Asaphiscus minor* Walcott *Asaphiscus granulatus* Walcott *Asaphiscus unispinus* Walcott. (The last two in horizon 1c only)		
	1d.	Reddish tinted more or less arenaceous shaly limestone with the same fauna as in 1c.	30 ft.	
	1e.	Shaly, gray limestone, similar to 1c with the same fauna	220 ft.	
	1f.	Even bedded bluish gray limestone, with traces of *Agnostus* and *Ptychoparia*	330 ft.	

1g. Calcareous shales with thin layers of limestone 60 ft.

MIDDLE CAMBRIAN

I. Marjum Formation. 1102 ft.

1a. Gray, more or less thin-bedded limestone, with flattened cherty nodules and thin irregular layers at intervals 305 ft.

In the upper 100 ft. *Obolus* (*Fordinia*) and *Acrotreta* are represented by several characteristic species. In the central portion, *Micromitra sculptilis*, *Lingulella arguta* and *Dicellomus prolificus* occur, together with *Acrotretas* and trilobites. In the lower part, *Iphidella pannula ophirensis*, *Obolus mcconnelli pelias* and *O. rotundatus* occur. The fauna is included in Table VI, where it will be seen that a number of the species are in common with the overlying Weeks formation. (See also Table B cols 6-8)

1b. Alternating bands of blue-gray compact limestone and gray arenaceous limestone 247 ft.

Ptychoparia is the only fossil recorded

	1c. Dark and light gray, thin-bedded limestones more or less arenaceous	250 ft.	
	This has furnished a fauna from near the top and another in the central 100-150 ft. of thin-bedded shaly limestone. This is given in cols 4 and 5 of the subjoined table (B). *Owenella* and *Neolenus* are the leading trilobites of this and the next lower division.		
	1d. Gray shaly limestone, passing below into shales, which are interbedded in the shaly limestone, and at 75 ft. from the top into drab argillaceous shales	105 ft.	
	The fauna is much as in the underlying bed and is given in col 3 of the subjoined table (B).		
	1e. Dark, bluish-gray limestone in thick beds	195 ft.	
	(Col. 2 Table B)		
H.	*Wheeler Formation.*		570 ft.
	Alternating beds of thin shaly limestone and calcareous shale, with shale gradually increasing and predominating towards the lower portion. At 405 ft. from the top, a band of blue-gray hard lime-		

stone 1/8 to 2 inches thick, another at 473 ft. and others lower down. A rich fauna occurs between 230 to 350 ft. from the base. The species are listed in Table VI.

G. *Swazey Formation.* 340 ft.

1a. Oolitic and arenaceous limestone in massive layers near the top. Below dark-bluish gray limestone is occasionally interbedded, gradually becoming the principal rock 152 ft. Species of *Zacanthoides* and *Dorypyge* occur.

1b. Drab and reddish shales, with interbedded fossiliferous limestone 63 ft.

1c. Massive limestone 17 ft.

1d. Calcareous and argillaceous shales with thin layers of limestone 102 ft. *Paterina labradorica utaensis*, and *Lingulella arguta* are found here.

1e. Limestones with concretions & characterized by *Westonia ella* 102 ft.

F. *Dome Limestone* 355 ft.

Massive-bedded cliff-forming, siliceous limestone, with occasional layers of thin-bedded brownish, yellow, arenaceous limestone, about 1/3 the thickness from the top.

E.	*Howell Formation*		435 ft.
	1a. Bluish black massive limestone	50 ft.	
	1b. Gray siliceous limestone	8 ft.	
	1c. Similar to la.	105 ft.	
	1d. Pinkish argillaceous shale, with interbedded thin layers of limestone	10 ft.	
	1e. Gray siliceous limestone	70 ft.	
	1f. Bluish-black, massive limestone	102 ft.	
	1g. Gray, siliceous limestone	90 ft.	

Fossils have been recorded from 1a, 1d, 1f and these are given in Table VI.

D. *Spence Shale* — 20 ft.

Pinkish argillaceous shale, with a rich fauna in which *Ptychoparia* (*Amecephalus*) *piochensis* and *Zacanthoides typicalis* are leading types. Both of these species are characteristic of the Chisholm formation of the Highland Peak and Pioche sections with which the Spence shale is tentatively correlated by Walcott. The fauna is given in Table VI.

C. *Langston? Formation* — 205 ft.

These beds are correlated with the Langston Formation of Northeastern Utah and Idaho, because in both cases they underlie the Spence shale.

1a. Massive bedded, bluish-gray, arenaceous limestone, with irregularly arranged buff-coloured arenaceous limestones — 170 ft.

The fauna includes species of *Billingsella*, *Platyceras*, *Hyolithes*, *Leperditia*, *Ptychoparia*, *Zacanthoides* and *Dorypyge?*

1b. Brown arenaceous limestones in thick layers, almost sandstone in places — 35 ft.

B. *"Pioche" Formation* — 125 ft.

Arenaceous and siliceous shales and quartzitic sandstones with annelid trails and *Cruziana*. This was originally referred to the Lower Cambrian together with the underlying sandstone, which was identified as the Prospect Mountain formation (see part I, p. 65) (*91*), but according to Resser both represent overlapping Middle Cambrian beds.

A. *Basal sandstone* — 1375 ft.

Gray and brownish quartzitic sandstone, formerly identified as the Prospect Mountain formation of the sections farther to the southwest. According to Resser (1933) these represent the basal beds of the overlapping Middle Cambrian, with probably in part reworked Beltian (Sinian) beds.

Table B.

Faunas of the Marjum Formation of House Range Utah.

	1 Below Marjum	2 Bed 1e	3 Bed 1d	4 Bed 1c center	5 Bed 1c top	6 Bed 1a base	7 Bed 1a middle	8 Bed 1a top	9 Above Marjum
Brachiopoda									
Micromitra sculptilis Meek	—	—	×	×	—	—	×	—	—
Iphidella pannula ophirensis (Walcott)	—	—	×	×	—	×	—	—	—
Obolus mcconnelli pelias Walcott	×	—	×	×	—	×	—	×	×
O. rotundatus Walcott.	—	—	×	×	—	×	—	—	×
O. (Fordinia) gilberti Walcott	—	—	—	—	—	—	—	×	—
O. (Fordinia) perfectus Walcott	—	—	—	—	—	—	—	×	×
Lingulella arguta Walcott	×	—	×	×	—	—	×	—	—
Dicellomus prolificus Walcott	—	—	—	—	—	—	×	—	—
Acrothele subsidua White	×	—	×	×	—	—	—	—	—
Acrothele subsidua laevis Walcott	×	—	×	—	—	—	—	—	—
Acrotreta attenuata Meek	×	—	×	×	—	—	×	—	—
Acrotreta bellatula Walcott	—	—	—	—	—	—	×	×	×
Acrotreta marjumensis Walcott	—	—	—	—	—	—	—	×	—
Acrotreta ophirensis Walcott	×	—	×	×	—	—	—	—	—
Acrotreta cf ophirensis Walcott	×	—	—	—	—	—	—	—	—
Acrotreta pyxidicula White	×	—	—	—	×	—	—	—	—
Acrotreta cf. sagittalis Salter	—	—	—	—	—	—	—	×	—
Jamesella nautus (Walcott)	×	—	—	×	—	—	—	—	—
Jamesella spencei (Walcott)	×	—	—	×	—	—	—	—	—
Eoorthis remnicha (Winchell)	—	—	×	×	—	—	—	—	—
Eoorthis thyone Walcott	—	—	×	×	—	—	—	—	—

Table B. (Concluded)	1	2	3	4	5	6	7	8	9
Brachiopoda									
Syntrophia? unxia Walcott	—	—	×	×	—	—	—	—	—
Linnarssonella sp.	—	×	—	—	—	—	—	—	—
Hyolithidae etc.									
Hyolithes sp.	—	—	—	×	×	—	—	—	—
Trilobita									
Agnostus sp. 1	—	sp	×	sp	sp	—	sp	4sp	—
Agnostus sp. 2	—	—	×	×	—	—	—	—	×
Agnostus sp. 3	—	—	×	×	—	—	—	—	—
Asaphiscus wheeleri Meek.	×	—	—	—	—	—	×	—	—
Bathyuriscus? sp.	—	—	—	—	—	—	—	—	—
Elrathia kingi (Meek)	×	—	—	—	×	—	—	—	—
Marjumia callas Walcott	—	—	—	—	—	×	—	—	—
Marjumia typa Walcott	—	—	×	×	—	—	—	—	—
Neolenus inflatus Walcott	—	—	×	×	—	—	—	—	—
Neolenus intermedius Walcott	—	—	×	×	—	—	—	—	—
Neolenus intermedius pugio Walcott	—	—	—	×	—	—	—	—	—
Neolenus superbus Walcott	—	—	×	×	—	—	—	—	—
Orria elegans Walcott	—	—	—	×	—	—	—	—	—
Poliella probus Walcott.	—	—	—	—	—	×	—	—	—
Ptychoparia sp.	—	×	×	3sp	—	×	×	—	×
Anomocare sp.	—	—	—	—	—	×	×	—	×
Solenopleura sp.	—	—	—	×	—	—	—	—	×
Owenella typa Walcott	—	—	×	×	—	—	—	—	—
Ogyopsis? sp.	—	×	×	×	—	—	—	—	—

The most important problem in this section is the position of the dividing line between the Middle and Upper Cambrian. Originally Walcott drew it between the Weeks and Orr formations, referring the former to the Middle and the latter to the Upper Cambrian. More recently he referred them both to the Upper Cambrian, drawing the line at the top of the Marjum formation. This question will be more fully discussed below. To furnish a basis for the discussion we give on the preceding pages a table of the faunas of the Marjum formation with their vertical range.

Section XXVIII Blacksmith Fork Canyon

The sections in the vicinity of Salt Lake City in the Northern Wasatch are numerous, the best known being that in Blacksmith Fork Canyon in the east side of Cash Valley, in the Wasatch Mountains. between the Logan Peaks, and about 10 miles east of the town of Hiram and about 60 miles north of Salt Lake City. (28a of the small map in Fig. 7.) It lies about 230 miles N.E. of the House Range section and is north of the greater effect of the pre-Cambrian Uinta Mountain uplift and island. The succession is as follows in descending order. (Walcott I, p. 191. & 16th International Geological Congress, Guide 17, pp. 130-133.)

LOWER ORDOVICIAN

Garden City limestone. 190 ft.

Dark-bluish-black and gray limestone, similar to and continuous with the underlying Upper Cambrian, and like it marked by flattened concretionary nodules and stringers, from minute size to 6 or more c.m in diameter. The fossils include.

Eoorthis coloradoensis (Meek)

Syntrophia nundina Walcott
Orthoceras, *Endoceras*, fragments of trilobites etc.

UPPER CAMBRIAN

St. Charles Formation **1227 ft.**

1.	Dark-bluish-gray and gray limestones, often made up of flattened concretions as in the overlying bed. Rich faunas at 25 ft. and between 105 and 125 ft. below the top and 20 to 30 ft. above the base.	190 ft.
2a.	Massive dark-gray arenaceous limestone.	195 ft.
2b.	Massive arenaceous limestone, with a few irregular chert layers and some concretion layers	100 ft.
2c.	Gray, siliceous and arenaceous limestone with *Westonia iphis* and *Lingulella desiderata*	85 ft.
2d.	Massive arenaceous limestone	397 ft.
3.	Bedded bluish-gray fossiliferous limestone	94 ft.
	Contains: *Lingulella manticula* *Billingsella coloradoensis* *Huenella lesliei* etc.	
4.	Sandstone, light-gray to brown, shaly and thin-bedded near the base	166 ft.

This sandstone marks the transgressive base of the Upper Cambrian and near its base carries *Lingulepis acuminata* and in its upper 20 ft, the following species.

Obolus discoideus (Hall & Whitfield)
Obolus (*Fordinia*) *bellulus* (Walcott)
Acrotreta idahoensis alta Walcott
Billingsella coloradoensis (Schum.)

Hiatus and Disconformity

Middle Cambrian

Nounan limestone **1041 ft.**

Light or dark-gray limestones, arenaceous throughout and cherty near the base. These beds represent the retreatal series of the Middle Cambrian. They carry a few fossils in the lower 28 feet of cherty arenaceous limestones, and numerous large annelid borings in many of the arenaceous limestones.

Bloomington Formation **1320 ft.**

1a-c.	Limestones with 12 ft. shale bed some distance above the base	47 ft.
1d-1f.	Argillaceous and sandy shale, with a 4 ft. bed of fossiliferous limestone 22 ft. above the base	173 ft.
2a.	Bluish gray limestone with fragments of fossils	380 ft.

2b.	Massive gray limestone. Fossiliferous	132 ft.	
2c.	Bluish gray limestone	290 ft.	
2d.	Greenish argillaceous shale, with *Westonia wasatchensis* and trilobites	39 ft.	
2e-2g.	Limestones, sometimes arenaceous	259 ft.	
	Micromitra sculptilis and trilobites in the lower part. The fauna which is fairly regularly distributed is listed in Table VI.		
Blacksmith limestone			**570 ft.**
1a.	Dark-lead-gray arenaceous limestone	195 ft.	
1b.	Arenaceous limestone, passing downward into compact limestones. Fragments of trilobites and annelid borings	375 ft.	
Ute limestone			**729 ft.**
1a.	Bluish-gray, compact, thin-bedded limestone with annelid borings, brachiopods, trilobites etc in the upper part	290 ft.	
1b.	Gray arenaceous limestone, often oolitic, with intraformational conglomerates and flattened concretions	135 ft.	
	Fossils in the upper 5 ft. and 70 to 80 ft. below the top. (See Table VI.)		

1c.	Gray limestone, with a few layers of intraformational conglomerate and some shaly limestone	58 ft.
2a.	Gray fine-grained calcareous and argillaceous beds with brachiopods and trilobites	38 ft.
2b.	Fine-grained, thin-bedded limestone	57 ft.
	Few fossils.	
2c.	Greenish, argillaceous and calcareous shale	51 ft.
2d.	Thin-bedded limestone	36 ft.
2e.	Gray oolitic limestone, with brachiopods *Hyolithes* and trilobites	24 ft.
2f.	Greenish, argillaceous and sandy shales with brachiopods and trilobites	18 ft.
2g.	Bluish gray, thin-bedded limestone with *Paterina*, *Hyolithes* and *Ptychoparia*	22 ft.

The fauna is distributed very generally throughout the formation and is listed in Table VI.

Spence shale 30 ft.

Greenish, argillaceous and sandy shale, with a very rich fauna listed in Table VI. The leading trilobites are *Dolichometopus productus* (Hall & Whitfield). *Ptychoparia* (*Amecephalus*) *piochensis* (Walcott) and *Zacanthoides idahoensis* and *Z. typicalis?*.

This horizon probably correlates with the Chisholm shale of the sections further south.

Langston Formation			498 ft.
1a.	Massive blue-gray limestone, passing downward into gray arenaceous limestone, with many round concretions. *Westonia ella* and *Dolichometopus productus* etc	64 ft.	
1b.	Massive blue-gray limestone, with many round concretions. *Dolichometopus productus* and *Ptychoparia*. A rich fauna of brachiopods at this horizon, 2 miles southeast of Malad.	44 ft.	
2.	Massive-bedded, dark arenaceous limestone passing at about 150 ft. down into a calcareous sandstone and then into a gray sandstone	390 ft.	
Brigham quartzite			1232 ft.
1a.	Gray-greenish, gray-brown etc quartzitic sandstone	28 ft.	
1b.	Greenish hard sandy shale, this contains annelid trails and trilobite tracks	4 ft.	
1c.	Quartzitic sandstone similar to la estimated	1200 ft.	

Walcott holds that a part of the Brigham quartzite may be of

Lower Cambrian age, the dividing line falling somewhere within the sandstone series. It is more likely however that the marine Lower Cambrian here is overlapped and that a good part of this basal sandstone represents continental sediments, which may be of Lower Cambrian or even Sinian age. This is in line with the correlation by Resser for the House Range section, 230 miles further southwest.

Section XXIX, Uinta Mountains

The Uinta Mountains represent an east-west anticlinal mountain range in northeastern Utah. The central eroded portion exposes the pre-Cambrian (Sinian) Uinta quartzite and the Cambrian and younger Palæozoic beds overlying it. Above these follow Mesozoic strata, up to and including the Cretaceous, while Tertiary beds rest unconformably on these near the flanks.

Only one Cambrian formation, the Lodore series of arenaceous shales and soft sandstones with conglomerates at the base, is recognized. This rests disconformably upon the Uinta quartzite, and is in turn disconformably succeeded by the Mississippian or later Palæozoic formations. The Lodore ranges from 0. to 1200 ft. and represents the overlap along the old shore line of the Middle or Upper Cambrian series. I have seen no record of fossils from this formation and so cannot make any suggestion regarding its age. In the correlation sheet of the U.S. Geol. Survey, it is referred to as probably Upper or Middle Cambrian. It may well represent the overlapping wedge-ends of both Middle and

Upper Cambrian transgressions in so far as it is of marine origin. The section lies some 30 or 40 miles E. S. E. from Blacksmith Fork section and perhaps twice that distance S. S. W from the Wind-River section near Landor (Section XXI) where the Cambrian strata are much more fully developed. This suggests a marked irregularity in the old shore line, due to what Walcott has called the *Pre-Cambrian Uinta uplift and island.* It must not be forgotten however, that this region may have suffered extensive erosion in pre-Mississippian time, so that some of the older Palæozoic strata formerly present, may have been again removed. This is strongly suggested by a comparison with the Leadville and Pike's Peak section in both of which there is a more complete representation.

Section XXX Leadville Colorado.

This section lies something over 200 miles E. S. E. from the preceding, or about 300 miles from Blacksmith Fork section. The succession in descending order here is as follows.

Superformation

Upper Devonian Quartzites

Upper Ordovician

Freemont limestone. } variable thickness to absent,
Harding sandstone }

Hiatus and Disconformity

Lower Ordovician [More probably late Upper Cambrian]

Manitou limestone. 95-120 ft.

Thin-bedded, light to gray dolomitic limestone, many shaly layers

Upper Cambrian [Pre-Cambrian and early Cambrian residual sands.]

Sawatch Quartzite			50-108 ft.
3.	Red-cast beds or transition shales	0-40 ft.	
2.	White quartzite upper part sometimes brownish	50-100 ft.	
1.	Conglomerate	0-1 ft.	

Hiatus and Unconformity

Sub-Formation

Pre-Cambrian gneisses and schists.

Section XXXI Pike's Peak Region.

This section along the Front Range of the Rocky Mountains some 75 miles southeast of the preceding, is one of the best known of the early Palæozoic of that region. It is best exposed in William's Canyon, near Manitou but other good exposures along the Front Range are also known. The old gneiss surface below the Cambrian rocks, shows a remarkably even erosion surface[1] the old peneplane in places being as level as a table top. On this rest the older Palæozoic beds, beginning with a very pure quartz sandstone, which evidently represents a residual sand which has been worked over by the wind for a long time, prior to the transgression of the sea. The general succession in this region is as follows:

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1 W. O. Crosby. Archæan-Cambrian contact near Manitou Colorado. Bull. Geol. Soc. America. Vol. X, pp, 141-164, 1899

Superformation Mississippian Millsap limestone.

Hiatus and Disconformity

Upper Ordovician

Freemont limestone (Type locality in Pike's Peak region) — 0-100 ft.

Bluish gray or pinkish dolomite, sometimes arenaceous. Richmond fossils in upper part. In the Colorado Springs region, this limestone is absent.

Hiatus and Disconformity?

Middle Ordovician.

Harding standstone — 0-100 ft.

Light-gray, saccharoidal quartz sandstone, its age thought to be early Trenton or late Black River.

Hiatus and Disconformity (?)

Cambrovician (Upper Cambrian transgression beds)

Manitou limestone (Type locality) — 50-250 ft.

4. Thick-bedded, dove-coloured limestone — 100 ft.
3. Massive gray limestone, in part granular — 100 ft.
2. Thin-bedded purplish and reddish gray limestone — 50 ft.
1. Red limestone — 6 ft.

Basal sand (more or less reworked residual sand)

Sawatch sandstone — 45 ft.

2. Reddish, calcareous and glauconitic sandstone, some limestone — 30 ft.

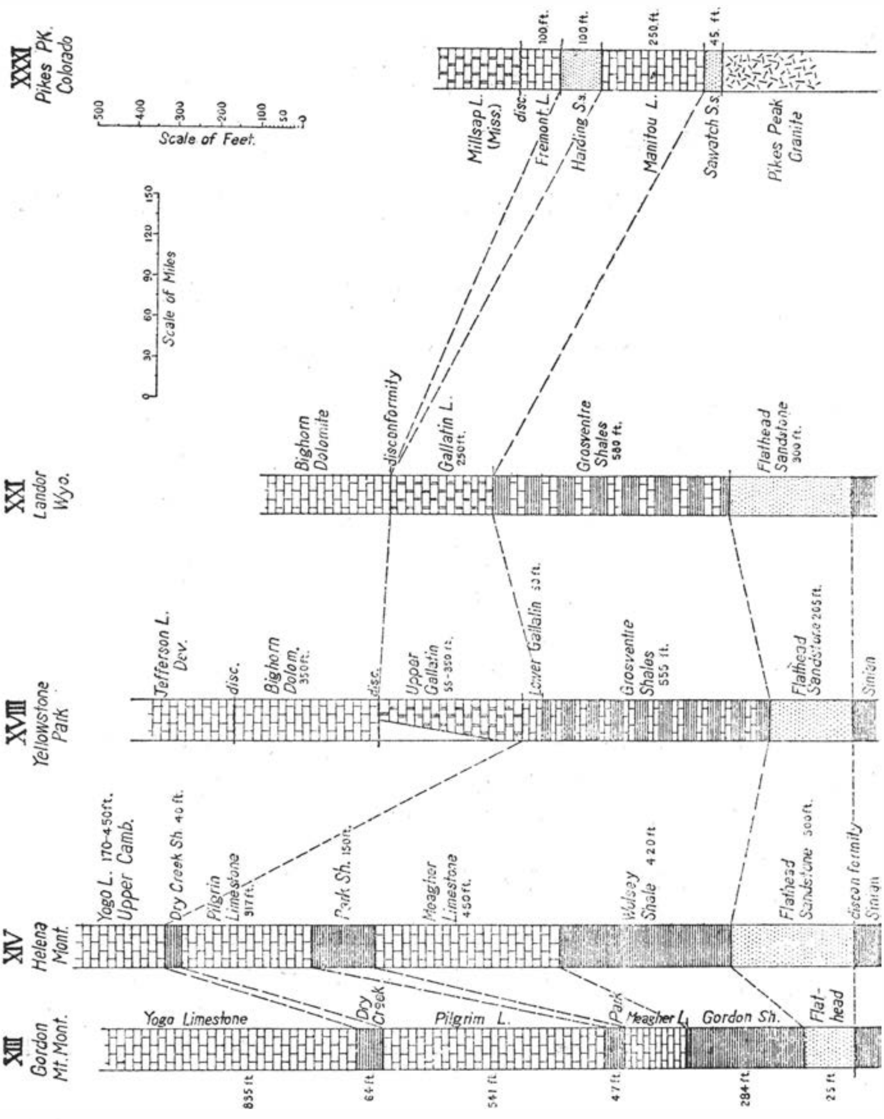
1. Cream-coloured quartz sandstone 11 ft.

Hiatus and Unconformity

Sub-Formation—Pre-Cambrian. Pike's Peak granite

The Manitou limestone referred by the U. S. G. S. to the Beekmantown is more recently regarded by Ulrich and Walcott as Ozarkian. Among its characteristic fossils are *Obolus loperi*, *O. matinalis* (Hall) *Schizambon manitouensis* Walcott, *Eoorthis desmopleura* Meek, *E. lineocosta* Walcott, *E. nympha* Walcott and *Syntrophia nundina* Walcott. The latter is also characteristic of the St. Charles Upper Cambrian, the Garden City and the Pogonip formations. Among the trilobites is *Liostegium manitouensis* Walcott, also found in the Chushina limestone of the northern Rockies which like the Manitou is referred to the Ozarkian. There can be no question that this limestone represents the transgressive phase of the 3rd marine pulsation and as such represents the Ozarkian of the Appalachian geosyncline, though its relationship may be with the Palæo-Cordilleran geosyncline. If as I believe, the Ozarkian transgression is the culminating phase of the Upper Cambrian, these limestones will have to be referred to that time division. The underlying quartzite merely represents the more or less reworked residual basal sand, which was found on the surface by the transgressing sea and so must be classed as a part of the same formation. Whether the higher part of the limestone in some sections is to be classed as the retreatal phase of the Cambrovician pulsation and therefore referable to the Beekmantown proper cannot be determined at present. If however, there is no hiatus between the Manitou and the Harding sandstone the latter would represent the sediment of the retreating phase of the Cambrovician pulsation and thus represent essentially the St. Peter sandstone of the Upper Mississippi region. If a hiatus does exist between these two formations, then the possibility of more or less erosion of the previously deposited Upper Cambrian and Lower Ordovician rocks must be taken into consideration.

A comparison of the Pike's Peak section with that of the Wind River region near Landor (No. XXI) more than 350 miles northwest, (Text-Fig. 8.) shows that the latter is markedly distinct, for though in a general way, the Bighorn limestone of the Wind River region can be correlated with the Freemont limestone of the Pike's Peak region, the subjacent beds of the two localities are quite different; the Manitou horizon being unrepresented in the Wind River region, while beds of earlier Cambrian age, Gallatin limestone and Grosventre shale, directly precede the Bighorn limestone of the Wind River region. This may be explained by overlap and subsequent erosion of the Manitou horizon in the more northwesterly region, but in that case such erosion must also have taken place in the Bighorn and Deadwood regions, where the Deadwood directly underlies the Upper Ordovician. This suggests that the deposits on the Front Range belong rather to the late Cambrian (Ozarkian) transgression over Mississippia, and that the transgression of the corresponding period of the Palæo-Cordilleran geosyncline, did not extend beyond central Utah. This is borne out by the Yellowstone, Helena, and Gordon Mountain sections, which are situated north westward along the Pike's Peak-Landor line, at approximate distances of 150, 300, and 360 miles from Landor. (Text-Fig. 8.) In all of these, the Upper if not the Middle Cambrian beds are followed directly and disconformably by Devonian or Mississippian beds. The Gordon Mountain



Text-Fig. 8. Sections approximately along the marginal plain of the Palæocordilleran Geosyncline from Gordon Mountain Montana to Pikes Peak Colorado, showing the variation of the overlapping beds of the Middle Cambrian and their relation to the enclosing formations. The scales of miles and of vertical feet are given. For location of sections see inset map in Text-Fig. 7.

and Helena sections have already been given, but the Yellowstone section deserves a brief consideration.

Section XVIII Yellowstone Region

The succession here in descending order is as follows.

Superformation Middle Devonian. Jefferson Limestone

Hiatus and Disconformity

Upper (Middle?) Cambrian

Gallatin limestone	110-400 ft.

Middle Cambrian

Grosventre Formation Flathead quartzite	700-750 ft.

Hiatus and Disconformity or Unconformity

Algonkian [Sinian] shales and quartzites.

In other sections in this general region, the Bighorn limestone, up to 350 ft. thick and of Ordovician age, lies between the Gallatin and the Jefferson limestones.

A. The Crowfoot Ridge Section

One of the most complete sections in the Gallatin Mountains, along the northern border of the Yellowstone Park is that of Crowfoot Ridge. Here the succession of the lower beds is as follows according to Iddings and Weed.[1]

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1 Geology of the Yellowstone National Park by Arnold Hague, J.P. Iddings, and W. H. Weed. Monograph of the United States Geol. Survey. Vol. XXXII, part 2, 1889, p. 8.

Gallatin limestone series			105 ft.
Upper Gallatin			
18.	Limestone conglomerate, nodular and shaly layers near the base overlain by thick and thin beds of densely crystalline limestone, alternating with thinner shaly and fissile strata with brown layers and layers of very fossiliferous crystalline limestone	40 ft.	
17.	Shales, calcareous, thin; purple green and brown	5 ft.	
16.	Limestone, very argillaceous, buff, brown, very fissile	5 ft.	
15.	Shale, greenish gray, very soft and crumbling	5 ft.	
	Disconformity (?)		
Lower Gallatin			
14.	Mottled limestone. The upper 2 ft. is an arenaceous conglomerate, in which the fragments are rounded pebbles of shale and sandstone. The matrix is slightly argillaceous sandstone. The mottled limestone is pure and thick bedded dark gray mottled with brown or black; crystalline, with granular weathered surfaces of unchanged colour	50 ft.	
Grosventre Formation			555 ft.
13.	Limestone variously modified. The lower levels, thickly and thinly		

	bedded, much of it coarsely crystalline with green grains of glauconite and great numbers of trilobite spines. Interbedded with this limestone are layers of dense-gray fissile and thinly-bedded limestone with yellow bands, and limestone conglomerate. About the middle of the series there are several thick beds of crystalline limestone containing green grains. This is overlain by a conglomerate. The matrix is pure limestone, the pebbles slightly argillaceous and resembling a mud deposit	100 ft.
12.	Shale, very thin, olive green to dark purple	150 ft.
11.	Limestone pure and ferruginous, some beds weathering into large limestone balls,	10 ft.
10.	Limestone conglomerate, the fragments well rounded, brown-gray and gray in buff matrix, underlain by crystalline limestones with green grains and thinly-bedded buff limestones	50 ft.
9.	Thin-bedded limestone	
8.	Massive bedded limestone	175 ft.
7.	Pure gray limestone, with dense layers	
6.	Thinly-bedded limestone, with shells and trilobites	10 ft.

	5. Thinly-bedded limestones, with inter-bedded micaceous shales	60 ft.	
	(Fossils were collected from the upper part and from the lowest beds)		
Flathead Formation			205 ft.
	4. Greenish and purplish micaceous shale	75 ft.	
	3. Red and green quartzose sandstones, the grains well rounded	30 ft.	
	2. Quartzite and sandstone, cross-bedded and containing well rounded pebbles of gneiss	100 ft.	
	Hiatus and Unconformity		
Archæan Gneiss			

In the original sections, beds 2 to 13 are included in the Flathead formation. Since that time the Grosventre formation has been separated and I have drawn the line at the base of the lowest limestone No. 5. The conglomerate near the middle of Bed 13, and the one at the top of Bed 14 demand more consideration than they have received.

The one in Bed 13 is perhaps less significant and may represent mud-balls in a shallow-water lime-sand. But the one terminating Bed 14, with rounded pebbles of shale and sandstone in matrix of slightly argillaceous sandstone, indicates a disconformity, the magnitude of which however is undetermined. If any part of the Gallatin limestone is to be considered of Upper Cambrian age, as is indicated in the correlation charts of the U. S. G. S. where the lower part of this limestone is referred to the Middle and the upper to the Upper Cambrian in the Yellowstone section, the dividing line must most certainly be drawn at this conglomerate. The validity of the division must however be tested by palæontological evidence.

B. The Soda-butte Creek Section.

This comprises the following divisions.

Superformation Jefferson limestone (Devonian)

Hiatus and Disconformity

Gallatin limestone (Perhaps in part Grosventre) 840 ft.

7. Beds not exposed 50 ft.
6. Thinly-bedded limestone with trilobites 50 ft.
5. Thinly-bedded limestone and limestone conglomerates carrying abundant fossils near the top. The limestones are glauconitic thinly-bedded and weather with a yellow surface, often studded with fossils in relief 190 ft
4. Thinly - bedded limestone, with much intraformational limestone conglomerate, formed of very thin and flat beach pebbles. Trilobites and a few shells occur at the summit 450 ft.
3. Massive, dark-coloured limestone, cliff-forming 100 ft.

Flathead (and? Grosventre) formation (exposed) 400 ft.

2. Black oolitic limestone, full of dark glauconitic grains and with trilobite remains. 100 ft. +
1. Soft, laminated shales 300 ft.

Lower beds not exposed.

Table C. *Fauna of the Flathead and Grosventre Formations of the Yellowstone Region.*	Flathead and Grosventre		
	Soda Butte	Crowfoot	Other Sections
Spongidæ			
Haguia sphaerica Walcott	×	—	—
Brachiopoda			
Lingulepis acuminatus meeki Walcott	—	13	—
Iphidea (*Micromitra*) *sculptilis* (Meek)	—	5	—
Iphidea sp.	—	5	—
Acrotreta gemma Billings	—	×	—
Gastropoda etc.			
**Platyceras primordialis* Hall	×	—	—
**Hyolithes primordialis* Hall	×	×	—
Trilobita			
Agnostus bidens Meek	—	×	—
Agnostus interstrictus White	—	×	—
Agnostus tumidosus Hall & Whitf.	—	×	—
Ptychoparia penfieldi Walcott	—	×	—
Ptychoparia antiquata (Salter)	×	×	—
Ptychoparia sp. 1	—	×	—
Ptychoparia sp. 2	—	×	—
**Crepicephalus texanus* (Shumard)	×	×	—
**Lonchocephalus hamulus* Owen?	×	—	—
**Lonchocephalus wisconsensis* (Owen)	×	—	—
**Ptychoparia*? *diademata* (Hall)	×	—	—
Arionellus sp.	×	—	—
Solenopleura? *weedi* Walcott	—	×	—
Zacanthoides sp.	—	×	—
Bathyuriscus? sp.	—	—	×
Liostracus parvus Walcott	×	—	—

Walcott in this Yellowstone monograph, divides the whole series into an upper part (Upper Cambrian) from which he lists 10 species and a Middle and Lower part which together contain 21 species and represent Middle Cambrian. *Acrotreta gemma* is the only form common between the two. The species obtained from the 2 lower divisions are listed in Table C.

Walcott calls attention to the fact that this fauna is more intimately related to that of the Black Hills and the Upper Mississippi Valley in Wisconsin and Minnesota, than to the Middle Cambrian fauna of Nevada or British Columbia. The species in common with the Upper Mississippi Valley are preceded by an asterisk.

The upper division also carries a fauna related in its brachiopods to the Mississippi Basin fauna. Walcott lists the following.

Table D. *Fauna of the Gallatin Limestone of the Yellowstone Region.*	Gallatin Limestone		
	Soda Butte	Crowfoot	Other sections
Brachiopoda			
Lingulella desiderata Walcott	—	×	—
Dicellomus nanus (Meek & Hayden)	—	18	—
**Billingsella coloradoensis* (Shum'd)	—	×	—
**Eoorthis remnicha* (Winchell)	—	14	
**Otusia sandbergeri* (Winchell)	—	—	×
Acrotreta gemma Billings	—	18	—
Trilobita			
Ptychoparia affinis Walcott	—	—	×
Ptychoparia llanoensis Walc.	—	—	×
Ptychoparia sp.	—	×	—
Arionellus levis Walcott	—	×	—

The species in common with the Mississippi Valley are marked by an asterisk as before. The figures in the colums refer to the number of the bed as given in the preceding discussion. An x means that it occurs in that division without definite determination of exact horizon.

Section XXXIII. The Grand Canyon Section

The section exposed in the Grand Canyon of the Colorado River in northern Arizona lies about 600 miles in a straight line somewhat west of south of Landor, Wyoming, or 400 miles due south from Salt Lake City. In its general character however, the section corresponds more to the former, in that it represents the over-lapping of the strata on the margin of the old Palæo-Cordilleran geosyncline. The general succession here is as follows.[1]

SUPERFORMATION *Redwall limestone* (Mississippian)
or *Temple Butte limestone* (Devonian)

Great disconformity and Hiatus.

CAMBRIAN. *Tonto Group*

UPPER Cambrian (may also be Middle Cambrian)

Muav limestone. about 100 ft.

Thin-bedded, bluish-gray, fossiliferous-limestone, with interbedded lenses of buff and green shale. The thickness in other sections ranges up to 650 ft.

MIDDLE CAMBRIAN

Bright Angel shale 450-650 ft.

Greenish gray, sandy often fossiliferous shale, with occasional bands of sandstone.

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1 H. E. Gregory, Guide book 18, 16th Int. Geol. Congress 1933, p. 11 and table. The thicknesses are averages.

Tapeats sandstone		225 ft.
Heavy-bedded, resistant, cliff-forming sandstone often pebbly and becoming a slabby quartzitic grit. In other sections it ranges up to 350 ft.		

Hiatus and Unconformity

SUBFORMATION Sinian. (Unkar Beds) or Archæn Vishnu schists.

A more detailed section in the Shinumo region, between Point Sublime and Powell Plateau, north side of the Canyon is as follows[1]

Section of the Tonto Group in the Shinumo Region.

Muav Limestone			493 ft.
9.	Dolomite, buff massive, cliff-forming	63 ft.	
8.	Calcareous sandstone, fine-grained buff massive at top, platy below	72 ft.	
7.	Limestone, thin-bedded, mottled, with thin members of intraformational conglomerate, platy, micaceous and calcareous sandstone or shale	241 ft.	
6.	Limestone, thin-bedded, gray to buff, mottled, partings of greenish sandy shale near base	97 ft.	

1 L. F. Noble, A section of the Palæozoic formations of the Grand Canyon at the Bass trail. U. S. Geol. Surv. Professional paper 131, p. 26, pls. XIX, XXI; condensed by Darton in "A Resumé of Arizona Geology" p. 40.

Bright Angel shale			391 ft.
5.	Shale and thin-bedded sandstone, greenish and buff, with beds of intercalated impure mottled limestone and snuff coloured dolomite at base	58 ft.	
4.	Shale and sandstone, thin-bedded greenish and buff, micaceous, 2 beds of snuff coloured dolomite and sandstone in middle portion	333 ft.	
Tapeats sandstone			328 ft.
3.	Sandstone, cross-bedded, white	35 ft.	
2.	Sandstone, chocolate with shaly partings	43 ft.	
1.	Sandstone, chocolate, cross-bedded mostly hard and massive up to	250 ft.	

Hiatus and Unconformity

Pre-Cambrian.

It thus appears that the Tapeats standstone is primarily to be considered a continental formation, the marine series beginning with the Bright Angel shale.

There has been some oscillation of opinion regarding the age of these formations, though now they are most generally called Upper Cambrian. Walcott, however, in his monograph on the Brachiopoda, places at least the Tapeats and a part if not the whole of the Bright Angel shale, into the Middle Cambrian and from our present point of view, this appears to be a more satisfactory classification.

From a horizon about 300 ft. above the base of the Tonto group, that is apparently in the lower part of the

Bright Angel shale, at the head of the Nonkoweap Valley, he cites the following species. (Locality 74).

1. *Micromitra pealei* (Walcott)
2. *Paterina crenistria* (Walcott)
3. *Paterina superba* (Walcott)
4. *Iphidella pannula* (White)
5. *Obolus zetus* (Walcott)
6. *Westonia chuarensis* (Walcott)
7. *Westonia euglyphus* (Walcott)
8. *Lingnlella lineolata* (Walcott)
9. *Lingulella perattenuata* (Whitfield)
10. *Billingsella obscura* Walcott

and the trilobites

1. *Alokistocare althea* Walcott
2. *Dolichometopus* (*Anoria*) *tontoensis* (Walc.)

From a sandstone 1000 ft. above the base of the Tonto group in Nonkoweap Valley, which he also refers to the Middle Cambrian, he cites, (Loc. 74 b) 6 *Westonia chuarensis* Walcott

No. 6 and the trilobites 1 & 2 of the above list, are again cited from locality 74 e. Middle Cambrian, Bright Angel Shale about 100 to 120 feet above Loc. 74 or 100 feet above the Tapeats sandstone on the west side of Cameron Trail in the Grand Canyon. With these occur 3. *Dolichometopus productus* (Hall and Whitfield) and *Eocystites?* sp and *Hyolithes* sp. (Walcott III p 374).

From Locality 74 d, Middle Cambrian sandstone beds in the Tonto shale, just above massive sandstone near the mouth of Bass Canyon, on the south side of the Grand Canyon, southeast of Powell's plateau, he cites Nos. 3, 4, 8, and 9, of the preceding list and in addition.

11. *Lingulepis spatula* Walcott. This horizon is probably also in the Bright Angel shale.

From several other localities in the "Tonto Group" of the Grand Canyon, he cites one or more of the above listed species. These include his localities 73, 73a and 73b.

On the other hand he refers to the Upper Cambrian, his locality 75. "Thin-bedded limestone below the base of the Ordovician, in the Tonto Group, near the water's edge at the mouth of Kanab Canyon, Grand Canyon of the Colorado."

This "Ordovician" limestone, is probably the Muav, since no Ordovician or Silurian strata are known from the Grand Canyon. The species listed by him from this horizon (Loc 75) are—

5. *Obolus zetus* (already listed from the lower beds) and in addition
12. *Lingulella winona convexa* Walcott
13. *Nisusia? (Jamesella?) kanabensis* Walcott
14. *Protorthis* sp.

Walcott says that the last two (13 and 14) may not occur in the same bed.

From sandy limestone, also referred to the Middle Cambrian and 235 ft. above the "Tonto" sandstone, Grand View Trail, north of "Last Chance" Copper mine, south side of the Grand Canyon, Walcott cites. No. 8, *Lingulella lineata* of the preceding list and in addition:

15. *Westonia themis*
16. *Lingulella acutangula*

Few trilobites have been described from these beds, those recorded are: (t = Tapeats ; b: Bright Angel ; m = Muav.)

1. *Alokistocare althea* (b) Walcott

2. *Anoria tontoensis* (Walcott) (t and b) (also in Nonkoweap formation).

3. *Dolichometopus productus* b, widespread Middle Cambrian species. This species is cited by Walcott (III, p 371) from Loc. 74e, in Bright Angel shale 100 feet above the Tapeats sandstone on Cameron trail, south side of the Grand Canyon.

So far as it is possible to determine from these lists, there is really nothing that prevents our reference of these beds to the Middle Cambrian. At least 4 of the species of brachiopods have also been reported from other Middle Cambrian horizons and none of them from undoubted Upper Cambrian. Of the trilobites the genus *Dolichometopus* (including *Anoria*) is confined to Middle Cambrian beds and the identification of *D. productus* from the Bright Angel shale shows that at least the Tapeats and Bright Angel are to be placed in the Middle Cambrian, since the higher of the two divisions contains the most typical of the Middle Cambrian trilobites. Whether the Muav limestone should also be referred to the Middle, or represents Upper Cambrian is a question which for the present cannot be answered, since too little is known of the fauna of this limestone and some of the species recorded at least, also occur in the lower horizon. It is not impossible that this limestone is compound and that somewhere within it exists a disconformity, separating the Middle from the Upper Cambrian.

Section XXXIV Bisbee Arizona

This is located in the southeastern part of the state near the Mexican border and lies about 350 miles, S.S.E.

of the Grand Canyon section. The succession here is as follows in descending order.[1]

SUPERFORMATION Devonian. Martin limestone.

Hiatus and Disconformity

CAMBRIAN

Abrigo limestone 770 ft.

Slabby-bedded limestones, with thin interbedded layers of chert. At the top is white quartzite about 8 ft. thick, into which the limestone grades. The upper member of the limestone is rather soft, sandy, thin-bedded and gray, with one bed of harder gray limestone about 40 ft. below the top.

Bolsa quartzite 430 ft.

Silicified sandstone, with a thin bed of basal conglomerate, 6 inches to 10 ft. thick lying upon the pre-Cambrian schists. The pebbles of this conglomerate consist of white vein-quartz and are from ½ inch to 2 inches in diameter. Next above it is coarse sandstone with pebbly streaks. The middle and upper members are thin-bedded finer-grained quartzites, which are overlain by the *Abrigo limestone* with apparent conformity. The formation is unfossiliferous and apparently corresponds to the Tapeats sandstone.

150 miles to the north in the Clifton-Morenci District, the basal formation is known as the *Coronado quartzite*. This consists chiefly of heavy beds of quartzitic sandstone of brown pink or maroon tints and locally conglomeratic at the base. It varies in thickness from 100 to 250 ft.

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1 Darton Geology of Arizona pp. 45-47

The Coronado probably corresponds to the upper Bolsa and perhaps the early Abrigo. From argillaceous shale 50 ft. above the Coronado quartzite 1.5 miles N. E. of Morenci, Walcott reports *Lingulella lingulata*. From siliceous limestone on Ash Creek in Pinal County Arizona, (Loc. 358a) Walcott reports *Lingulella pogonipensis?* and *Dicellomus politus*. and from limestone on the S. W. side of Escabrosa Ridge, 4.5 miles W. S. W. of Bisbee (Loc 358 b) he reports *Obolus zetus*, referring it to Middle Cambrian.

Finally, from Middle Cambrian beds, about 400 ft. above the bettom of Tombstone Gulch, in the Abrigo limestone, in the N. W. suburb of Bisbee Walcott cites (Loc 14x)

Obolus tetonensis
Billingsella? sp.

Eastward in New Mexico the Cambrian beds die away only to reappear again in Eastern Texas. In Eastern New Mexico, the Bliss sandstone varying from 0 to 300 ft. in thickness, is referred to the Upper Cambrian. It rests unconformably on the pre-Cambrian schist and gneiss and is overlain by the Lower Ordovician *El Paso* limestone 500-1000 ft. thick. It is possible that these are separated by a disconformity but it is also apparent that no Middle Cambrian beds were deposited in this region, or if they were desposited, they were removed again by early Palæozoic erosion. Since the Middle Cambrian reappears in central Texas, but this time as a transgression from the Southern Appalachian geosyncline, it is evident that a land mass, the remnant of the then largely submerged Mississippia extended northward from Mexico, probably to Wyoming, where the Deadwood Straits connected the

Appalachian extension with the Palæo-Cordilleran trough. (See Map, Fig. 15, and Plate II).

Section XXXII. The Bristol Hill Section (Iron Mountain) near Cadiz, California.

This section has already been described on page 71 (*IV-1 p. 97*) It is the only other section of these strata at present known, but it suggests former continuity with the southern sea or that portion of it which has been named *Crepicephalus Bay* and which furnished some of the important trilobites of this fauna.

The Middle Cambrian rests disconformably upon the Lower, but is represented by only 120 ft. of dark shales, from which, 12 feet above the base, have been obtained two characteristic Middle Cambrian trilobites.

Dolichometopus productus (Hall & Whitfield)

Dolichometopus? lodensis (Clark)

A great hiatus separates the Middle Cambrian from the next overlying Mississippian beds and there can be little doubt that a very large amount of erosion of the older Palæozoic beds affected this region in pre-Mississippian Time.

The Upper Boundary of the Middle Cambrian in the Palæo-Cordilleran region.

If the Middle Cambrian presents an independent pulsation, we should expect it to be marked off by a pronounced disconformity, not only from the preceding Lower Cambrian but also from the succeeding Upper Cambrian or Cambrovician. The lower disconformity is, I believe, well established for the Palæo-Cordilleran geosyncline, as it is for the others. For, although the physical disconformity has not everywhere been recognized, the abrupt faunal change as well as the variation within small areal limits in the thicknesses of the beds on either side of the disconformity, leaves little doubt of its reality.

As we have seen the disconformity and hiatus separating the Middle from the Upper Cambrian is well characterized in the Canadian portion of the Palæo-Cordilleran geosyncline, from Robson Peak, the northernmost section studied, to Castle Mountain, the southernmost section in which this contact is exposed. Everywhere the continental *Arctomys formation,* with its ripple marks, cross-bedding and salt crystals, separates the two series, and in some of the more northerly sections the entire Eldon formation of limestones, over 2700 ft. in thickness, is cut out by this disconformity. (Text-Fig. 5. *ante* p. 250 (*446*))

The Montana sections are less satisfactory because too little is known of the faunas of the higher beds, nor has there been any recognition of the physical relations of the different divisions so far as I have been able to find. There is great variation in thickness of the beds referable to the Middle Cambrian, but a part of this may be due to lateral variation in facies. The basal Flathead sandstone, which everywhere rests disconformably upon the Sinian or unconformably upon older beds, varies not only greatly in thickness, from 640 ft. east of Helena to 65 ft. in the Big Snowy Mountains, but is conceivably not of the same age everywhere. The same thing is probably true of the other members, though the variation in the thickness of the Wolsey shale from 150 ft. in the Little Belt Mountains to 750 ft. 60 miles east in the Big Snowy Mountain, may indicate a collateral variation representing replacing overlap of lithologic units. It is probable that the greater part of the series is referable to the Middle

Cambrian, certainly up to and including the Dry Creek shale. In the Gordon Mountain section, where the Flathead and immediately overlying Gordon formation contain the *Albertella* fauna, the Dry Creek shale lies approximately 1200 ft. above the base, and carries *Asaphiscus* cf. *wheeleri*, *Micromitra* sp, *Hyolithes* sp, and *Ptychoparia* sp. The overlying Yogo limestone 835 ft. thick, is characterized by annelid borings and trails at several horizons and may represent the retreatal phase of the Middle Cambrian or else the shallow water transgressing phase of the Upper Cambrian. The latter is suggested by the presence in this limestone of *Obolus discoideus* Hall & Whitfield, a species elsewhere recorded only from typical Upper Cambrian formations *i.e.* the St. Charles and Dunderberg, and from the Garden City and Mons Formation, referred to the Ozarkian. (Late Upper Cambrian).

In southeastern Idaho and northern Utah, the terminal disconformity of the Middle Cambrian is well-marked. For here the Nounan limestone, the highest Middle Cambrian, which in the vicinity of Bear Lake has a thickness of 950 ft. and in Blacksmith Fork Canyon of 1041 ft. is disconformably succeeded by the basal Worm Creek sandstone of the St. Charles formation. This is a massive gray quartzite 300 ft. thick in the Bear Lake region and 166 ft. thick in the Blacksmith Fork Section.

In the latter section, it carries *Obolus discoidens, O. (Fordinia) bellulus, Acrotreta idahoensis alta* and *Billingsella coloradoensis* in the upper 20 ft., and *Lingulepis acuminata* near the base. It is succeeded by about 1060 ft. of typical St. Charles limestone. In the Bear Lake region, the total thickness of the St. Charles, including the Worm Creek basal quartzite, varies from less than 500 to

1300 ft. in thickness. Not only then is the physical break well indicated, but the faunal break is equally abrupt.

Farther to the northeast, in the Yellowstone, Landor and Big Horn sections, the contact again becomes obscured. For though the Grosventre and underlying so-called Flathead are referable to the Middle Cambrian, the age of the Gallatin limestone is more questionable. In some sections the whole of it may be of Middle Cambrian age, but in the Yellowstone there seems to be a disconformity and hiatus between the lower and upper portions as described in the section. The lower portion is still referable to the Middle Cambrian, while the upper part may be referable to Upper Cambrian.

The possibility of the break in the Deadwood Series, above the horizon of the *Crepicephalus* zone has already been suggested.

Neither in Nevada nor Southern Utah, has a disconformity between the Middle and Upper Cambrian been established, but it must be remembered that most of these sections have only been studied in a cursory way. The exception to this is the House Range in southwestern Utah and here we are confronted by a real difficulty. It is true that so far as the record goes, the different division especially in the upper part of the section, are not in close contact, but the section is a composite one, erected into a unit by tracing the lines of division along the strike. Thus the summit of the Orr formation is located by tracing the section along the strike of the exposed strata 2 miles east from where the Notch Peak section was made, to the west side of Orr Ridge, while the Week's Formation is typically exposed at Week's Canyon, where it is overlain by the massive limestone of the Orr. Formerly Walcott drew the

Middle-Upper Cambrian boundary line between the Weeks and the Orr, but more recently he has included the Weeks in the Upper Cambrian, drawing the line between it and the underlying Marjum Formation.

So far as we can judge from the descriptions of the characters of the formations along the lines of contact, between the successive divisions there appears no disconformity within the entire section and we are left to judge entirely by the fauna. There can be little doubt that the Weeks and Orr formations belong together, and to whichever horizon one is referred, the other must follow. As will be seen from Table VI, the faunas of these two formations are markedly distinct from those in higher divisions. Among the trilobites not a single species of these formations ranges into the Upper Cambrian, though for that matter, few of the species are known from other horizons. Only *Alloristocare linnarssoni* Walcott occurs in the Orr and the Secret Canyon shale. On the other hand there are a number of species that show generic affinities with the Middle Cambrian. Thus the genus *Acrocephalites* has one species in the Weeks and 3 in the Middle Cambrian elsewhere, though two of these are questioned generically. The genus *Asaphiscus* typically developed in the Middle Cambrian of this geosyncline has 4 species in the Weeks, but none in the Upper Cambrian. The genus *Crepicephalus* typical of the Middle Cambrian as here defined, has two species, *C. coria* and *C. dis*, both present in the Weeks and Orr. These were originally referred to the well-known *Crepicephalus texanus*, characteristic of the Middle Cambrian, (in our sense) of the southern Appalachians.

The genus *Housia* on the other hand, has one species *H. varro* in the Orr and one *H. canadensis* in the Goodsir

(Cambrovician) limestone of Western Canada but though referred to the same genus, they are rather markedly distinct, and the Orr species was formerly referred to the typical Middle Cambrian genus *Dolichometopus*, while the Goodsir species was originally described as a *Ceratopyge*.

The genus *Lonchocephalus*, is represented by 2 species in the Weeks, and by one in the Grosventre limestone of the Yellowstone. None are recorded from the typical Upper Cambrian of this region. At least one species occurs in the Conasauga and Maryville of the southern Appalachians and 4 in the formations of the Upper Mississippi Valley here referred to the Middle Cambrian, including the Lower Deadwood. Only one species has been recorded from the Potsdam of New York. The genus *Millardia* has one species, *M. simile* in the Weeks, one in the Eauclaire, referred to the Middle Cambrian, and one in the Kittatinny. None occur in the undoubted Upper Cambrian of the Palæo-Cordilleran geosyncline. *Norwoodia* is another isolated genus in the Weeks, but 4 species are known from the Conasauga and the Nolichucky of the Southern Appalachians and the genus appears to be well represented in the lower part of the Bonneterre formation of Missouri[1] a horizon here referred to the Middle Cambrian.

The brachiopods tell a somewhat more convincing story. *Paterina crenistria* of the Orr also occurs in the Secret Canyon and Bright Angel shales, both of which are here regarded as Middle Cambrian. *Obolus mcconnelli peleus* also represented in the Orr, is characteristic of the Middle Cambrian of the Palæo-Cordilleran geosycline but unknown in typical Upper Cambrian faunas of that region.

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1 Christina Lochman. *Loc. cit.*

Obolus rotundatus, another Orr species is elsewhere known only in this region from typical Middle Cambrian. *Fordinia perfectus* of the Weeks, belongs to a genus equally distributed among the Middle and Upper Cambrian. The species also occurs in the Marjum formation (Middle Cambrian). *Westonia notchensis* is only reported from the Orr. The genus however, ranges thoughout the Cambrian. *Lingulella desiderata*, another species of the Orr, is widespread in the Middle Cambrian throughout this region, but also occurs in the Upper Cambrian, St. Charles and Dunderberg Formations.

Lingulella isse, found in both the Weeks and Orr, also occurs in the Eldon and Langston Middle Cambrian, but extends into the Notch Peak and occurs in the St. Charles. *Lingulella monticula* another Orr species, is doubtfully reported from the Nounan and Bloomington formations, but also occurs in the St. Charles, Dunderberg and Pogonip formations. This is one of the species, suggestive of the Upper Cambrian age of this formation. *Linnarssonella* is represented by 3 species in the Orr, one of which *L. tennesseensis* occurs in the basal Middle Cambrian (Upper Rome) of Tennessee. The other two are restricted to it. The genus however ranges into the Upper Cambrian. *Acrothele ballatula* of the Weeks, also occurs in the Marjum of the same section. *Acrothele idahoensis* of the Orr, is another dominantly Cambrovician species, occurring in the St. Charles, the Dunderberg and the Pogonip. It has however, also been recorded from the Ute, near the base of the Middle Cambrian. *Acrothele idahoensis sulcata* another Orr species, occurs in the St. Charles, but in the Langston and Spence of the Middle Cambrian as well. *Acrothele ophirensis* of the Weeks is a typical Middle Cambrian species, while *A. ophirensis descendens* is only known from the Weeks.

This comprises the recorded species of this formation and it will be seen that only one is an Upper Cambrian form, but it is also recorded from the Middle Cambrian. The others that occur also in the Upper Cambrian have a wide range, but otherwise the species of these two formations are either restricted to them or occur in the unquestioned Middle Cambrian.

There is thus nothing to forbid the reference of these two formations to the Middle Cambrian. Indeed, what basis for palæontological correlation there is, points to the Middle Cambrian. It would be desirable to have further field work carried on for the purpose of obtaining evidence of a physical break in this section.

The correlation of the Grand Canyon and Bisbee sections, must also be tentative for lack of conclusive evidence. That the Tapeats sandstone and Bright-Angel shale, are referable to the Middle Cambrian, is clearly indicated by their faunas which are listed in Table VI. All the trilobites recorded from them are of Middle Cambrian type, and the brachiopods when known elsewhere, also point to the Middle Cambrian, none being recorded from typical Upper Cambrian, the Orr formation excepted, which however has only *Paterina crenistria* in common with it, a species also found in the Secret Canyon shale. The Muav limestone, is less certain, *Saukiella pepinensis* (Owen) has been reported from it and from the Lodi and from the overlying "Gordon" sandstone of the Upper Mississippi Valley, these last two being referred to the Upper Cambrian. On the other hand, the brachiopods are generally found in the preceding two formations or are else restricted to it, but they all belong to genera, which have other representatives in the Middle Cambrian.

The Abrigo limestone of the Bisbee District is equally uncertain. *Crepicephalus texanus,* typical of the Appalachian region and occurring in the Grosventre of the Yellowstone, has also been recorded from this formation. The few brachiopods known from it are also species found in the Tonto Group of the Grand Canyon. Since the Bolsa grades into the Abrigo and the Bright Angel appears to be continuous with the Muav, and since no disconformity is recorded from the interior of these limestones, it would appear that both are also referable to the Middle Cambrian and that the great disconformity at the top, cuts out entirely the Upper Cambrian, as it does in the southern California section nearly 300 miles west of the Grand Canyon Section.

Altogether then, where the evidence is available, it shows a disconformity and a hiatus at the top of the Middle Cambrian, together with a complete or nearly complete change of fauna between it and the superjacent Upper Cambrian. The evidence is so strong and so widely distributed, that there can exist no reasonable doubt that the Middle Cambrian is a pulsation unit, representing transgression from the north as well as the south and a retreat towards the end of the period in the same directions.

The definitely recorded species from the Middle Cambrian of the Palæo-Cordilleran geosyncline so far as available are given in Table VI.

THE MIDDLE CAMBRIAN OF THE ANDEAN GEOSYNCLINE

Cambrian and Ordovician strata form a large part of the older Palæozoic rocks of the eastern ranges of the

Andes in South America. They are known to occur in Peru as far north as Huanuco, (approximately latitude 10° S.). From here they extend southward through Bolivia into central Argentine (South of 30° S. Lat.) although the region between Lake Titicaca and Tarma (11° 20′ S.) is still practically unexplored, so far as its Palæozoic stratigraphy is concerned.

Ordovician beds are most widely recognized over this area of 20° latitude but Cambrian beds have only been found in a few localities, especially along the border line between Bolivia and Argentine. The outcrops of the Cambrian generally appear beneath the Ordovician in broad eroded anticlines.[1] In the region between Tarija and the Rio San Juan, (vicinity of Longitude 65° W, and Latitude 22° S.) in southern Bolivia, the lower beds exposed in these anticlines are sandstones and quartzites, often reddish, but usually gray and frequently ripple-marked. They contain no fossils and their thickness is unknown, since the base of the series is not exposed. These beds are succeeded by very fossiliferous micaceous sandstones, the thickness of which is not given. These have furnished a few species on the basis of which they are referred to a Middle Cambrian age. Those described by Hoek comprise:

Crepicephalus cf. argentinus (Kayser)
Arionellus sp.
Liostracus sp.
Chonocephalites cf. *striatus* Emm.

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1 Steinman G. and Hoek. H. Das Silur und Cambrium des Hochlandes von Bolivia und ihre Fauna. Beiträge zur Geologie und Paläontologie von Südamerika XVIII, Neues Jahrbuch für Mineralogie Geologie und Paläontologie. Beilage-Band XXXIV, 1912, pp. 176-252, plates VII-XIV.

Essentially the same fauna had previously been described by Kayser from the material obtained from the northern Argentine.[1]

These together with the species described in 1897, comprise the following.

Brachiopoda

- *Obolus* sp.
- *Lingulella darvisii* M'Coy
- *Lingulella ferruginea* Salter
- *Orusia lenticularis* (Wahlenberg)[2]
- *Eoorthis saltensis* (Kayser)[2]

Trilobites

- *Agnostus iruyensis* Kayser
- *Agnostus tilcuyensis* Kayser
- *Agnostus* sp. Kayser
- *Arionellus lorentzi* Kayser
- *Arionellus hyeronimi* Kayser
- *Liostracus steinmanni* Kayser
- *Liostracus ulrichi* Kayser
- *Crepicephalus argentinus* (Kayser)

Hyolithids

- *Hyolithes* sp.

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1 E. Kayser, Ueber primordiale und untersilurische Fossilien aus der Argentinischen Republik. Palæantographica. Supplement III 1878.
E. Kayser. Beiträge zur Kenntniss einiger palæozoischer Faunen Süd-Amerikas. Zeitschrift d. deutsch, geologischen Gesellschaft Bd. XLIX, 1897 pp 274-317 pls VII-XII (Camb.-Ord.-Dev.)
See also Walcott C. Monograph of the Cambrian Brachiopoda p. 122 for generic revision.

2 Described under *Orthis*

Originally these faunas were referred to the Upper Cambrian because of the supposed presence of *Olenus argentinus*. This species was subsequently recognized as more closely related to *Crepicephalus*, to which genus it has since been referred.

"If this supposition is well founded" says Kayser, "the principal reason why I referred the Argentinian Cambrian to the *Olenus* stage would disappear, because the doubtfully identified *Orthis lenticularis* cannot be of much weight, and of the other forms of the fauna, the species of *Arionellus* point to the lower rather than to the higher horizon."[1] Steinmann and Hoek came to the same conclusion regarding the age of this fauna, Discussing the similar forms found in Bolivia they say "Our fossil finds support the opinion of Kayser in respect to the Middle Cambrian age of the fossiliferous strata. (Loc. cit. p. 185)

These Middle Cambrian beds are disconformably succeeded either by later Cambrian or by the *Dictyonema* beds of the Cambrovician. The latter with their surfaces thickly covered with *D. murrayi* Hall and *D. irregulare* Hall, (both species found in the corresponding beds of Eastern North America) constitute the most usual superformation which covers the Middle Cambrian strata above referred to. But near the Bolivian-Argentinian boundary at Salitre, Steinman found clay-shales with north-south strikes and with intercalated quartzite beds overlying the hard brown Middle Cambrian quartzite. These have furnished.

Agnostus bolivianus Hoek
Parabolinella andina Hoek

1 Kayser 1897. p. 306-7.

These apparently represent very high Upper Cambrian and it thus appears that the Cambrovician transgression in the Andean geosyncline, reached the Argentine-Bolivian boundary towards the close of Upper Cambrian time.

MIDDLE CAMBRIAN OF THE CALEDONIAN GEOSYNCLINE

This comprises the historic regions of the Middle Cambrian deposits, for almost without exception it is in this geosyncline that all the Middle Cambrian formations of Europe have their location. Some of them are actual geosynclinal deposits, but the great majority of them are marginal overlaps.

It is these marginal overlapping portions, which present the astounding facts that crowded into an almost infinitessimal vertical interval, there are a number of distinct palæontological zones. Thus in the famous Bornholm section, where the entire Middle Cambrian is only 4 meters thick we have 4 distinct zones and at least one or two additional sub-zones. Nowhere in Europe or America, where deposits of this geosyncline are known, is there anything comparable to the great development of the Middle Cambrian which is so striking a feature of the Palæo-Cordilleran geosyncline or even that found in the Southern Appalachians. Whether this has any relation to the relative position of these geosynclines, with reference to the pole and equator, might be a matter for speculation, and certainly when we consider the assumed position of the poles in the Palæo-geographic map of this period which is here given, it is evident that the deposits of this geosyncline come nearer perhaps, than those of any other to the assumed polar region of the period, though the source of the faunas like that of the other geosynclines lies within the equatorial belt. (Plate II)

Be that as it may, the fact remains that in the West European deposits, we have the best known sections of the Middle Cambrian, as well as those that have given us our most detailed knowledge of that part at least of our Middle Cambrian fauna.

So far as the Middle Cambrian deposits of the Caledonian geosyncline are known, the most distal deposits recognized are those of Eastern Massachussetts on the American side and the Spanish and Mediterranean deposits on the European.

But it is just these deposits which have been subjected to a great amount of subsequent deformation, so that the details of characters and sequence of formations have never yet been adequately ascertained. We will therefore leave the discussion of these deposits, until we have studied those in which the sequence is better known and more fully preserved. These all lie on the western border of the geosyncline and we shall consider them progressively, beginning with those of Cape Breton and New Brunswick for the older and the Baltic, British and New Foundland regions for the higher parts, after which we shall follow the known southern border of the geosyncline in reverse order.

In our discussion we shall adopt the following larger divisions for the Middle Cambrian as preserved in this geosyncline.

III. The Acadian[1] or *Paradoxides* Series
II. The Hanfordian[2] or *Protolenus* Series
I. The Dugaldian Series

1. Name given by the late Dr. Geo. F. Matthew
2. Name given by the late Prof. Gilbert van Ingen

There may be a still older series the *Myrabayan* of Cape Breton but from this no fossils are at present known. What is known of the Coldbrookian of Matthew links it with the Dugaldian.

I. *The Dugaldian or Older deposits of the Cape Breton Region*

Cape Breton Island, off the present northern coast of Nova Scotia, has furnished one of the most interesting successions, although its exact significance is not yet fully understood. Its importance lies in the fact, that we have there exposed a succession of formations as yet unknown in any of the other sections and apparently underlying the normal *Protolenus* (Hanfordian) and *Paradoxides* (Acadian) series, in unquestioned concordance. This series originally described in detail by Dr. George F. Matthew was by him considered as a distinct system preceding the St. John system which began with the Middle Cambrian *Protolenus* and *Paradoxides* Beds, and which at one time was considered the oldest fossiliferous Cambrian Series. At first Matthew considered that he had discovered a pre-Cambrian fossiliferous series, and he gave to it the name, *Etcheminian* while to a still older, chiefly volcanic group, underlying the Etcheminian, he applied the name *Coldbrookian.*

The name Etcheminian was first applied by Matthew to the fossiliferous strata underlying the *Protolenus* zone in Hanford Brook New Brunswick, and these as we have already seen, (see *ante* p. 80) (*IV page 106*) represent a typical Lower Cambrian horizon, the equivalents of which are found in the Manuel's Brook and Conception Bay sections of Southeastern Newfoundland. (Avalon Peninsula) and which have furnished a typical *Callavia* fauna.

Naturally enough, on finding a fossiliferous series of essentially similar lithic character below the *Paradoxides* Beds in the Cape Breton section, Matthew identified it as the equivalent of the Etcheminian of Hanford Brook and after the establishment of the fact that the Hanford Brook Etcheminian was of Lower Cambrian age it was but natural that the apparently equivalent beds of Cape Breton Island were considered to be of the same age. We have referred to these beds on page 82, (*108*) citing Matthew's estimate of their thickness at Myra Bay on the east coast, as ranging from 3,000 to 5200 ft, and decreasing by overlap until at the Bras d'Or Lakes, 20 miles farther west, they have become reduced to a thickness of only 500 ft. Although, as suggested, there may be a disconformity between these "Etcheminian" and the overlying *Paradoxides* beds, the decrease in thickness is as stated, primarily due to overlap.

