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PALÆONTOLOGICAL BULLETIN No. 14.

THE FAUNA OF THE REEFTON BEDS, (DEVONIAN) NEW ZEALAND;

with Notes on Lower Devonian Animal Communities in relation to the Base of the Devonian System.

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PART I.—THE FAUNA OF THE REEFTON BEDS.

CHAPTER I.—INTRODUCTION.

ACKNOWLEDGMENTS.

THE research herein summarized was carried out in 1926–29 during the tenure of an 1851 Exhibition Science Research Scholarship, at the Sedgwick Museum, Cambridge, England. The subject was suggested to the writer by his teacher, Professor W. N. Benson, of Otago University, who has taken a kindly interest in the progress of the work.

Grateful thanks are due to Miss G. L. Elles, D.Sc., who supervised the writer's studies in Cambridge. Many of the ideas here put forward were born of her inspiring teaching, and have taken shape under her trenchant but helpful criticism. To Professor O. T. Jones, of the University of Manchester, my sincere thanks are given for an illuminating criticism of my work. The Woodwardian Professor of Geology in the University of Cambridge, Professor J. E. Marr, offered many useful suggestions.

Of other Cambridge friends I must note my indebtedness to Dr. F. R. Cowper Reed, for generous help on many occasions, also to Mr. Henry Woods and Mr. W. R. B. King, and to my fellow-students Dr. H. D. Thomas, O. A. Jones, J. V. L. Rennie, and A. G. Brighton.

Part of the work was carried out in the Department of Palæontology, British Museum (Natural History), South Kensington, London. For facilities granted there so freely I desire to thank Dr. F. A. Bather (then Keeper), Dr. W. D. Lang (his talented successor), and Dr. C. D. Sherborn. The latter deserves the warm thanks of all systematists for his magnificent "Index Animalium."

In the same institution I had the advantage of considerable help and unfailing kindness from Dr. Stanley Smith, of Bristol University. The value of his interest will be apparent in the section dealing with the corals.

It is a pleasure to record my gratitude to Monsieur E. Maillieux, Conservateur, Musée Royal d'Histoire Naturelle, Bruxelles, and to Professor E. Asselberghs, of the University of Louvain, both of whom generously placed a first-hand knowledge of the Devonian of Belgium at my disposal. In Germany, Professor J. Wanner, of Bonn, proved a good friend and adviser concerning Devonian occurrences in the Rhine Valley and in the Eifel. Dr. W. Henke, of Siegen, Dr. Jaworsky, of Bonn, and Dr. Dohm, of Gerolstein, each added to the value of my stay in Germany.

For granting me permission to study the Reefton fossils in the New Zealand Geological Survey Collection I must thank the late P. G. Morgan (then Director). His successor, Dr. J. Henderson, has shown a similar kindness. Professor R. Speight, Curator of the Canterbury Museum, and Professor J. A. Bartrum, of Auckland University College, both loaned the material in their collections, for which courtesy I pay tribute.

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Reefton material in the National Museum, Melbourne, was available, through the kindness of the Director, and Mr. F. Chapman, Palæontologist. Thanks are due also to the late Mr. W. S. Dun, Palæontologist to the Geological Survey of New South Wales, for help in assembling the collections in Sydney.

The excellent figures which illustrate this report were done by Miss E. T. Talbot, of Cambridge, whose work needs no recommendation.

Finally, without the help and inspiration of my wife, this work would never have been completed.

HISTORICAL INTRODUCTION.

An adequate account of the early geological exploration in the Reefton District has been given by Henderson in his "Geology and Mineral Resources of the Reefton Subdivision" (Bull. No. 18 (New Series), New Zealand Geol. Surv., 1917), where complete references can be found.

The rock sequence containing Palæozoic fossils was investigated by Hector(1), Cox(2), and McKay(3), and a considerable collection of valuable material was accumulated by these brilliant pioneers. Little, however, was done in the way of systematic study of the fauna. Hector(4) and Hutton(5) each described a species of *Homalonotus*, while the former(6) also figured one species of Avicula and one of Strophomena.

J. Allan Thomson in his "Materials for the Paleontology of New Zealand" (N.Z. Geol. Surv. Pal. Bull. No. 1, pp. 31-2, 1913) gave a list of the names which had been applied to Reefton fossils in the early reports of the Hector Survey. With the exception of Homalonotus expansus Hector, none of these determinations was accompanied by description or figure, and the names used are of no value.

In 1917 Henderson (vide supra) supplied the most recent account of the stratigraphy in the Reefton district⁽⁷⁾. A brief summary of his work follows.

The Reefton beds cover a very limited area—in all, three and a half square miles—and occur in a zone of intensely faulted country in the Reefton Survey District. Although numerous lithological types-greywacke, argillite, shale, limestone, quartzite, and sandstone-are present, great difficulty is found in arriving at definite conclusions in regard to the succession of the beds and their thickness. A generalized sequence, in descending order, appears to be as follows :---

A. Argillites and greywackes.

B. Arenaceous and coralline limestone. 600 ft.

C. Quartzite and calcareous sandstone. 300 ft.-1,000 ft.

D. Lower argillites or shale. 300 ft.

The thicknesses are only approximate, and the sequence varies in detail in different sections. The diverse rock-types in the sequence and their rapid alternation indicate deposition in relatively shallow water-a point independently suggested by the nature of the fossils.

The relation of these beds to the auriferous Aorere Series is not clearly demonstrated. Henderson considered that the latter underlie the fossiliferous strata. The sequence is further obscured by the covering-strata of Miocene rocks.

No palæontological studies accompanied Henderson's Bulletin. He quoted Thomson's list, and, on the authority of Dr. J. Wanner, of Bonn, who paid a visit to Reefton in 1910, added Pleurodictyum problematicum Goldfuss, and species of Orthis, Chonetes, Stringocephalus, and, apparently, Tentaculites. A footnote recorded that in the Canterbury Museum Reefton fossils are labelled as Homalonotus herschelii and Spirifer bisulcatus.

 J. Hector: Progress Reports, 1873-74. Rep. Geol Explor. during 1873-74, No. 8, pp. xiv-xvi, 1877.
 S. H. Cox: "Report on the Western District." Rep. Geol. Explor. during 1874-76, No. 9, pp. 66-93, 1877.
 A. McKay: "On the Geology of the Reefton District, Inangahua County." Rep. Geol. Explor. during 1882, No. 15, pp. 91-153, 1883.

(4) J. Heeter: "On a New Trilobite (Homalonotus expansus)." Trans. N.Z. Inst., IX, p. 602, pl. 27, fig. 2, 1877.
 (5) F. W. Hutton: "On a Trilobite from Reefton, New Zealand, new to Australasia." Proc. Linn. Soc. N.S.W.,

ser. 2, vol. 2, pp. 57, 258, 1887.

(6) J. Hector: Catalogue and Guide to the Geological Exhibits, New Zealand Court, Indian and Colonial Exhibition, 1886, p. 80, 1886.

(7) The results of a visit to Lankey Gully, Reefton, made by the writer in January, 1930, will be found in an appendix to this report.

At the time when the writer commenced his investigation of the fauna the position was that one species, Homalonotus expansus Hector, had been definitely named, figured, and described. The provisional determinations that have appeared in print from time to time are not accepted.

In view of the small amount of positive evidence as to the nature and affinities of the fossils the exact time locations given by early workers were hardly justified. Henderson has summed up the the various opinions prior to 1917 as follows :----

"The officers of the old Geological Survey consistently advocate a Devonian age for the beds here considered. Statements to this effect may be found in the report of geological explorations by Hector(1) and McKay(2), while Cox(3) maintains a neutral attitude. Hutton(4) placed the Reefton beds in his Takaka System of Siluro-Devonian age, correlating them with a similar sequence of rocks developed in the valley of the Baton River. Park(⁵) and Marshall(⁶) are in practical agreement with Hutton on both points, the former placing them in his Wangapeka Series and the latter in his Baton River System, both thus ascribing a Silurian age for the group." (Op. cit.. p. 78)(⁷).

Benson ("Recent Advances in New Zealand Geology" Pres. Add., Sect. C., A.A.A.S., 1921. p. 12) pointed out that Pleurodictyum is represented in the Upper Silurian rocks of Victoria and New South Wales, and hence that that genus does not necessarily indicate a Devonian age. He also quoted a private communication from Mr. W. S. Dun, of Sydney University, to whom the collections had been sent for examination and report, to the effect that the Reefton fauna contained "a group of forms comparable with those of the Silurian rocks of the Yass series of New South Wales, and the Yeringian of Victoria, both considered to be of Wenlock age. He (W. S. Dun) was of the opinion that the Reefton beds are probably coeval with those of the Baton River." (Benson, op. cit., p. 12.)

In point of fact, Mr. Dun did not actually handle any Reefton fossils, his provisional determinations, based on cursory examination, were all of Baton River specimens.

In 1923 Benson(⁸) again referred the Reefton beds to the Silurian period. He noted that Mr. F. Chapman had determined a Reefton coral in the National Museum, Melbourne, as Pleurodictuum allied to P. megastomum Dun from the Upper Silurian of Australia.

It is obvious that this unsatisfactory state of affairs can be remedied only by a comprehensive study of the fauna on morphological and comparative lines. This the writer attempts in the sequel.

(7) This statement is not absolutely correct. Hector (Trans. N.Z. Inst., IX, 1876, p. 602), in his description of Homalonotus expansus states that the probable age is Upper Silurian. (⁸) "Palæozoic and Mesozoic Seas in Australia." Trans. N.Z. Inst., 54, 1923, pp. 24-5.

⁽¹⁾ op. cit., p. xiv.

²) op. cit., p. 104.

³) op. cit., p. 74.

⁽⁴⁾ Hutton, F. W.: "The Geological History of New Zealand." Trans. N.Z. Inst., XXXII, 1900, p. 104.
(5) Park, J.: "The Geology of New Zealand," 1910, p. 40.
(6) Marshall, P.: "Geology of New Zealand," 1912, p. 178.

CHAPTER II.—SYSTEMATIC DESCRIPTION OF THE REEFTON FAUNA.

(Type material.—Unless otherwise stated, the originals of type and illustrated material are in the New Zealand Geological Survey Collection, Wellington.)

Class ANTHOZOA.

Subclass ZOANTHARIA RUGOSA Milne Edwards.

Eridophyllum Edwards and Haime, 1850.

Mon. Brit. Foss. Corals, p. lxxi.

Type (teste Smith and Lang): E. seriale Edwards and Haime, 1850, p. lxxi = E. verneuilanum Edwards and Haime, 1851, Pal. Foss. Ter. Pal., p. 424, pl. VIII, fig. 6. Middle Devonian.

(See Smith and Lang, Ann. Mag. Nat. Hist., ser. 9, Vol. XX, 1927, pp. 307-8, pl. VI, figs. 8-9 for synonymy, diagnosis, and figure of the genotype(¹).)

Eridophyllum bartrumi n. sp. (Pl. V, figs. 1-3.)

Material: Holotype in four pieces, one of which is in the British Museum (Natural History), and the others in the Auckland University College collection. Numerous specimens in the Survey Collection, and further material in the British Museum (Nat. Hist.), and in the collection of Professor J. Wanner, Bonn, Germany. The microscope slides of the holotype are in the Auckland collection.

Description of holotype: Corallum phaceloid. Corallites round to oval, cylindrical, tapering, not always straight. Average diameter of adults, $\frac{2}{4}$ in.

In transverse section the septal area is wide, the theca is not very distinct, and lies irregularly outside a more marked axial tube. In places the axial tube and the theca coincide. The septa are numerous, major and minor alternating. Major septa (30-32) ending abruptly, and by stereoplasmic thickening, and a slight but decided turning, in the cardinal quadrants, towards the cardinal septum, forming the axial tube. Minor septa rather more than half the length of the major, both strongly carinate. Where the stereoplasmic thickening is greatest there is a zone of crowded dissepiments. The latter are numerous, and convex outwards.

The longitudinal section shows a wide area of dissepiment, of numerous, small, rounded cysts. The tabulæ are divided by an axial tube into an inner and an outer series. The outer series is not clearly developed, and is narrow. In the inner series the tabulæ are numerous, close spaced, generally horizontal but frequently incomplete, oblique, and inosculating.

A rather ill-defined theca is formed by the junction of the outer series of the tabulæ and the dissepiments.

Gemmation(2) is clearly shown by means of serial sections of the holotype. The type of reproduction is parricidal—*i.e.*, a ring of buds or gemmæ appear in the calvx of the adult.

The first stage is apparently the deposition of new epitheca over the floor of the calyx. In transverse section this appears as a central ring, which then splits up axially to form the neo-epitheca of the gemmæ. The peripheral epitheca of the daughter corallites is atavo tissue.

Similarly the atavo septa form the peripheral septa of the bud, and neo septa are introduced into the daughter corallite in those portions of it nearest to the axis of the parent.

⁽¹⁾ Stanley Smith (Amer. Journ. Sci., 5th ser., vol. 26, 1933, pp. 518-21) has redescribed Eridophyllum seriale (Ed. and H.).

^(*) The nomenclature employed is that proposed by S. Smith and T. A. Ryder: "On the Structure and Development of Stauria favosa (Linnaeus)." Ann. Mag. Nat. Hist., ser. 9, vol. xx, 1927, pp. 377-43.

In the smallest buds observed (diameter 2 mm.) major septa only are present. The peripheral atavo septa are long, wavy, and non-carinate. The inner neo septa are very short. The bud therefore has a lopsided appearance.

At a further stage (diameter 3 mm.) the septa are longer and non-carinate, but the intrathecal space is wide. At a diameter of 5 mm, the chief feature is the axial growth of the septa with a consequent reduction of the intrathecal area. The septa are still non-carinate but show a tendency to a zig-zag line. The secondary neo septa are still undeveloped, and the axis is still excentric.

At slightly greater diameters, as seen on a polished surface, minor neo septa appear, and at a still later stage carinæ are developed upon both major and minor septa.

In corallites of about 1 cm. the theca is much more distinct than the axial tube. With increasing growth the theca becomes comparatively ill-defined, and the axial tube more marked.

Dimensions: Holotype-corallum: Axial length, 8 in. or more; diameter, 4 in.

Remarks and affinities: This handsome coral is named in honour of Professor J. A. Bartrum, who generously allowed the writer to study the Auckland University College collection of Reefton fossils.

Two genera have been considered as a possible location for this species—viz., Heliophyllum Dana, 1846(1), and Eridophyllum Edwards and Haime, 1850.

"Compound Rugose Corals, typically phaceloid, in which the tabulæ are divided by an axial tube into an inner and outer series. The major septa reach the axial tube; the septa are typically carinate; and the dissepiments small and numerous." (1927, p. 308.)

The Reefton coral differs in certain respects from the holotype of Eridophyllum, E. seriale Edwards and Haime (see Smith and Lang, 1927, pl. VI, figs. 8, 9). First the axial tube in bartrumi is more feebly developed, the outer tabulæ are likewise feeble, the theca is not distinct, and the dissepimental zone is considerably greater. These differences may be specific, but it is in them that the Reefton coral approaches the genotype of Heliophyllum Dana.

As judged by the available figures of H. halli Edwards and Haime, Heliophyllum has no axial tube. However, the only longitudinal sections $figured(^2)$ are somewhat poor; and Lambe's description is not quite clear. He stated "Tabulæ small, flat in the centre, bent down at the edge, rendered vesiculose by the introduction of cystose plates and generally somewhat disturbed in their regularity by the inner ends of the septa \ldots "(³)

The Reefton coral, in transverse section, is not unlike *Heliophyllum halli*, but in this species the whole of the tissue is less abundant, and some of the major septa reach the centre of the corallite --i.e., the intrathecal area is not marked.

In respect of intrathecial characters bartrumi would appear to be intermediate between Heliophyllum and Eridophyllum. These genera are probably closely related. The gemmation does not help much in the determination of the generic position. In Heliophyllum halli, Nicholson(4) has noted that reproduction is by simple calicular gemmation, and by compound calicular gemmation (parricidal gemmation). For the same species Lambe notes that "increase [is] by lateral calicinal gemmation, sometimes as many as eight or nine buds springing simultaneously in a circle from the sides of the calyx." (Op. cit., 1901, p. 149.)

Smith and Lang do not mention the gemmation of Eridophyllum, but Lambe (op. cit., 1901, p. 154) states that in Crepidophyllum, a synonym of Eridophyllum, the increase is by marginal calicinal gemmation.

Both Heliophyllum and Eridophyllum are characteristic of the Middle Devonian (Erian and Ulsterian) of North America.

 ⁽¹⁾ Amer. Journ. Sci. and Arts, ser. 2, vol. i, 1846, p. 183. Type (by subsequent designation—Edwards and Haime, 1850, p. lxix): Heliophyllum halli Edwards and Haime, Brit. Foss. Corals (Pal. Soc. III) Aug. 1850, p. lxix (= Strombodes helianthoides Hall, 1843, non Phillips, 1841, non Goldfuss, 1826).
 (2) See J. HALL: Illust. Devon. Foss., 1876, pl. XXIII, fig. 4, and Edwards and Haime, Mon. Poly. Foss. Terr. Pal. (Arch. Mus. Hist. Nat. t. V), 1851, pl. 7, fig. 6A.
 (3) Contrib. Canad. Palaeont., IV (2), 1901, pp. 149-50.
 (4) Franze Roy Soc. Edin XXIII, 1875, pp. 227-50, pl. XVII figs 1-6.

⁽⁴⁾ Trans. Roy. Soc. Edin. XXVII (3), 1875, pp. 237-50, pl. XVII, figs. 1-6.

From the evidence available Eridophyllum would seem a more suitable generic location for the Reefton coral than Heliophyllum.

In 1930 the writer found this species to be very abundant in the dark-coloured limestone at, or near, the top of the sequence in Lankey Creek. It was not found in lower beds.

Cyathophyllum.

This term is here utilized in a wide sense as equivalent to a cyathomorph coral. Lang and $Smith(^1)$ have shown that the genolectotype of Cyathophyllum Goldfuss(²) is C. plicatum Goldfuss(3), and that that species is very obscure. Cyathophyllum is therefore meaningless at present.

"Cyathophyllum " dunstani, R. Etheridge, jun., 1911. (Pl. V, figs. 4, 5.)

1911. Cyathophyllum dunstani Eth. fil., Queensland Geol. Surv. Pub. No. 231, pp. 3-4, pl. A, figs. 1-2. Clermont.

Description of Reefton material: Corallum ceroid, of large size. Corallites long, polygonal, usually pentagonal or hexagonal, average diameter 7 mm.

In transverse section the walls are well defined and sometimes thickened. Septa of two orders, 32 and 34 in number, normally straight, sometimes slightly curved. Major septa ending freely, and not reaching to the axis. Minor septa rather more than half the length of the major.

The intrathecal area is but moderately well defined. There is no septal dilation. There are few cut edges of dissepiments near the periphery, but a marked concentration near the theca. In the longitudinal section there is a wide dissepimental zone, of from four to five series of small, rounded cysts. The theca is distinct, and the narrow tabulate area consists of fairly close-spaced, incomplete, and irregular tabulae.

Remarks: This Reefton coral is not specifically distinct from "Cyathophyllum" dunstani Eth. fil., described from the Middle Devonian of Clermont in Queensland. Etheridge records the species also from the Upper Silurian of Yass, New South Wales, but this may be doubted. Etheridge compared the Queensland fossil with "Cyathophyllum" hexagonum Goldfuss as figured by Frech(4). The species are probably congeneric, but are specifically distinct. Etheridge cited a further comparison with "Cyathophyllum" quadrigeminum Goldfuss as figured by Lambe(5) from Canada. In this case the agreement does not seem to be close. The Canadian coral has a very wide tabulate area.

The exact generic location must await a revision of Devonian cyathomorph corals-a huge task. However, the interesting point is not the label, but the presence at Reefton of a wellmarked Australian Middle Devonian species.

Order TABULATA Milne Edwards and Haime.

Family FAVOSITIDAE Milne Edwards and Haime.

Favosites J. de Lamarck, 1816.

Hist. Anim. sans Vert., 2nd ed., vol. ii, p. 204.

Type (by subsequent designation-Edwards and Haime, 1850, p. lx): Favosites gothlandica Lamarck, 1816, p. 206. Upper Silurian, Gotland.

(For a definition of the genotype and for a diagnosis of the genus, see Smith and Gullick, Ann. Mag. Nat. Hist., ser. 9, vol. XV, 1925, pp. 116-26, pl. VIII.)

⁽¹⁾ Quart. Journ. Geol. Soc., vol. lxxxiii, pt. 3, 1927, pp. 454-55.

 ⁽²⁾ Peter G. Germ., I, 1826, p. 54.
 (3) Ibid., p. 54, and pl. XV, fig. 12, Devonian, Kentucky.
 (4) Pal. Abhandl., Bd. III, Heft 3, 1886, pp. 77-78, taf. III, figs. 20-20A.
 (5) Geol. Surv. Canada, Contrib. Canad. Pal., IV (2), 1901, pp. 153-54, pl. XII, figs. 7A-7B.

Favosites murrumbidgeensis O. A. Jones, MSS. (Pl. IV, figs, 5, 6.)

Corallum massive, hemispherical below, more or less flat above, diameter of specimen 4 in, Corallites small, contiguous, prismatic, regular, usually hexagonal but occasionally pentagonal or tetragonal, average diameter approximately 1 mm. Walls thick. Septa spinose, long (sometimes reaching to the centre of the corallite), irregular, not numerous. Mural pores uniserial, circular. Tabulæ more or less horizontal, but frequently irregular, complete or incomplete, 8 to 11 in a space of 3 mm.

The New Zealand representatives of this interesting species were collected at Remarks: Reefton by Professor J. Wanner, of the Geologische Institut, University of Bonn, Germany. The species is apparently not uncommon. The corallum from which the above diagnosis was made is now divided into two, half being retained in Bonn, and the other part has been presented to the New Zealand Geological Survey by Professor Wanner. The species is identical in all essential respects with the holotype of Favosites murrumbidgeensis O. A. Jones (MSS.), a species to be described from "Clear Hill," West of Boambolo Crossing, Murrumbidgee River, New South Wales, Australia, from Middle Devonian beds. (South-eastern Province of W. N. Benson(1).) In Australia the same species occurs also at Taemas, New South Wales, in the Middle Devonian rocks, and again at the foot of Mount Etna, Rockhampton, Queensland in (?) Upper Middle Devonian rocks, in the North-eastern Province of Benson.

The presence of this species in New Zealand indicates a Middle Devonian age for the Reefton limestones, and thus strengthens the suggestion made by the presence there of Eridophyllum bartrumi, another coral with Middle Devonian affinities.

I have to thank Professor Wanner for his kind permission to study this coral, and also Mr. O. A. Jones for his criticism and his help with the Australian material.

Pleurodictyum G. A. Goldfuss, 1829.

Petref. Germ., I (2), 1829, p. 113.

Type (by monotypy): Pleurodictyum problematicum Goldfuss, 1829.

Pleurodictyum cf. problematicum G. A. Goldfuss, 1829. (Pl. III, figs. 11, 12.)

(Petref. Germ., I (2), 1829, pp. 113-14, pl. XLIII, figs. 18a-q.)

