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TRILOBITES FROM THE SILURIAN OF NEW SOUTH WALES.

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(Plates xv–xvi.)

In this paper three new species of trilobites are described from a Lower Silurian horizon at Borenore, near Orange, New South Wales, as *Encrinurus borenorensis*, *Phacops macdonaldi* and *Dicranogmus bartonensis*. The genus *Encrinurus* Emmrich, 1844, is discussed and it is considered that the genus *Cryptonymus* Eichwald, 1825, is an abandoned name and cannot be used outside certain limits. Reference is made to the recorded Australian species of the family Lichidae and their geological age.

The fossil material was originally found and forwarded to the Australian Museum by Mr. George McDonald, of "Rosyth", Borenore, on whose property the new horizon of fossils is situated. The author visited the locality later and collected additional specimens of all the described species. My thanks are due to Mr. McDonald for his assistance and interest, which have made possible the preparation of this paper. I am also indebted to Mr. F. Booker and Mr. L. Hall, of the Geological Survey of New South Wales, for assistance in determining the geological succession of the area.

The trilobite remains are not well preserved and in not one instance was a complete specimen collected. Conditions for their preservation must have been most unfavourable, and it appears as if the trilobites were transported some distance before burial, as the fragmentary remains are found closely packed together in definite zones. The specimens are represented by numerous head-shields and pygidia but, although an intensive search was made, no thoracic segments were found.

STRATIGRAPHICAL NOTES.

The fossil beds are exposed on Portion 292, Parish of Barton, County Ashburnham. They are Lower Silurian in age and the sequence consists of limestones, shales, and dacitic tuffs. The basal limestone in the area is richly fossiliferous and contains an abundant coral fauna in which the genus *Halysites* predominates. Overlying this coralline limestone is approximately 190 feet of non-fossiliferous shales, while overlying this again is a thin band of ferruginous shales, a small exposure of which contained a trilobite fauna consisting mainly of the genera *Encrinurus*, *Phacops* and isolated fragmentary remains of the family Lichidae. Very occasional brachiopods and corals are also found in this horizon.

At the top of the sequence of rocks in this area is a crinoidal limestone, approximately 380 feet in thickness, in which the genus *Halysites* has not been found.

The geological sequence is as follows:

Lithology.	Thickness in feet.
Crinoidal limestone	380
Dacitic tuff	130
Shales and tuffs	330
Ferruginous shale with trilobites	20
Shales	190
Coralline limestone with *Halysites*	260

These Silurian rocks are the northerly extensions of the horizons tabulated by Sussmilch (1906, pl. xviii) and Sussmilch and Jensen (1909, p. 159).

Sussmilch (1906, pp. 131–2) recorded a coralline limestone about twenty feet in thickness outcropping close to the junction of Spring and Gap Creeks. It was traced to the north-west for a short distance towards the junction of Spring and Quarry Creeks. In this coralline limestone the corals are completely silicified and are beautifully preserved. It contains a most characteristic coral fauna in which the genus *Halysites* is abundant, being represented by six species.

A second limestone horizon was mapped by Sussmilch about four miles to the north-east of the coralline limestone in portions 156, 196, 180, 136, Parish of Barton. This limestone horizon, referred to by Sussmilch as a crinoidal limestone, attains a thickness of at least 400 feet and is built up mainly of crinoid stems and brachiopods with a fair proportion of corals. Three species of trilobites are recorded from this limestone: *Bronteus*, sp. indet.; *Calymene*, sp. indet.; and *Encrinurus* ?, sp. indet.

No additional information was published in regard to the Silurian rocks of this area by Sussmilch and Jensen in 1909, with the exception of a revised list of Silurian fossils. In this list the genus *Encrinurus*, doubtfully recorded from the crinoidal limestone by Sussmilch in 1906, was omitted.

The two limestone horizons outcropping on portion 292 at Borenore can be correlated with those recorded by Sussmilch from the vicinity of Gap and Spring Creeks and at Oakey Creek, in the country west of the Canobolas.

In both areas the coralline limestone beds, although varying a great deal in thickness are characterized by possessing a rich *Halysites* fauna and must represent the one horizon. At Borenore the basal bed of the sequence is the coralline limestone with overlying dacitic tuffs, at the top of which is found the ferruginous shale containing *Encrinurus* and *Phacops* in abundance. Sussmilch did not apparently find this particular trilobite horizon in the area west of the Canobolas and not a great distance south of its occurrence at portion 292, Borenore. He did record a thin band of red shales, about forty feet in thickness, in the succession of strata along Oakey Creek in portions 249, 136, etc., but this bed overlies the crinoidal limestone and is apparently unfossiliferous.

Further field work is necessary in this area before any definite correlations can be made between the complete sequence of rocks on portion 292 and those recorded and mapped by Sussmilch. There are discrepancies in the two successions, although the distance between the two areas is only between four and six miles.

The trilobite and coral fauna found in these rocks indicates a Lower Silurian age. The only published record of *Halysites* in the Yass district is H. *pycnoblastoides* Eth., from the Bango Series of the Lower Silurian, the type locality of this species being the coralline limestone at Spring Creek, portion 221, Parish Barton. In recent years it has been found that *Halysites* is not an uncommon genus in the Bango Series and this occurrence can be correlated with the *Halysites* horizon at Borenore. The Bango Series is below the Hume Series in the Yass area, in which is found a rich trilobite fauna in the Lower, Middle and Upper Trilobite Beds. Above the Middle Trilobite Bed is the Monograptus Bed, the fauna of which indicates in the English Silurian sequence an age equivalent to the top of the Wenlock and the base of the Lower Ludlow. The complete Hume Series is considered by Ida Brown (1941, p. 335) to be of Upper Silurian age.

Notes on the Genus Encrinurus

After a most comprehensive examination of the family Encrinuridae, Cowper Reed (1928, p. 51) came to the conclusion that it contained the genera *Ectenonotus*, *Encrinurella*, *Cybele*, *Dindymene*, *Encrinurus* and *Cybeloides*. These genera have distinctive features, with the exception of *Encrinurus*, where there has been some controversy regarding the limits of its generic characters.

It is pointed out by Reed that the genus *Encrinurus* as instituted by Emmrich (1844, p. 16) would restrict to that genus those species having "the genal angles of the head produced into spines, the pygidium with a many-jointed axis terminating in a long caudal spine or blunt point, with 9–10 pleurae".