It is in the Bras d'Or region on Dugald Brook, that we have the most detailed section of these beds which has been made, and it is from the critical review of the fossils, especially the brachiopods by Walcott, that it is now apparent that the Dugald Brook Beds or Dugaldian Series have little if anything in common, with the Etcheminian of Hanford Brook; that indeed they represent a higher horizon referable to the basal part of the Middle Cambrian and not to the Lower. This series thus is wedged in between the normal *Paradoxides* beds as developed in both sections and the typical Lower Cambrian Etcheminian with the *Callavia* fauna. As such it becomes a significant evidence for the fact, that the Middle Cambrian series is separated from the Lower by a pronounced hiatus and that these basal Middle Cambrian beds overlap progressively on the older Lower Cambrian or the pre-Cambrian horizons.

Since it is now evident that the Etcheminian of Dugald Brook, is not the Etcheminian of Hanford Brook, N. B., or that of Manuel's Brook N-F, and since the name Etcheminian should be retained for these Lower Cambrian divisions, we shall use the name Dugaldian for the Dugald Brook Series, which overlies the Coldbrookian and precedes the *Protolenus* beds (Hanfordian of van Ingen) and the Acadian or *Paradoxides* Beds of Matthew.

Section at Dugald Brook, Cape Breton[1]

The succession here in descending order is as follows:

Superformation. Hanfordian (Division c1, b1) *Protolenus* Beds.

Dugaldian (Etcheminian of Matthew; Fauna in Table E)[2]				507 ft.
Division E3			234 ft.	
E3f, (Faunas 13n, and 344d, Col. 15 of table E)		82 ft.		
3 Siliceous gray shale	10 ft.			
2 Dark-gray rather coarse shales	32 ft.			
1 Dark-gray somewhat siliceous flaggy shales	40 ft.			

1 Matthew, George F. Report on the Cambrian Rocks of Cape Breton. Geol. Surv. of Canada 1903, pp. 21-25.
Walcott Cambrian Brachiopoda p. 133.

2 Table E, cols. 3-15. In col. 1 are indicated the species also found in the Lower Cambrian. In col. 2 the Coldbrookian species are given. In col. 16 the species which range into the *Protolenus* zone, and in col. 17 those extending into the *Paradoxides* zone are indicated.

	(Fauna 13m referred to this horizon)		
E3e	(Contains fauna 13n', also 344j Table E col. 14) Dark-gray shale, alternating harder and softer.	18 ft.	
E3d	(Contains faunas 13n'', and 344b, also 344c) (Table E col. 13) Dark-gray and some purplish gray shale.	30 ft.	
E3c	(Contains fauna 344a) (Table E col. 12) Gray, argillaceous sandstone.	25 ft.	
E3b	(Contains fauna 344) (Table E, col. 11) Fine gray shale.	25 ft.	
E3a	(Contains faunas 13l, 13 l', 344i) (Table E, col. 10)	54 ft.	
	2 Dark-gray feldspathic sandstone having seams of gray grit with felsite debris 50 ft.		
	1 Gray micaceous shale 4 ft.		
Division E2			151 ft.
E2c	(Contains faunas 13e, and 344l) (Table E, col. 9) Sandstones	21 ft.	

E2b (Contains faunas 10p, 10q, 344o, 372f, also 10p′, 10p″) (Table E, col. 8) 57 ft.

Dark purplish gray feldspathic sandstone.

E2a (Contains faunas 13 d, 13d′, 13d″ 13f, 13g, 13p? 13p′? also 307d) (Table E, col. 7) 73 ft.

3. Dark - purplish feldspathic sandstone with beds of gray quartzite about the middle 37 ft.

2. Dark - purplish gray feldspathic sandstone with some slate conglomerate 33 ft.

1. Gray fine-grained felsite conglomerate and grit 3 ft.

Division E1 122 ft.

E1e (Contains fauna 344h) (Table E, col. 6) 3 ft.

Gray shale, with seams of greenish-gray-sand and lavender-gray shale.

E1d	(Contains faunas 13 t″ and 344m, also 344e, and 344n?) (Table E, col. 5)	21 ft.
	Compact dark-gray sandy shale.	
E1c	(Contains faunas 13t″ and 344g) (Table E. col. 4)	21 ft.
	Dark-gray shale.	
E1b	(Contains faunas 13t, 13t′, 344k) (Table E, col. 3)	34 ft.
	3. Gray quartzite, with sand and clay seams at top 6 ft.	
	2. Shales? concealed 10 ft.	
	1. Purplish - gray finely crystalline trap 18 ft.	
E1a	(Unfossiliferous beds)	43 ft.
	3. Soft purplish red shale 18 ft.	
	2. Dark purplish gray trap and ash rock 10 ft.	
	1. Dark purple amygdaloid and bright red shale 15 ft.	

Hiatus and Disconformity

Coldbrookian		310 ft.
Felsites	185 ft.	
Gray shale (Contains faunas 13k, and 344f Col. 2 of Table E)	25 ft.	
Felsitic conglomerate	100 ft.	

Hiatus and Disconfomity or Unconformity

Subformation. Lower Cambrian or Older Rocks.

It is significant that the Coldbrookian of this section, rests with a basal conglomerate upon older beds. Walcott said (Loc. cit. p. 135) "The Lower Cambrian is not represented in the brachiopod collection from Cape Breton." But he recognized that Lower Cambrian is represented by the Etcheminian of Hanford Brook. It is moreover, quite probable that the conglomerate at the base of the Coldbrookian is a purely continental formation and its age may therefore be anything below the Middle Cambrian, but the succeeding 25 ft. of gray shales, mark the beginning of marine sedimentation in this region, and although most of the fossils found here also occur in the overlying Dugaldian, there is undoubtedly a period of interruption marked by the great flow of felsitic lava, which overlies these shales. Of the species found in the Coldbrook shales, only one, *Iphidella pannula* White, has been recorded from Lower Cambrian rocks, but the same species, also occurs in the Middle Cambrian of the Palæo-Cordilleran and Appalachian geosynclines. Moreover the identification of the specimen from the Coldbrookian strata is a questionable one.

Table E

Faunas of the Coldbrookian and Dugaldian Formation

	Low. Cambrian	Coldbrookian	Dugaldian: Div. E1: E1b	E1c	E1d	E1e	Div. E2: E2a	E2b	E2c	Div. E3: E3a	E3b	E3c	E3d	E3e	F3f	Protolenus Z.	Paradoxides Z.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Brachiopoda																	
1. Iphidella pannula (White)	×	x?	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2. Obolus selwyni (Matthew)	—	—	—	—	—	—	×										
3. Obolus torrentis Matthew	—	×															
4. Palæobolus bretonensis Matthew	—	—	—	—	—	—	×	×	—	×	×	—	×				
5. Palæobolus bretonensis lens Matthew	—	—	—	—	—	—	—	—	×	×	—	—	—	×	×		
6. Lingulella atava (Matthew)	—	—	—	—	—	—	×	×	—	×	×	—	×	×	×		
7. Lingulella atava insulæ (Matthew)	—	—	—	—	—	—	×										
8. Lingulella collicia (Matthew)	—	—	—	—	×	—	×	×	—	—	—	×	—	×	×		
9. Lingulella torrentis (Matthew)	—	×	—	—	×												
10. Lingulella triparilis Matthew	—	cf	×	×	×	×	×	×									
11. Lingulella tumida (Matthew)	—	—	×	×	—	cf	—	—	—	—	—	—	—	×	—	—	×
12. Lingulepis gregwa (Matthew)	—	—	×	×	×	—	—	×									
13. Lingulepis gregwa robusta (Matthew)	—	—	—	×	×	×	—	×									
14. Lingulepis longinervis (Matthew)	—	—	—	—	—	—	×	×	—	×							
15. Lingulepis pumila Matthew	—	×															
16. Lingulepis roberti Matthew	—	—	—	—	—	—	×										
17. Acrothele avia (Matthew)	—	—	—	—	—	—	×	×	—	×	×	×	×	×	×		
18. Acrothele avia puteis (Matthew)	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×	×	
19. Acrothele prima (Matthew)	—	—	×	—	—	—	×										

Table E (Continued)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Brachiopoda (cont.)																	
20. Acrothele proles Matthew	—	—	—	—	—	—	—	—	—	×	—	—	—	—	×		
21. Acrotreta gemmula Matthew	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	×	×
22. Acrothyra proavia (Matthew)	—	—	—	—	—	—	—	×	×	×	—	×	×	×	×	—	×
23. Acrothyra sera Matthew	—	×	—	×	×	—	×	×	×								
24. Acrothyra signata Matthew	—	—	×	×	×	—	×	×									
25. Acrothyra signata orta Matthew	—	—	—	—	—	—	×	×	×								
26. Acrothyra signata prima Matthew	—	×															
27. Loperia dugaldensis Walcott	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	×	
28. Billingsella retroflexa (Matthew)	—	—	—	—	—	—	x?										
Gastropoda etc.																	
1. Hyolithes cf. tenuistriata	—	—	—	—	—	—	×										
2. Hyolithes sp.	—	×	—	×	—	×	—	—	—	—	—	—	—	—	×		
3. Orthotheca sp.	—	—	—	×	×	×	—	×									
Trilobita & other crustacea.																	
1. Solenopleura? bretonensis Matthew	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×		
2. Paradoxidoid trilobite	—	—	—	—	—	—	x?										
3. Holasaphus centropyge Matthew	—	—	—	—	—	—	x?										
4. Eurypterid	—	—	—	—	—	—	x?	—	—	—	—	—	—	—	×		
5. Crustacean	—	—	—	×													
Phyllopoda & Ostracoda																	
1. Bradoria acuta (Matthew)	—	—	—	—	—	—	—	×	—	×	—	—	×	—	×		
2. Bradoria benepuncta Matthew	—	—	—	—	—	—	×	×	—	—	—	—	—	—	—	×	
3. Bradoria concinna Matthew	—	—	—	×	×												
4. Bradoria curta Bassler	—	—	—	—	—	—	—	—	—	×							

Table E (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Phyllopoda & *Ostracoda* (cont.)																	
5. Bradoria elongata Bassler	—	—	—	—	—	—	—	×	—	—	—	—	×				
6. Bradoria obesa Matthew	—	—	—	—	—	—	—	—	—	—	—	—	×				
7. Bradoria ovalis Matthew	—	—	—	—	—	—	—	×	—	—	—	—	—	×			
8. Bradoria ornata Matthew	—	—	—	×													
9. Bradoria perspicator (Matthew)	—	—	—	×	×	—	×	×									
10. Bradoria robusta (Matthew)	—	—	×	×	×	—	×	×	—	—	—	—	×	×			
11. Bradoria robusta var. Bassler	—	—	×														
12. Bradoria rugulosa Matthew	—	—	×	—	—	—	×	—	—	—	—	—	—	×			
13. Bradoria rugulosa var. Matthew	—	—	—	×													
14. Bradoria scrutator (Matthew)	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×		
15. Bradoria spectator (Matthew) Bassler	—	—	—	—	—	—	—	×									
16. Bradoria vigilans obesa Matthew	—	—	×	×	×												
17. Bradorona acuta Matthew	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
18. Bradorona observator Matthew	—	—	—	×	×												
19. Bradorona observator benepuncta Matthew	—	—	—	×	×												
20. Bradorona observator ligata Matthew	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
21. Bradorona observator laevis Matthew	—	—	×	—	—	—	—	—	×								
22. Bradorona perspicator Matthew	—	—	—	—	×												
23. Bradorona perspicator major Matthew	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×		
24. Bradorona perspicator magna Matthew	—	—	—	—	—	—	—	×									
25. Bradorona perspicator maxima Matthew	—	—	—	×													
26. Bradorona scrutator Matthew	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×		
27. Bradorona spectator Matthew	—	—	×	×	×												
28. Bradorona spectator acuta Matthew	—	—	×	×	×												
29. Bradorona spectator aequat Matthew	—	—	—	—	—	—	—	—	—	—	—	—	×				

Table E (*Concluded*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Phyllopoda & *Ostracoda* (cont.)																	
30. Bradorona spectator spinosa Matthew	—	—	—	—	—	×											
31. Bradorona (Bradoria) vigilans Matthew	—	—	—	—	—	—	—	—	—	—	—	—	×	×	×		
32. Beyrichona rutellum Matthew	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×		
33. Escasona rutellum Matthew	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×		
34. Escasona rutellum prima Matthew	—	—	—	—	×												
35. Escasona? ingens Matthew	—	×															
36. Hymenocaris matthewi Bassler	—	—	—	—	—	—	×										
37. Indiana lippa (Matthew)	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	×	
38. Indiana ovalis Matth.	—	—	—	—	—	×	—	—	—	—	—	—	—	×			
39. Indiana ovalis prima Matth.	—	×															
40. Leperditia? rugosa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×		
41. Schmidtella acuta (Matth.)	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×		
42. Schmidtella pervetus (Matth.)	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
43. Schmidtella pervetus concinna (Matth.)	—	—	—	—	×												
44. Walcottia fusiformis (Matthew)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	

(Some of the Phyllopods listed may be synonyms)

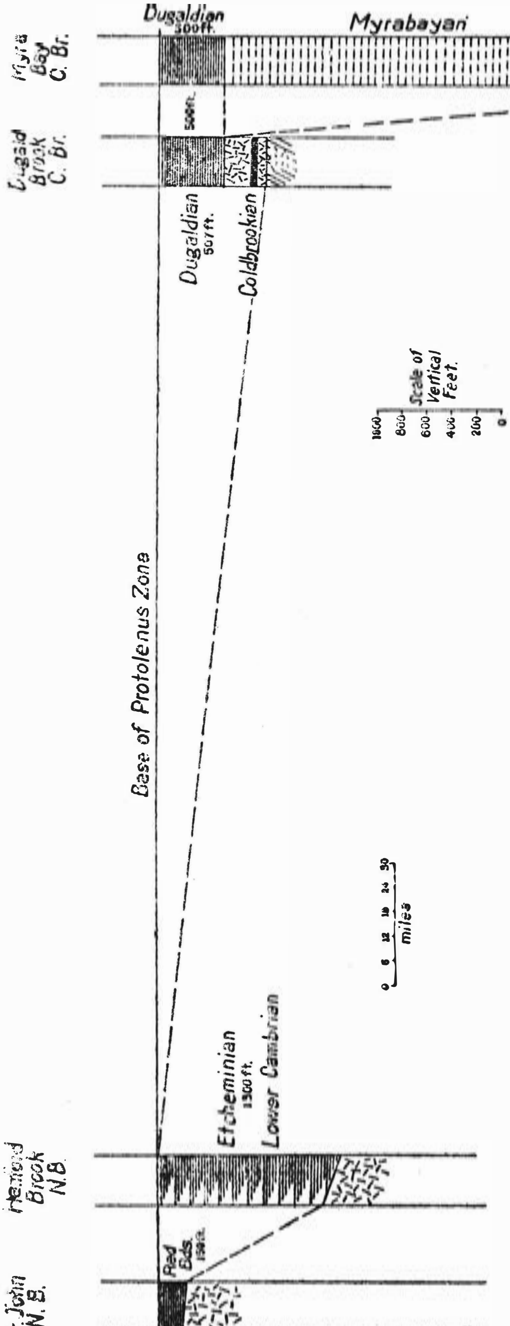
Taking the brachiopod fauna of the Dugaldian in its entirety (See Table E) we find that it has only 3 species in common with the *Protolenus* (Hanfordian) fauna, one of these, together with 2 others occurring in the *Paradoxides* beds as well. The three *Protolenus* horizon species are *Acrotreta avia puteus* Matthew, *A. gemmula* and *Loperia dugaldensis* Walcott. The 3 *Paradoxides* horizon species are *Lingulella tumida* Matthew, *Acrotreta gemmula* Matthew and *A. proavia.* Thus 5 out of the 28 species of brachiopods, of the Dugaldian occur outside of it, that is about 82 per cent of the species are confined to it. 3 *Hyolithes* occur in the Dugaldian but only 1 has been specifically identified and that doubtfully. All are restricted to it and the Coldbrookian. The trilobites are sparingly represented, *Solenopleura ? bretonensis* Matthew, occurs in the highest division of the Dugaldian. From the Middle division, a paradoxidoid trilobite and *Holasaphus centropyge* Matthew and a Eurypterid have been recorded. But the most characteristic element of the fauna seems to be the Phyllopod-Ostracod group, of the genera *Bradoria*, *Bradorona*, *Beyrichona*, *Escasona*, *Hymenocaris* and *Indiana*. Of the 42 recorded Dugaldian species, only 3 are found in the overlying *Protolenus* Bed leaving 93 per cent restricted to it. Two additional species are found in the Coldbrookian.

The fauna thus seems to be a rather peculiar one, Linguloid, Oboloid, and *Acrothele-Acrothyra* etc. types of brachiopods forming the chief element besides the peculiar genera of bivalve-crustaceans, which appear to be referable to the Phyllopoda and possibly are relatives of the Estheridæ. The fact that these forms are practically unknown in the Acadian *Paradoxides* beds (a single species of *Beyrichona*, *B. triceps* Matthews has been recorded from the *Paradoxides* Beds, Horizon c2 b) suggests that they did not live in normal pure sea water such as probably characterized the habitat of the *Paradoxides.* On the other hand the fact that they ranged throughout the Dugaldian, while the brachiopods equally ranged throughout this series, suggests that the habitat was not unfavourable to the brachiopods. If these phyllopods were fresh water types as seems not unlikely, it would appear that we have here a deposit formed in a sheltered or semi- if not entirely enclosed bay, into which fresh-water streams were pouring, and the probabilities are that the salinity of the water was considerably below the normal for ocean water. This would not only result in the restriction of the marine types, to certain euryhaline or adaptable forms but would account for the presence of so many specialized types. One would of course expect that the marine forms under such an environment would show a dwarfed condition as compared with those from normal sea water, but since as already noted, only 3 species occur in the *Paradoxides* beds, and as there is no record of the relative size of these as compared with their representatives in the Dugaldian, we are left without a basis for comparison. Nevertheless in view of the all but unique character of the entire fauna, and the fact that this series has not been found elsewhere within the known portion of the geosyncline, it furnishes strong presumptive evidence for the belief, that we are dealing here with a temporary and incomplete first invasion of the Middle Cambrian Sea and the formation of a Caspian type of isolated relict water body, in which the development of the meager fauna was undergoing its own course, and where a considerable thickness of sediment accumulated which has no parallel in any other portion of this geosyncline.

If the measurements of over 5000 ft. given by Matthew are substantiated and if the lower beds (Myrabayan series) exposed on Myra Bay, belong to this unit of deposition, we ought to have there further indication of the development of this specialized fauna from a normal sea water fauna, which was the first to invade this region. This normal fauna may or may not have been preserved in sediments formed along the line of invasion, but if so its typical marine character would tend to link it rather with the higher beds from which nevertheless it might be separated by a disconformity. For if our supposition is correct, the Cape Breton region remained isolated for a considerable period after the first invasion and consequently, the basal sediments of this early invading sea, in other parts of the geosyncline, would again have become exposed to erosion with the evident possibility of their complete removal before the second or Protolenian invasion of the Middle Cambrian. (For the relationships of these beds in the serveral localities see Text-Fig. 9.)

II. *The Hanfordian or Protolenus zone.*

New Brunswick. If I am correct in the explanation above given of the origin and nature of the Dugaldian series of Cape Breton, we must regard the *Protolenus*-bearing Hanfordian beds which succeed the Dugaldian, as the first record of the successful marine invasion of the geosyncline. These beds have been recognized in widely different regions of this ancient geosyncline, from the Sancta Crucian Mountains of Central Poland on the east, to the Comley district of western England and the Cape Breton — New Brunswick region of the Maritime Provinces of Canada. In most of these sections the *Protolenus* beds rest either upon the Lower Cambrian or on the older rocks. In either case, their basal relation is disconformable or unconformable with the underlying rocks, but it must not be forgotten that



Text-Fig. 9. Sections of the lower Middle Cambrian Formations of Cape Breton and their relation to the New Brunswick Sections. Both horizontal and vertical scales are indicated, the latter exagerated about 158 times over the former.

the entire Dugaldian series, 5000 ft. in thickness, lies between the Lower Cambrian and the *Protolenus* beds. In many of these sections we might readily expect something of an intermingling of Lower Cambrian fossils, with those normal to the *Protolenus* beds, for if our general thesis is correct, there should be a very long time interval between the Lower Cambrian retreat and the Middle Cambrian readvance and consequently the surface of the country previously covered by Lower Cambrian formations should, as the result of prolonged weathering, be strewn with the fragments or even the unbroken remains of Lower Cambrian organisms, while the advancing Middle Cambrian seas, in disturbing these products of weathering, would by floatation sort them out into fossiliferous layers, in which the remains of the organisms of the invading sea may likewise be commingled. This is probably the reason why many students of these early rocks would enclose the *Protolenus* beds in the Lower Cambrian, whereas, according to Matthew, these overlie the Dugaldian early Middle Cambrian beds in Cape Breton, although in Hanford Brook the type locality, they have overlapped these beds and rest directly on the Etcheminian Lower Cambrian.

The *Protolenus* beds (Matthew's division C1b1, to C1b5,) have furnished no fossils in Cape Breton and their exact thickness and character is not known. Neither is that of the Lower Acadian or *Paradoxides* beds, (Matthew's divisions C1c and C1d.) All of these are well developed in New Brunswick. It is not until we reach division C2a, of Matthew, with *Lingulepis exigua*, corresponding to some of the later *Paradoxides* zones, and division C2b, which is supposed to represent the *Forchhammeri* zone, and C2c, possibly a still higher zone, that we meet with fossiliferous representatives in Cape Breton. It is in this region that the Upper Cambrian is well developed, for which reason I long ago proposed the name Bretonian, as a group name for this division of the system.

The type section of the *Protolenus* zone of Matthew is at Hanford Brook, St. Martin's, New Brunswick, about 30 miles from St John. This stream runs at right angles to the strike of the beds, which here dip at a moderately steep angle to the north. Unfortunately Matthew gives no thickness, but if we can judge by his section, the *Protolenus* group which he makes division 1b of his Acadian part of the St. John group, should be in the neighbourhood of 300 ft. It is preceded by division 1 a of the St. John group, which is an unfossiliferous sandstone and which in turn is separated from the underlying Lower Cambrian Etcheminian series by an unexposed interval. This sandstone, Division 1 a is represented as even thicker than the *Protolenus* group and the whole of the Acadian group of this section would cover at least 600 or 800 ft. whereas we know that its thickness at St. John is not over 200 ft. As we have seen (*ante* p. 81, *107*) the highest exposed division of the Etcheminian (Division 2c) has a thickness of 300 ft. and consists of purplish sandy shale, with a few bands of greenish shale and carries *Scolithus*. Whether the concealed interval of 320 ft. also belongs to the Etcheminian or together with the sandstone 1a, of the Acadian group represent the Dugaldian of Cape Breton Island is unknown.

Matthew divides the *Protolenus* zone into 5 distinct subzones. These in descending order are as follows.[1]

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1 G. F. Matthew. *Protolenus* zone. Transactions of the New York Academy of Science, March 17th, 1895 p. 106.

5. Subzone with unknown crustacean fauna.
4. Subzone of *Beyrichona tinea* (ostracod)
3. Subzone of *Protolenus paradoxoides*
2. Subzone of *Protolenus* (*Bergeronia*) *elegans*
1. Subzone of *Hipponicharion eos* (ostracod)

The fauna is given in table F, Cols 3-7, the horizons there being marked C1b1-C1b5 in conformity with the usage adopted by Walcott, (Cambrian Brachiopoda p. 133) and by others working on these faunas in America. In Col 8 the overlying Paradoxides beds are represented, while in Cols. 1 and 2, the Lower Cambrian and the Dugaldian are shown respectively. The study of this table will show that the relationship of the *Protolenus* fauna is more marked with the *Paradoxides* fauna than with the Dugaldian, especially among the brachiopods.

With the Lower Cambrian it has only *Botsfordia caelata* (Hall) in common, and a few of the pelagic Hyolithids, including *Hyolithellus micans*, *Coleoloides typicalis*, and *Hyolithes americanus*. The trilobites of the Protolenus beds are confined to it, as are also most of the ostracods and phyllopods, though as already noted 3 of these, *Indiana lippa*, *Bradoria benepuncta* and *Walcottia fusiformis* also occur in the Dugaldian. *Hipponicharion eos* occurs in the Lower Cambrian of Poland. The characteristic trilobites of this fauna are confined to subzones 2 and 3, (cols. 4 & 5) an undetermined species of *Ellipsocephalus* being recorded from subzone 1, (col. 3) and none from either subzone 4 or 5, (cols. 6 & 7) where the only species are ostracods and brachiopods.

Newfoundland The Manuels Brook section of Newfoundland has been the subject of most careful recent studies by the late Professor Gilbert van Ingen of Princeton and by Dr. B. F. Howell, whose work on the lower portion of the section has already been referred to (*ante* p. 79 (*105*)

Table F.

Fauna of the Hanfordian or Protolenus Beds of New Bunswick

		Lower Cambr.	Dugaldian	Hanfordian or Proto-lenus Beds					Paradox. Beds
				C1b1	C1b2	C1b3	C1b4	C1b5	
		1	2	3	4	5	6	7	8
Brachiopoda									
1	Lingulella ferruginea Salter	—	—	—	—	x?	—	—	×
2	Lingulella martinensis Matthew	—	—	×	×	×			
3	Botsfordia caelata (Hall)	×	—	×					
4	Botsfordia pulchra (Matthew)	—	—	×	×	×	×		
5	Trematobolus insignis (Matthew)	—	—	—	×				
6	Trematobolus kempanum (Matthew)	—	—	—	—	×			
7	Trematobolus pristinus (Matthew)	—	—	—	×	×			
8	Acrothele matthewi (Hartt)	—	—	×	—	—	—	—	×
9	Acrothele matthewi lata Matthew	—	—	—	×	×	—	—	×
10	Acrothele prima (Matthew)	—	—	×	×	×			
11	Acrothele prima costata (Matthew)	—	—	—	×	×	—	×	×
12	Acrotreta baileyi Matthew	—	—	—	×	—	—	—	×
13	Acrotreta gemmula Matthew	—	×	—	×	×	—	—	×
14	Acrotreta inflata Matthew	—	—	×					
15	Acrotreta sagittalis Salter	—	—	×	—	—	—	—	×
16	Acrotreta sagittalis magna (Matthew)	—	—	—	—	×	—	—	×
17	Acrotreta sagittalis transversa (Hartt)	—	—	×	×	×	—	×	×
18	Protorthis helena Walcott	—	—	—	—	×			
19	Protorthis (Loperia) dugaldensis (Walc.)	—	×	—	—	×			
Hyolithidæ etc.									
1	Hyolithes (Diplotheca) acadica crassa Matthew	—	—	—	—	×			
2	Hyolithes (Diplotheca) hyattina Matthew	—	—	—	—	×			
3	Pelagiella atlantoides Matthew	—	—	—	×	×			
4	Hyolithellus micans Bill.	×	—	—	x?				
5	Coleoloides typicalis Walcott	×	—	—	x?				
6	Orthotheca cf emmonsi Ford	—	—	—	×				
7	Hyolithes cf princeps Bill.	×	—	—	—	×			
8	Hyolithes americanus Bill.	×	—	—	—	×			
9	Hyolithes cf. obtusa Bill.	—	—	—	—	×			
10	Hyolithes decipiens Matthew	—	—	—	×				
11	Hyolithes gracilior Matthew	—	—	—	—	×			

Table F. (*Continued*)	1	2	3	4	5	6	7	8
Cephalopoda								
1 Volborthella tenuis Schmidt	—	—	—	—	—	—	×	×
Trilobita								
1 Agraulos? arcticephalus Matthew	—	—	—	—	×			
2 Protagraulos priscus Matthew	—	—	—	—	×			
3 Ellipsocephalus galeatus Matthew	—	—	—	—	×			
4 Ellipsocephalus grandis Matthew	—	—	—	×				
5 Ellipsocephalus sp.	—	—	×					
6 Micmacca matthewi Matthew	—	—	—	—	×			
7 Micmacca vaningeni Matthew	—	—	—	—	×			
8 Micmacca recurva Matthew	—	—	—	—	×			
9 Micmacca? plana Matthew	—	—	—	—	×			
10 Avalonia acadica Matthew	—	—	—	—	×			
11 Protolenus paradoxoides Matthew	—	—	—	—	×			
12 Protolenus bituberculatus Matthew	—	—	—	—	×			
13 Protolenus (Bergeronia) elegans Matthew	—	—	—	×				
14 Prot. (Bergeronia) articephala Matthew	—	—	—	—	×			
Ostracoda & *Phyllopoda*								
1 Hipponicharion eos Matthew	—	—	×					
2 Hipponicharion cavatum Matthew	—	—	×	—	×			
3 Hipponicharion minus Matthew	—	—	—	—	×			
4 Beyrichona papilio Matthew	—	—	—	×	×	×		
5 Beyrichona tinea Matthew	—	—	—	×	×	×		
6 Beyrichona tinea planata Matthew	—	—	×	×	×			
7 Beyrichona tinea triangularis Matthew	—	—	—	×	×			
8 Beyrichona ovata Matthew	—	—	—	×				
9 Beyrichona rotundata Matthew	—	—	—	×	×			
10 Indiana lippa (Matthew)	—	×	—	—	×			
11 Indiana secunda (Matthew)	—	—	—	×	×			
12 Indiana secunda pyriformis Matthew	—	—	—	—	×			
13 Bradoria benepuncta (Matthew)	—	×	—	—	×			
14 Bradoria minor (Matthew)	—	—	—	—	×			
15 Bradoria cambria (Matthew)	—	—	—	—	×			
16 Bradoria oculata (Matthew)	—	—	—	—	×			
17 Walcottia fusiformis (Matthew)	—	×	—	—	×			
18 Lepiditta sigillata (Matthew)	—	—	—	—	×			
19 Primitia aurora Matthew	—	—	×					
20 Leperditia ventricosa Matthew	—	—	×					
21 Leperditia steadi Matthew	—	—	×					
22 Leperditia primæva Matthew	—	—	—	—	×			

with reference). In Dr. van Ingen's table, republished in Howell's paper, he applied the name *Hanfordian* to the beds overlying the Etcheminian and although he placed them in the Lower Cambrian, he recognized the existence of a disconformity between the Etcheminian and the Hanfordian. We may give here the Cambrian portion of Van Ingen's table, retaining his classification though rearranging his items.

G. van Ingen's classification of Manuel's Brook Cambrian.

ST. JOHN GROUP

Upper Cambrian or Johannian

Elliot Cove Formation.

E. gray and black shales with concretions; contains:

Olenus
Orusia lenticularis
Lingulella ferruginea

Middle Cambrian or Acadian

Manuel's Formation

D2. Black, brown and olive shales, thin-bedded sandstone and Kalkballen, fossils:

Paradoxides
Conocoryphe
Liostracus
Agnostus
Microdiscus

D1. Phosphorite. Lower *Paradoxides* horizon

Disconformity

Lower [?] *Cambrian* Hanfordian [our Middle Cambrian]

Hanford formation.

C2. Green and red shale, with manganiferous limestones. Fossils:

Protolenus
Ellipsocephalus
Avalonia

C1. Phosphorite with Radiolaria and sponges.

Disconformity

ETCHEMINIAN

Lower Cambrian

Smith Point limestone

B3. Red limestone with red shale, with *Hyolithes* etc.

Brigus Formation

B2. Red shales with nodular limestones.

Callavia bröggeri
Strenuella strenuus

Bonavista Formation

B1. Red and green shales with limestone nodules.

Coleoloides etc.

Van Ingen records 2 disconformities one below and one above, the Hanfordian, and he places the latter in the Lower Cambrian. Since his Hanfordian is essentially the *Protolenus* zone, it is here placed at the base of the Middle. He records a phosporite bed at the base of the Hanfordian and another at the base of the Acadian, each of these signalling the return of the sea, after a period of exposure. The lowest of these is regarded as the most important.

In the classification adopted by Howell in his paper on the *Paradoxides* beds of Manuels, in Newfoundland, he divides the original Hanfordian of van Ingen, especially his division C2 into a *Protolenus* zone at the base, followed by a *Catadoxides* zone, and this by a Manganiferus zone, above which lie in turn the lowest *Paradoxides* beds. He expresses doubt as to the exact position of these beds in the classification. We have already referred to the contact between these Hanfordian beds and the underlying Etcheminian and the evidence which indicates a disconformity.

The Hanfordian with its 2 zones is 34 ft, thick, the characteristic trilobite of the upper zone, *Catadoxides magnificus*, has been compared with the Sardinian genus, *Metadoxides* which characterizes the *Olenopsis* beds of that section (see below). The *Catadoxides* beds are succeeded by a thin bed of dark bluish-gray shale 4 to 5 inches thick and full of flattened sub-spherical nodules which are one inch in diameter and were regarded by Dale as composed of manganiferous calcite.[1] Overlying this is a thin layer described by Dale as "*Cryptozoon* shale" "containing roughly concentric or zonal structures measuring 1 ½ inches in diameter, irregular and subspherial nodules, measuring one inch

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1 N. C. Dale. The Cambrian manganese deposits of Conception and Trinity Bays Newfoundland. Proceedings American Philosophical Society, Vol. 54, 1915, p. 371-456 (p. 385).
ibid 1914. Manganese deposits of Conception and Trinity Bays. Newfoundland. Bull. Geol. Soc. of America, Vol. 25, 1914. p. 73-74.

in diameter, and intercalated lenses of manganiferous calcite.[1]

This "Cryptozoon" layer is succeeded by 3 ft. of hard green shale, with manganiferous calcite nodules in its upper portion. In the lower part of this, a specimen of a trilobite has been found which is tentatively identified by Howell with *Catadoxides magnificus* (Matthew).

Succeeding this are 10 ft. and 10 inches of unfossiliferous manganiferous red and green shales, some of which contain small flat nodules, some of them similar to those occurring in the beds below, but others may be phosphatic.

Above this follow the beds referred to the *Paradoxides* zone i.e. the true *Acadian* with a thickness of 302 ft. The details of these beds will be given later.

It thus appears that the Hanfordian series which disconformably overlies the Etcheminian, has a thickness of 77.5 ft, and that it contains the *Protolenus* zone in the lower part and the *Catadoxides magnificus* zone in the upper part. No detailed study has yet been made of the fauna of this series, but it appears to be essentially the equivalent of the *Protolenus* zone of Hanford Brook.

England. The *Protolenus* zone has been found by Cobbold in the Comley district of Shropshire in Western England.[2] It rests upon the *Strenuella* limestone (Ac4,)

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1 Loc. cit. 1915 p. 385.

2 Edgar Stirling Cobbold. The Cambrian horizons of Comley, Shropshire and their Brachiopoda, Pteropoda, and Gastropoda etc, with faunal tables. Quarterly Journal of the Geol. Soc. London vol. LXXVI pp. 325-386. pls. XXI-XXIV, 1920.
Cobbold. E. S. On some small trilobites from the Cambrian Rocks of Shropshire. Quarterly Journal of the Geol. Soc. London. vol. LXVI, 1910, p. 19 et seq.

0.75 ft. thick, which is a gray to red-purple gritty limestone, with phosphatic inclusions and apparently marks the top of the Lower Cambrian, being separated from the *Olenellus* limestone by 1.75 ft. of *Microdiscus bellimarginatus* limestone. (*ante* p. 91, *117*.)

The *Protolenus* limestone of this section has a maximum thickness of 6 inches and consists of black to pale-gray compact phosphatic limestone. It is followed by the *Lapworthella* limestone (Ad.) which is formed of 6 inches of calcareous and phosphatic granular material. Then follows a disconformity and erosion, which often cuts away these two formations, so that the lowest *Paradoxides* bed, may rest directly on the *Strenuella* limestone or on either of the 2 succeeding beds.

In the famous Comley quarry, the *Lapworthella* limestone is a highly phosphatic bed. "It is probably an impersistent bed and has a thickness of say from 4 to 6 inches. (Cobbold).[1]

Cobbold relegates this to the Lower Cambrian "because it contains *Acrothyra* cf. *sera* Matthew, *Hyolithellus micans* Billings etc, as well as the *Salterella*-like *Lapworthella* and because angular fragments occur in the conglomerate above." *Acrothyra sera* Matth. however, is typical of the Dugaldian, which we have seen is not Lower but Middle Cambrian and *Hyolithellus micans* is a species which also occurs in the *Paradoxides* beds. *Lapworthella* is new and so are the other fossils found there.

In the Comley quarry, the *Protolenus* and *Strenuella* limestones are represented by some 9 inches of deeply

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1 Notes on the Cambrian area of Comley. E.S. Cobbold. Proceedings of the Geological Association, vol. XXXVI, part IV, 1925. pp. 367-374. (p. 371)

weathered rock, much fractured by strike faulting. 200 yards south however, these 2 formations are well shown. In Table G, the fossils of the *Protolenus* zone of Comley are recorded in Col. 2, those of the *Lapworthella* bed in Col. 3, while Col. 4 indicates those species which range into the Acadian of Comley. Cols. 5 & 6 show the species which are also known from the Dugaldian and Hanfordian respectively of eastern North America, while Col. 1, indicates those that range down into the Lower Cambrian of the Comley district.

At first sight, there seems to be a rather closer relationship to the Lower, than to Middle Cambrian, but this is less significant than it appears. Two small brachiopods, *Paterina labradorica* and *Obolus parvulus*, the latter new, may be regarded as typical Lower Cambrian forms which range into the *Protolenus*, but not into the *Lapworthella* bed. Recalling the slight thickness of the *Protolenus* bed and the fact that it certainly represents a new invasion of the sea, since it is characterized by a new fauna, these two brachiopods might well be regarded as residual Lower Cambrian fossils, picked up by the transgressing Middle Cambrian sea and incorporated in its deposits. Among the trilobites, two species of *Microdiscus*, *M. lobatus* and *M. speciosus* may also be regarded as Lower Cambrian forms incorporated in the higher deposit. If we regard these forms as separated by weathering from the underlying rocks, we can understand that their minute size has preserved them intact, and this applies to the brachiopods also, though as a matter of fact, the best specimens figured by Cobbold are nearly all broken. The measurements given by Cobbold for *Obolus parvulus*, range from 0.9 to 2.35 mm, in length, with the width 8/10 to 9/10 the length. Species of *Paterina labradorica*, range up to 10 or 11 mm in width, but

Table G.

Fauna of the Protolenus Bed of Comley

(Cobbold--Quart. Journ. Geol. Soc. Lond. Vol. 76, 1921, p. 372)

	Lower Cambrian	Protolenus zone Comley	Lapworthella zone Comley	Acadian of Comley	Coldbr. & Dugaldian	Protolenus N. B.	Middle Cambr. Acadia
	1	2	3	4	5	6	7
Brachiopoda							
Paterina labradorica Bill	×	×	—				
Obolus parvulus Cobbold.	×	×	—				
Lingulella viridis Cobbold.	—	×	×				
Acrothyra cf. *sera* Matthew	—	—	×	—	×		
Hyolithids etc.							
Hyolithes crassus Cobbold	—	×	—				
Hyolithes sculptilis Cobbold	—	×	—				
Orthotheca bayonet Matthew	—	×	—	—	—	×	
Salterella (?) *bella* Cobbold	—	×					
Salterella (?) *striata* Cobbold	—	×					
Lapworthella nigra Cobbold	—	—	×				
Hyolithellus micans Bill.	×	×	×	×	—	×	
Helenia cancellata Cobbold	×	×	×				
Helcionella cingulata Cobbold	?	×					
Latouchella (?) *striata* Cobbold	—	×					
Latouchella costata Cobbold	×	×					
Trilobita							
Microdiscus comleyensis Cobbold	—	×					
Microdiscus lobatus Hall	×	×					
Microdiscus speciosus Ford	×	×					
Protolenus latouchii Cobbold	—	×					
Protolenus morpheus Cobbold	—	×					
Mohicana lata Cobbold	—	×					
Mohicana clavata Cobbold	—	×					
Callavia cf. *callavii* (fragments)	×	×					

we are not told the size of the specimens from the *Protolenus* bed. However none of the shells figured, which all come from the *Olenellus* limestone some 2½ ft. below the *Protolenus* limestone, are perfect. Of much greater significance however is the fact that the large Lower Cambrian trilobite *Callavia calavii*, typically found in the *Olenellus* limestone, is represented by fragments only, in the *Protolenus* beds and the two thin layers of limestone below it.

Aside from these fragmentary and minute organisms, which might well be regarded as reincorporated residual material, there are only *Hyolithids* and the apparently pelagic pteropod *Latouchella costata* which has a maximum length of 4.5 mm and may either be classed with the incorporated forms or the presistent pelagic types.

I am well aware that I have merely stated a possibility, when I refer to these minute organisms as secondarily included, though that this was the manner of incorporation of the *Callavia* fragments can hardly be questioned. I would base the classification of the *Protolenus* bed with the Middle rather than the Lower Cambrian, on the occurrence of the new and distinctive types, among which *Protolenus* itself is represented by 2 species, though they are distinct from the species found in New Brunswick. This incoming of a new fauna, can hardly be explained otherwise than by renewed marine invasion, and since we have seen that in Cape Breton, the *Protolenus* zone is underlain by more than 500, and possibly by more than 5000 feet of strata with a Middle Cambrian fauna, the correctness of that classification seems to be beyond question.

Other countries The *Protolenus* zone is unknown in Scandinavia, where the *Paradoxides* beds, lie disconformably on the Lower Cambrian *Holmia* Beds. It is equally unrepresented, at least by fossiliferous beds, in Bohemia, but has been reported from the Lausitz Mountains[1] on the Bohemian border and from the Sancta Crucia Mountains of Central Poland.

In the latter region, these *Protolenus* Beds have also been classed with the Lower Cambrian and they have been subdivided as follows.

Superformation

Middle Cambrian. Sandstones without fossils, Bed 7

II *Protolenus Series, Bed 6,* Shales and sandstone with a rich fauna including *Protolenus* 3 species, *Ellisocephalus* etc. the greater part of the fauna consists of new species. This fauna has been given in Col. 21, Table III (*ante* p. 140 (*p. 166*).

Bed 5. Yellowish green shales, with light coloured sandstones and shales and a rich fauna, most of the species being new and a few ranging into the higher beds.

Bed 4. Sandstones and sandy shales with a sparse fauna, including *Strenuella kiaeri.*

The faunas of beds 4 and 5 are given in Col. 20 of Table III, p. 140 (*166*).

Division I Lower Cambrian Holmia Bed, with a fauna given in Column 19 of Table III.

So far as the lists of species are available, *Protolenus* seems to be restricted to the highest bed (6) of Division II and as the table shows, the only trilobite in common with the preceding beds and the Lower Cambrian is *Strenuella kiaeri*. *Elipsocephalus intermedius* is mistakenly recorded in the table under Col. 20. If these lists give the true relationship of the fauna, it is possible that bed 6 alone is referable to the *Protolenus* zone.

1 This is questionable; see below

The *Protolenus* fauna of the Lausitz Mountain granite massif, on the northern border of the Bohemian mass is less satisfactory, for the species described from there by Richter,[1] *Eodiscus* cf *speciosus*, and an undetermined Ptychoparid and Mesonacid suggest rather Lower Cambrian, though as Richter says, the Mesonacid may be a *Paradoxides*. He however, concludes that the probabilities are that the red shale in which these fossils are found, and which was formerly referred to the Devonian, most probably represents Lower, rather than Middle Cambrian. Certainly there is no justification for Bubnoff's confidence in referring this horizon to the *Protolenus* zone.[2]

III *The Acadian or Paradoxidean Series*

The Acadian or *Paradoxides* series is a well defined group, representing the typical development of the Middle Cambrian in the Caledonian geosyncline. There has never been any doubt about its delimitation when the strata carry fossils, for the typical species of *Paradoxides* are found throughout. Everywhere too, critical study has shown that this series is limited below as well as above by disconformities, and there is not wanting evidence at least in some sections that there are disconformities within the series. This indeed, is strongly suggested by the marked zoning of these Middle Cambrian beds and by the well-known fact, that the species of *Paradoxides*, which characterize the successive zones are practically if not wholly

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1 R. and E Richter. Eine Kambrische fauna im Niederschles. Schiefergebirge. Centralblatt für Mineralogie, Geologie, etc, 1923 pp. 730-735.

2 Geologie von Europa pp. 523 and 632.

confined to these zones, and that such distinct zones can be recognized even where the entire series is represented only by an insignificant thickness. The case of Bornholm has already been referred to where the entire *Paradoxides* series has a thickness of only 4 meters or approximately 13 ft. and where the series is divisible into 4 palæontological zones.

To consider such a series as representing continuous deposition, and representative of the entire Middle Cambrian, ignores the very significant fact of sharply delimited zones. In the region of continuous deposition, successively invaded by faunas from an outside source, we should expect to find a commingling and gradual replacement of the older by the younger fauna. Even if it were a question of a single leading trilobite only, such as the *Paradoxides,* it is inconceivable that with the arrival of the new zone species, only slightly different from the one preceding, the latter should disappear abruptly. To take our most completely investigated example, that of the *Paradoxides* Beds of Bornholm, studied in such great detail by Grönwall[1], we have the following remarkable facts. (See Table H)

In the Læsaa section, the total number of species described is 61 and two doubtful. Of these 7 occur in the Lower Alum shales, or zone of *Paradoxides tessini* which has a thickness of only 160 to 165 cm. 20-25 cm. of this representing the *Exsulans* horizon but here unfossiliferous. 29 occur in the zone of *Paradoxides davidis* a phosphoritic anthraconite[2] only 20 cm in thickness; 12

1 Karl A. Grönwall Bornholm's Paradoxideslag og deres Fauna. Denmark geologiske Undersögelse, Series II No. 13, 1902, with English summary

2 Carbonaceous calcite.

Table H Fauna of the Paradoxides Beds of Bornholm (After Grönwall)	Læsaa					Ole Aa							Skania Sweden	Oslow Region
	Tessini Zone	Davidis Zone	Transition Bed	Andrarum Limest.	Laevigatus Zone	Tessini Z.				Davidis Zone	Andrarum Limest.	Lævigatus Zone		
						Exsulans Lime.	Agnost. parvulus	Alumn Shale	Conocor. equalis					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Brachiopoda														
1 Acrotreta sagittalis (Salt.) Walcott	—	—	×	×	—	×	×	—	—	×	×	—	×	
2 Lingulella sp. indet.	—	—	—	×	—	×	×	—	—	—	×	—	×	
3 Acrotreta socialis v. Seeb.	—	—	×	×	—	×	—	—	—	—	×	—	×	
4 Acrothele intermedia Lnrs.	—	—	—	—	—	×	?	—	—	—	—	—	×	
5 Acrothele coriacea Lnrs.	—	—	×	×	—	—	×	—	—	—	×	—	×	×
6 Iphidea ornatella Lnrs.	—	—	×	×	—	×	—	—	—	—	×	—	×	
7 Kutorgina cingulata Bill. var. pusilla Lnrs.	—	—	×	×	—	—	—	—	—	—	×	—	×	
Gastropoda														
1 Metoptoma barrandii Lnrs.	—	—	—	—	—	×	—	—	—	—	—	—	×	
2 Raphistoma bröggeri Grönwall	—	×	×	—	—	—	?	—	×	×	×	—	—	×
Hyolithidæ														
1 Hyolithes (Orthotheca) lineatulus Holm.	—	×	—	—	—	—	—	—	—	×	—	—	×	
2 Hyolithes (Orthotheca) affinis Holm.	—	×	—	—	—	—	—	—	—	×	—	—	×	
3 Hyolithes (s. str.) tenuistriatus Lnrs.	—	—	—	—	—	—	—	—	—	—	×	—	×	×
4 Hyolithes (s. str.) obscurus Holm.	—	×	—	—	—	—	—	—	—	×	—	—	×	
5 Hyolithes (s. str.) socialis Lnrs.	—	×	—	—	—	—	×	—	×	×	—	—	×	?
Trilobita														
1 Agnostus gibbus Lnrs., var. hybrida Br.	—	—	—	—	—	—	×	—	—	—	—	—	—	×

Table H (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Trilobita (cont.)														
2 Agnostus fissus Lgn. var. perrugata Grönwall	—	—	—	—	—	—	×							
3 Agnostus lundgreni Tbg.	—	×	—	—	—	—	—	—	—	×	—	—	×	
4 Agnostus lundgreni Tbg. var. nana Grönwall	—	×	—	—	—	—	—	—	—	×				
5 Agnostus intermedius Tbg.	—	—	—	—	—	—	—	×	—	—	—	—	×	
6 Agnostus incertus Br.	—	×	—	—	—	—	—	—	—	×	—	—	×	×
7 Agnostus exsculptus Ang. (ex parte)	—	—	—	×	—	—	—	—	—	—	?	—	×	
8 Agnostus nathorsti Br.	—	×	—	—	—	—	—	—	—	×	—	—	×	×
9 Agnostus aculeatus Ang.	—	—	—	—	—	—	—	—	—	—	×	—	×	×
10 Agnostus punctuosus Ang.	×	×	—	—	—	—	×	?	×	×	—	—	×	×
11 Agnostus elegans Tbg.	—	×	—	—	—	—	—	—	—	×	—	—	×	
12 Agnostus altus Grönwall	—	×	—	—	—	—	×	—	—	×				
13 Agnostus cicer Tbg.	—	×	—	—	—	—	—	—	—	×	—	—	×	
14 Agnostus cicer var. forfex Grönwall	—	×	—	—	—	—	—	—	—	×				
15 Agnostus laevigatus Dalm.	—	×	—	—	×	—	—	—	—	×	×	—	×	×
16 Agnostus nudus Beyr., var. scanicus Tbg.	—	—	—	—	—	—	×	—	×	—	—	—	×	
17 Agnostus nudus Beyr., var. marginatus Br.	—	×	×	×	—	—	—	—	—	—	×	—	×	×
18 Agnostus glandiformis Ang.	—	—	—	×	—	—	—	—	—	—	×	—	×	×
19 Agnostus glandiformis var. resectus Grönwll	—	—	—	—	—	—	—	—	—	×				
20 Agnostus lens Grönwall	—	—	—	—	—	—	×							
21 Agnostus lens var. frondosus Grönwall	—	—	—	—	—	—	×							
22 Agnostus fallax Lnrs.	—	—	—	—	—	—	×	?	—	—	—	—	×	×
23 Agnostus fallax Lnrs. forma ferox Tbg.	—	×	×	—	—	—	—	—	×	×	×	—	×	×
24 Agnostus kjerulfi Br.	—	×	—	—	—	—	—	—	—	—	—	—	×	×
25 Agnostus planicaudus Ang.	—	×	×	—	—	—	—	—	—	×	—	—	×	×
26 Agnostus quadratus Tbg.	—	—	—	×	—	—	—	—	—	—	×	—	×	
27 Agnostus insularis Grönwall	—	×												
28 Agnostus lingula Grönwall	—	—	—	—	—	—	—	—	—	×				
29 Agnostus parvifrons Lnrs.	?	—	—	—	—	—	×	?	—	—	—	—	×	×

Table H (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Trilobita (cont.)														
30 Agnostus parvifrons. var. mammillatus Br.	—	—	—	—	—	—	×	—	×	—	—	—	×	×
31 Agnostus parvifrons var. nepos Br.	—	×	—	—	—	—	—	—	—	—	—	—	×	×
32 Agnostus brevifrons Ang.	—	—	—	×	—	—	—	—	—	—	×	—	×	×
33 Agnostus stenorrhachis Grönwall	—	×	—	—	—	—	—	—	—	×				
34 Agnostus exaratus Grönwall	—	—	—	—	—	—	×	—	—	×				
35 Agnostus pusillus Tbg.	—	×	—	—	—	—	×	—	×	—	—	—	×	
36 Agnostus rotundus Grönwall	—	—	—	—	—	—	—	—	×	×				
37 Microdiscus scanicus Lnrs.	—	—	—	—	—	—	×	—	?	—	—	—	×	
38 Microdiscus scanicus eucentrus Lnrs.	—	?	—	—	—	—	×	—	×	×	—	—	×	
39 Conocoryphe (s. str.) sulzeri v. Schloth.	—	—	—	—	—	—	—	—	—	?	—	—	—	×
40 Conocoryphe (s. str.) aequalis Lnrs.	×	—	—	—	—	—	—	—	×	—	—	—	×	
41 Conocoryphe (s. str.) glabrata Ang.	—	—	—	—	—	—	—	—	—	—	×	—	×	
42 Conocoryphe (s. str.) tenuicincta Lnrs.	—	—	—	—	—	×	—	—	—	—	—	—	×	
43 Conocoryphe (s. str.) dalmanni Lnrs.	—	—	—	—	—	×	—	—	—	—	—	—	×	
44 Conocoryphe (Erinnys) venulosa Salt.	—	—	—	—	—	—	—	—	—	×				
45 Conocoryphe (Erinnys) breviceps Ang.	—	—	—	—	—	—	—	—	—	—	×	—	×	
46 Conocoryphe (Ctenocephalus) exsulans Lnrs.	—	—	—	—	—	×	—	—	—	—	—	—	×	
47 Conocoryphe (Ctenocephalus) tumida Grönwall	—	—	—	—	—	—	—	—	—	×				
48 Conocoryphe (Ctenocephalus) laticeps Ang.	—	—	—	—	—	—	—	—	—	—	×	—	×	
49 Conocoryphe (Liocephalus) impressa Lnrs.	—	—	—	—	—	×	—	—	—	—	—	—	×	
50 Conocoryphe (Liocephalus) linnarssoni Grönwall	—	—	—	—	—	×								

	Table H (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Trilobita (cont.)														
51	Conocoryphe (Liocephalus) teres Grönwall	—	×	—	—	—	—	—	—	—	×				
52	Paradoxides tessini Brgn.	×	—	—	—	—	×	×	—	×	×	—	—	×	×
53	Paradoxides davidis Salt.	—	×	—	—	—	—	—	—	—	×	—	—	×	
54	Paradoxides forchhammeri Ang.	—	—	—	×	—	—	—	—	—	—	×	—	×	×
55	Paradoxides rugulosus Corda	—	×	—	—	—	—	—	—	—	×	—	—	×	×
56	Paradoxides hicksi Salt.	—	—	—	—	—	×	×	—	—	—	—	—	×	
57	Paradoxides sjögreni Lnrs. var. nepos Grönwall	—	—	—	—	—	—	—	—	—	—	×			
58	Paradoxides? sp. indet. No. 1. (Cranidium).	—	—	—	—	—	—	—	—	×					
59	Paradoxides sp. indet. No. 2. (Pygidium).	—	—	—	—	—	—	—	—	—	—	×			
60	Paradoxides? sp. indet. No. 3. (Hypostoma)	—	—	—	—	—	—	?	—	?	?				
61	Centropleura loveni Ang.	—	—	—	×	—	—	—	—	—	—	×	—	×	
62	Centropleura steenstrupi Ang.	—	—	—	—	—	—	—	—	—	—	×			
63	Dorypyge oriens Grönwall	—	—	—	—	—	×								
64	Dorypyge danica Grönwall	×	—	—	—	—	—	—	—	×					
65	Corynexochus bornholmiensis Grönwall	—	—	—	—	—	—	×	—	×	?				
66	Anomocare limbatum Ang.	—	—	—	×	—	—	—	—	—	—	×	—	×	
67	Anomocare excavatum Ang.	—	—	—	×	—	—	—	—	—	—	×	—	×	×
68	Anomocare excavatum var. dentatum Grönwall	—	—	—	×										
69	Anomocare læve Ang.	—	—	—	×	—	—	—	—	—	—	×	—	×	
70	Anomocare angelini Grönwall	—	—	—	—	—	—	—	—	—	?				
71	Liostracus linnarssoni Br.	×	—	—	—	—	—	×	—	×	—	—	—	×	×
72	Liostracus globiceps Grönwall	—	—	—	—	—	—	—	—	—	?				
73	Liostracus microphthalmus Ang.	—	—	—	×	—	—	—	—	—	—	×	—	×	×
74	Liostracus platyrrhinus Grönwall	—	—	—	×	—	—	—	—	—	—	×			

Table H (Concluded)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Trilobita (cont.)														
75 Ptychoparia johnstrupi Grönwall	—	×												
76 Conocephalina ornata Br.	—	×	—	—	—	—	—	—	—	×	—	—	—	×
77 Solenopleura canaliculata Ang.	—	—	×	×	—	—	—	—	—	—	×	—	×	
78 Solenopleura parva Lnrs.	—	—	—	—	—	×	—	—	—	—	—	—	×	
79 Solenopleura bucculenta Grönwall	—	—	—	—	—	—	—	—	—	×	×			
80 Solenopleura brachymetopa Ang.	—	—	×	×	—	—	—	—	—	—	×	—	×	×
81 Solenopleura brachymetopa var. alutacea Br.	—	—	—	×	—	—	—	—	—	—	×	—	×	×
82 Solenopleura brachymetopa var. nuntia Grönwall	—	—	—	—	—	—	—	—	—	×				
83 Solenopleura holometopa Ang.	—	—	×	×	—	—	—	—	—	—	×	—	×	×
84 Solenopleura acadica Whiteaves var. elongata Matth.	—	—	—	—	—	—	—	—	—	—	×			
85 Agraulos ceticephalus Barr.	—	×	—	—	—	—	—	—	—	×				
86 Agraulos depressus Grönwall	—	—	—	—	—	—	—	—	—	×				
87 Agraulos difformis Ang.	—	—	—	×	—	—	—	—	—	—	×	—	×	×
88 Agraulos difformis aculeata (Ang.)	—	—	—	×	—	—	—	—	—	—	×	—	×	×
89 Agraulos difformis acuminata (Ang.)	—	—	—	×	—	—	—	—	—	—	×	—	×	×
Ostracoda etc.														
1 "Leperditia" primordialis Lnrs.	—	—	—	—	×	—	—	—	—	—	—	×		
2 "Beyrichia" angelini Lnrs., var. armata Grönwall	—	—	—	—	—	—	—	—	—	×				
3 Problematic Organism	×													

occur in the so-called transition zone, which has a thickness of only 1 cm in the Ole Aa section, but is so thin in the Læsaa section as to escape measurement. 26 species occur in the Andrarum limestone or zone of *Paradoxides forchhammeri* which in this section has a thickness of 85 cm. Finally the Upper Alum shale, which is not over 2 meters thick and is characterized by *Agnostus lævigatus*, carries only 2 species, the zone fossil and *Leperditia primordialis*.

Taking first the trilobites, *Paradoxides tessini* is restricted to the Lower Alum shale of 160-165 cm. *Paradoxides davidis* Salter, is restricted to the phosphoritic anthraconite 20 cm in thickness, and *Paradoxides forchhammeri* Angelin, is restricted to the Andrarum limestone 85 cm thick. *Paradoxides rugulosus* Corda, occurs with *P. davidis* in the 20 cm beds representing that zone.

Taking the zones in detail in this section the *Paradoxides tessini* and *P. davidis* zone, the former with 7, the latter with 29 species have only 1 species in common and that is *Agnostus punctuosus*. The Davidis and Forchhammeri zone likewise, have only one species in common that is *Agnostus nudus* Beyr. var. *marginata* Grönwall. This form occurs also in the transition zone between the two. This transition zone, infinitesimal as it is in thickness, appears to represent the commingling of some of the species from the lower with some of those of the higher zone, and this in view of the sudden cessation of the lower species in the transition zone, and the sudden beginning of the new species here or in the higher zone, indicates mechanical admixture such as is found along a line of disconformity, rather than actual transition. Ommitting the one form we have noted as occurring in the Davidis zone, the intermediate bed, and the Forchhammeri zone, we find

3 others of the Davidis zone species, occurring in the intermediate zone and stopping there. These are

Raphistoma bröggeri Grönwall
Agnostus fallax ferox Tbg.
Agnostus planicauda Ang.

Again, in addition to the one common species already mentioned, 8 of the 26 Forchhammeri zone species, begin in the dividing or intermediate bed, 5 brachiopods and 3 trilobites. These are

Brachiopoda
Acrotreta sagittalis (Salter)
Acrothele socialis v. Seeb.
Acrothele coriacea Lnrs.
Iphidea ornatella Lnrs
Kutorgina cingulata pusilla Lnrs

Trilobita
Solenopleura canaliculata Ang.
Solenopleura brachymetopa Ang.
Solenopleura holometopa Ang.

None of these occur in the lower horizon but all begin here and continue upwards.

It must be obvious, that in view of this remarkable relationship, continuous deposition, with the successive arrival of new faunas in a persistent basin is out of the question. Only successive floodings and retreats can account for such faunal distribution, and as we have noted, this alone can account satisfactorily for the layer with commingled faunas, between the Davidis and Forchhammeri zones.

Taking the other section *i.e.* that at Ole Aa less than 20 km, east of the preceding, we find the *Paradoxides tessini* beds to have a thickness of 105 cm, with 3 subzones. The *P. davidis* zone varies from 10-20 cm in thickness and is succeeded by 1 cm of Alum shale, which separates it from the *P. forchhammeri* zone or Andrarum limestone, which here has a thickness of 55 cm. Finally, the *Agnostus laevigatus* zone is contained in the higher Alum shale approximately 2 m in thickness and this in turn is succeeded by the *Olenus* shale of Upper Cambrian age. Taking the 3 *Paradoxides* zones first, we find one point of difference in the distribution of the *Paradoxides*, namely *P. tessini* continues into the Davidis zone, but both *davidis* and *rugulosus* are confined to the Davidis zone. *P. hicksi* occurs in the lower Tessini zone only, while a new variety *P. sjögreni* Lnrs. var *nepos* Grönwall, occurs in the Forchhammeri zone, but nowhere else. In this section 3 species occur in all 3 zones. Namely *Acrotreta sagittalis* (Salter) *Raphistoma bröggeri* and *Agnostus fallax ferox*. The total number in each zone is as follows:

Zone	*Total number of species*	*Number in common*	*Thickness*
Tessini zone	40		105 cm
		3 + 7	
Davidis zone	45		10-20 cm
		3 + 2	
Forchhammeri zone	37		55 cm
		0.	
Laevigatus zone	1		200 cm

Aside from the 3 mentioned, which extend entirely across, the Tessini and Davidis zone have 7 other species in common. These are

Pteropods.

Hyolithes socialis Lnrs

Trilobites

Agnostus punctuosus Ang

Agnostus altus Grönwall
Agnostus exaratus Grönwall
Agnostus rotundus Grönwall
Microdiscus scanicus eucentrus Lnrs.
Paradoxides tessini

The latter is represented in the Davidis zone of Ole Aa by 2 cranidia, 6 pygidia, and 2 hypostoma.

Again omitting the 3 forms, which range through the 3 zones, we find, only 2 others in common between the Davidis and Forchhammeri zones, both trilobites, namely *Agnostus laevigatus* Dalman, and *Solenopleura bucculenta* Grönwall.

Once more then, though this section is not quite so striking as the preceding, the differences between the zones are so sharp and pronounced that there can be no question of continuous depositon. The only explanation which satisfies, is successive invasions separated by emergences long enough to permit a complete or nearly complete change in fauna in the center of evolution and dispersal, for of course it is out of the question that this center could have been situated within the geosyncline.

The Tessini zone of the Ole Aa section has been divided by Grönwall into 4 divisions, 3 of them representing distinctive palæontological zones. The lowest of these is the *Exsulans limestone* or zone of *Conocoryphe* (*Ctenocephalus*) *exsulans*, which is confined to this zone. This bed has a thickness of only 25 cm, and rests disconformably upon the upper sandstone of the Lower Cambrian. The species also occurs in the corresponding zone of Scania in southern Sweden. Besides this, there are 14 other species in the Exsulans subzone, 4 of which also occur in the next succeeding *Agnostus parvifrons* zone, which occupies the lower part of the succeeding 80 cm of Alum shale. These include the zone fossil *Paradoxides tessini* and *P. hicksi* and the 2 brachiopods *Acrotreta sagittalis* and *Lingulella* sp. Thus of the total 15 species in the Exsulans zone, 4, or less than 27 per cent, pass into the next higher *Agnostus parvifrons* subzone, and of the 22 species in this subzone, 4 or slightly more than 18 per cent have come up from below.

In the middle part of the Alum shale, which separates the *A. parvifrons* from the *Conocoryphe aequalis* subzones, only a single species *Agnostus intermedius* has been found, this species not occurring elsewhere. A comparison of the *Conocoryphe aequalis* subzone, with the two earlier ones, shows the following. Of the 15 species occurring in this subzone 9 or 60 per cent also occurs in lower beds. 7 of these occur in the *Agnostus parvifrons* subzone, namely.

Hyolithes socialis Lnrs. (also ranges into the Davidis zone)
Agnostus punctuosus Ang. (also ranges into the Davidis zone)
Agnostus nudus scanicus Tbg.
Agnostus parvifrons mammillatus Br.
Agnostus exaratus Grönwall
Microdiscus scanicus eucentrus Lnrs. (also ranges into the Davidis zone.)
Corynexochus bornholmienses Grönwall (Doubtfully in the Davidis zone)
Liostracus linnarssoni Brögger

One species of this subzone; *Agnostus rotundus* Grönwall occurs in the Alum shales immediately below and these may be regarded as a part of the subzone and 1 species, the zone fossil, *Paradoxides tessini* occurs in the lower 2 subzones and ranges into the Davidis zone as already noted. Thus, ommitting the species which pass up into the Davidis zone, 5 of the 15 species of the *Con. equalis* subzone, also occur in the *Agnostus parvifrons* subzone. There can then be little question that we are dealing with successive invasions of faunas and though the subzones of the *P. tessini* zone may represent more or less continuous deposition, or at least with only mild interruptions, the zones themselves represent such pronounced differences that long interruptions must be assumed to account for this difference.

The Bornholm section as already noted rests disconformably upon the *Rispebjaerg* sandstone 3 m or 10 ft. in thickness, which encloses phosphorite pebbles and lies upon the green shales with *Holmia* which are 178 ft. or 57 meters thick, and in turn rest upon the Nexo sandstone 197 ft. or 50 meters thick. This rests unconformably upon the old granite. Thus, the Lower Cambrian of this section is less than 400 ft. in thickness and more than half of this is unfossiliferous sandstone.

The contacts between the several zones likewise present certain evidence of disconformity. Thus both the Exsulans limestone or the base of the Tessini zone as well as the base of the Davidis zone is characterized by phosphate-bearing layers and as we have already seen, either a bed of barren alum shale or a thin layer of commingled fossils separate the Davidis and Forchhammeri zones. The abrupt change from Andrarum limestone to Alum shales is also consistent with the belief in a disconformity between the two higher zones.

As we shall see more fully, the physical evidence for disconformity between the zones is very strongly marked in the Comley section of Great Britain. That the possibility of sedimentary interruptions in these thin-bedded many-zoned formations has been recognized in the past, is shown by a statement of Fernside's in the discussion of the zonal development in, and physical characters of the Comley beds. Speaking of the latter he says "The erosion-partings, the minute unconformities between successive beds, the limestone pellets with associated phosphatic nodules and glauconitic grains, could all be matched exactly among the Cambrian rocks of northern Oeland and were there interpreted as distinctive of a period of recurrent alternating deposition and erosion in shallow water, of the sea bed."[1]

Fernsides, as appears from other statements of his as well, considered the erosion to be sub-marine, and while this might account for the physical character, it certainly could not account for the abrupt faunal changes. Andersson, in his study of the phosphate beds, also suggests interrupted deposition.

If then, our interpretation that these thin zonal divisions of the Middle Cambrian beds in the Caledonian geosyncline represent successive wedge-like overlaps of portions of the great depositional series, with pronounced unrepresented intervals between the successive wedges, is correct, we can understand why certain zones are unrepresented in some of the localities while other zones of restricted representation may occur there. Thus the standard of one region may not serve for another, where some of the intermediate zones are occupied by different faunas, for the intermediate zones in different sections are not necessarily equivalent.