Description (based on a specimen in the National Museum, Melbourne): The coral appears to be attached to a pelecypod. Shape of corallum not visible, probably more or less circular. Corallites small, numerous, rapidly tapering, more or less circular in cross-section. Wall of cast-(i.e., internal wall of corallite)-axially striate. Mural pores (preserved as connecting-rods) stout, numerous, irregularly placed.

Henderson⁽²⁾ records that Dr. J. Wanner, of Bonn, positively identified Remarks : Pleurodictyum problematicum Goldfuss on a visit to Reefton in 1910. In the Survey collection there are three specimens of *Pleurodictyum*, but the material is too poor for description. Α single well-preserved example occurs in the National Museum (Melbourne) Collection, and this has served for the description given.

The Reefton coral is, as far as comparison is possible, close to P. problematicum Goldfuss. It is quite distinct from P. megastomum Chapman(3), a typical fossil from the Yeringian of Benson(4) records "the presence of a Pleurodictyum allied (vide Chapman) to Victoria. P. megastomum Dun," but this determination applies only to the Baton River fossil, while the specific name should be attributed to Chapman.

In Western Europe P. problematicum Goldfuss(5) is found in the Siegenian and Emsian beds of the Ardennes and in equivalent strata in Germany.

⁽¹⁾ See W. N. Benson, Rec. Geol. Surv. N.S.W., X (2), 1922, p. 93 et seq., and pls. XIII, XIV.

N.Z. Geol. Surv. Bull. No. 18 (N.S.), 1917, pp. 78 and 79.
 Proc. Roy. Soc. Vict., XV (2), 1903, pp. 105-7, pl. XVI, figs. 2-5.
 Trans. N.Z. Inst., 54, 1923, p. 25.

^{(&}lt;sup>5</sup>) For further details concerning Pleurodictyum see Allan, Trans. N.Z. Inst., 60 (2), 1929, pp. 320-23.

Class BRYOZOA Ehrenberg.

Order CYCLOSTOMATA Busk.

Family FISTULIPORIDAE Ulrich.

Fistulipora F. McCoy, 1849.

Ann. Mag. Nat. Hist., ser. 2, vol. iii, p. 130.

Type (by subsequent designation): Fistulipora minor McCoy, 1849, p. 130. Carboniferous.

(See Nicholson, Tab. Corals Pal. Per., 1879, pp. 304-8, for a description of the genotype; and Nickles and Bassler, U.S. Geol. Surv. Bull. 173, 1900, p. 266, for a generic synonymy.)

Fistulipora cf. trifoliata Schluter, 1885. (Pl. IV, figs. 3, 4.)

(See Schluter, Abh. Geol. Specialk. Preuss. u. Thüring. Staaten, Bd. VIII, Heft 4, 1889, pp. 151-53, taf. XI, fig. 9, taf. XIII, figs. 1-6.)

Description: Zoarium massive, subspherical, $2\frac{1}{2}$ in. in diameter. Zooecia cylindrical, direct, thin-walled. No trace of communication pores is visible. Diaphrams complete, horizontal, at fairly regular intervals, and tending to be at the same level in adjacent zooecia. Vesicular tissue of small, uniserial or biserial cysts, angular and irregular in cross-section. In longitudinal section the vesicular space is less than half the width of the zooecia. The aperture has not been observed.

Remarks: This species occurs in large, subspherical masses, and also as encrusting layers upon a cyathomorph coral. It is frequently intimately associated with smaller masses of the bryozoan described below as *Lioclema* (?) *reeftonensis* n. sp. In general appearance this species recalls *Fistulipora trifoliata* Schluter, described from the lower Middle Devonian of Gees, near Gerolstein, in the Eifel. The genus is not recorded from the Middle Devonian of Australia.

Order TREPOSTOMATA Ulrich.

Family BATOSTOMELLIDAE Ulrich.

Lioclema E. O. Ulrich, 1882.

Journ. Cincinnati Soc. N.H., V, p. 141 (as Leioclema).

Type (by original designation): Callopora punctata Hall, 1858. Geol. Iowa, I (2), p. 653.

Lioclema (?) reeftonensis n. sp. (Pl. IV, figs. 1, 2.)

Zoarium laminar, encrusting, or in small globular masses. In the first habitat the species is associated with a cyathomorph coral; in the second it occurs with *Fistulipora* cf. trifoliata Schluter. Zooecia prismatic, with few widely spaced diaphrams not in contact, but separated by narrow mesopores in which diaphrams are more numerous. In cross-section the zooecia are polygonal or rounded, the walls are thickened, but occasionally thin and defined. Acanthopores of small size and circular cross-section, and situated at the angles of junction of adjoining zooecia. Apertures not observed.

Remarks: This species is referred with some hesitation to the genus *Lioclema* Ulrich, and a comparison suggested with L. subramosum Ulrich and Bassler⁽¹⁾ from the Keyser Member of the Helderberg Formation of Maryland.

(1) Maryland Geol. Surv., Lower Devonian, 1913, pp. 273-74, pl. XLIII, figs. 1-4; pl. XLIV, fig. 5.

Class **BRACHIOPODA** Dumeril.

Order NEOTREMATA Beecher.

Family TREMATIDAE Schuchert.

Lingulidiscina R. P. Whitfield, 1890 (emend.): Girty, 1909.

Bull. Amer. Mus. N.H., III (1), pp. 121-22-originally Lingulodiscina.

Type (by original designation): Lingula exilis Hall, Nat. Hist. N. York, VI, Palaeont., IV (1). 1867, p. 7, pl. 1, fig. 9. Hamilton.

(?) 1892. Ochlertella Hall and Clarke, Nat. Hist. N. York, VI, Palaeont., VIII (1), p. 133. Type, Discina pleurites Meek.

1909. Lingulidiscina Girty, U.S. Geol. Surv. Bull. 377, pp. 18-19.

1911. Lingulidiscina Girty, U.S. Geol. Surv. Bull. 439, pp. 37-38.

Lingulidiscina ranfti sp. nov.⁽¹⁾ (Pl. II, fig. 8.)

Material: Holotype and two paratypes in the National Museum, Melbourne. All dorsal valves.

Description: (Holotype).

Dorsal valve, elongate oval in outline. Apex situated about the posterior sixth. Slope from the apex abrupt and concave behind, gradual and convex in front. Ornamentation of rather widely spaced, thin, concentric laminæ.

Remarks: The determination of the generic location of this species necessitated an investigation of the status of the name Orbiculoidea under which related forms have been placed by most authors.

Orbiculoidea was first introduced by A. D. d'Orbigny as a genus caelebs in 1847(2). It was first validly employed by its author in 1850(3). The three genosyntypes were in order :-

- 314. Forbesii, d'Orb., 1848. Orbicula Forbesii, Davidson, 1848. Bull. de la soc. géol. de France, Angleterre, Walsall.
- 315. Morissii, d'Orb., 1847. Orbicula Morissii, Davidson, 1848. Bull. de la soc. géol. de France, Angleterre, Dudley.

316. Davidsonii, d'Orb., 1848. Orbicula Koninckii, Davidson, 1848. Bull. de la soc. géol. de France (non Geinitz, 1848). Angl., Dudley.

The "d'Orb., 1848," and "d'Orb., 1847," in the first and second of these are meaningless. The third species dates from January, 1850. The second specific name is spelt incorrectly, and should be morrisii.

Early workers(⁴) who employed Orbiculoidea d'Orbigny, 1850, failed to select a genolectotype, but W. H. Dall⁽⁵⁾ cited O. morrisi as first species, and subsequent authors, Ochlert (1887), Schuchert (1897), and Bassler (1915) have accepted Orbicula morrisi Davidson, 1848, as the type of Orbiculoidea d'Orbigny, 1850. Dall, however, gave an incorrect citation, as follows: "Prodr. Pal. Strat. 1849 (Sil.), p. 21. 1st. sp. O. Morrisi, d'Orb., 1847." Actually the year is 1850, the page 44, and the first species cited is Forbesii.

Hall and $\operatorname{Clark}(^{\mathfrak{s}})$ first repeated Dall's error then added a postcript(^{\mathfrak{q}}) rectifying it, but decided to use Orbiculoidea with type O. morrisi Davidson, because the first-named species was a Schizotreta.

All the authors noted have unfortunately overlooked the fact that in 1849(8) J. Morris employed Orbiculoidea validly, and mentioned as sole species Orbicula forbesi Davidson. This usage has two months' priority over the first valid use of the term by d'Orbigny.

- 7) Ibid., p. 160.
- (⁸) Ann. Mag. Nat. Hist., ser. 2, vol. IV (Nov.), pp. 318-19.

⁽¹⁾ The species is named after Theodore Ranft, Esq., who discovered fossils in Lankey Gully in 1872.

²) Compt. Rend. Acad. Sci. 25, 1847, p. 269.

 ^(*) Comp. Reta. Adut. Sci. 29, 1847, p. 203.
 (*) Prodr. de Paleont., I (issued January, 1850), p. 44.
 (*) M'Coy: Brit. Pal. Foss., II, fasc. 2, 1852, p. 189; and Davidson: Mon. Brit. Foss. Brach. (Pal. Soc.) III, pt. VII, No. 1, 1866, pp. 72-73.
 (*) Bull. U.S. Nat. Mus., No. 8, 1877, p. 51.
 (*) Nat. Hist. N. York, VI, Palaeont., VIII (1), 1892, p. 128.

The result of this discussion so far shows that the genus Orbiculoidea must be attributed to Morris, and that the type, by monotypy, is Orbicula forbesi Davidson, 1848(1).

It now becomes necessary to discuss, first the relation of Orbiculoidea Morris, 1849, to Schizotreta Kutorga, 1848(2), and, second, the generic location of Orbiculoidea d'Orbigny, 1850, as interpreted by its genolectotype Orbicula morrisi Davidson. Hall and Clarke(3) have concluded that Orbiculoidea Davidson-i.e., O. forbesi Dav.-is essentially the same as Schizotreta as defined by its type species, S. elliptica Kutorga, a view which later authors have accepted.

Hence Orbiculoidea Morris, 1849, must be regarded as a synonym of Schizotreta Kutorga, 1848. and for this reason cannot be employed again in any other sense. Orbiculoidea d'Orbigny, 1850, may be a distinct group, but the genolectotype is imperfectly known. The species congeneric with O. forbesi may find a place in one or other of the genera proposed by Hall and Clarke. The elaborate diagnosis provided for this genus by Hall and Clarke was based upon American species presumed The New Zealand material is not congeric with either Schizotreta to be congeric with the type. forbesi (Dav.) or "Orbiculoidea" morrisi (Dav.).

For Orbiculoidea of Hall and Clarke, 1892, the following genera are available. Lingulidiscina Whitfield, 1890, Ochlertella Hall and Clarke, 1892, Lindstromella Hall and Clarke, 1892, and Roemerella Hall and Clarke, 1892. Of these Roemerella (type Discina grandis Vanuxem) has a dorsal valve which is elevated and obtusely conical, while the apex is subcentral. Lindstromella was based upon internal characters which are not available in the Reefton material.

Girty (1909 and 1911) has used Lingulidiscina Whitfield for Orbiculoidea Hall and Clarke, 1892. This genus, according to Schuchert(⁴) is synonymous with Ochlertella Hall and Clark, 1892. Girty was inclined to accept this view, and, pending a revision of the American material, the Reefton shell may be referred provisionally to Whitfield's genus. Should the genera prove distinct, perhaps Ochlertella would be the more suitable location. Specifically L. ranfti is quite distinct from the "Austral" Lower Devonian "Orbiculoideas" of South America. It is, however, comparable with Orbiculoidea (?) aberrans Reed(5) from the Bokkeveld Beds of South Africa, but no trace of radial ornamentation is shown on the New Zealand fossil.

Reed was doubtful of the generic position of the South African species and suggested a comparison with Schizobulus truncatus (Hall)(⁶), originally described from black Genesse shales of New York, but also figured by Clarke⁽⁷⁾ from the Devonian of Brazil. L. ranfti n. sp is also quite distinct from O. siegenensis (Kayser)(⁸) and O. anomala (Kayser)(⁹) of the Siegener Schichten. A species from the Bornicher Horizont of the Hunsruckschiefer, Orbiculoidea sinuosa Fuchs(10) agrees in the posterior position of the apex in the dorsal valve, but appears to have a rather different ornamentation.

The writer, since writing this account, has seen a reference to further papers dealing with the genera Lingulidiscing(¹¹) and Orbiculoidea(¹²), but they are not available in New Zealand.

Order PROTREMATA Beecher.

Family RHIPIDOMELLIDÆ Schuchert, 1913.

Proschizophoria E. Maillieux, 1912.

Bull. Soc. belge Géol., tome XXV, 1911 (1912) Proces-Verbaux, pp. 177-78.

Type (by original designation): Orthis personata Zeiler, 1857(¹³), (emend. Kayser), Jahrb. d. k Preuss. Geol. Landes., 1890 (1892), pp. 98-101, t. XI, figs. 3-6; t. XII, figs. 1-4. Siegener Schichten.

- (1) Abh. d. k. Preuss. Geol. Landes, N.F., Heft 79, 1915, pp. 7-8, t. I, fig. 9.
 (11) Girty, G. H.: "Characters of the Brachiopod Genus Lingulidiscina Whitfield." J. Wash. Acad. Sci. 18 (9), 1928, pp. 241-49.
-) Girty, G. H.: "The Generic Name Orbiculoidea d'Orbigny and its application." [Ibid., 18 (5), 1928, `12⁵-42.

Bull. soc. géol. France, ser. 2, t. V, 1848, p. 334, pl. III, fig. 45.
 Verhandl. d. russ. hais, min. Ges. St Petersb., 1848, pp. 272-73.

Op. cit. supra., 1892, p. 136.

 ⁽³⁾ Op. cit. supra., 1892, p. 136.
 (4) Bull. U.S. Geol. Surv., 89, 1897, p. 260.
 (5) Ann. S. African Mus., XXII, 1925, p. 38, pl. IV, figs. 4, 4A.
 (6) Pal. N. York, VIII (1), 1892, pp. 87-90, pl. III, figs. 11-14.
 (7) Mon. Serv. Geol. Min. Brasil, Vol. I, 1913, p. 325, pl. XXV, figs. 1-4.
 (8) Jahrb. d. k. Preuss. Geol. Landes., für 1890, 1892, pp. 95-96, pl. XI, figs. 1, 2.

⁹⁾ Ibid, pp. 96-97, pl. X, figs. 1-3.

⁽¹³⁾ Verh. d. naturhist. Ver. fur Rheinl. Westfal., p. 48, pl. IV, fig. 11, caet. excel. (teste Maillieux).

Proschizophoria cf. provulvaria (Maurer, 1893). (Pl. III, figs. 4 and 7.)

Compare :---

1893. Orthis provulvaria Maurer, Neues Jahrb. f. Min., 1893, (1), pp. 7-9, t. 3, figs. 1-4. Grauwacke von Seifen.

1904. Orthis (Schizophoria) provulvaria Drevermann, Palaeontographica, L, pp. 267-69, t. 30, figs. 29-30; t. 31, figs. 11-19.

1913. Orthis provulvaria Asselberghs, Mem. Inst. Géol. Univ. Louvain, t. 1, mem. 1, p. 93. (Not figured. Belgian Lower Hunsrückian localities only.)

Description: (a) From a squeeze of the internal mould of the dorsal valve. (Pl. III, fig. 7.)

General form transversely oval, hinge-line moderately long, anterior margin with a narrow Dental sockets strongly developed, two short, stout, divergent plates form the striate fringe. inner margins of the sockets. Cardinal process with a central tubercle prolonged anteriorly into a feeble median septum. A very faint line, parallel to the hinge-line, divides the adductors transversely into two parts.

(b) From a squeeze of the internal mould of the ventral valve. (Pl. III, fig. 4.)

General shape similar to that of the dorsal valve. Dental plates strongly developed. The muscular impression is clearly defined by the anterior extension of the dental plates, but the posterior end of the area merges into the surface of the valve. The large diductors are narrowly elongate, a weak septum divides the structure medially, and the small, narrow adductors are separated off by weak diverging lines. The lateral boundary of the muscle impression is slightly curved and the whole not noticeably fan-shaped.

Breadth of dorsal valve, 24 mm.; length of dorsal valve, 17 mm.

Remarks: This species belongs to a species-group in which the members have been referred by Belgian and German paleontologists to Orthis, Dalmanella, Schizophoria, and Proschizophoria. It is typical of the West European Lower Devonian facies, and, as far as I can discover, is not known to occur in the austral South African and South American region.

The generic position of the New Zealand species is somewhat difficult to determine precisely. The hinge characters of the dorsal valve indicate a relationship to Proschizophoria Maillieux of which the type is Orthis personata Zeiler (emend. Kayser), a species which ranges from the Gedinnian⁽¹⁾ (Schistes de Mondrepuis), into the Lower Hunsrückian⁽²⁾ in Belgium, while Quiring(3) records it (under Dalmanella) from the three divisions of the Siegener Schichten in Germany. The New Zealand material agrees in all essential generic characters except that in the dorsal valve the median septum is more feebly developed, and the division of the adductors into two parts by a transverse line is almost wanting. The ventral valve differs in the much weaker definition of the posterior part of the musculature.

The Reefton fossil was first compared with typical species of Schizophoria King(4) (type Anomites resupinatus W. Martin(5)), but the essential characters of this genus-the greater convexity of the dorsal valve, the strongly developed ventral median septum, and the deeply incised muscular area-are not found.

Proschizophoria is, perhaps, a more suitable location than Schizophoria, although species referred to the latter genus are remarkably similar in general appearance to the Reefton species.

The most striking resemblance is to a species identified as Orthis (Schizophoria) provulvaria Maurer(6), by F. Drevermann(7). The specimen figured by Drevermann on taf. 31, fig. 19, agrees closely with the New Zealand fossil.

Drevermann appears to have dealt with more than one species because some of his figures do not compare closely with those of Orthis provulvaria Maurer.

(⁵) Petref. Derb., 1809, t. 49, figs. 13, 14.
 (⁶) Neues Jahrb. f. M., 1893 (1), pp. 7–9, t. 3, f. 1–4. Grauwacke von Seifen.
 (⁷) Palaeontographica, L. 1904, pp. 267–69, t. 30, figs. 29, 30; t. 31, figs. 11–19. Seifen.

⁽¹⁾ M. Leriche, Mem. Mus. Roy. Hist. Nat. Belg., t. 6, 1912, pp. 26-27, pl. 1, f. 30 and text fig. 1 on p. 26.

⁽²⁾ E. Asselberghs, Mem. Inst., Geol. Univ. Louvain, t. 1, mem. 1, 1913, p. 93.

⁽³⁾ Jahrb. d. Preuss. Geol. Landesanst. für 1922, Bd. 43, 1923, pp. 91, 94, and 98.

Mon. Permian Fossils (Pal. Soc., 1850), pp. 105-6.

The provulvaria type as interpreted by Drevermann, Asselberghs, and others is typical of the Belgian-Rhine Siegenian faunas. In the Siegener Schichten Quiring⁽¹⁾ records it (under Dalmanella) from the Rauhflaserschichten and the Herdorfer Schichten, but not from the Tonschieferschichten. Asselberghs(2) records it as abundant in the Lower Hunsrückian of the Ardennes, and notes that it ranges in the Dinant from the Taunusian into the Emsian(3). The same author found this species abundantly in the facies de Saint-Vith of the Upper Hunsrückian of the Ardennes(⁴).

Family STROPHOMENIDÆ King.

Leptostrophia Hall and Clarke, 1892.

Pal. New York, VIII (1), p. 288.

Type (by subsequent designation): Stropheodonta magnifica Hall, Regent's Report, 1857, p. 54; Palæozoic Fossils, 1857, p. 14 (for description and figures see Nat. Hist. N. York, Pal., III, 1859, pp. 414-15 and 482, pl. 93, f. 4; pl. 94, figs. 2a-d; pl. 95, f. 8; pl. 95A, figs. 15-19).

Leptostrophia reeftonensis n. sp. (Pl. I, figs. 9-10.)

Description: (a) From a squeeze of the internal mould of the ventral valve (holotype). (Pl. I, fig. 10.)

Shell wider than long (ratio 8:5), anterior margin incomplete, probably gently arched, rounding into the sides which are sub-parallel. Hinge extremities sub-rectangular. Hinge-line straight, equal to the greatest width of the valve. Cardinal area not visible. Musculature flabelliform, with a central ridge and five diverging ridges on either side, reaching about two-thirds of the length of the valve, not strongly limited anteriorly, bounded on either side by strongly developed ridges. Central adductors obscure. Lateral posterior areas strongly pustulate irregularly. Near the anterior margin the pustules are arranged radially.

(b) From a squeeze of the internal mould of the dorsal valve (paratype). (Pl. I, fig. 9.) Shell wider than long (ratio 1.5:1), anterior margin gently arched, rounded into the sides, the latter subparallel, lateral cardinal area acute. Hinge-line straight, equal to the greatest width of the shell. Cardinal process small, dividing an expanded median septum which extends for half the length of the valve and divides the muscle scar into two. Hinge crenulate for Cardinal apophyses stout, first transverse then oblique, with rather less than half its length. Muscle scars well developed, posterior pair pyriform, raised above rounded anterior margins. the surface and bounded laterally by ridges. Anterior pair smaller, triangular, sharply defined. Dental sockets flat and wide. Surface of the valve with fine radii, anterior margin with concentric folds and a striate fringe.

Dimensions: Length of ventral valve, 32 mm.; breadth of ventral valve, 52 mm.; length of dorsal valve, 30 mm.; breadth of dorsal valve, 42 mm.

Remarks and affinities: The first point to be noted is that it is not absolutely certain that the two valves described, which are on separate blocks, belong to the same species. It is highly probable; but if a mistake has been made, the specific name will apply to the ventral value. L. reeftonensis belongs to the species-group containing L. magnifica (Hall) (⁵), the genotype, and its varieties tullia (Billings)(⁶), parva Clarke(⁷), also L. irene Billings(⁸), all from the Lower Devonian of North America; and the Siegenian form L. explanata (Sowerby)(⁹).

Bull. Soc. Belge Géol., t. 36, 1926 (1927), p. 208.
 As well as the references cited, see J. M. Clarke, N.Y. State Mus. Mem. 9, vol. I, 1908, pp. 190-91, pl. 38, figs. 1, 2,

(*) As well as the references cited, see 5. M. Charke, V. 1. State Max. Mem. 5, Vol. 1, 1806, pp. 190-91, pl. 35, ligs. 1, 2, pl. 39, figs. 9, 10; ibid., vol. II, 1909, p. 87, pl. 20, figs. 20, 21, pl. 21, figs. 15, 16; and plate in text opp. p. 134.
(*) Palaeozoic Fossils, vol. 2 (1), 1874, p. 29, pl. 2, figs. 6, 6a, and Clarke, op. cit., vol. 1, pp. 191-92, pl. 37, figs. 1-6.
(*) Clarke, op. cit., 1909, pp. 123-24, pl. 31, figs. 5-9.
(*) See Clarke op. cit., 1908, pp. 193-94, pl. 38, fig. 3; pl. 39, figs. 5-8.
(*) Trans. Geol. Soc. London, 2nd ser., vol. VI, 1842, p. 409, pl. 38, fig. 15, under Leptaena; also J. Schnur, Palaeontographica, Bd. 3, Lief. 4-6, 1853, p. 221, pl. 39, fig. 6, under Leptaena; E. Kayser, Abh. d. k. Preuss. Geol. Landesanst N.F., Heft. 1, 1889, footnote p. 102, pl. XXI and pl. XXII, fig. 1, under Strophomena.