The generic name *Cryptonymus* of Eichwald (1840, p. 71) was re-introduced by Vogdes (1907, p. 63) to include those species of *Encrinurus* in which the genal angles of the head are not produced into spines after the type of *E. variolaris* Brongn. His diagnosis of the genus is "Head shield semi-circular; genal angles rounded, not produced into spines. Glabella gibbous and overhanging, with obscure furrows. Eyes prominent, smooth. Thorax with eleven segments; pleurae without grooves, notched at ends. Pygidium triangular; convex and rounded at the end, with 9–15 (axial) joints and few pleurae (seven or more)."

The main points of difference, therefore, between *Cryptonymus* and *Encrinurus* are the character of the genal angles and the termination of the pygidium. Vogdes also defined the characters of *Encrinurus* as including 18–23–30 joints in the axis of the pygidium, the centre of which is marked by a single row of nodes.

This division into the above two groups was not generally accepted by later workers. Weller (1907, p. 157) defined the genus *Encrinurus* in such a way that it included species with or without genal spines, and he made no reference to the nodular arrangement found on the pygidium.

The genus *Cryptonymus* has been referred to a great deal as far as the Silurian trilobites of Australia are concerned. Mitchell (1924, p. 46) introduced the genus to include several known species of *Encrinurus* and a number of his new species. In his previous paper on the family Encrinuridae, written in collaboration with Etheridge (1915, p. 646), the genus *Cryptonymus* was not mentioned.

In 1924 Mitchell proposed that the generic characters of *Encrinurus* should remain as already recognized, that is, the genal angles could be produced into spines or else rounded. He thought, however, that the genus *Cryptonymus* should be recognized on pygidial characteristics. The genus would have a head-shield and thorax similar to *Encrinurus*, but its separation from that genus would depend on the presence of continuous axial rings on the pygidium. The species with interrupted or discontinuous axial rings would form the genus *Encrinurus*.

It was pointed out by Reed that this method of classification is doubtfully of any value, as it is more than possible that the non-continuity of the axial rings on the pygidia is of a secondary nature. In some Ordovician species, Reed states, the axial rings consist of both continuous and non-continuous types. However, Reed (1928, p. 66) uses this character to some extent in determining groups within the species of *Encrinurus*.

Etheridge and Mitchell (1915, p. 656) have pointed out that within certain species of *Encrinurus* the axial rings are continuous on testiferous specimens while they are discontinuous and median spaces are developed when the test is not preserved. Unfortunately almost all the specimens of *Encrinurus* found in Australian Silurian rocks are non-testiferous and rarely is one found in which the test is preserved. After an examination of a good deal of material the continuous or discontinuous nature of the axial rings of the pygidium together with the ornamentation of the axis by nodes appears to be a constant specific feature.

The possession of both types is a feature well developed in specimens of *E. borenorensis*, and on well-preserved but non-testiferous examples the axial rings consist of both continuous and broken ones with a median flattened space on which tubercles or nodes may be present or absent. The first six anterior axial rings are continuous and ornamented with tubercles. The seventh and eighth are discontinuous, the median spaces being ornamented by single nodes. On the ninth and tenth the

median spaces are smooth. The eleventh and twelfth are more or less continuous with a single central node. The following three are discontinuous with smooth median spaces with the sixteenth and seventeenth complete and a single central node. The eighteenth is incomplete, while the remaining four small axial rings are complete.

The possession of both types of axial rings on the pygidia of *E. borenorensis* is additional evidence in support of Reed's contention that the character of these is of insufficient importance to be used as a generic distinction. It seems better, therefore, to follow the example of authors who have discarded the genus *Cryptonymus* in favour *of Encrinurus*. The distinguishing features which have separated the two genera are not constant or distinctive enough to be of generic importance. The genus *Encrinurus* is one in which we have to accept a considerable amount of variation amongst the many species referred to it. As it stands, the genus is well defined and the species it contains form an easily recognized and compact group.

Of still greater importance, however, is the fact that *Cryptonymus*, according to the rules of nomenclature, must be considered as an abandoned name. Some authors have recognized this fact, while others are of the opinion that the name can still be used. Eichwald (1825, p. 44) instituted this genus to include eight species of trilobites, all of which are now classed as *Asaphus* or *Illaenus*. Vogdes (1907, p. 62) is of the opinion that the genus *Cryptonymus* should stand under the strict rule of priority for at least such species as *Encrinurus punctatus* or *E. variolaris*. This, however, cannot be the case. Not one of the species originally included in the genus *Cryptonymus* of 1825 can be referred to the family Encrinuridae and it was not until fifteen years later that Eichwald (1840, p. 71) included *C. punctatus* and *C. variolaris* in the genus. Vogdes points out that Eichwald was correct in re-introducing his abandoned name in 1840, as he originally only pointed out his generic types without giving a generic description. I am of the opinion that the genus *Cryptonymus* can be used only for any of the original eight species, and the species *Cryptonymus punctatus* and *C. variolaris*, introduced later in 1840, must therefore each be placed as a synonym, *Cryptonymus* (non *Cryptonymus*, 1825) of *Encrinurus* Emmrich, 1844.

Salter (1866, p. 168) used the genus *Cryptonymus* with *Asaphus expansus* as a typical species, while Woodward (1877, p. 26) placed *Cryptonymus* as a sub-genus of *Asaphus*, giving *A. scutalis* Salter as an example.

There has been a considerable amount of discussion over the status of the genus *Cromus*. Some authors have accepted Barrande's (1852, p. 821) definition of its characters as being of generic value, while others have referred to it as a synonym of *Encrinurus*.

Etheridge and Mitchell (1915, p. 648) failed to see how the two genera could be united. They enumerated the characters of *Cromus* as follows: "The glabella bears four pairs of distinct lateral furrows, the hypostome lacks the forward prolongation of that of *Encrinurus*; the eyes are sessile, poorly developed and, so far as known, there are but ten segments in the thorax against eleven in that of *Encrinurus*."

These two authors in describing the Encrinuridae of Australia stated that only species of *Encrinurus* were represented, thereby intimating that lateral glabella furrows are not developed on the Australian specimens of *Encrinurus*. However, Mitchell (1924, p. 51) in describing *Encrinurus frontalis* mentions the presence of pseudoglabella furrows, while in the same paper he refers to five pairs of glabella furrows, "if such they may be called", on the glabella of *Cryptonymus robustus*.