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1 Discussion of Cobbold's paper on the Comley rocks, Quarterly Journal of the Geol. Soc. of London, Vol. LXVI, 1910, p. 51.

The Southern Swedish Section

Southern Sweden and especially Scania has always been regarded as one of the type regions of the Cambrian beds of Europe. because it is here that so much detailed work has been done. Moberg[1] has summarized this work and given a complete bibliography up to date of publication. The zones recognized are those known from Bornholm with the addition of the *Paradoxides oelandicus* zone, which is now known to be the lowest of the series, lying between the Tessini zone and the Lower Cambrian.

In Scania, especially in the Andrarum region, a very detailed subdivision or zoning has been undertaken. The following is the succession in descending order, according to Moberg.[2]

Middle Cambrian Section of Southern Sweden after Moberg

SUPERFORMATION. Upper Cambrian. *Agnostus pisiformis* beds.

Hiatus and Disconformity

MIDDLE CAMBRIAN or *Paradoxides* Beds		23-27.6 m.
Lævigatus zone	2-3 m.	
16. Zone of *Agnostus lævigatus*		
Forchhammeri Zone		
15. Andrarum limestone 14. Hyolithes limestone	0.6-1 m.	

1 J. C. Moberg. The Silurian of Sweden. Special Publication for the 11th International Geological Congress. Stockholm 1910.

2 J. C. Moberg, Guide to the principal Silurian Districts of Scania 11th International Geological Congress. Stockholm 1910. Guide Book 40. Reprinted from Geol. Fören. i Stockholm Förhandl. Bd. 32. Häft 1. Jan. 1910.

13. Subzone of *Agnostus lundgreni*		
Davidis Zone		
12. Zone of *Paradoxides davidis*		
Tessini Zone		
11. Subzone of *Conocoryphe æqualis*	15-17 m.	
10. Subzone of *Agnostus rex*		
9. Subzone of *Agnostus iutermedius*		
8. Subzone of *Microdiscus scanicus*		
7. Subzone of *Conocoryphe exsulans*	1.5-1.8 m.	
6. Subzone of *Agnostus atavus*	3.6 m.	
Oelandicus Zone		
5. Fragment limestone	0.3-0.6 m.	
4. Alum shales (Ritskiffer of Nathorst)	0.6 m.	
Hiatus and Disconformity		
LOWER CAMBRIAN or Holmia Beds		102 m.
Kjerufli Beds	1-2 m.	
3. Phosphatic limestone (thin)		
2. Graywacke shales (Gravakke skiffer)	1.5-1.8 m.	
Torreli beds	100 m. plus	
1. Basal sandstone.		

Unconformity.

Precambrian crystallines

OELANDICUS ZONE: The lowest zone with *Paradoxides oelandicus* was first recognized on the island of Oeland. The rock there is a light grayish-green, argillaceous shale or laminated clay, with scattered boulders of grayish-green limestone. More seldom it is somewhat sandy, resembling certain varieties of the Tessini sandstone.

In the Province of Scania on the mainland of South Sweden, the lowest subzone (4) which rests upon the phosphoritic zone (3) of the Lower Cambrian, consists of about ½ a meter of black shales, with only a few brachiopods of the genera *Lingulella*, *Obolella*, *Acrotreta* and *Acrothele* and possibly a *Hyolithes*. This is followed by subzone 5, the "Fragment limestone," so called from the fact that all the fossils, chiefly trilobites and brachiopods, are broken into indeterminable fragments. The limestone ranges from 0.3-0.6 meters in thickness and is tough, of light-gray colour, with iron pyrites, glauconite grains and phosphorite. All the trilobites are so comminuted, that even the genera cannot be determined, except a *Paradoxides* which may be *P. hicksi* Salter. Besides this the brachiopod genera, *Lingulella*, *Acrotreta*, and *Acrothele* were obtained. From its position beneath the Exsulans limestone, and above the Lower Cambrian, these beds have been referred to the *P. oelandicus* zone, though that species is not found.

The extreme fragmentation of the fossils is significant. As I have already pointed out, it is very unlikely that such fragmentation over wide areas can be produced by wave activity, but a thin layer of fossiliferous mud may, on long exposure to the atmosphere, have its organic remains thoroughly comminuted and the returning sea, by reworking such material, would separate out the limestone fragments by gravitative sorting, and collect them into a fragmental limestone bed. Thus the occurrence of such a stratum in itself suggests a disconformity and hiatus.

Further north in Sweden, the Oelandicus zone appears to be present in the Province of Västergötland where Holm found a shale believed to represent this horizon, near Kinnekulle on Lake Vennern and at Hvalsta, where a gray to greenish-gray clay and slaty sandstone devoid of fossils, underlies the beds of the Tessini zone. The zone is also believed to exist in the Province of Närke north of Lake Vettern, where Andersson found a blue-gray argillaceous shale with limestone containing *Paradoxides sjögreni* and *Acrothele granulata*. The strata are somewhat disturbed[1] and it may be that these beds should be classed with the base of the succeeding zone. Still farther northwest in Jämtland, an alum shale and stink-stone occurs at a number of localities and represents this horizon. Finally in Norrland (Lapland) in the parish of Stensele at Tallträsk and Kyrkberget, boulders of gray hard compact limestone have been found with a fauna indicating this horizon. This is the locality already referred to (*ante* p. 156, *182*) where *Holmia kjerulfi* was found, and which is regarded as representing the Lapland embayment from the Siberian Sea.

TESSINI ZONE. In Sweden, this zone is usually made to include the *Paradoxides davidis* zone, but in conformity with the usage elsewhere, I have separated it and include only Moberg's subzones 6-11. Since the Scanian succession

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1 J. G. Andersson. Ueber Cambrische und Silurische Phosphorit-führende Gesteine p. 37.

has been worked out in much detail, we shall consider that first. (*See Table I* p. 387, *583*)

Subzone 6. Immediately overlying the "Fragment Limestone" which as we have seen is best explained as a record of a period of exposure, and separated from it by a hiatus and disconformity, follow 3.6 meters of Alum shales rich in iron pyrites but poor in fossils. The latter include *Acrotreta sagittalis* and *Protospongia fenestrata.* A number of spheroidal blocks of "stink-stone" have been found about 2 meters above the fragment limestone (Subzone 5) at Forsemölla, and in loose fragments of these *Agnostus atavus* Tullb. and *Liostracus* sp. have been found. The first of these is made the subzone fossil, although Moberg has expressed some doubt regarding the desirability of distinguishing the zones on such evidence. (Col. 6. of table)

Subzone 7. This is the *Exsulans limestone,* the equivalent of which in Bornholm was found to rest directly upon the Lower Cambrian beds, while the Oelandicus zone is wanting there. Although this is not now shown in place in the rather unsatisfactorily exposed section of Scania, its stratigraphic position has been carefully determined along the line of the Verka River, where we were enabled to study these zones in 1910, under the guidance of the late Professor Moberg himself.

Besides the guide fossil *Conocoryphe* (*Ctenocephalus*) *exsulans* Linrs. these beds contain *Paradoxides tessini*, *P.*

palpebrosus Linrs. and a variety of *P. hicksi* Salter, besides a number of other species listed in Table I Col. 7. Unfortunately from the manner of outcrop, neither the character nor the full thickness of these beds could be obtained but the latter is almost 1.5 meters or a little more. The fossils occur in spheroids (concretions?) in a somewhat disturbed mass of shale.

Subzone 8. This is exposed a little further south on the bank of the stream, for a thickness of 1 ½ meters. The subzone consists primarily of shales, in which fossils are abundant. These are the original *tessini-hicksi* beds of Tullberg for both these species of *Paradoxides* occur here together with other trilobites listed in Col. 8 of the table. Lower down in this section, and perhaps a meter or so below the shales, occurs a band of "stink-stone" with *Agnostus fissus* and *A gibbus* which may be a part of this subzone or belong to the one next below, since these species are characteristic of both subzones.

Subzone 9. This is partly exposed some 750 meters S. E of the preceding but as in the other case the exact thickness cannot be ascertained. The zone fossil is *Agnostus intermedius* and with it occurs *Paradoxides tessini* and the other species listed in Col. 9 of the table.

Subzone 10. This is exposed half-way between the last 2 localities, but 100 meters or more southwest than the line connecting them. It consists of Alum shales with *Agnostus rex* Barrande and *Paradoxides tessini* and the other fossils listed in Col. 10 of the table.

As in the other cases, the precise thickness is not ascertainable.

Subzone 11. This and zone 12 are exposed on the Saw Mill Creek, a tributary of the Verka, some 300 and 150 meters respectively west of the junction with the Verka. The material is Alum shale and the zone fossil is *Conocoryphe aequalis*. *P. tessini* has not been specifically identified from this horizon, but the other fossils (Col. 11 of table) ally it more closely with the *P. tessini* zone, and it is regarded as forming the highest subzone of that division, although as before stated Moberg included the *P. davidis* zone (zone 12) because it is of the same lithological character as zone 11.

The Tessini zone, or at least, its basal portion, the Exsulans limestone is also known from other parts of Sweden. In southern Oeland it has a thickness of 11 cm, and rests directly upon the *Acrothele granulata* conglomerate. This is a remarkable bed, which forms the base of the Tessini zone in Oeland and is apparently the *Conglomeratum calcareum* mentioned in 1851 from this region by Angelin. It abounds in the brachiopods *Acrothele granulata* and contains also *Hyolithes socialis* and *Paradoxides tessini*.

This conglomerate, resting as it does on the *Paradoxides oelandicus* beds, is undoubtedly to be regarded as a basal bed of the transgressing sea, and this indicates a pronounced disconformity between the Oelandicus and Tessini zones. Since the shells of *A. granulata* occur between the boulders, it is probable that this represents a subaereal conglomerate subsequently covered by the sea, the brachiopods living in the protected interstices between the boulders.

Unlike its development in the Andrarum region, where the middle portion of the Tessini zone is mainly an alum-shale, its character on the Island of Oeland is generally a slabby, often calcareous sandstone in which sometime layers with cone-in-cone structure are developed. Sometimes the sandstone alternates with greenish-blue clay resembling that of the underlying Oelandicus zone. Sometimes ellipsoids of a greenish-gray limestone are found in the calcareous sandstone. At Borgholm and several other localities, boulders or concretionary layers of green "stink-stone" occur in the highest part of the zone.

At Borgholm city the thickness of the Tessini zone reaches 25 to 30 meters but in the northernmost part of Oeland it appears to be missing. In some sections boulders of green "stink-stone" with layers of sandstone, bearing *Ellipsocephalus muticus* Ang. occur, and these indicate the former wider extension of the zone. On the northwest promontory of Oeland, J. G. Andersson[1] found evidence that the Upper Cambrian (i. e. Cambrovician) *Obolus apollinis* beds were deposited directly upon Oelandicus strata, the Tessini zone being absent, (probably through post-mid-Cambrian erosion). At Horn on Oeland the *Obolus* conglomerate which underlies the *Dictyonema* shales, rests directly upon the beds of the Tessini zone. In the cement of the conglomerate are found, besides *Obolus apollinis* Eichwald, a mixed assortment of *Paradoxides tessini*, *Olenus gibbosus* Wahl. and *Agnosti*.

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1 J. G. Andersson Ueber Cambrische und Silurische Phosphorit-führende Gesteine. 1896, p. 37.

In Västergötland the Tessini zone is found at various localities, though at the Kinnekulle it is only a few centimeters thick. Both *P. oelandicus* and *P. tessini* have been recorded from Oestergötland and the Tessini zone is reported from Närke, W. Dalarne and Jämtland provinces. In Närke a blue-green lamellated clay shale carries embedded limestone layers with *Par. tessini*. A dark bituminous limestone conglomerate covers it and fills cracks in its upper part. This limestone conglomerate contains *Agnostus pisiformis* and *Acrothele coriacea*, the former an Upper Cambrian, the latter an Andrarum limestone (*P. forchhammeri* zone) species. This again illustrates the Middle-Upper Cambrian disconformity. In Jämtland the zone is poorly represented by alum shale and foetid limestone. In Lapland too this zone is believed to occur, being represented by boulders in Stensele and Wilhelmina parishes. These probably belong to the Lapland embayment.

DAVIDIS ZONE. (*Subzone 12.*) This zone appears not to differ lithologically from the anthraconite-bearing alum shale, which lies between the Exsulans and Andrarum limestones, and includes zones 8-13. It however, marks the first appearance in this region of *Paradoxides davidis*, which is abundant. *Paradoxides tessini* still lingers, but is very rare and *Paradoxides brachyrhachis* is also rare. The remainder of the fauna so far as recorded is made up of 7 species of *Agnostus*. Among them is *A. punctuosus* Ang. (See *Table I* col. 12)

This zone has positively been identified in Sweden only at Andrarum, but it may also occur at Kiviks Esperöd, and perhaps at Baskemölla, and a few other localities. In none of them however has *Paradoxides davidis* itself been found, but *Agnostus punctuosus*, which is one of the associated fossils at Andrarum, occurs in these localities mostly in loose blocks, and has been regarded as a secondary guide fossil.

If it is true that the Davidis zone is generally wanting, except in Andrarum and in Bornholm, while the next succeeding Forchhammeri zone is widespread, we have here further evidence of the discontinuity of sedimentation and the existence of a more or less pronounced hiatus between the zones.

Subzone 13. This is the highest division of the Alum shales but it contains no *Paradoxides davidis*, and the only fossil found in it, *Agnostus lundgreni* Tullberg, associates it rather with the overlying *P. forchhammeri* zone. The entire thickness of this shale series (subzones 8-13 inclusive) is 15-17 meters.

FORCHHAMMERI ZONE. THE ANDRARUM LIMESTONE This limestone is a well-marked lithologic unit, which has long been known as the most important representative of the *Paradoxides* beds of Sweden, although its position near the summit of that series was recognized much later. At Andrarum its thickness varies from 0.6 to 1 meter, and Moberg has separated it into 2 subzones, a lower *Hyolithes* limestone, followed by the main Andrarum limestone with trilobites.

Subzone 14. The Hyolithes limestone. This limestone formerly classed as a part of the Andrarum, is according to Moberg a thin band, which lies 0.3 meters below the Andrarum limestone proper and is seen to rest directly on the shales of subzone 13. It is rich in *Hyolithes*, both species and individuals, and Moberg says that it is possible that *H. obscurus* Holm, recorded from the Andrarum limestone, may actually belong in this bed, though he does not deny the possibility that some of the species may continue upward. Moreover he notes that a number of the typical Andrarum brachiopods and Agnosti already appear in the *Hyolithes* limestone. The shales in which this limestone is embedded are rich in *Protospongia fenestrata*. (See column 14 of table)

Subzone 15. The Andrarum limestone. (Sens. strict.)

This is characterized by *Paradoxides forchhammeri* and *Centropleura loveni*, besides a large number of other trilobites, including some 14 species of *Agnostus*. Brachiopods are likewise characteristic of this rock. (See col. 15 of table)

This zone is rather widespread in Sweden though it is not always developed as limestone. The latter is chiefly developed in Scania, where at the type locality in Andrarum, its thickness ranges up to 1 meter. At Kiviks Esperöd it is only 0.6 meters thick. At Læsaa in the Island of Bornholm as we have seen, it is 0.85 meters thick, but at Ole Aa in that island it is only 0.65 meters. Besides a number of other localities where it occurs in Scania, it is occasionally represented in other provinces. Thus in Västergötland, a slight development occurs near the Kinnekulle, where it is included in the 6.4 meters which separate the Upper Cambrian from the Lower Cambrian *Lingula* sandstone, though the exposures are very poor. In Oestergötland there is a dark limestone with *Paradoxides forch-*

hammeri underlying the *Agnostus laevigatus* zone, while elsewhere in that province foetid limestone in alum shale contains *P. forchhammeri* and represents this zone. In Närke, *P. forchhammeri* has been obtained from alum shale.

There is however another very significant facies of this horizon in Sweden and that is the so-called Exporrecta conglomerate, a conglomerate-like limestone, crowded with *Billingsella exporrecta* (Linrs.) This occurs in Oeland, where however it is sporadic and it is also found in Västergötland in Närke and in Jämtland Province, and has even been recorded from the parish of Stensele in Lapland. It is possible that this limestone conglomerate, like the *Acrothele granulata* conglomerate at the base of the Tessini zone, records an interval of exposure either preceding or succeeding the invasion of the sea with *P. forchhammeri*.

THE AGNOSTUS LÆVIGATUS ZONE. This is made the highest division of the Middle Cambrian, being followed directly by the basal Upper Cambrian beds, with *Agnostus pisiformis*, which by overlap may rest on various horizons. These *A. lævigatus* beds are not very well developed in Scania, where shales with the zone fossil overlie the Andrarum limestone, which however also contains that species of *Agnostus*. In Bornholm, as we have seen, some 2 meters of anthraconite-bearing alum shale with this fossil overlie the Andrarum limestone and represent this zone. The zone is typically developed in Västergötland, where besides the zone fossil *A. lævigatus*, it is characterized by *Liostracus costatus* and the ostracod, *Leperditia primordialis*. In this region it reaches a thickness of from 3 to 4 meters, and has been divided into 3 subzones, an upper with *Agnostus exsculptus* (Exsculptus beds) a middle with *Leperditia primordialis* and a lower without *Leperditia*.

This zone is widespread in Västergötland and also occurs in Oestergötland. Even in Lapland some boulders have been found, which are believed to represent this horizon, and strata with *Agnostus lævigatus* have been reported from the Province of Västerbotten in the far north-east.

THE FAUNA. In table I, the Middle Cambrian fauna of Scania is listed so far as I have been able to obtain the record. While it may not be complete, it represents at least the distribution of the most characteristic and typical species. As such it again shows the remarkable dissimilarity of the zones. It will be remembered that the Oelandicus zone is virtually absent, though it is believed to be represented by the fragment limestone and the underlying Ritskiffer. These beds have only furnished specifically unidentified brachiopods and Hyolithids. The over-lying alum shale (subzone 6) has furnished *Agnostus atavus* and *Acrotreta sagittalis*, the first restricted to it, the second occurring in the Tessini as well as the Forchhammeri zones. All of these beds are absent in the Bornholm sections, where the Exsulans limestone lies directly upon the Lower Cambrian, thus emphasizing the basal disconformity and hiatus in this section. It will be remembered moreover, that in other sections, the *Protolenus* or Hanfordian beds, and in one case at least, the Dugaldian Series underlie the *Paradoxides* Beds and separate them from the Lower Cambrian. With the Exsulans limestone, the Tessini zone shows a typical development in Scania. In Oeland, it will be remembered it begins with the remarkable *Acrothele granulata* conglomerate, which marks the hiatus between the Oelandicus and Tessini zones. *A.* (*Redlichella*) *granulata* is not known from Scania or Bornholm, but is a characteristic species of the limestone of the *P. oelandicus* zone at Borgholm on the island of Oeland. Its occurrence in the basal conglomerate of the Tessini zone therefore clearly indicates the distinctness of those two periods of deposition. As it has also been reported from Jämtland, it indicates an original wide distribution of the Oelandicus zone.

The Tessini zone is essentially a unit and the localized distribution of the species with the various subzones and their abundance in the Exsulans limestone, is probably an effect of the facies. As we have seen the shale immediately above the Exsulans limestone in Bornholm, still carries the Tessini fauna but its maximum thickness is only 1.4 meters, followed by 0.2 meters of calcareous beds with the Davidis fauna. On the other hand, the Exsulans limestone at Andrarum is succeeded by 16 to 17 meters of shale, the greater part of which still carries the Tessini fauna, the Davidis fauna coming in only in the upper part. Moreover, the Exsulans limestone of Andrarum is more than 6 times the thickness of that limestone in Bornholm. In Kiviks-Esperöd Scania, the shale between the Exsulans and Andrarum limestone has been reduced to 13 meters, the limestone itself being even thinner than on Bornholm. This extensive cutting out of Tessini shales and the reduction of the limestone in Bornholm, suggests a disconformity, and this as we have seen is clearly indicated by the faunas of the two zones in Bornholm. At Andrarum, the distinction is also shown, though not so pronouncedly. Of the 8 species recorded from the Davidis zone, 2 have come up from the underlying Tessini zone. One of these is *Agnostus nudus scanicus* Tullberg and the other is *Paradoxides tessini*. The latter however, is very rare. When it is remembered however, that the shale of the Davidis zone at Andrarum is of the same type as that of the Tessini zone, and that no marked lithic boundary is seen, we should expect, if there was a hiatus between the two, that the weathered Tessini shales, were reworked by the advancing Davidis sea and that hence, some of the remains of the underlying zone are secondarily enclosed in the new horizon. This I say, is a possibility although I certainly do not intend to stress this explanation.

The Forchhammeri zone of Scania is again distinctive. Of the 38 specifically identified species recorded from the Andrarum limestone, 4 have also been recorded from lower horizons. These are *Agnostus fallax ferox* which is also found in the Davidis zone, *Erynnia breviceps*, which is also found in the upper subzone of the Tessini beds, *Arcotreta sagittalis* which is characteristic of the lower Tessini zones and the ubiquitous *Protospongia fenestrata*. The latter may be disregarded for its spicules are spread widely wherever the clays of older series are incorporated in younger beds. The *Acrotreta sagittalis* may or may not be identical in the two horizons, or it may be a form which, as in Bornholm, ranges throughout the series, recurring in nearly all the zones.

Agnostus fallax ferox is recorded from the Davidis and Forchhammeri horizons of Sweden, though the species is characteristic of the Tessini horizon in Scania and Bornholm.

With the exception then of these few wide-ranging forms, the faunas are distinct and clearly represent independent invasions from the center of distribution and evolution.

The Southern Norway Region.

In the vicinity of Christiania or Oslo, a group of early Palæozoic strata is faulted down in the form of a graben between two masses of crystalline pre-Cambrian rocks. This

Table I

Paradoxides Beds of Scania

	Bornholm			Scania Sweden												
	Tessini Zone	Davidis Zone	Forchhammeri Zone	Oelandieus Zone		Tessini Zone						Davidis Zone	Forchhammeri Zone			Laevigatus Zone
Subzones	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Spongidæ																
1 Protospongia fenestrata Salt.	—	—	—	—	—	×	—	—	×	—	×	—	—	×	×	
Brachipoda																
1 Billingsella exporrecta Linnrs	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
2 Lingulella sp.	—	—	—	×	×	×	×	—	—	—	—	—	—	—	×	
3 Acrotreta sagittalis (Salter)	×	×	×	—	—	×	×	—	—	—	—	—	—	—	×	
4 Acrotreta socialis v. Seebach	×	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
*5 Acrothele coriacea Linnrs.	×	—	×													
†6 Acrothele granulata	—	—	—	×												
*7 Acrothele intermedia Linnrs.	×															
8 Iphidella ornatella Linnrs.	×	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
9 Mickwitzia pusilla (Linrs.)	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
10 Acrotreta sp.	—	—	—	×	×											
11 Acrothele sp.	—	—	—	?	×											
12 Obolella sp.	—	—	—	×												

Table I (*Continued*) Subzones	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gastropoda etc.																
1 Metoptoma barrandii Linnrs.	×	—	—	—	—	—	×									
2 Hyolithes obscurus Holm	—	×	—	—	—	—	—	—	—	—	—	—	—	?	×	
3 Hyolithes excavatus Holm	—	—	—	—	—	—	—	—	—	—	—	—	—	×		
4 Hyolithes tenuistriatus Linnrs.	—	—	×	—	—	—	—	—	—	—	—	—	—	×		
5 Hyolithes socialis Linnrs	×	×	—	—	—	—	×									
6 Hyolithes sp.	—	—	—	×												
7 Orthotheca affinis Holm	—	×	—	—		—	—	—	—	—	—	—	—	×		
8 Orthotheca lineatus Holm	—	×	—	—	—	—	—	—	—	—	—	—	—	×		
Trilobita																
1 Acrocephalus stenometopus (Ang.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
2 Agnostus atavus Tullb.	—	—	—	—	—	×										
3 Agnostus aculeatus Ang.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
4 Agnostus bituberculatus Ang.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
5 Agnostus brevifrons Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
6 Agnostus exsculptus Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
7 Agnostus fallax Ang.	×	—	—	—	—	—	×	×	×	×	×					
8 Agnostus fallax ferox Tbg.	×	×	×	—	—	—	—	—	—	—	—	×	—	—	×	
9 Agnostus fissus Lundgr.	—	—	—	—	—	—	×	×								
10 Agnostus gibbus Lundgr.	—	—	—	—	—	—	×	×								
11 Agnostus glandiformis Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
12 Agnostus kjerulfi Brögger	—	×	—	—	—	—	—	—	—	—	—	—	—	—	×	
13 Agnostus laevigatus Dalm.	—	×	×	—	—	—	—	—	—	—	—	—	—	—	×	×
14 Agnostus lundgreni Tullb.	—	×	—	—	—	—	—	—	—	—	—	—	×	—	×	
15 Agnostus nathorsti Brögger	—	×	—	—	—	—	—	—	—	—	—	—	—	—	×	
*16 Agnostus nudus Beyr.	?															

Table I (*Continued*) Subzones	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Trilobita (cont.)																
17 Agnostus nudus marginatus Brögg.	—	×	×	—	—	—	—	—	—	—	—	—	—	—	×	
18 Agnostus parvifrons Linnrs.	×	—	—	—	—	—	—	×	×	×	×					
*19 Agnostus parvifrons mammillatus Brögg.	×															
*20 Agnostus parvifrons nepos Brögg.	—	×														
21 Agnostus parvifrons Linrs var.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
22 Agnostus planicaudus Ang.	—	×	—	—	—	—	—	—	—	—	—	—	—	—	×	
23 Agnostus quadratus Tullb.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
24 Agnostus elegans Tullb.	—	×	—	—	—	—	—	—	—	—	—	×				
25 Agnostus incertus Brögger.	—	×	—	—	—	—	—	—	—	—	—	×				
26 Agnostus nudus scanicus Tullb.	×	—	—	—	—	—	—	—	×	×	×	×				
27 Agnostus punctuosus Ang.	×	×	—	—	—	—	—	—	—	—	—	×				
28 Agnostus pusillus Tullb.	—	—	—	—	—	—	—	—	—	—	—	×				
29 Agnostus barlowi (Belt)	—	—	—	—	—	—	—	—	×	—	×					
30 Agnostus rex Barr. (*A cicer* Tbg)	—	×	—	—	—	—	—	—	—	×						
31 Agnostus intermedius Tullb.	×	—	—	—	—	—	—	—	×							
32 Anomocare excavatum Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
33 Anomocare laeve Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
34 Anomocare limbatum Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
35 Aneuracanthus acutangulus Ang.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
36 Agraulos difformis Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
37 Agraulos difformis acuminatus Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
38 Agraulos difformis aculeatus Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
39 Conocoryphe (Ctenocephalus) laticeps Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
40 Conocoryphe aequalis Linnrs.	×	—	—	—	—	—	—	—	—	—	×					
41 Conocoryphe dalmani Ang.	×	—	—	—	—	—	×	×								

Table I (Continued) Subzones	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Trilobita (cont.)																
42 Conocoryphe (Ctenocephalus) exsulans Ang.	×	—	—	—	—	—	×									
43 Conocoryphe (Liocephalus) impressa Linrs.	×	—	—	—	—	—	×									
44 Conocoryphe tenuicincta Lnrs.	×	—	—	—	—	—	×									
45 Conocoryphe glabrata Ang.	—	—	×													
46 Centropleura lovéni Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
47 Corynexochus spinulosus Ang.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
48 Dolichometopus suecicus (Ang.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
49 Ellipsocephalus muticus Ang.	—	—	—	—	—	—	×									
50 Erynnia breviceps (Ang.)	—	—	×	—	—	—	—	—	—	—	×	—	—	—	×	
51 Liostracus linnarssoni Brögger.	×	—	—	—	—	—	—	×	×	×	×					
52 Liostracus aculeatus Ang.	—	—	—	—	—	—	×									
53 Liostracus micropthalmus Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
‡54 Liostracus costatus Ang.	—	—	—	—	—	—	—	—		—	—	—	—	—	—	×
55 Microdiscus eucentrus Linnrs.	×	×	—	—	—	—	—	—	—	—	×					
56 Microdiscus scanicus Linnrs.	×	—	—	—	—	—	—	×								
57 Paradoxides forchhammeri Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
58 Paradoxides davidis Salter	—	×	—	—	—	—	—	—	—	—	—	×				

Table I (*Concluded*) Subzones	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Trilobita (cont.)																
59 Paradoxides tessini Brongn.	×	×	—	—	—	—	×	×	×	×	?	×				
60 Paradoxides brachirhachis Lnrs.	—	—	—	—	—	—	—	—	—	—	—	×				
61 Paradoxides hicksi Salter	×	—	—	—	cf	—	—	×								
62 Paradoxides hicksi Salt. var.	—	—	—	—	—	—	×									
63 Paradoxides palpebrosus. Lnrs.	—	—	—	—	—	—	×									
64 Solenopleura brachymetopa Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
65 Solenopleura canaliculata Ang.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
66 Solenopleura parva Linnrs.	×	—	—	—	—	—	×									
67 Solenopleura brachymetopa alutacea Grönwall	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
68 Solenopleura holometopoa Ang.	—	—	×													

* Cited from Scania. Exact horizon not known

† From Oelandicus Zone of Oeland (basal Tessini Conglomerate.)

‡ From Westergötland only.

"Oslo Graben" as it is called, contains the entire basal portion of the Palæozoic, so far as that was deposited. As we have already seen (*ante* page 95 (*121*)) the Lower Cambrian ends with the *Strenuella linnarssoni* limestones and this is followed disconformably by basal conglomerates, which locally overlap, and characterize the transgressing sea. The *Paradoxides oelandicus* zone is wanting, the first fossiliferous bed representing the Tessini zone.[1]

The leading fossils of the Tessini zone are:

1. *Acrothele granulata*
2. *Acrotreta sagittalis* (Salt.) also in Forchhammeri zone
3. *Hyolithes tenuistriatus* Linrs.
4. *Agnostus gibbus* Linrs.
5. *Agnostus hybridus*
6. *Agnostus fallax* Ang.
7. *Liostracus linnarssoni* Brögg.
8. *Conocoryphe sulzeri* Barr.
9. *Conocephalites ornatus* Brögg.
10. *Paradoxides rugulosus* Corda
11. *Paradoxides tessini* Brongn.

Of these No. 1, it will be remembered, is characteristic of the Oelandicus zone and the basal conglomerate of the Tessini zone in Oeland. Its mode of occurrence in Norway has, so far as I know, not been recorded. No. 2 is a widespread brachiopod found in most of the higher zones as well. No. 3 has been recorded from Bornholm only in the Andrarum limestone, and from Scania in the shales of zone 14, just below that limestone, but in the Forchhammeri zone, and its oscurrence in the Tessini zone of

1 Broegger W. C. Die Silurischen Etagen 1, 2 und 3 im Kristianiagebiet. Universitätsprogramm, Kristiania, 1882

the Oslo region is unique. *Agnostus gibbus* occurs in the Tessini zone of Andrarum and *A. hybridus* (5) in that of Bornholm. *A. fallax*, as we have seen, is wide ranging, occurring in the Tessini zone of Bornholm and the Davidis and Forchhammeri zones of Scania. *Liostracus linnarssoni* (7) is characteristic of the Tessini zone of Scania and Bornholm, but *Conocoryphe sulzeri* (8) a Bohemian form is doubtfully recorded from the Davidis zone of Bornholm. *Conocephalus ornatus* has not been recorded from either Scania or Bornholm. *Paradoxides rugulosus*, on the other hand, occurs in the Davidis zone, of Bornholm as well as in Bohemia.

Except for the last mentioned species, and the doubtfully recorded *Conocoryphe sulzeri*, there is no indication of the existence of the Davidis zone in the Oslo region, but the upper half of the Middle Cambrian (1d) represents the zone of *Paradoxides forchhammeri*.

The species recorded from this zone are:

1. *Billingsella exporrecta* Linrs. also found in the Andrarum limestone of Scania
2. *Acrotreta socialis* v. Seeb. also found in the Andrarum of Scania and Bornholm
3. *Acrotreta sagittalis* (Salt.) wide ranging
4. *Hyolithes plicatus*
5. *Agnostus sulcatus* Illing
6. *Agnostus kjerulfi* Brögg. recorded from the Davidis zone of Bornholm and the Andrarum (Forchhammeri zone) of Scania
7. *Agnostus brevifrons* Ang. Andrarum limestone of both Scania and Bornholm.
8. *Anomocare excavatum* Ang. also characteristic of the Andrarum limestone of Scania and Bornholm.

9. *Liostracus microphthalmus* Ang. (range as above)
10. *Solenopleura brachymetopa* Ang. (range as above)
11. *Ellipsocephalus circulus* Brögger
12. *Paradoxides forchhammeri* Ang. a wide-spread zone fossil of this horizon.

Apparently the Laevigatus zone is absent, for the Forchhammeri zone is succeeded by (2d) the Upper Cambrian zone of *Agnostus pisiformis* and *Olenus truncatus*. The total thickness of the Middle and Upper Cambrian in this region is placed at 75 meters[1] but what part of this represents Middle Cambrian, I have not been able to ascertain.

It thus appears that the Oslo region is merely the western extension of the Scania-Bornholm district, but so far as the evidence available goes, the Davidis zone and the Laevigatus zone are both wanting.

The British Sections

The sections in the western part of Great Britain, especially in Wales, lie within the Caledonian geosyncline, and hence represent extensive accumulations of clastic material. In the Midland country on the other hand (Shropshire, Warwick, etc) we meet only with the overlapping wedges on the marginal plain. Consequently the beds there are much thinner and more incomplete, so far as the deposition is concerned.

North Wales Section. This is the classical region, which furnished Sedgwick with his facts for the establishment of his Cambrian system. The Lower Cambrian, as today understood, is chiefly a continental series, with the thickness ranging up to 4000 ft. A few fossils have been

1 Bubnoff, Loc. cit. p. 12.

found in the upper part (*ante* p. 86. *112*). The Middle Cambrian on the other hand, is much more pronouncedly marine or with marine members in its upper portion. These have recently been studied in detail on St. Tudwal's Peninsula, which is the southeastern extremity of the Lleyn Peninsula that remarkable extension of Carnarvonshire, which separates Cardigan Bay from Carnarvon Bay. The outcrops are mostly along the shore, in the bay of Hell's Mouth on the west, and Cardigan Bay on the east (approximately Longitude 4°30′ W., Latitude 52°50′N.) The beds are moderately folded and faulted[1]. The succession here in descending order is as follows.

LOWER ORDOVICIAN Arenig (Extensus zone)	
Llanengan mudstone, with *Azygograptus*	250 ft. +
Tudwal sandstones and grits, with *extensiform Didymograpti*	300-400 ft.
Hiatus and disconformity	
Elsewhere in this region this interval is occupied by the Tremadoc flags and mudstones, 250 ft. or more in thickness and carrying *Dictyonema*, and by the Dolgelly beds.	
UPPER CAMBRIAN LINGULA FLAGS.	
Ffestiniog Beds with *Lingulella davisi*, gray sandy shales & grits, exposed	350 ft.

1 Nicholas, Tressilian Charles. The geology of the St. Tudwal's Peninsula, Carnarvonshire. Quarterly Journal of the Geol. Soc. of London, Vol. LXXI, 1915, pp. 83-141, Geol. Map and plates. Also Notes on the Trilobite fauna of the Middle Cambrian of the St. Tudwal's Peninsula, *ibid*, pp. 451-472, pl. XXXIX.

	Maentwrog Beds. Blue & gray shales & grits with *Olenus* and *Agnostus pisiformis*, var *obesus* at the base	?
	Hiatus and Disconformity	
MIDDLE CAMBRIAN		
5.	Nant-pig mud-stones Blue-black banded pyritous mud-stones Menevian fauna	? 220 ft.
4.	Caered mud-stones and flags, Blue and green mud-stones and green flags, with *Paradoxides hicksi*.	500 ft. +
3.	Cilan Grits. Coarse massive bluish grits, with some interbedded green and red mud-stones	1000 ft.
2.	Mulfran or Manganese beds Blue mud-stones, containing manganese and interbedded grits	450 ft.
1.	Hell's mouth grits, exposed part: Alternations of blue and green mud-stones with massive grits. Base of section not seen,	700 ft.

Divisions 1 to 4 are correlated with the Harlech grits of Merionethshire, the county just south of Carnarvonshire in North Wales, where the rocks are exposed along the east shore of Cardigan Bay from Harlech southward, and in the mountains of that region. A section from Cader Idris (2898 ft.) in Merionethshire on the south, to Mount Snowdon (3690 ft.) in. Carnarvonshire in the north, approximately along the meridian of 4^0 longitude, shows on the whole a regular anticline between two synclines. The anticline is strongly eroded and forms the Harlech Dome of North Merionethshire, in which the succession is exposed in a series of rimming bands, which however, are broken on the coast. Both north and south they pass under the Ordovician beds, which form these two high mountains.

North of the Mount Snowdon syncline these beds appear again on the surface and here, in the center of another anticline, the pre-Cambrian crystallines are exposed, and so the base of the series is shown. But the formations here have become thinner and the lower beds have changed from grits to shales. They rest with a basal conglomerate upon the pre-Cambrian rocks, and this is followed by a series of greenish and purple, and occasionally green slates, called the *Llanberis slates*. At the top of the series in the green slates the trilobite *Conocoryphe viola* has been found, this representing the oldest fossil of the North Wales series. This fossil indicates Middle Cambrian, and thus it would appear that Lower Cambrian beds, if represented in this region, are entirely unfossiliferous. In the typical Harlech grit only so-called worm tracks have been found.

In the St. Tudwal's section, no fossils whatever are known from the Hell's-Mouth grits nor from the Cilan grits. They likewise have not been found in the intervening Mulfran mudstones, but the fact that these contain manganese beds has led to the hope that eventually fossils will be found. Similar manganese beds form a well-marked horizon in the Harlech Dome.

The Cilan grits appear to be purely continental, containing pebble beds derived from various crystalline rocks.

The Caered mud-stones on the other hand contain a number of fossil zones, especially in their upper portions.

The fossils here found are given in Cols 9-11 of Table J. These all belong to the *Paradoxides hicksi* zone, as does also the greater portion of the succeeding 220 ft. of the Nant-pig mud-stones (see Cols 12-14, Table J). Only the highest portion of these, occupying about 30 ft. of the strata is regarded as representing the Davidis zone, although *Paradoxides davidis* itself has not been found. It is rather because of the occurrence here of *Agnostus kjerulfi* which is a wide-spread fossil of the lower part of this zone, that these upper beds are referred to the Davidis zone. (col. 15)

One fact however, stands out conspicuously, namely the entire absence of the *Paradoxides forchhammeri* zone, which, as we have seen, is one of the richest fossiliferous zones in the Middle Cambrian of the Baltic region. What is more significant is that throughout all the British sections this zone is absent, nor is there any positive evidence of its occurrence in the east American section. Wherever the succession has been fully studied, the *Agnostus pisiformis* beds of the Upper Cambrian rest directly upon the *P. davidis* zone, and even this zone may scarcely be represented as in the St. Tudwal's section. As we shall see presently, there is evidence of a physical break in many sections, but this seems to be less marked in North Wales. Nicholas indeed said, that in the Harlech Dome, where he has found only one place near Dolgelly where the contact is clearly shown, he was unable to recognize any indications of a physical disconformity (*Loc. cit.* p. 104)

There can be no question however, that the disconformity does exist, and that it represents the break everywhere seen between the Middle and Upper Cambrian. It is not impossible that beds representing the Forchhammeri zone were deposited in the British region and subsequently removed by erosion, although it is also possible that they may never have been deposited.

Whether the Menevian beds of North Wales represent continual deposition throughout the Tessini period, or whether they were interrupted by minor retreats of the sea, does not appear to be indicated, since the fauna seems to be more or less continuous throughout except, in the uppermost bed (Col. 15) in which the trilobites at least are distinctive, though it is tied to the lower horizons by the presence of the brachiopod *Acrotreta sagittalis*, which is equally characteristic of the upper Nant-pig beds.

SOUTH WALES. A far more complete section of these rocks is found in South Wales, on the promontory of St. Davids. Here Harkness and Hicks in 1871, first separated the Menevian from the old "Longmyndian" Rocks,[1] which name was previously applied to the beds below the *Lingula* flags. Subsequently, this name was restricted to the pre-Cambrian somewhat altered rocks of that region and the upper part of the sands and shaly rocks, referred to in 1871 as Longmyndian, was separated as the Solva group or series.

In the typical section given by Harkness and Hicks,[2] the lower members of their original Longmyndian B and C, are unfossiliferous, but rest unconformably on the pre-Cambrian, more or less metamorphosed arkoses or volcanics (Division A). The lowest of the Cambrian beds (Division B) is a conglomerate 60 ft. in thickness and this is fol-

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1 The true Longmyndian are pre-Cambrian, or possibly early Cambrian, developed in Shropshire.

2 Harkness R. and Hicks, H. C. On the ancient rocks of the St. David's Promontory South Wales, and their fossil content. Quart. Journ. Geol. Soc. London Vol. 27 (1871) pp. 384-404.

lowed by (division C) 400 ft. of green flags, also without fossils. These may perhaps represent the Lower Cambrian Cærfai series. The succession as given by Harkness and Hicks is as follows in descending order:

Superformation Lingula flags.

Hiatus and Disconformity

Middle Cambrian.

Menevian		950 ft.
Division K.[1] sandstones and shales (Table J, col. 8)	100 ft.	
Division J. Black flags with *Paradoxides davidis*, *Centropleura* (*Anapolenus*) *salteri* and *C.* (*A.*) *henrici*, besides many other species (Table J, col. 7)	350 ft.	
Division I. Gray flags with *Paradoxides hicksi* and other fossils (Table J, col. 6)	300 ft.	
Solva group		
Division H. Gray flaggy beds with *Paradoxides aurora* (Table J, col. 5)	150 ft.	
Division G. Gray, purple and red flaggy sandstones, with *Paradoxides harknessi* and other fossils (Table J, col. 4).	1500 ft.	

1 These letters are here used instead of the numbers employed by Harckness and Hicks.

Division F. Yellowish-gray sandstones shales and flags, with *Paradoxides harknessi*. (Table J, col. 3)	150 ft.
Lower Cambrian. Cærfai Series.	
Division E. Purple sometimes greenish sandstones, no fossils recorded.	1000 ft.
Division D. Red flaggy or shaly beds with *Leperditia cambrensis*, *Lingulella* cf. *ferruginea* and *Lingulella primæva* Hicks (Table J, col. 2)	50 ft.

These are the oldest fossils found in this section.

Division C. Green flaggy sandstone	460 ft.
Division B. Conglomerates, composed chiefly of well-rounded masses of quartz embedded in the purple matrix	60 ft.

Hiatus and Unconformity

Division A. Pre-Cambrian crystalline rocks.

(In Col: 1. Table J. are recorded the species from South Wales whose exact horizon is not given).

The relationship of the Middle Cambrian to the Lower Cambrian in this section is obscure. The lowest beds with *Paradoxides harknessi* rest with apparent concordance upon the purple sandstone, but if there is a disconformity, it is probably masked, since in rocks of this type disconformities are not easily determinable. In any case, it may be said that the Middle Cambrian transgression began with the *Paradoxides harknessi* beds.

The disconformity between the Menevian and overlying *Lingula* flags of Upper Cambrian age is more evident, since the zone of *Paradoxides forchhammeri* is wholly wanting, although the typical *P. davidis* beds are succeeded by 100 ft. of sandstone, which however contain no species indicative of the higher horizon.

When we now compare the fossils of the several divisions of the Menevian and Solva of South Wales, we find that only some of the apparently wide-ranging brachiopods like *Lingulella ferruginea*, *Orbiculoidea pileolatus* and *Acrotreta sagittalis* are common to both divisions, although the possibility that these may be shown by closer specific discrimination to be distinct must not be overlooked. The only other form which passes across, is the ubiquitous *Protospongia fenestrata* Salter. But the trilobites and other crustaceans are entirely distinct in the two series. Moreover, there is a certain amount of distinctness between the *Paradoxides aurora* and *Paradoxides harknessi* beds, only one trilobite *Agnostus cambrensis* being common to both. In North Wales only the *P. hicksi* beds are known, the beds correlated with the lower horizon being unfossiliferous. The thickness of these North Wales beds is much greater, the *P. hicksi* beds being about twice as thick as they are in South Wales, though the Davidis beds of the north are only one tenth as much. On the other hand, in the Nuneaton district of Central England *Paradoxides aurora* and *P. hicksi* appear at the same time, though the latter continues after the former has disappeared.

Table J. Paradoxides Beds of St. Davids South Wales and St. Tudwals North Wales. (Hicks and Nicholas)	St. Davids South Wales								St. Tudwals North Wales							Nuneaton Dist.	Comley Dist.	Scania
	General	Caerfai	Solva			Mene-vian			Caered Forma-tion			Nantpig Forma-tion						
		D	F	G	H	I	J	K										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Spongidæ																		
1 Protospongia major Hicks	—	—	×															
2 Protospongia fenestrata Salter	—	—	×	—	—	×	×	×	—	—	—	—	×					
3 Protospongia diffusa Salter	—	—	—	—	—	×	×											
4 Protospongia flabellata Hicks	—	—	—	—	—	—	×	×										
Cystoidea																		
1 Protocystites menevensis Hicks	—	—	—	—	—	×	×											
Brachiopoda																		
1 Acrotreta sagittalis Salter	—	—	—	—	×	×	×	×	—	—	—	—	×	×	×			
2 Acrothele maculata Hicks	—	—	—	—	—	—	×	×	—	—	×							
3 Billingsella hicksi (Salter)	—	—	—	—	—	—	·	×										
4 Lingulella ferruginea Salter	—	×	×	×	×	×	×	×	cf	×	—	?	×					
5 Lingulella primæva Hicks	—	×																
6 Lingulella sp.	—	—	—	—	—	—	—	—	×	×	—	—	—	×	×			
7 Orbiculoidea pileolus (Hicks)	—	?	—	×	×	×	×	×										
Hyolithidæ																		
1 Hyolithes (Theca) antiqua Hicks	—	—	×	×														
2 Hyolithes (Theca) corrugata Salter	—	—	—	—	—	—	×	×										

Table J. (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hyolithidæ (cont.)																		
3 Hyolithes (Theca) penultimus Hicks	—	—	—	—	×	×												
4 Hyolithes (Theca) stiletto Hicks	—	—	—	—	—	×	×											
Gastropoda																		
1 Stenotheca cornucopia Salter	—	—	—	—	—	×	×											
2 Cyrtotheca hamula Hicks	—	—	—	—	—	×	×											
Trilobita																		
1 Agnostus altus Grönwall	×	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×	—	×
2 Agnostus barrandii Salter	—	—	—	—	—	×	—	—	—	—	—	—	—	×	—	×		
3 Agnostus cambrensis Hicks	—	—	×	×	×	—	—	—	×									
4 Agnostus davidis Salter	—	—	—	—	—	×	×	—	×									
5 Agnostus eskriggii Hicks	—	—	—	—	—	—	×											
6 Agnostus exaratus Grönwall.	×	—	—	—	—	—	—	—	×	×	—	×	×	×	—	×	—	×
7 Agnostus exaratus tenuis Illing	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×		
8 Agnostus fallax Lnrs.	×	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×	×	×
9 Agnostus fissus Lnrs.	×	—	—	—	—	—	—	—	×	×	—	—	×	—	—	×	—	×
10 Agnostus granulatus Barr.	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×		
11 Agnostus kjerulfi Brögger	×	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	×
12 Agnostus longifrons Nich●las	—	—	—	—	—	—	—	—	×	×								
13 Agnostus nudus Beyr.	×	—	—	—	—	—	—	—	×	—	—	—	—	×	—	×	—	×
14 Agnostus punctuosus Ang.	×	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×	—	×
15 Agnostus scarabæoides Salter	—	—	—	—	—	—	×											
16 Agnostus scutalis Salter	—	—	—	—	—	—	×	×										
17 Agnostus truncatus Brögger	—	—	—	—	—	—	—	—	—	—	—	—	×					
18 Agnostus typicalis Nicholas	—	—	—	—	—	—	—	—	×	×	—	—	×					
19 Agraulus cf. holocephalus Matthew	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×	

Table J. (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Trilobita (cont.)																		
20 Anopolenus henrici Salter	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	×		
21 Anopolenus salteri Hicks	×	—	—	—	—	—	×	—	—	—	—	—	—	×				
22 Arionellus longicephalus Hicks	—	—	—	—	—	×												
23 Carausia menevensis Hicks	×																	
24 Clarella impar (Hicks)	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
25 Conocoryphe bufo Hicks	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	×		
26 Conocoryphe coronata Barrande	—	—	—	—	—	—	×											
27 Conocoryphe cf. dalmani Angelin	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
28 Conocoryphe homfrayi Salter	—	—	—	—	—	—	×											
29 Conocoryphe humerosa Salter	—	—	—	—	—	×												
30 Conocoryphe lyelli Hicks	—	—	×															
31 Conocoryphe perdita Salter	—	—	—	—	—	×												
32 Conocoryphe sp. Salter	—	—	—	—	—	—	—	×										
33 Corynexochus cambrensis Nicholas	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
34 Dorypyge cf. richthofeni Dames	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
35 Erinnys venulosa Salter	—	—	—	—	—	—	×	—	—	—	—	—	—	×	—	×	—	×
36 Hartshillia inflata (Hicks)	×	—	—	—	—	—	—	—	—	—	×	—	—	—	—	×		
37 Holocephalina primordialis Salter	—	—	—	—	—	—	×											
38 Microdiscus punctatus Salter	—	—	—	—	—	×	×	—	×	—	—	×	×	×	—	×	×	×
39 Microdiscus sculptus Hicks	—	—	×															
40 Paradoxides aurora Salter	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	×		
41 Paradoxides davidis Salter	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	×	×	×
42 Paradoxides harknessi Hicks	—	—	×	×														
43 Paradoxides hicksi Salter	—	—	—	—	—	×	—	—	×	—	—	?	—	?	—	×	—	×
44 Paradoxides solvensis Hicks	—	—	—	×														

Table J. (*Concluded*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Trilobita (cont.)																		
45 Plutonia sedgwicki Hicks	—	—	×															
46 Solenopleura applanata Salter	—	—	—	—	—	×	—	—	?	—	—	—	×	×	—	×		
47 Solenopleura variolaris Salter	—	—	—	—	—	—	×	—	—	—	—	—	—	?	—	×		
Ostracoda																		
1 Leperditia cambrensis Hicks	—	×																
2 Leperditia hicksi Jones	×																	
3 Leperditia solvensis Jones	—	—	—	—	—	—	×											
4 Leperditia? vexata Hicks (laval trilobite)	—	—	—	—	—	×	×											
5 Entomis buprestis Salter	—	—	—	—	—	×	×											

Table K.

Paradoxides Beds of Nuneaton
Warwickshire England
(Illing)

		Zones at Nuneaton									
		A. Aurora	C.B. Lower Hicksi	D. Upper Hicksi	E. Hartshillia	F. Lower Davidis	G. Upper Davidis	Comley	North Wales	South Wales	Scania
		1	2	3	4	5	6	7	8	9	10
Trilobita											
1	Agnostus rex Barrande,	×	×	×	—	—	—	—	—	—	×
2	Agnostus exaratus Grönwall	—	—	—	—	×	×	—	×	×	×
3	Agnostus exaratus tenuis Illing	×	×	×	×	×	×	—	×	×	
4	Agnostus granulatus Barrande	×	×	×	—	×	—	—	×		
5	Agnostus lobatus Illing	×	×								
6	Agnostus cf intermedeus Tulb.	×	×	×	—	—	—	—	—	—	×
7	Agnostus fallax Linrs.	—	—	×	—	×	?	×	×	×	×
8	Agnostus fissus Linrs.	—	×	×	—	—	—	—	×	×	×
9	Agnostus fissus perrugatus Grönwall	—	—	—	—	×	—	—	—	—	×
10	Agnostus barrandii Salter	?	?	×	×	×	—	—	×	×	
11	Agnostus corrugatus Illing,	—	×	×							
12	Agnostus sulcatus Illing,	×	×	×	×						
13	Agnostus barlowi spinatus Illing	—	×								
14	Agnostus integer Beyrich	—	×	×	×	—	—	—	—	×	
15	Agnostus regius globosus Illing	—	×								
16	Agnostus nudus Beyrich	—	×	—	—	—	—	—	×	×	×
17	Agnostus nudus ovalis Illing	—	—	—	—	×					
18	Agnostus parvifrons Linrs	—	×	×	—	×	—	—	—	—	×
19	Agnostus gracilis Illing	—	—	×							
20	Agnostus triangulatus Illing	—	—	×							
21	Agnostus tuberculatus Illing	—	—	×	×	×					
22	Agnostus lens Grönwall	—	—	—	×	×	—	—	—	—	×
23	Agnostus punctuosus Angelin,	—	—	—	—	×	×	—	×	×	×
24	Agnostus bibullatus Barrande	—	—	—	—	×					
25	Agnostus pulchellus Illing	—	—	—	—	×					
26	Agnostus altus Grönwall	—	—	—	—	×	×	—	×	×	×
27	Agnostus cf. incertus Brögger	—	—	—	—	×	—	—	—	—	×
28	Agnostus kierulfi Brögger	—	—	—	—	—	×	—	×	×	×
29	Agnostus bifurcatus Illing	—	—	—	—	—	×				

Table K. (*Concluded*)	1	2	3	4	5	6	7	8	9	10
Trilobita (cont.)										
30 Agnostus rotundus Grönwall	—	—	—	—	—	×	—	—	×	×
31 Agnostus glandiformis Angelin	—	—	—	—	—	×	—	—	—	×
32 Agnostus cf nathorsti Brögger	—	—	—	—	—	×	—	—	—	×
33 Microdiscus punctatus Salter	—	—	—	×	×	×	×	×	×	×
34 Microdiscus punctatus scanicus Linrs	—	×	×	—	×	—	—	—	×	×
35 Hartshillia inflata (Hicks)	—	×	×	×	×	—	—	×	×	
36 Hartshillia spinata Illing	—	—	—	—	×					
37 Conocoryphe bufo Hicks	×	—	—	—	—	—	—	—	×	
38 Erinnys venulosa Salter	—	—	—	—	×	—	—	×	×	×
39 Holocephalina primordialis Salter	—	—	—	—	—	×	—	—	×	×
40 Holocephalina incerta Illing	—	×	×	×						
41 Paradoxides aurora Salter	×	—	—	—	—	—	—	—	×	
42 Paradoxides sp.	×									
43 Paradoxides hicksi Salter	×	×	×	—	—	—	—	×	×	×
44 Paradoxides rugulosa Corda	—	—	—	×	×	×	×	—	—	×
45 Paradoxides davidis Salter	—	—	—	—	—	×	×	—	×	×
46 Clarella pugnax (Illing)	—	—	×	×						
47 Anopolenus henrici Salter	—	—	—	—	—	×	—	—	×	
48 Corynexochus pusillus Illing	—	×								
49 Liostracus elegans Billings	—	×	×							
50 Solenopleura applanata Salter	—	—	×	—	—	—	—	×	×	
51 Solenopleura cf. applanata Salter	—	—	—	—	×					
52 Solenopleura variolaris Salter	—	—	—	—	×	—	—	×	×	
53 Agraulos sp.	—	—	—	—	×					

Explanation (For detail see text)

Cols. 1—6 Zones of the Paradoxides Bcds at Nuneaton Warwickshire England (Condensed From Illing)

Col. 1.—Zone of *Paradoxides aurora* Hor. A4

Col. 2.—Zone of *Paradoxides hicksi* Lower division Hor. B & C.

Col. 3.—Zone of *Paradoxides hicksi* Upper division Hor. D.

Col. 4.—Zone of *Harlshillia* Hor. E.

Col. 5.—Zone of *Paradoxides rugulosus* Hor. F.

Col. 6.—Zone of *Paradoxides davidis* Hor. G.

Cols. 7—10. Occurrences in other Localities

Col. 7.—Comley district of Shropshire England

Col. 8.—North Wales

Col. 9.—South Wales

Col. 10.—Scania South Sweden

The Nuneaton District of Warwickshire. The Cambrian of Warwickshire has long been included in the two great divisions of the Hartshill quartzite at the base and the Stockingford shale above. The former is essentially equivalent to the Lower Cambrian, but the Stockingford shale series includes Middle and Upper Cambrian, as well as the Tremadoc series. The detailed studies of Illing have made possible a more precise discrimination of horizons within these shales[1]. The Nuneaton District (approximately Long. 1° 30′ W, Lat. 52° 30′ N.) shows only discontinuous exposures, but by the digging of trenches it was possible to get the relationships in the greatest detail. The old Stockingford shale series was subdivided by Lapworth into:

D. Upper or *Merevale Shales,* (Tremadoc)
C. Middle or *Oldbury Shales* (mostly Upper Cambrian)
B. Lower or *Purly Shales.* (mostly Middle Cambrian)
These rest in turn upon the
A. *Hartshill quartzite* (Lower Cambrian)

The faunal divisions however, do not correspond entirely with the lithological ones.

A more detailed subdivision of these beds was subsequently made by Illing as follows.

Merevale Shales	Lower Tremadoc	
Oldbury Shales	(Approx.)	2000 ft.
Monk's Park Shales	Dolgelly	

1 B. C. Illing, *Paradoxides* fauna of part of the Stockingford shale of Nuneaton. Quarterly Journal of the Geol. Soc. of London. Vol. LXXI, 1915, p. 391, et seq. with Geological map.

Murriwood flags and shales	Ffestiniog?	
Outwoods shale	Maentwrog	
Abbey Shales (90 ft.)	Menevian	
Purley Shales		630 ft.[1]
Upper Purley shales	Menevian	
Middle Purley shales	Menevian?	
Lower Purley shales	Lower Cambrian	
Hartshill quartzite		
Camp Hill grit		
Tuttle Hill quarzite		
Park Hill quartzite.		

The upper 2 divisions of the Oldbury shales are correlated on the basis of their position, but the Mæntwrog age, or Lower part of the Upper Cambrian of the Outwood shale member, is known from fossils, for *Olenus* and other early Upper Cambrian fossils have been obtained from it. Only the Abbey shales, which name is given to the lower 90 ft. of the original Oldbury shales, has been studied in great detail and has yielded a rich Menevian fauna, but from an excavation in a horizon about 100 ft. below the top of the Purley shales, a specimen of *Paradoxides sjögreni* has been obtained together with *Conocoryphe coronata.* As the *Paradoxides* mentioned is known only

1 This thickness is taken from Illing's map, where the width of the outcrop of the shale appears to be fairly constant between the Hartshill sandstone and Abbey shales. The width of the outcrop, as nearly as can be determined, is 825 ft. and the dip at the contact with the Hartshill quartzite is 50°. This would give a thickness of slightly over 630 ft. That this is a conservative figure is indicated by the fact that 3/4 of a mile further northwest at Abbey Mount, the upper contact with the Abbey shales shows an increase of dip to 70°

from the *P. œlandicus* zone of Sweden, these upper Purley shales are tentatively correlated with that zone. Again in the Lower Purley shale, up to 40 ft. above the base, specimens of *Callavia* have been found, thus showing that the lower division of the group belongs to the Lower Cambrian. It would be of interest to know the general character and faunal succession in the intermediate portion of the Purley shales.

The entire series of the Abbey shales has been subdivided into 7 groups, these being lettered from A to G. Division A the lowest, with a thickness of nearly 20 ft. is again subdivided into 4 parts numbered A1 to A4. In the lower 3 divisions, A1 to A3, only brachiopods and sponge spicules are found, and these have not been determined. There are also a few fragments of trilobites. These beds rest upon the reddish-colored Purley shales and contain intercalated red layers in the lower part. At the top of division A2, the hard bluish-gray shale contains brick-red inclusions, while the base of the succeeding horizon is separated from it by a distinct erosion surface, shown by the variation in thickness of the shale bed, which separates continuous limestone beds, in the adjoining portion of the two divisions, this thickness changing from 6 to 3 ft. in the distance of 5 yards, while at the same time, the base of the overlying calcareous bed is irregular. Also the line of contact is marked by glauconite and abundant fragments of brachiopods.

Illing suggests "that this probably is merely an instance of contemporaneous erosion of slight extent, due to shallowing of the water", (Loc. cit. page 396) Viewed however in its broader aspect as marking a distinct line of division between the *Paradoxides hicksi* and older zones, it assumes more sigificance, especially when considered in the light of the evidence for a disconformity indicated by the "Fragment Limestone" at the base of the Tessini zone in Scania, and the very pronounced disconformities found in the Comley region.

The succession of faunas in the several large divisions of the Abbey shale are given in cols 1 to 6 of Table K which is condensed from the much more detailed table given by Illing. From this it will be seen that there are a number of distinct faunal zones. These are summarized by Illing as follows in descending order.

Horizons G3 to G1. Upper *Paradoxides davidis* zone, also contains *P. rugulosus* which however is rare. The fauna is given in Col. 6.

Horizons F3, to F1, Lower *Paradoxides davidis* zone (Illing), but better designated *Paradoxides rugulosus* zone, since this alone is present while *P. davidis* is wanting.

Horizon E3-E1. (in part). *Hartshillia* zone with *H. inflata* common. This species however also occurs in lower horizons. *Paradoxides rugulosus* still occurs in E 3 but is rare, nor is it known from horizons lower down. (Col. 4 Table K)

Horizons D3-D1, are referred to the Upper *Paradoxides hicksi* zone, in which *P. hicksi* is abundant and *Agnostus fissus* is common. D3 and E1, are moreover closely united by having *Clarella pugnax* in common just as E3 is united to F1 and F2 by the presence of *Paradoxides rugulosus*. E2 is rather a transition bed between the two, its 4 determined species occurring both in the lower and the higher horizons.

Horizons C3-B1, are designated the Lower *Paradoxides hicksi* zone, for here that species is rare. *Agnostus rex* on the other hand is abundant though it also occurs in higher beds. *Liostracus elegans* on the other hand is characteristic though it extends into horizon D1. (Table K col. 2)

Finally, the Lower bed A4, (Table K col. 1) is characterized by *Paradoxides aurora* which is restricted to it, but *P. hicksi* is also found there though rare. Other species are *Conocoryphe bufo* and *Agnostus sulcatus*. The 5 other species of *Agnostus* found here continue through the series, nevertheless it is apparent that we have a zone sufficiently distinct and this can be compared with the *Paradoxides aurora* zone, which in the St David's region lies between the *P. hicksi* and *P. harknessi* zone, which there is the lowest *Paradoxides* zone.

The absence of the *Paradoxides forchhammeri* zone, and the immediate superposition of beds with *Olenus* upon those with *Paradoxides davidis*, indicates a hiatus in the succession, representing as it does the final retreat of the Middle Cambrian sea from this section and probably the long exposure before the return of the Upper Cambrian Sea. The disconformity moreover, is recognizable in the physical characters of the beds. To quote Illing (*Loc. cit.* p. 395). "The upper limit of the Abbey shales is marked by a coarse calcareous conglomerate, varying in thickness from 1-3 inches. It rests upon an eroded surface of the underlying blue shales, though the extent of the erosion cannot well be judged, owing to the proximity of the 2 trenches.[1] In a single trench the bed is found to migrate over horizons varying in vertical position by 2 inches, while between 2 trenches, about 70 ft. apart, the migration is

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1 The reference here is to the trenches dug for the purpose of studying these shales, as the surface exposures were inadequate.

at least 6 inches. The conglomerate contains large flat and rounded pebbles of the underlying shales, abundant irregular quartz grains, showing strain-shadows, a few feld-spars, large zircons and numerous pebbles of fine-grained igneous material, which appears to be a partly devitrified pitchstone. The glauconite and calcite are both abundant and many of the pebbles and crystals have an iron-stained border."

Illing's comments on the significance of the material in these conglomerates, are of great interest in this connection, and clearly indicate the importance of this disconformity.

He says "There is no known horizon either in the underlying Abbey shales or in the Purley shales, from which the igneous materials could have been derived, and the facts seem to require the postulation of extensive erosion in the neighbourhood, with perhaps the exposure to denudation of the pre-Cambrian igneous suite. The large pebbles in the bed, the rapid variation in thickness and the abundant glauconite and quartz grains, all point to the conclusion, that it was deposited under shallow water conditions. Further, this conglomerate is followed by a type of lithology quite different from that of the beds below, consisting of a greenish-gray micaceous shale, which at a higher horizon alternates with abundant beds of flag-stones" (*Loc. cit. p.* 395.)

Further comment is unnecessary and when this well-characterized example is considered in connection with the fact that all over the British, and a large part of the east American region, this same hiatus is indicated by the absence of the higher zone, and now and then by physical characters, it is quite evident that this is not a local feature but one of the major breaks in the geological succession. As such it falls in line with the similar great disconformities which we have recognized at the summit of the Middle Cambrian in nearly all the sections in the other geosynclines which have so far been discussed.

The Comley District. But England presents us with an even more interesting example of the incomplete representation of the Middle Cambrian deposits in the famous Comley section of Shropshire. We have already considered the character of the *Protolenus* bed in this section. The relationship is best brought out if we consider two sections in this region, but we will first give the complete succession of formations in this locality in descending order.

Cambrovician

Shoot-Rough Wood shale (Cx) soft blue-gray shale Tremadoc

Shoot-Rough Road shale, *Orusia* shales (Ca) 500? Micaceous shales, with thin mud-stones or calcareous courses. Upper Cambrian fossils.

Hiatus and Disconformity

Middle Cambrian

Shoot Rough Road Flags

Billingsella Beds (Bc) 5 ft.
For the fossils see Table L. Col 12, Fine and coarse grits with calcareous and shaly beds, held to represent the *P. forchhammeri* zone

Paradoxides davidis Flags (Bb5) 18 ft.
Coarse gritty flags with a calcareous bed at the summit. The

fossils are given in Col. 11, Table L.

Shoot Rough Road sandstones.

Paradoxides rugulosus sandstone (Bb4) ? ft.

Green and brown sandstones with a calcareous bed at the summit. The fossils are given in Col 10 Table L.

Unexplored interval (Bb3)

Hill House shale. (Bb2) 300 ft.

Micaceous flaggy shales, with occasional beds of grits. The fossils are given in Col 8. Table L.

Hill House grits or *Comley breccia bed.*

Paradoxides intermedius grits B. b 1 5-38 ft.

Coarse conglomeratic grits and breccias, of fragments of Ac 2, and A c 1, below. The fauna is given in Col 7 of Table L.

Hiatus and Disconformity

Hill House Flags.

Dorypyge lakei flags (Ba3) fauna in Col. 6 Table L, 4 ft. +

Phosphatic gritty flags.

Quarry Ridge shales (Ba2) 300 ft.

Fine blue and brown shales with bands or beds of hard ringing grits. Fossils in Col. 5, Table L.

Quarry Ridge grits

Paradoxides groomi grits (Ba1) 25 ft.

Hard, ringing, glauconitic grit, with conglomerate and a thin phosphatic deposit at the base. Fauna in Col. 4, Table L.

Hiatus and Disconformity

The Black limestone

Lapworthella limestone (Ad) 0.5 ft.

Calcareous and phosphatic granular material, fauna in Col. 3, Table L.

Protolenus limestone (Ac5) 0.5 ft.

Black to pale-gray compact phosphatic limestone, fauna in Col. 2, Table L.