⁽¹⁾ Op. cit., pp. 90 et seq.

²) Op. cit., pp. 93 and 126.

³⁾ Asselberghs (Ann. Soc. Geol. de Belg., t. 39, 1912, p. 61), has also recorded S. provulvaria from the Middle Emsian of Luxembourg.

I am unable to appreciate the fine distinctions suggested by Clarke for his and Billings's subspecies of *L. magnifica* (Hall).

Williams and Breger, who discuss the Oriskany species of this group, note that "a close study of the Leptostrophias from these formations (Late Silurian, Helderberg, and Oriskany) indicates that the plastic variability developed here prohibits very close specific demarcation \ldots "⁽¹⁾.

Only a general comparison with L. magnifica (Hall) is attempted. The ventral valve of L. reeftonensis is very similar to that of L. magnifica as figured by Hall in 1859 on pl. 95A, fig. 17. The angle between the ridges bounding the muscle scars is considerably less in the New Zealand species. The dorsal valve shows differences in the cardinal apophyses and in the general contour of the muscle scars, which would appear to be of value. L. magnifica is typical of the sandy deposits of Oriskanian age in Eastern North America.

The agreement with L. explanata (Sow.) is also close, although Sowerby's original figure does not show clearly the details of the flabelliform muscle scars. Quiring(²) records L. explanata from the Rauhflaser and the Herdorfer horizons of the Siegener Schichten, while Asselberghs(³) notes that it occurs abundantly in the Lower Hunsrückian of the Ardennes. The species is most characteristic of Lower Emsian horizons.

The same species-group is present in the "austral" Lower Devonian of the Falkland Islands and Argentina (San Juan)⁽⁴⁾.

Family **PRODUCTIDÆ** Gray.

Chonetes G. Fischer, 1830.

Oryct. Gouvern. Moscou, 1830, sign. d.,

Type: Schuchert and Le Vene (Foss. Cat. 1, pars. 42, 1929, pp. 40-41) cite as genolectotype "Chonetes sp. Fischer = C. variolata D'Orbigny 1842, as interpreted by De Koninck 1847." Sherborn gives the following reference: "variolata Chonetes (Orb.), L. G. de Koninck, Rech. Anim. foss. (1) post June 1847, 206."

Chonetes maoria n. sp. (Pl. I, fig. 6.)

Material: Numerous casts somewhat imperfectly preserved.

Description: Holotype-the internal cast of the ventral valve.

Shell transverse, more or less semicircular, convex. Hinge-line straight, slightly less than the greatest width. No spines are visible on the cardinal margin, but this fact is not significant, for if they had existed the preservation is such they may have been destroyed. Cardinal angles sub-rectangular. Ornamentation of 90 to 100 rounded radii which frequently bifurcate. Anterior margin somewhat sharply bent to produce a Leptaenid-like appearance. Teeth strong. Median septum short, narrow, extending about one-third of the length. Wellmarked grooves diverge from the beak suggesting a depressed, strong, flabellate musculature.

Length of shell, 12 mm.; width of shell, 20 mm.

Remarks: The general appearance of this species suggests such genera as *Plectambonites* Pander, but it probably belongs to *Chonetes*. The state of preservation of the Reefton material does not allow of any accurate comparative studies. The difficulties of comparative work, in regard to Lower Devonian Chonetids from casts and moulds, have been emphasized by Williams and Breger in their treatment of American Chapman Sandstone species of this group. However, certain more or less well-defined groups have been recognized amongst Lower Devonian species.

⁽¹⁾ U.S.G.S. Prof. Paper 89, 1916, p. 26.

⁽²⁾ Op. cit., 1923, pp. 94 and 98.

^{(&}lt;sup>3</sup>) Op. cit., 1913, p. 94.

⁽⁴⁾ See Leptostrophia concinna (Morris and Sharpe) J. M. Clarke, Mon. Serv. Geol. Min. Brasil, vol. 1, 1913, pp. 285-86, figs. 1-4.

The species-group of Chonetes vicina(1), which includes the European Chonetes plebeja Schnur(²) is not represented in New Zealand.

The group placed in the subgenus Eodevonaria Breger(3) (type: Chonetes arcuata Hall(4)) characterized by a denticulate cardinal margin, and containing the European Chonetes dilatata F. Roemer(⁵), is likewise unrepresented at Reefton.

Ch. maoria belongs to the group of Ch. sarcinulata (Schlotheim)(*) which contains the North American species Ch. novascotica Hall(7), and Ch. falklandica (Morris and Sharpe)(8) from the Lower Devonian of Brazil (Parana), the Falkland Islands, and South Africa.

In Western Europe Ch. sarcinulata first appears in the Middle Siegenian of the Ardennes and continues into the Emsian. It also occurs in the Rauhflaser and Herdorfer horizons of the Siegener Schichten, and in the Untercoblenzschichten of the Eifel. It seems to be most abundant in the Upper Siegenian (Herdorferhorizont) of Belgium and Germany.

This is no doubt the Chonetes striatella(⁹) of Hector, 1880. It differs from that species which is typical of the Upper Ludlow of Shropshire, in several respects: (1) C. maoria is slightly longer in proportion to the width; (2) the radii are much coarser in the Reefton form; and (3) the muscular impressions are strong in C. maoria but weak in C. striatella Dalman.

Chonetes nigricans n. sp. (Pl. I, figs. 7, 8.)

Material: Holotype (interior (?) of ventral valve); paratype (juvenile-ventral valve).

Description: (from holotype). (Pl. I, fig. 8.)

Shell depressed, convex, transverse, semicircular. Hinge-line straight, forming the greatest width. Cardinal margin more or less rectangular, lateral margin very slightly arched, anterior margin evenly arched. Median septum (?) short, a central triangular area (muscle scar) (?) slightly raised is imperfectly defined. Ornamentation of about 100 irregular, narrow radii which frequently bifurcate. The hinge-line shows the bases of several stout spines apparently widely spaced.

Paratype: (Pl. I, fig. 7.)

This juvenile specimen is interesting because it shows that the ribs, especially at the lateral margins, are scaly. At the margin it has only half the radii shown by the holotype.

Length of holotype, 11 mm.; width of holotype, 17 mm.

Locality: 129, Reefton.

Remarks: This species is apparently distinct from Ch. maoria n. sp. It differs from the latter in relative proportions being longer in proportion to width, and imperfect specimens show that the adult is considerably larger. The radii too are finer, more numerous, and more flexuous.

Order TELOTREMATA Beecher. Superfamily SPIRIFERACEA Waagen. Family SPIRIFERIDÆ King.

The majority of the Upper Silurian and Devonian spiriferids have hitherto been referred to the "genus" Spirifer which contains a most heterogeneous assemblage of genetically unrelated stocks, and might well be compared with such "genera" as "Rhynchonella" and "Terebratula." Just as these "genera" have been redefined and subdivided by S. S. Buckman, J. A. Thomson, M. R. Sahni, and others, so must Spirifer be treated.

This task is to a certain extent simplified, since the type of Spirifer, long in dispute, has been definitely fixed by International Zoological Congress(¹⁰).

 See Williams and Breger, op. cit., 1916, p. 52.
 Schnur, Palaeontographica, III, 1853, pl. 21, fig. 6.
 Am. Journ. Sci., ser. 4, 22, 1906, p. 534.
 See Nat. Hist. N. York, VI, Palaeont., VIII (1), 1892, pl. 16, figs. 15, 35, 36.
 Das Rheinische Uebergansgebirge, 1844, p. 75, t. 1, figs. 5a; b.
 See Schnur, Palaeontographica, III, 1853.
 See Schnur, Palaeontographica, III, 1853.
 See Williams and Breger, U.S. Geol. Surv. Prof. Paper 89, 1916, pp. 45-48, pls. IX and X.
 See Clarke, Mon. Serv. Geol. Min. Brazil, I, 1913, pp. 295-97, pl. XXIV, figs. 1-25; F.R.C. Reed, Ann. S. Afr.
 XYII 1025 pp. 42-43. (*) See Davidson, Mon. Brit. Foss. Brach. (Pal. Soc.), vol. III (VII), 4, Jan. 1871, pp. 331-3, pl. XLIX, figs. 23-26.
 (*) Nature, vol. 122, Dec. 8, 1928, p. 881.

Spirifer J. Sowerby, 1816⁽¹⁾, is now restricted to a small group of Carboniferous species phyletically related to the genotype, Anomites striatus Martin, 1809(2).

Other Upper Palæozoic (Carboniferous and Permian) groups have been named by Frederics(3) and other Russian palæontologists, but these groups do not seem to be based upon evolutionary studies, and may have to be considerably revised.

Devonian Spiriferids with few exceptions are still referred to Spirifer, but it is certain that few, if any, of the many Devonian lineages are closely related to Spirifer striatus (Martin). The issue is confused by the prevalence of homoemorphy amongst spiriferids, but lack of critical studies is the chief cause of confusion.

With the above considerations in mind, therefore, it will be clear that the task of naming the Lower Devonian spiriferids from Reefton has not been easy. It should have been preceded by a revision of Upper Silurian and Devonian groups of the Northern Hemisphere-no light task.

There are four spiriferids present at Reefton, two of these are rare, and will be referred provisionally to Spirifer sensu lato—this merely from lack of knowledge as to their real relationships. The remaining pair are both very abundant and, as will be seen, represent stages in development in a single lineage. They are therefore congeneric. Both belong to what may be termed the "gens" of Spirifer hercyniae Giebel, and the members of this gens or lineage are extremely wide-spread in and characteristic of Lower Devonian horizons throughout the world.

- Before describing the Reefton material I propose to discuss the gens in some detail.

Synonymy of S. hercyniae Giebel. (Pl. III, figs. 1, 2.) Gens of **Spirifer hercyniæ** Giebel.

1858. Spirifer hercyniae Giebel, Silur. Fauna Unterharz., p. 30, pl. 4, fig. 14. (Reproduced by Béclard, Bull. Soc. Belge Geol., t. IX, 1895, Mem., pl. XIV, fig. IX.)

1878. Spirifer hercyniae E. Kayser, Abh. Geol. Specialk. Preuss. u. Thuring. Staat., Bd. II, Heft. 4, pp. 168-69, taf. 23, figs. 7-13.

- 1900. Spirifer hercyniae H. Scupin, Palaeont. Abhandl., N.F. Bd. IV, Heft. 3, pp. 86-89, taf. VIII, figs. 4. 5a. b.
- 1900. Spirifer hercyniae var. primaeviformis H. Scupin, ibid., pp. 88-89, taf. VIII. figs. 3. 10 a-c.
- 1902. Spirifer hercyniae F. Drevermann, Palaeontographica, Bd. XLIX, p. 95 (not figured) Oberstadtfeld.
- 1915. Spirifer assimilis A. Fuchs, Abhandl. d. K. Preuss. Geol. Landesanst, N.F., Heft. 79, pp. 22-23, taf. 5, figs. 9-13. Hunsrückschiefer.

Description (based upon material from the Untercoblenzschichten of Oberstadtfeld in the Eifel, Germany): The specimens here figured (pl. III, figs. 1, 2) and described are internal moulds, hence no details of external characters can be given other than those which leave their impress on the internal moulds.

Cardinal margin spiriferid. Valves convex. General shape alate, triangular. The ventral valve has a deep sinus, and the dorsal a corresponding fold. Anterior commissure uniplicate. The flanks are ornamented by flat, rounded plicæ which become obsolete laterally. The number varies from nine to fourteen. It may be noted that the number of ribs impressed on to the mould will vary according to the age of the individual, also that the shape of the wings may vary considerably in the same way. In this connection reference should be made to an article by E. Maillieux(*).

Interior of dorsal valve (from a squeeze of the internal mould). (Pl. III, fig. 1).

Cardinalia strong, forming a solid bench along the cardinal margin, excavated medially. Dental sockets pyriform with the point directed to the beak, rounded laterally, and deepest at the lateral ends. Outer socket ridges not prominent. Socket ridges, massive, rounded, directed towards the beak and forming an acute angle with the cardinal margin. In the umbonal angle between the outer socket ridges and the socket ridges, and nearer the beak than the dental sockets, are somewhat irregular, shallow fissures. Laterally from the dental sockets the platform is flattened. Cardinal

⁽¹⁾ Min. Conch., II, No. 21 (Feb.), pp. 41-42.

⁽²⁾ Petref. Derb., 1809, tab. XXIII.

^{(&}lt;sup>3</sup>) G. Frederics: Table pour la Definition des Genres de la Famille Spiriferidae King. (In Russian): Bull. Acad. Sci. U.S.S.R., ser. 6, vol. XX, 1926, pp. 393-422, 1, plate.

⁽⁴⁾ Sur une cause fréquente d'erreurs dans la détermination de certains Brachiopodes de l'Infradévonien. Bull. Soc. Belge Géol., XXIII, 1909, pp. 314-18.

process large, rounded, striated in an anterior-posterior direction, and merging anteriorly into a wide platform sunk below the surface of the socket ridges. This structure has not apparently been named. It is produced anteriorly into a narrow low median septum which is lower than the platforms on either side forming the area of attachment for the posterior adductor muscles. These scars are very large, each shaped like an isosceles triangle with the base parallel to the margins of the dorsal fold.

The median septum spreads out laterally into a flat lamella about its middle distance, but narrows anteriorly and divides the anterior adductors which are relatively large and narrowly elongate. The septum extends about two-thirds of the total length of the valve.

Interior of ventral valve (from a squeeze of the internal mould). (Pl. III, fig. 2.)

Teeth large and strong, supported by short dental plates. Delthyrium triangular; rather broad. The muscle scars form a rhomboidal area depressed, except over the ventral sinus, below the general level of the valve surface, and divided medially by a short, feeble septum. The long narrow central adductors are not clearly defined. The divaricators surround the adductors, and occupy the great bulk of the scar. The dendroid ornament of the divaricators is somewhat irregular.

Remarks: The gens of *Sp. hercyniae* includes a very widespread group of typically Lower Devonian spiriferids. The type is highly characteristic of the Untercoblenzschichten (Emsian) of the Rhine and Belgium, where it occurs in the psammopelitic facies. Scupin's variety *primaeviformis* is regarded by Drevermann⁽¹⁾ as founded on senile individuals of *hercyniae*, and in this the writer agrees.

Spirifer assimilis Fuchs is here relegated to the synonymy of S. hercyniae. It is characteristic and widespread in all horizons of the Hunsrückschiefer. It can be paralleled very exactly among the Reefton fossils, and there grades into typical hercyniae.

S. hercyniae also occurs in the Upper Siegenian of Belgium, but is subordinate in importance to Spirifer hystericus Schlotheim. In Lower Devonian strata of calcareous facies S. hercyniae occurs in Europe, in the Harz, and elsewhere.

The following species are referred to this gens (the list is probably incomplete) :--

- A. Western Europe-
 - (1) Spirifer primaevus Steininger, 1853. (For synonymy see below.)
 - (2) Spirifer paradoxus (Schlotheim, 1813). (See Scupin, 1900, pp. 89-90.)
 - (3) Spirifer follmanni Scupin, 1900, p. 90. This species is doubtfully separable from S. hercyniae.
 - (4) Spirifer arduennensis Schnur, 1853. (See Scupin, 1900, pp. 90-92.)
 - (5) Spirifer herrmanni Kegel, 1926. (Abh. d. Preuss. Geol. Landes. N.F., Heft 100, pp. 49-51, taf. 4, figs. 2, 3.) Steinberger Kalk.

B. South Africa, the Falkland Islands, and Parana, Brazil-

- (6) Spirifer iheringi Kayser, 1900. (See Clarke, 1913, Mon. Serv. Geol. Min. Brasil, I, pp. 243-49), Parana.
- (7) Spirifer kayserianus Clarke, 1913, pp. 252-58, Ponta Grossa, Brazil.
- (8) Spirifer antarcticus Morris and Sharpe, 1846. (See Clarke, 1913, pp. 258-62, and F. R. C. Reed, Ann. S. African Mus., XXII, 1925, pp. 47-51. Reed regards S. kayserianus Clarke as a variety of antarcticus.)
- (9) Spirifer ceres Reed, 1903. (See Reed, op. cit., 1925, pp. 51-53. Reed treats S. iheringi Kayser, noted above, as a variety of S. ceres.) Bokkeveld Beds, S. Africa.
- C. North-east America---
 - (10) Spirifer murchisoni Castelnau, 1843. (See Williams and Breger, U.S. Geol. Surv., Prof. Paper 89, 1916, pp. 95-104.) This species is the North American equivalent of S. primaevus. Moose River sandstone.
 - (11) Spirifer gaspensis Billings, 1863. (See Williams and Breger, op. cit., pp. 107-113.)
 "S. gaspensis is equivalent to and identical with S. hercyniae Giebel." (Williams and Breger, op. cit., p. 112.)

(1) Op. cit. supra, 1902, p. 95.

This list is probably incomplete, and it is not possible to state that all the species noted are distinct.

In Western Europe the members of this gens provide evolutional stages which are of marked stratigraphical importance, and can be paralleled very closely in North America, and, in part, in South America, South Africa, and New Zealand, where homotaxial strata of the same general psammo-pelitic facies occur.

Scupin (1900, op. cit., p. 132) suggested the following genetic line :--

paradoxus \bigwedge hercyniæ \bigstar primævus \bigwedge subhystericus \bigwedge hystericus.

S. hystericus is a characteristic species of the Upper Hunsrückian (Upper Siegenian) in Belgium, and of the equivalent Herdorfer Horizont of the Siegener Schichten, therefore, if Scupin's suggestion is correct, as I believe it is, hystericus has come into prominence less rapidly than its derivative S. primaevus, which is the characteristic species of the Lower Hunsrückian (Middle Siegenian) of the Ardennes, and of the Rauhflaserhorizont of the Siegener Schichten⁽¹⁾. Sp. hercyniae is very characteristic of the Untercoblenzschichten of the Rhine, and of the Lower Emsian (Assise de Pesche) of Belgium. Sp. paradoxus is typical of the oberen Coblenzschichten of the Rhine.

In North-eastern America the members of the same stock have received different names as follows :--

gaspensis (= hercyniæ type). \bigwedge murchisoni (= primaevus type).(²) \bigwedge cyclopterus (= hystericus type).

S. cyclopterus is typical of the Upper Helderbergian (Chapman Sandstone, &c.) and is followed by typical murchisoni in the Oriskanian. (See Williams and Breger, op. cit., p. 93.) (Moose River sandstone, &c.) S. gaspensis occurs in the Moose River sandstone of Maine, and in the Gaspe limestones Nos. 7 and 8, and in the lower part of the Gaspe sandstone, but is unknown in the New York Oriskany (teste Williams and Breger, op. cit., p. 112). What is apparently an unsuccessful offshoot of the hystericus-paradoxus line occurring in the Moose River sandstone of Maine has been designated Antispirifer (type A. harroldi W. and B.), by Williams and Breger(³). Antispirifer agrees in all essentials with members of the hercyniae-gens except that the ventral valve is flat, depressed convex, or slightly concave. The question of the classificatory value of such an abnormality in valve convexity demands further study. Is it not possible that the phenomenon is purely pathological, and hence of no generic significance whatever ?

For one of the stages of evolution of the gens of *hercyniae* Helmbrecht and Wedekind(⁴) proposed the name *Acrospirifer* in the following words: "Ausser den beiden beschriebenen Spiriferen (*Sp. primaevus* und *Sp. Decheni*) die wir zur Gattung *Acrospirifer* zusammenfassen, gehort in diese Gattung noch ein Spirifer den wir *Sp. septalis* nennen." I propose to select one of the genosyntypes—viz., *Spirifer primaevus* Steininger, 1853, as genolectotype, and to utilize the genus *Acrospirifer* not only for the stage of development represented by the genotype, but also for the whole *hercyniae* lineage as far as it is known.

(1) S. hystericus, however, is not uncommon in the Taunusian (Lower Siegenian).

- (3) Op. cit., pp. 114–16.
 (4) Glückauf, Jahrg. 59, Nr. 41, 1923, p. 952.
 - 2—Pal. Bull. No. 14.

⁽²⁾ Murchisoni as interpreted by various American palæontologists covers species comparable with S. primaevus; species intermediate between S. primaevus and S. hercyniae; and species comparable with S. hercyniae.

Acrospirifer W. Helmbrecht and R. Wedekind, 1923.

Glückauf, Jahrg. 59, Nr. 41, 13 Oktober, 1923, p. 952.

Type (here selected): Spirifer primaevus Steininger, 1853.

Synonymy of genolectotype :---

- 1853. Spirifer primaevus Steininger, Geogn. Beschreib. der Eifel., p. 72, taf. 6, fig. 1.
- 1895. Spirifer primaevus F. Beclard, Bull. Soc. Belge. Géol., t. IX, M.m. pp. 137-47, pl. XI.
- 1900. Spirifer primaevus H. Scupin, Pal. Abhandl., N.F., Bd. IV, Heft. 3, pp. 84-5, taf. VIII, fig. 9.
- 1904. Spirifer primaevus F. Drevermann, Palaeontogr., Bd. L, pp. 246-49, taf. XXIX, figs. 1-7.
- 1910. Spirifer primaevus E. Maillieux, Bull. Soc. Belge. Géol., t. XXIII (1909), Mém., pp. 345-48, text-figs. 15-17a on p. 345.
- 1913. Spirifer primaevus W. Kegel, Abh. d. K. Preuss. Géol. Landes., N.F., Heft. 67, pp. 108-10, . taf. 6, figs. 3u, 4.
- 1913. Spirifer primaevus E. Asselberghs, Mem. Inst. Géol. Univ. Louvain, t. I, mém. 1, p. 102, not figured.

Diagnosis.—Lower Devonian spiriferids, with a multiplicate(1) ornament and a uniplicate anterior commissure, in which the development is from the primitive type of Spirifer hystericus (Schlotheim) to the progressive type of Sp. paradoxus Schlotheim. This diagnosis is admittedly lacking in precision, but it is almost impossible to frame a diagnosis for a changing, progressive lineage, since no one structural unit is constant. It is much easier to define stages of development within the lineage. The citation of the first and last species in the sequence (of Devonian members only), however, should serve for all practical purposes.

Acrospirifer cf. hercyniæ (Giebel), 1858. (Compare synonymy given above.) (Pl. II, figs. 1-3.)

Material: This species is the most characteristic fossil of the Reefton beds, and is represented in the Survey Collection by some fifty specimens.

Description (based upon an internal mould of the ventral valve). (Pl. II, fig. 1.)

Ventral valve convex, broadly transverse, fusiform, width nearly three times as great as the length. Hinge-line straight, equal to the width of the shell. Cardinal area triangular, transversely striated. General form basin-shaped, cardinal margins acute.