On a few well-preserved specimens of *Encrinurus borenorensis* there are developed grooves which in my opinion must be referred to as lateral glabella furrows. These are four in number, the posterior two extending right across the glabella, while the remaining anterior two are much reduced, being little better than notches in the sides of the glabella. The presence of furrows is shown to better advantage on impressions where definite ridges mark their position. The glabella lobes are four in number, the

basal one being small, the others enlarged, swollen, and separated by deep glabella furrows. These are very distinct from the tubercles of the glabella and appear to have no association with them.

It is interesting to note, however, that on the inner margin of the fixed cheeks there are developed four to five enlarged tubercles which project into the dorsal furrows. These, although much smaller in size than the lateral lobes, appear to correspond to them to some extent, and the significance of these in relation to the origin of the glabella lobes must be of interest.

As a distinctive generic feature it appears as if the absence or presence of lateral glabella furrows is not a good one as far as the genera *Cromus* and *Encrinurus* are concerned. The other distinguishing features of *Cromus* are not of generic importance, and Etheridge and Mitchell, strong advocates of the separation of the two genera, admit that in general features both genera agree as far as thoracic segments, test-ornamentation, outline of the pygidium, etc., are concerned.

It is considered, therefore, that Reed, Raymond and other authors are correct in placing *Cromus* as a synonym of *Encrinurus*. Reed (1928, p. 66) came to the conclusion that even with the head-shield and pygidial characters taken into consideration it was most difficult to decide upon a natural and satisfactory classification of sub-division of the various species of *Encrinurus* sens. ext.

He recognized six sub-divisions, which were defined on morphological features and which also possess a certain phylogenetic significance. No attempt was made to introduce any new nomenclature, as Reed considered the groups did not even warrant sub-generic status and they were put forward simply as a suggested grouping.

The species described in this paper as *E. borenorensis* is not assigned readily to any one of these groups. The possession of complete and incomplete axial rings on the pygidium suggests certain groups but other diagnostic characters prevent a definite reference to any single group.

Geological Range of *Encrinurus* in Australia.

It is generally accepted that members of the genus *Encrinurus* came into existence in the Ordovician and became extinct at the close of the Silurian. The Australian species of the genus have so far been recorded only from Silurian rocks in New South Wales, Tasmania and Victoria.

In the Yass-Bowning district of New South Wales all the species of *Encrinurus*, with two exceptions, have been recorded from the Middle or Lower Trilobite Beds in the Hume Series and are below the Monograptus Horizon. The two exceptions are *E. rothwellae* Eth. and Mit. and *E. incertus* (Mit.), which occur in the Upper Trilobite Bed immediately overlying the Monograptus Horizon. These deposits are Upper Silurian in age and with them have been correlated the beds at Yarralumla and the Back Creek beds of the Tarlo River, in which the genus has also been collected.

At Quidong, near Bombala, New South Wales, a locality also referred to as Delegate, fragmentary remains of *Encrinurus* have been collected from shales associated with limestone. The limestone contains a coral fauna, including *Hercophyllum shearsbyi*, and is considered to be identical in age with the Yass beds.

The shales at Borenore, near Orange, which contain an abundance of *E. borenorensis*, as mentioned before in this paper, immediately overlie a limestone horizon with a rich assemblage of species of *Halysites*. Although this genus is well known from the Lower Devonian, it is more typically a Silurian coral. In Australia *H. chillagoensis* Eth. is recorded from Chillagoe in Queensland in a limestone originally thought to be Silurian in age. In a recent paper, Hill (1943, p. 58) thinks it possible that Lower and Middle Devonian may be represented in the Chillagoe limestone belt. However, as pointed out earlier in this paper, *Halysites pycnoblastoides* Eth., with other associated, unrecorded species of the genus, from the Bango Series at Yass, New South Wales, is

definitely of Lower Silurian age. The type locality of this species is at Spring Creek, Parish Barton, in a coralline limestone which has been correlated with the *Halysites* limestone at Borenore. There seems to be little doubt that the genus *Halysites* in New South Wales, as far as our present knowledge is concerned, is restricted to the Silurian. The overlying shales at Borenore containing *Encrinurus* would also be of the same age.

In Victoria one species, *Encrinurus* (*Cromus*) *spryi*, was described by Chapman (1911, p. 297) from the Melbournian Series of the Silurian. Although Etheridge and Mitchell (1915, p. 653) stated that this specimen was possibly not an *Encrinurus* as understood by them, it had previously been examined by Mitchell and identified as *E. mitchelli*. It thus would no doubt fall into the genus *Encrinurus* sens. ext. The age of the Melbournian beds has recently been placed as the equivalent of the Lower Ludlow.

The specimens of *Encrinurus* from Tasmania have been collected from localities where the beds are supposedly of Silurian age, but so far little information is available regarding their exact geological position. In a recent paper, Gill (1948, p. 68), in recording *Encrinurus* (*Cryptonymus*) *silverdalensis* Eth. and Mit. from strata of the Eldon Group on the Lyell Highway, near Queenstown, Tasmania, raised a doubt whether *Encrinurus* is an absolute index of Silurian age. It is still largely an open question, however, whether the species of *Encrinurus* at this locality were collected from Silurian or Devonian rocks.

Notes on the Family Lichidae Corda, 1847, in Australia.

Representatives of the family Lichidae are comparatively rare in Australian rocks and in most instances only fragmentary material has been dealt with. Two specimens of incomplete cranidia and a fragment of a pygidium belonging to this family were collected from the Lower Silurian trilobite horizon at Borenore.

One of these, an incomplete cranidium, reveals some affinities with the genus *Dicranogmus* of Corda, and is described in this paper as *D. bartonensis*. The remaining material is indeterminate.

Etheridge and Mitchell (1917, p. 503) revised the then only two described species of the Lichidae from Australia, *Lichas australis* McCoy (1876, p. 18) and *Lichas palmata* var. *sinuata* Ratte (1886, p. 1065, and 1887, p. 95). Etheridge and Mitchell referred *Lichas australis* to the genus *Acanthopyge* of Corda. Gill (1939, p. 140) when adding to the description of the species made no reference to this change in nomenclature, the species being left in the genus *Lichas*.