Hiatus and Disconformity

Lower Cambrian

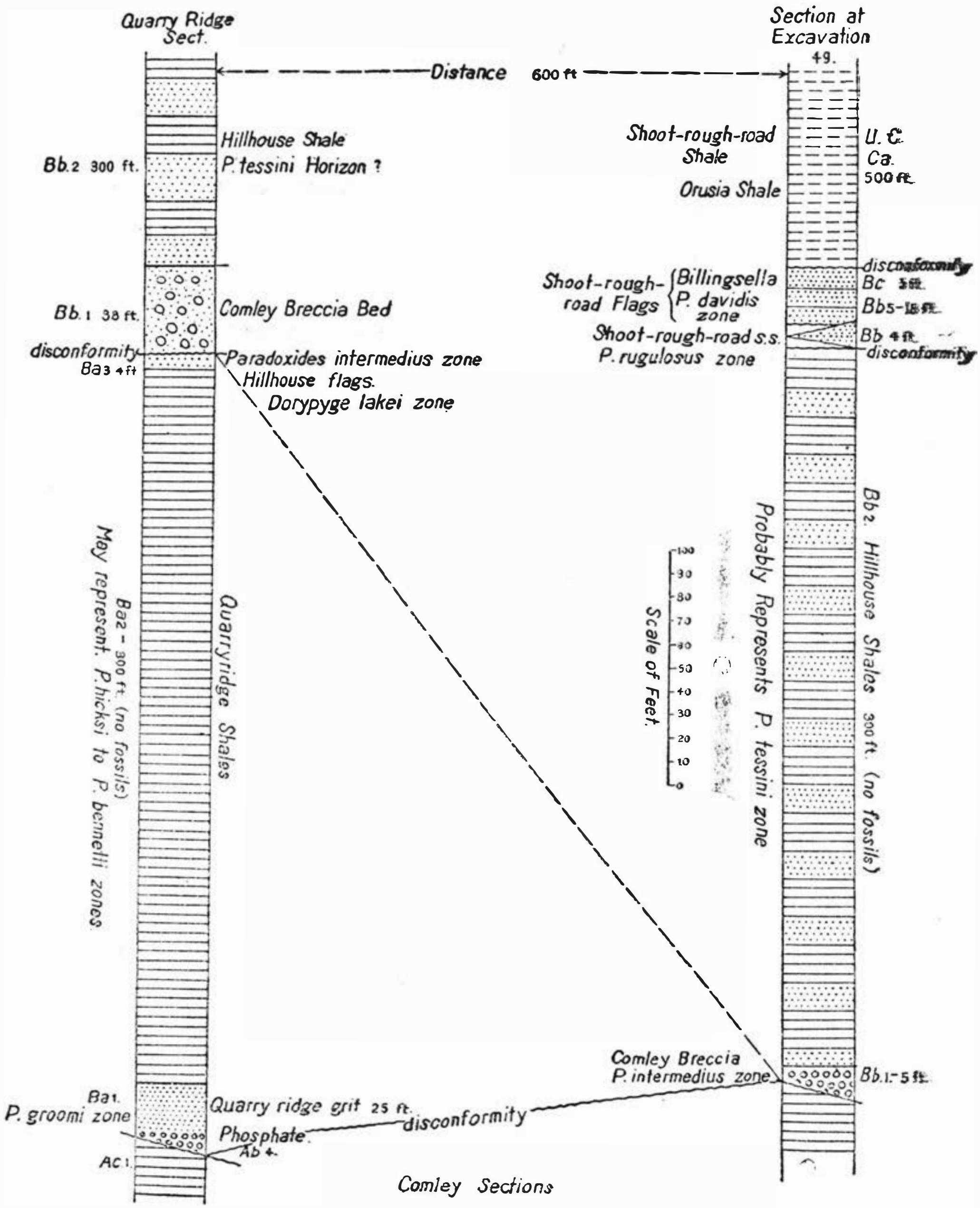
For the description of lower beds see *ante* p. 91, (p. *117*)

The disconformity between the Middle and Upper Cambrian, appears not to be indicated by any marked physical feature. But the highest bed of the Middle Cambrian Bc, is only 5 ft. thick. It contains no *Paradoxides forchhammeri* and the correlation with that zone is based on its superposition on the Davidis beds. The zone fossils *Billingsella lindströmi salopiensis* Matley, also occurs in the Davidis beds, where another species *B. cobboldi* is also found. Three species of *Obolus?* one of *Acrothele* and 2 of *Acrotreta* represent the only other specifically identified species from these beds. The *Acrothele* and *Acrotreta* occur in the Davidis bed, (the 2nd species doubtfully). It is quite probable that the true Forchhammeri zone, the Andrarum limestone of Sweden, is unrepresented here. Possibly careful study, such as made by Illing at Nuneaton, will also disclose physical evidence of the break between Upper and Middle Cambrian.

Another break seems to separate the Rugulosus beds, from the underlying horizons, though these beds have not been studied. But the most significant break in the section is represented by the Comley breccia beds and this is well brought out by a consideration of the two sections, separated only by a distance of 200 yards. (Text-Fig. 10)

In the Quarry Hill section at Comley, the Hill House Shales rest on 38 ft. of the Comley breccia bed. This is a coarse conglomeritic rock, with fragments of *Paradoxides intermedius* and occasionally other fossils. These grits mark a distinct disconformity, but they rest upon 4 ft. of the Hill House shale with *Dorypyge lakei* and *Acrothyra comleyensis*. Both of these species are again characteristic of the Quarry Ridge grits near the base of the section, but these 2 formations are separated by 300 ft. of shales and grits, the Quarry Ridge shales (Ba 2), which moreover carry no zone fossils. This quarry ridge grit, 25 ft. in thickness contains *Paradoxides groomi* which is correlated by Cobbold with the *P. œlandicus* zone of Sweden and rests with a conglomerate and thin phosphatic deposit, on the Hanfordian or on the Lower Cambrian beds, there being here a pronounced disconformity between the two.

This same disconformity is seen in what is known as excavation No. 49 of the British Association, which is 200 yards away, but here the remarkable fact is found that it is the Comley breccia bed with *Paradoxides intermedius*, which here lies directly upon the older rocks,



Text-Fig. 10. Two sections, 600 feet apart in the Comley District of Shropshire England showing the remarkable overlaps of Middle Cambrian strata, and the disconformities and gaps in the section. Drawn to scale from descriptions by Cobbold.

but shows a thickness of only 5 ft. This clearly shows a remarkable overlap, and the evident erosion of the Quarry Ridge shales, which 200 yds away, underlie the Comley breccia bed, with a thickness of 300 ft, and are preceded by the Quarry Ridge grits, with *P. groomi*, 25 ft. thick. Thus in the short distance of 600 feet, about 330 ft. of the lower series are cut out by erosion and 33 ft. of the Comley breccia bed are cut out by overlap. As Cobbold distinctly says, "faulting is here out of the question."

With this well authenticated example of interzonal erosion and overlap in England and the examples already described from Sweden, we are justified in interpreting the zonal arrangement of the faunas and the often insignificant thicknesses of the formations, as pointing to a succession of floodings and emergences over the flat marginal plain of the geosyncline, and we may hope on careful search, to find other evidences of such breaks between the various zones where these are well exposed to observation.

In the following table the zonal distribution of the Middle (and some Upper) Cambrian fossils of this region are given.

The great terminal disconformity between the Middle and Upper Cambrian is further emphasized by the fact already noted (*ante* p. 89 (*115*)) that in the Malvern Hills, the Middle Cambrian is entirely wanting. The White-Leaved-Oak shales, with Upper Cambrian fossils rest directly and disconformably on the Lower Cambrian Hollybush sandstone.

The Acadian of Eastern North America

The Middle Cambrian beds of Eastern Canada were first studied most extensively in the region around St. John

Table L.

Middle and Upper Cambrian of Comley England (after Cobbold)

	Lower Cambrian	Protolenus bd. Ac5	Lopworthella Ad	Groomi bed Ba1	Quarry-ridge Ba2	Dor. lakei bd. Ba3	Breccia bd. Bb1	Hillhouse bd. Bb2	Unexplored Bb3	Rugulosus bd. Bb4	Davidis bed. Bb5	Billingsella bd. Bc	Orusia bed Ca	Tremadoc Cx
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Brachiopoda														
1 Micromitra sp.	—	—	—	—	—	—	—	—	—	—	—	×		
2 Paterina labradorica Billings	×	×												
3 Obolus parvulus Cobbold	×	×												
4 Obolus cf. schmalenseei Walcott	—	—	—	—	—	—	—	—	—	—	—	×		
5 Obolus? gibbosus Cobbold	—	—	—	—	—	—	—	—	—	—	—	×		
6 Obolus? linnarssoni Cobbold	—	—	—	—	—	—	—	—	—	—	—	×		
7 Obolus? sp. a	—	—	—	—	×									
8 Obolus? sp. b	—	—	—	—	—	—	—	×						
9 Lingulella ferruginea Salter	—	—	—	—	—	—	—	—	—	×	×			
10 Lingulella nicholsoni Callaway	—	—	—	—	—	—	—	—	—	—	—	—	—	×
11 Lingulella viridis Cobbold	×	×												
12 Lingulella sp.	—	—	—	—	—	—	—	—	—	×				
13 Acrothele coriacea Linnrs.	—	—	—	—	—	—	—	—	—	—	×	×	×	
14 Acrothele saggittalis (Salter)	—	—	—	—	—	—	—	—	—	—	×	×		
15 Acrothele schmalenseei var matleyi Cobbold	—	—	—	—	—	—	—	—	—	—	?	×		
16 Acrothele socialis v. Seebach	—	—	—	—	—	×								
17 Acrothele sp. a.	—	—	—	—	—	—	—	—	—	—	—	×		
18 Acrothele sp. b	—	—	—	—	—	×								
19 Acrothele sp. c	—	—	—	—	—	—	—	×						
20 Acrothyra comleyensis Cobbold	—	—	—	×	—	×								
21 Acrothyra cf. sera Matthew	—	—	×											
22 Billingsella lindströmi salopiensis Matley	—	—	—	—	—	—	—	—	—	—	×	×		
23 Billingsella cobboldi Matley	—	—	—	—	—	—	—	—	—	—	×			
24 Billingsella sp.	—	—	—	—	—	—	×							
25 Orusia lenticularis Wahlenberg	—	—	—	—	—	—	—	—	—	—	—	—	×	

Table L. (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pteropoda etc.														
1 Hyolithes crassus Cobbold	—	×												
2 Hyolithes sculptilis Cobbold	—	×												
3 Orthotheca bayonet Matthew	—	×												
4 Lapworthella nigra Cobbold	—	—	×											
5 Salterella? bella Cobbold	—	×												
6 Salterella? striata Cobbold	—	×												
7 Hyolithellus micans Billings	×	×	×	×	×	×	×							
8 Hyolithellus micans var. robusta Cobbold	—	—	—	×	—	—	×							
9 Helenia cancellata Cobbold	×	×	×											
10 Helcionella cingulata Cobbold	?	×												
11 Helcionella oblonga Cobbold	—	—	—	×										
12 Latouchella costata Cobbold	×	×												
13 Latouchella? striata Cobbold	—	×												
Trilobita														
1 Microdiscus comleyensis Cobbold	—	×												
2 Microdiscus lobatus Hall,	×	×												
3 Microdiscus punctatus Salter	—	—	—	—	—	—	×							
4 Microdiscus cf. punctatus Salter	—	—	—	—	—	—	—	—	—	—	×			
5 Microdiscus simplex Salter	—	—	—	×										
6 Microdiscus speciosus Ford	×	×												
7 Agnostus fallax Linrs	—	—	—	—	—	—	—	—	—	—	×			
8 Conocoryphe emarginata longifrons Cobbold	—	—	—	×										
9 Conocoryphe equalis Linrs	—	—	—	—	—	—	×							
10 Conocoryphe bufo Hicks	—	—	—	—	—	—	×							
11 Liocephalus impressa Linrs.	—	—	—	—	—	—	×							
12 Liostracus dubia Cobbold	—	—	—	—	—	—	×	—	—	—	×			
13 Liostracus lata Cobbold	—	—	—	—	—	—	×							
14 Liostracus pulchella Cobbold	—	—	—	—	—	—	—	—	—	—	×			
15 Agraulos cf. quadrangularis Hall & Whitfield	—	—	—	—	—	—	×	—	—	—	×			
16 Agraulos holocephalus Matthew	—	—	—	—	—	—	—	—	—	—	×			

Table L. (*Concluded*)	1	2	3	4	5	6	7		9	10	11	12	13	14
Trilobita														
17 Strenuella sp.	—	—	—	—	—	—	×							
18 Protolenus latouchii Cobbold	—	×												
19 Protolenus morpheus Cobbold	—	×												
20 Mohicana clavata Cobbold	—	×												
21 Mohicana lata Cobbold	—	×												
22 Dorypyge lakei Cobbold	—	—	—	×	—	×								
23 Dorypyge reticulata Cobbold	—	—	—	—	—	—	×							
24 Paradoxides davidis Salter	—	—	—	—	—	—	—	—	—	—	×			
25 Paradoxides rugulosus Corda	—	—	—	—	—	—	—	—	—	×				
26 Paradoxides intermedius Cobbold	—	—	—	—	—	—	×							
27 Paradoxides groomi Lapworth	—	—	—	×										
28 Paradoxides sp.	—	—	—	×										
29 Callavia cf. callavii (fragments)	×	×												

Explanation (For details see Text)

Col. 1. Lower Cambrian (See Further Table III Cols 7-11)
Col. 2. Protolenus beds (Hanfordian) Ac5
Col. 3. Lapworthella limestone Ad.
Col. 4. Quarry Ridge grits. *Paradoxides groomi* Zone Ba1
Col. 5. Quarry Ridge shales Ba2.
Col. 6. Hillhouse Flags *Dorypyge lakei* Zone Ba3.
Col. 7. Comley Breccia bed. *Paradoxides intermedius* Zone Bb1
Col. 8. Hillhouse shales Bb2.
Col. 9. Unexplored horizon Bb3.
Col. 10. Shootrough-road sandstones *Paradoxides rugulosus* Zone Bb4
Col. 11. *Paradoxides davidis* Zone Bb5
Col. 12. *Billingsella* Zone Bc.
Col. 13. Upper Cambrian *Orusia* shales Ca
Col. 14. Shootrough-wood shales (Tremadoc) Cx.

New Brunswick, where Dr. G. F. Matthew named them the Acadian series, and with the Johannian and Bretonian included them in his St. John group. The Acadian series, which is here not over 200 ft. thick, rests by overlap upon the crystallines, beginning with basal sandstone. Although this and some of the immediately succeeding beds have been identified with the *Protolenus* horizon, it is somewhat questionable whether that division is actually represented in the St. John section. The lithological divisions of the St. John group do not fully correspond with the palæontological zones, for a part at least of the Johannian division, which is primarily a sandstone series, appears to be referable to the Middle Cambrian. The zones here recognized are the following in descending order.

Division C1d2 *Dorypyge zone*. (Table M. col. 11)

Dark-gray shales and limestone lentils. Among the species are:—

Liostracus ouangondianus (Hartt) var
Agraulos ceticephalus carinatus Matthew
Anomocare magnum Brögger var
Agnostus parvifrons tesselus Matthew
Agnostus punctuosus Angelin var.

Besides species of *Dorypyge* (see the table M. col. 11)

As Howell said, the presence of *Agnostus punctuosus* var, "may indicate that some of that zone may lap over from Hicksi into Davidis time, as *A. punctuosus* is not known below the Davidis zone of Manuels. *P. davidis* itself is absent.."

Division C1d1 *Paradoxides abenacus* zone (Table M. col. 9)

Dark-gray shales, characterized by *Paradoxides abenacus* Matthew, *Conocoryphe pustulosa* and many other species of trilobites including 13 species and varieties of *Agnostus* (see table M. col. 9)

Division C1c2 *Paradoxides eteminicus* zone (Table M. col. 8)

With *P. eteminicus* and 4 varieties, *P. acadicus* Matthew, *P. regina* Matthew and *P. micmac* Hartt besides many other species of trilobites and some brachiopods, all of which are confined to this zone.

Division C1c1 Zone of *Paradoxides lamellatus* Hartt, *Liostracus ouangondianus* (Hartt) and several varieties as well as other trilobites and some brachiopods listed in table M. col. 6.

From an inspection of this table, it will be seen that so far as the trilobites are concerned at least, the zones are distinct. Where only the divisions C1c or C1d are given however, (cols 7 and 10 respectively) the respective species may occur in both of the minor divisions, though more often this classification is due to the fact that the exact position of the species in either sub-division 1 or 2 was not given.

As we have seen, the *Paradoxides davidis* zone is not present in this section, unless it is in part represented by zone C1d2, the *Dorypyge* zone which is the highest in the typical Acadian division of this region.

The zone of *Paradoxides forchhammeri* is likewise unrepresented so far as that species is concerned, though the lower part of the Johannian of the St. John region, that is C2, is regarded as representing that horizon. The Johannian consists of 750 ft. of sandstones and flags, mostly with worm borings. Only 2 species of *Lingulella* or *Lingulepis* have been found, namely *L. starri* and *Lingulella rugula* and both of these may belong to the upper rather than the Middle Cambrian portion. On the whole, the Johannian division must be regarded as representing to a large extent a group of continental sediments which accumulated in this region chiefly after the final retreat of the sea at the end of Middle Cambrian time and before its return in Upper Cambrian time.

Cape Breton. In Cape Breton, where the Dugaldian is so well developed, both the Hanfordian (*Protolenus*) and Acadian have a very incomplete development and may even in part at least be absent. In fact the Middle Cambrian seems to be largely represented by shallow water or even continental deposits, in which felsite conglomerates, ranging up to 70 ft. in thickness, are of rather frequent occurrence. At Boundary Brook and elsewhere from 300 to 400 ft. of Middle Cambrian deposits occur with at least 3 of these conglomerate beds. On the east side of Myra Valley, the formation is more largely clayey beds with lentils or irregular layers of carbonate of lime carrying *Paradoxides* cf *rugulosus* and other fossils apparently of the *P. rugulosus* zone. The higher beds are often very shallow water if not continental deposits, containing trails (*Ctenichnites*) and burrows (*Monocraterion*).

What is regarded as representing the *Paradoxides forchhammeri* zone is found in the Myra Valley, consisting of flags and slates with *Lingulella, Acrothyra* etc listed under Division C2a and C2b in the table.

Eastern Newfoundland. The most detailed recent work which has been done on the Middle Cambrian of Eastern North America is that by Dr. B. F. Howell on the "Faunas of the Cambrian Paradoxides Beds at Manuels"[1]. Here

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1 Princeton University Contributions to the Geology of Newfoundland No. 7. Bull. of American Pal. Vol. XI, No. 43, pp. 140 with plates and tables. 1925.

Table M. Acadian or Paradoxides beds of Newfoundland, New Brunswick and Cape Breton	Manuels Newfoundl.					St. John New Brunswick						Cape Breton		
	Parad. bennetti Zone			P. hicksi	P. davidis	P. lamellatus C1c1	C1c	P. eteminicus C1c2	P. abenacus C1d1	C1d	Dorypyge C1d2	Par. forch-hammeri Zone		
	(1-18)	(19)	(21-35)	(36-92)	(93-125)							C2a	C2b	C2c
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Spongidæ														
1 Protospongia minor distans Matthew	—	—	—	—	—	—	—	—	×					
2 Protospongia fenestrata Salter	—	—	—	—	×									
3 Eocoryne geminum Matthew	—	—	—	—	—	×	—	—	×					
Archæocyathidæ														
4 Archæocyathus? paranoides Matthew	—	—	—	—	—	—	—	—	×					
Graptozoa														
5 Dendrograptus? primordialis Matthew	—	—	—	—	—	—	—	—	×					
6 Protograptus alatus Matthew	—	—	—	—	—	×								
Cystoidea														
7 Eocystites primævus Matthew	—	—	—	—	—	×								
Hyolithidæ and Gastropoda etc.														
1 Hyolithes tenuistriatus Linrs	—	—	—	—	×									
2 Hyolithes (Camerotheca) danianus Matthew	—	—	—	—	—	×	—	—	×					
3 Hyolithes (Camerotheca) micmac Matthew	—	—	—	—	—	×								
4 Hyolithes (Camerotheca) gracilis Matthew	—	—	—	—	—	—	—	—	×					

Table M. (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Hyolithidæ and Gastr. etc. (cont.)														
5 Hyolithes (Diplotheca) acadicus Matthew	—	—	—	—	—	—	—	—	×					
6 Hyolithes (Diplotheca) acadicus sericus Matthew	—	—	—	—	—	—	—	—	×					
7 Hyolithes (Diplotheca) acadicus obtusus Matthew	—	—	—	—	—	×								
8 Hyolithes (Diplotheca) hyatti caudatus Matthew	—	—	—	—	—	—	—	—	×					
9 Stenotheca (Parmaphorella) acadica (Hartt)	—	—	—	—	—	×								
10 Stenotheca concentrica Matthew	—	—	—	—	—	—	—	—	×					
11 Stenotheca cf. cornucopia Salter	—	—	—	—	×									
12 Stenotheca hicksiana Matthew	—	—	—	—	—	—	—	—	×					
13 Stenotheca nasuta Matthew	—	—	—	—	—	×								
14 Stenotheca radiata Matthew	—	—	—	—	—	×								
15 Stenotheca triangularis Matthew	—	—	—	—	—	×								
Brachiopoda														
1 Obolus fragilis (Walcott)	—	—	—	—	×									
2 Westonia escasoni (Matthew)	—	—	—	—	—	—	—	—	—	—	—	—	×	
3 Lingulella cania Walcott	—	—	—	—	—	—	—	—	—	—	—	—	×	
4 Lingulella concinna Matthew	—	—	—	—	—	—	—	—	—	—	—	—	×	
5 Lingulella ferruginea Salt.	×	×	×	×	×	—	×	—	—	×	—	—	×	
6 Lingulella flumenis Matthew	—	—	—	—	—	—	—	—	—	—	—	—	—	×
7 Lingulella radula Matthew	—	—	—	—	—	—	—	—	—	—	—	—	—	×
8 Lingulella rotunda Matthew	—	—	—	—	—	—	—	—	—	—	—	—	×	×
9 Lingulella tumida Matthew	—	—	—	—	—	—	—	—	—	—	—	—	×	
10 Lingulepis exigua (Matthew)	—	—	—	—	—	—	—	—	—	—	—	×	×	
11 Lingulepis starri Matthew	—	—	—	—	—	—	—	—	—	—	—	—	×	

Table M (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Brachiopoda (cont.)														
12 Acrothele matthewi (Hartt)	?	—	×	?	—	—	×	—	—	×				
13 Acrothele matthewi lata Matthew	—	—	—	—	—	—	×	—	—	×				
14 Acrothele matthewi multicosta Matthew	—	—	—	—	—	—	×	—	—	×				
15 Acrothele prima costata Matthew	—	—	—	—	—	—	—	—	—	×				
16 Acrotreta baleyi Matthew	—	—	—	—	—	—	—	—	—	×				
17 Acrotreta gemmula Matthew	—	—	×											
18 Acrotreta gracia Walcott	—	—	—	—	—	—	—	—	—	×				
19 Acrotreta misera (Billings)	—	—	—	×	×	—	—	—	—	×				
20 Acrotreta sagittalis (Salter)	—	—	—	—	×	—	—	—	—	×				
21 Acrotreta sagittalis magna Matthew	—	—	—	—	—	—	×	—	—	×				
22 Acrotreta sagittalis transversa (Hart)	—	—	—	—	—	—	×							
23 Acrothyra proavia (Matthew)	—	—	—	—	—	—	—	—	—	—	—	—	×	
24 Discinopsis gulielmi (Matthew)	—	—	—	—	—	×								
25 Protorthis billingsi (Hartt)	—	—	—	—	—	×	—	×						
26 Protorthis latourensis (Matthew)	—	—	—	—	—	—	—	×						
27 Protorthis quacoensis (Matthew)	—	—	—	—	—	—	—	×						
28 Billingsella coloradoensis (Schumard)	—	—	—	—	—	—	—	—	—	×				
29 Eoorthis hastingsensis (Walcott)	—	—	—	—	—	—	×	—	—	×				
30 Eoorthis papias (Walcott)	—	?	×											
31 Iphidella ornatella Linrs.	—	—	cf											
32 Iphidella pannula maladensis (White)	—	—	×											
Trilobta														
1 Agnostus acadicus Hartt	—	—	—	—	—	—	—	×						
2 Agnostus acadicus declivis Matthew	—	—	—	cf	cf	—	—	—	×					
3 Agnostus barlowi Belt	—	—	—	—	×									

Table M. (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Trilobita (cont.)														
4 Agnostus barlowi definitus Howell	—	—	×											
5 Agnostus barrandii Salter	—	—	—	×										
6 Agnostus bilobatus Barrande	—	—	—	—	×									
7 Agnostus bifurcatus Illing	—	—	—	—	×									
8 Agnostus claræ Howell	—	—	×											
9 Agnostus cf. exeratus tenuis Illing	—	—	×	—	×									
10 Agnostus fallax Linrs.	—	—	—	cf	cf	—	—	—	×					
11 Agnostus fallax concinnus Matthew	—	—	—	—	—	—	—	—	×					
12 Agnostus fallax trilobatum Matthew	cf	—	cf	—	—	×								
13 Agnostus fallax vir Matthew	—	—	—	—	—	×								
14 Agnostus fissus Lundgren	—	—	—	×	—	—	—	—	×					
15 Agnostus cf. fissus perrugatus Gröuwall	—	—	—	—	×									
16 Agnostus fissus trifissus Matthew	—	—	—	—	—	—	—	—	×					
17 Agnostus gibbus Linrs	—	—	—	cf	—	×								
18 Agnostus gibbus acutilobus Matthew	—	—	—	—	—	—	—	—	×					
19 Agnostus gibbus hybrida Brögger	—	—	—	cf										
20 Agnostus gibbus partitus Matthew	—	—	—	—	—	—	—	—	×					
21 Agnostus gracilis Illing	—	—	—	—	×									
22 Agnostus granulatus (Barrande)	—	—	×	×	×									
23 Agnostus incertus Brögger	—	—	—	—	cf									
24 Agnostus kjerulfi Brögger	—	—	—	—	cf									
25 Agnostus lævigatus ciceroides Matthew	—	—	—	×	×									
26 Agnostus lævigatus mamilla Matthew	—	—	—	—	×									
27 Agnostus lævigatus terranovicus Matthew	—	—	—	×	×									

Table M. (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Trilobita (cont.)														
28 Agnostus longifrons parvulus Howell	—	—	—	—	×									
29 Agnostus nathorsti Brögger	—	—	—	—	—	—	—	—	×					
30 Agnostus nathorsti confluens Matthew	—	—	—	—	—	—	—	—	×					
31 Agnostus nudus Beyrich	—	—	—	cf	cf									
32 Agnostus obtusilobus Matthew	—	—	—	—	—	—	—	—	×					
33 Agnostus parvifrons Linrs.	—	—	—	cf	cf	—	—	—	×	—	×			
34 Agnostus parvifrons mammillatus Brögger	—	—	—	—	×									
35 Agnostus parvifrons nepos Brögger	—	—	—	—	—	—	—	—	—	—	cf			
36 Agnostus parvifrons punctifer Howell	—	—	—	—	×									
37 Agnostus parvifrons tessela Matthew	—	—	—	cf	—	—	—	—	—	—	×			
38 Agnostus parvifrons truncata Matthew	—	—	—	—	—	—	—	—	—	—	×			
39 Agnostus planicauda Angelin	—	—	—	—	cf									
40 Agnostus punctuosus Angelin	—	—	—	—	×									
41 Agnostus punctuosus Angelin, var.	—	—	—	—	—	—	—	—	—	—	×			
42 Agnostus pusillus Tullberg	—	—	—	—	cf									
43 Agnostus rectangularis Howell	—	—	—	—	×									
44 Agnostus regulus Matthew	—	—	—	—	—	×								
45 Agnostus rex Barrande	cf	cf	cf	×	×									
46 Agnostus rex transectus Matthew	—	—	—	—	—	—	—	—	×					
47 Agnostus sulcatus Illing	—	—	—	?	?									
48 Agnostus umbo Matthew	—	—	cf	cf	—	—	—	—	×					
49 Agnostus vaningeni Howell	—	—	—	×										
50 Agraulos affinis Billings	cf													
51 Agraulos ceticephalus carinatus Matthew	—	—	—	—	—	—	—	—	—	—	×			
52 Agraulos hallianus Matth.	—	—	—	—	—	—	—	×						

Table M. (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Trilobita (cont.)														
53 Agraulos? holocephalus Matthew	—	—	—	—	—	—	—	×						
54 Agraulos? nanus Matthew	—	—	—	—	—	—	—	×						
55 Agraulos? pusillus Matthew	—	—	—	—	—	—	—	×						
56 Agraulos? roberti Matthew	—	—	—	—	—	—	—	×						
57 Agraulos socialis Billings	—	—	—	×	—	—	—	—	—	×				
58 Agraulos? whitfieldianus Matthew	—	—	—	—	—	×								
59 Agraulos? whitfieldianus compressus Matthew	—	—	—	—	—	×								
60 Anopolenus henrici Salter	—	—	—	—	×									
61 Anomocare magnum Brögger var.	—	—	—	—	—	—	—	—	—	—	×			
62 Bailiella baileyi (Hartt)	—	—	cf	—	—	—	—	×						
63 Bailiella baileyi arcuata Matthew	—	—	—	—	—	—	—	×						
64 Bailiella venulosa (Salter)	—	—	—	×	×									
65 Bailiella walcotti Matthew	—	—	—	—	—	×								
66 Centropleura pugnax Illing	—	—	—	—	×									
67 Clarella venusta (Billings)	—	—	—	×										
68 Conocoryphe aequalis Linrs	—	—	—	×										
69 Conocoryphe bullata Howell	—	×												
70 Conocoryphe elegans (Hartt)	—	—	×	×	—	—	—	×						
71 Conocoryphe elegans granulata Matthew	—	—	—	—	—	—	—	×						
72 Conocoryphe pustulosa Matthew	—	—	—	—	—	—	—	—	—	×				
73 Corynexochus minor Walcott	—	—	—	—	×									
74 Ctenichnites sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	×
75 Dolichometopus acadicus Matthew	—	—	—	—	—	—	—	—	—	×				
76 Dorypyge horrida Matthew	—	—	—	—	—	—	—	—	—	×				
77 Dorypyge quadriceps valida Matthew	—	—	—	—	—	—	—	—	—	×				
78 Dorypyge wasatchensis acadica Matthew	—	—	—	—	—	—	—	—	—	×				

Table M. (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Trilobita (cont.)														
79 Harttella matthewi (Hartt)	—	—	×	—	—	—	—	×						
80 Harttella matthewi gemminispinosus Matthew	—	—	—	—	—	—	—	×						
81 Harttella matthewi hispidus Matthew	—	—	—	—	—	—	—	×						
82 Harttella matthewi perhispidus Matthew	—	—	—	—	—	×								
83 Hartshillia inflata (Hicks)	—	—	—	—	×									
84 Holocephalina primordialis Salter	—	—	—	—	×									
85 Liostracus globiceps jaculator Howell	—	—	—	×										
86 Liostracus ouangondianus (Hartt)	cf	cf	×	—	—	×								
87 Liostracus ouangondianus aurora Matthew	—	—	—	—	—	—	—	×						
88 Liostracus ouangondianus emarginatus Matthew	—	—	—	—	—	—	—	×						
89 Liostracus ouangondianus gibbus Matthew	—	—	—	—	—	×								
90 Liostracus ouangondianus planus Matthew	—	—	—	—	—	×								
91 Liostracus tener (Hartt)	—	—	×	×	×									
92 Liostracus tener acuminatus Matthew	—	—	—	—	—	—	—	×						
93 Liostracus tener lævis Matthew	—	—	—	—	—	—	—	—	—	×				
94 Liostracus validus Matthew	—	—	—	—	—	—	—	—	—	×				
95 Microdiscus (Eodiscus) præcursor Matthew	—	—	—	—	—	—	—	×						
96 Microdiscus (Eodiscus) pulchellus (Hartt)	—	—	—	—	—	—	—	—	—	×				
97 Microdiscus (Eodiscus) punctatus Salter	—	—	—	×	×									
98 Microdiscus (Goniodiscus) dawsoni Hartt	—	×	—	—	—	×								
99 Paradoxides abenacus Matthew	—	—	—	cf	—	—	—	—	—	×				

Table M. (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Trilobita (cont.)														
100 Paradoxides acadicus Matthew	—	—	—	—	—	—	—	×						
101 Paradoxides acadicus suricus Matthew	—	—	—	—	—	—	—	×						
102 Paradoxides bennetti Salter	×	×	×	?										
103 Paradoxides davidis Hicks	—	—	—	—	×									
104 Paradoxides eteminicus Matthew	—	×	×	?	—	—	—	×						
105 Paradoxides eteminicus breviatus Matthew	—	—	—	—	—	—	—	×						
106 Paradoxides eteminicus malicitus Matthew	—	—	—	—	—	—	—	×						
107 Paradoxides eteminicus quacoensis Matthew	—	—	—	—	—	—	—	×						
108 Paradoxides eteminicus suricoides Matthew	—	—	—	—	—	—	—	×						
109 Paradoxides forchhammeri Angelin	—	—	—	—	—	—	—	—	—	—	—	—	?	
110 Paradoxides hicksi Salter	—	—	—	×										
111 Paradoxides lamellatus Hartt	—	—	×	—	—	×								
112 Paradoxides lamellatus loricatus Matthew	—	—	—	—	—	—	—	×						
113 Paradoxides regina Matthew	—	—	—	—	—	—	—	×						
114 Paradoxides rugulosus Corda	—	—	—	—	×									
115 Ptychoparia adamsi Billings	—	—	—	—	—	—	—	—	—	×				

Table M. (*Concluded*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Trilobita (cont.)														
116 Ptychoparia linnarssoni Brögger	—	—	—	—	—	—	—	—	—	×				
117 Ptychoparia linnarssoni alata Matthew	—	—	—	—	—	—	—	—	—	×				
118 Ptychoparia limbata Matthew	—	—	—	—	—	—	—	—	—	×				
119 Ptychoparia rogersi (Walcott)	cf													
120 Solenopleura acadica Whiteaves	—	—	—	—	—	—	—	—	—	×				
121 Solenopleura acadica elongata Matthew	—	—	—	—	—	—	—	—	—	×				
122 Solenopleura arenosa Billings	—	—	—	—	—	—	—	—	—	×				
123 Solenopleura applanata (Salter)	—	—	—	cf	cf									
124 Solenopleura communis Billings	—	—	—	—	×									
125 Solenopleura robbi (Hartt)	—	—	—	—	—	—	—	×						
126 Solenopleura robbi orestes (Hartt)	—	—	—	—	—	—	—	×						
127 Solenopleura robbi parva Matthew	—	—	—	—	—	—	—	—	—	×				
128 Solenopleura variolaris Salter	—	—	—	—	×									
Ostracoda														
Beyrichona triceps Matthew	—	—	—	—	—	—	—	—	—	=	—	—	×	
Leperditia curta Matthew	—	—	—	—	—	—	—	—	×					

the Acadian beds, which, as we have seen, lie disconformably upon the *Catadoxides* beds of the Hanfordian have a total thickness of 302 ft. and they have been divided by Howell into 3 zones as follows in descending order.

3. Zone of *Paradoxides davidis* (Beds 93-125) Kellegrew Brook formation 31 ft.
2. Zone of *Paradoxides hicksi* (Beds 36-92) Long Pond Formation 37 ft.
1. Zone of *Paradoxides bennetti.* (Beds 1-35) Chamberlains Brook formation 234 ft.

The zone of *Paradoxides forchhammeri* is entirely wanting in this section, the Upper Cambrian beds with *Agnostus pisiformis*, which occur some 30 ft. above the highest layer with *Paradoxides davidis*, terminating this part of the section. The lower part of this intervening series appears to be barren, but just below the top, a few fossils have been found which suggest the possibility that the beds separating the highest *P. davidis* layer, (Bed 125) from the *Agnostus pisiformis* bed may represent either or both of the zones of *P. forchhammeri* and *Agnostus laevigatus*. Walcott considered that Bed 125 represents a basal conglomerate varying from 2-6 inches in thickness and containing many dark argillaceous concretions, also pebbles of a reddish siliceous rock. This narrow band of conglomerate, which is found on both sides of the river, is taken by Walcott as the base of the Upper Cambrian.

Howell rather questions this interpretation because he says "Many of the pebbles, concretions or whatever they may be that occur in it, appear to show by their shapes and positions that they could not have been rolled into place" (*Loc. cit.* p. 63). The bed in question marks the dividing line "between the fossiliferous shales of the *Paradoxides davidis* zone and the superjacent barren measures of unknown age."

The only fossils from bed 125 occur in the masses of phosphatic material, not in the surrounding matrix and hence "it is possible that the phosphatic masses of this bed are really fragments of older deposits." (*Loc. cit.*)

Whether the true conglomeritic nature of these beds is established or not, there can be little question that a hiatus exists between the Middle and Upper Cambrian beds of this section.

The very detailed analysis to which Howell has subjected these beds, gives us an excellent record of the range of the faunas. It is true that Howell has come to the conclusion that he has "discerned no good evidence of subaereal erosion in any part of the Paradoxides section at Manuels."

"The varied character of the sediments involved" he continues "proves that the condition of deposition changed from time to time, some of the beds, such as the phosphatic ones at the base and summit, may possibly indicate some sort of stratigraphical break, for some or all of their phosphatic bodies may really be pebbles that have been rolled into place, but no good evidence of the erosion of any bed after its consolidation has been found, nor have any suncracks or indubitable ripple-marks been discovered" (*Loc. cit.* p. 62). Howell considers that the suggestion of ripple-marks is due to the unevenness of the upper and lower surfaces, caused by the development of a nodular structure. He finds such evidence in beds 1, 4, 21, 24 and 27.

In considering the various beds of this section and their faunas somewhat in detail, it is perhaps possible to make a slightly more detailed subdivision. Thus while *Paradoxides bennetti* Salter runs through the entire 237½ ft. of his Bennetti zone (beds 1-35), and is only questionably represented in the next higher bed, we find that it is present alone only in the lower 139 ft. and 7 inches, that is in his beds 1-18 or to be more exact in beds 1-13 which aggregate 31 ft. and 7 inches. Bed 13 contains many black, probably, phosphatic nodules in some of the beds, and lenses of uneven upper and lower surfaces usually from 1-4 ft. or more broad and from a few inches to 1 ft. thick. The faunas of beds 1-18 (chiefly 1-13) are listed in Col. 1 of Table M. Bed 14, 2 ft. thick has furnished no fossils. Bed 15, 40 ft. thick is very poor in fossils, containing an undetermined species of *Paradoxides* (rare) *Liostracus* cf. *ouangondianus* which here makes its first appearance and an undetermined Hyolithid, all of them rare. Bed 16, which is 11 ft. thick contains no fossils, while bed 17 which is 15 ft. thick has only furnished *Liostracus* cf. *ouangondianus* (Hartt,) which is rare. Again Bed 18, which is 40 ft. thick has furnished no fossils. Thus we have here a group of beds 14 to 18 with an aggregate thickness of 108 ft. which are mostly unfossiliferous, the only significant species being *Liostracus* cf. *ouangondianus* which is a new arrival in this region.

Bed 19, 4 ft. and 5 inches thick, is again fossiliferous and consists of 2 beds of tough nodular shaly limestone enclosed between, as well as separated by, 6 inch beds of bluish gray shale. *Paradoxides bennetti* is again common, but with it *Paradoxides* cf. *eteminicus* Matthew makes it first appearance and is common. Another common form is *Liostracus* cf. *ouangondianus* (Hartt,) while *Conocoryphe bullata* Howell and *Goniodiscus dawsoni* (Hartt) make their first and last appearance here. The other fossils too are rare. They are listed in Col. 2 of table M.

The next succeeding bed (No. 20) with a thickness of 82 ft. appears to be again unfossiliferous and consists of alternating greenish gray and bluish gray shales. These beds separate bed 19 which may be called *P. bennetti eteminicus* zone from the next succeeding division beds 21-35 which is again markedly fossiliferous and has an aggregate thickness of 11 ft. 6 inches, Both *P. bennetti* and *P. eteminicus* continue, but in Bed 21, which is only 7 inches thick *Paradoxides lamellatus* makes its first and last appearance in this section. This may then be called the *P. bennetti eteminicus lamellatus* zone.

The other fossils associated with this are

Liostracus cf. *ouangondianus* (Hartt) (rare)
Harttella matthewi (Hartt) common and first appearance
Lingulella ferruginea Salter (rare)
Acrothele sp.
Acrotreta cf. *gemmula* Matthew (rare, first appearance)
Micromitra (*Iphidella*) cf. *ornatella* (Linnarsson) first and only appearance in this bed.
Stenotheca sp.

The bed is a tough nodular gray limestone with uneven upper and lower surfaces, which Howell thinks are probably due to the nodular character of the bed and not to erosion. Scattered crystals of iron pyrites occur.

The first 2 species continue into bed 22, which is one inch thick, but *P. lamellatus* does not occur again. On the other hand, in the next succeeding bed No. 23, which is 8 inches thick *Paradoxides parvoculus* Howell makes its first appearance. Its last recorded occurrence is in bed 26. We have thus a new combination which continues for 2 ft. and 4 inches, and may be called the *P. bennetti eteminicus-parvoculus* zone.

P. bennetti and *P. eteminicus* continue to bed 35, when both disappear, although the former is no longer represented by positively identified individuals in beds 33-35, which occupy the upper 2½ ft. of this division. Again *P. bennetti* is doubtfully recorded from bed 41. They are replaced by the new zone fossil *Paradoxides hicksi.* In Col. 3 of Table M are given the fossils recorded from beds 21 to 35. The next succeeding series of 37 ft. constitutes the *P. hicksi* zone of Howell.

As touching on the question of abrupt faunal change, we may here note that the typical last occurrence of *Paradoxides bennetti* is in bed 32, where it is associated with *P. eteminicus* which extends to the top of Bed 35, when it disappears, being followed by 1½ inches of unctuous white shale covered by ½ inch of soft blue shale. This bed contains no fossils, but is followed immediately by beds with *Paradoxides hicksi.* We should however note, that after the normal disappearance of *Paradoxides bennetti* fragments doubtfully identified with it occur in the succeeding 2½ feet of limestones. Such fragments have been found as high as bed 41, some 9 ft. above the point of last appearance, and about 6½ ft. above the base of the *P. hicksi* zone. In like manner rare fragments doubtfully identified as *P. eteminicus* occur in bed 49, more than 9 ft. above the base of the *P. hicksi* zone or the top of the last normal occurrence of *P. eteminicus.* These fragmentary occurrences need not necessarilly be explained as the continuance of the species, but might very well indicate broken fragments from the older horizons included in the newer ones. If that is the case they serve to indicate the existence of a hiatus, between the Bennetti and the Hicksi zones. That the two faunas are on the whole distinct, is shown by the fact that out of the 27 species recorded from it, 4 or about 15 per cent come up from below. One of these is the wide-ranging *Lingulella ferruginea*. Of the others *Liostracus tener*, abundant in the upper part of the Bennetti zone, recurs in beds 38 to 40, thus extending for about 6 ft. into the Hicksi zone, which is as far as the fragments of *P. bennetti* extend above the last normal occurrence of the species. The same thing may be said of the next species, *Conocoryphe elegans*, which recurs in beds 40 and 41, that is beds which Howell has called the transition zone. The third species of trilobite *Agnostus granulatus*, must be considered a persistent type, since, it not only occurs in various beds of the Hicksi zone, but continues into the Davidis zone. Thus there are 2 wide-ranging forms and 2 trilobites which extend only into the so-called transition beds, that is beds which contain fragments of the characteristic trilobites of the underlying zone. If the interpretation, that these are reworked beds, is correct, then these trilobites may also be weathered out inclusions, though of course, there is no proof here that they are not also persistent types.

If we now summarize these lower zones, we note that *P. bennetti* is the first to make its appearance, continuing for something less than 30 ft. (See Text-Fig. 11). Then during an interval when 108 ft. of strata is deposited, this trilobite is absent, after which it appears again abruptly in bed 19, but with it appears a new form *P. eteminicus*, which is a zone fossil of the Middle Cambrian beds at New Brunswick, where *P. bennetti* does not occur, although

Howell holds that it is represented by *P. regina.* After continuing for an interval of about 4½ ft., both these trilobites disappear from the Manuel's region, while 82 ft. of barren strata are deposited.

Then they both return to continue to the end of the zone, but with them occurs an invasion of *P. lamellatus*, another New Brunswick zone fossil. This however, continues only through a bed 7 inches thick, when it is replaced by *P. parvoculus* which remains during the deposition of some 2/3 ft. of strata after which it also disappears.

With the appearance of *Paradoxides hicksi* the other species of *Paradoxides*, as we have seen, disappear, except for the sporadic occurrence of more or less indeterminable fragments. But near the Middle of the Hicksi zone, we have another abrupt incursion of a New Brunswick zone fossil namely *Paradoxides abenacus*, though in this case, the identification is only comparative. This extends through beds 51 and 52 which have a thickness of 2 ft. 4 inches.

Turning now to the *Paradoxides davidis* zone, we find that it ranges through the upper 30 ft. of this series. In the highest 4 inches it is represented only by doubtfully identified fragments. *Paradoxides hicksi* has disappeared, except for a doubtfully identified fragment in bed 101 about 9½ ft. above the base. A new form, one of the European fossils *Paradoxides rugulosus* makes its abrupt appearance in a phosphorite-bearing bed (No. 115). This bed 2 ft. 8 inches thick, has 7 species restricted to it, namely *Centropleura* (*Anopolenus*) *henrici* (Salter) *Solenopleura variolaris* (Salter) *Solenopleura communis* Billings, *Holocephalina primordialis* Salter, *Agnostus laevigatus mamilla* Matthew, *Stenotheca* cf. *cornucopia* Salter, *Hyolithes* cf. *tenuistriatus* Linrs. 4 other species have here their last appearance and only 3 *Agnosti* continue onward as do the *Paradoxides*. Of these however *P. rugulosus* disappears in the overlying pyritous shale 9 inches thick, where one of the Agnosti also disappears. It is of interest to note, that underlying this bed is a hard heavy-bedded dark-gray limy shale, full of fragments of *Paradoxides davidis*. This is bed 114, which has a thickness of 1 ft. and six inches. Below it is another bed (112) full of trilobite fragments. Do these beds mark exposure with fragmentation of the trilobites and did the renewed marine invasion bring with it the *Paradoxides rugulosus* and the 7 other new species which here appear suddenly? This possible line of interruption between Bed 114 and 115, lies 22 ft. above the base of the Davidis zone, that is above the middle of that zone. *P. davidis* itself seems to continue.

Although the leading trilobites are distinct, there is a greater similarity between the faunas of the Davidis and the Hicksi zones. Out of the 41 species listed from the zone, 13 or nearly 32 per cent, are held over from below. These are

Solenopleura cf *applanata,* characteristic up to the base of 113,

Baileyella venulosa rare in 109 and 113, but common in bed 88 of the upper Hicksi zone,

Eodiscus punctatus, widely ranging through both horizons up to 115,

Agnostus rex, rare in 109, 112, but frequent in the lower zones,

A. granulatus already referred to as a persistent form, extends to bed 110.

Agnostus cf. *acadicus declivis* extends to 115.

Agnostus cf. *parvifrons* rare only in bed 99, near the bottom of the Davidis and rare in 90 or 91, near the top of the Hicksi zone,

Agnostus laevigatus terranovicus Matthew, characteristic of the Davidis zone up to bed 115. Occurs only and that rarely in bed 90, 2 ft. below the top of the Hicksi zone

A. laevigatus ciceroides, common and rather widely ranging, in both Davidis and Hicksi zone.

Agnostus cf. *nudus*, characteristic of both zones but not extending above 110,

Lingulella ferruginea, wide-ranging through the Bennetti and the lower Hicksi zone, but occurring only as rare individuals in Bed 101 of the Davidis zone.

Acrotreta misera, typical of both zones, but not extending above bed 109.

Recalling the remarks made about the possible break between beds 114 and 115, we see that most of these forms that have come up from below do not extend beyond this point.

We may now summarize the several Paradoxides zones of the sections studied. In descending order these are

I. Bornholm. zone of *Paradoxides forchhammeri*
zone of *P. davidis* and *P. rugulosus*
zone of *P. tessini*
zone of *P. hicksi*

II. Andrarum and Oeland. Southern Sweden.
zone of *Paradoxides forchhammeri*
zone of *P. davidis* and *P. brachyrhachis*
zone of *P. tessini*

zone of *P. hicksi*
zone of *P. oelandicus* and *P. sjögreni*

III. Nuneaton Warwickshire England
zone of *P. davidis*
zone of *P. rugulosus*
zone of *P. hicksi*
zone of *P. aurora*
zone of *P. sjögreni*

IV. Comley. Shropshire England
zone of *P. davidis*
zone of *P. rugulosus*
zone of *P. intermedius*
zone of *P. groomi*

V. St. Davids, South Wales.
zone of *P. davidis*
zone of *P. hicksi*
zone of *P. aurora*
zone of *P. harknessi*

VI. Manuels, Newfoundland
zone of *P. davidis* and *P. rugulosus*
zone of *P. hicksi* and *P.* cf *abenacus*
zone of *P. parvunculus*
zone of *P. lamellatus*
zone of *P. eteminicus*
zone of *P. bennetti*

VII. St. John, New Brunswick.
zone of *P. abenacus*
zone of *P. eteminicus*
zone of *P. lamellatus*

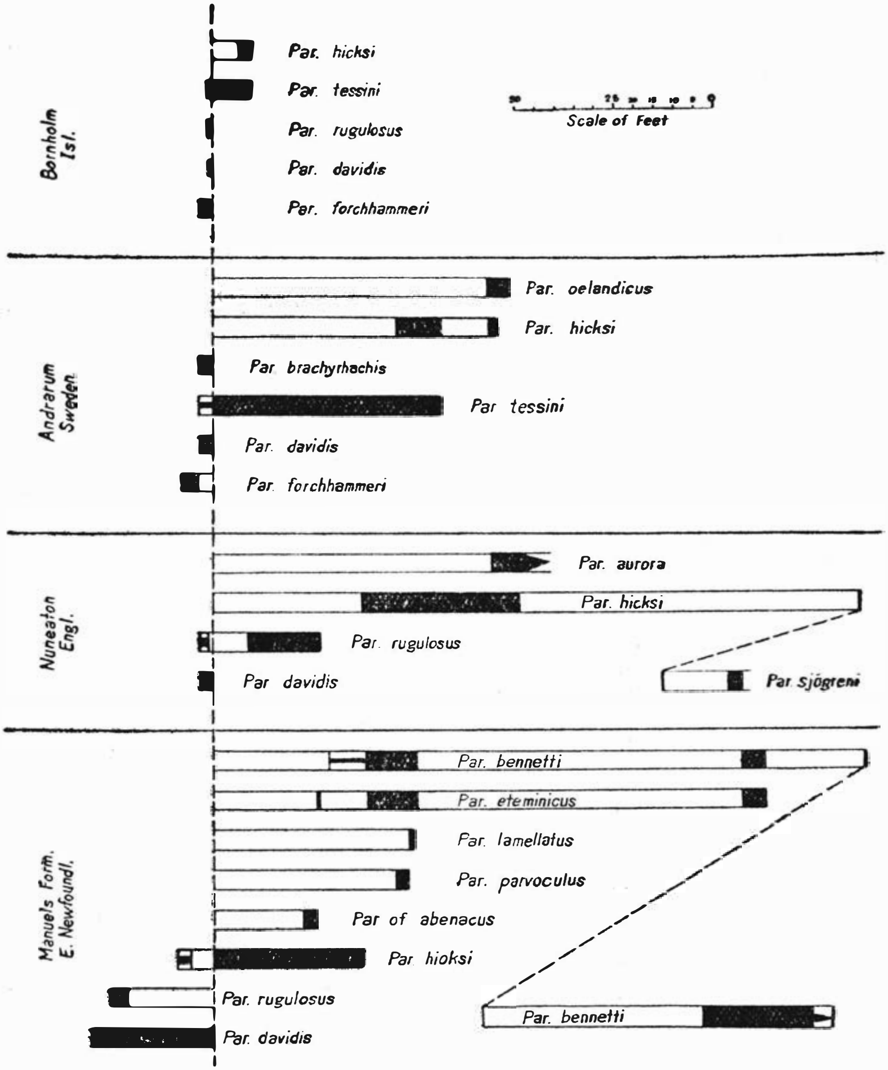
If we now compare these various zones, we see that there is considerable discrepancy, only the *Paradoxides* *davidis* zone being found in all the sections except that in New Brunswick. It has been customary to consider the 4 zones of the Swedish region as typical namely *P. oelandicus* at the base, *P. tessini*, *P. davidis*, and *P. forchhammeri*, and correlate, as best may be, the zones in the other sections with these. This practice is based on the supposition that all these sections are complete i.e. without breaks in continuity, and that therefore in each section the deposits there found represent the entire Middle Cambrian interval, except where either the lowest or *P. oelandicus* zone was missing at the base of the section as in Bornholm, or the highest *P. forchhammeri* was missing as in England or Newfoundland, though even here attempts were sometimes made to find representatives of these beds.

If however, we consider the possibility that none of these sections are complete throughout, and that in all of them we find a greater or lesser number of gaps, separating the zones, then we are not restricted to the 4 standard zones but may have twice or 3 times that number. Some of these may be present in several, others possibly only in one or two districts, being elsewhere represented by gaps due to actual emergences. For the supposition that extensive areas may remain submerged for long periods of time without sedimentation and without the invasion of the faunas found in neighbouring districts, appears to me something of a geological myth. Such conditions might be possible for a few years, but can hardly be expected to continue for centuries, and if we give the Middle Cambrian its proportionate share of the full length of Palæozoic time, we are not dealing with centuries, but with millenniums, and at the very least with several thousand of these. To assume that in such a length of time, with continuous submergence, only 4 meters of sediments can accumulate, is placing a rather heavy burden on the imagination of the geologist. It seems far more likely that such a succession represents repeated emergences for considerable time periods, generally one at the end of a zone of deposition, followed by resubmergence, with the invasion of a new fauna. That during the emergence a portion of the previous sediment should be rendered available for reincorporation in a succeeding deposit is to be expected, and this would in itself readily account for the inclusions of fragments of the larger, and more or less unbroken parts of the smaller trilobites and other organic remains of the older in the newer series. It might be profitable to keep this suggestion in mind as a working hypothesis to guide further field researches in the detailed zoning.

If we now attempt to range these successive *Paradoxides* zones in the order of their appearance, it is probable that the succession would be somewhat as follows beginning with the oldest. (See Text-Figs 11 and 12).

1. *Zone of Paradoxides oelandicus and P. sjögreni* (Text-Fig. 11). It is very probable that this is to be regarded as the oldest zone, despite its limited distribution, which as we have seen is restricted to Southern Sweden though *P. sjögreni* has been found 100 ft. below the top of the Purley shales in Nuneaton England, and that as Illing suggests, may represent this zone. There are however several hundred feet of lower strata in that section, before we come to the known Lower Cambrian and it is not impossible that an older *Paradoxides* zone may be found, or else representatives of the Hanfordian and possibly the Dugaldian.

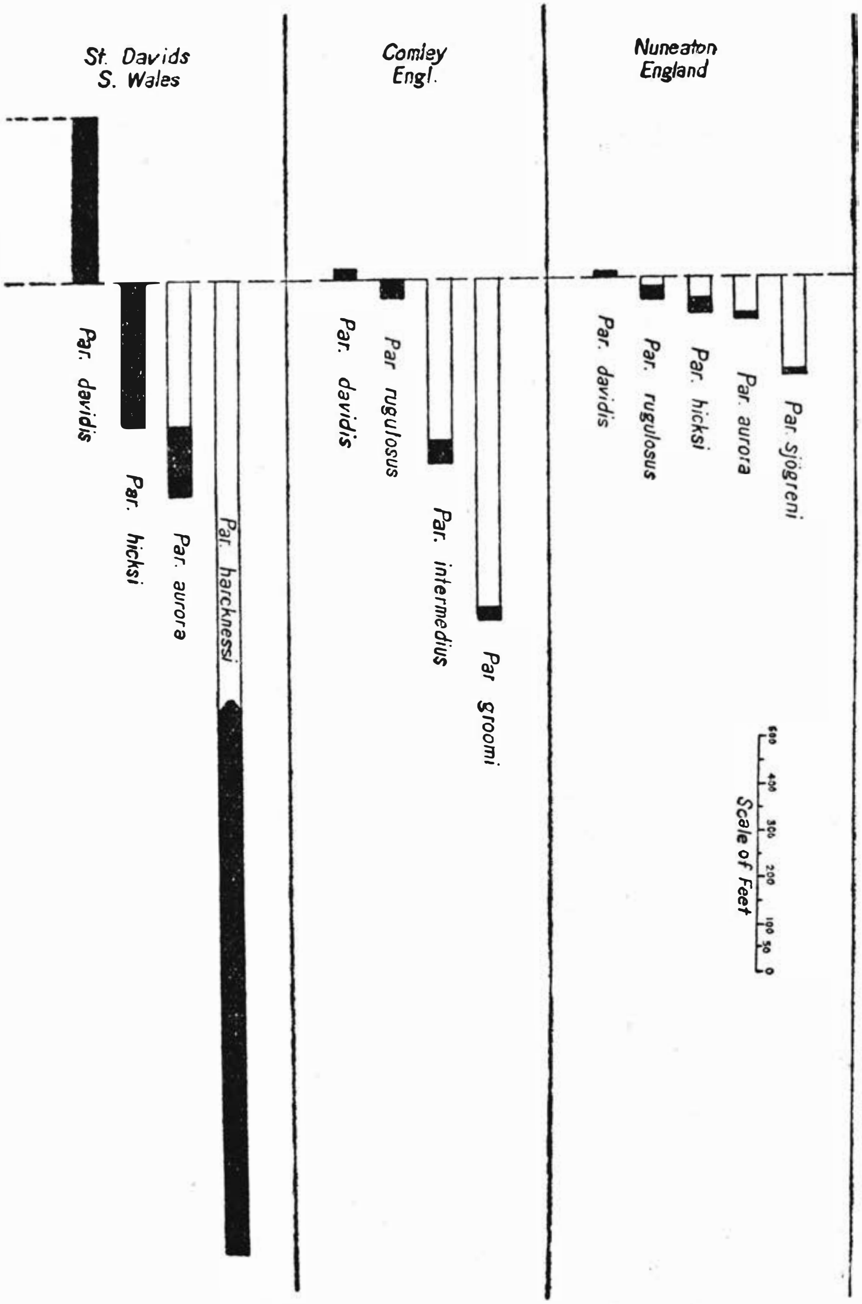
2. *The P. harknessi Zone.* (Text-Fig. 12). Although there is no section known, in which the relation of this



Text-Fig. 11. Diagrams showing in black rectangles, the relative position and the vertical ranges of the several dominant species of *Paradoxides* in the Middle Cambrian of

1. Manuels Brook New Foundland (Howell)
2. Nuneaton England (Illing)
3. Andrarum Sweden (Moberg)
4. Bornholm Isl. Denmark (Westergaard)

They are all drawn to the same scale, as given, and the reference line is the base of the *P. davidis* zone. (See Text)



Text-Fig. 12. Diagrams showing in black rectangles, the relative positions, and the ranges of the dominant species of *Paradoxides* in the Middle Cambrian of

5. St. Davids South Wales (Hicks)
6. Comley district England (Cobbold)

A different scale is used as indicated because of the greater thickness of the sections, but the Nuneaton ranges (2) are reproduced on the same scale to facilitate comparison with Fig 11. The reference as in Fig. 11, is the base of the *P. davidis* zone (For further details see Text).

to the preceding zone is shown, it is probable that this constitutes the second invading fauna, though there is no proof that it may not antedate the *P. œlandicus* zone. *P. harknessi* is the lowest zone in South Wales, (Text-Fig. 12) but though we know that it occurs in yellow sandstones of division F, 150 ft. thick, and in the succeeding 1500 ft. of gray purple and red rock (Dev. G) we do not know its zonal distribution, frequency, or state of preservation in these formations. It is quite possible that a part of the 1500 ft. of Division G of the section may represent a barren interval, which would provide room for the *P. œlandicus* zone. Again the lowest *P. harknessi* sandstone, is preceded by 1000 ft. of purple sandstone (division E) and this may represent the barren interval, equivalent to the Oelandicus zone. All that we know is that the *P. aurora* zone, occupies the next higher division (H) gray rock 150 ft. in thickness, but whether this zone follows immediately upon the Harknessi zone or is separated from it by an interval, is not known. In the Nuneaton district, the *P. aurora* zone is separated from the lowest *P. sjögreni* zone (?=Oelandicus zone) by an unknown interval of 100 ft. of shales. This may include the horizon of *P. harknessi*. But it must not be forgotten that there is also a lower zone, below the lowest zone of Nuneaton, which leaves space for the Harknessi zone. On the other hand, the striking fragment limestone of the upper Oelandicus zone of Sweden is suggestive of a long period of exposure in post-Oelandicus time, and therefore makes possible an interval for the Harknessi zone.

3. *The P. groomi Zone.* This is the lowest zone in the Comley district where the clastic beds enclosing it rest disconformably upon the *Protolenus* or older horizons. It is succeeded there by 300 ft. of shales without *Paradoxides*

and by 4 ft. of grits with *Dorypyge lakii*. Cobbold correlates this entire group of beds with the Oelandicus zone, but this is merely in deference to the prevailing opinion that the four Swedish zones represent the entire Middle Cambrian. *P. groomi* probably belongs later in the succession and it is very probable that it is younger than the *P. harknessi* zone, but it is more difficult to decide whether it belongs below or above the *P. aurora* zone, since there is nothing to guide us with certainty. There is another fact which we must not forget, namely that Illing recognized a distinct hiatus and disconformity in the lower part of his section (in A3) below the horizon in which *S. aurora* actually was found. This hiatus may have a greater significance than he was willing to assign to it, and it may indicate the place of insertion of the Groomi and the east American zones which precede the Hicksi zone. The *P. hicksi* zone follows the Aurora zone both in St. Davids and at Nuneaton. On the other hand in Newfoundland the Hicksi zone is preceded by a considerable series of beds with at least 4 other zones represented. We therefore consider that these 4 zones also fall below the Aurora horizons. I have placed them above the Groomi horizon, but that is purely tentative and due to the fact that we do not know the exact position of the *P. groomi*, with reference to the other horizons. We do know however that in the Comley district the *P. groomi* horizon is separated from the next succeeding one, with *P. intermedius* not only by 300 ft. of shales without *Paradoxides*, but also by a great hiatus and erosion interval (see *ante* p. 416 (*612*)). This gives room here for any number of additional zones.

4. *The P. bennetti Zone.* This is the lowest zone in the Manuels section of Newfoundland, where it rests dis-

conformably upon the Hanfordian. Howell correlates it with the Harknessi-Aurora and Groomi zones of Great Britain and the *P. sjögreni* zone as well, but since there are only 3 species of *Agnostus* common to the Bennetti zone and one or the other of the European zones referred to, and since only one of these *A. granulatus* Barrande is positively identified from Newfoundland, this correlation does not seem to have a very strong foundation. Moreover *A. granulatus* ranges from the Aurora to the lower Davidis zone in the Nuneaton district and occurs in the Nantpig of North Wales.

Again of the other two species mentioned, *A. exaratus tenuis*, ranges throughout the entire series from the Aurora to the upper Davidis bed in Nuneaton, while the other, *Agnostus rex*, ranges through the Aurora and both the lower and upper Hicksi beds of Nuneaton.

The only other fossil in common between the Newfoundland and British zones is *Lingulella ferruginea*, which occurs in the Rugulosus and Davidis zones of Comley and in both the Cæred and the Nantpig formations of North Wales. *Paradoxides bennetti* itself was originally described by Salter from the Newfoundland region.[1]

This trilobite occupies the lower 31½ ft. of the section, (Fig. 11) though in the first 3 ft, it is represented only questionably. After that it disappears and the next 108 ft. of strata are mostly barren except for *Liostracus* cf *ouangondianus*. After this interval *P. bennetti* appears again in bed 19, and continues for 4 ft. 9 inches, while a new form *P. eteminicus* appears at the same time. Both however again disappear in the next 82 ft, which is barren. Both then reappear in bed 21 and continue to

1 Quarterly Journal Geol. Soc. of London 1859 Vol. XV, p. 552.

the end of the zone after which they are represented by fragmentary specimens of mostly doubtful identification in the transition beds of the *P. hicksi* zone as already noted. (*ante*, p. 440 (*636*)) *P. bennetti* is not known from any other locality.

5. *P. eteminicus Zone.* This was first described from the Acadian of New Brunswick, where it forms the second zone (C1c2) being preceded by the *Paradoxides lamellatus* zone. If however, the identification of *P. eteminicus* in bed 19 is correct, then that species really precedes *P. lamellatus*, since the latter only comes in with the reappearance of *P. eteminicus* and *P. bennetti* in the Newfoundland section more than 82 ft. above the first appearance of the former.

It may of course be true that *P. lamellatus* really appeared earlier, than *P. eteminicus* as assumed by Matthew, and the fact that it only occurs in bed 21 of the Newfoundland section means that it is merely a sporadic recurrence or perhaps a left over. This species too has not been reported from other localities.

6. *Zone of P. lamellatus.* This species occupies the lowest bed (C1c1) of the Acadian series of New Brunswick and there it was found by Matthew to underlie the *P. eteminicus* zone. Though as we have seen, it really appears later than *P. eteminicus* in the Newfoundland section, but that may not be its true zonal position. If not, the order of the 2 zones should be reversed.

7. *Zone of P. parvoculus.* It is questionable whether this should be regarded as a distinct zone, since it only occupies a small interval, *i.e.*, 2 ft. 4 inches appearing immediately above the bed in which *P. lamellatus* occurs. Like that species, it is a companion of *P. eteminicus* and *P. bennetti* and it probably has not distinct zonal value.

8. *Zone of P. aurora.* This is the lowest zone in the Abbey shale of the Nuneaton district occupying division A4 above the hiatus and disconformity in A3. According to the range-table published by Illing it wholly precedes the *P. hicksi* zone though that species is also found, though rarely, in Division A4. The Aurora zone occupies about 10 feet at Nuneaton but continues through 150 feet at St. Davids.

9. *Zone of P. hicksi.* This is a very important and wide-spread zone. In St. David's South Wales, it occupies division I, which is 300 ft. thick and immediately succeeds beds with *P. aurora.* It is not known at Comley, but although it occupies less than 39 feet in the Nuneaton district it also follows the *P. aurora* zone. In Sweden it is doubtfully recorded from the "Fragment limestone," is represented by a variety in the Exsulans limestone (5.58 ft.) and occurs again in the *M. scanicus* zone (5 ft). Throughout this higher part, it is accompanied by *P. tessini.* The same relation holds true for Bornholm, where the *P. hicksi* zone is the lowest in the entire succession, occupying the Exsulan's limestone and the overlying *Agnostus parvifrons* bed. The thickness it occupies however is less than 2 ft. On the other hand *P. tessini* continues to a much higher horizon. The Hicksi zone is thus so wide-spread, occurring in all the sections except the Comley, that we must regard it as a distinct zone.

10. *Zone of Paradoxides abenacus.* This zone too was first recognized in New Brunswick, and its only other occurrence is in Newfoundland, from 13-15 1/3 ft. above the base of the Hicksi zone, which however continues beyond it. In the Newfoundland region, the identification is not wholly without doubt and it may be that here too

we have included fragments from a horizon which really belongs below the Hicksi zone.

11. *Zone of P. intermedius.* This is only known from Comley where it forms the second zone, occupying the Comley breccia bed, which is separated from all the underlying beds by a disconformity and in some cases at least by 300 ft. of strata. Cobbold correlates it with the *P. hicksi* zone and when the Comley and St. David's are compared, it is seen to fall in the upper part of the interval occupied by that form. But we do not know what zones are cut out in this great disconformity and since *P. intermedius* has so far been found only in this one section, it may well occupy the horizon between the *P. hicksi* and the next succeeding zone, which in the St. Davids and Newfoundland regions is the Davidis zone, but elsewhere the two are separated by the Tessini and the Rugulosus zones.