Musculature very strongly developed, elongate-oval, widening anteriorly. Median adductors long, narrow, sharply elevated, striate. Diductors deeply depressed, triangular, ornamented with transverse striæ at the end nearest the hinge, and by longitudinal striæ on the anterior half. Ventral sinus deep, smooth except for concentric growth stages. Ribs more or less obsolete except at the anterior margin, where there are 8 to 10 wide flatly rounded radials(²) on each side of the sinus.

Length of shell, 3-3.5 cm.; width of shell, 8-9 cm.

Locality: 130, Reefton.

Range of variation: The variation shown by the Reefton material is considerable, and depends upon two main factors, other than a possible inherent plasticity. The age of the individual determines to a large extent the relative massiveness or otherwise of the musculature, and its depth of depression, while the thickening of the hinge area in gerontic specimens regulates the number of ribs or plice impressed on to the internal mould.

The relative shape, particularly of the cardinal extremities, is likewise determined by age, and to a surprising degree in some specimens by the cleavage, and the position of the valve with regard to the direction of cleavage.

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⁽¹⁾ J. A. Thomson (N.Z. Board Sci. & Art, Man. No. 7, 1927, p. 61, footnote) restricts the term "plica" to increases or decreases of shell-conexity in an anterior-posterior direction which affect both inner and outer surfaces of the shell. The ribs of members of Acrospirifer are true plicæ, therefore I use the term "multiplicate" rather than "multicostate." The anterior commissure is, of course, affected by the plicæ—*i.e.*, has a minor multiplication superimposed upon the major uniplication.

⁽²⁾ Williams and Breger (U.S.G.S. Prof. Paper 89, 1816, p. 93), Drevermann (Palaeontographica, Bd. L, 1904, p. 247), Maillieux (Bull. Soc. belge Géol., t. XXIII, 1909, pp. 314-16) and probably others have noted that in this type of Spirifer the internal mould does not reproduce the external features exactly. The cardinal angles may appear to be more rounded in the mould than in the external shell. Also owing to the thickening of the hinge area, dental plates, &c., the number of ribs impressed through the shell on to the mould is less than the number shown externally.

Individual specimens (pl. II, fig. 1) compare closely with typical *hercyniae*, while others (pl. II, fig. 2) would be referred to *assimilis* Fuchs. Others again resemble Scupin's variety *primaeviformis*, and, indeed, approach the massiveness of *primaevus*.

Comparison with typical *hercyniae*: The relationship is amazingly close, and Reefton material, if found in Western Europe, would undoubtedly be classed as *A. hercyniae*. In the Reefton fossils the angle formed by the lateral margins of the posterior part of the muscle scars is uniformly more acute than in the northern type, but this is hardly sufficient for specific or varietal differentiation.

A. cf. hercyniae (Giebel) is superficially strikingly similar to certain Carboniferous spiriferids e.g., Spirifer vespertilio G. Sowerby, as figured by Frech⁽¹⁾ from Tasmania, but this is a case of homoeomorphy⁽²⁾.

Acrospirifer cf. hystericus (Schlotheim, 1820). (Pl. II, figs. 4, 5.)

Compare :---

1820. Hysterolithes hystericus Schlotheim, Die Petref., p. 249, t. 29, figs. 1a, b.

- 1895. Spirifer hystericus Schlotheim, F. Beclard, Bull. Soc. Belge. G(ol., t. IX, M(m., pp. 148-68, pl. XII, figs. 1-16.
- 1900. Spirifer hystericus Schlotheim, Scupin, Pal. Abhandl., N.F., Bd. IV, Heft 3, pp. 12-15, t. 1, figs. 3-5.
- 1904. Spirifer hystericus Schlotheim, Drevermann, Palaeontographica, Bd. L, pp. 253-54, t. XXX, figs. 1-7.
- 1916. Spirifer cyclopterus Hall, Williams and Breger, U.S. Geol. Surv. Prof. Paper 89, pp. 88-95, pl. I, figs. 1, 4, 5, 8, 9, 12, 16, 18-20; pl. II, figs. 3, 5, 6, 7, 8, 10, 13, 14, 20; pl. IV, figs. 1, 10.

Description from-(a) Internal mould of a ventral valve (pl. II, fig. 5); (b) external cast of a ventral valve in the Auckland University College Geological Department collection.

Description: Shell moderately small, transverse, more than twice as broad as long, more or less semicircular. Hinge-line equal to the whole width of the shell. Cardinal angles rounded to acute. Dental plates, diverging, reaching slightly less than half the length of the shell. Musculature not observed. Sinus deep but rather narrow. Six to eight rather sharply rounded radials on each side of the sinus.

Length of shell, 1.3 cm.; width of shell, 3.5 cm.

A specimen, kindly lent by Professor J. A. Bartrum, of Auckland University College, shows that the whole of the ventral valve, including the sinus, is ornamented with fine, dense striæ. (Pl. II, fig. 4.)

Locality: 130, Reefton.

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Remarks: This species is common at Reefton, and is in all essentials comparable with A. hystericus (Schlotheim) as interpreted by Scupin and Drevermann. In Western Europe hystericus comes in in the Lower Siegenian (Taunusian), and gives rise to what is here called the gens of Sp. hercyniae. A. hystericus becomes of greatest importance in, and is characteristic of, the Upper Hunsrückian of Belgium, and of the Herdorferhorizont of the Siegener Schichten of Germany. It is not recorded from the Untercoblenzschichten of the Eifel by Drevermann.

The North-east American equivalent of *A. hystericus* is *A. cyclopterus* (Hall). This species has been ably described by Williams and Breger, who likewise instituted comparisons with the European material. This monograph should be consulted for further details.

This type of spiriferid is not found in the "austral" Lower Devonian strata of South America and South Africa, but derivatives of it do occur in these localities, as has been noted above.

⁽¹⁾ Ueber marine Dyas-Brachiopoden aus Australien. Zeitsch. d. Deutsch. geol. Gesell., Jahrg. 1898, taf. IV, fig. 3. (2) Hector (1880, p. 29) actually referred the Reefton fossil to Sowerby's species.

Spirifer (sensu lato).

"Spirifer " chapmani n. sp. (Pl. II, fig. 7.)

Material: A single internal mould of the dorsal valve in the collection of the National Museum, Melbourne.

Description: Dorsal valve semicircular, slightly convex, without plication. Anterior margin rounded, cardinal extremities likewise, hinge-line relatively short, beak not prominent, nor incurved. Ornamentation of flat, concentric, lamellæ, no radial sculpture is visible on the mould. The most striking features of the weak cardinalia are the prominent crural bases.

Length of dorsal value, 12 mm.; breadth of dorsal value, 18 mm.

Remarks: This imperfectly known species appears to belong to the group of Sp. modestus Hall(1), a well known Helderbergian fossil found in various parts of Eastern North America.

This type of Spirifer is apparently unknown in the Lower Devonian of Western Europe, and has not been noted from the "austral" Lower Devonian of South America, the Falkland Islands, or South Africa.

The species is named in honour of F. Chapman, Palæontologist to the National Museum, Melbourne, who made a preliminary study of the small collection of Reefton fossils in Melbourne.

The generic location is quite provisional, the species is certainly not a Spirifer in the strict sense. Further materials might necessitate a reference to Ambocoelia Hall(2), 1860 (type Orthis umbonata Conrad(3)).

"Spirifer" bensoni sp. nov. (Pl. II, figs. 12, 13.)

Description: (Holotype).

Shell (dorsal valve) transverse, nearly twice as wide as long, hinge-line spiriferid, anterior margin semicircular, convexity greatest near the umbo. The hinge apparatus consists of small dental sockets, well-developed socket ridges which give rise to stout, short, straight, divergent crural plates, and a small cardinal process. There is no median septum. Anterior commissure, incipiently uniplicate. Shell multiplicate, the median area occupied by a wide plica, on either side of which are 4-5 plicæ divided by narrow sulci, the whole being crossed by moderately regular concentric growth lines.

Length of dorsal valve, 6.5 mm.; breadth of dorsal valve, 11 mm.

Ventral valve unknown.

Remarks : This interesting species, dedicated to my friend and teacher, Professor W. N. Benson, of Otago University, occurs on the same slab as *Camarotoechia mackayi* n. sp. The rather peculiar matrix gives no indication as to the age of these species. They may prove to be Middle rather than Lower Devonian species.

"S." bensoni n. sp. may prove to belong to the genus Vitulina(4), but further specimens are necessary to settle this point.

Family COELOSPIRIDÆ Hall and Clarke.

Leptocoelia J. Hall, 1859.

1857. Leptocoelia J. Hall, 10th Ann. Rep. N. York State Cab. Nat. Hist., pp. 107-8. (n. n.) 1859. Leptocoelia J. Hall, Nat. Hist. N. York, Palaeont., III, p. 449.

Type (by subsequent designation): Leptocoelia flabellites (Conrad).

⁽¹⁾ See Hall, Nat. Hist. N. York, VI, Palaeont. III, 1859, p. 203, pl. XXVIII, fig. la-e; Maynard, Maryland Geol. Surv., Lower Devonian, 1913, pp. 399-400, pl. LXVIII, figs. 17-22; and Clarke, N. York State Mus., Mem. 9, (1), 1908, pp. 182-83, pl. 31, figs. 18-24. (var. nitidulus Clarke).
(2) 13th Rept. N.Y. State Cab. N.H., p. 71.
(3) Jour. Acad. Nat. Sci. Philad., VIII, 1842, p. 264, pl. XIV, fig. 4.
(4) Sea Schubart Rull U.S. Clarke, N. 7, 459 for references.

^(*) See Schuchert, Bull. U.S. Geol. Surv., 87, 1897, p. 459, for references.

Leptocoelia flabellites (Conrad, 1841). (Pl. II, fig. 6).

- Atrypa flabellites Conrad, 5th Ann. Rep. N.Y. Geol. Survey, p. 55. Oriskany sandstone. 1841.
- Atrypa palmata Morris and Sharpe, Q.J.G.S., 2, p. 276, pl. X, figs. 3a-d. Falkland Islands. 1846.
- Leptocoelia flabellites Hall, Pal. N. York, 3, pp. 449-50, pl. CVI, figs. 1a-f; pl. CIIIB, figs. 1a-f. 1859. Oriskany sandstone.
- 1913. Leptocoelia flebellites (in error) J. M. Clarke, Mon. Serv. Geol. Min. Brasil, vol. I, pp. 269-75, pl. 22, figs. 13-32. Parana, Brazil; Matto Grosso, Brazil; Argentine; Falkland Islands.
- 1916. Leptocoelia flabellites Williams and Breger, U.S. Geol. Surv. Prof. Paper 89, pp. 120-24, pl. V, figs. 19-30. Moose River sandstone of Maine.
- 1923. Leptocoelia flabellites R. Kozlowski, Annales de Paléont., t. XII, p. 96, not figured. Bolivia.
- 1925. Leptocoelia flabellites F. R. C. Reed, Ann. S. African Mus., XXII, pp. 56-57, not figured. Bokkeveld beds, South Africa.

In the synonymy given, only the major references to this species are included, pages of references could be compiled from the sources indicated.

Description (based on an internal mould of the dorsal valve): Dorsal valve flat, with a straight hinge-line and semicircular outline. The hinge equals the greatest width of the valve. Anterior margin strongly geniculate (or apparently so). Cardinal process strongly developed, massive, lobed. Median septum narrow, dividing the muscle scars into two similar parts, and extending rather more than half the length. The crural bases leave a well-defined pit on the mould at the base of the cardinal process. The muscle scars are definitely circumscribed laterally, but tend to become indefinite at the anterior margin. The ornamentation consists of 10 to 11 broadly rounded ribs.

Breadth of dorsal valve, 20 mm.; length of dorsal valve, 15 mm.

Remarks: Leptocoelia flabellites (Conrad) was first described from the Oriskany sandstone of Eastern North America, and it is a characteristic and widespread member of the normal Oriskany fauna. It also occurs in Lower Devonian faunas in Brazil, Bolivia, Argentina, and Falkland Islands, and South Africa (Bokkeveld beds). It may be noted that Williams and Breger(1) consider that Trigeria (?) oehlerti Drevermann(2), in part, is probably identical with L. flabellites (Conrad). Drevermann's species was described from the Siegener Schichten of Seifen, Westerwald, but the figure in question (pl. XXX, fig. 23) is poor and seems to the writer not to bear the interpretation placed upon it by Williams and Breger.

It is rather amazing that this abundant cosmopolitan species has not been definitely recorded from the Siegenian beds of Western Europe.

Superfamily RHYNCHONELLACEA Schuchert.

Family RHYNCHOTREMIDÆ Schuchert.

Eatonia Hall, 1857.

10th Rep. New York State Cab. Nat. Hist., p. 90.

Type (by subsequent designation-Hall and Clarke, Pal. N. York, VIII (II), 1894, (1895): p. 205) Atrypa medialis Vanuxem, Geol. New York, Rep. Third Dist., 1842, p. 120, fig. 4. Lower Helderberg.

Schuchert (U.S.G.S. Bull. 87, 1897, p. 219) and Bassler (U.S. Nat. Mus., Bull. 92 (1), 1915, p. 465) both give "Genotype Atrypa peculiaris Conrad," but this seems to be in error(3).

U.S. Geol. Surv. Prof. Paper 89, 1916, pp. 123-24.
 (2) Palaeontographica, Bd. L, 1904, pp. 206-11, pl. XXX, fig. 23 (not fig. 24).
 (3) Schuchert and Le Vene (Foss. Cat. I, pars. 42, 1929, p. 55), cite Atrypa medialis Vanuxem as genolectotype.

Eatonia parki n. sp. (Pl. II, fig. 11.)

Material: Holotype and three paratypes.

Description: (a) Holotype (internal mould of the ventral valve).

Ventral valve convex, transversely ovate with a pronounced median sulcus and deeply crenulated anterior margin. The anterior-lateral area is strongly concave ventrally. The wide sulcus commences anterior to the musculature and increases in depth anteriorly. Anterior commissure strongly uniplicate. Musculature large, flabellate, deeply incised (raised in the mould). Diductors elongated, extending for half the length of the shell and enclosing small central adductors, which are separated from the diductors by a ridge, and divided medially by a faint septum, which does not extend anteriorly into the diductors.

Cardinal margin with very strong teeth, which appear to have grooves on the inner surface. Beak prominent.

(b) Paratypes.

One of the paratypes shows that the ventral valve is strongly multiplicate. The flat base of the fold bears four plicæ and each lateral area 4 to 5 similar plicæ. The dorsal valve (rather poorly preserved) is convex, with a single median fold and multiplicate shell. Median septum short, possibly expanding posteriorly. Crura prominent. Other hinge characters difficult to determine.

Length of the ventral valve, 23 mm.; width of the ventral valve, 18 mm.

Remarks: The genus has been subdivided by Breger(1) on a basis of external sculpture into three major groups, and the Reefton fossil belongs to the group of *E. medialis* Vanuxem, with a surface covered with broad plications. This group does not seem to be represented in the Lower Devonian beds of Western Europe, but occurs in the Oriskany sandstone, and is very abundant in the Lower Devonian of Bohemia where, however, the facies is very distinct. *E. parki* is distinct from the Oriskany members of this group, *E. whitfieldi* Hall(²) and *E. sinuata* Hall(³). The genus is not present in the "austral" Lower Devonian fauna.

Camarotoechia Hall and Clarke, 1895.

Nat. Hist. N. York, VI, Palaeont., vol. VIII, (II), pp. 189-92.

Type (by original designation); Rhynchonella congregata (Conrad), 5th Ann. Rep. N. York Geol. Surv., 1841, p. 55. Devonian.

Camarotoechia mackayi n. sp. (Pl. II, fig. 14.)

Material: Holotype, an internal mould of the dorsal valve. Paratype, an external cast of the dorsal valve. Description (holotype).

Dorsal valve subcircular, hinge-line very short, posterior lateral margins straight, anterior margin rounded and crenulated, greatest breadth about the anterior third. Ornament of 16 to 18 welldefined rounded plicæ with wider interspaces. Median septum narrow, extending about one-third of the length of the valve, and forking posteriorly, hence indicating a hollow cavity. Crural processes not observed. There is no cardinal process. The anterior commissure appears to be uniplicate, but the dorsal fold is slight.

Length of dorsal valve, 7 mm.; breadth of dorsal valve, 8 mm. An external cast of the dorsal valve shows that the shell is impunctate.

(2) Nat. Hist. N. York, Palaeont., vol. III, 1859, p. 437, pl. CIA, figs. 2a, b.
 (3) Op. cit., p. 438, pl. CIA, figs. 3-6.

⁽¹⁾ In Williams and Breger, U.S.G.S., Prof. Paper, 89, 1916, pp. 67-69.

Remarks: The absence of a punctate shell-structure separates the Reefton fossil from a group of genera such as Retzia, Eumetria, and Homoeospira, to which the external casts bear a A reference to the impunctate Camarotoechia must, however, be consuperficial resemblance. sidered provisional, for the distinctive characters of that genus are internal, and cannot be examined in material such as is preserved at Reefton. I have not been able to trace closely comparable forms in the sandstone-mudstone facies of the Lower Devonian, but C. mackayi is clearly of the same group as the genotype(1) and C. prolifica Hall(2) from the Middle Devonian of New York.

Superfamily TEREBRATULACEA Waagen.

Family TEREBRATULIDÆ Gray.

Subfamily MEGANTERINÆ Waagen.

Meganteris E. Suess, 1855.

Meganteris Suess, Sitz. d. math.-nat. Cl. d. K. Akad. d. Wissensch. Wien., Jahrg., 1855, pp. 51-65, 1855. pls. I-III.

1887. Megalanteris Ochlert, in Fischer, Man. Conch., p. 1319.

Type (by subsequent designation, here selected): Megalanteris suessi Drevermann, 1902, Palwontographica, XLIV, p. 102 = Meganteris archiaci Suess, 1855 (not Terebratula archiaci Verneuil, 1850, Bull. Soc. géol. France, 2 sér., tome VII, pp. 175-76, pl. IV, figs. 2a-d).

The type demands a short discussion. Suess (1855) described material from the Eifel, and referred it to Terebratula archiaci Verneuil originally based upon Devonian fossils from the Sabero (Leon) in Spain. Meganteris was founded upon the Eifel fossil which is, however, distinct from Verneuil's species. In this case it seems advisable to follow the example of S. S. Buckman(3) in his selection of the genotype of Martinia M'Coy. It may be argued that there are two genosyntypes-Terebratula archiaci Verneuil, indicated by name, and Meganteris archiaci Suess == Megalanteris suessi Drevermann, indicated by figure. To carry out Suess's intentions it is necessary to select the latter as genolectotype. Taf. I, fig. 5, of Suess 1855 may be selected as the lectotype of M. suessi Drevermann(⁴).

Meganteris neozelanica n. sp. (Pl. II, figs. 9, 10; pl. III, figs. 3 and 5.)

Material: This is one of the most abundant species in the psammo-pelitic facies at Reefton. More than fifty specimens are represented in the Survey collection alone.

Description: (a) Holotype (taken from a squeeze of the internal mould of the ventral valve). (Pl. II, fig. 9.)

Outline semicircular, convex, cardinal margin terebratulid, anterior commissure rectimarginate. Area moderately wide, concave (in the natural mould this concave area produces two tapering funnellike processes lying on either side of the beak). Teeth strong with a solid base. The muscle scars are elongated, tear-shaped, depressed, and divided by a relatively low, broad septum. They reach rather more than half the length of the valve. The ornamentation consists of wide, shallow, concentric furrows, which become obsolete near the posterior margins.

Length, 35 mm.; breadth, 38 mm.

(b) Paratype (description taken from a squeeze of the internal mould of the dorsal valve). (Pl. II, fig. 10.)

⁽¹⁾ Hall and Clarke, 1895 : Op. cit., pl. LVII, figs. 15 and 16.

²⁾ Ibid., pl. LVII, figs. 42 and 43.

 ³ Quart. Journ. Geol. Soc., 64, 1908, p. 30.
 ⁴) I have to thank Dr. J. Marwick for pointing out that the argument used here is not in harmony with Opinion 65 of the International Rules of Zoological Nomenclature which states that: "If an author designates a certain species as genotype, it is to be assumed that his determination of the species is correct . . Wash., 39, 1926, p. 99). In order to draw attention to this case I retain the original paragraph. (Proc. Biol. Soc.

General shape similar to that of the ventral valve, but hinge-line long and little angled, shorter than the greatest width. Cardinal process small. Dental sockets triangular, diverging, their inner margins giving rise to strong crura. Muscle scars elongate, sharply circumscribed posteriorly, but indefinite anteriorly, divided longitudinally by a well-developed median septum. Anterior to the scars is a series of ramifying vascular markings.

Remarks and affinities: This is one of the commonest species at Reefton. It shows great variability in general outline. Typically (as in the type material) both valves are more or less circular, but other specimens are transverse semicircular, while others again are twice as long as wide. In spite of this state of flux the hinge characters remain constant. Many of the elongate forms are deformed and the median groove on the ventral valve is accentuated, thus giving a false Pentamerid appearance.

The Reefton fossil is a fairly typical *Meganteris*, and, though closely related to the genotype, is specifically distinct. *M. suessi* ranges in Western Europe from Middle Siegenian to Emsian.

It has been very completely described by both Suess (1855) and Drevermann (1902, pp. 100-2, pl. XIII, figs. 1-11).

M. neozelanica finds its equivalent in North-eastern America in the Oriskanian *Megalanteris* diobolaris Clarke⁽¹⁾, a species well illustrated but inadequately described by its author. No related species has been described from the "austral" Lower Devonian of South America and South Africa.

Phylum MOLLUSCA.

Class **PELECYPODA** Goldfuss.

Family GRAMMYSIIDÆ Fischer.

Grammysia Verneuil, 1847.

Bull. Soc. Géol. France, 2nd sér. vol. 4, p. 696.

Type (by subsequent designation): Grammysia bisulcata (Conrad 1838) (= Grammysia hamiltonensis Verneuil, 1847). Middle Devonian.

(For full discussion and diagnosis of the genus, and for the selection of genotype, see Williams and Breger, U.S.G.S. Prof. Paper 89, 1916, pp. 128-33.)

Subgenus GRAMMYSIOIDEA Williams and Breger, 1916.

U.S. Geol. Surv. Prof. Paper 89, 1916, pp. 133-35.

Type (by original designation): Grammysioidea princiana Williams and Breger, 1916. Moose River sandstone, Maine, Lower Devonian.

Grammysia (Grammysioidea?) sp. ind. (Pl. III, fig. 10.)

Description and remarks: In the National Museum (Melbourne) collection there is a single, imperfectly preserved specimen which belongs to the Grammysioides and possibly to the subgenus *Grammysioidea* of *Grammysia*. *Grammysia* s.str. has a radial fold and sulcus, and the subgenus differs essentially in the absence of these features.

The Reefton fossil appears at first sight to have a well-developed fold but no sulcus, but this feature may be due to distortion. Better material is necessary before an exact determination can be made.

The specimen is a left valve, in which the anterior margin and most of the dorsal area are missing. Shell very inequilateral, transversely oblong, with truncated posterior margin. Ventral margin more or less parallel to the hinge line.

(1) New York State Museum, Mem. 9 (2), 1909, pp. 142-43, pl. 34, figs. 1-5, particularly fig. 5.