Gürich (1901, p. 527) proposed the name *Euarges* for forms after the type of *Lichas haueri* Barrande from Bohemia. McCoy had already stressed the relationship of *Lichas australis* with *L. haueri*, although Gill, after an examination of some better material, was able to determine distinctive points of difference between the two species. Phleger (1936, p. 610) places Australia in the range of the genus *Euarges*, apparently recognizing *L. australis* as a species of that genus.

It is interesting to note that *Euarges australis* (McCoy) is now considered by Gill (1945, p. 184) to be of Lower Devonian age and not Silurian, as thought originally. He lists the localities from which *E. australis* has been collected—"junction of Woori-Yallock and Yarra (Stewart's Station)" and "Syme's Quarry, Killara"—as being of Lower Devonian (Yeringian) age.

Etheridge and Mitchell (1917, p. 504) referred *Lichas palmata* var. *sinuata* Ratte to the genus *Corydocephalus* of Corda, 1847. Only the pygidium of this species has been described, but an examination of some fragments of the glabella supports its reference to the genus *Corydocephalus* or, as it is now recognized by Phleger and Warburg, *Trochurus* of Beyrich, 1845. A small fragment of the glabella of *Trochurus palmata* var. *sinuata* Ratte shows the characteristic median depressed area immediately

anterior to the occipital ring, with a single prominent tubercle situated at each side. No complete glabella lobes are preserved on this fragmentary specimen, but the furrows present are wide and deep. The occipital ring is arched.

This species was collected from a limestone near the Wellington Caves, New South Wales, originally thought to be of doubtful Upper Silurian age, but now known to be of Lower Devonian age.

Another reference to the family Lichidae in Australian rocks is that of Gürich (1901, p. 532), when he described *Craspedarges wilcanniae* from Upper Devonian rocks at White Cliffs, New South Wales.

An incomplete and badly preserved specimen from Rock Flat Creek, New South Wales, was recorded by De Koninck as having relationships with *Lichas palmata* Barrande. This specimen was destroyed in the Garden Palace fire of 1882, and although Etheridge and Mitchell (1917, p. 504) state that it may belong to *T. palmata* var. *sinuata* (Ratte), it would be far better to ignore any reference to this specimen in the future. De Koninck did not give any description or figure of the single specimen.

Descriptions of Species.

Order OPISTHOPARIA.

Family LICHIDAE Corda.

Genus DICRANOGMUS Corda, 1847.

[Genotype, *Dicranogmus simplex* (Barande, 1846).]

Dicranogmus bartonensis, sp. nov.

(Plate xvi, figure 8.)

Holotype, F.42932, Australian Museum collection.

Specific Characters.—Glabella wider than long, rather narrowly rounded and convex in front, flattened posteriorly; curving steeply downwards anteriorly. Median lobe about 8 mm. in length, slightly more than twice as long as wide; projecting beyond bicomposite lobes. Lateral margins almost parallel, with a slight widening anteriorly; antero-lateral extremities pointed. Median lobe strongly curved downwards in front from the inner extremities of the bicomposite lobes; from this point the lateral margins are parallel with the median lobe curving gradually posteriorly. Convexity from side to side fairly strong and uniform. Bicomposite lobes elongated, somewhat wedge-shaped, tapering posteriorly, following the same general curve of the median lobe. Prolonged first lateral furrows strongly defined posteriorly, but becoming almost obsolete at the inner extremities of the bicomposite lobes; anteriorly the furrows are weak and ill defined, but there is no complete fusion between the bicomposite lobes and the antero-lateral portions of the median lobe. The second lateral furrows are well developed, deep, curving broadly around the bicomposite lobes, bending downwards from their junction with the first lateral furrows and extending to the occipital furrow. That portion of the glabella consisting of the median lobe and the bicomposite lobes well marked off by the second lateral furrows is very convex and elevated well above the remainder of the glabella.

Third lateral lobes large, inner portion slightly convex, flattening and rapidly widening outwardly, confluent with fixed cheeks. Occipital lobes sub-ovate, well defined; situated beyond main portion of occipital ring, marked off by well-impressed, short furrows curving around the occipital lobes and joining the marginal furrow. Occipital ring broad, straight below the median lobe, then curving downwards and outwards. Surface is relatively coarsely tuberculate with tubercles of varying size and height.

Remarks.—A single incomplete cranidium is the only representative of the above species which has, with some hesitation, been placed in the genus *Dicranogmus*. It differs from typical members of that genus in having the prolonged anterior lateral glabella furrows weakly marked in front, whereas in the genotype, *D. simplex*, they are obsolete, the bicomposite lobes being fused anteriorly with the antero-lateral portions

of the median lobe. Warburg (1939, p. 147), however, has placed *Lichas aequalis* Tornquist in the genus *Dicranogmus*, and in that species the prolonged first anterior glabella furrows are weakly developed and not obsolete as in the genotype. Warburg considers that the character of the anterior portions of these furrows, whether they are weak or obsolete, does not seem to be of generic importance. Another point of difference is that the prolonged anterior furrows in *D. bartonensis* do not extend back directly to the occipital furrow. They meet the second glabella furrows back from the inner extremities of the third lateral lobes and communicate with the occipital furrow by well-defined and slightly curved furrows.

The Australian species has some characters in common with *Trochurus speciosus* Beyrich, 1845, the genotype of that genus. It differs, however, in the third lateral lobes being separated from the median lobe by a distinct furrow and also in that the third lateral lobes are confluent with the fixed cheeks.

Locality.—Portion 292, Parish Barton, County Ashburnham, near Borenore, New South Wales.

Geological Age.—Lower Silurian.

Order PROPARIA.

Family ENCRINURIDAE.

Genus ENCRINURUS Emmrich, 1844.

Encrinurus borenorensis, sp. nov.

(Plate xv, figures 1–7; Plate xvi, figures 1, 5–6.)

Holotype, F.42694. Paratypes, F.42909, F.42696, F.43053, Australian Museum collection.