12. *The P. tessini Zone.* This is known only from Continental Europe, where it is typically developed in Scania and in Bornholm. In both it begins with the Exsulans limestone simultaneously with *P. hicksi* in Bornholm, but somewhat later than the first appearance of that in Scania. In the latter region, it ranges through some 60 ft. of strata, extending into the Davidis zone, where however, it is very rare, and probably represents a sporadic inclusion from the lower horizon. For as we have seen there is good reason for believing in the existence of a disconformity between the Tessini and Davidis zones.

13. *Zone of P. rugulosus.* This is typically developed in Comley and Nuneaton, in both of which localities it underlies the Davidis zone. In Nuneaton it rests on the Hicksi zone, but in Comley, it is separated by 300 ft, of

practically unfossiliferous rocks from the preceding *P. intermedius* zone. As we have seen, the Tessini zone also comes between the Hicksi and the higher zones, so it would appear that that zone belongs just below the Rugulosus horizon. It is true that in Bornholm *P. rugulosus* occurs in the Davidis horizon, and that *P. tessini* is also represented there, but if we consider that there is a hiatus between the Davidis and Tessini zone as previously suggested, we can understand that material from several lower horizons may be included secondarily in the higher zone.

In Newfoundland too the Rugulosus zone is found, its only occurrence however being in beds 115 and 116 within the Davidis zone and from 22 ft. to 25 ft. 5 inches above the base of that zone. Either then these 2 forms existed simultaneously or else the older forms inclusions in the higher beds, and this is borne out by the British section where *P. rugulosus* distinctly precedes *P. davidis*. Finally it should be said that *P. hicksi* is also reported from the Davidis bed of Newfoundland, occurring in bed 101, from 7 ft. 11 inches to 9 ft. 5 inches above the base of the Davidis zone. Since this is a questionably identified fragment, it probably represents an inclusion from below as in the case of Scania and not a recurrence. *P. rugulosus* is also a zone fossil in Spain and Montagne Noire, in France.

14. *P. davidis Zone.* This is the best characterized zone throughout all the sections occurring, as already noted, in all the northern except the incomplete New Brunswick sections. At St. Davids it occupies 350 ft. of strata and follows the Hicksi zone. At Comley, it occupies 18 inches and follows directly on the Rugulosus zone. In Nuneaton it occupies about 4 ft. and follows the Rugulosus zone

with an interval between, but *P. rugulosus* recurs in the highest 2 2/3 ft. of the Davidis zone where it is rare and may represent a secondary inclusion. In Andrarum, this zone occupies also only a few feet and lies on the Tessini zone with a sporadic recurrence of that species, probably an inclusion, and with it is associated *P. brachyrhachis*. In Bornholm it occupies less than 3/4 of a foot and appears to be associated with *P. rugulosus* and the last occurrence of *P. tessini*. Finally in Newfoundland it occupies some 30 ft. of strata and likewise contains in its upper portion what is either a recurrence or an inclusion of *P. rugulosus* and lower down probably an inclusion of *P. hicksi*. Finally as we shall see *P. davidis* is absent from the northern section (Spanish and Montagne Noire regions) and from the Polish region in the far East.

15. *Zone of P. forchhammeri*. This is widely distributed throughout the continental part of Europe being known as far east as Central Poland and even in the Siberian Basin of Russia. Throughout the Scandiavian region it is the terminal member of the series and this is true for the Montagne Noire region as well. It is however, absent from all the regions of the western border of the geosyncline, that is from all the British and east American sections, though the zone has been cited from Cape Breton where so far only the brachiopod facies has been found.

It must be clearly understood here that this arrangement into 15 zones instead of the original 4, which have always been considered as occupying the entire interval is purely tentative, and based on the assumption of discontinuous deposition and repeated invasion of the Acadian sea from the center of evolution. Whether all or even most of these zones will turn out to be valid, depends on future careful zoning, and the study of recurrent lower types in higher horizons, to determine whether or not they represent mechanically included fragments. It is therefore merely suggested as a guide for future research.

Other Localities in the Caledonian Geosyncline

Having reviewed the important sections in which zonal arrangement of the species of *Paradoxides* is recognized, we may briefly note the more or less incomplete or inadequately studied Middle Cambrian sections, in other parts of this geosyncline. (See Plate II b.).

Eastern Massachusetts. In the Braintree region south of Boston, *Paradoxides* has long been known from the Hayward quarry,[1] this being the first *Paradoxides* found in America. The rocks consist of a series of greenish argillites often interbedded with reddish slates and not infrequently intruded by granite. The thickness, though considerable, is unknown, since the beds are all much disturbed and neither basal nor upper contacts are known. The fossils so far obtained from these beds are the following

Paradoxides harlani Green
Paradoxides haywardi Raymond
Ptychoparia rogersi (Walcott)
Agraulos quadrangularis (Whitfield)
Agnostus cf. *rex* (Barrande)
Acrothele gamagei (Hobbs)
Hyolithes shaleri (Walcott)
Hyolithes? haywardensis Grabau

1 See Grabau. Cambrian Terranes or the Boston Basin. Occasional Papers of the Boston Society of Natural History, Vol. IV part 3, pp. 601-604, pls. 31-38

P. harlani has been thought to be allied to *P. bennetti*, and it is with the lower part of this zone that Howell correlates these beds. There are two species in common between the Braintree fauna and that of *P. bennetti*, namely *Ptychoparia rogersi* (Walcott) and *Agnostus* cf. *rex* (Barrande). Howell thinks that *P. bennetti* & *P. harlani* are closely related if not identical. Still it appears from Salter's figure of the type, and from his description that *P. bennetti* is a much broader form, and if the two are distinct, as I am inclined to think they are, we may perhaps have another zone represented by the Braintree slates. They mark the south-western-most extension of the *Paradoxides* beds on the Atlantic coast.

Iberian Peninsula. Middle Cambrian beds appear to be wide-spread over Spain and Portugal, extending into southern France, where they are known from the Montagne Noire.

Neither Lower nor Upper Cambrian seems to be present, but only the Acadian *Paradoxides* beds. One of the best developments is in the Province of Aragon, in northeastern Spain, where outcrops in the vicinity of the village of Murero and on the Jiloca River, south of the Ebro, (approximate Long. 1° 30′ W, Lat 41°, 30′ N.) give a nearly continuous succession. The strata here are inclined but not strongly faulted or folded.[1]

The section in descending order is as follows.

Superformation Tertiary beds.

Hiatus and Unconformity

Cambrian beds.

13. Unfossiliferous shales, passing in their upper part into the Grés Armoricain 300 m

1 Douvillé R. La Peninsula Iberique. Handbuch der Regionalen Geologie. Heft. VII, (Vol. III, pt. 3) pp. 9, 10, Fig. 7. 1911 (?)

12.	Shales with some sandstone beds and beds with *Scolithes* and *Tigillites*	50 m
11.	Fissile shales. Unctuous to the touch, non-fossiliferous	20 m
10.	Green shales, with large *Paradoxides*	25 m
9.	Unfossiliferous shales, with beds of dolomitic limestone ?	10 m
8.	Green sandy shales, ferruginous and non-fossiliferous	6 m
7.	Very ferruginous shales, with strongly sandy beds passing into sandstones without fossils	15-20 m
6.	Reddish shales, more or less ferruginous	15 m
5.	More strongly red-coloured beds, with small ferruginous layers	10 m
4.	Greenish argillaceous shales, with spots of red, fossiliferous	20 m
3.	Green and grayish shales, with quartzite bed, non-fossiliferous	10 m
2.	Marly shales, ferruginous and non-fossiliferous	8 m
1.	Greenish shales, with *Paradoxides*	15 m

The base of the section is not shown nor is it known what the underlying strata are. Again, there is no clear indication in the recorded section where the upper border of the Acadian is to be drawn. In any case above Division 10 the beds appear to be of continental type, this indicating the retreat of the sea. Continental sedimentation probably continued to Lower Ordovician time, the sea returning early in Lower Ordovician time, as shown by the fossiliferous members of the Armoricain sandstone.

The Middle Cambrian fossils apparently all belong to one zone that of *P. rugulosus*, or, if there are several zones present, they have not been differentiated. The following are the characteristic species.

1. *Paradoxides rugulosus* Corda, Very abundant
2. *Paradoxides pradoanus* Barrande
3. *Conocoryphe sulzeri* Schloth.
4. *Conocoryphe heberti* Munier-Chalmas et Bergeron, very abundant
5. *Conocorype coronata* Barrande
6. *Solenopleura riberoi* Barrande
7. *Solenopleura* cf. *rouairouxi* Munier-Chalmas et Bergeron
8. *Agnostus sallesi* M-Ch. et Berg.

The same fauna has been found in other parts of Spain, *i. e.* in the Toledo Mountains in the province of Ciudad-Real in South Central Spain; in the Province of Leon and the Asturias in northwest Spain, and in the Cantabrian Mountains. From none of these localitites however is a detailed section available. The locality at Villa Boim in eastern Portugal has already been referred to (*ante* p. 93, (*119*)). No section is available, but the list of fossils quoted by Walcott contains, as already noted, a curious mixture of Middle and apparently Lower Cambrian fossils, which means that the collections were not kept distinct. The identifications of the trilobites probably need revision.

Montagne Noire, France. The southern extension of the Central Plateau of France (Long 2-3^0 E, Lat 43^0 25′ N) which rises through a mantle of younger deposits, has the general character of 2 anticlines, in the centers of which the crystallines are exposed by erosion. One of these is Montagne Noire. The older Cambrian here has been thought to be affected to some extent by the metamorphism, so that it has been held that towards the centers of the anticlines the Cambrian slates grade into mica schists, and the limestones into epidote and amphibole rocks.

The thickness of the Cambrian beds appears to be very great, the estimates being 2000 meters. The lower beds are chiefly continental sandstones but locally with *Kutorgina*. They probably represent the Lower Cambrian. The higher beds underlying the Tremadoc shales are unfossiliferous Upper Cambrian sandstones. Between the two are marine Middle Cambrian beds, and these in descending order comprise the following:

C. Upper Shales with:
Paradoxides cf. *forchhammeri*
Liostracus cf. *linnarssoni*
Solenopleura cannati
Agraulos difformis
and others

B. Middle Shales, Yellow and violet, with:
Paradoxides mediterraneus Pomp.
Paradoxides cf. *pradoanus*
Conocoryphe coronata
Conocoryphe heberti
Conocoryphe levyi
Solenopleura ribeiroi
Agnostus sallesi
Agnostus cf. *glandiformis*
Trochocystites bohemicus
Trochocystites barrandii
and others

A. Lower dark limestones with
Paradoxides rouvillii
Conocoryphe coronata
Conocoryphe heberti
Holocephalina holocephala
Solenopleura cf. *ribeiroi*
Liostracus couloumanus
Agraulos ceticephalus
Agraulos longicephalus
Corynexochus delagei
Microdiscus cf. *sculptus*
and others

It thus appears that both the *Paradoxides forchhammeri* and the *P. rugulosus* beds are here represented, but the *Paradoxides davidis* beds seem not to be present, unless indeed the Rugulosus bed represent them. Some of the leading species of the *P. rugulosus* zone are also found in the beds of that zone in Aragon, and elsewhere in Spain, as comparison with the list on p. 461 (*657*) will show.

Sardinia. The Cambrian beds of the Island of Sardinia are a part of the deposits formed in the old Mediterranean extension of the Caledonian geosyncline, the same extension in which the Cambrian of Spain and Montaigne Noire were deposited, while in the extreme end of this extension the Cambrian beds of Syria were formed. We have here thus a Mediterranean arm from the Caledonian geosyncline, which probably was the forerunner of the Tethys of the later geological periods.

The age of the Sardinian deposits has long been in doubt and it has been a general custom to refer them to the Lower Cambrian. They comprise a series of argillutites rich in trilobites, alternating with quartzose sandstones, and dark limestones. Some of the sandstones are unfossiliferous and strongly cross-bedded and are regarded as beach or dune formations, while others show their true beach character by the occurrence of trilobite shields, *Lingula* shells and *Archæocyathids*, spread out in a manner closely comparable to the conditions seen on modern flat sandy beaches.

The argillaceous beds abound in trilobites the early stages of which are often abundantly represented. First among these in point of importance, is the genus *Olenopsis*. (*O. zoppii* Meneghini, *O. bornemanni* Meneg., *O. micruroides*. Bornemann, *O. longispinatus* Born.)

The genus *Conocephalus* is represented by 5 species, and another remarkable trilobite is the genus *Metadoxides*, with which the *Catadoxides* of the Hanfordian of Newfoundland was once identified.[1] The original locality from which Bornemann and Meneghini described these Sardinian fossils was at Iglesias and Canalgrande. According to Bornemann the succession at Canalgrande is as follows in descending order.

4. Sandstones with trilobites (*Giordanella*) and *Archæocyathus*.
3. Extensive alternations of sandstones, with *Olenopsis*, *Metadoxides* and other trilobites and limestones with *Archæocyathus* and *Coscinocyathus*, with *Lingula* shales and coarse sandstones with *Cruziana* or *Bilobites*.

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1 Bornemann. Die Versteinerungen des Cambrischen Schichtensystems der Insel Sardinien. Nova Acta d. Kaiserlich-Leopoldisch-Carolisch-Deutschen Akademie der Naturforscher, Bd. L1, No. 1, 1886, Bd. LVI, No. 3, 1891

2. Massive limestone beds.
1. Alternating layers rich in trilobites and quartzitic sandstone with sponge remains, also dark limestones.

From several of these strata Meneghini and Bornemann described fragments of *Paradoxides* among them *P. gennari* Men. and *P. bifidus* Born. which Pompeckj regards as perhaps belonging to the group of *Paradoxides rugulosus*. Another species described by Bornemann is *P. asper*, the generic position of which is questioned by Pompeckj, though he thinks that if it is a *Paradoxides*, it is probably referable to the group of *P. spinosus* Boeck. The exact position of the *Paradoxides* in the stratigraphic series of the Sardinian Cambrian is still in doubt, but Pompeckj holds that they could only come from horizons 1 or 3 of Bornemann, or possibly from both, which would place these beds in the Middle Cambrian instead of the Lower as originally assumed. The sandstones of division 4, with *Archæocyathus* and *Giordanalla* were referred by Frech to the Tremadoc, since *Giordanella* resembles *Angelina*, a typical Welsh Tremadoc form.

Recently Pompeckj has described some additional Cambrian trilobites from a new locality, La Cabitza, which lies about 30 km E of Canalgrande, but only about 5 km S.E. of Iglesias.[1] The rocks here are steeply inclined and are vari-colored fossiliferous shales ranging from violet or claret color to yellow or ochre when weathered. From these beds he has described the following species.

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1 G.F. Pompeckj. Versteinerungen der Paradoxides Stufe von La Cabitza in Sardinien, und Bemerkungen zur Gliederung des Sardinischen Cambrium. Zeitschrift der Deutch. Geol. Gesellschaft, Bd. 53, 1901, pp. 1-23.

Paradoxides mediterraneus Pomp. (of *P. rugulosus* group)
Conocoryphe heberti Mun.-Chalm. et J. Berg.
Conocoryphe levyi Mun.-Chalm. et J. Berg.
Ptychoparia sp.

The close similarity of this small assemblage to the Rugulosus fauna of Montagne Noire is evident and emphasizes the fact that both belong to the same basin of deposition. Pompeckj has regrouped the trilobite faunas of Sardinia in the following manner.

Division C. Fauna with *Giordanella dilatata* Bornemann, *Anomocare arenivagum* Menegh. and *Archæocyathus ichnusæ*.

Division B. Fauna with *Olenopsis* and *Metadoxides* and (?) *Paradoxides asper* etc.

Division A. Fauna with *Paradoxides mediterraneus*, *Conocoryphe heberti* and *C. levyi* (La Cabitza fauna)

Pompeckj would put all these divisions, even division C, into the Middle Cambrian. His reason for placing the higher division in the Middle Cambrian rather than the Tremadoc is first, the entire faunal distinctness from that of the Tremadoc of Montagne Noire, and secondly the presence of *Anomocare* and the fact that *Giordanella dilatata* is a close relative of *Anomocare*. This highest fauna may then represent the Forchhammeri horizon.

It is still a matter of some uncertainty whether the rich Archæocyathid fauna described by Bornemann from Sardinia occurs in beds alternating with or in those overlying the Cambrian faunas. The stratigraphy of Canalgrande is involved because of disturbances, and unfortunately the outcrops are no longer accessible and no one appears to have studied the section since Bornemann's time. I have repeatedly expressed the opinion that the age of the Archæocyathid beds might be post-Cambrian, for the fact that the same species occur in Siberia (Torgoshino limestone) and South Australia, makes the question of distribution one of great difficulty, if they are of Cambrian age, whereas if they belong to the Tremadoc or early Ordovician, their distribution offers no difficulty. At present no final answer can be given to this question.

Syria. The ultimate extension of the Middle Cambrian sea in the Mediterranean region is found on the side of Wadi Saramudj in the Wadi el Araba district of Arabia Petraia, about midway between the Dead Sea and the Gulf of Akaba. (approximately Long. 35^0 30′ E, and between Lat 30^0 and 31^0 N.) Here a formation of red sandstones lies discordantly upon the pre-Cambrian volcanic and other sediments, with a maximum thickness of about 240 meters. The base of the series consists of conglomerates and coarse rubble rock in which the blocks are fragments of the old crystallines but little worn, giving the aspect as if they were formed at the foot of a cliff.[1] Above these are red sandstones of uniform character and regular horizontal bedding with occasional layers of thin pebble bands and layers of magnetite grains. These beds are followed by red and green-gray marls 14 meters thick, and these pass upward into a series of hard dolomitic limestones, dolomites, siliceous limestones, and quartzites, from 50 to 60 meters in thickness. There are occasionally coarse oolite grains, and in some of the layers more or less silicified shells of brachiopods (*Siphonotreta*) and Hyolythids are found. In some sections fragments of large

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1 Can this be an old ground-moraine? See the position on the map. Plate II.

trilobites have been found, which suggest *Paradoxides*. Others suggest the occurrence of *Ptychoparia*. Of interest is the presence of copper in these deposits.

While this is suggestive, the identification of the fossils is by no means sufficiently accurate to determine the age of these beds as Middle Cambrian. Indeed, it is not even certain that the beds are Cambrian at all. In any case, they mark a temporary invasion of the sea after a long period of purely continental (possibly in part glacial) deposition.

The Bohemian Basin. The classical section for the Cambrian of the continent of Europe in central Bohemia, presents still many puzzling questions, especially in regard to the degree of the completeness of the sections and the relation of the several parts to the more northerly development.

Although the thickness of the series is equal to, if not greater than, any other found on the continent of Europe, the fact remains that the greater part of the series is composed of non-marine sediments. Frequently a portion of these have been placed in the Lower Cambrian but there is no convincing palæontological proof that either the Lower Cambrian or the early Middle Cambrian (Dugaldian and Hanfordian) are present.

The most complete succession is found in the vicinity of Przibram in Central Bohemia, about 35 miles S. W. of Prague, (Approximately Long. 14^0 E, Lat 49^0 40′ N.) The succession according to Kettner[1] is as follows in descending order.

1 Bull International du L'Academie des Sciences de Boheme, Prague 1915. Sbornik Statniho, Géologickeho, Ustavu Ceskoslovenske, Republiky. Prague. Vol, III, 1923. French summary. Vol. V. 1925 (see table p. 48). Summarized by Bubnoff, Geologie von Europa 1930, Vol. II, part I, p. 436.

Upper Cambrian. Cγ

Cγ *Brezove Hory* conglomerates 400-500 meters

Similar to the conglomerates of Cα4 but containing fragments of the underlying Jince shales. Interbedded are siliceous shales of oolitic structure. Northward the thickness decreases to 200 meters.

Middle Cambrian. Cβ

Cβ *Jince Shales* 200-250 meters

Gray-green shales, which in the type region show little bedding structure and contain the famous Primordial Fauna of Barrande. Southward this division dwindles to 80-120 meters. The bedding becomes more pronounced and sandstone beds are intercalated while the shales become unfossiliferous.

Recently the following zones have been established in this series: in descending order.[1]

5. Zone of *Lingulella walcotti*
4. Zone of *Ellipsocephalus hoffi*
3. Zone of *Paradoxides bohemicus*
2. Zone of *Stromatocystites pentangularis* and *Paradoxides spinosus*
1. Zone of *Paradoxides rugulosus*

For list of species see Table VII

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1 Kettner, R. Deux excursions dans d'Algonkien et le Cambrien de la Boheme. Zvlastni Otisk z. Vestniku Statniho Geolog. Ust. Cesk. Rep. VII, 3, 1931, p. 39.

Lower Cambrian Przibram Series C*a* (in part probably continental Middle Cambrian)

C*a*4 *Tremosna conglomerates* 175-300 meters.

Predominantly light-coloured, very hard conglomerates with white quartz pebbles and quartz-sand cement. Near Przibram, where the thickness is reduced to 130 meters, it is occasionally of reddish colour. (Svatahora facies) possibly equivalent in part to the Milec conglomerates farther Northwest.

C*a*3 *Sadek-Bohutin* graywacks 500-600 meters.

Reddish, greenish and gray sandstones, alternating with clay shales. Cross-bedding is common, and so are ripple-marks and mud-cracks. Siliceous shales and conglomeratic graywacks form a definite horizon in this series. The greatest thickness is at Przibram, thinning away in all directions to 300 meters.

C*a*2 *Hlubos conglomerate* 350-500 meters

Chiefly with quartzite and liddite pebbles, embedded in a reddish ground mass. The greatest thickness is N. E. of Przibram. Towards the Northwest they decrease to 150 or even 60 meters. Southwestward they pass into quartz sandstone and conglomerates and cannot easily be distinguished from the overlying or underlying formations.

C*a*1 *Zitec conglomerate* 20-100 meters.

Variable conglomerates of greenish colour, with chloritic cement. They contain pebbles of nearly all the rocks of the Algonkian (Sinian), and granite and gneiss fragments as well.

The source of the sediments evidently was in the Old-Land to the south and east of Przibram, and the overlap is towards the Northwest. Also in the northwest, the marine transgression reached earlier, as is shown from the sections in the departments of Skrej and Tejrovice[1].

The succession here is as follows in descending order.

$C\beta'3$ VOSNIK CONGLOMERATE

Complex conglomerate, with many varieties of pebbles, only found at Tejrovice.

$C\beta'2$ SKREJE PARADOXIDES SHALES.

Gray-green shales, sometimes sandy in the lower part. The fauna is very rich, containing

Paradoxides 7 species.

(Including *P. spinosus*, *P. rotundatus* etc.)

Agnostus many species

(including *A. nudus* and *A. bibullatus*)

Conocoryphe 2 species.

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1 Pompeckj, Die Fauna des Kambriums von Tejrovice und Skrej in Böhmen. Jahrbuch der Geologischen Reichsanstalt (Bundesanstalt) Vienna, Vol. 45. 1895.

Kettner R. La Géologie du Cambrien de Skreje et de Tejrovice, et des terrains environants. With Geol. map. Sborni Statniho geologickeho Ustavu Ceskoslovenské Republiky. Vol. III, 1923 French Summary p. 52-63.

Ptychoparia several species including *Pt striata* and *Pt marginata*
Solenopleura 2 species
Agraulos 2 species
Ellipsocephalus 3 species
Sao hirsuta
Trochocistides etc.
Acrothele, *Acrotrata*, *Orthis* etc.

According to Pompeckj the relationships are most pronounced with the Middle Cambrian of Scandinavia and England, even more so than with the corresponding beds of Southern France. He correlates these beds with the *P. tessini* and *P. davidis* zones, *i.e.* the Menevian of England.

Cβ'1 TEJROVICE SANDSTONES and conglomerates underlain by brownish-gray graywacks with an abundance of *Billingsella romingeri*. The fauna comprises:

Trilobites
Paradoxides sp.
**Ptychoparia* cf. *striata* Emmr.
Ptychoparia emmrichi Barr.
**Ptychoparia* cf. *marginata* Pomp.
**Ellipsocephalus vetustus* Pomp.

Brachiopoda
Billingsella romingeri (Barr.)
**Jamesella perpasta* Pomp.
**Jamesella kuthani* Pomp.

Gastropoda
Helcionella tenuis Smet.
Helcionella lata Smet.
**Helcionella ava* Perner
**Helcionella pompeckji* Perner
Helcionella media Smet.

Helcionella anullata Smet.
Pelagiella jahni Smet.
Pelagiella lohovicensis Smet.
**Pelagiella perneri* Smet.

C a' 4 *Milec conglomerate* Light coloured conglomerates & sandstones with the oldest fauna of Bohemia.

The following have been listed:

Trilobita

Paradoxides perneri Smetana
Paradoxides kustai Smetana
Paradoxides walcotti Smetana
Paradoxides tejrovicensis Smetana
**Ptychparia striata* Emmr.
**Ptychoparia cf. marginata* Pomp.
Ptychoparia sp. nov.
**Ellipsocephalus vetustus* Pomp.
Ellipsocephalus sp. nov.
Conocoryphe conifrons Pomp.
Solenopleura? torifrons Pomp.
Agraulos sp. nov.

Brachiopoda

**Jamesella kuthani* Pomp.
**Jamesella perpasta* Pomp.
Jamesella perpasta macra Pomp.
Jamesella perpasta subquadrata Pomp.

Gastropods etc.

**Pelagiella* cf. *perneri* Smetana
Pelagiella sp. nov.
**Helcionella* (*Calloconus*) *ava* Perner
**Helcionella pompeckji* Perner

It has been suggested that this represents the Oelandicus horizon, but the distinctness of the fauna is apparent.

At the base near Skreje are breccias

Hiatus and unconformity

PRE-CAMBRIAN crystallines etc.

In general then, while continental deposits were forming in the south, marine sedimentation began in the more northern section.

In his table (loc. cit 1923 p. 59) Kettner correlates the three divisions $C\beta'1$, $C\beta'2$ and $G\beta'3$ of the Skreje and Tejrovice region with the Jince beds of the Przibram and Jince regions but still considers the underlying Milec beds $C\alpha'4$, which Pompeckj thought to be Lower Cambrian, as referable to the Middle. This is certainly borne out by the fauna, for though that is distinct, it is a Middle rather than a Lower Cambrian fauna, carrying as it does four species of *Paradoxides*. On the whole it is not so different from the next succeeding fauna $C\beta'1$ for at least 8 or 50% of the 16 specifically named forms of $C\alpha'4$ pass up into this next higher bed $C\beta'1$. These are marked by asterisks. It is however quite different from the normal Jince fauna.

The Bavarian extension. West of the Bohemian border in the Frankenwald of Bavaria South Germany, two interesting Middle Cambrian faunas have been discovered and described by A. Wurm.[1] (See map, Plate II b)

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1 A. Wurm. Ueber ein Vorkommen von Mittel-cambrium (*Paradoxides* Schichten) im bayrischen Frankenwald bei Wildenstein, südlich Presseck. Neues Jahrbuch für Mineralogie etc. Beilage-Band Vol LII, B, 1925 pp. 71-93, pl. III.
A. Wurm. Ueber eine neue Mittelcambrische Fauna aus dem bayrischen Frankenwald und ihre Bedeutung für die Stratigraphie des älteren Paläozoicums. Neues Jahrbuch für Mineralogie etc. Beilage-Band LIX, Abt. B, 1928, pp 31-47 plate V.

The following is the general succession in descending order, including the formations of both localities.
Superformation. Tremadoc. Leimitz Beds.

Hiatus and Disconformity

Middle Cambrian

5.? Orthis shales of Poppengrün
4.? Döbra sandstone
3. Paradoxides beds of Wildenstein
2. Red shales and sandstone series of Schwarzenbach and *Conocoryphe* beds of Lippertsgrün.
1. Border Shale series.

Hiatus and Unconformity

(Lower Cambrian absent)
Subformation Precambrian gneiss.

The exact age of the Lower Border shales (Randschiefer Serie) is not known, but Wurm places them in the Middle Cambrian. No fossils have been found in this series. In a number of localities effusive diabases occur in the series showing that this was a period of vulcanicity. These beds rest on gneiss.

The lowest fossiliferous horizon is that at Lippertsgrün west of Hof and about 15 miles west of the Bohemian border. (Approximately Long. 11^0 50′ E, Lat. 50^0 20′ N.) The fauna here occurs in reddish and yellowish somewhat quartzitic shales, which alternate with flaggy sandstones and carry nodules of limestone. The series is several hundred meters thick, though exact measurements are impossible as the beds are included in an extensive series of apparently isoclinal and steeply dipping strata.

In the heart of the Frankenwald at Culmitz, shales of similar petrographic character are called the Schwarzenbach series. They were formerly referred to the Upper Devonian, but the discovery of Middle Cambrian fossils in what appears to be the same series leaves little doubt that they too belong in this lower horizon.

The following species are described from these Lippertsgrün beds.

Conocoryphe heberti Mun.-Chalm. et Berg.
Conocoryphe coronata (Barrande)
Solenopleura ribeiroi (Barrande)
Sao hirsuta Barrande
Paradoxides sp.
Trochocystites

This fauna is referred by Wurm to the horizon of the Exsulans bed of the Scandinavian series, which, it will be recalled is in the Tessini zone. There are 3 species characteristic of the Bohemian middle division and one, *Conocoryphe heberti*, which is typical of the lower and middle division of the Montagne Noire series and the Spanish *Paradoxides* beds. This last species is also found in Sardinia, and appears to be represented in Bohemia as well. A higher Middle Cambrian fauna has been described from the Bavarian Frankenwald at Wildenstein, south of Presseck (Approx Long. 11^{0} 30′ E. Lat. 50^{0} 15′ N. See map Plate II b.) These beds have been named the Wildenstein series.

The rock consists of graywacke-quartzite, quartzitic clay-slates, and, less frequently, quartzitic sandstones. The graywacke is generally micaceous, sometimes the sandstones are somewhat arkosic, and locally the color indicates much iron oxide. The quartzitic clay-slates that chiefly carry the fossils, are markedly bituminous, the bituminous matter forming irregular concretions or cloudy impregnation centers. The molds of the trilobites are generally covered with them. Wurm holds that the deposits were formed in shallow water.

The mode of occurence of the fossils has some interest. The trilobites are mostly fragmentary, the head shields predominating. Some of the strata are entirely filled with fragments. Of an ochery quartzite from the Röslein district, Wurm remarks "that it carries quantities of trilobite fragments, often in a remarkable state of preservation, showing the surface sculptures. The fragmentation and destruction is largely of a primary nature and resulted in strongly agitated waters. Entire exo-skeletons, such as are common in Bohemia, are here among the rarities." Wurm here resorts to the usual explanation for the cause of such fragmentation, but we have already raised the question in an earlier part of this article, whether such explanation is really valid. Fragmentation under subaerial conditions during emergence, and subsequent reassemblage of the fragments in layers by gravitative assortment in the readvancing sea, seems a more normal explanation of the phenomenon, but, as previously remarked, one that must also be subjected to rigid test. The effect of the commingling of the faunas of two zones, fragments of the older and more or less complete individuals of the latter, deserves consideration in this connection. The fauna described from these beds comprise the following determined forms.

Paradoxides spinosus Boeck
Ptychoparia striata (Emmr.)
Agraulos ceticephalus Barrande
Agraulos frankenwaldensis Wurm
Conularia schloppensis Wurm

Besides these, there are unidentified trilobite fragments, 3 specifically unidentified *Conularias*, 3 specifically unidentified *Hyolithes*, *Orthis* sp, and remains of cystoids and cirripedes. Wurm points out the fact that there are no species in common with the older fauna of this region *i. e.* the Lippertsgrün fauna, but that there is close analogy with the younger Bohemian fauna, with which indeed it has all except the new species in common.

Central Poland. The Lower Cambrian of the Ste. Croix Mountains of central Poland has already been given, (see p. 99, *125*) and the approximate location of the region has been indicated. The *Protolenus* fauna also has been given in Table III Col 21 and referred to in the discussion of that horizon (p. 357, *553*). We may now summarize the remainder of the section, though leaving the discussion of the Upper Cambrian for a separate article.

Section in the Ste. Croix Mts. (Swiety Krzyz) of Central Poland[1]

SUPERFORMATION Tremadoc. Glauconite sandstones.

UPPER CAMBRIAN

10. Shales and quartzites with the *Peltura scarabæoides* fauna.

9b. Shales and quartzites with the *Parabolina* fauna.

9a. Shales and quartzites without fossils.

Hiatus and Disconformity

MIDDLE CAMBRIAN

Acadian

8b Coarse sandstones with poor fauna including *Ellipsocephalus polytomus* and *Paradoxides* sp.

1 J. Czarnocki. Le Cambrien et sa faune dans la partie centrale du massif de S-te Croix. Bull. du Service Géologique de Pologne vol. IV, liv. 1-2 pp. 189-207, 1927, (Polish) *Ibid*: Extr. du Compte Rendu XIV Congrès International, 1926 Madr,d 1927. 18 pp.

8a Coarse sandstones but somewhat finer than the higher beds, white and yellow and greenish shale layers.

The following species have been recorded:

Paradoxides polonicus Czarnocki
Paradoxides slowiecensis Czarnocki
Paradoxides tessini Brongn.
Paradoxides lamberti Czarnocki
Liostracus linnarssoni Ang.
Solenopleura brachymetopa Ang.
Solenopleura bucculenta Grönw.
Agraulos cf. *quadrangularis* Whitf.
Strenuella wimani Czarnocki
Strenuella? mobergi Czarnocki
Ellipsocephalus cobboldi Czarnocki
Ellipsocephalus multiformis Czarnocki
Conocoryphe sp.
Acrothele granulata Lnrs.
Lingulella siemiradzkii Walcott
Mickwitzia variabilis Czarnocki

7. Fine-grained sandstones without fauna.

Probable hiatus and disconformity

Hanfordian

6. Shales with sandstone layers and a rich fauna with *Protolenus* as the leading type. (The fauna is given in Col. 21. Table III.)
5. Light green shales, with light-coloured sandstone layers and a rich fauna, with *Ellipsocephalus* predominating. This and the fauna of Division 4 below are listed in Col 20 of Table III.
4. Sandstones and sandy shales with a poor fauna. *Strenuella kiaeri*, *Hyolithes*, *Lingulella*, etc.

Hiatus and Disconformity

LOWER CAMBRIAN

Mesonacis Beds. Divisions 3, 2 and 1.[1]

These have been described on pages 99-100, and the fauna listed in Col. 19 of Table III.

Unfortunately I have not been able to find any record of the thicknesses of these beds, in any of the Polish literature available.

So far as the available lists of fossils indicate, there are no species in common between the Hanfordian (*Protolenus*) and Acadian (*Paradoxides*) and as already noted, the only species which the Hanfordian has in common with the Lower Cambrian is *Strenuella kiaeri*, which ranges through all these divisions of the Polish Hanfordian.

Between the Hanfordian and Acadian, the hiatus, besides being indicated by a change in fauna, is further emphasized by the unfossiliferous sandstone No 7, which separates the fossiliferous beds of the two series. The far greater hiatus between the Middle and Upper Cambrian is indicated by the unfossiliferous beds 9a of the section, which divides the *Parabolina* beds of the Upper Cambrian from the *Paradoxides* beds of the Middle Cambrian. Moreover the lower fossiliferous zones known in the Upper Cambrian elsewhere in this geosyncline, are absent here.

Division 8b of the Middle Cambrian has been thought to represent the Forchhammeri zone, but even so the still higher *Agnostus laevigatus* zone, known in Sweden, is wanting. In like manner the *P. davidis* zone appears to be unrepresented, for division 8a carries the zone fossil *P. tessini*.

1 The numbering is that used by Bubnoff pp. 631-632

In the Pepper Mountains (Gôry Pieprzowe) of Poland on the shores of the Vistula, 3 km, below Sandomir, Gürich has studied an outcrop of steeply dipping, much folded and disturbed clay-shales, with extensive intercalations of hard, light-gray quartzite in the upper portion, this becoming darker towards the top, where a thin conglomerate layer with pebbles up to the size of a nut seems to terminate the series. In these beds Gürich[1] discovered a Middle Cambrian fauna. Some of the blocks of the black quartzite were completely filled with fragments of trilobites, including the following species.

Agnostus fallax Linnrs.
Agnostus gibbus Linnrs.
Agnostus sp.
Liostracus linnarssoni Brögger
Paradoxides cf. *tessini* Brngn.

From these Sandomir beds, apparently Division 8b of our section, J. Samsonowicz[2] has obtained *Lingulella vistulæ* and *Paradoxides*? sp. Samsonowicz also recognizes an older Middle Cambrian fauna, that of the Sloptow sandstones from which he obtained *Paradoxides* cf. *oelandicus* Sjögren and *Agraulos* sp.

Incomplete as our knowledge of these Polish beds is, it serves to point the probable pathway, by which these Middle Cambrian faunas arrived in Europe. Present indications point to the Irkutsk Basin of Siberia as the

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1 G. Gürich. Ueber eine Cambrische Fauna von Sandomir in Russisch Polen. Neues Jahrbuch für Mineralogie etc. Vol 1, 1892 p. 69

2 Sur la Stratigraphie du Cambrien et de l'Ordovicien dans la partie orientale des Montagnes Swiety Krzyz (Sainte Croix) Pologne Centrale, Bull. du Service Geologique de Pologne Vol. 1. French resumé pp. 68-70. 1920.

center of evolution of this fauna, as it apparently was the center of evolution of the preceding Lower Cambrian fauna. Some authors (A. Born and Holtedahl) have sought to derive the fauna directly from the Boreal realm across the whole of Scandinavia.[1] There are however several objections to this. First and foremost we have the absence of the entire pre-Acadian Middle Cambrian series, which therefore could not have been derived from the northern region along this line. Secondly the development of the various zones is so scattered, and there are so many interruptions indicating periods of exposure, and moreover the formations are so thin, that it does not seem possible that this was the pathway of invasion. Thirdly, the number of zones represented in Scandinavia is limited to at most 4, but since the many other species of *Paradoxides* and other trilobites, which in other sections form distinct zones, must have come from the same center of evolution, the Scandinavian region cannot be considered as the pathway. For as we have seen, these forms appear suddenly and can only be explained as successive invasions from without, and therefore the central portion of the pathway along which this repeated invasion took place should show at least a greater array of them, than is seen in the Scandinavian region. For although interzonal erosion would remove some of them, as we know that it has removed them from many parts of the Swedish and British region, it is not likely that such erosion would remove them from

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1 A. Born. Cambrium, Ordovicium, Gotlandium; in W. Solomon, Crundzüge der Geologie Vol 2, Pt. 1, 1926. P. Holtedahl. Palæogeography and Diastrophism in the Atlantic Artic region, during Palæozoic time. American Journal of Science. Vol 49, 1920.

the entire pathway of the invasion.[1] The Scandinavian, like all the other regions at present known, which carry Middle Cambrian deposits in the Caledonian geosyncline must be regarded as marginal to the pathway of invasion with the overlaps on the shallow borders.

There seems then at present no escape from the necessity of regarding, with Bubnoff, the broad east-west lowland belt of North Germany, between the Baltic and the region of the Bohemian and Bavarian Mountains, as the pathway of invasion, and that the west Norwegian region was separated from the Baltic region by that same Caledonian *Limen*[2] which Holtedahl has indicated for the Ozarkian-Canadian that is Cambrovician time on his palæogeographic map of the Arctic region.[3] Of course we know little or nothing of the formations beneath the Ter-

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1 Hans Frebold, (Zentren epirogener Hebung als Schwellengebiete in den paläozoischen Meeren des baltischen Schildes, und seiner randlichen Teile;—Neues Jahrbuch für Mineralogie etc. Beilage-Band LIX Abt. B, pp. 48-79) would refer these disconformities to local elevations or "Schwellen" (*limens*, see below) in the sea-bottom with the formation of island-like land-masses, subject to erosion and non-deposition. This would be a satisfactory explanation if deposition in the surrrounding regions were uninterrupted.

2 I suggest this name for those separating elevations to which the Germans apply the name "Schwelle" and for which we could use the word *sill* if that had not been preoccupied for intrusive sheets of volcanic material. *Limen* used in this sense in a topographical term. If it, or another suitable one has been used for such structures before this, I willingly cede priority.

3 Olaf Holtedahl. On the Palæozoic formations of Finmarken in Northern Norway. American Journal of Science 4th Series. Vol. XLVII, 1919, p. 102, fig. 8.

tiary and Quaternary beds, but unless this can be regarded as the pathway of immigration, we are at a loss to find another, unless of course we can regard the Atlantic Ocean as in existence at that time when it might fulfill the requirements of a center of evolution of this phase of the Cambrian fauna. Then however we are faced with several new difficulties. First among these is the absence, in all the sections bordering the Atlantic, of the true *Paradoxides oelandicus* zone at the bottom of the Acadian Series, and again the absence of the *P. forchhammeri* zone at the top, both being found farther east. Again we have to explain the pathway of communication between the Altantic and the North Siberian region, though if there is no continuity of the Caledonian Limen, such communication could easily be affected along the roadway between Scandinavia and Greenland. In that case however, we must provide another barrier to prevent this fauna from entering the Palæo-Cordilleran geosyncline.

If then the Atlantic Ocean was in existence at this time, that is, if the continents held essentially their present position in Palæozoic time, we may regard the Atlantic as the center of evolution of the *Paradoxides* fauna, as well as the center of evolution of the *Holmia-Callavia* fauna. For this earlier time however, we must erect the Caledonian Limen or barrier across the entire North Atlantic to keep the *Holmia* and *Olenellus* faunas from intermingling.

If on the other hand the Atlantic Ocean was not in existence, and the land masses were united into one, as shown in Pl. II, there seems no other pathway of invasion than a former geosyncline, now occupied by the North German lowlands. In that case however, we meet with another difficulty in the Ural Mountains. For to connect the European geosyncline with the North Siberian basin, such a pathway across the Urals seems necessary. As we have already seen when discussing the Lower Cambrian of this geosyncline (*ante* p. 107, *133*) no Cambrian strata are known from the Urals, the oldest beds resting upon the crystallines being Devonian or possibly late Silurian.

Of course it is possible that the Cambrian and Ordovician strata of this region were metamorphosed in the first elevation of the Urals, or, if they once extended across some part of the Urals in unaltered form, they were removed again by pre-late Silurian or pre-Devonian erosion. That for such erosion there was plenty of opportunity, we shall see as we progress in our studies. Again it is possible that the pathway of connection was further south, somewhere along the northern border of the Caspian and through Central Asia. The recently discovered, and still undescribed, Cambrian fauna of the Tianshan region in Western China, may throw light on this problem. Middle Cambrian beds are recorded from the head-waters of the river Ob in western Siberia, as far south as 50^0 North Lat. and as far west as 80^0 E. Long. The Chinese occurrences are south of Lat 45^0. (See Plate IIc).

Middle Cambrian of Siberia

The greatest development of the Cambrian on the Eurasiatic Continent is in the Irkutsk Basin of Siberia, between the Lena on the east and the Yenissei on the west. Unfortunately neither the stratigraphy nor the palæontology of this vast region has been studied in detail and we are still dependent on reconnaissance work. Fortunately this was summarized for us by Obrutschew, who has made the obscure Russian literature available in his Geologie von Sibirien 1926. He has also given us a summary of the latest and most detailed work of S. Obrutschew Jr. for the Angara region from the cataract of that river to the Yenissei, and this may serve as a basis for the discussion of the Siberian Cambrian.

The Lower Cambrian has already been given (*ante*, p. 102 (*128*)). The Middle Cambrian has the following succession in the Angara region in descending order.

Superformation. Upper Cambrian 550-600 m.

Probable hiatus and disconformity,
but contact hidden in a concealed interval.

Middle Cambrian (Cm2) 1100 m.

7.	Tschadobez Series Various bituminous limestones and dolomites with varicolored marl layers in the upper part.	250 m.
6.	Gray limestones and dolomites	100 m.
5.	Gray limestones and dolomites with layers of red and green marls	100 m.
4.	Dark-gray limestone with dolomite layers.	100 m.
3.	Light-gray dolomites	150 m.
2.	Gray limestones with dolomite layers	200 m.
1.	Black bituminous limestones, with layers of red and green argillaceous limestones	200 m.

Probable hiatus and disconformity
but contact hidden in a covered interval.

Subformation. Lower Cambrian.

All the limestones and dolomites of the Middle Cambrian are bituminous with foetid odour (Stinkstein) and they have a notable salt (NaCl) content. The only fossils reported are *Stromatopora*-like structures.

It is by no means certain that the three divisions of the Cambrian are here separated by disconformities though in some of the marginal districts this has been found. For when we consider the great thicknesses of the formations and their prevailingly calcareous character, it seems probable that we have in at least some parts of this region continuity of marine sedimentation throughout Cambrian time. If that was the case, we must expect to find there the record of the continuous evolution of the faunas throughout the entire Cambrian time. For it is of course obvious that this evolution must have proceeded in the Littoral district, and it is not likely that all parts of this Littoral district of Cambrian time have been destroyed. It is of course only the fauna preserved in the deposits of the Caledonian geosyncline, with which this basin is concerned, for as is obvious from earlier discussions, the faunas of other geosynclines had separate centers of evolution. But it is probably only the Siberian region, which is so situated, that this record is available, and it promises a rich harvest for the future students of the palæontology of the earlier Palæozoic rocks.

In the upper Lena River region, between Kirensk (approximately Long. 109° E. Lat. 56° 30′ N.) and Witimsk (approximately Long. 113° E, Lat. 59° N.) the Middle Cambrian is again exposed. In the vicinity of Kirensk, the rocks are much disturbed, and here and elsewhere the limestones of the Middle Cambrian form the high rocky banks of the Lena from Kirensk down stream.

In this section too, limestones are dominant. Sometimes they are well stratified, at others they appear massive and siliceous or dolomitic, rarely argillaceous, but often bituminous. The texture is variable and sometimes appears brecciated with chert veins, but rarely with sandstones. Many beds show a concentric structure, suggestive of *Stromatopora*. The colors are more often light but occasionally dark-gray or brown. In the upper part of the series the rock is thinner-bedded, and intercalations of sandy-clayey marls are frequent. In the middle part marls and sandstone layers are rare, dense uniform limestones predominating. In the lower part finally, the limestones are thin-bedded the colours variable and interbedded layers of greenish, reddish, violet and even bright-red marls and clays become characteristic. Gypsum too, occurs here and the presence of salt is indicated by saline waters. This suggests the possibility of salt lagoonal formations at the end of the Lower Cambrian retreat, and during the early stages of the Middle Cambrian advance.

The thickness of the entire Middle Cambrian series is several thousand meters. A trilobite fauna has been found on Peledui River, one of the tributaries of the Lena at Witimsk, and on the Lena below Olekminsk (approximately Longitude 120° E. Lat. 60° N).

The palæontological studies of Miss B. W. Lermontowa, as reported by Obrutschew, gave the following results:

At the junction of the Sinjaja River, on the left bank of the Lena, about 350 versts below Olekminsk, the base of the Middle Cambrian is shown resting upon the marls, clays, and platy limestones of the fossiliferous Lower Cambrian black shaly bituminous limestones. Apparently from the lower part of the Middle Cambrian, the following fossils have been obtained:

Microdiscus lenaicus
Agnostus schmidti
Solenopleura bituberculata Lermontowa
Protolenus asiaticus Lermontowa

Here is evidently the source of the *Protolenus* fauna of the Hanfordian. Previously noted species are *Ptychoparia czekanowskii* and *P. meglizkii*, together with *Microdiscus kochi*, *M. lenaicus* and *Agnostus schmidti*. The *Kutorgina cingulata* reported from these beds was shown by Walcott not to belong to that species. As further bearing on the relationship with the west European fauna, may be stated that the two species of *Ptychoparia* mentioned, are closely related to *P? (Microdiscus) annio* Cobbold and *Microdiscus lenaicus* is close to *M. comleyensis* Cobbold of the British *Protolenus* fauna

At three localities on the Peledui River which joins the Lena below Witimsk, the following species were found in siliceous limestones.

Olenoides sibericus Lermontowa
Solenopleura bella Lermontowa
Ptychoparia? rschonsnizkii Lermontowa
Hyolithes sp.
Kutorgina? sp

These again suggest Middle Cambrian.

In the extreme southeast of the basin, on the Maja and Aldan rivers, which become confluent on the parallel of 60° North latitude (approximately Long. 135° E) and subsequently join the Lena below Yakutsk, the following section is reported by Obrutschew in descending order.

e. Dark-gray, calcareous, quartzite-like sandstone, passing into quartzitic flagstones.

d. Greenish-gray siliceous shales and black clay shales.

c. Gray and green crystalline limestones.

b. Reddish-brown and brick-red marls.

a. Gray-green dense siliceous shales, somewhat marly with layers of dark-gray quartzitic sandstone, and some light-gray siliceous fossiliferous limestones. From the latter, the following fossils were obtained at localities between the mouths of the Tschaiskaja and Tschabda, according to the identifications of Lermontowa.

Anomocare limbatum (= *Coosia? limbata* Walcott.)
Anomocare difformis (Angelin) (= *Agraulos difformis* Ang.)
Anomocare excavatum (Ang.)
Centropleura sp.
Corynexochus macrophthalmus Lermontowa
Agnostus aculeatus micropunctatus Lermontowa
Agnostus laevigatus Dalm. (or *A. altus* Grönw.)
Agnostus gibbus hybrida? Brögger.
Agnostus parvifrons? Lnrs.

The first 7 of this series determine the age of these beds on the Maja to be that of the *Paradoxides forchhammeri* zone, though the last two would indicate a lower horizon. The determination of these two however is unsatisfactory for lack of pygidia.

It is evident that we are here in the region of the shallow marginal zone of the basin, where clay and sandy beds predominate. It is of further interest to note that this region is less than 400 versts from the shores of the Okhotsk Sea. It has in fact been suggested that some of the red beds underlying the Devonian on the shores of Okhotsk Sea may also belong to the Cambrian.

The Wilui River joins the Lena below the great bend at Yakutsk approximately on the 64th parallel. Within the basin of this river the Middle and Upper Cambrian beds are well exposed, the Upper Cambrian on the Wilui and the Njuja, the latter a tributary of the Lena between Witimsk and Olekminsk. The thickness here is not less than 1500 meters. The Middle Cambrian in this section consists of a great series of limestones, reddish brown, red and greenish gray, coarse-bedded, dense and sometimes siliceous. In both the lower and upper part the limestones sometimes become sandy and contain intercalations of red sandstones and clays, sometimes with gypsum. Two trilobites *Anomocare pavlowskii* and *Liostracus maydeli* were identified by Schmidt from these beds and referred by Walcott to the Middle Cambrian genus *Anomocarella*.

Among the formations whose age must still be considered as not fully established is the Archæocyathid limestone of Siberia. Limestones with Archæocyathids have been reported from many localities, but it is by no means certain whether they are all referable to the same horizon, nor is the exact horizon itself known. The best known of these deposits is the Torgoschino limestone, exposed on the banks of the Yenissei, opposite the city of Krasnoiarsk (approximately Long. 93° E. Lat 56° N.) Here above the village of Torgoschino, the limestone has a thickness of 10-15 meters, and rests unconformably upon the strongly folded Pre-Cambrian graywacke sandstones and shales with diabase and porphyry dykes. The limestone is poorly stratified, light-coloured, dense, somewhat siliceous and dolomitic, with numerous veins of red sardonyx. A rich fauna of Archæocyathids has been obtained here including the following species:

ARCHAEOCYATHIDS

Coscinocyathus corbicula
Coscinocyathus dianthus
Coscinocyathus calathus
Coscinocyathus aff. *cancellatus*
Coscinocyathus vesica
Coscinocyathus campanula
Coscinocyathus elongatus
Coscinocyathus irregularis von Toll
Archæocyathus patulus
Archæocyathus acutus
Archæocyathus aduncus
Archæocyathus sibiricus von Toll
Archæocyathus proskurjakowi von Toll
Archæocyathus ijitzkii von Toll.
Rhabdocyathus sibiricus von Toll (gen. et. sp.)
Spirocyathus sp.

Algæ

Confervites primordialis

Trilobites

Dorypyge slatkowskii
Solenopleura? siberica

With the exception of the new species described by von Toll, the Archæocyathids are mainly the same species, as those found in the Archæocyathus limestone of Sardinia. The trilobites indicate Middle Cambrian, and while it is not difficult to understand the presence of similar Archæocyathids in the Middle Cambrian of Sardinia, their presence in Australia, where many of the same species occur, is more difficult to understand, if they are referable to the Middle Cambrian.

The Torgoschino limestone, if not interrupted by faulting, passes beneath the level of the river, and apparently under an extensive series of red shales and sandstones, the Katscha series, the age of which is entirely unknown, as it contains no fossils. This is in turn succeeded by the Lower Dinantian Ursa Series of continental sediments. The age of the Katscha series, which is some 200 meters in thickness, has been variously designated as from the Devonian downwards. Obrutschew is inclined to call it Upper Cambrian, merely because of its super-position on the Torgoschino limestone. There may however be a hiatus of unknown magnitude between the two, and hence nothing definite can be said regarding their ages.

Limestone with *Archæocyathus* and *Coscinocyathus* also occurs in the Kusnezk basin of Siberia on the northwest slope of the Salair Mountains. Here the species of the Torgoshino limestone occur. The same group of limestones appears again in the Minussinsk region.

Bennett Island

Far to the north in the Arctic Ice Ocean of today, lies Bennett Island, north of the New Siberian group of Islands, in approximal Lat. 78^0 N. Long. 150^0 E. Here a Middle Cambrian fauna was found by von Toll, and this has recently been described by Holm and Westergaard[1]

Bennett Island with an area of 200 square km. and a maximum elevation of 1500 ft, is a continuation of the Northern Siberian Tableland. It consists of Cambrian and

1 G. Holm and A. H. Westergaard. A Middle Cambrian Fauna from Bennett Island. Memoires de l'Academie des Sciences de L'Urss. Classe Physico-Mathematique, Vol. XXI, No. 8, Résultats scientifiques de l'Expedition Polaire Russe en 1900-1903, sous la direction de E. Toll. Sect. C, Géologie et Paleontologie Livr. 8, 1930. with 4 plates.

Lower Ordovician strata, which are traversed and covered by basalts. Von Toll's collections were brought to Europe after his tragic death, and so far only the Cambrian have been described. The material is shale, the "matrix mainly composed of chlorite and muscovite, in which fragments of quartz are fairly abundant and scattered laminæ of graphite and rare grains of sulphite are to be seen. In the nodules, calcareous matter is fairly abundant. It contains quartz fragments often accumulated into thin layers, also scales of chlorite and muscovite."[1] The rocks appear to have been somewhat metamorphosed. In some parts of the shales, the fossils are frequent, though not often well preserved. The following are the species described.

1. *Agnostus pisiformis bater* Westergaard
2. *Agnostus glandiformis* Angelin
3. *Agnostus bituberculatus* Angelin
4. *Agnostus nudus hyperboreas* Westergaard
5. *Agnostus latirhachis* Westergaard
6. *Agnostus arcticus* Westergaard
7. *Agnostus repandus* Westergaard.
8. *Agnostus* 5 undetermined species.
9. *Centropleura loveni* (Angelin)
10. *Anomocare excavatum* (Angelin)
11. *Anomocare sibericum* Westergaard
12. *Anomocare?* sp.
13. *Solenopleura?* sp.
14. *Agraulos difformis* (Angelin)?
15. *Agraulos acuminatus* (Angelin)?

With two exceptions, Nos. 4 and 5, all these specifically identified forms are represented in the zone of *Paradoxides forchhammeri* in Scandinavia, either by the

1 N. H. Magnasson. Quoted by Westergaard.

same or closely related forms. Only one, No. 4, represented by *Agnostus nudus marginatus* Brögger, is characteristic of the Davidis zone of Scandinavia and doubtfully reported from the Forchhammeri zone. *Agraulus difformis* occurs in both zones.

There is thus no doubt that the Bennett Island fauna represents the zone of *Paradoxides forchhammeri* and if our interpretation of the palæogeography is correct, these forms are representatives from the center of origin and distribution of these animals, in other words the Scandinavian forms are migrants from the region now including Bennett Island. The distance between the two regions is more than 4000 km, but the remarkable similarity of the faunas clearly indicate that little modification took place during the migration. The fauna of the Maga River, already referred to on p. 490 (*686*) is essentially this same fauna, as the deposits there are beyond doubt contemporary with those of Bennett Island.

There can be little doubt that this fauna will eventually be found widespread over the Irkutsk basin, unless subsequent erosion has removed it.

One point is significant, and that is that "no form of the Bennett Island fauna is related to any one of the genera distinctive of the contemporary fauna of Eastern Asia, which is one more proof that there existed no direct communication between the Siberian Sea and the Sinian (Cathaysian) Sea in Cambrian time." (Westergarrd *loc. cit.* p. 21.)

This requires the rectification of the palæo-geographic map of Asia in Middle Cambrian time, published in 1923, and this is given here in Plate IIc.

THE NORTHERN APPALACHIAN GEOSYNCLINE

In Lower Cambrian time, the Northern Appalachian geosyncline was an extension of the American Boreal Sea, and for a time at least continuous with the Southern Appalachian geosyncline (see Pl. I). In Middle Cambrian time, on the other hand, the Northern and Southern Appalachian geosynclines were separated by the Albany axis, and the connection with the Boreal Sea came to an end. This is clearly shown by the distinctness of the faunas of the Middle Cambrian, so far as they are known from the Northern Appalachians. It is true there are only two localities, Little Metis Quebec and St. Albans western Vermont which have so far furnished undoubted Middle Cambrian fossils, but it is precisely the second of these localities in which the Boreal or *Olenellus* type of fauna is most typically developed in Lower Cambrian time, and on that account it is most significant. As we have seen, the Lower Cambrian of the Appalachian and of the Atlantic Provinces, or if we accept Pangæa, the Caledonian geosyncline, were absolutely distinct faunistically except for pelagic types. This distinctness is maintained by the southern Appalachians in Middle Cambrian time, but not in Vermont, where the surprising discovery of a typical Acadian fauna closely related to the fauna of the Caledonian geosyncline was made.

This raises the question of the entrance of that fauna into the Northern Appalachians, for the nearest point at which this fauna occurs *i. e.* in eastern Massachusetts, is more than 150 miles distant, and if we eliminate the extensive foldings of the rocks which have occurred since, it is more than likely that the original distance between these points was at least twice if not 4 times this amount. Either then, there must have been a connection across this intervening portion of this Old Land of Appalachia, or else the connection must have been direct with the Siberian Sea, which as we have seen was the most probable center of origin of these faunas.

Transection of the Old Land of Appalachia, especially in the New England region, seems, unthinkable, and a violation of the normal sequence of geographical development, so far as this has been ascertained. On the other hand the extension of the Finmarken Gulf of the Siberian Sea, and its junction with the northern Appalachian geosyncline, is in perfect harmony with the general plan of paleogeographic evolution which has so far emerged. For as we have seen, this Gulf already existed in Lower Cambrian time, extending as far south as Lat. 65°, if not further. All that is required is the further extension of this gulf across the Norwegian region, its junction with the Northern Appalachian region and the more or less complete separation of the Northern Appalachian from the Boreal Sea by the slight upwarping of the geosynclinal bottom between Greenland and the northern extension of Fennoscandia. In other words it requires the formation of a barrier axis or *limen* comparable to the Albany axis which divides the Northern from the Southern Appalachian geosyncline. Such changes are most readily comprehended on a geographic basis of Pangæa, but even with the continents in their present position, such a geographic differentiation could be affected. For in that case the geography would be essentially similar to that shown on Holtedahl's map for Lower Ordovician *i. e.* Ozarko-Canadian or Cambrovician time. (*Loc. cit.* 1919 p. 102, fig. 8).

On Plate II this relationship is shown as it would appear approximately in Pangæa. The exclusion of the Boreal Sea by the Greeno-Scandian axis or limen may or may not have been completely effective. If not, we may expect to find Boreal elements in the Middle Cambrian of this region, mingled with Siberian elements, which alone are at present known. So far as now known, Middle Cambrian deposits of this geosyncline are preserved only in northwestern Vermont and in Quebec. But that does not signify that they may not have existed, or may still be found to exist, in western Newfoundland, the Durness region of Scotland, and eastern Greenland. According to Poulsen (*Loc. cit. ante* 1932) Middle Cambrian is entirely wanting in the east Greenland region, where beds referred to the Ozarkian, (Cambrovician of our classification) appear to follow disconformably upon the Lower Cambrian. It is true his Hyolithes Creek and Dolomite Point formations lie between the Ella Island Lower Cambrian, and the Cas Ford Cambrovician formations, and these may actually represent Middle Cambrian. On the other hand they may belong to the Upper or to the Lower Cambrian. In any case, Poulson's correlation table shows a considerable hiatus above the Ella Island formation.

The older Palæozoic strata of East Greenland were apparently involved in the Taconic folding, which affected all the beds from the pre-Cambrian (Sinian) to the Ordovician inclusive. The Old Red Sandstone type of Devonian rests unconformably upon the eroded anticlines and synclines of the older Palæozoic. There is however, no discordance between the Lower Cambrian and overlying rocks, and consequently no marked deformation took place in the development of the Greeno-Scandian limen.

No Middle Cambrian beds have been recognized in the Durness limestone series of Northwest Scotland. The disconformity however, which I located in that section, lies in the midst of calcareous strata, that is within the Eilene Dubh group, (see *ante* p. 35 (*61*)). The Grudie Group below it still contains the *Salterellas* of the Lower Cambrian, but it is not impossible that another disconformity exists between the Grudie and the Eilene Dubh and that the lower part of the latter may represent Middle Cambrian. The upper series, that is the Sailnhor group which overlies the Eilene Dubh, carries lower Beekmantown fossils, and it and the upper part of the preceding group, down to the recognized disconformity, undoubtedly represents the Cambrovician transgression. Here then is one of the critical sections that calls for further detailed research.

As already suggested, Middle Cambrian may be found to overlie the Lower Cambrian of Northwestern Newfoundland, though at present Cambrovician beds alone appear to be present. At Little Metis,[1] Province of Quebec, black shales carry *Acrotreta sagittalis* (Salter) a typical Middle Cambrian species of the Caledonian geosyncline. Aside from this, the Vermont region is the only other locality which has so far yielded undoubted Middle Cambrian faunas from this geosyncline. (See Pl. II a, also fig. 3. *ante* p. 77 (*103*))

Middle Cambrian of Vermont

The history of the discovery of these strata is a part of the Taconic epic of American Stratigraphy. It has been outlined in some detail by Dr. B. F. Howell through whose tireless investigations in this region, we owe much of our more detailed knowledge.[2]

1 On the St. Lawrence River 175 miles below Quebec city. Approx. Long 68° W. Lat 48° 40′ N.

2 B. F. Howell. The Cambrian *Paradoxides* Beds of Northwestern Vermont. 16th Biennial report of the Vermont State geologist 1927-1928 pp. 249-273.

The most recent summary of the stratigraphy and structure, based on his extensive field researches, is given by Arthur Keith and will be used as the basis of our discussion.[1]

The stratigraphic succession in this region, known familiarly as the Slate Belt, has already been given in the first of these articles, (p. 23 (*49*)). The Middle Cambrian *St. Albans Slate,* lies disconformably upon the Lower Cambrian and is disconformably succeeded by the Upper Cambrian. Its maximum thickness is 200 ft. and in some localities it has been entirely removed by pre-Upper Cambrian erosion. Its present outcrop extends for a few miles north and south of St. Albans.

The rock is a dark micaceous slate with small lenses of limestone and sandstone. The base of the slate is marked by conglomerate containing pebbles of dolomite.

Only a few of the fossils found in these beds have so far been identified but these are sufficient to show the stratigraphic position of the formation. The list includes:

Brachiopoda

- *Obolus matinalis* Walcott
- *Huenella vermontana* Walcott
- *Huenella billingsi* Walcott (horizon not wholly certain)
- *Lingulella franklinensis* Walcott

Trilobita

- *Centropleura vermontana* Howell
- *Elyx* sp.
- **Agnostus* (2 species)

1 Arthur Keith, Outlines of the Structure and Stratigraphy of Northwestern Vermont. 16th International Geological Congress Guide-Book I, pp. 48-61. *Ibid.* Wash. Acad. Sci. vol. 22, 1932, p. 357 *et seq.*

**Agraulos*
**Menocephalus*
**Ptychoparia* (3 species)
**Anomocare*.

Other crustacea
**Leperditia* sp.

Hyolithids
**Hyolithes* sp.

Dr. Howell[1] has recently announced the following new classification of these Paradoxidoid trilobites. He also created a new subfamily.

Sub-Family *Centropleurinæ* (in the family Paradoxidæ) with three genera.

1. *Centropleura* Angelin, with
   - *C. loveni* Angelin, (genotype) Forchhammeri zone of Sweden and Bennett Island
   - *C. vermontana* Howell, Vermont.
2. *Anopolenus* Salter, with
   - *A. henrici* Salter (genotype) Upper Davidis beds of Nuneaton and St. Davids (Div. F *ante*)
   - *A. salteri* Hicks, Hicksi zone (Nantpig beds) of North Wales, Davidis beds of St. Davids, S. Wales (Div. F *ante*)
3. *Clarella* Howell, with
   - *C. venusta* (Billings) (genotype). Hicksi zone of Manuels Brook N. F.

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* Provisional identifications by Walcott, listed by Perkins. Rep. Vermont State Geologist 1907-8 pp. 208 and 209.

1 Geol. Society of America Preliminary list of Titles and Abstracts of Papers to be offered at the 46th Annual Meeting, Chicago Ill., Dec. 28-30, 1933, p. 69.

- *C. steenstrupi* (Angelin). Forchhammeri zone of Sweden and Bornholm
- *C. pugnax* (Illing) Upper Hicksi and Hartshillia zones.
- *C. impar* (Hicks) Hicksi zone (Nantpig bed) of North Wales—Menevian
- *C. grönwalli* Howell and Poulsen *Conocoryphe æqualis* zone (upper Tessini zone).

As the only other species of *Centropleura* (in the narrow sense) occurs in the Forchhammeri zone of Sweden and Bennett Island, Howell concludes that the St. Albans beds of Vermont are also referable to the Forchhammeri zone.

The Finmarken Region

In Northern Norway, far beyond the Arctic circle between latitudes 69° and 71° N, lies the district of Finmarken the most northern promontory of the Scandinavian peninsula.

According to Holtedahl (*loc. cit.* 1919) the Lower Cambrian Dividals series or *Hyolithes* zone, with a thickness of about 240 meters, rests unconformably upon the highly metamorphosed Pre-Cambrian gneisses, schists etc. The Dividals series consists of shales and sandstones with *Platysolenites antiquissimus*[1] and other fossils. The same series is again found in the Tromsö district farther southwest in Norway and in the Torneträsk section of northern Sweden.[2] These beds are succeeded with apparent con-

1 A slender cylinder resembling a crinoid stem.—of unknown systematic rank.

2 Guide Book 6, XIth Int. Geol. Congr. Stockholm

formity by the *Porsanger sandstone*. This is a very light-colored sandstone composed chiefly of quartz with some grains of feldspar (generally kaolinized) and having a thickness of 500 meters or more. Some thinner darker sandstones, covered with exceedingly fine interference ripple-marks, and some dark gray sandy shales occur in the higher part. In the upper portion are thick, often reddish-brown shales and green shales with only thin beds of sandstones, the whole having a thickness of 50-100 meters. Then follow the Porsanger dolomites, at least 100 meters thick, with curious cylindrical *Cryptozoon*-like stromatoliths (*Gymnosolen*). Then the series is cut off by a thrust fault which carries the metamorphic rocks over the old Palæozoics.