Beaks directed forward, curvature and exact position not visible. Ornamentation imperfectly preserved, of irregular concentric folds, which are more strongly developed in the posterior-dorsal area. No radial sculpture.

Approximate length, 50 mm.; approximate width, 30 mm.

Grammysioidea ranges from the Silurian (Clinton) to the Upper Devonian, but is most abundant in Lower Devonian beds. It occurs in strata of this age in Maine (Chapman sandstone(¹) and Moose River(¹) sandstone), Western Europe (Siegener Schichten)(¹), Brazil (Rio Maecuru), and South Africa (Bokkeveld Beds)(²).

Superfamily NUCULACEA Dall(³).

Palaeoneilo J. Hall, 1870.

Prelim. Notice Lamelli, 2, p. 6. See Hall, Nat. Hist. N. York, VI, Palaeont., V (1), 1885, pp. xxvii-xxviii, for diagnosis.

Type = Nuculites constricta Conrad, 1842, Journ. Acad. Nat. Sci. Philid., VIII, p. 249, pl. 15, fig. 8. (See Hall, 1885, pl. XLVIII, figs. 1-16, pl. LI, fig. 17.)

Palaeoneilo sp. ind. (Pl. III, fig. 9.)

Material: Three specimens—one, here figured, in the National Museum, Melbourne, and the other two in the Survey collection. All are imperfect.

Description (from the specimen in the National Museum, Melbourne-a right valve).

Shell elongate, ovate, twice as long as wide. Anterior margin rounded. Posterior margin incomplete. Ornamentation of concentric regular, strong, elevated striæ apparently over the whole surface.

Remarks: This incomplete record is not of great value, but the material is such that I hesitate to suggest a specific name. Comparison may be made with *Ctenodonta eschbachiana* Spriestersbach⁽⁴⁾ from the Remscheider Schichten of Germany. (Ober-Coblenzschichten.)

Family MODIOLOPSIDÆ Fischer.

Goniophora J. Phillips, 1844.

Mem. Geol. Surv. Gt. Brit., II (1), p. 264.

Type (by original designation): Cypricardia cymbaeformis J. de C. Sowerby, in R. I. Murchison, Sil. Syst., 1839, p. 602, pl. 3, fig. 10A.

Goniophora hendersoni n. sp. (Pl. III, fig. 6.)

Description: (Based on the holotype in the Auckland University College collection).

Shell equivalve, very inequilateral, sub-rectangular in general outline, anterior margin incomplete, short and probably round. Posterior margin convex outwards. Beaks situated about the anterior fourth, curvature not visible. Hinge-line long, nearly straight, parallel to the ventral margin. Umbonal ridge defined, crossing the valves from the beaks to the ventral-posterior extremity, in a concave line. There is no median ridge on the posterior-cardinal slope. Ornamentation poorly preserved, of concentric lamellæ, irregularly placed. The internal characters of the hinge have not been observed.

Length, 55 mm.; breadth, 25 mm.; thickness, 20 mm.

(4) In S. and Fuchs, Abh. d. k. Preuss. Geol. Landesanst., N.F., Heft 58, 1909, pp. 28-31, taf. III, fig. 8a.

⁽¹⁾ See Williams and Breger, op. cit.

⁽²⁾ F. R. C. Reed, Ann. S. Africa Mus. XXII, 1925, pp. 89-91.

⁽³⁾ The families included in the Nuculacea are, as far as the Palæozoic members are concerned, indefinitely defined. In Zittel-Eastman (1913) Palaeoneilo is included in the Ledidæ Adams.

Remarks: In general outline the Reefton fossil is not unlike the genotype of Sphenotus(1), S. arcaeformis Hall(2), but the absence of the median ridge on the posterior cardinal slope precludes such a generic location. It is allied to species referred to Leptodomus by Beushausen(3). but Reed(4) has pointed out that Leptodomus M'Coy(5) has been applied in more than one sense and the genotype is a Carboniferous shell. M'Coy also changed the scope and definition of Leptodomus(6). Reed(7) concluded that the genus was of doubtful valve. If Leptodomus M'Coy be restricted to the genosyntypes(8), then the Reefton fossil is certainly not congeneric.

Williams and Breger(⁹), in a detailed and lengthy discussion of the genus Goniophora Phillips⁽¹⁰⁾, type Cypricardia cymbaeformis Sowerby⁽¹¹⁾, note that Leptodomus latus Krantz, described and figured by Beushausen(12) and compared above with the Reefton shell, is a Goniophora, in the generally accepted usage of that term. The New Zealand fossil may be referred to Goniophora, at least temporarily. Better specimens may be found which will show hinge characters and thus allow of a more precise generic determination. Goniophora attains its acme in the Lower Devonian of Western Europe.

The species is named in honour of Dr. J. Henderson, Director of the New Zealand Geological Survey, whose stratigraphical studies at Reefton this work in part supplements.

Class GASTROPODA.

Family CAPULIDÆ Cuvier.

Platyceras Conrad, 1840.

4th Ann. Rep. New York Geol. Surv., p. 205.

Type: Platyceras dumosum Conrad, 1840, p. 205.

Platyceras sp. ind. (Pl. III, fig. 13.)

A single internal cast referable to this genus occurs in the Survey collection. The record is valueless from the stratigraphical point of view. The Reefton fossil has a strongly coiled apex, and hence probably belongs to the group of P. contortum Barrois⁽¹³⁾. It may be compared with *Platyceras* sp. figured by Drevermann (1^4) from the Untercoblenzschichten of Oberstadtfeld in the Eifel. It is distinct from P. bokkeveldense Reed(15), the only species in the Lower Devonian beds of South Africa. Further comparisons could be cited, but little of value would result.

The genus ranges from the Silurian to the Carboniferous, but is particularly characteristic of the Lower Devonian calcareous facies.

Suborder CONULARIIDA Miller and Gurley.

Family TENTACULITIDÆ Walcott.

Tentaculites Schlotheim, 1820.

Petref., p. 377.

Type (by subsequent designation): T. scalaris Schlotheim(16) 1820, ibid., p. 377. Silurian.

(1) J. Hall, Nat. Hist. N. York, Palaeont., V (1). Lamelli., II, p. xxxiii.
(2) For description and figures, see Hall, *ibid.*, p. 395, pl. LXV, figs. 7-11. Hamilton Group.
(3) See particularly L. latus (Krantz) in Beushausen, Abh. d. K. Preuss. Geol. Landesanst., N.F., Heft. 17, 1895, pp. 270-72, t. XXIV, fig. 1a-b.
(4) Ann. S. African Mus., vol. XXII, 1925, p. 94.

 (5) Syn. Carb. Foss. Ireland, 1844, pp. 66-67.
 (6) See Wheelton Hind. Mon. Carb. Lamellibr. (Pal. Soc.) 1898 and 1900, pp. 226, 361, 363, and 419. (7) Op. cit., p. 94.

(1) Op. Cut., p. 54.
(2) Leptodomus fragilis M'Coy (op. cit., p. 67, pl. X, fig. 11) and L. senilis (Phillips) (op. cit., p. 67, not figured).
(3) U.S. Geol. Surv. Prof. Paper 89, 1916, pp. 223-30.
(10) Mem. Geol. Surv. Gt. Brit. II (1), 1848, p. 264.
(11) J. de C. Sowerby in R. I. Murchison. Sil. Syst., 1839, p. 602, pl. 3, fig. 10a.

(^{1 2}) Op. cit.

(13) Mem. Soc. géol. du Nord. tome III, 1885, pp. 201-2, pl. 14, fig. 1. Calcaire d'Erbray.
(14) Palaeontographica, XLIX, 1902, p. 78, t. IX, f. 11.
(15) Ann. S. African Museum, XXII, 1925, pp. 108-9, pl. VII, fig. 1.
(16) T. scalaris Schloth. and the second genosyntype, T. annulatus Schloth., are a single species, teste Williams and Breger, U.S.G.S. Prof. Paper 89, 1916, p. 284.

Tentaculites sp. ind.

In the Survey collection there are two slabs each bearing a large number of casts of what is almost certainly a *Tentaculites*. The material is too poorly preserved to provide an adequate description, and a specific determination is impossible. Tentaculites is widely distributed in the Lower Devonian beds throughout the world. Leriche(1) has described and figured T. tenuis Sowerby from the Gedinnian of the Ardennes. The genotype, or a fossil confused therewith. occurs in the Siegener Schichten(2), and in the Siegenian of the Ardennes(3). According to Williams and Breger (4) the T. scalaris of authors from the Lower Devonian of Coblenz should bear the name T. schlotheimi Koken(5), the latter species being recorded also from the Chapman Sandstone of Maine(6). In the "austral" Lower Devonian Clarke has described T. jaculus Clarke(7), and T. crotalinus Salter(8) from Southern Brazil. The latter species occurs in the Falkland Islands, and is abundant in the Bokkeveld beds of South Africa(⁹), where it is accompanied by T. baini Reed(10) and T. desuetus Reed(11).

Phylum ARTHROPODA. Class CRUSTACEA. Subclass TRILOBITA Walch. Family PROETIDÆ Corda.

Dechenella E. Kayser, 1880.

Zeitschr. deutsch. geol. Ges., 32, pp. 703-5.

Subgenus EUDECHENELLA Rud. Richter, 1912.

Abhandl. d. Senckenberg. Naturf. Gesell., XXXI, p. 262.

Type (by subsequent designation): Phillipsia verneuili Barrande, 1852, Syst. Sil., V, p. 478.

Dechenella (Eudechenella) mackayi n. sp. (Pl. I, fig. 2.)

Material: Holotype, an almost complete pygidium preserved in a greyish-green limestone. Also three imperfect specimens in rock of the same nature. Type and other material in the Auckland University College Geological Department, Auckland.

Description: (Holotype).

Pygidium semicircular, anterior junction convex, surface arched, trilobation very distinct. Axis narrow elongate, tapering to a sharp point which does not reach the posterior margin. which is entire. Axis with from 12 to 15 narrow, raised, granulated annulations. Pleuræ wide. flat near the axis, then dropping rather rapidly, with 7 or 8 ribs, each bifid. Each ray carries a single row of granules. The ribs become obsolete at the margin which is slightly flattened.

Locality: Reefton.

Remarks: The Reefton trilobite appears to belong to the subgenus Eudechenella Richter, and is comparable, as far as it is possible to determine by the pygidium alone, with Dechenella (Eudechenella) granulata R. Richter (Abhandl. d. Senckenberg. Naturf. Gesell., Bd. XXXI, 1912, pp. 304-7, taf. 21, fig. 9) a species from the Stringocephalen-Kalk of Sotenich in the Eifel. It is very interesting to find that the evidence of this trilobite from the Reefton limestone has, as have the corals, very definite Middle Devonian affinities. The Stringocephalen-Kalk is the Lower horizon of the Givetian in the Eifel.

- (1) Mem. Mus. Roy. Hist. Nat. Belg., t. 6, 1912, pp. 40-41, pl. III, figs. 1-3.
- ²) Drevermann, Palaeontogr., L. 1904, p. 234.
- (3) Asselberghs, Mem. Inst. Geol. Univ. Louvain, t. 1, mem. 1, 1913, p. 121.
- 4) Williams and Breger, op. cit., 1916, p. 284.
- (*) Wintams and Dieger, op. oir., 1510, p. 2021.
 (5) Zeitsch. Deutsch. geol. Gesell., 41, 1889, p. 82.
 (6) Williams and Breger op. cit., 1916, pp. 283-84, pl. V, fig. 30, pl. XIV, figs. 23, 24.
 (7) Mon. Serv. Geol. Min. Brazil, vol. 1, 1913, pp. 88-89, pl. VIII, figs. 5-6.
 (8) See Clarke, op. cit., 1913, pp. 86-88, pl. VIII, figs. 1-4.
 (9) D. D. G. D. dams Materia Materia Will 1925, p. 118

- ⁹) F. R. C. Reed, Ann. S. African Mus., XXII, 1925, p. 118.
- (1°) Op. cit., 1925, p. 118. (11) Op. cit., 1925, pp. 118–19, pl. VII, figs. 9, 10.

Family CALYMENIDÆ Milne Edwards.

Homalonotus Koenig, 1825.

Icones Fossilium Sectiles, p. 4.

Type (by monotypy): H. knightii Koenig, ibid., p. 4, pl. VII, fig. 85.

Subgenus BURMEISTERIA Salter, 1865.

Mon. Brit. Tril. (Pal. Soc. for 1863), (June, 1865), p. 105.

Type (by original designation): *H. herschelii* Murchison, 1839, Sil. Syst., pp. 652-53, pl. vii bis, fig. 2.

(See F. R. C. Reed (Ann. S. African Museum, XXII, 1925, pp. 163-64) for a complete synonymy of the genotype; and the same author (Geol. Mag., Dec. VI, vol. V, 1918, pp. 314-16 and p. 324) for a discussion and definition of the subgenus.)

Homalonotus (Burmeisteria) huttoni n. sp. (Pl. I, figs. 4, 5.)

1887. Homalonotus sp. F. W. Hutton, Proc. Linn. Soc. N.S.W., 2nd Ser., vol. 11, pl. 11 (Aug. 31, 1887), pp. 257-58, no figure.

Material: A unique holotype in the Canterbury Museum⁽¹⁾.

Hutton's original description :---

I have obtained from Mr. R. Helms, of Greymouth, a very fine Tribolite belonging to the genus *Homalonotus*, which was found near Reefton, and, as it appears to be new to New Zealand, I give a description of it. The specimen is rolled up, and the anterior portion of the cephalic shield, as well as the posterior end of the pygidium, are absent. It is filled with brown chert, which cannot be scratched with a knife, but the exoskeleton is black.

cannot be scratched with a knife, but the exoskeleton is black. *The body* is elongate, tubercled, broadest at the base of the cephalic-shield, thence gradually tapering backwards to a point. The greatest breadth is 3.25 in., and the total length was probably about 8 in. or rather more.

Cephalic-shield.—The apex is gone, the posterior angles are broken, and the surface of the glabellum and fixed cheeks is much rubbed, so that the description of this part is necessarily deficient. The shield itself is broadly triangular, the ratio of length to breadth being about 2:3. The glabellum is distinctly lobed, but the surface is entirely rubbed away. The cheeks are inflated and bend suddenly down outside the eyes, the exterior margins are also incurved; the surface is covered with scattered granules, which are placed more closely together on the free cheeks and are especially close and coarse on the incurved exterior margins. The eyes are situated on large rounded swellings of the cheeks, but their surfaces are rubbed off. The facial suture is well marked, but as the posterior angles of the shield are broken off it is impossible to say whether it ran out exactly at that angle or a little in front of it.

The thorax is very indistinctly trilobed, and consists of thirteen segments, all of which are more or less tuberculose along a transverse rib on the posterior half of each segment. There are about seven or eight tubercles on the tergal portion of each segment and several smaller ones on the pleuræ. The tergal portion is smooth and very finely pitted, but the anterior portion of each pleura is coarsely granulated, resembling the granulations on the margins of the free cheeks.

The tubercles are irregularly placed. The length of the thorax is rather more than 4 in.

Pygidium.—Six segments only remain, each has about ten small tubercles on the tergal part and five or six on each pleura. The surface is smooth, except towards the margin, where there are scattered granules. The margin itself is incurved and coarsely granulated like that of the cheeks. Its length may have been about $1\frac{1}{2}$ in.

This species very closely resembles, and is perhaps identical with, *Homalonotus Herschelii* (Murchison), from South Africa, described and figured by Mr. Salter (Trans. Geol. Soc., 2nd Series, vol. VII, p. 215, pl. 24, figs. 1–7). The differences appear to be that our specimen is broader in proportion and the thoracic segments are flatter and with more tubercles. However, until the rostral and caudal portions are known it is impossible to give a decided opinion on this point. At any rate it belongs to a group highly characteristic of the Lower Devonian.

(1) My thanks are due to Professor R. Speight for permission to study this material.

Remarks: The single specimen described so completely by Hutton is still the only material available, and under the circumstances nothing need be added to his description. The fact that Hutton has placed the species correctly, and has deduced the true age from his comparison, is symptomatic of the general high ability and wide knowledge he displayed in his pioneer work in New Zealand. The species may fittingly be dedicated to him.

Burmeisteria is based upon Murchison's Homalonotus herscheli described from the Lower Devonian of South Africa (Bokkeveld beds) and later noted from the Falkland Islands by J. M. Clarke⁽¹⁾. E. Haug⁽²⁾ had previously recorded the same species from Devonian beds at Wady Lezy and Tindesset in the Sahara.

The Reefton fossil belongs to the herscheli group, but appears to be specifically distinct. It may be compared with H. quernus Lake(3), as interpreted by Reed(4), rather than with H. herscheli itself. With H. quernus the Reefton species agrees in the parabolic shape of the head-shield, in the ornamentation of head-shield and thorax, and in the shape and anterior truncation of the glabella.

It may be remarked, however, that many, if not all, of the Bokkeveld Homalonoti require revision from complete specimens. Reed (op. cit., 1918, p. 324) has suggested that Burmeisteria is restricted to the Southern Hemisphere, but in recent lists of Belgian fossils Maillieux(⁵) has referred H. armatus Burmeister(⁶) to this subgenus.

Subgenus DIGONUS Gurich, 1909.

Leitfossilien, Lief. ii. Devon, pp. 156-57.

Type (by original designation): Homalonotus gigas F. A. Roemer, 1843, Verstein. Harzgeb., p. 39, pl. XI, fig. 10.

Homalonotus (Digonus) expansus Hector, 1876. (Pl. I. fig. 1.)

1876. Homalonotus expansus J. Hector, Trans. N.Z. Inst., vol. IX, p. 602, pl. XXVII, fig. 2 (p. 474).

Material: Two syntypes, both imperfectly preserved and incomplete.

Description: (From lectotype). (Pl. I, fig. 1.)

Pygidium (imperfect and slightly crushed) more or less triangular, junction with thorax distinctly curved, transverse surface not noticeably convex. Axis defined, narrower than the pleuræ, elongated, pointed conical, not reaching the posterior margin, with thirteen or more Pleuræ wide, expanding laterally, ten in number, posterior members flattened annulations. directed longitudinally. Whole surface covered with exceedingly fine granulations.

Length of pygidium, 35 mm.; width of pygidium, 40 mm.

Locality 129, Rainy Creek, Reefton.

Remarks: The specimen figured by Hector on the right-hand side of his plate is here selected as lectotype of H. expansus. Thomson (1913, p. 31) records "4 syntypes, 3 figured." Of the four specimens before me labelled H. expansus, one is but the reverse of the figured lectotype, and Hector figured two specimens only. The material figured by Hector is from Locality 129, the third specimen and "syntype" is from Locality 130.

Hector's left-hand-side figure is probably referable to H. expansus, although it differs considerably from the lectotype in size and mode of preservation. It is poorly preserved.

The "syntype" from Locality 130 is a well preserved pygidium (pl. I, fig. 3). It differs from the lectotype chiefly in the presence of well-developed tubercles, and is possibly distinct from H. expansus. However, since so much confusion has in the past been caused by providing specific names for fragments of trilobites, and in view of probable sex differences among these organisms, it is not wise to name the single specimen. It may be described as follows :-

Pygidium widely parabolic, strongly arched transversely, slightly wider than long. Axis slightly convex, conical, moderately well defined, consisting of from 12 to 13 (or more) rounded

⁽¹⁾ Foss. Devon. Parana, 1913, pp. 93-97.

 ⁽¹⁾ Foss. Decom. Farana, 1913, pp. 93-97.
 (2) Mission Saharienne, Documents Scientifiques; Paléont., 1905, p. 772, pl. 14, figs. 5-6.
 (2) Ann. S. Afr. Mus., IV (4), 1904, p. 216, pl. XXVII, fig. 1.
 (4) Ibid., XXII, 1925, pp. 181-83, pl. X, fig. 1; pl. IX, fig. 13.
 (5) C.B. Cinq. Sess. Extraord. Soc. Géol. Min. Bretagne, 1925 (1926), p. 142.
 (5) See Koch. Abh. geol. Specialk, Preuss. Thüring-Staaten, Bd. IV, Heft 2, 1883, Atlas, taf. 1, figs. 1-6.

annulations which are granulated and carry a single row of large granules, point circumscribed and bluntly rounded, not reaching to the margin. Pleuræ arched and rounded, granulated, widening laterally and bearing a single row of large granules. Posterior lobes more or less longitudinal.

Length of pygidium, 35 mm.; width of pygidium, 50 mm.

Locality 130, Reefton.

The fragmentary state of this material, and, in particular, the lack of knowledge of the cephalon, precludes any comparative study at the present time.

The subgenus Digonus is restricted to the Lower Devonian, and occurs in the Harz, in the Belgian-Rhine area, France, South Africa, and Brazil.

It is of interest to note that the New Zealand Homalonoti are quite distinct from the Upper Silurian forms, H. harrisoni McCoy(1) and H. vomer Chapman(2), of Australia. F. R. C. Reed (Geol. Mag., Dec. VI, vol. V, 1918, p. 323) refers these species to the subgenus Trimerus Green(3), a group of Wenlockian trilobites found also in Europe and North America.

Division PHYLLOCARIDA Packard.

Family ECHINOCARIDÆ Clarke.

Echinocaris R. P. Whitfield, 1880.

Amer. Journ. Sci. ser. 3, vol. XIX (Jan.), p. 34.

Type (by original designation): Echinocaris sublevis Whitfield, 1880, pp. 36-37, not figured. Devonian, Ohio.

Echinocaris sp. ind. (Pl. III, fig. 8.)

In the Survey collection of fossils from Reefton there occurs a single specimen which appears to represent a cercopod or possibly a telson-spine of a Phyllocarid.

The fragment preserved is some 35 mm. in length, in the form of an elongated, tapering cone, slightly curved, and bearing strong carinæ on the exposed surface. There is no sign of other external ornament. The cross section is subcircular. A precise generic determination is not possible, but a provisional reference to Echinocaris is suggested. (cf. the cercopods and telsonspine of Echinocaris socialis Beecher, 1884 (see Beecher Quart. Journ. Geol. Soc., 58, 1902, pp. 441-43, pl. XVII). Echinocaris is restricted, as far as is known, to strata of Upper and Middle Devonian age.

UNDESCRIBED MATERIAL.

At least 25 per cent. of the Survey collection from Reefton is quite valueless, and the fragments of genera not recorded in this report are numerous. Amongst the Mollusca this is particularly the case, and the number of genera and species could be considerably increased if all the material was fit to describe. A pterineoid genus is apparently not uncommon. Several specimens, some of large size, of Orthoceras or an allied genus, likewise occur.

In the Brachiopoda there are probably several species of the Rhynchonellacea, which must be left undescribed for want of adequate material. Some Orthids, too, are present.

A bryozoan, probably *Fenestella*(⁴), is represented by numerous fragments.

It is quite safe to predict from the evidence of fragments alone that many more species will be obtained by careful collecting at Reefton. At the present time it would be foolish to cumber the literature with inadequate descriptions and valueless determinations.

 Prod. Pal. Vict., Dec. III, 1876, pp. 19-20, pl. 23, f. 11. Flemington (Melbournian).
 Proc. R.S. Vict., XXIV (n.s.), pt. II, 1912, pp. 198-99, pl. LXII, figs. 2, 3; pl. LXIII, figs. 1, 2. Wandong (Melbournian).