Specific Characters.—Cranidium sub-triangular in outline. Glabella prominent, broadly sub-pyriform, as long as wide; rounded anteriorly and narrowing gradually to half its greatest width at the occipital furrow. Moderately convex, sharply curved downwards in front, then sloping gradually posteriorly. Ornamented with numerous but not closely packed, well-developed tubercles following no definite pattern except on the extreme posterior constricted area. Immediately above the occipital furrow two tubercles are situated centrally, one on each side of a median line. The next row consists of three tubercles. On each side of the lower half of the glabella are developed five lateral glabella lobes, projecting to a marked degree into the axial furrows. The most posterior or basal lateral glabella lobes are small; the fourth, third and second lobes are large, while the most anterior or first are slightly smaller in size. Lateral furrows well developed, deep, but not extending far across the glabella. The three posterior lateral glabella furrows are wide and fairly elongate, the most anterior pair short.

The axial furrows are deeply impressed, wide, and impinged upon posteriorly by the lateral glabella lobes and by four enlarged tubercles on the inner margin of the fixed cheeks. The lobes and tubercles alternate with one another.

Occipital furrow well defined, narrow and deeply impressed at its junction with the axial furrows. Occipital ring wide and flattened, ornamented with a single row of tubercles, slightly arched, extending on both sides to a point immediately below the inner margin of the fixed cheeks and separated from the posterior lateral borders by a short, but very distinct, outwardly sloping groove.

Fixed cheeks moderately convex, widely elongate, narrowing and curving downwards to the genal angles. On the margin of the axial furrow four enlarged tubercles are developed which project into the groove. Surface covered with tubercles smaller in size than those on the glabella. The well-defined, wide and deep posterior marginal furrows of the fixed cheeks extend from the lateral extremities of the occipital furrow to the genal angles. The posterior borders rounded, not as wide as the marginal furrow, ornamented with a single row of tubercles, increasing in width at the genal

angles. The borders curve downwards rather considerably to the genal angles, which are somewhat produced by a thickening of the borders but are not developed into genal spines.

Free cheeks, relatively large, wide and very convex, ornamented with uniform tubercles of similar size to those of the glabella. The latero-posterior portions possess wide, rounded borders, increasing considerably in width both at the genal angles and at the junctions with the axial furrows; they terminate slightly forward of these furrows. Borders ornamented with a row of closely set tubercles. Marginal furrows deep, particularly where they communicate with the axial furrows, posteriorly communicating with the transverse marginal furrows of the fixed cheeks. The inner surface of the posterior portion of the free cheeks rises abruptly from the marginal furrow, almost straight-sided, then moderately convex; the pedunculate eyes are placed on the inner margin of the free cheeks in a slightly depressed area free of tubercles. The anterior portions of the free cheeks inside the axial grooves, and which rest on the glabella front, very convex, widely elongate. The border originates from that of the posterior portion, but is considerably depressed, narrow, and gradually decreasing in width anteriorly. Ornamented with a single row of small tubercles. Axial furrows, where they cross the free cheeks, deep and very pronounced, shallowing as they pass around and forward. Facial sutures are of the usual generic type.

Dimensions of the cephalon are as follows:

	F.42694.		F.42696.
Length of cephalon	23 mm.	..	24 mm.
Width of cephalon	46 mm.	..	—
Length of glabella, excluding occipital ring	21 mm.	..	21 mm.
Width of glabella	21 mm.	..	21 mm.

Thorax unknown.

Pygidium.—Large, sub-triangular, much wider than long, not produced into a caudal spine. The axial furrows broad and well defined anteriorly, narrowing posteriorly. Axis prominent, the width at the anterior end being about one-fourth the total width of the pygidium; posteriorly tapering to a relatively fine point at the extremity. Axial rings are twenty-two in number and consist of both continuous and discontinuous types. From above downwards the axial rings are characteristically as follows: The first five are continuous, ornamented with closely set tubercles, and distinctly arched; the remainder are straight, the sixth and seventh discontinuous with a centrally placed tubercle in each smooth median space. The eighth and ninth are discontinuous, with no apparent central tubercle; tenth and eleventh are more or less continuous, with a central tubercle, while the twelfth, thirteenth and fourteenth are discontinuous, with smooth central spaces. The fifteenth is continuous, the sixteenth discontinuous, with a central tubercle; the seventeenth discontinuous and the remainder continuous.

Pleural lobes anteriorly curve gradually downwards from the axial furrows to the lateral margins, abruptly so at the posterior end; lobes marked by ten pleural ribs, which are stronger anteriorly. Pleural ribs bent backwards, progressively becoming more pronounced posteriorly, where the last pair are almost parallel with the axis. Surface of ribs ornamented with small tubercles.

The dimensions of two pygidia are as follows:

	F.42926.		F.43053.
Greatest width	50 mm.	..	31 mm.
Length	32 mm.	..	22 mm.
Greatest width of axis	13 mm.	..	9 mm.

Observations.—Complete specimens of this species would attain a length of approximately 90 mm. and a width of 55 mm., and to my knowledge it is the largest of any known species of the genus *Encrinurus*. The specimens dealt with in this paper are all incomplete and non-testiferous cranidia and pygidia. No segments of the thorax have yet been found.

The extremely large size of *Encrinurus borenorensis*, the almost oval-shaped glabella with a wide posterior constricted portion and very distinctive lateral glabella lobes are characteristic features of this species. Other important differences are the extreme downward curvature of the posterior borders of the fixed cheeks, the relatively small eyes, and also the proportionately greater width of the pygidium.

The species can be compared to some extent with *E. robustus*, *E. bowningensis* and *E. etheridgei*. The latter species attains a length of two and a half inches and it has well-developed lateral glabella lobes. It differs markedly, however, from *E. borenorensis* in the shape of the pygidium and certain features of the cephalon, particularly the structure of the posterior borders of the fixed cheeks and the type of the tuberculation on the glabella, fixed cheeks and the free cheeks. From *E. robustus* and *E. bowningensis* it differs in a number of important features and comparison with either of them is not necessary.

Following is a table showing the number of pleural ribs and axial rings found on the pygidia of *E. borenorensis* and some allied Australian species, although doubt has been raised by some authors whether these are good diagnostic characters:

	Pleural Ribs.	Axial Rings.
E. borenorensis, sp. nov.	9 ..	22
E. etheridgei Mitchell	13 ..	36
E. bowningensis Foerste	7 ..	20
E. silverdalensis Eth. & Mit. ..	10 ..	26–30
E. robustus Mitchell	11–12 ..	24
E. mitchelli Foerste	10–11 ..	26–32

Locality.—Portion 292, Parish Barton, County Ashburnham, Borenore, near Orange, New South Wales.

Geological Age.—Lower Silurian.