Summarized we have

Middle ? and Upper Cambrian etc.	
Porsanger dolomites with *Gymnosolen*	100 meters
Porsanger shales	50-100 m.
Porsanger sandstones	500 m. +
Hiatus and disconformity	
Lower Cambrian	
Dividals Series	240 m.
Hiatus and Unconformity	
Pre-Cambrian crystallines	

Among the Stromatoliths of the Porsanger dolomite is one identical with *Gymnosolen ramsayi* Steinmann obtained from dolomites of the western shore of Kanin Peninsula, east of the White Sea. Similar forms occur in the Upper Cambrian Lyell formation of the Canadian Cordillerans.

If the age of the Porsanger dolomite is Upper Cambrian or Cambrovician, the Porsanger shales and sandstones may represent shallow water marine and in part continental deposits of Middle Cambrian age. If so, and if marine, they ought to carry the *Centropleura* fauna.

In the Trondhjem district of west Norway (Lat. 64°-65° N), the Sparagmite formation (L. Cambrian?) is followed by the Röros Slates, which though rather strongly metamorphosed into brown, and higher up, gray-green graphitic mica slates, still carry *Dictyonema* in their upper beds. Their thickness ranges from 100 meters in the eastern to more than 1000 meters in the western part, showing that in that direction lay the geosyncline. These beds are covered by the Bumark Volcanics and Jasper conglomerates of early Ordovician age.

Considering the great thickness of the Röros group, which is believed to represent metamorphosed Alumn shales (1000 meters or more) and the fact that it terminates with the *Dictyonema* beds, it seems probable that not only Upper but Middle Cambrian as well is represented in this series. This would then represent the continuation of the Finmarken embayment and its junction with the extension of the North-Appalachian geosyncline. We need however the confirmation of this supposition which would be furnished by the discovery of the Middle Cambrian *Centropleura* or Forchhammeri zone fauna.

Incomplete as our knowledge of these formations is at present, there are no known facts that militate against the interpretation here advanced, and unless new facts are discovered, inharmonious with it, we may tentatively hold that the *Centropleura* fauna of the Northern Appalachians (Vermont etc.) was derived from the Siberian basin by a transgression of the late Middle Cambrian sea through the Finmarken—Tröndhjem district of Western Norway as shown upon the map of Pangæa in Plate II or on that given by Holtedahl (*loc. cit*) which conforms to the orthodox doctrine of the permanence of continents and ocean basins.

MIDDLE CAMBRIAN OF THE INDO-CHINESE GEOSYNCLINES

The Middle Cambrian of the Himalayan geosyncline is still only very partially known, in fact there is only one locality from which we have anything like an adequate section. This is at Spiti, in northern India close to the Tibetan border (about Long. 78° 20′ E, Lat. 32° N). The pre-Silurian rocks of this region fall into 3 main subdivisions, but so far only the upper one has furnished fossils. The entire sequence is said to be continuous, though it is highly probable that there are at least several disconformities in the section. Hayden has referred the entire series to the Cambrian system, and describes the three parts as having the following character in descending order.

III. *Upper Division* (*Parahio Series*) about — 1200 ft.

Gray and green micaceous quartzites and thinly foliated slates and shales with narrow bands of light gray dolomite. Fossiliferous at various horizons.

II. *Middle Division* (*Upper Haimanta of Griesbach*) about — 1000 ft.

Bright red and black slates, with some quartzites, well exposed in the Parahio and Upper Pin Valleys of Spiti and in the Thanam Valley of Bashahr, forming a conspicuous and constant horizon. In the Parahio Valley these beds pass upward into the overlying series.

I. *Lower Division (Middle Haimanta of Griesbach)* 2000-3000 ft.

Dark slates and quartzites.

The upper fossiliferous or Parahio series has been subdivided by Cowper-Reed as follows.[1]

Section in the Parahio Valley of Spiti

19.	Conglomerate	
18.	Quartzite and siliceous shale about	50 ft.
17.	Gray dolomite weathering brownish red	20 ft.
16.	Flaggy sandstone, quartzite and siliceous slate	40 ft.
15.	Gray dolomite, weathering brownish red	30 ft.
14.	Siliceous slates with gray quartzite bands and thin beds of pink dolomite, (slates chiefly gray and green, but weathered pink)	250 ft.
13.	Dark siliceous slates with a few fragmentary trilobites	30 ft.

The species recorded are
Bathyuriscus? stolitskai Reed
Dicelocephalus? interpres Reed
Olenus? himantensis Reed
These are regarded as Upper Cambrian

Probable Hiatus and Disconformity

Middle Cambrian

12. Siliceous slate and flaggy quartzite 30 ft.

1 F. R. Cowper-Reed. The Cambrian fossils of Spiti. Palæontologia Indica, Series XV, Vol VII, Memoir 1, pp. 70, Pls. 1-6.

11.	Siliceous and argillaceous shales with undetermined trilobites	6 ft.
10.	Gray slaty quartzite capped by 6 inch bed of dolomite	50 ft.
9.	Slate, siliceous above and argillaceous below, with a rich Middle Cambrian fauna	30 ft.
8.	Dark-gray quartzite	60 ft.
7.	Pink shaly dolomite limestone, with indeterminable trilobites	12 ft.
6.	Calcareous quartzite with *Lingulella* and trilobites underlain by a narrow band of fossiliferous sandstone 2 inches thick, and argillaceous slate with a rich Middle Cambrian fauna, every species of which however is distinct from those in bed 9.	10 ft.
5.	Gray micaceous quartzite, with thin bands (1/4 to 2 inches) of mica-schists, no fossils.	150 ft.
4.	Slates, alternating with narrow bands of gray limestone ½ inch to 4 inches thick, and with *Lingulella* and trilobites	10 ft.
3.	Slates, chiefly siliceous, and quartzite	150 ft.
2.	Dark slates with trilobites	30 ft.
1.	Red and green slaty quartzites with *Lingulella* and *Nisusia* and some trilobites in the uppermost beds	250 ft:
	Total thickness	1000-1800 ft.

The distribution of the species in the several horizons is given in Table N, from which the remarkable fact appears that no two of the horizons have the same species, not a single one of the species having been obtained from more than one horizon. With the exception of the highest fossiliferous bed (13), the fauna appears to show a certain unity, and there seems no doubt that the lower part of the series is referable to the Middle Cambrian. The highest of the beds with this fauna is No. 9, for although trilobites have been reported from bed 11, nothing is known of their character. Nevertheless, I have drawn the dividing line between beds 12 and 13, for the gray quartzites and siliceous shales, which succeed bed 9, are best classed with the retreating phase of the Middle Cambrian, while bed 13 may be considered the beginning of the Upper Cambrian transgression. This would give thicknesses of 788 and 400 ft. for the Middle and Upper Cambrian (or Cambrovician) respectively, not a very great thickness, when it is considered that a considerable portion of this comprises quartzites, and other unfossiliferous beds.

Another remarkable fact is that the fauna of these Middle Cambrian beds of Spiti has no species entirely in common with those of China, although there are a certain number of related forms. Of course we are dealing with distinct geosynclines, although these appear to have a common center of faunal supply, and the localities in which the fossils are found are very far apart.

If the palæogeography shown in the map Pl. II, is correct in essentials, there is another fact to be borne in mind, namely that the Spiti, like the Salt Range localities, are much nearer the suggested North Pole of the period, than was the Cathaysian Geosyncline. As reconstructed, the Spiti locality would lie between 50^0 and 60^0 North latitude, whereas the Cathaysian geosyncline would rest in the vicinity of 15^0 N. latitude. Hence we would expect to find differences between the two, comparable to, and even more pronounced than those between the Mediterranean and Scandinavian regions.

Table N. Fossils of the Middle Cambrian of the Parahio Series of Spiti	Horizons in *Parahio Series*						Chinese allies *Palæocordilleran allies
	1	2	4	6	9	†13	
Coelenterata							
Coscinocyathus cf. corbicula Bornemann	—	×	—	—	—	—	C. *elvira* Walcott
Brachiopoda							
1. Nisusia depsaensis Reed	×						
2. Lingulella haimantensis Reed	—	—	?	×	—	—	*Lingulepis eros* Walc.
3. Lingulella spitiensis Reed	—	—	—	×			
4. Lingulella cf. coelata Hall ?	—	×					
5. Lingulella? sp.	×						
6. Lingulepis? sp.	—	—	—	—	×		
*7. Obolus (Westonia)? sp.	—	—	—	—	—	—	
8. Acrotreta parahioensis Reed	—	—	×				
9. Obolella cf. crassa Hall?	—	—	—	—	×		
10. Obolella cf. atlantica Walcott	—	—	—	×			
11. Acrothele præstans Reed	—	—	—	×			
12. Acrothele vertex Reed	—	—	—	—	×		
13. Acrothele cf. spurri Walcott	—	—	—	—	×		
14. Acrothele? sp.	—	—	—	×			
Pteropoda							
1. Orthotheca aff. plicata Brögg.	—	—	—	—	×		
2. Hyolithes aff. danianus Walcott	—	—	—	—	×	—	*Hyolithes cybele* Walc.

Table N. (*Continued*) Fossils of the Middle Cambrian of the Parahio Series of Spiti	Horizons in *Parahio Series*						Chinese allies *Palæocordilleran allies
	1	2	4	6	9	†13	
Echinodermata							
1. Eocystites sp.	—	—	—	×			
Trilobita							
*1. Agnostus spitiensis Reed	—	—	—	—	—	—	*Agnostus* sp. Walc.
2. Microdiscus griesbachi Reed	—	×	—	—	—	—	*M. orientalis* Walc.
3. Microdiscus haimantensis Reed	—	—	—	—	×		
*4. Redlichia noetlingi (Redlich)	—	—	—	—	—	—	*R. nobilis* Walc.=L. Camb.
5. Zacanthoides indicus Reed	—	×					
6. Oryctocephalus salteri Reed	—	—	—	—	×		
7. Oryctocephalus cf. reynoldsi Reed	—	×					
8. Ptychoparia spitiensis Reed	—	—	—	×	—	—	*P. lilia* W., *P. granulosa* W.
9. Ptychoparia stracheyi Reed	—	—	—	×	—	—	*P. aclis* W., *P. tolus* W.
10. Ptychoparia urceolata Reed	—	—	—	×			
11. Ptychoparia consocialis Reed	—	—	—	—	×	—	*P. lilia* Walc.
12. Ptychoparia admissa Reed	—	—	—	—	×		
13. Ptychoparia pervulgata Reed	—	×	—	—	—	—	*P. titiana* W., *P. granulosa* W., *P. constricta* W.
14. Ptychoparia maopoensis Reed	—	—	—	—	×		
15. Ptychoparia defossa Reed	—	—	—	×	—	—	*P. tellus* Walc.
16. Liostracus civica Reed	—	—	×				

Table N. (*Concluded*) Fossils of the Middle Cambrian of the Parahio Series of Spiti	Horizons in *Parahio Series*						Chinese allies *Palæocordilleran allies
	1	2	4	6	9	†13	
Trilobita (cont.)							
17. Ptychoparia? hostilis Reed	—	—	—	—	×	—	*Solenopleura beroe* W., *S. agno* W.
18. Ptychoparia? praeterita Reed	—	—	—	—	×		
19. Ptychoparia? himalaica Reed	—	—	—	×	—	—	*Anomocarella irma* W., *A. chinensis* W., *A. albion* W.
20. Conocephalites memor Reed	—	—	—	—	×	—	*Anomocare flava* W.
21. Conocephalites hesterna Reed	—	—	—	×	—	—	*Anomocare temenus* W., *A. latilimbatum* Dames
22. Bathyuriscus stoliczkai Reed	—	—	—	—	—	×	*Anomocare nereis* W., **B. rotundatus* (Rom)
23. Dicellocephalus? interpress Reed	—	—	—	—	—	×	*Anomocare megalurus* (Dames)
24. Olenus? haimantensis Reed	—	—	—	—	—	×	
25. Agraulos aff. roberti Matthew	—	×	—	—	—	—	*A. nitida* Walcott
26. Agraulos? fervidus Reed	—	×					
27. Agraulos? simulans Reed	—	—	—	×	—	—	*A. dryas* W., *A. abaris* W., *A. nitida* W.
*28. Anomocare conjunctiva Reed	—	—	—	—	—	—	*Anomocarella chinensis* W.
*29. Anomocara sp.	—	—	—	—	—	—	*Dolichometopus deois* W.
30. Shantungia cf. frequens Dames	—	—	—	—	×	—	*Chuangia nitidans* W. *Damesella blackwelderi* W.

* Exact horizon not recorded.

† Horizon 13 is regarded as Upper Cambiran.

The Middle Cambrian of China

In the Cathaysian geosyncline, the Middle Cambrian fauna has been found at various intervals from Tongking to Manchuria, and throughout this region it has proved richly fossiliferous. The sections for the various important districts are summarized by Walcott[1] and these may here be given in approximate order from the north southward.

Section I Fuchou Series of Changhsingtau (Tschanghsingtau) Island, Liaotung Province, Manchuria.

This lies about 240 miles east of Peking in approximate Longitude 121°10′ E. lat. 39°30′ N. The thickness of the Cambrian beds exposed is from 1225 to 1250 feet. The succession is as follows in descending order.

8.	Massive dark gray limestone in places mottled (may be Upper Cambrian)	200 ft.
7.	Thinly-bedded, nodular limestone and shale. Hard and upturned with occasional signs of trilobites. Loc 36f (about 800 ft. above 35q or 1000 ft. above the base) is in the upper portion of this belt. Fossils listed in Col. 26, Table O. Thickness about	500 ft.
6.	Massive limestone, in places oolitic. (Loc 36j) No fossils identified. Thickness about	300 ft.
5.	Shale, followed by thinly-bedded limestone. Loc. 35q about 70 ft. above 36h	

1 Research in China Vol. III. The Cambrian faunas of China by Charles A. Walcott, Carnegie Institute of Washington. Publication No. 54, 1913.

	and 200 ft. above the white quartzite. Fossils listed in Col. 25, Table O. Thickness	20 ft.
4.	Huge concretions, resembling corals. 4-6 ft. in diameter, in thin buff shale (Loc. 36i, no identifiable species)	4-6 ft.
3.	Chiefly shale, with less limestone and green dark-gray and brownish shale, with thin layers of nodular limestone. In the lower part is Loc. 35p which is about 80 ft. above the basal quartzite. The fossils are listed in Col. 23, Table O. About 50 feet higher is Loc. 36 h, and approximately at this level also lie localities 36g and 35o. The fossils are given in Col. 24 of Table O.	200 ft.
2.	Green and purple shales, (localities 35n, 35r, 36c, and 36e,) Fossils listed in Col. 22 of Table O. These are nearly on the same horizon in a bluff 10 ft. high, the lowest fossiliferous bed recognized	10 ft. +
1.	White quartzitic sandstone in low cliffs only narrow belt exposed (may be Lower Cambrian)	Thickness unknown

Section II Cambrian strata of the Kaiping Basin, Hopei Province.

This lies about 125 miles east of Peking. The following section is shown in this basin in descending order.[1]

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1 Y. C. Sun. Contributions to the Cambrian faunas of North China. Palæontologia Sinica, Series B., Vol. I, Fasc. 4, p. 7.

Snperformation. Lower Ordovician
Yehli limestone

Disconformity

The disconformity at this point is very pronounced, but apparently no great time interval is represented so far as can be judged. The character of the contact has been fully described elsewhere.[1]

UPPER CAMBRIAN

5. Fengshan Series 200-300 ft.

Shales and thin-bedded calcilutites with the following species:

Lingulella kayseri Grabau
Obolus luanhsiensis Grabau
Ptychaspis subglobosa Grabau
Ptychaspis suni Grabau
Mansuya orientalis (Grabau) Sun
Illaenurus sp.
Anomocare sp.

These species are fully described in Dr. Sun's monograph.

4. Changshan Series 150-200 ft.

Red or purple shales, with 7 or 8 intraformational or edgewise limestone conglomerates (Wurmkalk)

The red shale is richly fossiliferous and it resembles the Manto shale, except for the intraformational conglomerates.

It contains the following species.

1 A. W. Grabau. Stratigraphy of China. Vol. I, p. 68 Figs. 33 and 34

Obolus mollisonensis Walcott?
Eoorthis sp
Changshania conica Sun
Changshania? truncata Sun
Agnostus hoi Sun

Probable Hiatus and disconformity

MIDDLE CAMBRIAN

? Kushan formation

This has not been differentiated from the other formations, as no distinctive fossils have been found and it is quite possible that it may be cut out in the disconformity. This is further suggested by the fact that the thickness of the underlying Changhsia limestone, is only about half that seen in the Lincheng section.

3. Changhsia Limestone 300-400 ft.

Oolitic limestones and massive limestones usually cliff forming. It contains the following species.

Brachiopoda
Nisusia hayasakai Sun

Trilobita
Solenopleura nodosa Sun
Anomocare flava Walcott
Lisania rectangularis Sun
Lisania? hsuchiachuangensis Sun
Damesella blackwelderi var *minor* Sun
Dorypyge richthofeni Dames
Dolichometopus deois Walcott
Crepicephalus sp.

These species are included in Col 20 of Table O

Probable hiatus and disconformity

LOWER CAMBRIAN

Manto Shales 400-500 ft.

Mostly red, purple and green shales, sometimes interbedded with sandy limestones. The formation has furnished the following species.

Brachiopoda

1. *Acrothele cheni* Sun
2. *Lingulella manchuriensis* Walcott?
3. *Obolus* sp.

Trilobita

1. *Conocephalina gerardi* Sun
2. *Conocephalina kaipingensis* Sun
3. *Emmrichella changshanensis* Sun
4. *Ptychoparia yohi* Sun
5. *Ptychoparia fongi* Sun
6. *Ptychoparia* sp.

(These species were inadvertently omitted from Table IV)

Hiatus and Disconformity

SUBFORMATION: SINIAN.

Section III. Western Hills of Peking.

In the Western Hills of Peking or the Hsi-Shan, the Cambrian strata have long been known, but it is only recently that careful sections have been made by Dr. Y. T. Sun and graduates of the National University.

One of the best sections is between Tao-Yuan and Shipa-Pan, where the strata are exposed in a series of anticlines. The succession here according to Dr. Sun is as follows.

Upper Cambrian

Taoyuan Formation. 656 ft.

This is a more or less compact limestone with many layers of intraformational conglomerate or Wurm Kalk throughout. It represents the *Tsinania* zone of the Upper Cambrian, in its lower portion, which is characterized by *Lingulella kayseri* Grabau and is therefore essentially equivalent to the Fengshan limestone of the Kaiping Basin. The two lower zones *i. e.* the *Kaolishania* zone (zone 2) and the underlying *Changhia* zone (zone 1) are here missing, having been cut out by overlap. The higher beds of this limestones probably represent the *Quadraticephalus* zone.

Hiatus and Disconformity

Middle Cambrian

Nanchuang Formation 262 ft.

Oolitic marly limestone, and shaly limestone with *Blackwelderia* and *Dorypyge*, probably corresponding to the Kushan and a part of the similar limestone in the Kaiping basin. A considerable part of the basal series of the Middle Cambrian is cut out by overlap.

Hiatus and Disconformity

Lower Cambrian

Manto Formation. Shales and sandstones partly red, with base not exposed.

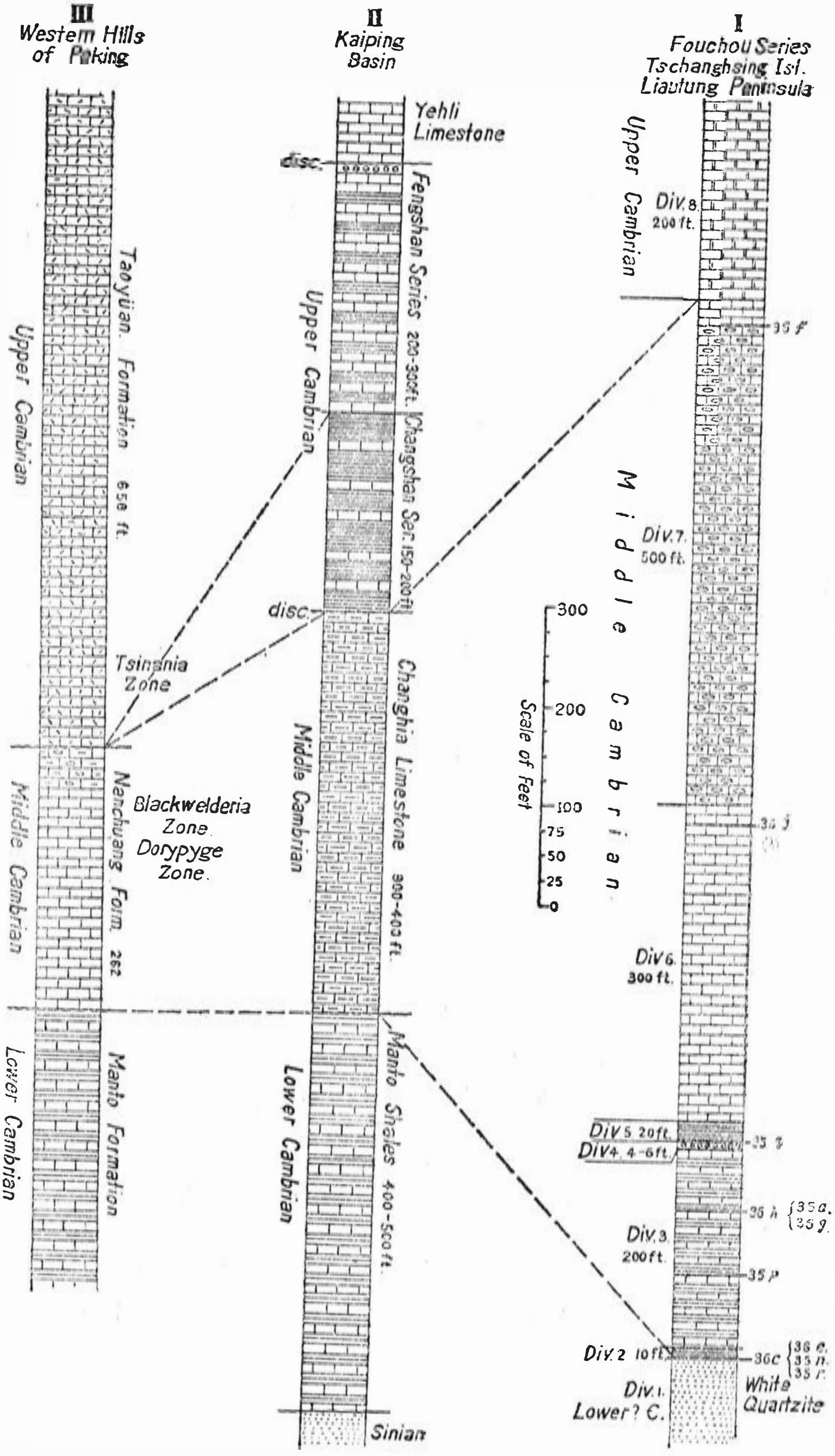
A comparison of the three sections in North China *i. e.* the Western Hills, the Kaiping, and the

Fuchou sections, shows a progressive increase in the thickness of the Middle Cambrian from west to east. In the Western Hills section, it is 262 ft. In the Kaiping Basin section, it is about 400 ft. maximum, and at Fuchou on the Liaotung Peninsula, it is something over 1,000 ft. This suggests that the Fuchou section lies near the center of the geosyncline and the other two on the marginal western plain. So far as we know, the Fuchou section is the most complete, the higher horizon 36 f, about 1000 ft. above the base, carrying the Kushan fauna. This horizon appears to be absent, in the Kaiping Basin due to off-lap and subsequent erosion, or to both but represented in the Western Hills.

In like manner, a portion of the basal beds seems to be absent by overlap, though as yet not sufficient studies have been made of the Kaiping Basin and the Western Hills, to enable us to identify the zones with those of the Fuchou section.

A comparison with the Lincheng Section, 170 miles S. W. of Peking shows that it too represents the greatest thickness of the Middle Cambrian, when compared with both the more easterly and the western sections, and in this section too, the Kushan shale is present.

Thus it would seem that the Lincheng section also lies near the center of the old geosyncline. It belongs to our second line of sections, which extends from Tungyü in Shansi Province, through Lincheng in W. Hopei Province, 100 miles S. E. of Tungyü, to Yenchuang in Shantung 165 miles E. S. E. of Lincheng. This passes through the classical Changhia



Text-Fig. 13. Three sections of the Middle Cambrian strata of North China in an east west section I Fouchou Section (Iddings); II Kaiping Basin Section (Sun) (225 miles west of Sect. I); III Western Hills Section near Peking (Sun) (125 miles west of Sect. II.) Compare with Fig. 14. For description see text.

and Kushan sections of Walcott, about 115 miles S. E. of Lincheng and 50 miles W. of Yenchuang. We shall first consider the Changhia-Kushan section and then the Yenchuang, the Lincheng and the Tungyü sections.

Section IV Ch'anghia District. Shantung.

This is one of the most typical sections with the strata nearly all well exposed and gently dipping. It lies 120 miles S. E. of Lincheng and about 200 miles south of Peking. The general succession is as follows in descending order.

Superformation. Lower Ordovician Dolomite and limestone 800 ft.

Upper Cambrian. Ch'aumitien limestone 600-800 ft.

Blue-gray limestone, conglomeritic at various horizons. In the upper part is horizon C45, which is 800 ft. above the Kushan shale.

Hiatus and Disconformity

Middle Cambrian

Kushan shale 50 ft.

Green shale and slabby limestone, especially characterized by the trilobites *Blackwelderia* and *Drepanura,* the latter widely known under the name of "Stone Swallow." A typical locality is at Tawenkou 40 miles S. E. of Changhia.

The fauna is given in Col. 12 of Table O

Changhia limestone 500 ft.

3. Gray limestone mottled with ochre, with the species listed in Col. 3 Table O. (Loc's C 18, 19, 21, 22, 24-26, 35, 46)
2. Dark-gray oolitic limestone, with the species given in Col. 2 Table O. (Loc's C 29, 30, 51.)
1. Olive gray oolitic limestone, with the fossils listed in Col. 1, Table O. (Loc's C 23, 28.)

Hiatus and Disconformity

Lower Cambrian. Mantó shale 500 ft.

Hiatus and unconformity

Subformation. Taishan complex.

——— : o : ———

Sections V. Sections at Yenchuang in the Sintai District Shantung.[1]

(Text-Fig. 14)

In this region which is 50 miles east of Changhia the Upper and Middle Cambrian divisions have not been differentiated, but are known as the Kiulung group. The following are the subdivisions according to Blackwelder and Walcott

Sect. VA Kiulungshan Yenchuang

(Walcott Sec. N. Fig. 8, p. 95)

Upper Cambrian portion of the Kiulung Group about 250 ft.

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1 Walcott. Research in China. Vol. III, pp. 44, and 45, Sections 5, 6 and 8.

Blue-gray and black limestones with various fossiliferous horizons (C 61, near base; C 64, at 125 ft, above C 61)

Hiatus and Disconformity (Masked)

Middle Cambrian portion of Kiulung group 345 ft.

A9. Shaly limestones and gray shales 25 ft. or less

At the base is horizon C 6 with the fauna given in Col. 12 of Table O. This is essentially the Kushan horizon

A8. Shaly limestone and nodular and calcareous green shale, with a thin bed of conglomerate limestone near the middle 120 ft.

At the base of this and the top of the next division, occur horizons C12, C13, C14 and C40. The fauna is given in Col. 11 of Table O.

A7. Thin-bedded, dense gray limestones, 75 ft.

At the base is fauna C62, given in Col. 10 of Table O.

A6. Gray shale and slabby limestone, preceded by dense gray limestone and then by nodular green shale 75 ft.

In the Middle portion is fauna C2, a little lower C1, and lower still C4. This horizon is represented in section V-B (M of Walcott) by horizon C10, and in Section L(of Walcott) by horizon C57. These species are given in Col. 9. of Table O.

A5. Dense gray limestone, preceded by dark limestone, partly oolitic 50 ft.

Hiatus and Disconformity

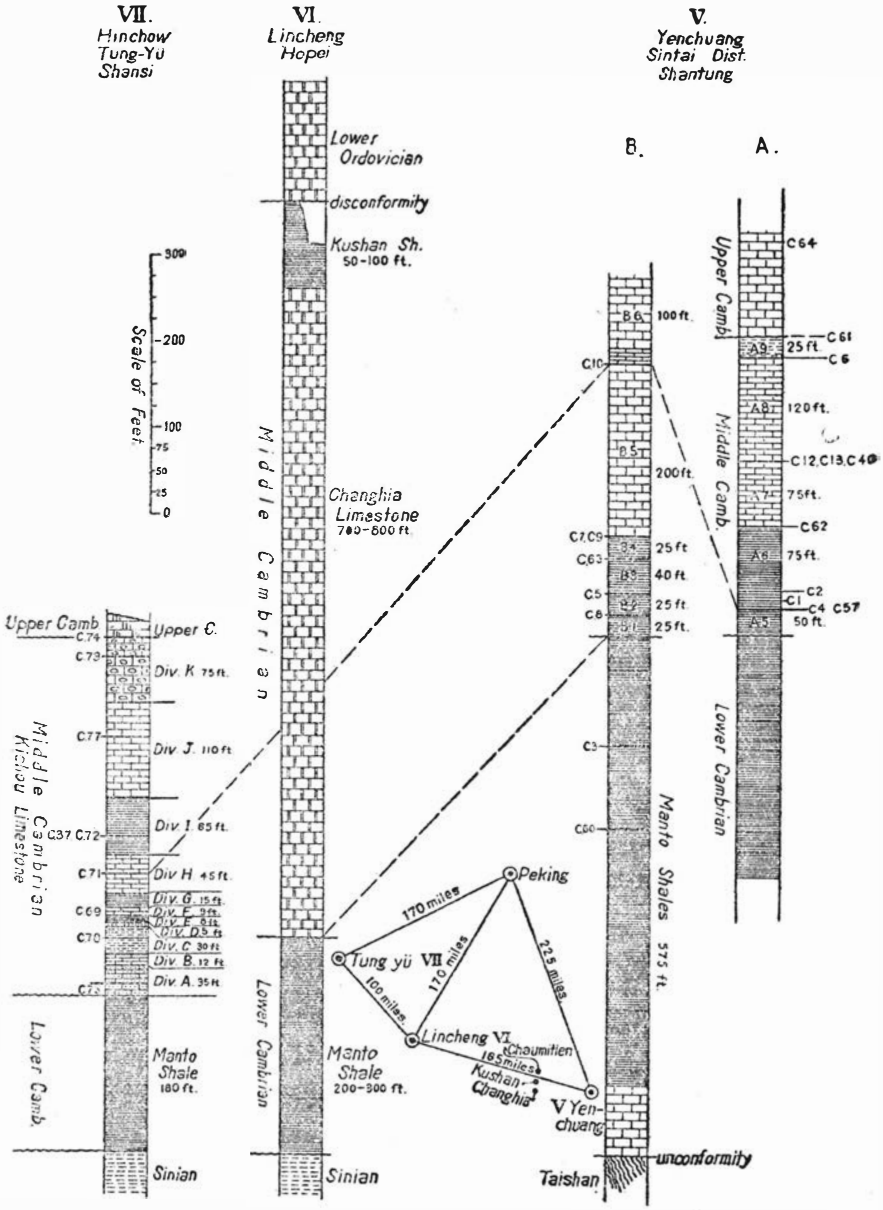
Lower Cambrian. Manto shales.

Section VB.

Section in Western Kiulungshan, Yenchuang, Sintai, Shantung

(Walcott: Section M. Figs. 5 and 6, p. 44)
(Text Fig. 14)

This section shows only the lower part of the Middle Cambrian and the entire Mantó shale, about 525 ft. thick, resting upon gray Archæan gneiss. The interesting fact about this section is that the highest fossiliferous horizon (C10), corresponds approximately to the horizons C2, and C1 and C4 of the preceding section (V-A) but whereas in that section, these beds lie only about 50 ft. above the Manto shale, the distance above that horizon in Section V-B is 315 ft., and there are 4 additional fossiliferous horizons, which are not found in Section V-A. This clearly shows disconformity and



Text-Fig. 14. Sections along a line from Central Shansi through Southern Hopei to Southeast Shantung Provinces in China showing the variation in the Cambrian strata and the disconformities which bound the Middle Cambrian (See Text). For location see Inset Map, compare with Figure 13.

overlap in the two sections. The following is the section in descending order.

B6. Massive limestone preceded by nodular shale, dense gray limestone and green shale about 100 ft.

In the lower part is horizon C10 with *Obolus damesi*, *Minocephalus* sp. and *Anomocarella temenus*. (Col. 8, Table ●) This is correlated by Walcott, with horizon C1 and C2 of Section V-A, and with hor. C57 in Walcott's section L. These are given together in Col. 8 of Table O, (compare also Sect. IV. bed H, Hor. C71.)

B5. Light gray and dark gray limestone (Bed 34), with hard dark gray oolite in the Lower part (Bed 33). 200 ft.

Horizons C7 and C9, lie in the upper part of Bed 33, at the base of division 5. The faunas are given in Col. 7 of Table O.

B4. Part of an oolite, (Bed 33) and gray sandy limestone (Bed 32) 25 ft.

Horizon C63, is in the Middle of the gray sandy limestone, the fauna includes only one species *Obolus obscurus*. (Col. 6, Table O)

B3. Lower part of sandy limestone, Bed 32 and olive shale, Bed 31 40 ft.

	Cross-bedded green-gray limestone, (Bed 30) Horizon C5 in the latter. The species are given in Col. 5, of Table O.		
B2.	Olive green shales, buff earthy limestone and brown shales. Beds 31-37	25 ft.	
	In the lower part of 27 is horizon C8, the fauna given in Col. 4, Table O, comprises *Ptychoparia impar Anomocare* sp.		
B1.	Brown shale, preceded by a greenish conglomeritic limestone (Bed 26), which forms the base of the Middle Cambrian in this section	25 ft.	
	Total Middle Cambrian shown		415 ft.

Hiatus and Disconformity

Lower Cambrian Manto shale 525 ft.

With *Redlichia* sp. at horizon C60, about 250 ft. below C8, or 225 ft. below the base of the Middle Cambrian.

Hiatus and Unconformity

Archæan gneiss

Section VI. Lincheng S. W. Hopei Province

This lies approximately 250 miles south-west of the Kaiping Basin, or approximately 160 miles S. S. W. of Peking. (Approximate Longitude 114° 30′ E, Latitude

37° 15′ N.) Here the following sections were made by the late Y. T. Chao and Mr. C. C. Tien.

SUPERFORMATION. Lower Ordovician

Hiatus and Disconformity

MIDDLE CAMBRIAN

Kushan formation 50-100 ft.

Shales and limestones with the following species.

Brachiopoda

Obolus linchengensis Sun

Trilobita

1. *Wongia triangulata* Sun (gen. et. sp.)
2. *Blackwelderia tieni* Sun
3. *Blackwelderia sinensis linchengensis* Sun
4. *Stephanocare richthofeni* Monke
5. *Teinistion subconica* Sun

These species are included in Col. 21 of Table O.

Changhia limestone 700-800 ft.

Massive and oolitic limestones. No fossils have been obtained from this formation.

Probable Hiatus and Disconformity.

LOWER CAMBRIAN Manto shale 200-300 ft.

Reddish and purplish shale which so far has not furnished fossils.

Hiatus and Disconformity

SUBFORMATION Sinian Beds.

This section is of great interest because of the great thickness of the Changhia limestone, which is here succeeded by the Kushan shales, with characteristic fauna. When compared with the section in the Kaiping Basin 250 miles N. E. where this limestone is only from 300-400 ft. thick, and with the Changhia section of Shantung, 125 miles S. E. where the thickness is 500 ft. it is apparent that portions of these section must be incomplete. In the Lincheng and Changhia district the Kushan shale is present, and the difference of 200 to 300 ft. in the thickness of the Changhia limestone may be accounted for by the basal overlap. This is also suggested by the fact that whereas the Manto shale is 500 ft. in the Changhia section, its thickness in the Lincheng section is only 200-300 ft.

In the Kaiping section on the other hand, the Manto shale is again from 400-500 ft. thick, but the Changhia limestone is only from 300-400 ft. in thickness and the Kushan shale seems to be absent. The Kaiping and Changhia sections are approximately along the line of strike, and the small thickness of the Changhia limestone in the Kaiping section, coupled with the absence of the Kushan is probably to be accounted for by pre-Upper Cambrian erosion or late Middle Cambrian off-lap.

Section VII Section at Hinchou Tung-yü Shansi
(Walcott Sect. O)

This lies about 170 miles south west of Peking (Approximately Long. 112° 50′ E, Lat. 38° 30′ N.)

UPPER CAMBRIAN

Dense blue limestone 20 ft.

At the base horizon C74, with *Eoorthis kayseri* and *Ptychaspis bella*.

Hiatus and Disconformity

MIDDLE CAMBRIAN			409 ft.
K.	Ocherous gray dense conglomeritic limestone	75 ft.	
	25 ft. below the top (below C74) is horizon C73, which has furnished *Blackwelderia cilix*, and *Inouyia? regularis*. (Col. 19 Table O).		
J.	Massive ocherous gray limestone	110 ft.	
	About 30 ft. below the top of this limestone, or 85 ft. below horizon C73, is horizon C77, with *Lisania* cf. *bura*, *Anomocare* sp. and *Anomocarella irma* (Col 18 Table O)		
I.	Brown gray shale and thin-bedded limestone	65 ft.	
	Near the middle, or 115 ft. below horizon C77, are horizons C37 and C72. The fossils here found, are given in Col. 17 Table O.		
H.	Massive gray oolitic limestone	45 ft.	
	About 20 ft. below the top, or 50 ft. below C37, is horizon C71, with the species given in Col. 16, Table O. This is regarded as the same horizon as C1 and C2 of section V-A and C10 of section V-B.		
G.	Gray shale.	15 ft.	
F.	Gray crystalline limestone	9 ft.	
	In the upper part, or about 35 ft. below C71, is horizon C69, with the fossils given in Col. 15 Table O.		

E. Gray calcareous shales 8 ft.

D. Oolitic limestone 5 ft.

C. Gray and buff shales, with limestone nodules 30 ft.

35 ft. below C69, is horizon C70 with the fossils given in Col. 14 Table O

B. Hard-brown gray oolitic limestone 12 ft.

A. Slabby buff limestone, dense and hard 35 ft.

In the lower part, or about 55 ft. below C70, and perhaps 15 ft. above the base, is C75, with the species listed in Col. 13, Table O

Hiatus and Disconformity

LOWER CAMBRIAN Mantó shales 180 ft.

Red shales with a basal sandstone and conglomerate, 3-15 ft. thick.

Hiatus and Unconformity

PRE-CAMBRIAN Hut'o System

Comparing this with the section of the Sintai District, we find first of all, an enormous difference in the thickness of the Manto shales, which is 180 ft. here, but over 500 ft. thick in the Kiulungshan section of Yenchuang, Sintai District in Shantung. A part of this is of course due to basal overlap, but another part undoubtedly was the result of erosion of the Mantó shale before the readvance of the Middle Cambrian Sea. Again the total thickness of the Middle Cambrian in the Hinchou Section, (Section VII) is 409 ft. while that in section V-A of the Sintai District, at Kiulungshan, is only about 345 ft, though when the missing portion from section V-B is added, the section would be over 750 ft. in thickness. Taking equivalent beds, we have in section VII horizon C71, 275 ft. below the top of the Middle Cambrian. In section V-A, the equivalent bed is 245 ft. below the top. The difference however is more pronounced when these equivalent beds are compared with the base of the section. Thus in Section VII Hinchou, C71 is 140 ft. above the base. In section V-B the equivalent horizon (C10) is 315 ft. above the base. Finally in section V-A it is only 50 ft. above the base. This testifies eloquently to the presence of a disconformity between the Lower and the Middle Cambrian, and to overlap.

The disconformity between the Middle and Upper Cambrian is shown by a comparison between sections in Ch'aumitien (Walcott Sect. E) and Yenchuan (Walcott's Section N, our Section V-A). In the former, horizon C45, lies 800 feet above the Kushan shale. In the latter which lies about 60 miles south east of the former, Hor. C64, which Walcott correlates with C 45, lies only 150 ft. above Hor. C6, the representative of the Kushan shale. This indicates overlap, but not much erosion since the Kushan is represented in both sections.

TABLE O.

MIDDLE CAMBRIAN OF CHINA

In the following table, Cols 1-3, represent the Middle Cambrian of the Changhia District of Shantung. (Walcott Fig. I, p. 43) Changhia limestone. Cols 4-8 represent the several fossiliferous zones of Section V-B. at Yenchuang in Shantung. (See Text-Fig. 14 and Walcott Figs 5 and 6, page 44).

Col's. 9-12 represent the Middle Cambrian or Lower Kiulung formation in the Kiulungshan of Henchuang Shantung. (Text-Fig 14, Col. V-A Walcott's fig. 8, page 45).

Col's. 13-19 repesents the several fossiliferous zones of the Kichou limestone (Middle Cambrian) of Hinchou south of Tungyü in Shansi. (Text-Fig 14, Col. VI, Walcott's fig 3, page 43.)

Cols. 20-21 represent the sections in Hopei province according to Y. C. Sun, and Cols 22-26 represent the fossiliferous zones, of the Fuch'ou formation of Tschanghsing Island Liautung Peninsula, Manchuria. The details are as follows:

Col. 1. Division I (lowest) of the Ch'anghia limestone, Changhia section (Walcott C. 23 and C. 28.)

Col. 2. Division II of the same. (Walcott's horizons C. 29, C. 30 C48 and C.51.)

Col. 3. Division III of Changhia limestone Changhia District (Walcott's horizons C18, C19, C21, C22, C24, C25, C26, C35, C46.)

Col. 4. Division B2, Section V-B. Yenchuang. (Walcott horizon C8.)

Col. 5. Division B-3, V-B, Yenchuang Horizon C5.

Col. 6. Division B4, Section V-B. Yenchuang (Walcott Horizon C63.)

Col. 7. Division B5. Section V-B. (Walcott horizons C7, C9.)

Col. 8. Division B6. Section V-B. (Horizon C. 10.) Also Walcott's Section L. Horizon C 57. and horizon Division H, Section VI C. 58.

Col. 9. Division A6, Lower Kiuling, Section V-A (Horizons C2, C1 and C4) correlated with horizons C10 in Col. 8 and with horizon 71 Division H, Section VI Col. 16.

Col. 10. Division A7, Lower Kiuling, Section V-A. (Walcott horizon C62.)

Col. 11. Division A8, Lower Kiuling, Section V-A. (Walcott's horizons C12, C13, C40.)

Col. 12. Division A9. Lower Kiuling, Section V-A (Walcott's horizon C.6.) Also horizon C.55 of Walcott's section F. (at Chaumitien) Shantung. These two represent the Kushan formation.

Col. 13. Division A. Kichou limestone, Section VII, Hinchow Shansi (Walcott horizon C. 75)

Col. 14. Division C., Section VI Hinchou. (Walcott's horizon C70.)

Col. 15. Division F., Section VII Hinchou. (Walcott's horizon C69.)

Col. 16. Division H., Section VII Hinchou. (Walcott's horizon C71.)

Col. 17. Division I., Section VII Hinchou. (Walcott's horizons C37 and 72).

Col. 18. Division J., Section VII Hinchou. (Walcott's horizon C77).

Col. 19. Division K, Section VII Hinchou. (Walcott's horizon C73). Probably the Kushan shale.

Col. 20. Changhia limestone of the Kaiping Basin, Hopei Province. (See Text-Fig. 13, Section II).

Col. 21. Kushan shale of Lincheng, Hopei Province. (Text Fig 14 Section VI).

Col. 22. Fuchou Series, Manchuria. Division 2. (Idding's horizons 36c, 36e, 35n, 35r). Sect. I.

Col. 23. Fuchou Series, Manchuria. Division 3a, Lower horizon, about 80 ft. above basal quartzite. (Idding's locality 35 p). Sect. I

Col. 24. Fuchou Series, Manchuria. Division 3b, Horizon about 50 ft. above the preceding. (Idding's locality 36h, also approximate equivalent localities 35o, 36g.) Section I

Col. 25. Fuchou Series, Manchuria. Division 5, horizon about 70 ft. above the preceding or 200 ft. above white quartzite. (Idding's locality 35q). Sect. I

Col. 26. Fouchou Series, Manchuria. Division 7. Upper part. Horizon 800 ft. above the preceding or 1000 ft. about the white quartsite. (Idding's Loc. 36f.) Sect. I

Table O. Middle Cambrian of China	Chang. hia. Dist. Shantung			Sect. V-B Yenchuang Shantung					Sect. V-A Yenchuang Shantung				Hinchou Sect. Tungyü Dist. Shansi							Hopei		Fuchou Ser. Tschanghsing Manchuria					Hor. Indet.
	Div. I	Div. II	Div. III	Div. B2	Div. B3	Div. B4	Div. B5	Div. B6	Div. A6	Div. A7	Div. A8	Div. A9	Div. A	Div. C	Div. F	Div. H	Div. I	Div. J	Div. K	ChanghiaKaiping	Kushan,Lincheng	Div. 2	Div. 3a	Div. 3b	Div. 5	Div. 7	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Foraminifera																											
1 Globigerina? mantoensis Walc.	—	—	—	—	×																						
Porifera																											
1 Protospongia chloris Walc.	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×		
2 Protospongia sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
Anthozoa																											
1 Coscinocyathus elvira Walc.	—	—	—	—	—	—	—	—	—	—	—	—	×														
Annelida																											
1 Planolites sp. (trails of annelida)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
Brachiopoda																											
1 Micromitra sculptilis (Meek)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					

Table O (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Brachiopoda (cont.)																											
2 Paterina labradorica orientalis Walc.	—	—	—	—	—	—	×																				
3 Paterina lucina Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
4 Iphidella pannula maladensis (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
5 Iphidella pannula ophirensis Walc.	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
6 Nisusia hayasakai Sun	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	×							
7 Obolus chinensis Walc.	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×					
8 Obolus damesi Walc.	—	—	—	—	—	—	×	×	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×			
9 Obolus linchengensis Sun	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
10 Obolus minimus Walc.	—	—	—	—	—	—	—	—	×																		
11 Obolus obscurus Walc.	—	—	—	—	—	×	—	—	—	—	—	—	×														
12 Obolus shansiensis Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	—	—	—	×					
13 Westonia blackwelderi Walc.	—	—	—	—	—	—	—	—	×	—	—	×															
14 Lingulella manchuriensis Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
15 Lingulella marcia Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	×	
16 Lingulepis eros (Walc.)	—	—	—	—	—	—	×																				
17 Lingulepis? sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
18 Dicellomus parvus Walc.	—	—	—	—	—	—	—	—	—	—	—	×															
19 Yorkia? orientalis Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×											
20 Acrothele matthewi eryx Walc.	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×			

Table O (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Brachiopoda (cont.)																											
21 Acrothele? minuta Walc.	—	—	—	—	—	—	—	—	—	—	—	×															
22 Acrothele rara Walc.	×	—	—	—	—	—	—	×																			
23 Acrotreta lisani Walc.	—	—	×																								
24 Acrotreta pacifica Walc.	—	—	×	—	×	—	—	—	×	—	×	—	—	—	—	—	—	—	—	—	—	—	×				
25 Acrotreta shantungensis Walc.	—	—	—	—	—	—	—	—	×	×	—	—	—	—		×	×	—	—	—	—	×	—	×			
26 Acrotreta venia Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×		
27 Eoorthis agreste Walc.	×																										
28 Eoorthis kichouensis (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	×														
29 Eoorthis sp. a	—	—	×																								
30 Eoorthis sp. b,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×											
Gastropoda																											
1 Scenella clotho Walc.	—	—	×																								
2 Scenella? dilatatus Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	×													
3 Straparollina sp.	—	—	—	—	—	—	—	—	—	—	—	×															
4 Pelagiella chronus (Walc.)	—	—	×	—	—	—	—	—	×																		
5 Pelagiella willisi (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
6 Helcionella? clurius (Walc.)	—	—	×																								
7 Helcionella rugosa orientalis (Walc.)	—	—	×																								
8 Helcionella? simplex Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	×													

Table O (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Pteropoda?																											
1 Hyolithes cybele Walc.	—	—	×	—	—	—	—	—	×	×	—	—	—	—	—	—	—	—	—	—	—	×					
2 Orthotheca cyrene Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
3 Orthotheca cyrene dryas Walc.	—	—	—	—	—	—	—	—	×																		
4 Orthotheca daulis Walc.	×																										
5 Orthotheca delphus Walc.	—	—	—	—	—	—	—	×	×	—	—	—	—	—	—	—	—	—	—	—	—	×					
6 Orthotheca cf. delphus Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
7 Orthotheca doris Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×
8 Orthotheca glabra Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	—	—	—	×					
Trilobita																											
1 Agnostus chinensis Dames	—	—	—	—	—	—	—	×	×	—	—	—	—	—	—	×	—	—	—	—	—	×	×	×			
2 Agnostus douvillei Bergeron	—	—	—	—	—	—	—	—	—	—	—	×															
3 Agnostus kushanensis Walc.	—	—	—	—	—	—	—	×																			
4 Agnostus parvifrons latelimbatus Lorenz	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×
5 Microdiscus orientalis W.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×
6 Shumardia sp.	—	×																									
7 Redlichia? finalis (Walc.)	—	—	—	—	—	—	—	×																			
8 Redlichia sp. a	—	—	—	—	—	—	—	—	—	—	—	×															
9 Albertella pacifica Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	

Table O (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Trilobita (cont.)																											
10 Dorypygebispinosa Walc.	—	—	—	—	—	—	—	—	×																		
11 Dorypyge richthofeni Dames	—	×	×	—	—	—	—	×	×	—	—	—	—	—	—	—	—	—	—	×	—	×	×				
12 Dorypyge richthofeni laevis Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×										
13 Teinistion alcon (Walc.)	—	—	—	—	—	—	—	—	—	—	×																
14 Teinistion lansi Monke	—	—	—	—	—	—	—	—	—	—	×	×															
15 Teinistion sodeni Monke	—	—	—	—	—	—	—	—	—	—	—	×															
16 Teinistion subconica Sun	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
17 Teinistion typicalis Walc.	—	—	—	—	—	—	—	—	—	—	×																
18 Stephanocare ? monkei Walc.	—	—	—	—	—	—	—	—	—	—	—	×															
19 Stephanocare richthofeni Monke	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	×						
20 Stephanocare? sinensis (Bergeron)	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
21 Stephanocare? sp.	—	—	—	—	—	—	—	—	—	—	—	×															
22 Blackwelderia alastor (Walc.)	—	—	—	—	—	—	—	—	—	—	×																
23 Blackwelderia cilix (Walc.)	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	×								
24 Blackwelderia sinensis (Bergeron)	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
25 Blackwelderia sinensis linchengensis Sun	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						

Table O (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Trilobita (cont.)																											
26 Blackwelderia tieni Sun	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
27 Damesella bellagranulata Walc.	—	—	—	—	—	—	—	—	—	—	×																
28 Damesella blackwelderi Walc.	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	
29 Damesella blackwelderi minor Sun	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
30 Damesella brevicaudata Walc.	—	—	×																								
31 Damesella sp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
32 Drepanura ketteleri Monke	—	—	—	—	—	—	—	—	—	—	—	×															
33 Drepanura premesnili Bergeron	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
34 Ptychoparia impar var Walc.	—	—	—	×																							
35 Ptychoparia kochibei Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
36 Ptychoparia lilia Walc.	—	—	—	—	—	—	—	—	—	—	—	—	×														
37 Ptychoparia? tolus Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×
38 Ptychoparia typus (Dames)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
39 Ptychoparia sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
40 Emmrichella bromus (Walc.)	—	—	—	—	—	—	—	—	—	—	—	×															

Table O (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Trilobita (cont.)																											
41 Emmrichella eriopia (Walc.)	×																										
42 Emmrichella theano (Walc.)	×																										
43 Conokephalina maia (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	×													
44 Conokephalina vesta (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×												
45 Conokephalina sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×										
46 Crepicephalus convexus Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
47 Crepicephalus damia Walc.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	×											
48 Crepicephalus magnus	—	×	×																								
49 Crepicephalus sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
50 Lonchocephalus tellus Walc.	—	—	—	—	—	—	—	—	×																		
51 Liostracina krausei Monke	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
52 Pterocephalus asiaticus Walc.	—	—	—	—	—	—	—	—	—	—	×																
53 Pterocephalus? liches Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
54 Shantungia spinifera Walc.	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	×	

Table O (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Trilobita (cont.)																											
55 Inouyia abaris (Walc.)	—	—	—	—	—	—	×																				
56 Inouyia? acalle (Walc.)	—	—	—	—	—	—	—	—	—	—	×																
57 Inouyia armata? (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	×														
58 Inouyia capax (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	×													
59 Inouyia divi (Walc.)	—	—	×	—	×	—	—	—	×																		
60 Inouyia? inflata (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×												
61 Inouyia melie (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	×	×													
62 Inouyia ? regularis (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
63 Inouyia thisbe Walc.	—	—	—	—	—	—	—	—	—	—	×																
64 Inouyia titiana (Walc.)	—	—	—	—	—	—	×																				
65 Agraulos abrota Walc.	×																										
66 Agraulos dirce Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×
67 Agraulos dolon Walc.	—	—	—	—	—	—	×																				
68 Agraulos dryas Walc.	—	×																									
69 Agraulos nitida Walc.	—	—	—	—	—	—	—	—	—	—	—	—	×														
70 Agraulos obscura Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×												
71 Agraulos sorge Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
72 Agraulos uta Walc.	—	—	—	—	—	—	—	—	—	—	—	—	×														
73 Agraulos vicina Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	×													
74 Lisania agonius (Walc.)	—	—	—	—	—	—	—	—	×																		
75 Lisania ajax (Walc.)	—	—	—	—	—	—	—	—	—	—	×																
76 Lisania alala (Walc.)	—	×	×	—	—	—	—	—	×																		
77 Lisania? belenus Walc.	—	—	×																								
78 Lisania bura Walc.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	cf									

Table O (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Trilobita (cont.)																											
79 Lisania ? hsuchiachuangensis Sun	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
80 Lisania rectangularis Sun	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
81 Lisania sp.	—	×																									
82 Solenopleura agno Walc.	—	×	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
83 Solenopleura beroe Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
84 Solenopleura chalcon Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
85 Solenopleura intermedia Walc.	—	×																									
86 Solenopleura nodosa Sun	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
87 Solenopleura pauperata Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×											
88 Solenopleura sp.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
89 Menocephalus abderus (Walc.)	—	—	×																								
90 Menocephalus acanthus (Walc.)	—	—	×																								
91 Menocephalus acerius Walc.	—	—	×																								
92 Menocephalus acidalia (Walc.)	—	×																									
93 Menocephalus acis Walc.	—	—	×																								
94 Menocephalus admeta Walc.	—	—	×																								

Table O (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Trilobita (cont.)																											
95 Menocephalus agave Walc.	—	×																									
96 Menocephalus? sp.	—	—	—	—	—	—	—	×																			
97 Levisia adrastia (Walc.)	—	×																									
98 Levisia agenor (Walc.)	—	—	×																								
99 Anomocare alcinoe Walc.	—	—	—	—	—	—	—	×																			
100 Anomocare daulis Walc.	—	—	×																								
101 Anomocare ephori Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
102 Anomocare flava Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×							
103 Anomocare latelimbatum Dames	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	×	—	×					
104 Anomocare lisani Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×		
105 Anomocare megalurus (Dames)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	×					
106 Anomocare minus Dames	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×			
107 Anomocare minus var Dames	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
108 Anomocare ? nereis (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×										
109 Anomocare subquadratum (Dames)	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
110 Anomocare sp.	—	×	×	×	×	—	—	—	—	—	—	—	—	—	—	—	—	×									

Table O (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Trilobita (cont.)																											
111 Anomocarella albion Walc.	—	—	—	—	—	—	—	×	×																		
112 Anomocarella bigsbyi (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×											
113 Anomocarella biston Walc.	—	—	—	—	—	—	—	—	×																		
114 Anomocarella butes Walc.	—	—	—	—	×																						
115 Anomocarella chinensis Walc.	—	—	—	—	—	—	—	×	×	×	—	—	—	—	—	—	—	—	—	—	—	×	—	×			
116 Anomocarella comus (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×											
117 Anomocarella hermias Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
118 Anomocarella cf hermias Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
119 Anomocarella irma Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×									
120 Anomocarella macar Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
121 Anomocarella speciosa Lorenz	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×
122 Anomocarella subrugosa (Walc.)	—	—	—	—	—	—	×																				
123 Anomocarella tatian (Walc.)	×																										

Table O (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Trilobita (cont.)																											
124 Anomocarella temenus (Walc.)	—	—	×	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
125 Anomocarella tenes (Walc.)	×																										
126 Anomocarella thraso (Walc.)	—	—	—	—	—	—	×																				
127 Anomocarella toxeus (Walc.)	×																										
128 Anomocarella trogus (Walc.)	—	—	×																								
129 Anomocarella tutia (Walc.)	—	—	×	—	—	—	—	—	—	—	×																
130 Anomocarella undata (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×											
131 Coosia? daunus (Walc.)	—	—	—	—	—	—	—	—	×																		
132 Coosia decelus (Walc.)	—	—	—	—	—	—	×																				
133 Dolichometopus alceste (Walc.)	—	—	—	—	—	—	—	—	×																		
134 Dolichometopus deois Walc.	—	—	×	—	—	—	—	×	×	—	—	—	—	—	—	—	—	—	—	×	—	×	×	×			
135 Dolichometopus derceto Walc.	—	—	—	—	—	—	—	—	×																		
136 Dolichometopus dirce Walc.	—	—	×																								
137 Dolichometopus hyrie Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×												

Table O (*Concluded*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Trilobita (cont.)																											
138 Dolichometopus? sp.	—	—	—	—	×																						
139 Bathyuriscus manchuriensis Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
140 Asaphiscus iddingsi Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
141 Bathyuriscus sp.	×																										
142 Wongia triangulata Sun	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
Ostracoda																											
1 Aluta bergeroni Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×
2 Aluta enyo (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×
3 Aluta eris (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×
4 Aluta fragilis (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×
5 Aluta sterope (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×
6 Aluta woodi (Walc.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×

Of interest in this fauna is the presence of several species characteristic of the Palæocordilleran geosyncline of western North America. These are

Iphidella pannula maladensis (Walcott)
Iphidella pannula ophirensis (Walcott)

also such characteristic American genera as *Albertella*, *Dorypyge*, *Crepicephalus*, *Coosia*, *Dolichometopus?** *Bathyuriscus*, *Asaphiscus*, etc. All of these indicate that a line of communication, however incomplete, was being established. If we accept the idea of a Pangæa as shown in Plate II, it is easy to see that such communication could be established by the development of a narrow continental shelf along the coast of South America.

* The Asiatic species of Dolichometopus? differ from the American in the character of the associated pygidia. Walcott suggests that they belong to a distinct subgenus (Walcott Camb. Geol & Pal. III p. 359.)

The Indo-China Sections

The Cambrian of Tongking has been investigated by Deprat and the faunas described by Mansuy[1]

The most complete section is in the region of Tenfong and Changchung. Here the main divisions, according to Deprat, are as follows.

Upper Cambrian.		968 meters
G. Beds with *Ptychaspis walcotti*	355 m.	
F. Beds with *Ptychaspis angulata*	220 m.	
E. Beds with *Dolychometopus*	175 m.	
D. Beds with *Chuangia nias*	228 m.	
Middle Cambrian.		804 meters
C. Beds with *Billingsella*	217 m.	
B. Beds with *Stephanocare richthofeni*	119 m.	
A. Beds with *Blackwelderia*	469 m.	

The detailed section as given by Deprat is as follows in descending order for the Middle Cambrian.

Division C, with *Billingsella*		221 meters
21. Thin-bedded limestone with thin interbedded sandy and marly layers and irregular lentils	110 m.	

1 *J. Deprat.* Étude Géologiques sur la Region Septentrionale Haut-Tonkin. Mémoirs du Service Géologique du l'Indochine. Vol. IV, Fasc. IV, p. 89, 1915.

H. Mansuy. Faunes Cambrien du Haut Tonkin. *Ibid.* Fasc. II, 1915.

H. Mansuy. Faunes Cambriens des l'extreme Orient Meridionale. *Ibid.* Vol. V. Fasc. I, 1916.

20.	Complex of alternating graywackes, thin limestone beds sands and marls with *Billingsella tonkiniana*	38 m.	
19.	Limestone similar to 21	25 m.	
18.	Graywackes	30 m.	
17.	Coarse sandstones	4 m.	
16.	Graywackes	10 m.	
15.	Coarse sandstones	4 m.	
	Division B, with *Stephanocare richthofeni*		119 meters
14.	Thin limestone beds, separated by thin sandy layers	65 m.	
13.	Yellow graywackes	19 m.	
12.	Dark oolitic limestones	10 m.	
11.	Yellowish and reddish marls, with intercalations of sandy beds	20 m.	
	Division A, with *Blackwelderia*		468 meters
10.	Yellow, sandy and gravelly beds	30 m.	
9.	Dark oolitic limestones, alternating with clayey marls	60 m.	
8.	Alternations of sandstones graywackes and shales	40 m.	
7.	Oolitic limestones, regularly bedded	40 m.	
6.	Sandy clay shales	30 m.	
5.	Black oolitic limestones	50 m.	
4.	Sandy beds	15 m.	
3.	Evenly bedded limestone	19 m.	
2.	Yellow sandstone	18 m.	
1.	Limestones with intercalations of phthanite	180 m.	

The Lower Cambrian appears to be wholly wanting in this region, though it is known from Yunnan in South China. Apparently the measured sections do not give the full thickness of this series, for Deprat says that the thickness of the entire Cambrian is at least 2500 meters and of this probably nearly one half would fall to the Middle Cambrian. Deprats lithological section loses much of its value for lack of precise correlation with the palæontological zones of Mansuy. There is even some question as to the dividing line between the Middle and Upper Cambrian, which Deprat puts above the beds with *Billingsella tonkiniana*, (Horizon 20,) while Mansuy considers this species, which is closely related to *Billingsella coloradoensis*, to mark the base of the Upper Cambrian. *B. coloradoensis* Schumard, is however, characteristic of the Langston and Ute formations of the Palæo-Cordilleran geosyncline, but also occurs in the Upper Cambrian St. Charles formation of that geosyncline. Again it has been reported from the *Paradoxides* beds in the Caledonian geosyncline.

The palæontological subdivisions by Mansuy distinguish 17 zones, 4 of which he places in the Upper Cambrian. Unfortunately Mansuy treats these zones purely palæontologically, giving neither thickness nor lithological character, nor does he attempt to correlate them with the section by Deprat. The following are the zones beginning with the lowest.

a. Zone of *Anomocarella* cf. *albion* Mansuy corresponding to the basal zone of the Middle Cambrian of Shantung.

b. Zone of *Tonkinella flabelliformis* Mansuy, a form generically related to *Karlia* Walcott and *Bathyuriscus* Meek.

c. Zone of *Anomocare* cf. *latilimbatum* Dames and *Ptychoparia* (*Emmrichella*) cf. *thiano*.

d. Zone with fragmentary fossils of unrecognizable genera and species (Crosiao Van beds).

e. Zone of *Conocoryphe lantenoisi* Mansuy (This species however, recurs in zone g.)

f. Zone of *Anomocare propinquum* Mansuy.

g. Zone of *Anomocare minus*.

With this occurs *Conocoryphe lantenoisi* and to this horizon has also been referred the *Dorypyge richthofeni*.

h. Zone of *Anomocare subquadratum* Dames

Probably only a mutation of *A. minus*.

i. Zone of *Conokephalina* Brögger, comprising

C. termieri Mansuy, *C. tienfongensis* Mansuy, *C. oblonga* Mansuy, *C. latifrons* Mansuy and *C. sinensis* Mansuy.

j. Zone of *Chuangia meridionalis* Mansuy

Somewhat related to *C. battia* Walcott, which occurs at the base of the Upper Cambrian in China.

k. Zone of *Ptychoparia* (*Annamites*) *spinifera*, together with *Coosia asiatica*

l. Zone of *Stephanocare monkei* Walcott and *Anomocarella* cf. *sinensis* Walcott

m. Zone of *Damesella brevicaudata* Walcott, and *Coosia deprati* Mansuy. Other characteristic species of this zone are *Blackwelderia sinensis* (Bergeron), *Black-*

weldaria celix Walcott, *B. alastor* Walcott, *Agraulos tonkinensis* Mansuy, and *Agnostus* cf. *douvillii* Bergeron.

This corresponds precisely to the *Damesella brevicaudata* beds of China, *i. e.* essentially the Kushan shale at the top of the Middle Cambrian, and this is where Mansuy draws the dividing line between the Middle and Upper Cambrian.

Upper Cambrian

n. Zone of *Chuangia nais* Walcott and *Billingsella tonkiniana* correlated with the Ch'aumitien limestones of Shantung.

o. Zone of *Ptychaspis angulata* Mansuy, *Illaenurus ceres* Walcott, and *Billingsella loungeoensis* Mansuy. *Ptychaspis angulata* is related to *P. acamus* Walcott of the Upper Cambrian of Shantung. *Illaenurus ceres* is characteristic of the Upper Cambrian Chaumitien limestone of Shantung. *Billingsella loungeoensis* suggests *B. exporrecta* and *B. rugosocostata* Linnarsson, of the Middle Cambrian of Sweden

p. Zone of *Ptychaspis walcotti*, associated with *Schumardia orientalis*. *P. walcotti* is related to *Pt. cadmus* Walcott and *Pt. acamus* Walcott of the Upper Cambrian.

q. Zone of *Ptychaspis walcotti* and *Eoorthis doris* Walcott.

r. Zone of *Anomocare* cf. *magalurus* Dames.

In table P, are given the species and their distribution in these various zones as given by Mansuy. Despite the number of new forms, the relation to the Chinese Cambrian is apparent.