³) Monthly Amer. Jour. Geol., 1, 1832, p. 559.

4) During a recent visit to Reefton the writer found numerous fragments of this form on the weathered surfaces of impure limestone. It was not found in the argillites.

CHAPTER III.—AGE OF THE REEFTON BEDS.

The Geological Survey collection of Reefton fossils contains material from two localities: (a) Locality 129 (McKay, 1874), Rainy Creek, Reefton; (b) Locality 130 (McKay, 1874), Lankey Gully, Reefton.

J. A. Thomson (N.Z. Geol. Surv. Pal. Bull. No. 1, 1913, p. 92) records that McKay collected 71 specimens from Locality 129, and 1,272 from Locality 130.

Locality 129: The specimens from this locality examined by the writer were few in number, and noticeably different in general appearance from the material from Lankey Gully.

The species are—(1) Chonetes nigricans n. sp.; (2) Homalonotus (Digonus) expansus Hector. It is possible that the holotype of Homalonotus (Burmeisteria) huttoni n. sp. ("found near Reefton") may have been collected from Rainy Creek.

Locality 130—Lankey Gully, Reefton: The Survey collection from this locality contains material in several types of matrix, and obviously from different horizons. From a knowledge of the succession in Lankey Gully, gained since the systematic section was written, I now attempt to separate McKay's material into groups that agree with my field observations. The following species may be grouped together, and are without any doubt derived from the argillites, some 600 ft. in thickness, which lie below the coral limestone of Lankey Gully:—

- 1. Proschizophoria cf. provulvaria (Maurer).
- 2. Leptostrophia reeftonensis n. sp.
- 3. Chonetes maoria n. sp.
- 4. Acrospirifer cf. hercyniae (Giebel).
- 5. Acrospirifer cf. hystericus (Schlotheim).
- 6. Eatonia parki n. sp.
- 7. Meganteris neozelanica n. sp.

The following are probably from the argillites, but their presence therein is not an observed fact: *Pleurodictyum* cf. problematicum Goldfuss, *Lingulidiscina ranfti* n. sp., *Leptocoelia flabellites* (Conrad), *Grammysia (Grammysioidea (?))* sp. ind., *Palaeneilo* sp. ind., *Goniophora hendersoni* n. sp., and *Platyceras* sp. ind.

In deriving the age of the Reefton argillites from the evidence of the contained fauna the greatest accuracy may be obtained by considering only those Reefton species which are the *characteristic fossils* for these beds. The evidence to be deduced from the affinities of those species which are sparsely represented, and which are not then essential components of this Lower Devonian animal community, is liable to be misleading, and hence may be neglected. A characteristic fossil has recently been defined by a Committee of the British Association for the Advancement of Science(¹), as follows :--

"A characteristic fossil is one, either genus or species, that is restricted to a particular horizon, or is abundant at the horizon and comparatively rare elsewhere, so that its presence in a bed would raise a clear presumption of the stratigraphical position or age of the bed."

This definition is open to criticism in that it does not stress the fact that the chief point concerning a characteristic fossil is that it is one which had a wide range of physical stability, and hence was not affected by minor changes in the physical environment. Generally speaking a characteristic fossil of a given age or zone will be abundant in most outcrops of a given formation of the same general facies.

(1) "A List of Characteristic Fossils," London, B.A.A.S. Pamphlet No. 18, reprinted from the report of the Toronto Meeting, 1924.

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-	Characteristic Species of the Reefton Beds.	Western European Equivalent.	Range of European Species.	Zone or Horizon at which European Species is a Characteristic Fossil.	
1	Acrospirifer cf. hercyniae (Giebel)	A. hercyniae (Giebel)	Upper Siegenian to Emsian	Belgium : Assise de Pesche (basal Emsian) and Upper Siegenian. Eifel : Untercoblenzschichten.	
2	Acrospirifer cf. hystericus (Schloth.)	A. hystericus (Schloth.)	Lower Siegenian to Upper Siegenian	Belgium : Upper Siegenian. Siegen : Herdorfer Schichten.	
3	Leptostrophia reeftonensis n. sp.	L. explanata (Sow.)	Middle Siegenian to Emsian	Belgium : Abundant in basal Emsian, and in the Hunsrückian (= U. & M. Siegenian). Eifel : Untercoblenzschichten.	
4	Proschizophoria cf. pro- vulvaria (Maurer)	P. provulvaria (Maurer)	Lower Siegenian to Basal Emsian	Belgium : Hunsrückian. Siegen : Herdorfer Schichten.	
5	Meganteris neozelanica n. sp.	$ \begin{array}{l} M. \ suessi \ Drevermann \\ = \ M. \ archiaci \ Suess \\ (non \ Vern.) \end{array} $	Middle Siegenian to Basal Emsian	Belgium : Basal Emsian and Upper Siegenian. Eifel : Untercoblenzschichten.	
6	Chonetes maoria n. sp.	C. sarcinulata (Schloth.)	Middle Siegenian to Emsian	Belgium : Upper Siegenian. Siegen : Herdorfer Schichten.	

The characteristic fossils(1) of the Reefton beds under discussion, are relatively few in number, and are tabulated below :---

NOTE.-(1) Upper Siegenian = Upper Hunstückian = Herdorfer Horizont of the Siegener-Schichten. (2) Assise de Pesche = Basal Emstan = Untercoblenzschichten.

This analysis shows conclusively that the age of these beds at Reefton is within the period Upper Siegenian to Lower Emsian. Three species, Acrospirifer cf. hystericus, Proschizophoria cf. provulvaria, and Chonetes maoria n. sp., point definitely to an Upper Siegenian age. Acrospirifer hercyniae is particularly characteristic of the Belgian Lower Emsian, and of the German Untercoblenzschichten, but Asselberghs (1913, p. 103) remarks that it is abundant in the Ardennes in Upper Siegenian strata. Leptostrophia explanata is perhaps more characteristic of the Lower Emsian in both Belgium and Germany, but it, too, is abundant in the Upper Siegenian of Belgium. Meganteris suessi is most characteristic of Lower Emsian horizons, but likewise is abundant in the Upper Siegenian of Belgium.

The weight of the evidence points to a correlation with the Upper Siegenian of Belgium, but the inference that both Upper Siegenian and Lower Emsian horizons are represented at Reefton is a legitimate one from the comparisons instituted.

It may be remarked that of the species other than those considered characteristic none suggests an age which conflicts with the above conclusion.

The degree of similarity between the characteristic fossils of the Reefton beds and their equivalents in Western Europe is so extraordinarily high that no hesitation is felt in utilizing the stratigraphical terms employed for the Belgian-Rhine succession. This statement holds good, in the author's belief, in spite of, first, a small New Zealand or austral element in the Reefton fauna, which is to be expected; and, second, the absence from Reefton of certain groups such as the Rensselaerias and Stropheodontas, which are highly important in Western Europe and there provide some of the characteristic fossils such as, in the Upper Siegenian, *Rensselaeria strigiceps*, or, in the Emsian, *Stropheodonta murchisoni*.

Fossils from the Limestones of Lankey Gully.—A second group of fossils, also based upon field observation, may be separated from the Survey collection. These fossils are preserved in darkcoloured (blue-grey) impure limestones, and these beds overlie the Lower Devonian argillites noted above.

The limestone fossils are-

- 1. Eridophyllum bartrumi n. sp.
- 2. "Cyathophyllum" dunstani Eth. fil.
- 3. Favosites murrumbidgeensis O. A. Jones MSS.
- 4. Fistulipora cf. trifoliata Schlüter.
- 5. Lioclema (?) reeftonensis n. sp.

(1) Fortunately all the species here listed as characteristic are known by actual observation to be from the argillites.

The most significant feature of the list, is the presence of two Australian, Middle Devonian species—" Cyathophyllum" dunstani Eth. fil., and Favosites murrumbidgeensis Jones MSS. The first is described from Clermont in Queensland from the North-eastern (Upper Middle Devonian) Province of W. N. Benson⁽¹⁾, and the second occurs in the same province, and in the South-eastern Province, in the Murrumbidgee area. A discussion of the value of Benson's "provinces" in the Middle Devonian of Australia is tempting but hardly germane to the present inquiry. This author has noted that "there is to be seen a marked affinity between the south-eastern and north-eastern (Givetian) faunas." (1922, p. 97.) The third coral from Reefton, Eridophyllum bartrumi n. sp. is likewise a Middle Devonian type.

The evidence, therefore, points fairly conclusively to a Middle Devonian age for the Reefton limestones, but the fauna is too small to allow of a more precise limitation.

Dechenella (Eudechenella) mackayi n. sp., a tribolite preserved in a light-green limestone, also suggests a Middle Devonian age. It is not included in the list above because I have not seen a similar matrix in the field.

From the point of view of palæogeography the evidence suggests that the Reefton area was flooded by the Australian Middle Devonian transgression, or by a sea connected therewith.

Certain species noted in the systematic section cannot be placed with any degree of certainty with either of the groups noted above. These include—"Spirifer" chapmani n. sp., "Spirifer" bensoni n. sp., Camarotoechia mackayi n. sp., Tentaculites sp. ind., and Echinocaris sp. ind. The second and third species occur on the same slab of rock.

(1) Rec. Geol. Surv. N.S.W., X (2), 1922, p. 93, et. seq., and pls. XIII, XIV.

CHAPTER IV.—ORIGIN OF THE LOWER DEVONIAN FAUNA OF REEFTON.

From the discussion of the characteristic species given above it will be clear that the Reefton fauna is most closely allied to that of the Western European area, Belgium and Germany. This is perhaps the most unexpected result of this study, for the two areas are literally poles apart. Comparable species are—

REEFTON.	WESTERN EUROPE.
1. Pleurodictyum cf. problematicum Goldfuss	P. problematicum Goldfuss.
2. Proschizophoria cf. provulvaria (Maurer)	P. provulvaria (Maurer).
3. Leptostrophia reeftonensis n. sp	L. explanata (Sow.).
4. Chonetes maoria n. sp	C. sarcinulata (Schloth.).
5. Acrospirifer cf. hercyniae (Giebel)	A. hercyniae (Giebel.).
6. Acrospirifer cf. hystericus (Schlotheim)	A. hystericus (Schloth.).
7. Meganteris neozelanica n. sp.	M. suessi Drevermann.

This resemblance is all the more remarkable when it is remembered that six of the Reefton species listed are there characteristic, while all the European species are characteristic of either Upper Siegenian or Lower Emsian horizons. How can this be explained in terms of Lower Devonian geography? Do the facts warrant a direct and intimate marine connection between New Zealand and Western Europe? If so, what was the route by which migration occurred?

A comparison of the Reefton fauna with those of areas other than Western Europe should throw light on this problem. With the North-eastern American Lower Devonian fauna the following comparisons may be suggested :---

	REEFTON.			North-eastern America.	
1	. Pleurodictyum cf. problematicum Gold	fuss	••	P. cf. problematicum Goldf.	
2	2. Leptostrophia reeftonensis n. sp.	••		L. magnifica (Hall).	
3	3. Acrospirifer cf. hercyniae (Giebel)	••	•••	A. gaspensis (Billings).	
4	Acrospirifer cf. hystericus (Schloth.)	••		A. cyclopterus (Hall).	
5	5. Leptocoelia flabellites (Conrad)	••		L. flabellites (Conrad).	
6	6. Meganteris neozelanica n. sp	••	••	M. diobolaris Clarke.	

In this comparison *Pleurodictyum* means little, for in both cases the species is provisional and not important. *Leptocoelia flabellites* (Conrad) is a very characteristic Oriskanian species, but is rare at Reefton. In the case of the other four species the Reefton fossils agree with the North American forms only where the latter agree with the Western European equivalents.

The characteristic species of the Oriskanian, as a whole, are absent from Reefton. It is clear that a migration from Europe to New Zealand (or *vice versa*) via North-eastern America has not occurred.

One might have expected a fairly close agreement between New Zealand and the comparatively near "austral" area of South Africa, the Falkland Islands, and South America in the Lower Devonian. Such, however, is not the case. Comparable species are—

	REEFTON.		"AUSTRAL" LOWER DEVONIAN.
1.	Lingulidiscina ranfti n. sp	••	Orbiculoidea (?) aberrans Reed
	•		(Bokkeveld beds).
2.	Leptocoelia flabellites (Conrad)	••	L. flabellites (Conrad), (Wide-
	•		spread).
3.	Homalonotus huttoni n. sp	••	H. quernus Lake (Bokkeveld
			beds).

The relationship is obviously not very close. None of the species characteristic at Reefton occur in the "Austral" Lower Devonian "province."

There is no evidence, as far as I am aware, that migration was possible along either a Tethys or a circum-Pacific route during Lower Devonian times. No strata comparable in facies or fauna with those at Reefton are known in the Mediterranean region, India, Southern China, or Australia.

All attempts in the past to delineate Lower Devonian provinces have failed to take into consideration the fundamental factor of the physical environment, and its resultant impress upon the sediments, and upon the contained faunas.

It is suggested then that facies has been the dominant element in the distribution of marine faunas at this period. The evidence points to a cosmopolitan fauna, which, as to-day, would vary with such factors as temperature, light, salinity, food conditions, and so on.

Species-groups at least must have been world-wide, as is clear from the distribution of the gens of *Spirifer hercyniae* Giebel discussed in detail above. That this is not an isolated case is also abundantly clear from the study of the Lower Devonian Leptostrophias, and other groups.

It is therefore possible to state that the Reefton fauna is most closely related to that of the same age in Western Europe not because of geographical station, but because in both areas the physical conditions were identical, and that those parts of the cosmopolitan fauna inhabiting those areas being subjected to, or stimulated by, a similar set of environmental controls, are therefore closely related in their characteristic fossils.

Similarly the Reefton fauna differs in its characteristic members from those of the Bokkeveld beds in South Africa not because one area is isolated from the other, but because the environment was dissimilar in the two areas.

A limitation of the above conclusions suggests itself. It will be noted that the characteristic species at Reefton are all brachiopods. This is general among Lower Devonian faunas, but in the calcareous facies, and in certain areas in arenaceous and argillaceous facies, trilobites and mollusca form important faunal elements. This is the case in the Helderbergian of North America, and in the "austral" province, including Parana, the Falkland Islands, and South Africa.

It is suggested therefore that conclusions based entirely upon the distribution of speciesgroups of Brachiopoda may not be valid when applied to other groups, and in particular to the Trilobita. The Brachiopoda apparently possessed a means of distribution—possibly in the larval stage of development only—which was not shared by the Trilobita.

It is thus possible to reconcile to some extent such apparently opposed views as those of J. M. Clarke and F. R. C. Reed, on one hand, and the writer on the other. The former palæontologists consider that the austral as opposed to the boreal aspect of the South American-South African Lower Devonian faunas is marked, and is due to isolation. The writer would suggest that members of cosmopolitan species-groups occur in this austral fauna. In the first case Clarke and Reed tend to stress the evidence of the trilobites, in the second the writer instituted comparisons among the Brachiopoda. Clarke has also stressed the austral aspect of certain of the Brachiopoda, but the writer believes that he has overemphasized his case.

Both in New Zealand and in Western Europe the trilobite element is unimportant, and, generally speaking, the Brachiopoda afford the only evidence which makes possible comparisons between widely separated areas in Lower Devonian times.

In the above discussion it has been stated that during the Lower Devonian the Brachiopoda were cosmopolitan in distribution. The evidence is quite conclusive. This would appear to demand wide powers of distribution for these organisms in their larval stages.

It must be noted that such evidence as is available from the study of Recent Brachiopoda, while it does not preclude the possibility suggested, is not strongly in favour of it.

3*
Blochmann⁽¹⁾ has concluded, from a somewhat restricted study, that the power of distribution in Brachiopoda, other than Lingulids and Discinids, is very limited, and that the larvæ are unable to cross the ocean from one coast to another. J. A. Thomson, in discussing Blochmann's work, stated, "Before these conclusions can be regarded as definitely established, however, more must be learnt of the structure of the larvæ and of the duration of the free-swimming stage in a larger and more varied series of genera "(²).

Thomson has cited a case of brachiopod migration which is perhaps not without significance. There is strong evidence of a migration, first suggested by W. H. Dall, of northern and central American brachiopods down the coast of South America to Antarctica. *Macandrevia diamantina* Dall, from off Coats Land, Antarctica, is a Panamic species. "Moreover, the two other Antarctic species, *M. vanhoffeni* Blochmann and *M. lata* Thomson, are closely comparable to the Panamic species *M. craniella* Dall and *M. americana* Dall respectively." (Thomson, 1927, p. 241.)

"The southward migration of *Macandrevia* must be assumed to be post-Miocene, since no species of the genus are known from the Oligocene-Miocene of South America, the Antarctic, or New Zealand." (Thomson, 1927, p. 241.)

The suggestion of widespread distribution of Lower Devonian species-groups is therefore quite tenable. It may be noted, too, that such Lower Devonian groups as the Spiriferids, the Leptostrophias, and the Orthids are extinct, and that the powers of distribution of these ancient groups may well have exceeded those of the modern Terebratulids and Terebratellids.

In a valuable criticism of the writer's manuscript, Professor O. T. Jones, of the University of Manchester, suggested that the wide distribution of Lower Devonian brachiopods was to be explained by migration along coast-lines. He was unable to accept my plea for special powers of larval distribution in Lower Devonian groups. If he is correct, then the remarkable similarity between the Lower Devonian faunas of this Dominion and Western Europe demands an actual shallow-water coastal connection between the two areas.

It has been shown that a migration via the Americas or South Africa is not feasible. It remains to postulate a migration (a) via a Devonian Tethys or (b) via the Arctic and so into the Pacific and New Zealand down a Western-Pacific Coast.

As far as I am aware, there is absolutely no evidence of Lower Devonian rocks with comparable faunas along either of these routes. This is not in itself an insuperable objection, especially so when the knowledge of Asiatic geology is so imperfect.

Further speculations along these lines would appear to be of little value in the present state of our ignorance.

(1) Zur Systematik und Geographischen Verbreitung der Brachiopoden. Zeitschr. f. Wissensch. Zool., Bd. 90, 1908, pp. 596-644.

(2) New Zealand Board Sci. and Art, Man. No. 7, 1927, p. 47.

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PART II.-LOWER DEVONIAN COMMUNITIES IN RELATION TO THE BASE OF THE DEVONIAN SYSTEM.

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INTRODUCTION.

The axiom, first enunciated clearly by James Hutton and John Plavfair, and later to be the leading principle of Lyell's geological teaching, that the present provides the key to the interpretation of the past, is still valid. The problem of the distribution of Palæozoic marine faunas, and hence of their bearing on correlation and classification, is best approached in the light of modern knowledge of the present-day distribution of marine faunas. In this connection the detailed and excellent work carried out by the Danish Biological Station under the direction of C. G. J. Petersen during the period 1883-1917 is particularly instructive. The value of this type of work was first brought to the notice of geologists by Miss G. L. Elles in her presidential address to the British Association in Liverpool in 1923(1).

The idea of animal communities was first elaborated by Petersen in 1914(2), and a subsequent extension of the research was summarized in $1918(^3)$.

In the waters surrounding the Island of Zealand, in the Kattegat, and in the Skagerrak, Petersen recognized eight typical animal communities based primarily upon "characteristic animals" belonging to the mollusca and the echinodermata.

It is not necessary to detail Petersen's communities here. Miss Elles has summarized some of the more important conclusions as follows :---

"(1) That certain characteristic animal communities undoubtedly exist under certain physical · conditions, and when these conditions remain constant even over wide areas the same community will be found, but each community is bounded by those physical conditions.

"(2) That change in physical conditions brings about a change in the characteristic animal community, though certain organisms may be found in more than one community.

"(3) The physical changes to be correlated with the change in community are those of temperature, salinity, and clearness of the water; depth as depth seems to be less important than the factors which go with depth, such as temperature, amount of light, character of the sea-bottom, and quietness of the water." (1923, p. 2.)

"(4) The difference between the *characteristic* animals of the communities living in waters of different depth is so great that none of the animals are common to both."

(2) The Animal Communities of the Sea-bottom and their importance for Marine Zoogeography. Rep. Danish Biol. Station, XXI, 1913 (114), pp. 1-68. (3) The Sea-bottom and its Production of Fish-food. Ibid., XXV, 1918, pp. 9-21.

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⁽¹⁾ Evolutional Palæontology in Relation to the Lower Palæozoic Rocks, pp. 2-3.

Petersen makes a further point of some importance. Certain communities are largely independent of physical conditions, thus the *Macoma* community is practically independent of conditions of bottom, clearness of water, temperature and salinity; but in spite of this and its many facies it is remarkably uniform in its characteristic species over wide areas, and does not to any extent overlap other communities.

Petersen considers this case inexplicable under purely physical conditions, and explains it by introducing the biological factor, *i.e.*, competition. The boundary of the *Macoma* community is determined by that of the *Venus* community, for where *Venus* exists *Macoma* is unable to gain a footing.

Thus the biological factor can be of major importance—and, it may be noted, cannot be assessed by the geologist—but, as Petersen explains, the physical factors are easier to understand and observe and are much less complicated. It is not necessary to assume a direct causal connection between this or that physical condition and a particular distribution, but it is possible to state that uniform physical conditions support uniform animal communities.

It must also be noted that characteristic animals can be recognized in succession along a profile from shallow to deep water. If the succession were plotted on a map the various communities would appear in belts or zones. (Petersen, 1914, p. 10.)

Finally it is to be noted that all the species listed from one locality are obviously not of the same importance, hence a mere list of species does not indicate the animals characteristic of any locality or community.

"The animals, which are not seasonal and which compose an important part of the whole mass of the community, owing to number or weight, will presumably be best suited for characterizing the community, and must also be considered as giving a good idea of the outer conditions on which the community is dependent." (Petersen, 1914, pp. 4-5.)

The importance of this discussion from the geological point of view, as pointed out originally by Petersen, and elaborated by Miss Elles, is that the *characteristic animal* of the neontologist is equivalent to the *characteristic fossil* of the paleeontologist.

In any one area it should be possible to determine a succession of faunal communities in time, and a faunistic classification is thus rendered possible which is superior to, and independent of, the host of local stratigraphical names which so encumbers geological literature. If the faunal chronology be based upon the open-water facies of a particular age, then a classification results that will be of international use. The major stratigraphical units might then be determined with reference to the limits between suitably chosen faunal communities and not, as at present, by lithological criteria.

From the point of view of correlation the concept of the faunal community is obviously fundamental, and false correlation based solely upon lists of species or genera may be corrected by its use.

In the sequel an attempt is made to determine faunal communities of characteristic species in vertical succession in the shallow-water sandstone-mudstone facies of the Western European sequence.

This will be followed by the definition of related communities in the shallow-water facies outside the Western European area, and finally the question of the international status of the limit between the Devonian and the Silurian periods will be discussed after dealing with communities in the open-water calcareous facies of Lower Devonian age.

It is obvious that all members of a faunal community are not of equal value in the life and development of that community. Some species play a dominant role, others are so rare as to be unimportant, while others may be stray migrants or seasonal visitors. The method almost universally adopted by paleeontologists and stratigraphers of providing a mere list of species gives no clue to the interrelationships of the component members of that list, whether it be of fossils from a particular locality or of a particular age.