Superfamily PHACOPIDACEA.
Family PHACOPIDAE Hawle and Corda.
Subfamily PHACOPINAE Reed.
Genus PHACOPS Emmrich, 1839.

Phacops crosslei Eth. & Mit.

1895. *Phacops crosslei* Etheridge and Mitchell, Proc. Linn. Soc. N.S.W., x, (2), 3, p. 489, pl. xxxix, figs. 9–11.

1915. *Phacops crosslei* Chapman, Proc. Roy. Soc. Vict., xxviii (N.S.), p. 168, pl. xv, figs. 14–15.

Observations.—In the collection of trilobites from Borenore there are several poorly preserved and exfoliated cranidia, but more or less complete, which have been identified as the above species.

It is difficult to find any important points of difference between *P. crosslei* and *P. serratus*, a fact already stressed by Etheridge and Mitchell (1895, p. 497). These authors state that the latter species is not separable from the former except by the presence of dorsal spines, a feature which in their opinion could be sexual. The glabella of *P. serratus*, in their opinion, seems to be more tumid in front and is more sharply contracted behind by the intercalary groove than in *P. crosslei*.

The cranidia representative of the above species compare favourably with the type material on which the species was based. They appear to be somewhat stronger and larger than the specimens described as *P. serratus*, and also the glabella does not possess the tumidity of that species. In each case the constricted portion of the glabella is wider at its junction with the occipital ring than is found in *P. serratus* and there is no trace of a spine on the occipital ring.

Chapman (1915, p. 168) recorded *P. crosslei* from several localities in Victoria and from deposits which at that time were thought to be of Silurian age (probably

Yeringian). In two recent papers Gill (1940 and 1945) refers the rocks of Yeringian age to the Lower Devonian, including those at the localities from which *P. crosslei* had been collected. A re-examination of the material identified by Chapman may prove the specimens to possess points of difference from the typical *P. crosslei*, which in New South Wales is fairly abundant in beds of definite Silurian age in the Yass district. Chapman does mention that the vertical rows of lenses in the eyes of the Victorian specimens vary from those of the type specimens.

Locality.—Portion 292, Parish Barton, County Ashburnham, Borenore, near Orange, New South Wales.

Geological Age.—Lower Silurian.

Phacops macdonaldi, sp. nov.

(Plate xvi, figures 2–4, 7, 9.)

Holotype: F.42952. Paratypes: F.42954, F.42949, F.43060, F.42946, Australian Museum collection.

Specific Characters.—Complete body unknown. Cephalon semi-ellipsoidal in outline, more than twice as wide as long. Margin broadly and evenly curved in front and laterally; genal angles rounded, not declining below the straight posterior borders of the free cheeks. Subcranial furrow well developed, continuous, slightly wider in the median position. The hinder border of the furrow the higher, rounded, narrowing on the lateral cheek extensions and becoming almost knife-edged. Glabella in front occupies about one-half of the width of the cephalon; it is somewhat pelecoidal in shape, only slightly curved along the anterior margin, with pointed angles at the junctions of the concave to straight lateral margins; relatively wide at the constricted posterior portion adjacent to the neck-ring. The glabella does not protrude beyond the hinder anterior border, and it is half again as wide as its length including the neck ring; strongly convex from side to side, with a short and abrupt downward slope in front and posteriorly sloping gradually to the intercalary furrow. Dorsal furrows deeply impressed posteriorly, but shallowing and widening in front of the palpebral lobes, bending outwards to meet the extremities of the glabella at an acute angle.

The basal or intercalary glabella furrow, well impressed and extending across the width of the glabella, the sides directed forwards and meeting in the mid-line. The second pair of glabella furrows are short, ill-defined and straight, and almost in communication with the apex of the intercalary furrow. Traces of a frontal pair are discernible but are almost obsolete. The constricted portion of the glabella between the intercalary furrow and the occipital furrow is prominent, elevated and rounded.

Occipital ring robust, elevated, very convex, wider than basal lobes. Occipital furrow well defined, narrow and not deeply impressed, terminating in cavities in which two small but well-developed basal lobes are developed; these are saparated in front by the intercalary furrows, laterally by the dorsal furrows and small furrows extending from the intercalary furrow and communicating with the occipital furrow.

Cheeks wide, flattened, with palpebral lobes and eyes abruptly elevated; facial sutures indistinguishable. Posterior marginal furrow is deeply impressed, narrow, becoming almost obsolete near the genal angles. Posterior border well defined, increasing in width at the rounded genal angles.

Palpebral lobes swollen, elevated almost to the level of the glabella in some specimens, but generally lower. Eyes parallel to axis, curved from side to side, semi-lunar or crescent-shaped; anterior extremities touching dorsal furrows and situated well inside the frontal extremities of the glabella; posterior extremities opposite intercalary furrows, separated from the dorsal furrows by a swollen area of the fixed cheeks, and below almost touching the marginal furrows. Distinct shallow furrows originate from the dorsal furrows immediately below the anterior extremity of the eyes and pass posteriorly around and under them, widening to form depressed areas

between the borders and the raised palpebral lobes. The lentiferous surface of the eyes with about 74 lenses arranged in 17 rows. The first row has two lenses, the second three, the third four, and then follow eleven rows of five, the remaining three rows containing four, three and two respectively. Only the casts of the cups which support the lenses are preserved, and these are separated from one another by narrow flattened areas.

The thorax is unknown.

Pygidium wide, more than semi-circular, moderately convex and almost twice as wide as long. Axis prominent, convex about one-third the width of the pygidium at the anterior end, tapering posteriorly to a bluntly rounded end at one-third of its length from the margin. Axis contains six or seven annulations separated from the pleural lobes by broad, shallow, dorsal furrows. Pleural lobes convex, not nearly as elevated as the axis, with five pairs of pleural ribs, which do not cross a rather broad convex margin.

The compiled dimensions of six specimens are as follows:

	F.42952.	F.42949.	F.42947.
Width of cephalon	28 mm.	28 mm.	28 mm.
Length of glabella	13 mm.	12 mm.	13 mm.
Width of glabella	15 mm.	13 mm.	13 mm.

	F.43060.	F.42957.
Length of pygidium	12 mm.	13 mm.
Width of pygidium	23 mm.	22 mm.
Width of axis of pygidium	6 mm.	6 mm.
Length of axis of pygidium	9 mm.	9 mm.