Table P

Distribution of Cambrian Species in Tonking

	Tonking Mansuy's Zones													China	
	a	b	c	d	e	f	g	h	i	j	k	l	m	Changhia	Kushan
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Brachiopoda															
1 Obolus shansiensis Walcott	—	—	—	—	—	—	—	×	—	—	—	—	—	×	
2 Obolus cf. shansiensis Walcott	—	—	—	—	—	—	—	—	—	—	—	×	—	×	
3 Obolus cf. chinensis Walcott	—	—	—	—	×	—	—	—	—	—	—	—	—	×	
4 Westonia cf. blackwelderi Walcott	—	—	—	—	—	—	—	—	×	—	×	—	—	×	×
5 Trematobolus?															
6 Lingulella cf. manchuriensis Walcott	—	—	—	—	—	—	—	×	—	—	—	—	—	×	
7 Lingulella cf. marcia Walcott	—	—	—	—	—	—	—	—	×	—	—	—	—	×	?
8 Acrothele cf. matthewi eryx Walcott	—	—	—	—	×	—	—	—	—	—	—	—	—	×	
9 Acrotreta lisani Walcott	—	—	—	—	—	—	—	×	—	—	—	—	—	×	
10 Eoorthis agreste Walcott	—	—	—	—	—	—	—	—	—	—	—	—	×	×	
Pteropoda etc.															
1 Hyolithes sp.	—	—	—	—	—	—	—	—	x?						
2 Orthotheca cf. cyrene Walcott	—	—	—	—	—	—	—	×	—	—	—	—	—	×	
3 Orthotheca cf. cyrene dryas Walcott	—	×	—	—	—	—	—	—	—	—	—	—	—	×	
4 Orthotheca sp. (cf. daulis Walcott)?	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
Trilobita															
1 Agnostus cf. chinensis Dames	—	—	×	—	—	—	—	—	—	—	—	—	—	×	
2 Agnostus cf. douvillei Bergeron	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×
3 Stephanocare richthofeni Monke	—	—	—	—	—	—	—	—	—	—	—	—	?	—	×

Table P (*Continued*)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Trilobita (cont.)																
4	Stephanocare (?) sinensis (Bergeron)	—	—	—	—	—	—	—	—	—	—	—	—	?	—	×
5	Stephanocare (?) monkei Walcott	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×
6	Blackwelderia sinensis (Bergeron)	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×
7	Blackwelderia cilix Walcott	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×
8	Blackwelderia alastor Walcott	—	—	—	—	—	—	—	—	—	—	—	—	×	×	
9	Damesella brevicaudata Walcott	—	—	—	—	—	—	—	—	—	—	—	—	×	×	
10	Damesella cf. blackwelderi Walcott	—	—	—	—	—	—	—	—	—	—	—	—	×	×	×
11	Damesella sp.	—	—	—	—	—	—	—	—	—	—	×				
12	Damesella (?) sp.	—	—	—	—	—	—	—	—	—	—	×				
13	Damesella (?) sp.	—	—	—	—	—	—	—	—	—	—	—	×			
14	Drepanura ketteleri mut. tonkinensis Mans.	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×
15	Drepanura cf. premesnili Bergeron	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×
16	Ptychoparia (Emmrichella) cf. theano Walcott	—	—	×	—	—	—	—	—	—	—	—	—	—	×	
17	Ptychoparia (Annamites) spinifera Mans.	—	—	—	—	—	—	—	—	—	—	×				
18	Conokephalina termieri Mans.	—	—	—	—	—	—	—	—	×						
19	Conokephalina tienfongensis Mans.	—	—	—	—	—	—	—	—	×						
20	Conokephalina oblonga Mans.	—	—	—	—	—	—	—	—	×						
21	Conokephalina latifrons Mans.	—	—	—	—	—	—	—	—	×						
22	Conokephalina sinensis Mans.	—	—	—	—	—	—	—	—	×						
23	Conocoryphe lantenoisi Mans.	—	—	—	—	×	—	×								
24	Agraulos tonkinensis Mans.	—	—	—	—	—	—	—	—	—	—	—	—	×		
25	Solenopleura (?)	—	—	×												

Table P (*Concluded*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Trilobita (cont.)															
26 Anomocare subquadratum (Dames)	—	—	—	—	—	—	—	×	—	—	—	—	—	×	
27 Anomocare minus Dames	—	—	—	—	—	—	×	—	—	—	—	—	—	×	
28 Anomocare cf. megalurus (Dames)	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
29 Anomocare cf. latelimbatum Dames	—	—	×	—	—	—	—	—	—	—	—	—	—	×	
30 Anomocare propinquum Mans.	—	—	—	—	—	×									
31 Anomocarella cf chinensis Walcott	—	—	—	—	—	—	—	—	—	—	—	×	—	×	
32 Anomocarella sp?	×														
33 Coosia deprati Mans.	—	—	—	—	—	—	—	—	—	—	—	—	×		
34 Coosia asiatica Mans.	—	—	—	—	—	—	—	—	—	—	×				
35 Tonkinella flabelliformis Mans.	—	×													

The Middle Cambrian of Australia is not well enough known to be included in this discussion. Since the preceding three tables cover the Faunas of the Indo-Chinese Geosynclines no summary table will be given of this region. In the following three tables, Tables V—VII the faunas of the Southern Appalachian, the Palæocordilleran and the Caledonian (and Northern Appalachian) Geosynclines are summarized.

TABLE V.

MIDDLE CAMBRIAN FAUNAS OF THE SOUTHERN APPALACHIAN GEOSYNCLINE AND ITS EXTENSION OVER MISSISSIPPIA.

In Cols 1-7, the formations of the southern part of the Southern Appalachians from Alabama to Tennessee are given.

In Cols 8-10 the northern parts of the Southern Appalachians from Virginia to Stissing Mountain, New York are given.

In Cols 11-16 the formations of the southern part of Mississippia from Texas to Missouri, are given. In Cols 17-20 the formations of northern Mississippia, chiefly Wisconsin and Minnesota and its extension to the Deadwood region of South Dakota, are given. In Cols 21-23 the distribution elsewhere and in other horizons is given. The Details are:

Col. 1. So-called Upper Rome. Representing reworked material of the Rome type of sediment sometimes with re-worked fossils, and a new Middle Cambrian Fauna.

Col. 2. Conasauga formation of Alabama and Tennesse.

Col. 3. Rutledge limestone of Tennessee

Col. 4. Rogersville shale of Tennessee

Col. 5. Honaker limestone of Virginia

Col. 6. Maryville limestone of Tennessee

Col. 7. Nolichucky shale of Tennessee

Col. 8. Ellbrook limestone of Pennsylvania Maryland and Virginia

8a Wolf Creek shale Rocky Gap, Bland Co. Va.

Col. 9. Warrior limestone (=Buffalo Run limestone)

9a York shale of Pennsylvania

9b Middle Cambrian Limestone Blair Co, Pennsylvania.

Col. 10. Stissing limestone of New York

10a Kittatinny Limestone New Jersey and Pennsylvania

Col. 11. Cap Mountain limestone. Burnet Co., Texas

Col. 12. Wilberns shale, Burnet County, Texas

Col. 13. Regan sandstone of Oklahoma etc.

Col. 14. Honey Creek Shales of Oklahoma etc.

Col. 15. Bonneterre formation of the Ozark region

Col. 16. Elvins formation of the Ozark region

Col. 17. Eauclaire formation of the Upper Mississippi region

Col. 18. Dresbach formation of the Upper Mississippi region

Col. 19. Franconia formation of the Upper Mississippi region.

Col. 20. Lower Deadwood formation of the Black Hills region of South Dakota

Col. 21. Also in Middle Cambrian of Palæo-Cordilleran geosyncline.

Cal. 22. Also in Lower Cambrian

Col. 23. Also in Upper Cambrian.

Table V. Middle Cambrian of the Southern Appalachian Geosyncline and its extension over Mississippia

<table>
<tr><th></th><th></th><th></th><th></th><th>SPONGIDÆ
Protospongia fenestrata Salter[1]</th><th>Chancelloria drusilla Walc.</th><th>Chancelloria libo Walcott</th><th>Chancelloria yorkensis Walc.</th><th>GRAPTOZOA
Callograptus antiquus Ruedemann</th><th>Dendrograptus edwardsi major Ruedemann</th><th>Dendrograptus thomasi Ruedemann</th><th>Haplograptus vermiformis Ruedemann</th></tr>
<tr><td colspan="3">Upper Cambrian</td><td>23</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Lower Cambrian</td><td>22</td><td>×</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Mid-Cambr. Palæocord.</td><td>21</td><td>×</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="4">Northern Missis-sippia</td><td>Deadwood Form.</td><td>20</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td>×</td><td></td></tr>
<tr><td>Franconia Form.</td><td>19</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td></td></tr>
<tr><td>Dresbach Form.</td><td>18</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td></td></tr>
<tr><td>Eauclaire Form.</td><td>17</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td></td></tr>
<tr><td colspan="2" rowspan="6">Southern Mississippia</td><td>Elvins Form.</td><td>16</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td></td></tr>
<tr><td>Bonneterre Form.</td><td>15</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td></td></tr>
<tr><td>Honey Creek Sh.</td><td>14</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td></td></tr>
<tr><td>Reagan Sandst.</td><td>13</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td></td></tr>
<tr><td>Wilberns Shale</td><td>12</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td></td></tr>
<tr><td>Cap Mt. Limest.</td><td>11</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td></td></tr>
<tr><td rowspan="10">Southern Appalachians</td><td rowspan="3">Northern Part.</td><td>Stissing Limest.</td><td>10</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td></td></tr>
<tr><td>Warrior Limest.
a York Shale Pa.</td><td>9</td><td>|</td><td></td><td></td><td>a</td><td></td><td></td><td>|</td><td></td></tr>
<tr><td>Elbrook Limest.</td><td>8</td><td>|</td><td></td><td></td><td>|</td><td></td><td></td><td>|</td><td></td></tr>
<tr><td rowspan="7">Southern Part.</td><td>Nolichucky Sh.</td><td>7</td><td>|</td><td></td><td></td><td>|</td><td></td><td></td><td>|</td><td></td></tr>
<tr><td>Maryville Limest.</td><td>6</td><td>|</td><td></td><td></td><td>|</td><td></td><td></td><td>|</td><td></td></tr>
<tr><td>Honaker Limest.</td><td>5</td><td>|</td><td></td><td></td><td>|</td><td>×</td><td>×</td><td>|</td><td></td></tr>
<tr><td>Rogersville Sh.</td><td>4</td><td>|</td><td></td><td></td><td>|</td><td>|</td><td>|</td><td>|</td><td></td></tr>
<tr><td>Rutledge Limest.</td><td>3</td><td>|</td><td></td><td></td><td>|</td><td>|</td><td>|</td><td>|</td><td></td></tr>
<tr><td>Conasauga Form.</td><td>2</td><td>×</td><td>×</td><td>×</td><td>|</td><td>|</td><td>×</td><td>|</td><td>×</td></tr>
<tr><td>Upper „Rome"</td><td>1</td><td>|</td><td>|</td><td>|</td><td>|</td><td>|</td><td>|</td><td>|</td><td>|</td></tr>
</table>

1 Also in Caledonian Geosyncline.

Table V (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
BRACHIOPODA																							
1. Micromitra alabamaensis (Walcott)	×	×	—	×	—	—	×	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	×
2. Micromitra sculptilis (Meek)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	×	—	×
3. Paterina crenistria (Walcott)	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	?
4. Paterina major (Walcott)	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
5. Paterina stissingensis (Dwight)	—	—	—	—	—	—	—	—	—	×	—	—	—	—	×	—	—	—	—	—	×		
6. Iphidella pannula (White)	—	—	×	×	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	?
7. Curticia elegantula Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?				
8. Obolus ismene Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
9. Obolus lamborni (Meek)	×	×	—	×	—	—	×	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	?
10. Obolus lamborni mininus (Walcott)*	×	—	—	×	—	—	×																
11. Obolus matinalis (Hall)	—	—	—	—	—	—	—	—	—	—	×	?	—	—	—	?	×	×	—	—	×	—	×
12. Obolus mikwitzi Walcott,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
13. Obolus namouna Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
14. Obolus nundina Walcott,	—	—	—	—	—	—	—	—	—	—	x?	x?	—	—	—	—	—	—	—	—	×	—	×
15. Obolus pandemia Walcott,	×																						
16. Obolus rhea Walcott,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
17. Obolus sinoe Walcott,	×	×	—	—	—	—	—	—	—	—	×	×	—	—	×	—	—	—	—	—	×	×	?
18. Obolus tetonensis ninus Walcott,	—	—	—	—	—	—	—	—	—	—	×	—	×	—	—	—	—	—	—	×	×	—	×
19. Obolus willisi Walcott	×	×	—	×	—	—	×																
20. Westonia aurora (Hall)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×	—	—	—	×
21. Westonia ella Hall & Whitfield	×	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	×
22. Westonia ollius Walcott	—	—	—	—	—	—	—	—	—	a													

* Also St. Albans Formation N. Appalachians?

Table V (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
BRACHIOPODA (cont.)																							
23. Lingulella acutangula (Rvemer)	—	—	—	—	—	—	—	—	—	—	×	×	—	—	×	×	—	—	—	—	×	—	?
24. Lingulella ampla (Owen)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×	×			
25. Lingulella auga (Walcott)	×																						
26. Lingulella buttsi Walcott	—	×																					
27. Lingulella cuneola (Whitfield)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
28. Lingulella desiderata (Walcott)	×	×	—	×	—	—	×	—	—	—	—	—	—	—	×	—	—	—	—	×	×	—	×
29. Lingulella hayesi (Walcott)	—	×																					
30. Lingulella ino (Walcott)	×	—	—	—	—	—	×																
31. Lingulella leos (Walcott)	—	?	—	—	—	—	—	—	—	—	—	—	—	—	×								
32. Lingulella mosia (Hall)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×	—	—	—	×
33. Lingulella mosia osceola (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	×
34. Lingulella nanno (Walcott)	—	×																					
35. Lingulella ora (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	×	—	cf								
36. Lingulella perattenuata (Whitfield)	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	×	×		
37. Lingulella phaon (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×				
38. Lingulella prima (Conrad)	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	×	—	—	×	×	—	—	×
39. Lingulella texana (Walcott)	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	×							
40. Lingulella quadrilateralis (Walcott)	—	×																					
41. Lingulella similis (Walcott)	×	×	—	—	—	—	—	—	—	—	—	—	×	—	—	×	—	—	?	×	×	—	×
42. Lingulella tarpa (Walcott)	×	—	—	—	—	—	?																
43. Lingulella upis (Walcott)	—	—	—	—	—	—	—	—	—	—	×	×											
44. Lingulella winona (Hall)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	?

Table V (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
BRACHIOPODA (cont.)																							
45. Lingulella winona convexa, (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	×	—	?
46. Lingulella sp.	—	—	—	—	—	—	—	—	a														
47. Lingulella acuminata (Conrad)	—	—	—	—	—	—	×	—	—	—	×	×	×	—	—	cf	×	×	×	×	×	—	×
48. Dicellomus appalachia (Walcott)	×	×	—	×	×	—	×	—	a														
49. Dicellomus fiestus Lochmann	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
50. Dicellomus nanus Meek and Hayden,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	—	—	×	×		
51. Dicellomus pectenoides (Whitfield)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×	×		
52. Dicellomus politus Hall	—	—	—	—	—	—	×	—	—	—	—	—	×	—	×	—	×	×	×	×	×	—	×
53. Acrothele bellula Walcott,	—	×																					
54. Acrothele yorkensis Walcott	—	—	—	—	—	—	—	—	a														
55. Linnarssonella girtyi Walcott,	—	—	—	—	—	—	—	—	—	—	×	×	×	—	×	×	—	—	—	×	×		
56. Linnarssonella tennesseensis Walcott,	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?
57. Acrotreta concentrica Walcott	—	×																					
58. Acrotreta curvata Walcott,	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	?		
59. Acrotreta idahoensis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	×
60. Acrotreta kutorgai Walcott	×	×	—	?	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×
61. Acrotreta microscopica Schumard	—	—	—	—	—	—	—	—	—	—	×	×	×	×	—	—	—	—	—	—	×		
62. Acrotreta microscopica missouriensis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
63. Acrotreta rudis Walcott	—	—	—	×																			
64. Acrotreta signalis Walcott,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?	?					

Table V (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
BRACHIOPODA (cont.)																							
65. Acrotreta ulrichi Walcott	—	—	—	—	—	—	—	—	—	—	—	—	×										
66. Wimanella? anomala (Walcott)	—	×																					
67. Wimanella harlanensis Walcott	×	—	—	×																			
68. Wimanella saffordi Walcott	×																						
69. Protorthis lævis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
70. Billingsella appalachia Walcott	—	—	×	×																			
71. Billingsella coloradoensis (Schumard)	—	—	—	—	—	—	—	—	—	—	×	×	—	—	—	×	×	—	×	—	×	—	×
72. Billingsella major Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
73. Otusia sandbergeri (N. H. Winchell)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?	—	—	—	?
74. Eoorthis fascigera Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×		
75. Eoorthis iddingsi (Walcott)	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	×		
76. Eoorthis indianola Walcott	—	—	—	—	—	—	—	—	—	—	×	?	×	—	—	×	—	—	—	—	×		
77. Eoorthis remnicha Walcott	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	×	—	×		
78. Eoorthis remnicha texana Walcott,	—	—	—	—	—	—	—	—	—	—	×	×	×	×	—	×	—	—	—	—	×		
79. Eoorthis remnicha winfieldensis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
80. Eoorthis wichitaensis Walcott,	—	—	—	—	—	—	—	—	—	—	×	×	×	×	—	×	—	—	—	—	×		
81. Eoorthis wichitaensis læviuscula Walcott	—	—	—	—	—	—	—	—	—	—	×	?	×										
82. Finkelnburgia osceola Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	×	—	—	—	×
83. Finkelnburgia osceola corrugata (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	×

Table V (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
BRACHIOPODA (cont.)																							
84. Syntrophia allata Walcott	—	—	—	—	—	—	—	—	—	—	—	?											
85. Syntrophia primordialis (Whitfield)	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	×	—	×		
86. Huenella abnormis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
87. Huenella texana (Walcott)	—	—	—	—	—	—	—	—	—	—	×	×											
88. Huenella texana læviuscula Walcott,	—	—	—	—	—	—	—	—	—	—	×	×											
GASTROPODA																							
1. Platyceras (Scavogyra) primordialis Hall.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
2. Scavogyra minnesotensis Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
3. Scavogyra elevata Whitfield	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?					
4. Scavogyra obliqua Whitfield	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?					
5. Scavogyra swezeyi Whitfield	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?					
6. Triblidium rectilaterale Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
7. Triblidium convexum Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
8. Triblidium barabuense (Whitfield)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?	—	—	—	—	?
9. Triblidium extensum Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
10. Triblidium corpulentum Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
11. Triblidium aduncum Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
12. Triblidium simile (Whitfield)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?					
13. Triblidium retrorsum (Whitfield)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?					
14. Hypseloconus recurvus Whitfield	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×					

Table V (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
GASTROPODA (cont.)																							
15. Hypseloconus recurvus elongatus Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
16. Hypseloconus recurvus attenuatus Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×					
17. Hypseloconus recurvus erectus Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×					
18. Hypseloconus recurvus marginatus Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×					
19. Hypseloconus cornutiformis Berkey,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×					
20. Hypseloconus capuloides Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×					
21. Hypseloconus cylindricus Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×					
22. Hypseloconus franconiensis Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×				
23. Hypseloconus stabilis Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
24. Euomphalus strongi Whitfield	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?					
25. Euomphalus strongi sinistrorsis Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
HYOLITHIDÆ																							
1. Hyolithes billingsi? (Dwight)	—	—	—	—	—	—	—	—	—	×													
2. Hyolithus primordialis Hall	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×	—	—	×		
OSTRACODA																							
1. Leperditia abenenia Dwight.	—	—	—	—	—	—	—	—	—	×													
TRILOBITA																							
1. Acrocephalites americanus Walc.	—	×																					

Table V (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
TRILOBITA (cont.)																							
2. Acrocephalites aoris Walcott	—	—	—	—	—	—	—	×	b														
3. Acrocephalites aster Walcott	—	×	—	—	—	×	×																
4. Acrocephalites insignis Walcott	—	×																					
5. Acrocephalites tutus Walcott	—	×																					
6. Agnostus josephus Hall	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
7. Agraulus hemisphericus Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
8. Amphion? matutina Hall	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	×						
9. Anomocare convexa Walcott	—	×																					
10. Anomocare sp.	—	×																					
11. Anomocarella modesta Myerhoff & Lochman	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
12. Anomocarella smithi	—	×																					
13. Arionellus bipunctatus Schumard	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
14. Armonia pelops Walcott	—	×																					
15. Asaphiscus? agatho Walcott	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	×				
16. Asaphiscus? anaxis Walcott	—	—	—	—	—	×																	
17. Asaphiscus calanus Walcott	—	—	—	—	—	—	—	a	×														
18. Asaphiscus? duris Walcott	—	—	—	—	—	—	—	—	—	a													
19. Asaphiscus? florus Walcott	—	—	—	—	—	—	—	—	—	a													
20. Asaphiscus sp. Walcott	—	×	—	—	—	×																	
21. Bathyuriscus bantuis Walcott	×																						
22. Bathyuriscus sp.	—	×																					
23. Blania elongata Walcott	—	×																					
24. Blania glabra Walcott	—	×	×																				
25. Blania gregarius Walcott	—	×	×																				

Table V (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
TRILOBITA (cont.)																							
26. Blania paula Walcott	—	×																					
27. Blountia alemon Walcott	—	—	—	—	—	×																	
28. Blountia alethes Walcott	—	—	—	—	—	×																	
29. Blountia alexas Walcott	—	—	—	—	—	×																	
30. Blountia amage Walcott	—	—	—	—	—	×																	
31. Blountia andreas Walcott	—	—	—	—	—	×																	
32. Blountia anser Walcott	—	—	—	—	—	×																	
33. Blountia mimula Walcott	—	×	—	—	—	×	×																
34. Brooksella altonata Walcott	—	×																					
35. Burnetia urania Walcott	—	—	—	—	—	—	—	—	—	—	×												
36. Calvinella newtonensis Walcott	—	—	—	—	—	—	—	—	—	a													
37. Camaraspis convexus (Whitfield)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
38. Cedaria prolifica Walcott	—	×																					
39. Cedaria tennesseensis Walcott	—	—	—	—	—	—	×																
40. Cedaria woosteri Whitfield	—	?	—	—	—	—	—	—	—	?													
41. Chariocephalus whitfieldi Hall	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
42. Cheilocephalus stcroixensis Berkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
43. Conocephalites anatina Hall	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
44. Conocephalites eos Hall	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
45. Conocephalites minor Shumard	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
46. Conocephalites nasutus Hall	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
47. Conocephalites patersoni Hall	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
48. Conocephalites perseus Hall	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
49. Coosia robusta Walcott	×																						

Table V (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
TRILOBITA (cont.)																							
50. Coosia superba Walcott	×	×																					
51. Crepicephalus camiro Walcott	—	—	—	—	—	×																	
52. Crepicephalus comus Walcott	—	—	—	—	—	×																	
53. Crepicephalus coosensis Walcott	—	×																					
54. Crepicephalus iowensis (Owen)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×					
55. Crepicephalus texanus (Shumard)	—	×	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	?
56. Crepicephalus texanus danace Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
57. Crepicephalus texanus elongatus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
58. Crepicephalus (Paracrepicephalus) thoosa Walcott	—	×	—	—	×	×	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
59. Crepicephalus tripunctatus magnispinus Walcott	—	—	—	—	—	×																	
60. Crepicephalus tumidus Walcott	—	—	—	—	—	×																	
61. Crepicephalus unca Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
62. Crepicephalus sp.	—	×																					
63. Crepicephalus sp.	—	—	—	—	—	×																	
64. Dicellocephalus barabuensis Whitfield	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?					
65. Dicellocephalus etonoi Whitfield	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?					
66. Dicellocephalus (Prosaukia) miser Hall.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
67. Dicellocephalus texanus Walcott	—	—	—	—	—	—	—	—	—	—	—	×											

Table V (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
TRILOBITA (cont.)																							
68. Dolichometopus productus (Hall & Whitfield)	×	×	×																				
69. Dorypyge sp.	—	—	×																				
70. Dresbachia amata Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×				
71. Ellipsocephalus curtis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
72. Elvinia roemeri (Shumard)	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	?				
73. Illaenurus convexus Whitfield	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?					
74. Irvingella major Ulrich & Resser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
75. Kingstonia apion Walcott	—	—	—	—	—	×																	
76. Kingstonia convexa Lochman	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
77. Laotira cambria Walcott	—	×																					
78. Lisania? breviloba Walcott	—	—	—	—	—	×																	
79. Lonchocephalites appalachia Walcott	—	×	—	—	—	×																	
80. Lonchocephalus bunus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
81. Lonchocephalus chippewaensis Owen	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
82. Lonchocephalus hamulus Owen	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
83. Lonchocephalus minor Shumard	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	×			
84. Lonchocephalus sospita Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
85. Maryvillia arion Walcott	—	—	—	—	—	×																	
86. Maryvillia ariston Walcott	—	—	—	—	—	×																	
87. Menomonia calymenoides (Whitfield)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×	×					
88. Millardia avitas Walcott	—	—	—	—	—	—	—	—	—	a													

Table V (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
TRILOBITA (cont.)																							
89. Millardia optata (Hall)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
90. Modocia oweni (Meek & Hayden)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
91. Norwoodia gracilis Walcott	—	×	—	—	—	—	×																
92. Norwoodia ponderosa Walcott	—	×																					
93. Norwoodia saffordi Walcott	—	—	—	—	—	—	×																
94. Norwoodia simplex Walcott,	—	×	—	—	—	—	×																
95. Olenoides curticii Walcott	—	×																					
96. Olenoides stissingensis White	—	—	—	—	—	—	—	—	—	×													
97. Olenoides sp.	—	×																					
98. Osceolia osceola Hall	—	—	—	—	—	—	—	—	—	—	—	×											
99. Poliella balus Walcott	—	—	—	—	—	—	—	—	×														
100. Prosaukia burlingensis Ulrich & Resser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
101. Prosaukia concava Ulrich & Resser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
102. Prosaukia dilata Ulrich & Resser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
103. Prosaukia granosa Ulrich & Resser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
104. Prosaukia halli Ulrich & Resser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
105. Prosaukia longula Ulrich & Resser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
106. Prosaukia misa (Hall)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
107. Prosaukia resupinata Ulrich & Resser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				

Table V (*Concluded*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
TRILOBITA (cont.)																							
108. Prosaukia sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
109. Pseudoagnostus dakotaensis Myerhoff & Lochman	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
110. Ptychaspis granulosus Owen	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
111. Ptychaspis miniscanensis Owen	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
112. Ptychoparia calymenoides Whitfield	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
113. Ptychoparia sp.	—	×																					
114. Saratogia arses Walcott	—	—	—	—	—	—	×																
115. Saratogia aruno Walcott	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
116. Saratogia hera (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
117. Saratogia volux Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
118. Saratogia wisconsensis Owen	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×	—	×		
119. Saukiella? fallax Walcott	—	—	—	—	—	—	—	—	—	—	—	×											
120. Taenicephalus shumardi (Hall)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
121. Ucebia ara Walcott	—	—	—	—	—	—	—	—	×														
122. Wilbernia diademata (Hall)	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×	—	—	—	×				
123. Wilbernia pero (Walcott)	—	—	—	—	—	—	—	—	—	—	—	×											
MEROSTOMATA																							
1. Strabobs thatcheri Beecher	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							

TABLE VI

MIDDLE CAMBRIAN FAUNAS OF THE PALÆO-CORDILLERAN GEOSYNCLINE

In Column 1 the fossils of the Cape Wood and Pemmican River (1a) formations of Inglefield Land and Washington Land Greenland are given. Columns 2 & 3 comprises the Middle Cambrian formations of the Robson Peak area. Columns 4 & 5 gives the Middle Cambrian of the Bow River Valley exposures in Alberta and British Columbia. Cols. 6-9 cover the Middle Cambrian of Montana and Cols. 10 & 11 those of Wyoming. Cols 12-13 gives the Middle Cambrian of the Nevada sections and Cols. 14-20 those of Utah and Idaho. Cols 21-23 cover the Middle Cambrian of Arizona Sections and southern California.

Finally in Col. 24 are given the Middle Cambrian species known from the Pre-Andean geosyncline of South America in Bolivia and the Argentine. In Col. 25 the distribution in other horizons and geosynclines are given, distinguished by letters. The following are the columns in detail. (5a, 5b are designated a; b, respectively in Col. 5 and the same method is followed in other columns. When *a*, *b* etc. are in italics, the species occurs in two horizons, the one represented by the column alone the other indicated by the letter.

Col. 1. Northwest Greenland Cape Wood formation
1a Pemmican River formation Greenland

Col. 2. Chetang formation, Robson Peak,

Col. 3. Titkana formation, Robson Peak

Col. 4. Ptarmigan formation of Mount Bosworth

Col. 5. Stephen formation, Mount Bosworth and Mount Stephen

5* = Burgess shale fauna, (mostly listed separately)

5† = Ogygopsis shale of Stephen formation.

5*a* Murchison formation, northern representative of the Stephen.

5*b*. Eldon formation, Alberta and British Columbia

Col. 6. Gordon formation. Montana

6*a* Dearborne No. 6, Montana

Col. 7. Flathead formation, Montana

Col. 8. Wolsey shale. Montana

8*a* Meagher limestone, Montana

8*b*. Dearborne formation No. 4, Montana

Col. 9. Park shale, Montana

9*a* Pilgrim limestone, Montana

9*b* Dry Creek shale

Col. 10. Grosventre formation, Wyoming

10*a* Deadwood formation of Wyoming

Col. 11. Gallatin formation Wyoming

Col. 12. Chisholm shale, Nevada

12*a* So-called "Prospect Mountain" beds, between Chisholm shale and *Olenellus* beds.

Col. 13. Highland Peak limestone, Nevada

13*a* Eldorado limestone, Nevada

13*b*. Secret Canyon shale, Nevada

13*c* Emigrant formation, Nevada

Col. 14. Langston formation of Idaho and Utah.
14a Hartman formation

Col. 15. Spence shale, Idaho and Utah
15a Ute formation, Idaho and Utah.

Col. 16. Blacksmith formation. Idaho and Utah.
16a Bloomington formation, Idaho and Utah.
16b Nounan formation, Idaho and Utah
16c Aowell formation of Utah
16d Swazy formation of Utah

Col. 17. Wheeler formation of Utah

Col. 18. Marjum formation of Utah

Col. 19. Weeks formation of Utah

Col. 20. Orr formation of Utah

Col. 21. Tapeats sandstone of Grand Canyon, Arizona

Col. 22. Bright Angel shale of Grand Canyon, Arizona
22a Nunkoweap shales of Grand Canyon, Arizona

Col. 23. Mouav limestone of Grand Canyon etc. Arizona
23a Abrigo limestone of Arizona
23b. Iron Hill formation of Mohave desert S. California

Col. 24. Middle Cambrian of South America, Argentine & Bolivia

Col. 25. Other horizons etc.
25a Also in Upper Cambrian
25b Also in Lower Cambrian
25c Also Middle Cambrian of Appalachian geosyncline
25d Also Middle Cambrian of Caledonian geosyncline

Table VI
Middle Cambrian of the Palæocordilleran Geosyncline

Formation	No.	Algae[1] 1. Dalyia racemata Walc.	2. Marpolia aequalis Walc.	3. Marpolia spissa Walc.	4. Wahpia insolens Walc.	Spongidae[1] 1. Chancelloria eros Walc.	2. Choia carteri Walc.	3. Choia utahensis Walc.
Other horizons & Geosynclines	25							
South Ameriea	24							
Mouav, a Abrigo b Iron Hill	23							
Bright Angel. a Nunkoweap	22							
Tapeats Arizona	21							
Orr Formation	20							
Weeks Formation	19							
Marjum Formation	18							×
Wheeler Formation	17							|
Blacksmith, a Bloomington b Nounan, c Howell d Swazy.	16							|
Spence Sh. a Ute Formation	15							|
Langston, a Hartman	14							|
Highland Pk. a Eldorado; b Secret Canyon; c Emigrant.	13							|
Chisholm; a Prospect Mt.	12							|
Gallatin Formation	11							|
Grosventre, a Deadwood Wy.	10							|
Park. a Pilgrim, b Dry Creek	9							|
Wolsey, a Meagher, b Dearbome 4	8							|
Flathead Formation Mont.	7							|
Gordon, a Dearborne 6	6							|
Stephen*†, a Murchison, b Eldon	5	+ *	+	+ *	+	+ *	† *	|
Ptarmigan Formation	4	|	|	|	|	|	|	|
Titkana Formation	3	|	|	|	|	|	|	|
Chetang Formation	2	|	|	|	|	|	|	|
Cape Wood, a Pemmican R. Greenl.	1	|	|	|	|	|	|	|

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
SPONGIDAE[1] (cont.)																									
4. Haguia sphærica Walc.	—	—	—	—	—	—	—	—	—	×															
5. Hazelia? grandis Walc.	—	—	—	—	†																				
6. Kiwetinokia spiralis Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
7. Kiwetinokia utahensis Walc.	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	×							
8. Pirania muricata Walc.	—	—	—	—	*†																				
9. Protospongia erixo Walc.	—	—	—	—	—	—	—	—	—	—	—	—	a												
10. Protospongia fenestrata Salter	—	—	—	—	×	—	—	—	—	—	—	—	—	—	×	—	—	×	—	—	—	—	—	—	b,c,d
11. Sentenelia draco Walc.	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×								
12. Tholiasterella? hindei Walc.	—	—	—	×																					
ANNELIDA[1]																									
1. Selkirkia major (Walc.)	—	—	×	—	†																				
2. Selkirkia fragilis Walc.	—	—	—	—	†																				
3. Selkirkia gracilis Walc.	—	—	—	—	†																				
4. Wiwaxia corrugata (Matthew)	—	—	—	—	†																				
BRACHIOPODA																									
1. Micromitra haydeni Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	×											
2. Micromitra pealli Walcott	—	?	—	—	—	—	—	*a*	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
3. Micromitra sculptilis Meek	—	—	—	—	—	—	—	—	—	×	—	—	b	—	—	a	—	×	—	—	—	—	—	—	a
4. Micromitra zenobia Walcott	—	—	—	—	×																				

1 For other species from the Burgess shale see list pp. 241-244 (437-440) 5* Burgess shale 5† Ogygopsis shale.

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BRACHIOPODA (cont.)																									
5. Paterina crenistria (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	b	—	—	—	—	—	—	×	?	×			
6. Paterina labradorica utahensis (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	d									
7. Paterina stissingensis Dwight	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c
8. Paterina stissingensis ora Walcott	—	—	—	—	×																				
9. Paterina stuarti Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	a										
10. Paterina superba (Walcott)	—	—	—	—	—	—	—	b	—	—	—	—	—	—	×	—	—	—	—	—	×	×			
11. Paterina wapta Walcott	—	—	—	×																					
12. Iphidella nyssa Walcott	—	—	—	—	—	*a*																			
13. Iphidella pannula (White)	—	—	—	—	×	*a*	—	—	—	—	—	—	—	—	×	c	—	—	—	—	?	×			
14. Iphidella pannula maladensis (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	×											
15. Iphidella pannula ophirensis (Walcott)	—	—	—	—	×	—	—	—	—	—	—	—	—	×	—	—	—	×							
16. Obolus mcconnelli (Walcott)	—	—	×	—	†b	×	—	—	—	—	—	—	—	×	×	—	—	×							
17. Obolus mcconnelli decipiens Walcott	—	—	—	—	—	—	—	—	—	—	—	—	c												
18. Obolus mcconnelli pelias Walcott	—	—	—	—	—	—	—	b	—	—	—	—	c	×	—	a	×	×	—	×					
19. Obolus maera (Hall & Whitf.)	—	—	—	—	—	—	—	—	—	—	—	—	b	—	—	—	—	—	—	—	—	—	—	—	a
20. Obolus matinalis (Hall)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
21. Obolus membranaceous Walcott	—	—	—	—	b	—	—	—	—	—	—	—	—	—	—	b	—	—	—	—	—	—	—	—	a,e

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BRACHIOPODA (cont.)																									
22. Obolus nundina (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	b	—	—	—	—	—	—	—	—	—	—	—	a
23. Obolus parvus Walcott	—	—	—	×																					
24. Obolus rotundatus (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c	—	×	—	×	—	—	—	—	c
25. Obolus septalis Walcott	—	—	×																						
*26. Obolus sinoe (Walcott)																									
27. Obolus wortheni Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	a	—	—	—	—	—	—	—	—	a
28. Obolus zetus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?	×	×		
29. Obolus parvus Walcott	—	—	—	×																					
30. Obolus (Fordinia) bellulus (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	c	—	—	—	—	—	—	—	—	—	—	—	a
31. Obolus (Fordinia) gilberti Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
32. Obolus (Fordinia) perfectus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×						
33. Obolus (Acrites) rugatus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	b												
34. Westonia chuarensis (Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	×		
35. Westonia dartoni (Walcott)	—	—	—	—	—	a	?	—	—	a															
36. Westonia ella (Hall & Whitfield)	—	—	—	—	×	×	×	×	—	—	—	—	—	×	×	(a) (c) (d)	—	—	—	—	—	—	—	—	a,c.
37. Westonia ella onaquiensis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	×											
38. Westonia euglyphus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	×			
39. Westonia notchensis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BRACHIOPODA (cont.)																									
40. Westonia themis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—			—	—	—	—	—	—	—	×		
41. Westonia wasatchensis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*a*									
42. Lingulella acutangula (Roemer)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?	×		
43. Lingulella arguta (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	a	?	—	d	—	×							
44. Lingulella clarkii Walcott	—	—	—	—	—	—	—	—	—	—	—	—	b												
45. Lingulella davisii Salter	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	cf	
46. Lingulella desiderata (Walcott)	—	—	—	—	×	—	—	×	—	—	×	—	a,b	×	×	a	—	—	—	×	—	—	—	—	a,e
47. Lingulella dubia Walcott	—	—	—	—	—	—	—	—	—	—	—	—	a												
48. Lingulella ferruginea Salter	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	cf	
49. Lingulella helena (Walcott)	—	—	—	—	—	×	—	—	—	—	×	—	—	×											
50. Lingulella isse (Walcott)	—	—	—	—	b	—	—	—	—	—	—	—	—	×	—	—	—	—	×	×	—	—	—	—	a
51. Lingulella lineolata (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	*b*		
52. Lingulella manticula (White)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	a,b	—	—	—	×	—	—	—	—	a
53. Lingulella perattenuata (Whitfield)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	*b*		
54. Lingulella punctata Walcott	—	—	—	—	—	—	—	—	—	—	—	—	a,b	—	—	—	—	—	—	—	—	—	—	—	a
55. Lingulella similis (Walcott)	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c
56. Lingulella waptaensis Walcott	—	—	—	—	x*																				
57. Lingulella winona convexa Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×		

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BRACHIOPODA (cont)																									
58. Lingulepis acuminata Conrad	—	—	—	—	—	—	—	—	—	—	—	—	a	—	—	—	—	—	—	—	—	—	—	—	a
59. Lingulepis acuminata meeki Walcott	—	—	—	—	—	—	—	—	—	×															
60. Lingulepis spatula Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
61. Dicellomus nanus (Meek and Hayden)	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	c
62. Dicellomus prolificus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
63. Acrothele artemis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	×											
64. Acrothele colleni Walcott	—	—	—	×	×	*a*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	b
65. Acrothele dichotoma Walcott	—	—	—	—	—	—	—	—	—	—	—	—	b												
66. Acrothele panderi Walcott	—	—	—	—	—	*a*																			
67. Acrothele subsidua (White)	—	—	—	—	×	—	—	—	—	—	—	—	—	×	×	a	×	×							
68. Acrothele subsidua lævis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	×							
69. Acrothele turneri Walcott	—	—	—	—	—	—	—	—	—	—	—	—	c	—	a										
70. Linnarssonella girtyi Walcott	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c
71. Linnarssonella modesta Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
72. Linnarssonella nitens Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
73. Linnarssonella tennesseensis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	c

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BRACHIOPODA (cont.)																									
74. Linnarssonella transversa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
75. Linnarssonella urania Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	?	—	—	—	—	—	×					
76. Acrotreta argenta Walcott	—	—	—	—	—	—	—	—	—	—	—	—	c												
77. Acrotreta attenuata Meek	—	—	—	—	—	—	—	—	—	—	?	—	—	—	—	—	×	×	—	—	—	—	—	—	a
78. Acrotreta bellatula Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×						
79. Acrotreta definita Walcott	—	—	—	—	—	—	—	—	—	—	—	—	a	—	×										
80. Acrotreta depressa (Walcott)	—	—	cf	—	†																				
81. Acrotreta gemma Billings	—	—	—	—	—	—	—	—	—	×	×														
82. Acrotreta idahoensis Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	×	—	—	—	—	a
83. Acrotreta idahoensis alta Walcott	—	—	—	—	—	—	—	—	—	—	—	—	b	—	—	—	—	—	—	—	—	—	—	—	a
84. Acrotreta idahoensis sulcata Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	—	—	—	×	—	—	—	—	a
85. Acrotreta marjumensis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
86. Acrotreta microscopica (Shumard)	—	—	—	—	—	—	—	—	—	—	—	—	b												
*87. Acrotreta neboensis Walcott																									
88. Acrotreta ophirensis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	?	×	—	—	×	×						
89. Acrotreta cf ophirensis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	c	—	×							
90. Acrotreta ophirensis descendens Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BRACHIOPODA (cont.)																									
91. Acrotreta ophirensis rugosa Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	×											
*92. Acrotreta ophirensis primæva Walcott																									
93. Acrotreta pyxidicula White	—	—	—	—	—	—	×	—	—	—	—	—	b	×	—	d	—	×							
94. Acrotreta cf. sagittalis (Salter)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	d
95. Acrothyra gregaria Walcott	—	—	—	—	×																				
96. Acrothyra minor Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	×											
97. Philhedra columbiana (Walcott)	—	—	—	—	†																				
98. Nisusia alberta Walcott	—	—	—	—	†																				
99. Nisusia alberta var Walcott	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	b
100. Nisusia burgessensis Walcott	—	—	—	—	×																				
101. Nisusia rara Walcott	—	—	—	—	×	—	—	—	—	—	—	—	—	—	×										
*102. Jamesella erecta Walcott																									
103. Jamesella? kanabensis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×		
104. Jamesella nautes Walcott	—	—	—	—	cf	—	—	—	—	—	—	—	—	—	×	—	—	×							
105. Jamesella spencei (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×							
*106. Jamesella utahensis Walcott																									
107. Wimanella borealis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
108. Wimanella simplex Walcott	—	—	—	×	—	*a*																			
109. Billingsella coloradoensis (Shumard)	—	—	—	—	—	—	—	?	—	—	×	—	—	×	×	—	—	—	—	—	—	—	—	—	a,b

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BRACHIOPODA (cont.)																									
110. Billingsella marion Walcott	—	—	—	—	×																				
111. Billingsella obscura Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?	×			
*112. Billingsella striata Walcott																									
113. Billingsella whitfieldi Walcott	—	—	—	—	—	—	—	—	—	—	—	—	a												
114. Orusia? eurekensis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	a												
115. Orusia lenticularis (Wahlenberg)	—	—	—	—	—	—	—	—	—	—	—	—	a												
116. Otusia utahensis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
117. Eoorthis bellicostata Walcott	—	—	—	—	×																				
118. Eoorthis fascigera Walcott	—	—	—	—	—	—	—	—	—	?	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c
119. Eoorthis iddingsi (Walcott)	—	—	—	—	—	—	—	—	—	—	?														
120. Eoorthis remnicha Winchell	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	×	—	—	—	—	—	—	c
121. Eoorthis remnicha texana Walcott	—	—	—	—	—	—	—	—	—	—	×														
122. Eoorthis saltensis (Kayser)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
123. Eoorthis thyone Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
124. Eoorthis wichitaensis Walcott	—	—	—	—	—	—	—	—	—	×	×	—	—	—	—	—	—	—	—	—	—	—	—	—	a
125. Eoorthis zeno Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*a*										
126. Finkelnburgia noblei Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×		

* Exact horizon not known.

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BRACHIOPODA (cont.)																									
127. Syntrophia cambria Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
128. Syntrophia? unxia Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
129. Huenella texana Walcott	—	—	—	—	—	—	—	—	—	—	×														
130. Huenella? weedi Walcott	—	—	—	—	—	—	—	—	—	—	×														
GASTROPODA ETC.																									
1. Scenella varians Walcott	—	—	—	—	†																				
2. Stenotheca wheeleri Walcott	—	—	—	—	†																				
3. Platyceras romingeri Walcott	—	—	—	—	†																				
4. Platyceras bellianus Walcott	—	—	—	—	†																				
5. Platyceras primordialis Hall	—	—	—	—	—	—	—	—	—	?	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c
6. Hyolithellus flagellum (Matthew)	—	—	—	×	†																				
7. Hyolithellus hectori	—	—	—	×																					
8. Hyolithellus annulatus (Matthew)	—	—	—	—	†																				
9. Orthotheca corrugata Matthew	—	—	—	—	†																				
10. Orthotheca major Walcott	—	—	—	—	†																				
11. Hyolithes carinatus Matthew	—	—	×	—	†																				
12. Hyolithes cecrops Walcott	—	—	—	×																					
13. Hyolithes primordialis Hall	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TRILOBITA																									
*1. Acrocephalites? glomeriatus Walcott																									
2. Acrocephalites haynesi Walcott	—	—	—	—	—	—	—	a																	
3. Acrocephalites? majus Walcott	—	—	—	—	—	—	—	×																	
4. Acrocephalites multisegmentus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
5. Acrocephalops gibber Poulsen	×																								
6. Agnostus bidens Meek	—	—	—	—	—	—	—	—	—	×	—	—	a												
7. Agnostus interstrictus White	—	—	—	—	—	—	—	—	—	×															
8. Agnostus iruyensis Kayser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
9. Agnostus montis Matthew	—	—	×	—	†																				
10. Agnostus tilcuyensis Kayser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
11. Agnostus tumidosus Hall & Whitfield	—	—	—	—	—	—	—	—	—	×															
12. Agnostus sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
13. Agraulos stator Walcott	—	×	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	b
14. Albertella bosworthi Walcott	—	×	—	×																					
15. Albertella helena Walcott	—	—	—	×	—	×	—	×																	
16. Albertella levis Walcott	—	×																							

* Exact horizon not known

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TRILOBITA (cont.)																									
17. Alokistocare althea Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×			
18. Alokistocare? labrosum Walcott	—	—	—	—	—	—	—	×																	
19. Alokistocare linnarssoni (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	b	—	—	—	—	—	—	×					
20. Alokistocare pomona Walc.	—	—	—	—	—	—	—	×																	
21. Alokistocare? prospectense (Walcott)	—	—	—	—	—	—	—	—	—	—	—	a	a												
22. Alokistocare subcoronatum (Hall & Whitfield)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*a*										
23. Alokistocare ticida Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	a									
24. Amecephalina mirabilis Poulsen	×																								
25. Amecephalus piochensis (Walcott)	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×										
26. Anomocare parvum Walcott	—	—	—	—	—	—	—	—	—	—	—	×													
27. Anoria tontoensis (Walcott)	—	—	—	—	—	—	—	—	—	—	—	-	—	—	—	—	—	—	—	—	×	*a*			
28. Arionellus hyeroniani Kayser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
29. Arionellus levis Walcott	—	—	—	—	—	—	—	—	—	—	×														
30. Arionellus lorenzi Kayser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
31. Asaphiscus calenus Walcott	—	—	—	—	—	—	—	×																	
32. Asaphiscus camma Walcott	—	—	—	—	—	—	—	×																	
33. Asaphiscus granulatus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TRILOBITA (cont.)																									
34. Asaphiscus minor Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
35. Asaphiscus rossensis Walcott	—	—	—	×																					
36. Asaphiscus unispinus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
37. Asaphiscus wheeleri Meek	—	—	—	—	—	—	—	—	b	—	—	—	—	—	—	c	×	×							
38. Asaphiscus sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
39. Bathyuriscus adæus Walcott	—	—	—	—	×																				
40. Bathyuriscus anax Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
41. Bathyuriscus atossa Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
42. Bathyuriscus belesis Walcott	—	—	—	—	—	×																			
43. Bathyuriscus belus Walcott	—	—	—	—	—	*a*																			
44. Bathyuriscus? bithus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
45. Bathyuriscus haydeni (Meek)	—	—	—	—	—	—	—	—	—	—	×														
46. Bathyuriscus howelli Walcott	—	—	—	—	—	—	—	—	—	—	—	×													
47. Bathyuriscus occidentalis (Matthew)	—	—	—	—	†																				
48. Bathyuriscus ornatus Walcott	—	—	—	—	†																				
49. Bathyuriscus pupa Matthew	—	—	—	—	†																				
50. Bathyuriscus rossensis Walcott	—	—	—	×																					
51. Bathyuriscus cf rossensis Walcott	—	—	—	×																					
52. Bathyuriscus rotundatus (Rominger)	—	—	—	—	*†																				

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TRILOBITA (cont.)																									
53. Bathyuriscus sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
54. Bonnia? stephenensis (Walcott)	—	—	—	—	†																				
55. Burlingia hectori Walcott	—	—	—	—	†																				
56. Chancia ebdome Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
57. Chancia evax Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
58. Corynexochus stevenensis (Walcott)	—	—	—	—	†																				
59. Crepicephalus argentinus Kayser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
60. Crepicephalus chares Walcott	—	—	—	×																					
61. Crepicephalus coria Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×					
62. Crepicephalus dis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×					
63. Crepicephalus texanus (Shumard)	—	×	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	×	—	c
64. Crepicephalus texanus elongatus Walcott	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	c
65. Crepicephalus tripunctatus (Whitfield)	—	—	—	—	—	—	—	—	—	—	×	—	×												
66. Crepicephalus unzia Walcott	—	—	—	—	—	—	—	—	—	—	×														
67. Crepicephalus upis Walcott	—	—	—	=	—	—	—	—	—	—	×														
68. Crusoia cebes Walcott	—	—	—	—	—	—	—	×																	
69. Dokimocephalus pernasutus (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	b												

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TRILOBITA (cont.)																									
70. Dolichometopus baton Walcott	—	—	—	—	—	a	—	×																	
71. Dolichometopus? bessus Walcott	—	—	—	—	—	—	—	×																	
72. Dolichometopus bion Walc.	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×										
73. Dolichometopus dawsoni (Walcott)	—	—	—	—	†																				
74. Dolichometopus? expansus (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	a												
75. Dolichometopus? lodensis (Clark)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	b		
76. Dolichometopus productus (Hall & Whitfield)	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×	c	—	—	—	—	×	×	b	—	c
77. Dorypyge? quadriceps (Hall & Whitfield)	—	—	—	—	—	-	-	×																	
78. Dorypyge obliquispina Poulsen	×																								
79. Dorypyge resseri Poulsen	×																								
80. Dunderbergia nitida (Hall & Whitfield)	—	—	—	—	—	—	—	—	—	—	—	—	b												
81. Elkia nasuta (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	b												
82. Elrathia cordilleræ (Rominger)	—	—	—	—	†																				
83. Elrathia? crassilimbata Poulsen	×																								

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TRILOBITA (cont.)																									
84. Elrathia groenlandica Poulsen	×																								
85. Elrathia kingi (Meek)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×							
86. Elrathiella obscura Poulsen	a																								
87. Eurekia dissimilis (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	b	—	—	—	—	—	—	—	—	—	—	—	a
88. Glossopleura boccar (Walc.)	—	—	—	—	×																				
89. Glossopleura expansa Poulsen	×																								
90. Glossopleura longifrons Poulsen	×																								
91. Glossopleura sulcata Poulsen	×																								
92. Glossopleura walcotti Poulsen	×																								
93. Glyphaspis capella Walcott	—	—	—	—	—	—	—	×																	
94. Glyphaspis perconcava Poulsen	×																								
95. Hanburia gloriosa Walcott	—	—	—	—	×																				
96. Holteria problematica (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	b												
97. Housia varro (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×					
98. Iddingsia similis (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	b												
99. Iddingsia robusta (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	b												
100. Karlia stephenensis Walcott	—	—	—	—	×																				
101. Kochiella cf. americanus Walcott	—	—	—	×																					

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TRILOBITA (cont.)																									
102. Liostracus parvus Walcott	—	—	—	—	—	—	—	—	—	×															
103. Liostracus steinmanni Kayser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
104. Leiostracus ulrichi Kayser	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	
105. Lonchocephalus hamulus Owen	—	—	—	—	—	—	—	—	—	?															
106. Lonchocephalus pholus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
107. Lonchocephalus plena Walc.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
108. Marella splendens Walcott	—	—	—	—	×																				
109. Marjumia callas Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
110. Marjumia typa Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
111. Millardia semele Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
112. Mollisonia gracilis Walcott	—	—	—	—	*																				
113. Mollisonia rara Walcott	—	—	—	—	*																				
114. Mollisonia symmetrica Walcott	—	—	—	—	×																				
115. Nathorstia transitans Walcott	—	—	—	—	*																				
116. Neolenus constans Walcott	—	—	—	×																					
117. Neolenus inflatus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
118. Neolenus intermedius Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
119. Neolenus intermedius pugio Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TRILOBITA (cont.)																									
120. Neolenus serratus (Rominger)	—	—	—	—	†																				
121. Neolenus superbus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
122. Norwoodia tenera Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
123. Ogygopsis klotzi (Rominger)	—	—	—	—	†	—	—	—	—	—	—	—	—	—	×										
124. Olenopsis americanus Walcott	—	—	—	—	—	*a*																			
125. Orria elegans Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
126. Oryctocare geikiei Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
127. Oryctocephalus reynoldsi Reed	—	—	—	—	†	—	—	—	—	—	—	—	—	—	×										
128. Pagetia bootes Walcott	—	—	—	—	*																				
129. Pagetia clytia Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
130. Poliella anteros Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
131. Poliella caranus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
132. Poliella chilo Walcott	—	—	—	×																					
133. Poliella occidentalis (Matthew)	—	—	—	—	†																				
134. Poliella powersi Walcott	—	—	—	—	—	—	—	—	—	—	×														
135. Poliella primus Walcott	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	b
136. Poliella probus Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
137. Poliella sylla Walcott	—	×																							
138. Polypleuraspis solitaria Poulsen	×																								
139. Ptychoparia affinis Walcott	—	—	—	—	—	—	—	—	—	—	×														

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TRILOBITA (cont.)																									
140. Ptychoparia antiquata Salter	—	—	—	—	—	—	—	—	—	×															
141. Ptychoparia candace Walcott	—	—	—	—	—	×																			
142. Ptychoparia charax Walcott	—	—	—	—	—	×																			
143. Ptychoparia? cilles Walcott	—	—	—	×																					
144. Ptychoparia diademata (Hall)	—	—	—	—	—	—	—	—	—	×															
145. Ptychoparia llanoensis Walcott	—	—	—	—	—	—	—	—	—	—	×														
146. Ptychoparia palliseri Walcott	—	—	—	—	†																				
147. Ptychoparia penfieldi Walcott	—	—	—	—	—	—	—	—	—	×															
148. Ptychoparia pylas Walcott	—	—	—	—	—	×																			
149. Ptychoparia sp.	—	—	—	×	—	a	—	×	—	×															
150. Saratogia wisconsensis (Owen)	—	—	—	—	—	—	—	—	—	×	×	—	—	—	—	—	—	—	—	—	—	—	—	—	c
151. Saukiella pepinensis (Owen)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×		
152. Solenopleura? weedi Walcott	—	—	—	—	—	—	—	—	—	×															
153. Solenopleura ulrichi Poulsen	×																								
154. Tontoia kwaguntensis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×			
155. Utia curio Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
156. Vanuxemella contracta Walcott	—	—	—	—	—	a																			
157. Vanuxemella nortia Walcott	—	—	—	×																					

Table VI (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TRILOBITA (cont.)																									
158. Vistoia prisca Walcott	—	×																							
159. Zacanthoides charilla Walcott	—	×																							
160. Zacanthoides? cimon Walcott	—	—	—	×																					
161. Zacanthoides cnopus Walcott	—	—	—	—	—	×																			
162. Zacanthoides idahoensis Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×										
163. Zacanthoides spinosus Walcott	—	—	×	—	†	—	—	—	—	—	—	—	a												
164. Zacanthoides typicalis Walcott	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×										
165. Zacanthoides sp.	—	—	—	—	—	a																			
OTHER CRUSTACEA																									
1. Anomalocaris canadensis Whiteaves	—	—	—	—	†																				
2. Anomalocaris? whiteavesi Walcott	—	—	—	—	†																				
3. Anomalocaris? acutangula Walcott	—	—	—	—	†																				
4. Isoxis argentea (Walcott)	—	—	—	—	b																				
MEROSTOMATA																									
1. Emmeraldella brocki Walc.	—	—	—	—	*																				

Table VI (*Concluded*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
MEROSTOMATA (cont.)																									
2. Emmeraldella micrura Walc.	—	—	—	—	×																				
3. Habelia obtata Walc.	—	—	—	—	*																				
4. Molaria spinifera Walc.	—	—	—	—	*																				
LIMULARVA																									
1. Amiella ornata Walc.	—	—	—	—	*																				
2. Sidneyia inexpectans Walc.	—	—	—	—	†																				
CYSTOIDEA																									
1. Eocystites? sp.	—	—	—	×																					

TABLE VII.

MIDDLE CAMBRIAN FAUNAS OF THE CALEDONIAN GEOSYNCLINE.

This table summarizes the occurrences of the Middle Cambrian faunas of the various districts. Only the Acadian or *Paradoxides* fauna is included, since the *Protolenus* (Hanfordian) and the Dugaldian have only a limited distribution and the faunas of these has already been given in detail. In the various separate tables which have been given, the detailed distribution by zones is shown, but in the present table the Acadian is treated as a whole, without discrimination of zones.

The following are the columns in detail.

Col. 1. Eastern Massachusetts. Hayward Creek and vicinity in South Braintree.

Col. 2. Acadian of New Brunswick and Cape Breton, for details see table M Cols. 6-14

Col. 3. Southeastern Newfoundland. Manuel's Brook section. For details see Table M, Cols 1-5. also Trinity and Conception Bays

Col. 4. Middle Cambrian of South Wales. For details of St. David's section, see Table J, Cols 1-8

Col. 5. North Wales. Middle Cambrian. For details of St. Tudwal's sections see Table J. Cols 9-15.

5a Cairn Burn & Druid Hill Burn Dumfrieshire, South Scotland

5b Bellewstown, County Meath; Balbriggan, County Dublin Ireland

Col. 6. Middle Cambrian (Acadian) of the Comley district. For details of distribution see Table L.

Col. 7. Middle Cambrian of Nuneaton district Warwickshire. England. For details of zoning see Table K.

Col. 8. Oslo (Kristiania) District of Norway

Col. 9. Southern Sweden, including Scania. For detailed distribution in Scania see Table I

Col. 10. Bornholm Island. For detailed zonal distribution see Table H

Col. 11. Spain (Asturias Leon, Aragon) Portugal (Only a few of the Villa Boim species are included. The rest are omitted as the horizon is not definitely determined.

Col. 12. Montagne Noire.

Col. 13. Central Bohemia

Col. 14. South Germany

Col. 15. Sardinia: Canal Grande and LaCabitza (25 km W. and 5. km S. E. respectively from Iglesias) (The Archæocyathids are omitted as their age is in doubt).

Col. 16. Sainte Croix Mountains (Gor Swietokryskich) and Pepper Mountains of Poland

Col. 17. Siberia, and Bennett Island. The Archæocyathids of the Torgoshino limestone are omitted, as the age of this formation is in doubt.

Col. 18. Finmarken Embayment of Northern Sweden and Norway and the Tröntjem District of Norway. The species here included may not belong to the Middle Cambrian

Col. 19. The St. Alban's Formation of Vermont.

19a At Little Metis on the St. Lawrence below Quebec Long. 68° W, Lat 48° 40′ N

Col. 20. Occurs also in Lower Cambrian of Caledonian geosyncline.

Col. 21. Occurs also in Upper Cambrian of the Caledonian geosyncline

Col. 22. Also in Middle Cambrian of Appalachian geosyncline

Col. 23. Also in Middle Cambrian of Palæo-Cordilleran geosyncline.

Table VII

Middle Cambrian Fauna of the Caledonian Geosyncline.

Spongidae

1. Choia hindii (Dawson)
2. Eocoryne geminum Matthew
3. Kiwetinokia metissica (Dawson)
4. Protospongia diffusa Salter
5. Protospongia fenestrata Salter
6. Protospongia flabellata Hicks
7. Protospongia hicksi Hinde
8. Protospongia major Hicks
9. Protospongia minor distans Matthew

Locality	No.	1	2	3	4	5	6	7	8	9
Also Mid. Camb. Palæocord.	23					×		×		
Also Mid. Camb. Appalach.	22					×				
Also Upper Cambrian	21									
Also Lower Cambrian	20									
St. Albans Vt & Little Metis (19a)	19	a		a						
Finmarken Embayment	18									
Siberia & Bennett Island	17									
Ste. Croix Mts. etc. Poland	16									
Island of Sardinia	15									
Frankenwald Bavaria	14									
Central Bohemia	13									
Montagne Noire. France	12									
Spain and Portugal	11									
Bornholm Island	10									
Southern Sweden	9					×				
Oslo (Kristiania) Norway	8									
Nuneaton England	7									
Comley. England	6									
N. Wales, 5a, S. Scotl., 5b, Ireland	5					×				
South. Wales	4				×	×	×	×	×	
S. E. Newfoundland	3					×				
New Brunswick & Cape Breton	2		×			×				×
Eastern Massachusetts	1									

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Stromatoporoidea																							
1. Gymnosolen ramseyi Steinmann	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?	?	—	—	?		
Archæocyathidæ																							
1. Archæocyathus ichnusæ Born.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
2. Archæocyathus? paranoides Matthew	—	×																					
Graptozoa etc.																							
1. Dendrograptus? primordialis Matthew	—	×																					
2. Protograptus alatus Matthew	—	×																					
3. Medusites cf. radialis (Linnrs)	—	—	—	—	—	—	—	—	—	—	—	—	×										
Cystoidea																							
1. Eocystites primævus Matthew	—	×																					
2. Lichenoides priscus Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
3. Protocystites menevensis Hicks	—	—	—	×																			
4. Stromatocystites pentangulatus Pomp. & Jaeckel	—	—	—	—	—	—	—	—	—	—	—	—	×										
5. Trochocystites barrandii	—	—	—	—	—	—	—	—	—	—	—	×											
6. Trochocystites bohemicus Barrande	—	—	—	—	—	—	—	—	—	—	×	×	×										
7. Trochocystites sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	×									
Brachiopoda																							
1. Acrothele bergeroni Walcott	—	—	—	—	—	—	—	—	—	—	—	×											
2. Acrothele bohemica (Barrande)	—	—	—	—	—	—	—	—	—	—	—	—	×										
3. Acrothele coriacea Linnrs.	—	—	—	—	—	×	—	×	×	×													

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Brachiopoda (cont.)																							
4. Acrothele gamagii (Hobbs)	×																						
5. Acrothele (Redlichella) granulata Linnrs.	—	—	—	—	—	—	—	×	×	—	—	—	—	—	—	×							
6. Acrothele intermedia Linnrs.	—	—	—	—	—	—	?	—	×	×													
7. Acrothele maculata (Hicks)	—	—	—	×	×																		
8. Acrothele matthewi (Hartt)	—	×	×																				
9. Acrothele matthewi lata Matthew	—	×																					
10. Acrothele matthewi multicostata Matthew	—	×																					
11. Acrothele prima costata Matthew	—	×	×																				
12. Acrothele primæva Vern. et Barr.	—	—	—	—	—	—	—	—	—	—	×												
13. Acrothele quadrilineata Pomp.	—	—	—	—	—	—	—	—	—	—	—	—	×										
14. Acrothele sp.	—	—	—	—	—	×	—	—	×														
15. Acrothyra comleyensis Cobbold	—	—	—	—	—	×																	
16. Acrothyra proavia (Matthew)	—	×																					
17. Acrotreta baileyi Matthew	—	×																					
18. Acrotreta gemmula Matthew	—	×	cf																				
19. Acrotreta gracia Walcott	—	×																					
20. Acrotreta misera (Billings)	—	×	×																				
21. Acrotreta parvula (Wallerius)	—	—	—	—	—	—	—	—	×														
22. Acrotreta sagittalis (Salter)	—	×	×	×	×	×	—	×	×	×	—	—	—	—	—	—	—	—	a	—	×		
23. Acrotreta sagittalis magna Matthew	—	×																					
24. Acrotreta sagittalis transversa (Hartt)	—	×	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×		

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Brachiopoda (cont.)																							
25. Acrotreta schmalenseei Walcott	—	—	—	—	—	×	—	×	×	×													
26. Acrotreta schmalenseei matleyi Cobbold	—	—	—	—	—	×																	
27. Acrotreta socialis v. Seeb.	—	—	—	—	—	×	—	×	×	×													
28. Acrotreta sp.	—	—	—	—	—	×	—	—	×														
29. Billingsella cobboldi Matley	—	—	—	—	—	×																	
30. Billingsella coloradoensis (Shumard)	—	×																					
31. Billingsella exporrecta (Linnrs)	—	—	—	—	—	—	—	×	×														
32. Billingsella exporrecta rugosicostata Walcott	—	—	—	—	—	—	—	—	×														
33. Billingsella hicksi (Salter)	—	—	—	×																			
34. Billingsella lindströmi (Linnarson)	—	—	—	—	—	—	—	—	×														
35. Billingsella lindströmi salopiensis Matley	—	—	—	—	—	×																	
36. Billingsella romingeri (Barrande)	—	—	—	—	—	—	—	—	—	—	—	—	×										
37. Billingsella sp.	—	—	—	—	—	×																	
38. Botsfordia? barrandii (Walcott)	—	—	—	—	—	—	—	—	—	—	×												
39. Botsfordia pulchra (Matthew)	—	×																					
40. Discinopsis gulielmi (Matthew)	—	×																					
41. Eoorthis hastingsensis (Walcott)	—	×																					
42. Eoorthis papias Walcott	—	—	×																				
43. Eoorthis primordialis (Vern. et Barr.)	—	—	—	—	—	—	—	—	—	—	×												
44. Huenella billingsi (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Brachiopoda (cont.)																							
45. Huenella vermontana Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
46. Iphidella ornatella Linnrs.	—	—	×	—	—	—	—	×	×	×													
47. Iphidella pannula maladensis (White)	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×
48. Jamesella kuthàni (Pomp.)	—	—	—	—	—	—	—	—	—	—	—	—	×										
49. Jamesella pellico (Vern. et Barr.)	—	—	—	—	—	—	—	—	—	—	×												
50. Jamesella perpasta (Pomp.)	—	—	—	—	—	—	—	—	—	—	—	—	×										
51. Jamesella perpasta macra (Pomp.)	—	—	—	—	—	—	—	—	—	—	—	—	×										
52. Jamesella perpasta subquadrata (Pomp.)	—	—	—	—	—	—	—	—	—	—	—	—	×										
53. Kutorgina sardiniaensis (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
54. Lingulella agnostorum (Wallerius)	—	—	—	—	—	—	—	—	×														
55. Lingulella bornemanni (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
56. Lingulella cania Walcott	—	×																					
57. Lingulella concinna Matthew	—	×	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×		
58. Lingulella ferruginea Salter	—	×	×	×	×	×	—	×	×	×	—	—	cf	—	—	—	—	—	—	—	×		
59. Lingulella flumenis (Matthew)	—	×																					
60. Lingulella franklinensis (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
61. Lingulella linnarssoni (Walcott)	—	—	—	—	—	—	—	—	×														
62. Lingulella martinensis Matthew	—	×																					
63. Lingulella? primæva Hicks	—	—	—	?	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?			
64. Lingulella radula Matthew	—	×																					
65. Lingulella rotunda (Matthew)	—	×																					
66. Lingulella siemiradzkii (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Brachiopoda (cont.)																							
67. Lingulella tumida Matthew	—	×																					
68. Lingulella sp.	—	—	—	—	×	×	—	—	×	×													
69. Lingulepis exigua (Matthew)	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×		
70. Lingulepis starri (Matthew)	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?		
71. Mickwitzia variabilis Czarnocki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
72. Micromitra pusilla (Linnrs.)	—	—	—	—	—	—	—	—	×	×	—	—	—	—	—	—	—	—	—	—	×		
73. Micromitra sp.	—	—	—	—	—	×																	
74. Nisusia? vaticina (Vern. & Barr.)	—	—	—	—	—	—	—	—	—	—	×												
75. Obolus apollinis Eichwald	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?	—	—	—	—	×		
76. Obolus fragilis (Walcott)	—	—	×																				
77. Obolus? gibbosus Cobbold	—	—	—	—	—	×																	
78. Obolus? linnarssoni Cobbold	—	—	—	—	—	×																	
79. Obolus matinalis (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×	×	×
80. Obolus? meneghinii (Walcott)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
81. Obolus? schmalenseei (Walcott)	—	—	—	—	—	cf	—	—	×	×													
82. Obolus? zoppi Walcott	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
83. Obolus? sp.	—	—	—	—	—	×																	
84. Orusia lenticularis (Wahlenberg)	—	—	—	—	—	×	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	—	×
85. Orbiculoidea pileolus (Hicks)	—	—	—	×	×																		
86. Protorthis billingsi (Hartt)	—	×	×																				
87. Protorthis latourensis (Matthew)	—	×																					
88. Protorthis quacoensis (Matthew)	—	×																					
89. Trematobolus kempanum (Matthew)	—	×																					
90. Trematobolus pristinus (Matthew)	—	×																					

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Brachiopoda (cont.)																							
*91. Westonia bottnicus (Wiman)	—	—	—	—	—	—	—	—	?	—	—	—	—	—	—	—	—	—	—	?			
92. Westonia escasoni (Matthew)	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?		
93. Westonia finlandensis Walcott	—	—	—	—	—	—	—	—	×														
Pteropoda etc.																							
1. Conularia schloppensis Wurm	—	—	—	—	—	—	—	—	—	—	—	—	—	×									
2. Conularia sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	×									
3. Cyrtotheca hamula Hicks	—	—	—	×																			
4. Hyolithes (Diplotheca) acadicus Matthew	—	×																					
5. Hyolithes (Diplotheca) acadicus obtusus Matthew	—	×																					
6. Hyolithes (Diplotheca) acadicus sericus Matthew	—	×																					
7. Hyolithes (Orthotheca) affinis Holm	—	—	—	—	—	—	—	—	×	×													
8. Hyolithes antiquus Hicks	—	—	—	×																			
9. Hyolithes corrugatus (Salter)	—	—	—	×																			
10. Hyolithes (Camerotheca) danianus Matthew	—	×																					
11. Hyolithes excavatus Holm	—	—	—	—	—	—	—	—	×														
12. Hyolithes (Camerotheca) gracilis Matthew	—	×																					
13. Hyolithes? haywardensis Grabau	×																						

* Exact horizon not determined.