Faunal communities can only be satisfactorily determined in the field, and the attempt to decide from literature alone which species are characteristic of faunas in areas not personally studied is hopeless in most cases.

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But, granted the necessary field work, how is the community to be determined? What unit is most convenient? Three modes of approach seem to be available. First a community may be expressed in terms of its major groups, thus to take the case of the "austral" Lower Devonian fauna of South America and South Africa, as composed of trilobites, mollusca, and brachiopods, or more precisely, as a Phacopid-Taxodont-Spiriferid community. A distinct community of the same age might be a Homalonotid-Aviculid-Orthid community, and so on. This method is valuable, but does not allow of very detailed analysis.

The second scheme makes use of the generic groupings in a community. The genera selected will be those which contain the greatest number of abundant species. To take the same case as above, the community consists essentially of the genera *Homalonotus-Cryphaeus-Calmonia-Conularia-Palaeoneilo-Spirifer-Orbiculoidea* and *Lingula*. This method is very unsatisfactory and difficult of application.

The most suitable method, and that adopted by Petersen for Recent communities, is to express the assemblage in terms of the *characteristic species*, that is to say, those fossils which by number or bulk form the major elements of the fauna. The factor of importance is the relative abundance of the characteristic fossils.

The characteristic species of the "austral" Lower Devonian include Spirifer antarcticus Morris and Sharpe, Leptocoelia flabellites (Conrad), Chonetes falklandicus Morris and Sharpe, and Orbiculoidea baini (Sharpe). These four species, and others to be noted in the sequel, occur abundantly in such widely separated areas as Bolivia, Brazil, Argentine, the Falkland Islands, and South Africa.

It should be noted that the characteristic species do not always belong to what were defined above as the dominant genera, and this fact shows one of the unsatisfactory features of a generic grouping.

To avoid circumlocution one of the characteristic species is chosen to provide a convenient community name. The particular case cited might be called the *antarcticus*-fauna or community from the first-named species.

It should be recognized that characteristic species are not necessarily restricted to one community. Such a species might have an extended range as an unimportant member of successive communities before or after it had been characteristic of a particular community. Further, in some cases the same species may be characteristic of two successive communities, but here the majority of its associates would be dissimilar in each case.

FAUNAL COMMUNITIES IN THE LOWER EMSIAN AND SIEGENIAN OF WESTERN $EUROPE(^1)$.

Lower Devonian marine sediments are widespread in the South of England, Belgium, and the Rhenish Schiefergebirge, and over this area, although local differences due to various causes may be noted, the general facies resemblance is strong.

The deposits were laid down in the relatively shallow-water seas forming the southern margins of the great continental area of North Europe. The fauna is littoral, and, as a whole, differs markedly from that which flourished at the same time farther to the South, where the clear-water calcareous strata were deposited.

The Rhenian area is of particular interest, because in it alone is it possible to trace a chronological series of faunal communities. Further, by comparing Rhenian communities with homotaxial faunas elsewhere it can be shown that a facies change in strata of the same age can, and does, bring about changes in the characteristic fossils. Also in an area outside Western Europe, when the facies is the same as that in Western Europe, the characteristic species are identical or closely allied.

It is not necessary to provide historical data concerning the stratigraphical nomenclature used herein; reference may be made on this question to papers by Maillieux and Asselberghs :----

MAILLIEUX, E. (1920): Pourquoi le terme Coblencien (Coblenzien, Coblenzien) devrait disparaître de la Nomenclature Stratigraphique. Bull. Soc. Belge. Géol., t. XXX (1920), Proc. Verb., pp. 6-13.

ASSELBERGRS, E. (1927): Siegenian, Siegenerschichten, Hunsruckschiefer et Taunusquarzit Bull. Soc. Belge. Géol., t. XXXVI (1926), pp. 206-22.

(1) See note on following page.

The lists of characteristic fossils cited below were forwarded for criticism to Professor E. Asselberghs, of Louvain. The writer then received lists prepared by Professor Asselberghs, and based upon his extensive field-knowledge of the Belgian area. The two sets of lists showed a marked agreement. My thanks are due to Professor Asselberghs for his kindness, and for supplementing the data concerning Lower Emsian and Taunusian communities.

The species of the Lower Emsian (Assise de Pesche, Ahrian, or Daunian) of Belgium have been listed by Maillieux (1926, pp. 140-43), but the relative abundance is not indicated. Asselberghs (1922, p. 144), however, has noted the most characteristic species from this horizon from Schiebach and Burg-Reuland.

These are Spirifer carinatus Schnur, Sp. hercyniae Giebel, Sp. subcuspidatus Schnur, Sp. arduennensis Schnur, Camarotoechia daleidensis (F. Roemer), Trigeria gaudryi (Oehlert) Leiopteria crenatolamellosa Sandberger, and L. pseudolaevis (Oehlert).

Also important are Pleurodictyum problematicum Goldfuss, Tropidoleptus rhenana Frech, Chonetes plebeja Schnur, Ch. sarcinulata (Schlotheim) Ch. dilatata (Roemer), Athyris caeraesanoides Steininger, Dielasma rhenana Drevermann, Meganteris suessi Drevermann, Cornellites costata (Goldfuss), Goniophora schwerdi Beushausen, and Grammysia ovata Sandberger.

This community may be termed the hercyniae-fauna, from Spirifer hercyniae Giebel.

The hercyniae-fauna has been monographed by Drevermann (1902) from the Untercoblenzschichten of Oberstadtfeld in the Eifel. The writer obtained a small but excellent collection The most characteristic species are-Pleurodictyum problematicum Goldfuss, from this locality. Spirifer hercyniae Giebel, Sp. arduennensis Schnur, Sp. carinatus Schnur, Athyris undata (Defrance), Tropidoleptus rhenana Frech, Meganteris suessi Drevermann, Dalmanella circularis (Sowerby), and Leptostrophia explanata (Sowerby).

The characteristic species of the Upper Siegenian of the Ardennes are indicated in the list provided by Asselberghs (1927, pp. 208-9). They are Spirifer hystericus (Schlotheim), Tropidoleptus rhenana Frech, Rhenorensselaeria strigiceps (Roemer), Trigeria gaudryi (Oehlert), and Tentaculites scalaris Schlotheim. Also abundant are Schizophoria provulvaria (Maurer),

(1) Since this section was written in 1929 the results of important studies in Belgium and Germany have been published. These are listed below, but since many of them are not available to me I am not able to incorporate the new data in the body of the work.

DAHMER, G. (1929): Waren Hunsrück und Taunus zur Zeit der Wende Unterdevon-Mitteldevon Land ? Jahrb. Preuss. Geol. Landesanst. xlix, pp. 1152–62, pl. lxxiii. — (1931): Fauna der belgischen "Quartzophyllades de Longlier" in Siegener Rauhflaserschichten auf

Blatt Neuwied. Ibid, lii.

Die Greiner auf der Greinen der Stratigraphie und Tektonic der Siegener Schichten zwischen Sieg und Rhein. Verb. naturb. Ver. preuss. Rheinl., lxxxvi, pp. 65-87.
 QUIRING, H. (1930): Neue Beiträge zur Geologie des Siegerlandes und Westerwaldes. II. Die Grenze der

Siegener Schichten und die Verbreitung des Hunsrückschlefers an der Südflanke des Siegener Hauptsattels. Jahrb. Preuss. Geol. Landesanst., L, (2), pp. 505-9, pl. xxix.

MAILLIEUX, E. (1931): La Faune des grès et schistes de Solières (Siegenien moyen). Mém. Mus. roy. Hist. nat. Belg., 51, 1931.

(1932): Un Aspect nouveau de Dévonien inférieur de l'Ardenne. Bull. Mus. roy. Hist. nat. Belg., vii, No. 17, pp. 1-18.

M. Maillieux's second paper, which has been available to me through the courtesy of Professor R. Speight, contains a lucid summary of this recent work.

Some points of outstanding importance are as follows :--

(1) The recognition by Quiring of the "Hunsrückstufe" as intermediate in age between the Emsian and the Siegenian. The sequence of beds in the Rhine area (Rhénanie) is now as follows :---

Lower Emsian Unterkoblenzschichten. . . 2. Hunsrückian (a) Bornicher Horizont. Cauber Horizont. (b)3. Siegenian Taunusquarzit. (a) Herdorferschichten. (b) Rauhflaserschichten. Tonschieferschichten. (d)Gedinneschichten. 4. Gedinnian

(2) The true Taunusquarzit is at the summit, not at the base, of the Siegener Schichten. It will be noted that the correlations suggested or accepted by Asselberghs (1927), and employed by the writer herein, must be modified in accordance with the above scheme.

(3) If the sequence established in Germany by Quiring is valid, important breaks, hitherto unrecognized, must be present in the Ardennes. (Cf. Maillieux, 1932, table, pp. 16-17.)

Leptostrophia explanata (Sowerby), Chonetes plebeja Schnur, Ch. sarcinulata (Schloth.), Camarotoechia daleidensis (R. Roem), Leiopteria pseudolaevis (Oehlert), Grammysia ovata Sandberger, Asteropyge drevermanni (Richter), and Homalonotus maillieuxi Asselberghs.

This assemblage may be termed the *hystericus*-fauna, from *Spirifer hystericus* (Schlotheim). The *hystericus*-fauna is recorded from the southern border of the Bassin de Couvin by Maillieux (1926, pp. 137-38 (Sg. 2B)), but the relative abundance of the species there is not indicated.

In Germany Quiring (1923, pp. 99 et seq.) has listed the hystericus-fauna from the Herdorfer Schichten, the top horizon of the Siegener Schichten. The characteristic fossils there are— Tropidoleptus rhenana Frech, Chonetes plebeja (Schnur), Ch. sarcinulata (Schloth.), Spirifer hystericus (Schloth.), Rhenorensselaeria strigiceps (Roemer), and Tentaculites scalaris (Schloth.), all of which are characteristic of the same fauna in the Ardennes.

The characteristic fossils of the Middle Siegenian have been cited by Asselberghs (1921, p. 165). They include Proschizophoria personata (Zeiler) em. Kayser, Stropheodonta murchisoni Archiac and Verneuil, S. sedgwick A. and V., S. gigas (M'Coy), Schuchertella ingens Drevermann, Spirifer hystericus (Schlotheim), S. excavatus Kayser, S. primaevus Stein., Rhenorensselaeria strigiceps (Roemer), Uncinulus frontecostatus Drevermann, Cornellites paillettei (Vern. and Barrande), Grammysia taunica Kayser, and Asteropyge drevermanni (Richter).

This assemblage may be termed the primaevus-fauna from Spirifer primaevus Steininger.

The above list was based upon the middle Siegenian of the Ardennes. The fauna from the same stage in the southern border of the Bassin de Dinant has been listed by Maillieux (1926, pp. 137-38 (Sg. 2A)), but, while all the species cited above, except three, occur, Maillieux has not indicated the relative abundance.

The primaevus-fauna is also found in the Rauhflaserschichten of Germany, the middle member of the Siegener Schichten. The fauna is listed by Quiring (1923, p. 94), but again the relative abundance of the species is not given. However, in company with Dr. W. Henke, the writer visited Gensberg, and the characteristic species there included Spirifer primaevus Steininger, Sp. solitarius Krantz, Proschizophoria personata (Zeiler) em. Kayser, Sp. hystericus (Schlotheim), Stropheodonta sedgwicki A. and V., and Athyris avirostris Krantz. The primaevusfauna from Seifen, Westerwald, had been admirably described by Drevermann (1904), while the Ardennes occurrence has been treated by Asselberghs (1913).

The writer collected the primaevus-fauna at Radelange (see Asselberghs, 1913, pp. 64-66, for a complete faunal list) in the Ardennes. The characteristic species collected were Spirifer primaevus Stein., Proschizophoria personata (Zeiler) em. Kayser, Stropheodonta murchisoni A. and V. (very abundant), St. gigas (M'Coy), and Athyris avirostris Krantz. The fauna is remarkable for the large size of the individuals.

Asselberghs (1923) has demonstrated that the *primaevus*-fauna is present in the middle member of the Meadfoot beds at Looe in Cornwall.

The fauna of the Lower Siegenian (Taunusian or Assise d'Anor) in Belgium has been listed by Maillieux (1926, pp. 135-36), but the characteristic species are not indicated. Asselberghs (1927, pp. 211-12) has given a concise summary of the lithology and correlation thereof with the German sequence. Quiring (1923, pp. 90-92) has discussed the fauna, poorly preserved, of the equivalent Tonschiefer Horizont of the Siegener Schichten. The writer made **a** small collection from Moulin des Bois near Petigny (see faunal list given by Maillieux, 1926, pp. 135-36). The most abundant species collected were *Rhenorensselaeria crassicosta* (Koch), *Stropheodonta sedgwicki* (Arch. and Vern.), *Spirifer hystericus* (Schlotheim), *Athyris undata* (Defrance), and *Cornellites paillettei* (Vern. and Barrande).

This may be termed the sedgwicki-fauna from Stropheodonta sedgwicki (Arch. and Vern.).

The sedgwicki-fauna is found in the Taunus and Hunsrück areas in Germany in the Taunusquarzit. The characteristic fossils (leitformen) cited by Kayser (1923, p. 181) are: Rhenorensselaeria crassicosta Koch, R. strigiceps (Roemer), Spirifer primaevus Stein., Sp. hystericus (Schloth.), Kochia capuliformis (Koch), Myalina crassitesta (Kayser), Proschizophoria personata (Zeiler) em. Kayser, and Cornellites paillettei (Vern. and Barr.). The extensive fauna of the Taunusquarzit of Katzenelnbogen has been monographed by Kegel (1913).

Professor Asselberghs has kindly supplied a list of the most characteristic fossils of the Taunusian of Belgium as follows: Rhenorensselaeria crassicosta (Koch), Spirifer primaevus Steininger, Sp. hystericus (Schlotheim), Sp. excavatus Kayser, Sp. bischofi (A. Roemer), Trigeria guerangeri (Verneuil.), Rousseauia pseudocapuliformis (Beushausen), Kochia capuliformis (Koch) Cornellites paillettei (Vern. and Barr.), Stropheodonta sedgwicki (A. and V.), and Plethorhynchus papilio (Krantz).

The relation of the Lower Devonian strata of the Mittelrheinfacies of Fuchs (1907, p. 118) to those of the same general age in Belgium and in Westerwald is difficult to determine. Asselberghs (1927, pp. 216-19) has given an excellent discussion of this question, and may be quoted at length :---

"Si la plupart des géologues allemands admettent, à la suite de Frech, Holzapfel et Kayser, la superposition des *Hunsrückschiefer* sur le *Taunusquarzit*, il y en a quelques-uns, tel Wedekind, qui considèrent le *Taunusquarzit* comme un facies d'une partie des *Hunsrückschiefer*. Ils suivent en cela l'opinion émise par Gosselet, en 1890.

"Il semble bien cette dernière hypothese est la plus probable et que le *Taunusquarzit stricto* sensu du Taunus (grès blancs avec accessoirement des phyllades) est représenté dans des régions voisines par des lentilles de quartzite et de grès gris, intercalés dans des phyllades fins et qui font partie de la masse des *Hunsrückschiefer*.

"Les géologues allemands ne sont pas d'accord non plus sur le parallele à établir entre les Siegener Schichten et les couches à Mittelrheinfacies . . . Kayser, Frech et Holzapfel considèrent les Hunsrückschiefer et le Taunusquarzit comme formant un seul étage, equivalent des Siegener Schichten. Kegel est moins catégorique; il admet que le Taunusquarzit, et au moins une partie des Hunsrückschiefer, sont de même âge que les Siegener Schichten (1913, p. 162). M. Richter pense que les Hunsrückschiefer sont probablement l'equivalent de la partie supérieure des Siegener Schichten (1926).

." Par contre, Fuchs et Spriestersbach voient dans le Taunusquarzit le représentant de l'ensemble des couches de la Siegenerstufe. Fuchs considère les Hunsrückschiefer comme un étage distinct entre le Taunusquarzit-Siegenstufe et les Untercoblenzschichten; Spriestersbach les rattache à ces derniers. Dans la légende d'une carte d'ensemble du massif rhénan, en cours de publication, W. Paeckelmann indique la succession suivanate: Koblenzstufe, Hunsrückschiefer, Siegenstufe. (Fuchs, 1907; Spriestersbach, 1924, tableau de la p. 391; W. Paeckelmann, 1926, pp. 8-15)."

The first point which seems definite is the correlation, by means of the *sedgwicki*-fauna of the Taunusquarzit of the Mittelrhein, with, first, the Taunusian of Belgium, and, second, the Tonschieferhorizont of the Siegener Schichten.

Further than this it is not possible to go at present. The characteristic species of the Hunsrückschiefer have not been cited. The extensive fauna has been described by Fuchs (1915), and from this source certain details can be gleaned.

In the Bornicher Horizont, which Asselberghs (1927, p. 218) was inclined to correlate with the Upper Hunsrückian of the Ardennes, the species Atrypa lornana Fuchs, Spirifer assimilis Fuchs (a synonym of Sp. hercyniae Giebel), Sp. incertus Fuchs, and Spirigera (= Athyris) globula Fuchs, are widespread and abundant. The second, third, and fourth of these species are, however, widespread in all horizons of the Hunsrückschiefer. Spirigera globula is equally widespread in the Untercoblenzschichten.

This community is not strongly suggestive of the hystericus-fauna of the Upper Siegenian of the Ardennes.

It will be noted that the *sedgwicki*-fauna is closely related to the *primaevus*-fauna; also that the *hystericus*-fauna has more in common with the *hercyniae*-fauna than with the preceding *primaevus*-fauna.

Faunas younger than the hercyniae fauna have not been studied by the writer, and can have no bearing on the Siluro-devonian boundary question.

A summary of the above discussion is presented below :---

Therese	Horizon.					
Fauna.	Belgium.	Germany.	England.	Stratigraphical Nomenciature(-).		
Hercyniæ	Assise de Pesche	UNTERKOBLENZ-SCHICHTEN	(?)	Lower Emsian, Ahrian, or Daunian		
Hystericus	·(GRAUWACKE SUPÉRIEUR)	HERDORFER SCHICHTEN (?) BORNICHER HORIZONT	ʻ (?)	UPPER SIEGENIAN OF UPPER HUNSRUCKIAN		
Primævus	(GRAUWACKE INFÉRIEUR)	RAUHFLASER SCHICHTEN	LOOE BEDS	Middle Siegenian or Lower Hunsruckian		
Sedgwicki	Assise D'Anor	Tonschiefer Horizont Taunusquarzit	(?)	Lower Siegenian of Taunusian		

FAUNAL COMMUNITIES IN THE GEDINNIAN OF WESTERN EUROPE (EXCLUDING THE **BRITISH ISLES).**

The Gedinnian in Belgium is subdivided as follows: (Maillieux, 1926, p. 130) :---

2. Gedinnien supérieur (G. 2).

(b) Assise de Saint-Hubert à Pteraspis dunensis (G. 2b).

(a) Assise d'Oignies à ? Pteraspis crouchi (G. 2a).

1. Gedinnien inferieur (G. 1).

(b) Assise de Mondrepuits à Pterinea retroflexa (G. 1b).

(a) Assise de l'arkose de Haybes et du poudingue de Fepin (G. 1a).

The most recent account(2) of the Gedinnian of the Ardennes is provided by Asselberghs (1927A, see particularly pp. 82-85); while Maillieux has summarized the data available concerning the Southern Border of the Bassin of Dinant. (1926, pp. 130-34.)

The Upper Gedinnian of the synclinorium of the Eifel is divisible into two horizons. "L'assise de Saint-Hubert . . . est formée de phyllades ou schistes phylladeux et de quartzophyllades verts ou gris verdâtre, avec accessoirement des grès et psammites de la même teinte et du quartzite gris ou gris verdâtre." (Asselberghs, 1927A, p. 82.) The Assise d'Oignies is similar to that of the type area of d'Oignies-i.e., "schistes bigarrés."

In the massif de Givonne this twofold division is not possible, and the "facies vert de Saint-Hubert" is alone developed.

In the Southern Border of the Bassin de Dinant the Assise d'Oignies consists of "schistes bigarrés," and the Assise de Saint-Hubert "est composée de schistes, quartzophyllades, grès et psammites verdâtres." (Maillieux, 1926, pp. 132-33.) In the Northern Border of the Bassin de Dinant the "schistes et psammites de Fooz" represents the Assise d'Oignies.

(2) Since this section was written the following papers have been published :-

ASSELBERGHS, E. (1929): Note sur la Faune marine du Gedinnien de l'Ardenne. Bull. Acad. roy. Belg., ser. 5, XV, pp. 756-60.

(1930): Description des Faunes Marines du Gedinnien de l'Ardenne. Mém. Mus. roy. Hist. nat. Belg., No. 41, pp. 1-73, pls. I-VI.
 FUCHS, A. (1929, A): Die unteren Gedinneschichten der Gegend von Wiesbaden. Jahrb. nassau. Ver. Naturk.

1xxx, pp. 74-86. — (1929, B): Beitrag zur Kenntnis der unteren Gedinnefauna. Jahrb. Preuss. Geol. Landesanst, L (1),

pp. 194-201, pls. xii-xiv.

Asselbergs (1930) has revised the fauna of the Gedinnian of the Ardennes. The abundant species at Mondrepuits are Dalmanella verneuili (de Kon.), Stropheodonta triculta Fuchs, Spirifer mercuri Gosselet, Tentaculites irregularis de Kon., Primitia jonesi de Kon., Bollia richteri (de Kon.), Homalonotus roemeri Gosselet, and Acaste spinosa Salter. (1930, pp. 62-63.)

The new studies do not, I think, necessitate any alteration in the scheme outlined by the writer. Asselberghs' opinion is that the Gedinnian stage should be retained at the base of the Devonian System. His beautifully illustrated monograph should be consulted for details.

⁽¹⁾ See footnote p. 134.

Taken as a unit the Upper Gedinnian is non-marine⁽¹⁾, and the strata were formed under lagoonal or terrestrial conditions. The fauna is not well known, but contains *Pteraspis dunensis* (F. Roemer), *P. crouchi* (Lankester), *P. rostrata* (Agassiz), *P. traquairi* Leriche, and *Cephalaspis lyelli* Agassiz.

This community may be called the lyelli-fauna from the last-named species.

The lyelli-fauna has been described by Leriche (1906) from Liévin, where it occurs in the grès bigarrés de Pernes, and presumably in the succeeding grès bigarrés de Vimy.

In the Ardennes the Lower Gedinnian—the Assise de Mondrepuits of Belgian geologists consists of a series of slates and phyllites with conglomerates at the base.

The fauna has been described by Leriche (1912) and revised by Barrois, Pruvost, and Dubois (1922). The latter authors have listed the fauna without indicating the most abundant species. (1922, p. 200.) Asselberghs (1927, A, p. 68) has indicated the characteristic fossils of this age in the Ardennes as follows: *Proschizophoria personata* (Zeiler em. Kayser), *Strophomena filosa* (Sowerby)(²), *Strophomena pecten* (L.)(²), *Spirifer mercuri* Gosselet, *Pterinea retroflexa* Wahlenberg, and *Homalonotus* cf. roemeri de Koninck. The determinations are by E. Maillieux.