Observations.—This outstanding species is based on a series of incomplete head-shields and several pygidia, but sufficient characters are present to reveal important points of difference from other Australian species of the genus. There is no trace of any tuberculation on the specimens, a feature common to the genus *Phacops*, but this can be explained by the strongly exfoliated nature of the material.

Etheridge and Mitchell (1895, p. 486) described four new species of *Phacops*: *P. crosslei* and *P. latigenalis* from the Silurian of New South Wales, and *P. sweeti* and *P. mansfieldensis* from the Yeringian Series of Victoria. They also gave a further description of *P. serratus* of Foerste and mentioned that they were of the opinion that *P. fecundus* McCoy (*non* Barrande) is in all probability identical with *P. sweeti.*

These are the only species of *Phacops* recorded previously from Australian rocks. As mentioned earlier in this paper, Chapman (1915, pp. 168–9) recorded the occurrence of *P. crosslei* and *P. serratus* from rocks of Yeringian age in Victoria, now considered by Gill to be of Lower Devonian age and not Silurian. In a recent paper Gill (1948, p. 14) states that *P. fecundus* recorded by McCoy from Victoria differs from the typical Bohemian species.

Of all the above species the wide cephalon of *P. macdonaldi*, a little more than twice as wide as long, and the wide flattened lateral margins of the cheeks compares rather favourably with *P. sweeti.* In that species, however, the eyes are very large, with 280 lenses in twenty-two vertical rows. The shape of the glabella of *P. macdonaldi* is a characteristic feature in that the frontal border is only slightly curved, almost straight, with rather pointed extremities where it is met by the outwardly curving dorsal furrows. The eyes are placed close to the posterior border of the cheeks and are separated from the frontal border by a comparatively wide flattened area; at least one-half of the eyes is placed inside a perpendicular line if dropped from the frontal glabella extremities. The pygidium of *P. macdonaldi* differs to some extent from those of other Australian species in being broad and possessing a very elevated and wide axis.

Dun (1907, p. 265) figured a small pygidium as *Phacops* (?) from Oakey Creek, Parish Barton, County Ashburnham. This specimen is entirely different from that of *P. macdonaldi* in that the axis is narrower and there is a greater number of pleural ribs.

Locality.—Portion 292, Parish Barton, County Ashburnham, Borenore, near Orange, New South Wales.

Geological Age.—Lower Silurian.

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EXPLANATION OF PLATES.

Plate xv.

Encrinurus borenorensis, sp. nov.

Fig. 1.—A complete glabella showing tuberculation and enlarged lateral glabella lobes. The right fixed cheek is attached and exhibits the downward curve to the genal angle. (Holotype, A.M. Coll., F.42694.)

Fig. 2.—Another glabella with incomplete right and left fixed cheeks. (A.M. Coll., F.42696.)

Fig. 3.—An enlarged right free cheek showing the deep marginal furrow and wide border. The eye is situated in a slightly depressed area free of tubercles. (A.M. Coll., F.42923.)

Fig. 4.—A poorly preserved glabella but with complete right and left fixed cheeks. (A.M. Coll., F.42909.)

Fig. 5.—Another view of specimen in figure 2. The tubercles are shown to better advantage.

Fig. 6.—A pygidium showing complete and incomplete axial rings. (A.M. Coll., F.43053.)

Fig. 7.—A larger pygidium. (A.M. Coll., F.42926.)

Plate xvi.

Encrinurus borenorensis, sp. nov.

Fig. 1.—The same specimen figured on Plate xv, figure 1. (Nat. size.)

Phacops macdonaldi, sp. nov.

Fig. 2.—Sub-cephalic view showing the sub-cranial furrow. The lateral cheek extensions are missing. (A.M. Coll., F.42954.)

Fig. 3.—An incomplete specimen showing portion of the glabella and the position of the palpebral lobe and eye. (A.M. Coll., F.42946.)

Fig. 4.—An incomplete cranidium showing the broadly curved margin in front and the well-developed flattened cheeks. (F.42952.)

Encrinurus borenorensis, sp. nov.

Fig. 5.—A left free cheek showing the wide border and deep furrow which in front of the axial groove becomes narrow and depressed. (A.M. Coll., F.42693.)

Fig. 6.—The latero-posterior portion of a right free cheek. (A.M. Coll., F.42886.)

Phacops macdonaldi, sp. nov.

Fig. 7.—An incomplete cranidium. (A.M. Coll., F.42949.)