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Pteropoda etc. (cont.)																							
14. Hyolithes (Diplotheca) hyattinus caudatus Matthew	—	×																					
15. Hyolithes (Orthotheca) lineatulus Holm	—	—	—	—	—	—	—	—	×	×													
16. Hyolithes (Camerotheca) micmac Matthew	—	×																					
17. Hyolithes obscurus Holm	—	—	—	—	—	—	—	—	×	×													
18. Hyolithes penultimus (Hicks)	—	—	—	×																			
19. Hyolithes plicatus	—	—	—	—	—	—	—	×															
20. Hyolithes primus Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
21. Hyolithes shaleri Walcott	×																						
22. Hyolithes socialis Linnrs.	—	—	—	—	—	—	—	—	×	×													
23. Hyolithes stiletto (Hicks)	—	—	—	×																			
24. Hyolithes tenuistriatus Linnrs	—	—	—	—	—	—	—	—	×	×													
25. Hyolithes sp.	—	—	—	—	—	—	—	—	×	—	—	—	—	×	—	—	—	—	×				
26. Hyolithellus micans Billings	—	—	—	—	—	×																	
27. Hyolithellus micans robustus Cobbold	—	—	—	—	—	×																	
28. Pelagiella jahni Smetana	—	—	—	—	—	—	—	—	—	—	—	—	×										
29. Pelagiella lohovicensis Smetana	—	—	—	—	—	—	—	—	—	—	—	—	×										
30. Pelagiella perneri Smetana	—	—	—	—	—	—	—	—	—	—	—	—	×										
31. Platysolenites antiquissimus Eichwald	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	×					
Gastropoda																							
1. Helcionella anullata Smetana	—	—	—	—	—	—	—	—	—	—	—	—	×										

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Gastropoda (cont.)																							
2. Helcionella (Calloconus) ava Perner	—	—	—	—	—	—	—	—	—	—	—	—	×										
3. Helcionella (Calloconus) ava excentrica Smet.	—	—	—	—	—	—	—	—	—	—	—	—	×										
4. Helcionella lata Smetana	—	—	—	—	—	—	—	—	—	—	—	—	×										
5. Helcionella lata glabra Smet.	—	—	—	—	—	—	—	—	—	—	—	—	×										
6. Helcionella maxima Smetana	—	—	—	—	—	—	—	—	—	—	—	—	×										
7. Helcionella media Smetana	—	—	—	—	—	—	—	—	—	—	—	—	×										
8. Helcionella oblonga Cobbold	—	—	—	—	—	×																	
9. Helcionella (Calloconus) pompeckji Perner	—	—	—	—	—	—	—	—	—	—	—	—	×										
10. Helcionella cf. rugosa (Hall)	—	—	—	—	—	—	—	—	—	—	—	—	×										
11. Helcionella tejrovicensis Smetana	—	—	—	—	—	—	—	—	—	—	—	—	×										
12. Helcionella tenuis Smetana	—	—	—	—	—	—	—	—	—	—	—	—	×										
13. Metoptoma barrandii Linnrs.	—	—	—	—	—	—	—	—	×	×													
14. Raphistoma bröggeri Grönwall.	—	—	—	—	—	—	—	—	—	×													
15. Stenotheca (Parmophorella) acadica (Hartt)	—	×																					
16. Stenotheca concentrica Matthew	—	×																					
17. Stenotheca cornucopia Salter	—	—	cf	×																			
18. Stenotheca hicksiana Matthew	—	×																					
19. Stenotheca nasuta Matthew	—	×																					
20. Stenotheca radiata Matthew	—	×																					
21. Stenotheca triangularis Matthew	—	×																					

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Ostracoda etc.																							
1. Beyrichia angelini armata Grönwall	—	—	—	—	—	—	—	—	—	×													
2. Beyrichona triceps Matthew	—	×																					
3. Entomis buprestis Salter	—	—	—	×																			
4. Leperditia cambrensis Hicks	—	—	—	×																			
5. Leperditia curta Matthew	—	×																					
6. Leperditia hicksi Jones	—	—	—	×																			
7. Leperditia primordialis Linnrs.	—	—	—	—	—	—	—	—	—	×													
8. Leperditia solvensis Jones	—	—	—	×																			
9. Leperditia sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
Trilobita																							
1. Acrocephalus stenometopus (Ang.)	—	—	—	—	—	—	—	—	×														
2. Agnostus acadicus Hartt	—	×																					
3. Agnostus acadicus declivis Matthew	—	×	×																				
4. Agnostus aculeatus Ang.	—	—	—	—	—	—	—	—	×	×													
5. Agnostus aculeatus micropunctatus Lermont	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
6. Agnostus altus Grönwall	—	—	—	×	×	—	×	—	—	×													
7. Agnostus atavus Tullb.	—	—	—	—	—	—	—	—	×														
8. Agnostus arcticus Westergaard	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
9. Agnostus barlowi (Belt)	—	—	×	—	—	—	—	—	×														
10. Agnostus barlowi definitus Howell	—	—	×																				

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
11. Agnostus barlowi spinatus Illing	—	—	—	—	—	—	×																
12. Agnostus barrandii Salter	—	—	×	×	×	—	×																
13. Agnostus bibullatus Barrande	—	—	×	—	—	—	×	—	—	—	—	—	—	×									
14. Agnostus bifurcatus Illing	—	—	×	×	—	—	×																
15. Agnostus bituberculatus Ang.	—	—	—	—	—	—	—	—	×	×	—	—	—	—	—	—	×						
16. Agnostus brevifrons Ang.	—	—	—	—	—	—	—	×	×	×													
17. Agnostus cambrensis Hicks	—	—	—	×	×																		
18. Agnostus cicer forfex Grönwall	—	—	—	—	—	—	—	—	—	×													
19. Agnostus clarae Howell	—	—	×																				
20. Agnostus corrugatus Illing	—	—	—	—	—	—	×																
21. Agnostus davidis Salter	—	—	—	×	×																		
22. Agnostus elegans Tullb.	—	—	—	—	—	—	—	—	×	×													
23. Agnostus eskriggii Hicks	—	—	—	×																			
24. Agnostus exaratus Grönw.	—	—	—	×	×	—	×	—	—	×													
25. Agnostus exeratus tenuis Illing	—	—	cf	×	×	—	×																
26. Agnostus exsculptus Ang.	—	—	—	—	—	—	—	—	×	×													
27. Agnostus fallax Linnrs.	—	×	cf	×	×	×	×	×	×	×	—	—	—	—	—	×							
28. Agnostus fallax concinnus Matthew	—	×																					
29. Agnostus fallax ferox Tbg	—	—	—	—	—	—	—	—	×	×													
30. Agnostus tricuspis Brögger	—	—	—	—	—	—	—	—	—	×													
31. Agnostus fallax trilobatus Matthew	—	×	cf																				
32. Agnostus fallax vir Matthew	—	×																					
33. Agnostus fissus Lundgren	—	×	×	×	×	—	×	—	×	×													

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
34. Agnostus fissus perrugatus Grönwall	—	—	×	—	—	—	cf	—	—	×													
35. Agnostus fissus trifissus Matthew	—	×																					
36. Agnostus gibbus Linnrs.	—	cf	×	—	—	—	—	×	×	×	—	—	—	—	—	×							
37. Agnostus gibbus acutilobus Matthew	—	×																					
38. Agnostus gibbus hybrida Brögger	—	—	cf	—	—	—	—	×	—	×	—	—	—	—	—	—	?						
39. Agnostus gibbus partitus Matthew	—	×																					
40. Agnostus glandiformis Angelin	—	—	—	—	—	—	×	—	×	×	—	cf	—	—	—	—	×						
41. Agnostus glandiformis resecta Grönwall	—	—	—	—	—	—	—	—	—	×													
42. Agnostus gracilis Illing	—	—	×	—	—	—	×																
43. Agnostus granulatus Barrande	—	—	×	—	×	—	×	—	—	—	—	—	×										
44. Agnostus hybridus	—	—	—	—	—	—	—	×															
45. Agnostus incertus Brögger	—	—	cf	—	—	—	×	—	×	×													
46. Agnostus insularis Grönw.	—	—	—	—	—	—	—	—	—	×													
47. Agnostus integer Beyrich	—	—	—	—	—	—	×	—	—	—	—	—	×										
48. Agnostus intermedius Tulb.	—	—	—	—	—	—	cf	—	×	×													
49. Agnostus kjerulfi Brögger	—	—	cf	×	×	—	×	×	×	×													
50. Agnostus lævigatus (Dalm.)	—	—	—	—	—	—	—	—	×	×													
51. Agnostus lævigatus ciceroides Matthew	—	—	×																				
52. Agnostus lævigatus mamilla Matthew	—	—	×																				

Table VII (*Concluded*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
53. Agnostus lævigatus terranovicus Matthew	—	—	×	—	—	—	×																
54. Agnostus latirhachis Westergaard	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
55. Agnostus lens Grönwall	—	—	—	—	—	—	×	—	—	×													
56. Agnostus lens frontosa Grönwall	—	—	—	—	—	—	—	—	—	×													
57. Agnostus lingula Grönw.	—	—	—	—	—	—	—	—	—	×													
58. Agnostus lobatus Illing	—	—	—	—	—	—	×																
59. Agnostus longifrons Nicholas	—	—	—	—	×																		
60. Agnostus longifrons parvulus Howell	—	—	×																				
61. Agnostus lundgreni Tullb.	—	—	—	—	—	—	—	—	×	×													
62. Agnostus lundgreni nana Grönwall	—	—	—	—	—	—	—	—	—	×													
63. Agnostus nathorsti Brögger	—	×	—	—	—	—	×	—	×	×													
64. Agnostus nathorsti confluens Matthew	—	×																					
65. Agnostus nudus Beyrich	—	—	cf	×	×	—	×	—	×	—	—	—	×										
66. Agnostus nudus hyperboreus Westergaard	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
67. Agnostus nudus marginatus Brögg.	—	—	—	—	—	—	—	—	×	×													
68. Agnostus nudus ovalis Illing	—	—	—	—	—	—	×																
69. Agnostus nudus scanicus Tbg.	—	—	—	—	—	—	—	—	×	×													
70. Agnostus obtusilobus Matthew	—	×																					
71. Agnostus parvifrons Linnrs.	—	cf	×	—	—	—	×	—	×	×	—	—	—	—	—	—	?						
72. Agnostus parvifrons mamillatus Brögger	—	—	×	—	—	—	—	—	×	×													

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
73. Agnostus parvifrons nepos Brögger	—	cf	—	—	—	—	—	—	×	×													
74. Agnostus parvifrons punctifer Howell	—	—	×	—	—	—	×																
75. Agnostus parvifrons truncatus Matthew	—	×																					
76. Agnostus pisiformis pater Westergaard	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
77. Agnostus planicauda Angelin	—	—	cf	—	—	—	—	—	×	×													
78. Agnostus punctuosus Angelin	—	—	×	×	×	—	×	—	×	×													
79. Agnostus punctuosus affinis Brögger	—	—	—	—	—	—	—	—	×														
80. Agnostus punctuosus bipunctatus Brögger	—	—	—	—	—	—	—	—	×														
81. Agnostus punctuosus Angelin var	—	×	—	—	—	—	×																
82. Agnostus pulchellus Illing	—	—	—	—	—	—	×																
83. Agnostus pusillus Tullberg	—	—	cf	—	—	—	—	—	×	×													
84. Agnostus quadratus Tlb.	—	—	—	—	—	—	—	—	×	×													
85. Agnostus rectangularis Howell	—	—	×																				
86. Agnostus regius Sjögren	—	—	—	—	—	—	—	—	—	×													
87. Agnostus regius globosus Illing	—	—	—	—	—	—	×																
88. Agnostus regulus Matthew	—	×																					
89. Agnostus repandus Westergaard	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
90. Agnostus rex Barrande	cf	—	×	—	—	—	×	—	×	×	—	—	×										
91. Agnostus rex transectus Matthew	—	×																					
92. Agnostus rotundus Grönwall	—	—	—	—	—	—	×	—	—	×													

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
93. Agnostus sallesi M-Ch. & Berg.	—	—	—	—	—	—	—	—	—	—	×	×											
94. Agnostus scarabæoides Salter	—	—	—	×																			
95. Agnostus schmidti v. Toll	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
96. Agnostus scutalis Salter	—	—	—	×																			
97. Agnostus securiger Lake	—	—	—	—	—	—	×																
98. Agnostus stenorrhachis Grönwall	—	—	—	—	—	—	—	—	—	×													
99. Agnostus sulcatus Illing	—	—	×	—	—	—	×	×															
100. Agnostus tesselus Matthew	—	×	×																				
101. Agnostus triangulatus Illing	—	—	—	—	—	—	×																
102. Agnostus truncatus Brögger	—	—	—	—	×	—	—	—	×														
103. Agnostus tuberculatus Illing	—	—	—	—	—	—	×																
104. Agnostus typicalis Nicholas	—	—	—	—	×																		
105. Agnostus umbo Matthew	—	×	cf																				
106. Agnostus vaningeni Howell	—	—	×																				
107. Agnostus sp.	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	×	—	×				
108. Agraulos acuminatus (Angelin)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?						
109. Agraulos affinis Billings	—	—	cf																				
110. Agraulos ceticephalus (Barrande)	—	—	—	—	—	—	—	—	—	×	—	×	—	×									
111. Agraulos ceticephalus carinatus Matthew	—	×																					
112. Agraulos depressus Grönwall	—	—	—	—	—	—	—	—	—	×													
113. Agraulos difformis Ang.	—	—	—	—	—	—	—	—	×	×	—	×	—	—	—	—	×						
114. Agraulos difformis aculeatus Ang.	—	—	—	—	—	—	—	—	×	×													
115. Agraulos difformis acuminatus Ang.	—	—	—	—	—	—	—	—	×	×													

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
116. Agraulos frankenwaldensis Wurm	—	—	—	—	—	—	—	—	—	—	—	—	—	×									
117. Agraulos hallianus Matthew	—	×																					
118. Agraulos? holocephalus Matthew	—	×	—	—	cf	×																	
119. Agraulos longicephalus	—	—	—	—	—	—	—	—	—	—	—	×											
120. Agraulos? nannus Matthew	—	×																					
121. Agraulos? pusillus Matthew	—	×																					
122. Agraulos quadrangularis (Whitfield)	×	—	—	—	—	cf	—	—	—	—	—	—	—	—	—	cf							
123. Agraulos? roberti Matthew	—	×																					
124. Agraulos socialis Billings	—	×	×																				
125. Agraulos? whitfieldianus Matthew	—	×																					
126. Agraulos whitfieldianus compressus Matthew	—	×																					
127. Aneuracanthus acutangulus Ang.	—	—	—	—	—	—	—	—	×														
128. Anomocare angelini Grönwall	—	—	—	—	—	—	—	—	—	×													
129. Anomocare arenivagum Menegh.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
130. Anomocare excavatum (Ang)	—	—	—	—	—	—	—	×	×	×	—	—	—	—	—	—	×						
131. Anomocare excavatum dentatum Grönwall	—	—	—	—	—	—	—	—	—	×													
132. Anomocare læve Ang.	—	—	—	—	—	—	—	—	×	×													
133. Anomocare limbatum Ang.	—	—	—	—	—	—	—	—	×	×	—	—	—	—	—	—	×						
134. Anomocare magnum Brögger var	—	×																					
135. Anomocare sibericum Westergaard	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
136. Anomocare sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×				

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
137. Anomocarella (Liostracus?) maydeli (Schmidt)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
138. Anomocarella pawlowskii (Schmidt)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
139. Anopolenus henrici Salter	—	—	×	×	—	—	×																
140. Anopolenus salteri Hicks	—	—	—	×	×																		
141. Arionellus longicephalus Hicks	—	—	—	×																			
142. Arionellus spinosus Pomp	—	—	—	—	—	—	—	—	—	—	—	—	×										
143. Bailiella baleyi (Hartt)	—	×	cf																				
144. Bailiella baleyi arcuata Matthew	—	×																					
145. Bailiella breviceps (Angelin)	—	—	—	—	—	—	—	—	×														
146. Bailiella elegans	—	×																					
147. Bailiella venulosa (Salter)	—	—	×	×	—	—	—	—	×														
148. Bailiella walcotti Matthew	—	×																					
149. Carausia menevensis Hicks	—	—	—	×																			
150. Centropleura loveni Ang.	—	—	—	—	—	—	—	—	×	×	—	—	—	—	—	—	×						
151. Centropleura vermontana Howell	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
152. Centropleura sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
*153. Clarella grönwalli Howell and Poulsen																							
154. Clarella impar (Hicks)	—	—	—	—	×																		
155. Clarella pugnax (Illing)	—	—	×	—	—	—	×																
156. Clarella steenstrupi Ang.	—	—	—	—	—	—	—	—	—	×													
157. Clarella venusta (Billings)	—	—	×																				
158. Conocephalites coronatus Barr.	—	—	—	—	—	—	—	—	—	—	×	—	×										

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
159. Conocephalites emmrichi Barr.	—	—	—	—	—	—	—	—	—	—	—	—	×										
160. Conocephalites striatus Emmrich	—	—	—	—	—	—	—	—	—	—	—	—	×										
161. Conocephalites ornatus Br.	—	—	—	—	—	—	—	×	—	×													
162. Conocoryphe aequalis Linnrs.	—	—	×	—	—	×	—	—	×	×													
163. Conocoryphe bufo Hicks	—	—	—	×	—	×	×																
164. Conocoryphe bullata Howell	—	—	×																				
165. Conocoryphe castroi Barr.	—	—	—	—	—	—	—	—	—	—	—	—	—	×									
166. Conocoryphe conifrons Pompeckj	—	—	—	—	—	—	—	—	—	—	—	—	×										
167. Conocoryphe (Ctenocephalus) coronata Barrande	—	—	—	×	—	—	—	—	—	—	×	×	×	×									
168. Conocoryphe dalmani Ang.	—	—	—	—	cf	—	—	—	×	×													
169. Conocoryphe elegans (Hartt)	—	×	×																				
170. Conocoryphe elegans granulata Matthew	—	×																					
171. Conocoryphe emarginata Linnrs	—	—	—	—	—	—	—	—	—	×													
172. Conocoryphe emarginata longifrons Cobbold	—	—	—	—	—	×																	
173. Conocoryphe glabrata Ang.	—	—	—	—	—	—	—	—	×	×													
174. Conocoryphe heberti Mun-Chalm. et Berg.	—	—	—	—	—	—	—	—	—	—	×	×	—	×	×								
175. Conocoryphe humerosa Salter	—	—	—	×																			
176. Conocoryphe homfrayi Salter	—	—	—	×																			
177. Conocoryphe impressa Linnrs.	—	—	—	—	—	—	—	—	×	×													
178. Conocoryphe latilimbata (Brögger)	—	—	—	—	—	—	—	—	×														

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
179. Conocoryphe levyi	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×								
180. Conocoryphe lyelli Hicks	—	—	—	×																			
181. Conocoryphe perdita Salter	—	—	—	×																			
182. Conocoryphe pustulosa Matthew	—	×																					
183. Conocoryphe sulzeri Schlotheim,	—	—	—	—	—	—	—	×	—	×	×	—	×										
184. Conocoryphe tenuicincta Linnrs.	—	—	—	—	—	—	—	—	×	×													
185. Conocoryphe sp. Salter	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×							
186. Conocoryphe (Ctenocephalus) exsulans Lnrs.	—	—	—	—	—	—	—	—	×	×													
187. Conocoryphe (Ctenocephalus) laticeps Ang.	—	—	—	—	—	—	—	—	—	×													
188. Conocoryphe (Ctenocephalus) tumida Grönwall	—	—	—	—	—	—	—	—	—	×													
189. Conocoryphe (Liocephalus) impressa Linnrs.	—	—	—	—	—	×	—	—	×	×													
190. Conocoryphe (Liocephalus) linnarssoni Grönwall	—	—	—	—	—	—	—	—	—	×													
191. Conocoryphe (Liocephalus) teres Grönw.	—	—	—	—	—	—	—	—	—	×													
192. Conocoryphe viola Woodward	—	—	—	—	×																		
193. Corynexochus bornholmiensis Grönw.	—	—	—	—	—	—	—	—	—	×													
194. Corynexochus cambrensis Nicholas	—	—	—	×	×																		
195. Corynexochus delagei Miquel	—	—	—	—	—	—	—	—	—	—	—	×											

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
196. Corynexochus macropthalmus Lermont.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
197. Corynexochus minor (Walcott)	—	—	×																				
198. Corynexochus pusillus Illing	—	—	—	—	—	—	×																
199. Corynexochus spinulosus Ang.	—	—	—	—	—	—	—	—	×														
200. Ctenichnites sp.	—	×																					
201. Dolichometopus acadicus Matthew	—	×																					
202. Dolichometopus suecicus (Ang.)	—	—	—	—	—	—	—	—	×														
203. Dorypyge danica Grönw.	—	—	—	—	—	—	—	—	—	×													
204. Dorypyge horrida Matthew	—	×																					
205. Dorypyge lakei Cobbold	—	—	—	—	—	×																	
206. Dorypyge oriens Grönw.	—	—	—	—	—	—	—	—	—	×													
207. Dorypyge quadriceps valida Matthew	—	×																					
208. Dorypyge reticulata Cobbold	—	—	—	—	—	×																	
209. Dorypyge cf richthofeni Dames	—	—	—	—	×																		
210. Dorypyge slatkowskii (Schmidt)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
211. Dorypyge wasatchensis acadica Matthew	—	×																					
212. Dorypyge sp.	—	—	—	—	—	—	—	—	—	—	—	×											
213. Ellipsocephalus circulus Brögger	—	—	—	—	—	—	—	×															
214. Ellipsocephalus cobboldi Czarnocki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
215. Ellipsocephalus germari Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
216. Ellipsocephalus granulatus Linnrs.	—	—	—	—	—	—	—	—	×														
217. Ellipsocephalus hoffi Schlotheim	—	—	—	—	—	—	—	—	—	—	—	—	×										

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
218. Ellipsocephalus linnarssoni Grönwall	—	—	—	—	—	—	—	—	×														
219. Ellipsocephalus multiformis Czarnocki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
220. Ellipsocephalus muticus Ang.	—	—	—	—	—	—	—	—	×														
221. Ellipsocephalus polytomus Linnrs.	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	×							
222. Ellipsocephalus vetustus Pomp.	—	—	—	—	—	—	—	—	—	—	—	—	×										
223. Elyx laticeps Ang.	—	—	—	—	—	—	—	—	×														
224. Eocoryne geminum Matthew	—	×																					
225. Erynnys breviceps (Ang.)	—	—	—	—	—	—	—	—	×	×													
226. Erynnys venulosa Salter	—	—	—	×	×	—	×	—	—	×													
227. Giordanella dilatata Bornemann	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
228. Harttella exsulans (Linnrs.)	—	—	—	—	—	—	—	—	—	×													
229. Harttella mathewi (Hartt)	—	×	×																				
230. Harttella matthewi gemminispinosus (Matthew)	—	×																					
231. Harttella matthewi hispidus (Matthew)	—	×																					
232. Harttella matthewi perhispidus (Matthew)	—	×																					
233. Harttella solvensis (Hicks)	—	—	—	×																			
234. Hartshillia inflata (Hicks)	—	—	×	×	×	—	×																
235. Hartshillia spinata Illing	—	—	—	—	—	—	×																
236. Hicksia barroisi Dalgado	—	—	—	—	—	—	—	—	—	—	×												
237. Hicksia castroi Dalgado	—	—	—	—	—	—	—	—	—	—	×												

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
238. Hicksia delwalquei Dalgado	—	—	—	—	—	—	—	—	—	—	×												
239. Hicksia elvensis Dalgado	—	—	—	—	—	—	—	—	—	—	×												
240. Hicksia hughesi Dalgado	—	—	—	—	—	—	—	—	—	—	×												
241. Hicksia minuta Dalgado	—	—	—	—	—	—	—	—	—	—	×												
242. Hicksia sphærica Dalgado	—	—	—	—	—	—	—	—	—	—	×												
243. Hicksia transtaganensis Dalgado	—	—	—	—	—	—	—	—	—	—	×												
244. Hicksia walcotti Dalgado	—	—	—	—	—	—	—	—	—	—	×												
245. Holocephalina holocephala	—	—	—	—	—	—	—	—	—	—	—	×											
246. Holocephalina incerta Illing	—	—	—	—	—	—	×																
247. Holocephalina primordialis Salter	—	—	×	×	—	—	×																
248. Hydrocephalus carens Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
249. Hydrocephalus saturnoides Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
250. Karlia minor Walcott	—	—	×																				
251. Liocephalus impressa Linnrs.	—	—	—	—	—	—	—	—	—	×													
252. Liocephalus linnarssoni Grönwall	—	—	—	—	—	—	—	—	×														
253. Liostracus aculeatus Ang.	—	—	—	—	—	—	—	—	×														
254. Liostracus costatus Ang.	—	—	—	—	—	—	—	—	×														
255. Liostracus couloumanus	—	—	—	—	—	—	—	—	—	—	—	×											
256. Liostracus dubius Cobbold	—	—	—	—	—	×																	
257. Lyostracus elegans Illing	—	—	—	—	—	—	×																
258. Liostracus globiceps Grönw.	—	—	—	—	—	—	—	—	—	×													
259. Liostracus globiceps jaculator Howell	—	—	×																				
260. Liostracus latus Cobbold	—	—	—	—	—	×																	

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
261. Liostracus linnarssoni Ang.	—	—	—	—	—	—	—	×	×	×	—	cf	—	—	—	×							
262. Liostracus microphthalmus Ang.	—	—	—	—	—	—	—	×	×	×													
263. Liostracus platyrrhinus Grönw.	—	—	—	—	—	—	—	—	—	×													
264. Liostracus pulchellus Cobbold	—	—	—	—	—	×																	
265. Liostracus ouangondianus (Hartt)	—	×	cf																				
266. Liostracus ouangondianus aurora Matthew	—	×																					
267. Liostracus ouangondianus emarginatus Matthew	—	×																					
268. Liostracus ouangondianus gibbus Matthew	—	×																					
269. Liostracus ouangondianus planus Matthew	—	×																					
270. Liostracus tener (Hartt)	—	×	×																				
271. Liostracus tener acuminatus Matthew	—	×																					
272. Liostracus tener lævis Matthew	—	×																					
273. Liostracus validus Matthew	—	×																					
274. Menocephalus sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×				
275. Metadoxides arenarius Bornemann	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
276. Metadoxides armatus Bornemann	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
277. Metadoxides bornemanni Dalgado	—	—	—	—	—	—	—	—	—	—	×	—	—	—	×								
278. Metadoxides torosus Bornemann	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
279. Microdiscus caudatus Delgado	—	—	—	—	—	—	—	—	—	—	×												
280. Microdiscus eucentrus Linnrs.	—	—	—	—	—	—	—	—	×	×													

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
281. Microdiscus (Goniodiscus) dawsoni (Hartt)	—	×	×																				
282. Microdiscus kochi von Toll	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
283. Microdiscus lenaicus von Toll	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
284. Microdiscus (Eodiscus) precursor (Matthew)	—	×																					
285. Microdiscus punctatus Salter	—	×	×	×	×	×	×																
286. Microdiscus punctatus scanicus Linnrs.	—	—	—	—	—	—	×																
287. Microdiscus pulchellus (Hartt)	—	×																					
288. Microdiscus scanicus Linrs.	—	—	—	—	—	—	—	—	×	×													
299. Microdiscus scanicus eucentra	—	—	—	—	—	—	—	—	—	×													
290. Microdiscus (Goniodiscus) sculptus Hicks	—	—	—	×	—	—	—	—	—	—	—	×											
291. Microdiscus simplex Salter	—	—	—	—	—	×																	
292. Microdiscus sousai Delgado	—	—	—	—	—	—	—	—	—	—	×												
293. Microdiscus subcordatus Delgado	—	—	—	—	—	—	—	—	—	—	×												
294. Microdiscus wenceslasi Delgado	—	—	—	—	—	—	—	—	—	—	×												
295. Microdiscus woodwardi Delgado	—	—	—	—	—	—	—	—	—	—	×												
296. Olenoides obrutschewi Lermont.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
297. Olenoides sibericus Lermont.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
298. Olenopsis bornemanni Menighini	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
299. Olenopsis longispinatus Bornemann	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
300. Olenopsis micruroides Menighini	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Tailobita (cont.)																							
301. Olenopsis zoppi Menighini	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
302. Paradoxides abenacus Matthew	—	×	cf	—	—	—	—	—	—	—	cf												
303. Paradoxides acadicus Matthew	—	×																					
304. Paradoxides acadicus suricus Matthew	—	×																					
305. Paradoxides aculeatus Linnrs.	—	—	—	—	—	—	—	—	—	×													
306. Paradoxides aurora Salter	—	—	—	×	—	—	×																
307. Paradoxides asper Born.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
308. Paradoxides barrandii Boeck?	—	—	—	—	—	—	—	—	—	—	×												
309. Paradoxides bennetti Salter	—	—	×																				
310. Paradoxides bifidus Born.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
311. Paradoxides bohemicus (Boeck)	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×							
312. Paradoxides bohemicus salopiensis Cobbold	—	—	—	—	—	×																	
313. Paradoxides brachirhachis Linnrs.	—	—	—	—	—	—	—	—	×														
314. Paradoxides choffati Delgado	—	—	—	—	—	—	—	—	—	—	×												
315. Paradoxides costæ Delgado	—	—	—	—	—	—	—	—	—	—	×												
316. Paradoxides davidis Salter	—	—	×	×	—	×	×	—	×	×													
317. Paradoxides decorus Billings	—	—	×																				
318. Paradoxides desideratus Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
319. Paradoxides etiminicus Matthew	—	×	×																				
320. Paradoxides etiminicus breviatus Matthew	—	×																					
321. Paradoxides etiminicus malicitus Matthew	—	×																					

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Tailobita (cont.)																							
322. Paradoxides etiminicus quacoensis Matthew	—	×																					
323. Paradoxides etiminicus suricoides Matthew	—	×																					
324. Paradoxides expectans Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
325. Paradoxides forchhammeri Ang	—	×	—	—	—	—	—	×	×	×	—	×											
326. Paradoxides gennari Menegh.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×								
327. Paradoxides groomi Lapworth	—	—	—	—	—	×																	
328. Paradoxides harknessi Hicks	—	—	—	×																			
329. Paradoxides harlani Green	×																						
330. Paradoxides haywardi Raymond	×																						
331. Paradoxides hicksi Salter	—	—	cf	×	×	—	×	—	×	×													
332. Paradoxides hicksi Salter var	—	—	—	—	—	—	—	—	×														
333. Paradoxides imperialis Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
334. Paradoxides inflatus Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
335. Paradoxides intermedius Cobbold	—	—	—	—	—	×																	
336. Paradoxides jemtlandicus Wiman	—	—	—	—	—	—	—	—	—	×													
337. Paradoxides kustai Smetana	—	—	—	—	—	—	—	—	—	—	—	—	×										
338. Paradoxides lamberti	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
339. Paradoxides lamellatus Hartt,	—	×	×																				
340. Paradoxides lamellatus loricatus	—	×																					
341. Paradoxides lyelli Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
342. Paradoxides mediterraneus Pomp	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×								
343. Paradoxides micmac Matth.	—	×																					

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Tailobita (cont.)																							
344. Paradoxides micmac pontificalis Matthew	—	×																					
345. Paradoxides ölandicus Sjögren	—	—	—	—	—	—	×																
346. Paradoxides orphanus Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
347. Paradoxides palpebrosus Brögger	—	—	—	—	—	—	—	—	×														
348. Paradoxides parvoculus Howell	—	—	×																				
349. Paradoxides perneri Smetana	—	—	—	—	—	—	—	—	—	—	—	—	×										
350. Paradoxides polonicus Czarnocki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
351. Paradoxides pradoanus Barr. et V.	—	—	—	—	—	—	—	—	—	—	×	cf											
352. Paradoxides pugnax Illing	—	—	—	—	—	—	×																
353. Paradoxides pusillus Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
354. Paradoxides regina Matthew	—	×																					
355. Paradoxides rotundatus Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
356. Paradoxides rouvillei	—	—	—	—	—	—	—	—	—	—	—	×											
357. Paradoxides rugulosus Corda	—	—	×	—	—	×	×	×	—	×	×	—	×										
358. Paradoxides sacheri Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
359. Paradoxides sjögreni Linnrs.	—	—	—	—	—	—	×	—	×	×													
360. Paradoxides sjögreni nepos Grönwall	—	—	—	—	—	—	—	—	—	×													
361. Paradoxides slawicensis Czarnocki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
362. Paradoxides solvensis Hicks	—	—	—	×																			
363. Paradoxides spinosus Boeck	—	—	—	—	—	—	—	—	—	—	×	—	×	×									
364. Paradoxides tejrovicensis Smet.	—	—	—	—	—	—	—	—	—	—	—	—	×										
365. Paradoxides tenellus Bill.	—	—	×																				
366. **Paradoxides tessini Brongn.**	—	—	—	—	—	—	—	×	×	×	cf	—	—	—	—	×							

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Tailobita (cont.)																							
367. Paradoxides walcotti Smetana	—	—	—	—	—	—	—	—	—	—	—	—	×										
368. Paradoxides sp.	—	—	—	—	—	×																	
369. Plutonia sedgwicki Hicks	—	—	—	×																			
370. Protolenus asiaticus Lermontowa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
371. Protypus? bohemicus Pomp.	—	—	—	—	—	—	—	—	—	—	—	—	×										
372. Ptychoparia adamsi Billings	—	×																					
373. Ptychoparia (Levisia) czeckanowskii v. Toll	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
374. Ptychoparia henrici Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×										
375. Ptychoparia johnsstrupi Grönw.	—	—	—	—	—	—	—	—	—	×													
376. Ptychoparia limbata Matthew	—	×																					
377. Ptychoparia linnarssoni Brögger	—	×	—	—	—	—	—	—	—	×													
378. Ptychoparia linnarssoni altata Matthew	—	×																					
379. Ptychoparia cf marginata Pomp	—	—	—	—	—	—	—	—	—	—	—	—	×										
380. Ptychoparia (Inoueya) meglizkii von Toll	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
381. Ptychoparia orestes Hartt	—	×																					
382. Ptychoparia orestes thyrsites Matthew	—	×																					
383. Ptychoparia rogersi (Walcott)	×	—	cf																				
384. Ptychoparia rschonsnizkii Lermontowa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
385. Ptychoparia striata Emmr.	—	—	—	—	—	—	—	—	—	—	—	—	×	×									
386. Ptychoparia sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	×				

Table VII (*Continued*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Tailobita (cont.)																							
387. Sao hirsuta Barrande	—	—	—	—	—	—	—	—	—	—	—	—	×	×									
388. Solenopleura acadica Whiteaves	—	×	—	—	—	—	—	—	—	×													
389. Solenopleura acadica elongata Matthew	—	×	—	—	—	—	—	—	—	×													
390. Solenopleura arenosa Billings	—	×																					
391. Solenopleura applanata (Salter)	—	—	cf	×	×	—	×																
392. Solenopleura bella Lermontowa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
393. Solenopleura bituberculata Lerm.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
394. Solenopleura brachymetopa Ang.	—	—	—	—	—	—	—	×	×	×	—	—	—	—	—	×							
395. Solenopleura brachymetopa alutacea Grönwall	—	—	—	—	—	—	—	—	×	×													
396. Solenopleura brachymetopa nuntia Grönwall	—	—	—	—	—	—	—	—	—	×													
397. Solenopleura bucculenta Grönwall	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	×							
398. Solenopleura canaliculata Ang.	—	—	—	—	—	—	—	—	×	×													
399. Solenopleura cannati	—	—	—	—	—	—	—	—	—	—	—	×											
400. Solenopleura castroi	—	—	—	—	—	—	—	—	—	—	×												
401. Solenopleura communis Billings	—	—	×																				
402. Solenopleura conifrons Pomp.	—	—	—	—	—	—	—	—	—	—	—	—	×										
403. Solenopleura cristata Linnrs.	—	—	—	—	—	—	—	—	—	×													
404. Solenopleura holometopa Ang.	—	—	—	—	—	—	—	—	×	×													
405. Solenopleura parva Linnrs.	—	—	—	—	—	—	—	—	×	×													
406. Solenopleura ribeiroi (Barr. et Vern.)	—	—	—	—	—	—	—	—	—	—	×	×	—	×									
407. Solenopleura robbi (Hartt)	—	×																					

Table VII (*Concluded*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trilobita (cont.)																							
408. Solenopleura robbi orestes (Hartt)	—	×	×																				
409. Solenopleura robbi parva Matthew	—	×																					
410. Solenopleura rouairouxi M.-Ch. et Berg	—	—	—	—	—	—	—	—	—	—	×												
411. Solenopleura? siberica (Schmidt)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
412. Solenopleura torrifrons Pomp.	—	—	—	—	—	—	—	—	—	—	—	—	×										
413. Solenopleura variolaris (Salter)	—	—	×	×	×	—	×																
414. Solenopleura sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×						
415. Solenopleura mobergi Czarnocki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
416. Solenopleura wimani Czarnocki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×							
417. Solenopleura sp.	—	—	—	—	—	×																	

* Exact Horizon and Locality unknown.

NOTE ON PLATE II. PALÆOGEOGRAPHIC MAP OF PANGÆA IN MIDDLE CAMBRIAN TIME

This map is drawn on the same principles and the same projection as is Pl. I (see *ante*, p. 156, *182*). The several geosynclines are lined as before, the Caledonian *horizontal*, the Southern Appalachian *vertical*, the Palæo-Cordilleran *horizontal* and *vertical* crossed and the Indo-Chinese *diagonal*. The Finmarken extension of the *Siberian Epi-Sea* now unites with the Northern Appalachian geosyncline, extending to the Albany axis (Ax) which divides it from the Southern Appalachian geosyncline. The latter is expanded over part of Mississippia, forming the *Mississippian Epeiric Sea* and more or less confluent on the south through the *Crepicephalus Epi-Sea* with the Palæo-Cordilleran geosycline, though this latter derived most of its fauna from the *Boreal Epi-Sea*, which also flooded the west[1] coast of Greenland.

Another junction between the Mississippian Epeiric sea and the Palæo-Cordilleran geosyncline is shown in the *Deadwood Straits* (D).

The *Pre-Andean geosyncline* now extended to Bolivia and the Argentine and since it formed another extension of the Crepicephalus Epi-Sea, it is also represented by vertical lining.

A narrow continental shelf is shown on the sea-board of South America, and on that of Antarctica, and along this a few types were able to migrate, thus explaining the

1 Compass directions apply to modern maps

occcurrence of some American brachiopods in the Indo-Chinese geosyncline, and the generic identity of a number of the trilobites.

The *Indo-Pacific Epi-Sea* was essentially the *Redlichia Sea* of Lower Cambrian time, and it was the faunal feeder of both the Himalayan and the Cathaysian geosynclines.

The Caledonian geosyncline covered a somewhat greater portion of Fenno-Scandia and more or less the same portions of England and Newfoundland, as well as New Brunswick and Eastern Massachusetts, as it did in Lower Cambrian time, though in Britain it extended into Southern Scotland (Dumfries-shire) and it also covered a small portion of the Irish Coast.

On the opposite side, it covered practically the whole of Spain and Southern France and had a Mediterranean extension across Sardinia into Syrabia. In the latter region, which is close to our hypothetical North Pole, we have over 200 meters of basal deposits of continental, possibly glacial type, followed by a few limestone layers with poorly preserved fossils.

It should be noted that the North Appalachian geosyncline, *i. e.* the second extension of the Siberian Epi-Sea, did not cover Northern Scotland and New-foundland, nor eastern Greenland as it did in Lower Cambrian time. It is however, not impossible that Middle Cambrian beds may be recognized in one or more of these localities, in which case a widening of the water-body will supply the proper correction. It should also be noted that the *Olenellus Bay* of Lower Cambrian time has been coverted into a land barrier, the Greeno-Scandian axis, (Gx), the width of which may of course be much less than represented. Should Boreal types of Middle Cambrian fossils eventually be found in this geosyncline, along with the Siberian types now known, some sort of connection across the axis will have to be restored.

The term *Epi-Sea* is here used for the large littoral water bodies that supplied the chief faunal elements of the several geosynclines and represented the centers of evolution and distribution of these faunas. In Middle as in Lower Cambrian time, the three principal Epi-Seas were the *Boreal*, the *Siberian*, and the *Indo-Pacific*, each with a distinctive fauna.

It is likely that by this time the *Crepicephalus Bay*, the feeder of the southern Appalachian geosyncline had acquired the dignity of an Epi-Sea. That it was to a certain extent a center of evolution and faunal distribution cannot be doubted. Certainly its successor, the Ozarkian Epi-Sea of Cambrovician time, became an important center of evolution and faunal distribution.

The *Mississippian Epeiric Sea*, on the other hand, merely represents the repeated floodings of the great marginal plain of the Appalachian geosyncline, and cannot be regarded as a center of faunal evolution.

The following localities are indicated by letters only, their position being approximate. (For exact location see the maps of the several continents Plates IIa-IIc)

A. Andrarum in Scania, Southern Sweden
Ax. Albany axis, between the southern and northern Appalachian Geosynclines.
B. Bohemian Basin.
D. Deadwood in South Dakota
Gx. Greeno-Scandian axis
J. St. John. New Brunswick
L. Little Metis, Quebec

M. Eastern Massachusetts
N. Montagne Noire. Southern France.
P. Central Poland. St. Croix Mountains etc.
S. Sardinia Island
V. St. Albans Vermont
W. Wadi Araba in Syrabia.

NOTES ON THE INDIVIDUAL PALÆOGEOGRAPHIC MAPS, PLATES IIa—IIc

The Palæogeography is here shown superimposed upon modern maps. This involves a series of inaccuracies for all those portions of the geosynclines with folded and disturbed strata, represented either by still unreduced modern mountains, or by the roots of ancient mountains which have been peneplaned. In general, it may be said, that the width of such geosynclines in folded regions, was originally perhaps 4 times that represented on the map, and the same thing is true for those ancient land masses which were affected by the folding. These maps are based on the supposition that the continents today are in all respects what they were in Palæozoic time, this being assumed also of the oceans. They should be compared with the map of Pangæa (Pl. II), which is based on the supposition that in Palæozoic times, the continents formed one land-mass.

Certain discrepancies which appear between the two groups of maps, are due to the fact, that the projections are of such a different character, and that hence the distortions are of a different order, and affect different parts of the continents.

PLATE IIa PALÆOGEOGRAPHIC MAP OF NORTH AMERICA IN MIDDLE CAMBRIAN TIME.

The two chief geosynclines represented here are the *Palæo-Cordilleran* in the west, represented by vertical and horizontal lines crossed, and the *Southern Appalachian*, together with its extension over *Mississippia*, indicated by vertical lining. The *Northern Appalachian* geosyncline is distinct, being separated from the southern by the Albany axis. It contains the fauna of the Atlantic province, which is also that of the *Caledonian* geosyncline of Europe. The extension of the latter is seen in Eastern Newfoundland (Manuels Brook), Cape Breton, the St. John area of New Brunswick, and in Eastern Massachusetts. This region is represented by horizontal lining. If the Atlantic Ocean was in existence at this time, and was the center of evolution and dispersal of the *Paradoxides* fauna, the marginal portions of the North American continent represented a transgression of this sea, while the northern Appalachian geosyncline represented an extension from the Atlantic, either through the Gulf of St. Lawrence or directly from the sea south of Greenland, the geosyncline having essentially the outline and form which it had in Lower Cambrian time. No attempt is made to indicate, the margin of the Atlantic nor is the eastern margin of the Appalachian continent represented.

The *Crepicephalus Epi-Sea*, which was the center of evolution of the Southern Appalachian Middle Cambrian fauna, occupies essentially the region of the present Gulf of Mexico and a part of Mexico and Central America, and is an embayment from the Pacific, the deep sea portion of which is here represented in black. These waters extended over the Mississippian flat-lands, the marginal shelf of the southern Appalachian geosyncline, essentially to the present Rocky Mountain border on the west, and over a large part of Wisconsin and Minnesota. In this, the sands of the Middle Cambrian portion of the St. Croix Formation accumulated, these comprising the formations to the top of the FRANCONIA in the Northern region, and to the top of the ELVINS, in the Ozark Mountains. The exact dividing line in the Arbuckle Mts. and the Pack-Saddle Mountain, of central Texas is still undetermined. It may be at the top of the Regan, or of the Honey Creek in the Arbuckle region, and at the top of the Cap Mountain or of the Wilberns shale in the Texas region.

Communication with the Palæo-Cordilleran geosyncline was made possible by the *Deadwood Straits* in South Dakota and Wyoming, but there also was connection with the Crepicephalus Epi-Sea on the south. The main faunal source of the Palæo-Cordilleran geosyncline, however, was the *Boreal Epi-Sea*, which bordered the deep ocean (in black) on the north.

It is to this group of deposits that the formations of northwest Greenland belong. The exact outline of the Boreal Epi-sea is of occurse conjectural. The location of the various important sections in this geosyncline are indicated.

PLATE IIb PALÆOGEOGRAPHY OF EUROPE IN MIDDLE CAMBRIAN TIME

This is again represented on the modern map and hence the regions are variously distorted. A portion of the deep sea is shown on the north and this is bordered by the littoral extension of the *Siberian Epi-Sea* which appears to have been the source of the faunas of these geosynclines. (See Plate IIc) All of the geosynclines and water bodies in this region are of one type and characterized by the *Paradoxides* fauna. The principal one is the *Caledonian Geosyncline*, which has an approximate east-west extension across Europe. Its greatest width is in the meridian of Berlin (B) where the Bavarian and Bohemian Basins form an extension southward, to the vicinity of Vienna (V). Whether this represents the original width of the geosyncline or whether the Bohemian region represents a southward thrusting of a northern block, as once suggested by the late Professor Rothpletz, remains to be determined. The British portion of the geosyncline on the west is much narrower, because there extensive folding of the strata has taken place.

This same folding together with much thrusting has narrowed the *Finmarken Gulf* or *Norwegian geosyncline* on the North. It has also narrowed the Fenno-Scandian land mass which divides this northern from the Caledonian geosyncline, and to which the greater part of Ireland and Scotland belong.

The northern part of the Caledonian geosyncline *i. e.* the part involving southern Sweden and Bornholm, as well as that of the Oslo region, represents marginal shelf deposits, with repeated floodings as outlined in the text. Whether the central part of the geosyncline was more rapidly subsiding and has thicker deposits is unknown.

The eastward extension of the geosyncline, beyond the regions of the St. Croix Mountains of Poland is purely conjectural. It has been placed in the region to the south of the main Urals, covering the northern part of the Caspian, together with the lower Volga Basin and the Aral Sea.

Of course if the Atlantic Ocean was in existence at this time, and the source of the fauna was there, the south-east Russian and Siberian extensions of this geosyncline are not needed. But, if the continents were in juxtaposition at this time, and the Siberian Epi-Sea was the source of the fauna, the only satisfactory pathway of connection was something like that indicated here, for reasons given in the text.

For the first time the *Tethyan geosyncline* on the south was outlined, this not having existed, so far as the facts now indicate, in Lower Cambrian time. This geosyncline covered much of Spain and Portugal and the Montaigne Noire region of Southern France, and in it are included the well-known Sardinian deposits and those remarkable deposits believed to be of Middle Cambrian age in Wadi-Araba, at its extreme eastern end. The locations of the main sections discussed are indicated and for purposes of orientation, the chief capitals are represented by letters as follows:

B.	Berlin	P.	Paris
C.	Constantinople	Pr.	Prague
L.	London	R.	Rome
Ls.	Lisbon	S.	Stockholm
M.	Madrid	V.	Vienna
Mo.	Moscow	W.	Warsaw

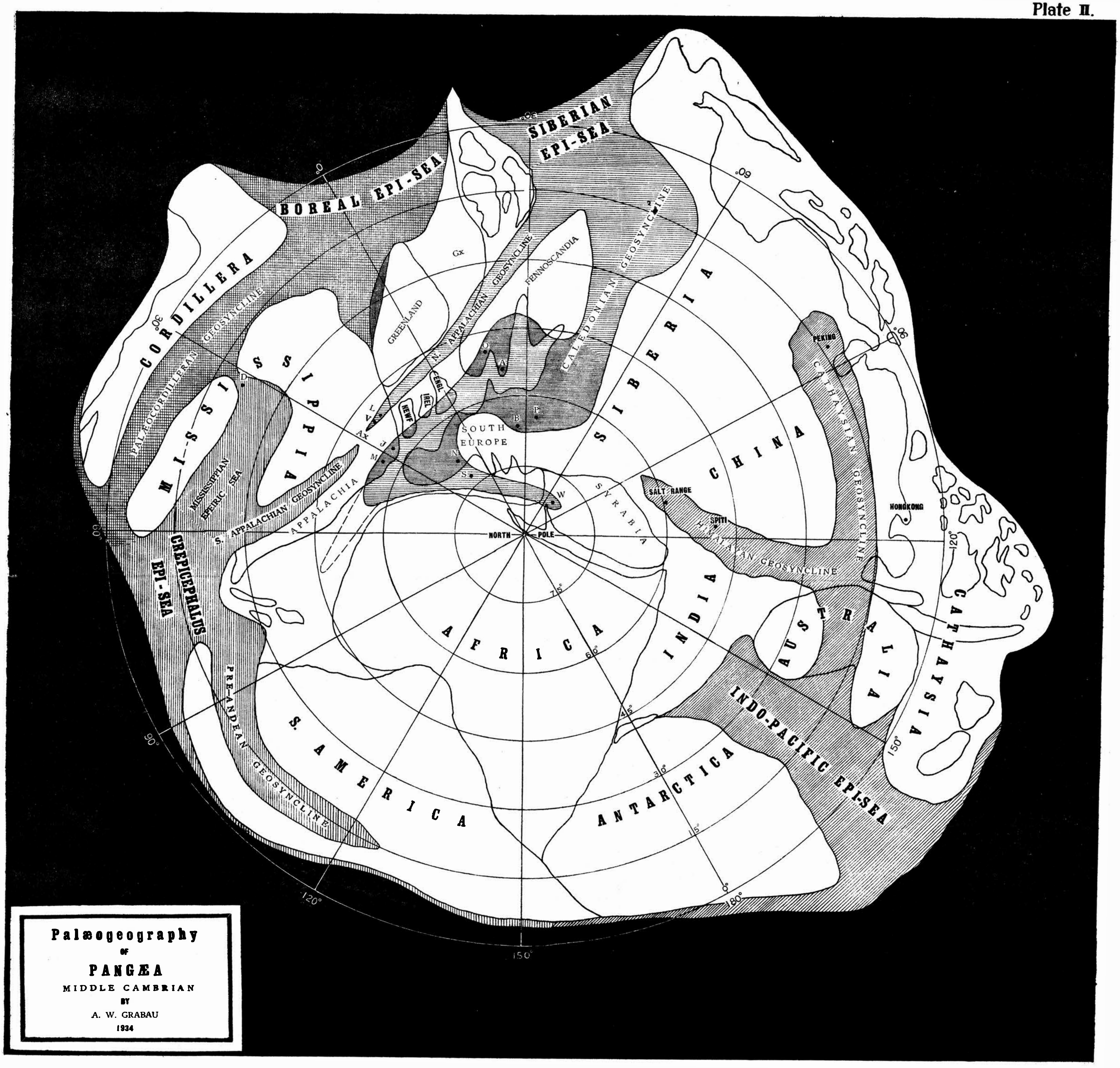
PLATE IIc PALÆOGEOGRAPHY OF ASIA IN MIDDLE CAMBRIAN TIME.

This, like the others is based on modern maps and therefore inaccurate so far as the ancient geography has been modified by compression of the geosynclinal areas. Two distincts geosynclines and centers of origin of faunas are shown.

In the north is the *Siberian Epi-Sea*, fronting the deep northern ocean. It is extended on the one hand into the *Finland Gulf* and on the other in the *Caledonian geosyncline*. All these are represented by horizontal lining. The other region shown is the *Indo-Pacific Epi-Sea*, which fronts the deep Indian Ocean, and has the two extensions, the *Cathaysian* and the *Himalayan geosynclines*. None of these seas are connected with the deep Pacific Ocean on the east.

A small portion of the *Tethyan geosyncline* including Wadi-Araba is shown on the left.

The localities of the principal sections in the geosynclines and the main land-masses of the period are indicated.



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OF
PANGÆA
MIDDLE CAMBRIAN
BY
A. W. GRABAU
1934

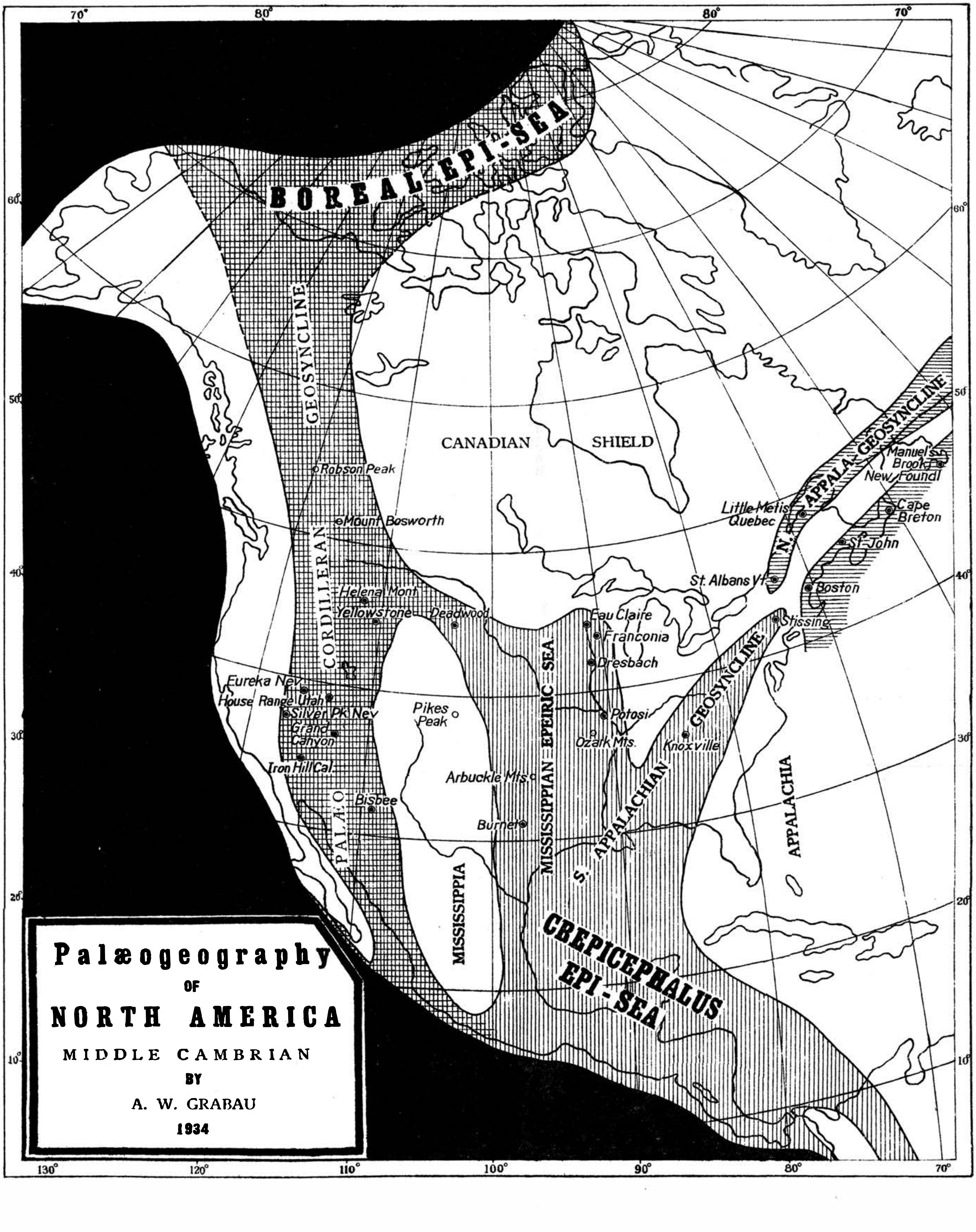
BOREAL EPI-SEA
CORDILLERAN GEOSYNCLINE
PALÆO
CANADIAN SHIELD
N. APPALA. GEOSYNCLINE
Manuel's Brook
New Foundl
Little Metis Quebec
Cape Breton
St. John
St. Albans Vt.
Boston
Stissing
Robson Peak
Mount Bosworth
Helena Mont
Yellowstone
Deadwood
Eau Claire
Franconia
Dresbach
Eureka Nev.
House Range Utah
Silver Pk. Nev
Grand Canyon
Iron Hill Cal.
Pikes Peak
Potosi
Ozark Mts.
Knoxville
Arbuckle Mts.
Bisbee
Burnet
MISSISSIPPIAN EPEIRIC SEA
S. APPALACHIAN GEOSYNCLINE
APPALACHIA
MISSISSIPPIA
CREPICEPHALUS EPI-SEA
Palæogeography
OF
NORTH AMERICA
MIDDLE CAMBRIAN
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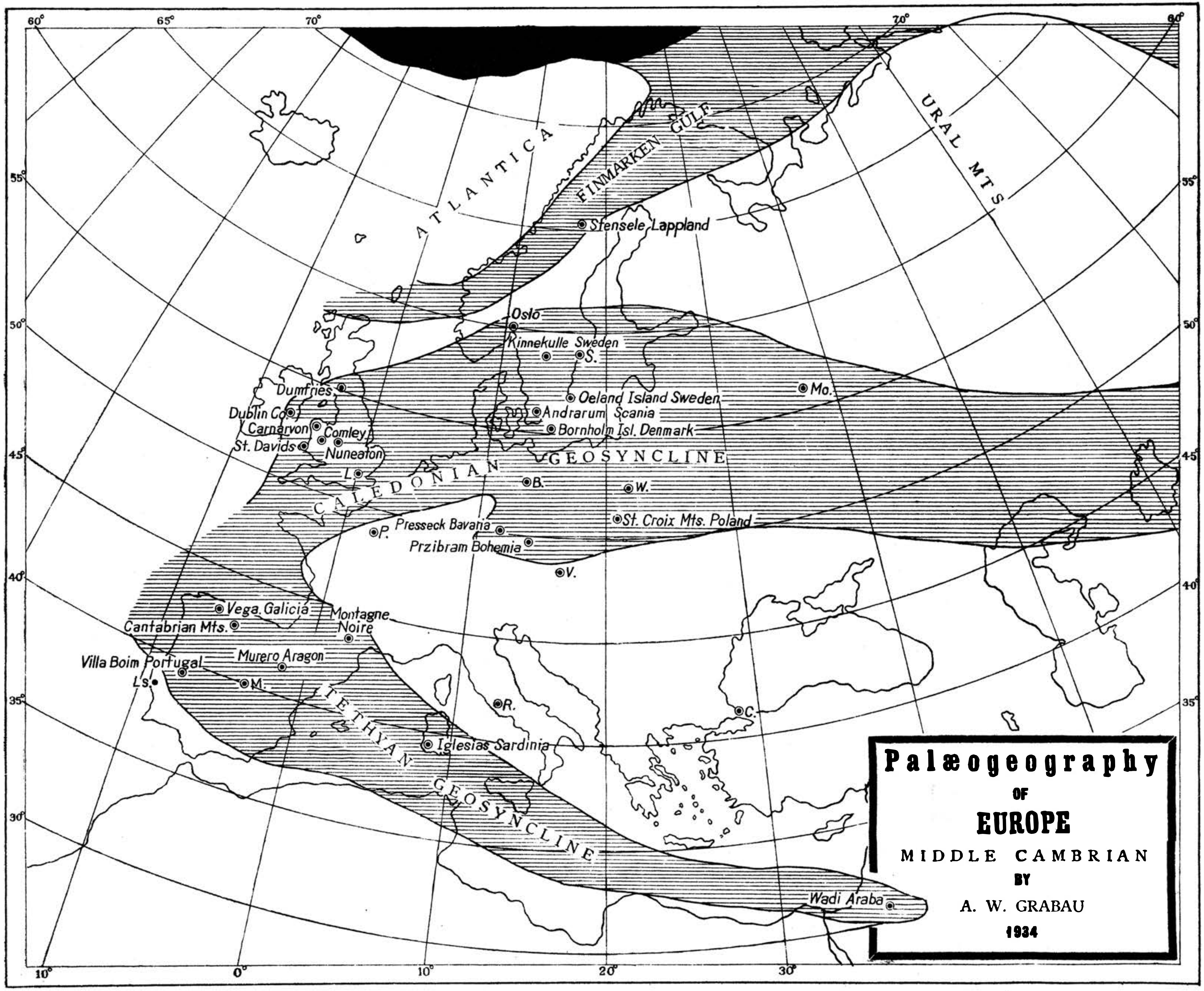
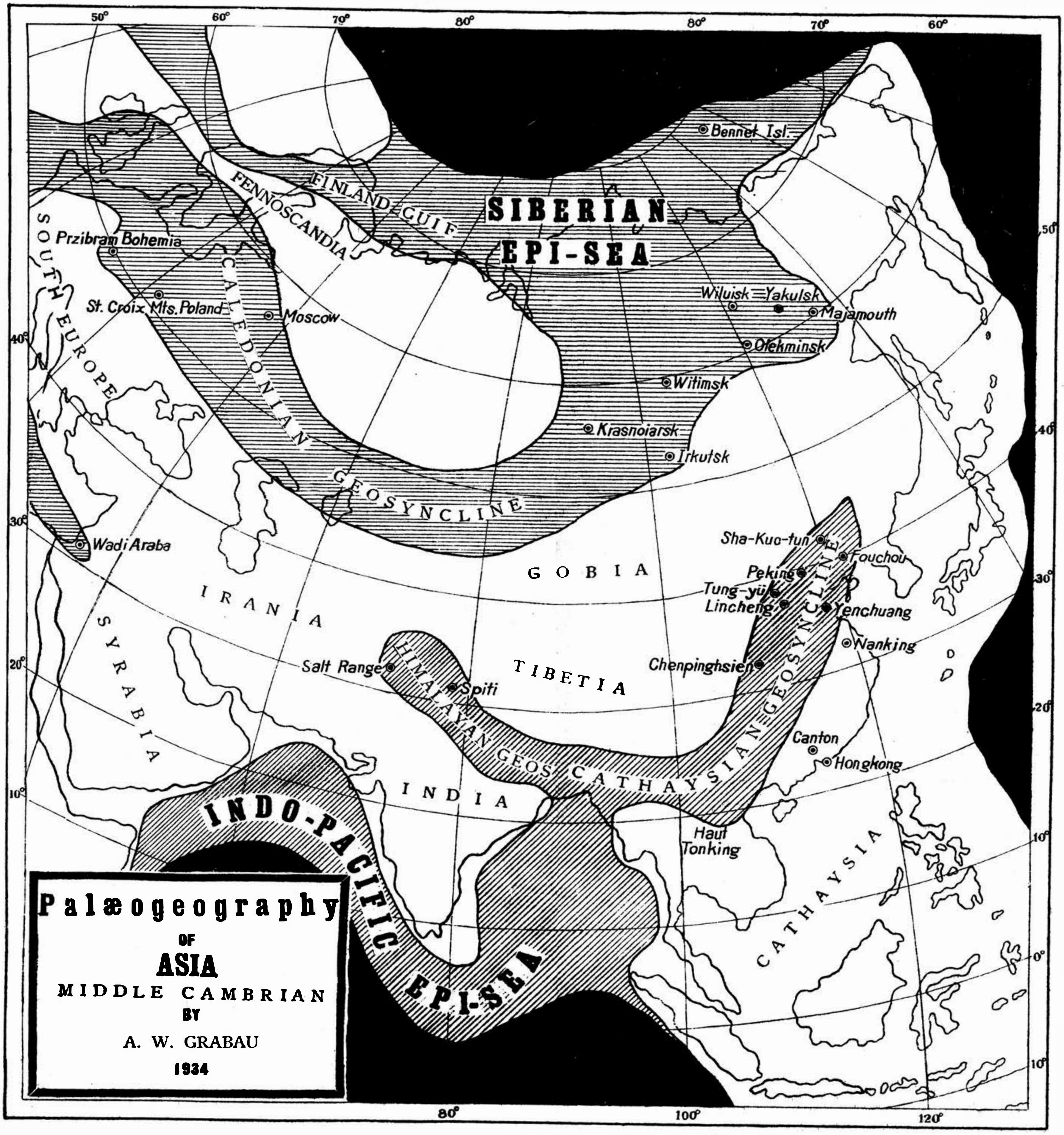
Plate IIb



ATLANTICA
FINMARKEN GULF
URAL MTS
Stensele Lappland
Oslo
Kinnekulle Sweden
S.
Dumfries
Dublin Co.
Carnarvon
Comley
St. Davids
Nuneaton
L.
Oeland Island Sweden
Andrarum Scania
Bornholm Isl. Denmark
Mo.
CALEDONIAN GEOSYNCLINE
B.
W.
St. Croix Mts. Poland
P.
Presseck Bavaria
Przibram Bohemia
V.
Vega Galicia
Cantabrian Mts.
Montagne Noire
Villa Boim Portugal
Murero Aragon
Ls.
M.
TETHYAN GEOSYNCLINE
R.
Iglesias Sardinia
C.
Wadi Araba
Palæogeography of EUROPE
MIDDLE CAMBRIAN
BY
A. W. GRABAU
1934

Plate IIc



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SIBERIAN
EPI-SEA
FINLAND GULF
FENNOSCANDIA
CALEDONIAN
GEOSYNCLINE
SOUTH EUROPE
Przibram Bohemia
St. Croix Mts. Poland
Moscow
Bennet Isl.
Wiluisk
Yakulsk
Majamouth
Olekminsk
Witimsk
Krasnoiarsk
Irkutsk
Wadi Araba
GOBIA
IRANIA
SYRABIA
TIBETIA
INDIA
CATHAYSIA
Sha-Kuo-tun
Fouchou
Peking
Tung-yü
Lincheng
Yenchuang
Nanking
Chenpinghsien
Salt Range
Spiti
HIMALAYAN GEOS
CATHAYSIAN GEOSYNCLINE
Canton
Hongkong
Haut Tonking
INDO-PACIFIC
EPI-SEA