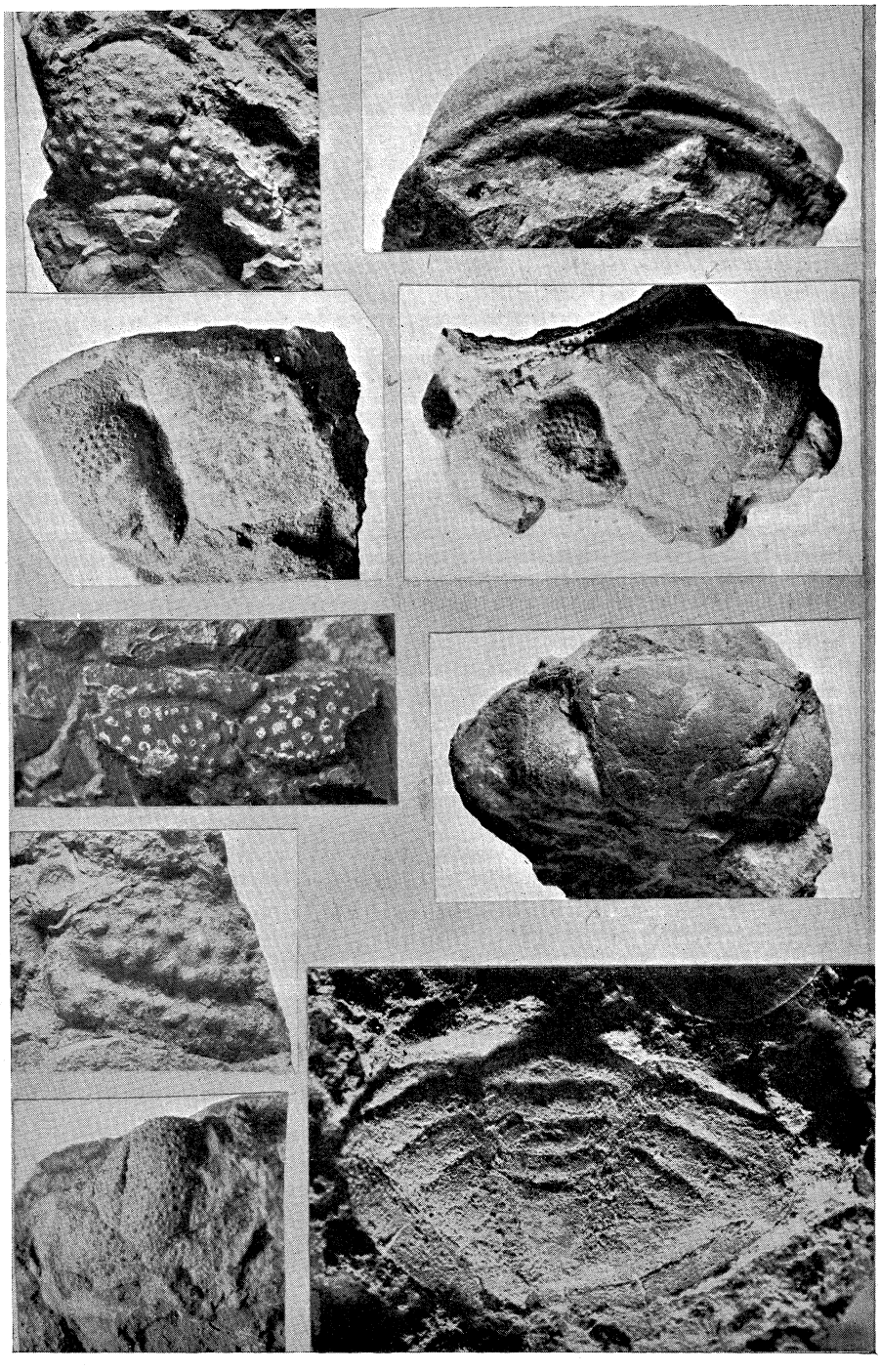
Dicranogmus bartonensis, sp. nov.

Fig. 8.—The holotype exhibiting the median lobe, a bicomposite lobe and a third lateral lobe of an incomplete glabella. (A.M. Coll., F.42932.)

Phacops macdonaldi, sp. nov.

Fig. 9.—An almost perfect pygidium featuring the pygidial characters of the species. (A.M. Coll., F.43060.)

Howard Hughes, photo.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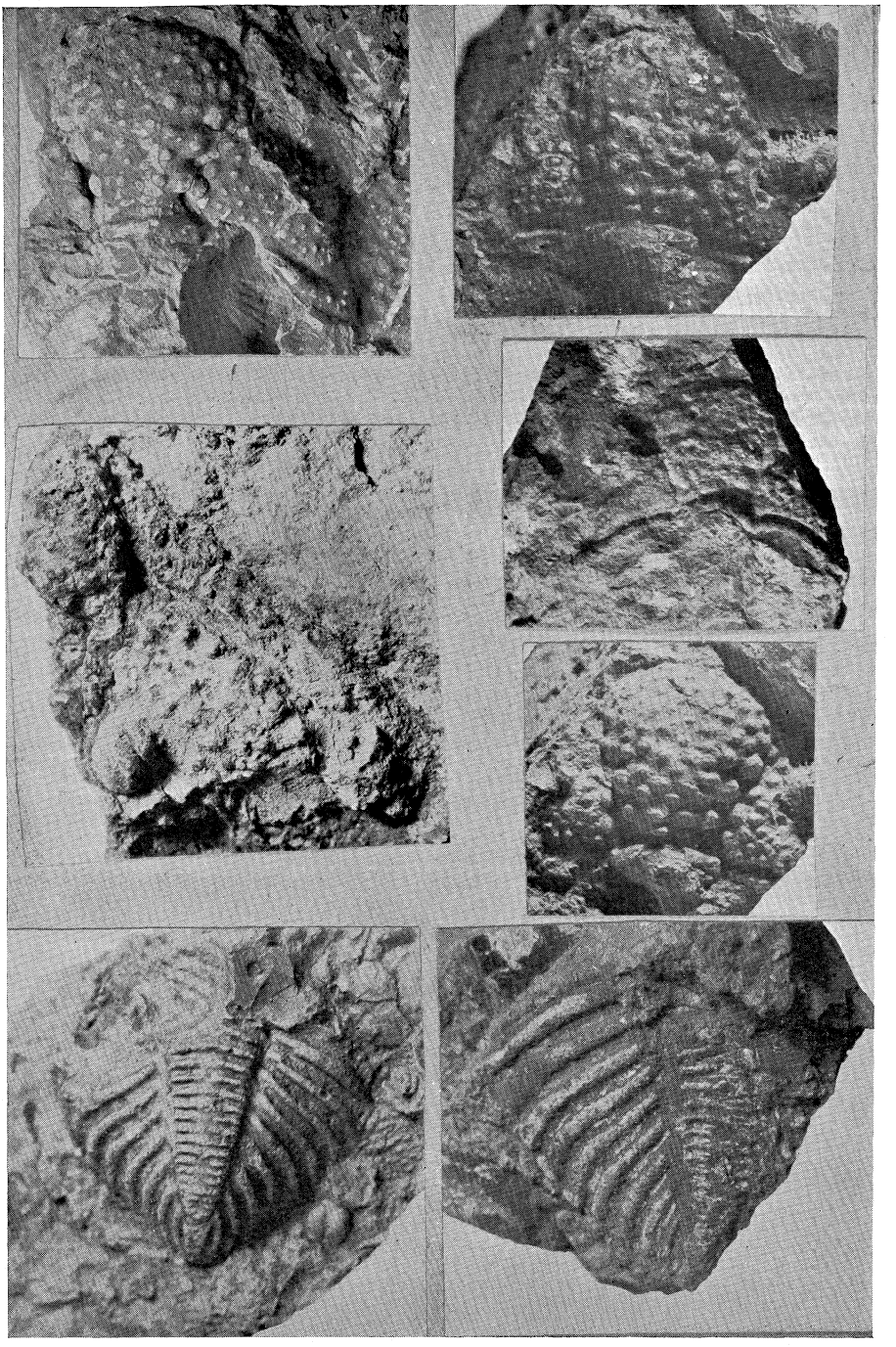

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