This community may be termed the mercuri-fauna from Spirifer mercuri Grosselet.

Maillieux (1926, p. 132) has recorded the mercuri-fauna in the Couvin area. The species are Retzia bouchardi Davidson, Spirifer mercuri Gosselet, Bucanella trilobita (Sowerby), Tentaculites irregularis de Koninck, and Pterinea retroflexa Wahlenberg.

The mercuri-fauna occurs in the Liévin area in the Schistes à Tentaculites de Mericourt. The characteristic fossils have been indicated by Barrois, Pruvost, and Dubois. (1922, p. 181.) These are Primitia jonesi de Koninck, Bollia richteri de Koninck, Kloedenia lievinensis Barr. Pruv. and Dubois, Tentaculites irregularis de Koninck, Pterinea retroflexa Wahlenberg, Lingula cornea Sowerby, Dalmanella lunata (Sowerby), Stropheodonta simulans M'Coy, Spirifer mercuri Gosselet, Retzia bouchardi Davidson, and Rennselaerina primaeva Barr. Pruv. and Dubois.

FAUNAL COMMUNITIES IN THE LIEVIN DISTRICT, NORTHERN FRANCE.

The sequence of strata in this area is as follows :---

1. Schistes et Grès Bigarrés de Vimy.

- 2. Schistes de Pernes.
- 3. Psammites et Schistes vert de Liévin.
- 4. Schistes de Méricourt.
- 5. Couches de Drocourt.
- 6. Calcaire d'Angres.
- 7. Calcaire de Liévin.

The highest beds, 1-2, contain the *lyelli*-fauna (Leriche, 1906), and are hence to be correlated with the Dittonian of the British Isles, and with the "Gedinnien supérieur" of Belgium.

The characteristic fossils, cited by Barrois, Pruvost, and Dubois (1922, p. 181) of the Schistes de Méricourt (see p. 37) belong to the Lower Gedinnian mercuri-fauna, and the same fauna extends up into the Psammites de Liévin in which Modiolopsis complanata Sowerby is abundant. It is here much impoverished.

The lower beds—Couches de Drocourt and the Calcaire d'Angres, are correlated by Barrois, Pruvost, and Dubois (1922) with the Upper Ludlovian of the British Isles. These authors have listed and described the fauna, but the characteristic fossils are not indicated. Indirectly, however, they state that the species Pterinea retroflexa Wahl., Grammysia massoni B.P.D., Spirifer elevatus Dalman, and Plethorhynchus dunensis Drevermann are abundant.

(2) These species previously described under these names by Leriche (1912) are, according to Barrois, Pruvost, and Dubois (1922), incorrectly named, and the Gedinnian fossils should be combined under the name *Stropheodonta* subarachnoides (d'Archiac and Verneuil). It is not clear whether or not Maillieux disagrees with this conclusion.

⁽¹⁾ Asselberghs (1930, pp. 62-63) lists marine fossils from the Upper Gedinnian of Gdoumont.

UPPER SILURIAN – LOWER DEVONIAN COMMUNITIES IN THE BRITISH ISLES (EXCLUDING DEVON AND CORNWALL).

It is considered unnecessary to give details of the Upper Silurian – Lower Devonian sequence in the British Isles because admirable summaries have recently (1929) been published by both O. T. Jones and J. W. Evans in the "Handbook of the Geology of Great Britain." Both authors deal with the Downtonian; the former includes it in the Silurian, the latter in the Devonian; and both provide adequate bibliographical details. The more important references are included in the list of literature herein, see under Elles and Slater, W. Wickham King, L. D. Stamp, &c.

The sequence of faunal communities is as follows :---

1. Upper Ludlovian : Whitcliffe Group.

Characteristic fossils: (Elles and Slater, 1906, pp. 219-220; O. T. Jones, 1929, pp. 109-10.)

Lingula lewisi Sowerby, Orbiculoidea rugata Sowerby, Crania implicata Sowerby, Dalmanella lunata (Sow.), Chonetes striatella Dalman, "Rhynchonella" nucula Sowerby, Spirifer elevata Dalman mut., Goniophora cymbaeformis Sowerby, Orthonota amygdalina Sowerby, Pterinea retroflexa Wahl., Orthoceras bullatum Sowerby, O. gregarium Sowerby, Homalonotus knighti Koenig, and Beyrichia kloedeni McCoy.

2. Lower (Grey) Downtonian: Temeside Group of Elles and Slater (1906), including, according to O. T. Jones (1929), the Ludlow Bone Bed.

Characteristic fossils: (Elles and Slater, 1906, pp. 219-20.)

Lingula minima Sow., Lingula cornea Sow., Modiolopsis complanata Sow., Platyschisma helicites Sow., Pachytheca sphaerica Hooker, Beyrichia kloedeni McCoy, Onchus murchisoni Agassiz, O. tenuistriatus Agassiz, Eurypterus spp., and Pterygotus spp.

The Downtonian fauna has more recently been listed and analysed by Stamp (1923, pp. 394-9), but, as far as the characteristic fossils are concerned, nothing is added to the earlier work quoted above.

3. Upper (Red) Downtonian.

Characteristic fossils⁽¹⁾: "A fish fauna similar to that of the grey Downtonian" (Jones, 1929, p. 118.)

The genera Tolypaspis, Cyathaspis, Auchenaspis, and Didymaspis appear to have zonal value. (Jones, 1929, p. 120A.)

4. Dittonian.

Characteristic fossils: Cephalaspis lyelli Agassiz, Pteraspis rostrata Agassiz, Pteraspis crouchi Lankester, and Scaphaspis lloydi (Agassiz). This fauna has been described by Lankester (1868-70).

Concerning these communities, it seems evident that the Dittonian with Cephalaspis lyelli and its associates must be referred to the Upper Gedinnian. The Red Downtonian does not seem to be represented outside the British Isles. Barrois, Puvost, and Dubois (1922) and L. D. Stamp have correlated the Lower (Grey) Downtonian with the Lower Gedinnian of Belgium. It may be noted that the lists of characteristic fossils here cited from these "correlatives" are not identical. Both the mercuri-fauna of the Lower Gedinnian of Belgium and Lievin and the Lower Downtonian fauna of Britain are undoubtedly of pre-lyelli age, and both are clearly descended from, and are closely related to, the true Upper Ludlow (Silurian) fauna. The Downtonian fauna and the mercuri-fauna both show the impress of a peculiar environment which resulted from a shallowing of the Ludlovian seas.

SUMMARY FOR THE WESTERN EUROPEAN AREA.

True Silurian, Upper Ludlovian faunas are succeeded by the *mercuri*-fauna (including the Lower (Grey) Downtonian fauna) of the Lower Gedinnian. The *mercuri*-fauna, in its characteristic fossils,

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has strong Ludlovian affinities, but little in common with the lowest true Devonian, *sedgwicki*-fauna, of Taunusian age.

The faunal break between the *mercuri*- and the *sedgwicki*-faunas is marked, and is much greater than that between the *mercuri*-fauna and its forerunners, or that between the *sedgwicki*-fauna and its derivatives.

The marine fauna connecting these units is not developed in Western Europe. The sequence is everywhere interrupted by strata with the non-marine lyelli-fauna.

It follows logically from these facts that it is impossible to fix the Siluro-Devonian boundary in the Western European area if marine faunas are to be the basis of the classification. That the marine faunas do yield the only basis for an international classification is the view of all geologists of repute.

The question of priority—the Devonian System was originally based upon the succession of strata developed in Devon and Cornwall—should not carry great weight at the present time. The term "Devonian" has long had an international value which is to a great extent independent of the British area. It is this international use of the term which is of paramount importance.

Any international definition of the Devonian System or Period must be based upon the openwater calcareous facies, and that scheme, which as far as possible satisfies considerations of priority (without demanding rigid adherence to the past), will be most acceptable to the majority.

The problem really resolves itself into (a) finding the equivalent of the *sedgwicki*- and *primaevus*faunas (of psammo-pelitic facies) in strata of the calcareous facies; and (b) finding the equivalent of the *mercuri*-fauna in strata of the calcareous facies. Then the fauna intermediate between these two faunas of open-water habit would represent the open-water marine fauna which existed at the same time as the non-marine *lyelli*-fauna.

In other words, the problem demands a sequence of strata of calcareous facies which continued without interrruption from definite Silurian to definite Devonian; and then the possibility of correlation of faunal communities (based upon characteristic fossils) from facies to facies.

Before going further, it is necessary to note the alternative scheme suggested by Barrois, Pruvost, and Dubois in France, and by Stamp in England.

The French geologists have produced, under great difficulties, an excellent monograph dealing with the succession of strata, and their faunas, in the Liévin District. These authors conclude that the base of the Devonian must be placed below the Schistes de Méricourt, which are correlated with the Schistes de Mondrepuits of Belgium on one hand and the Temeside group (Downtonian) of the Ludlow District on the other. In other words, the *mercuri*-fauna is referred to the Devonian. This follows mainly from a detailed analysis of the fauna of the Schists de Méricourt. (1922, pp. 180-83.) Out of a fauna of forty-three species eleven are stated to be Devonian. This number includes species from the "Devonian" of the *Gedinnien inférieur* and the *Grès Downton*. But even if 25 per cent. of the species were Siegenian, and this is not the case, the whole argument falls to the ground because but a single Siegenian species occurs among the characteristic fossils.

This case shows clearly the fallacy underlying correlation by means of faunal lists alone.

Stamp (1923) has studied the Downtonian and its correlatives at some length. His main thesis (the words are his own) is to show that the Ludlow Bone-bed forms the true base of the Devonian System(¹). This is urged on several grounds :---

"(a) Priority.—It was the limit originally used by Murchison. Although subsequently altered by him, one finds if one attempts to use his later limit—

"(i) That the Old Red Sandstone was not redefined accordingly."

- "(ii) That Dumont's Rhénan (Devonian) System, defined in 1845, has priority over Murchison's later definition (1848).
- "(iii) That the later limit adopted by Murchison does not form a true horizon and has been very differently interpreted by later writers.

(1) See also in this connection T. Robertson, 1928: The Siluro-Devonian Junction in England. Geol. Mag., LXV, pp. 385-400.

" (b) Palaeontology-

- "(i) There is a marked faunal change at the Ludlow Bone-bed. The Bone-bed marks the first appearance of fossil fishes, and thus the Devonian marks the dawn of an age of vertebrates. [Two sentences are here omitted.]
- "(ii) The limit adopted after a detailed study by other writers of an uninterrupted marine series is on the same horizon. The succession of Lievin (Northern France) forms a standard for comparison of all areas of the Devonian (marine) type of deposit.

"(c) Stratigraphical.—In England the Ludlow Bone-bed marks also a change in physical conditions, more noticeable elsewhere as an unconformity. Physical breaks or unconformities on the same horizon occur in Scotland, Belgium, Brittany (slight), Norway, Sweden, and Spitsbergen.

"(d) Practical Considerations. — The Downtonian rocks—*i.e.*, the strata from the Ludlow Bone-bed horizon upwards—form a stratigraphical and palæontological entity, incapable of broad or even of rough separation below the Dittonian. The Ludlow Bone-bed, on the other hand, forms an horizon which can be recognized and mapped all over North-western Europe. In England there appears to be a slight faunal break between the Downtonian and Dittonian, but this is less marked elsewhere." (1923, p. 410.)

That Stamp's conclusions are not altogether acceptable is clear from criticisms made since his work was published.

In discussing the principles of the modern classification of strata Miss Elles (1923, pp. 5-6) stated, "In spite of all that has been urged by Stamp, I am not yet convinced that his claim that the boundary-i.e., between the Silurian and the Devonian-should be shifted to the base of the Downtonian rests upon a satisfactory basis. Towards the close of the Silurian, as is perfectly well known, far-reaching changes in physical conditions took place, necessarily involving changes in the character of the shallow-water fauna whenever and wherever these occurred, and the coming-in of fishes appears to be directly connected with them. That these changes took place simultaneously over wide areas is in the highest degree improbable, and, having had some experience of the behaviour of these rocks in the field, I have felt that the evidence at times so strongly suggested that the Downtonian was essentially a *facies* formation that the possibility of its horizons being eventually found to be almost as inconsistent as that of the Millstone Grit was far from improbable. That there may appear to be a similar change of conditions in parts of Britain and France at about the same time is not really the point; it is not the succession of shallow-water marine faunas that is important from the point of view of classification, but how far these are really of the same age in different places, and how much change is reflected in the fauna of the more stable deeper-water beds. The author-i.e., Stamp-may be perfectly right in his contention, only up to the present, as I see the problem, he has not proved his case." (1923, pp. 5-6.)

If it be granted that the open-water type of fauna must form the basis of a modern, international classification, then Stamp's first plea, based upon priority, falls to the ground. Stamp has confused a problem of local stratigraphy with the larger problem of an international classification.

The palæontological evidence also is unconvincing. The incoming of the fish-fauna is a point of great interest, but it hardly affects the problem under discussion⁽¹⁾. It is inconceivable that an international classification can be based upon the fish-faunas, which are, practically speaking, confined to a single facies in Western Europe.

Further, the statement that there is an "uninterrupted marine series" in the Liévin district, and that "the succession at Liévin (Northern France) forms a standard for comparison of all areas of the Devonian (marine) type of deposits" seems to the writer most misleading, and, in fact, not correct. The marine series is not uninterrupted, for above the *Schistes de Méricourt*

(1) O. T. Jones (1929, p. 112) records, on the authority of Straw (1927), the occurrence of fish remains not uncommonly in the Upper Ludlovian of the Ludlow District.

Old Red Sandstone conditions appear. The second part of the statement is practically true only on the assumption, which Stamp is seeking to prove, that the Downtonian is Devonian. There is no uninterrupted marine sequence ranging from the Upper Ludlow to the Taunusian in Western Europe.

The arguments based upon stratigraphical and practical considerations fail to take into account the high probability of the facies nature of the Ludlow Bone-bed, and of the Downtonian as a whole.

A table of correlations embodying the views expressed may be of value. It is possible that the range of the *lyelli*-fauna in the Dittonian of the British Isles may be greater than it is on the Continent. The Dittonian may, therefore, in its upper part be equivalent to the marine *sedgwicki*-fauna.

Fauna.	an Sc	outh Devon d Cornwall.	Ludlow.	Liévin.	Ardennes.	
Hystericus	-TO .	(?)			SIEGENIAN SUPÉRIEUR	
PRIMÆVUS	NDFO	LOOE BEDS		e e e	SIEGENIAN MOYEN	
SEDGWICKI	MEAGI	(?)			Siegenian Inférieur (Taunusien)	
Lyelli	DARTMOUTH SLATES		PURPLE-RED SANDSTONE AND MARLS LOWER O.R.S.=DITTONIAN	Schistes et Grès Big- arrés de Vimy Schistes de Pernes	Assise de Saint Hubert Assise D'Oignies Gedinnien Supérieur	
Manorati			Red Downtonian Temeside Shales	Psammites et Schistes Vert de Liévin	Assise de Mondrepuits	
MERCURI			Downton-Castle Sandstone	Schistes de Méricourt	- (GEDINNIEN INFERIEUR)	
		4 H	Upper-Whitcliffe or Chonetes-Flags	Couches de Drocourt		
		2 2 2	Lower-Whitcliffe of "Rhynchonella" Flags	Calcaire D'Angres		
9 10			Mocktree or Dayia–Shales	Calcaire de Liévin		
		· · · · · ·	Aymestry of Conchidium-Limestone	[FAULT]		

SOUTH AMERICAN - SOUTH AFRICAN LOWER DEVONIAN COMMUNITIES.

Lower Devonian strata are comparatively widespread in Bolivia, Brazil, Argentine, the Falkland Islands, and South Africa. From the point of view of fauna and facies this area is remarkably uniform and has been called the "austral Lower Devonian province."

The fauna was first described in detail by J. M. Clarke in his fine monograph "Fosseis Devonianos do Parana" (1913), and Parana in Southern Brazil may be considered the type locality. The strata, the Ponta Grossa series, show a threefold division. The lowest member is the Furnas Sandstone, which is unfossiliferous. It is followed conformably by the Ponta Grossa shales, consisting of 80-120 metres of soft, bluish-grey shales, with bands of densely black compact bituminous shales, and thin intercalations of sandstone. This series is remarkably uniform in lithology. At the northern end of the area from Tybagy to Jaguariahyra the shales are succeeded by the Tybagy sandstones.

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The Ponta Grossa shales and Tybagy sandstones are profusely fossiliferous, and, although many species range throughout both beds, certain species are confined to the upper sandstones, notably a great development of *Spirifer iheringi* Kayser. The Ponta Grossa shales contain nearly three times as many species as the Tybagy sandstones.

The fauna as a whole consists essentially of Phacopids, Homalonoti, Taxodont Pelecypods, Bellerophonts, and Spiriferids.

In the shales the most characteristic species are Calmonia signifer Clarke, Homalonotus noticus Clarke, Leptocoelia flabellites (Conrad), Orbiculoidea baini (Sharpe), and Spirifer kayserianus Clarke.

The following species are also common: Chonetes falklandica M. and S., Cryphaeus australis Clarke, Lingula lepta Clarke, Nuculites sharpei Reed, and Schuchertella agassizi (Hartt.). To this assemblage of fossils the name antarcticus-fauna derived from Spirifer antarcticus

Morris and Sharpe, may be applied. Sp. antarcticus is chosen because it is found throughout the "austral" area, and is everywhere fairly common.

Clarke (1913, pp. 41-46) has shown that the antarcticus-fauna is developed at Santanna de Chapada, in the state of Matto Grossa in Brazil. Characteristic species there include Chonetes falklandica M. and S., Spirifer antarcticus M. and S., and Orbiculoidea baini (Sharpe).

The Chapada Series consists, according to H. Smith (quoted from Clarke, 1913, p. 46), of a basal quartz conglomerate, followed by pink sandstones, mottled sandy clays, whitish clay shales with *Orbiculoidea*, and finally a succession of thin beds of shales, sandy clays, and sandstone.

Leme (1924) placed the thickness of the series at 500 metres. (Du Toit, 1927, p. 61.)

The antarcticus-fauna of Bolivia has been monographed by Kozlowski (1923), and reference may be made to his work for the results of early investigations in this area. The Lower Devonian sequence consists of the Schistes de la Cordillère Real, and the succeeding Formation d'Icla. Middle Devonian beds, the Formation de Sicasica are also present.

The small fauna from the Schistes de la Cordillère Real is not very distinctive, and it is apparently not yet clear that this horizon is distinct from the Formation d'Icla (Kozlowski, 1923, p. 12). The latter has a threefold division into (a) Grès à *Rensselaeria knodi*, (b) Schistes à Conulaires, and, at the top, (c) Grès de Huamampampa. The two lower members are richly fossiliferous. The fauna may be considered as a unit, and is listed by Kozlowski (1923, pp. 106-9).

The characteristic species include Conularia ulrichana Clarke, Cryphaeus australis Clarke, Leptocoelia flabellites (Conrad), Orbiculoidea baini (Sharpe), Schuchertella agassizi (Hartt), and Spirifer antarcticus Morris and Sharpe.

In its main outlines this Icla fauna is clearly a northern extension of the *antarcticus*-fauna. As compared with Parana the specific identity is not great, and new groups, such as *Bouleia*, *Dereimsia*, and *Actinopteria*, occur, but the characteristic species, and the facies, agree with those of the type area.

Clarke (1913, pp. 332-53) has revised the paleontology of the Devonian strata of San Juan in Western Argentine. His views are somewhat different from those expressed earlier by Kayser (1897) and Thomas (1905). Stratigraphical details are not available, but Clarke has recognized the *antarcticus*-fauna at several localities. The species include *Leptocoelia flabellites* (Conrad), *Conularia quichua* Ulrich, *Spirifer antarcticus* M. and S., *Chonetes falklandica* M. and S., and *Leptostrophia concinna* (M. and S.), all of which are typical of the antarcticus-fauna elsewhere.

The Lower Devonian fauna of the Falkland Islands was discovered by Charles Darwin, and his material described by Morris and Sharpe (1846). Clarke (1913) was able to describe a relatively large fauna collected by various South Polar Expeditions and local enthusiasts. Stratigraphical details have been supplied by Anderson (1907), Halle (1912), and Baker (1924), and summarized by Du Toit (1927).

The basal beds are barren false-bedded sandstones and quartzitic sandstones. These are succeeded by fossiliferous slates, shales, flagstones, and sandstones, and overlain by the plantbearing beds of the Gondwana System. (Du Toit, 1927, p. 12.)

The fauna determined by Clarke (1913, pp. 330-32) is characteristically the antarcticus-fauna in all respects. The characteristic species are Chonetes falklandica M. and S., Homalonotus herscheli Murchison, Leptocoelia flabellites (Conrad), Leptostrophia concinna (M. and S.), Orbiculoidea baini (Sharpe), Schuchertella sulivani (Sharpe), and Spirifer antarcticus M. and S.

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The antarcticus-fauna has been studied in South Africa by Lake (1904), Reed (1903, 1904, 1906, 1908), and Schwarz (1906). The whole fauna was revised by Reed (1925), and this revision is here utilized.

The characteristic species include Cryptonella (?) baini (Sharpe), Leptocoelia flabellites (Conrad), Orbiculoidea baini (Sharpe), Schuchertella sulivani (Sharpe), Spirifer iheringi Kayser, and Sp. kayserianus Clarke. Of species characteristic elsewhere in the antarcticus-fauna the following are present in the Bokkeveld beds: Chonetes falklandica M. and S., Cryphaeus australis Clarke, Nuculites sharpei Reed, Spirifer antarcticus M. and S., and several others.

Taken as a whole the similarity to the fauna of Parana and the Falkland Islands is very striking. Reed (1925, pp. 195–98) lists forty species common to the Bokkeveld beds and the corresponding beds of South America and the Falkland Islands, and many of the South African species are closely allied to South American forms.

The Bokkeveld fauna shows minor faunal differences, which are only to be expected. The most important are the relative abundance in South Africa of the pelecypods Modiomorpha, Ctenodonta, and Grammysia (Grammysioidea), and the remarkable development of Homalonotus (Burmeisteria). These facts do not invalidate the conclusion that the fauna of the Bokkeveld beds is in all essentials the antarcticus-fauna.

Du Toit (1927) has demonstrated that the lithological resemblances between the Brazilian and South African sequences are remarkably strong. Thus the Furnas sandstone is "marvellously like the Table Mountain sandstone of the Cape Western Province" (1927, p. 59); the Ponta Grossa shales "recall down to the minutest detail the lowermost shale group of the Bokkeveld series of the Cape Western Province" (1927, p. 59); and finally the Tybagy Sandstone corresponds "stratigraphically with the well-known soft, red-weathering 'fossiliferous sandstone' of the Bokkeveld." (1927, p. 60.)

It has not been possible to differentiate faunules in vertical succession in the "austral" region, but it is probable that future research will show that the community of the sandstone facies is distinct from that of the shale member *in its characteristic fossils*.

The characteristic fossils of the *antarcticus*-fauna are tabulated below. It will be noticed that certain species are characteristic of certain areas only, but that others are present throughout the whole area, although they are more abundant in some areas than in others. Four species, *Chonetes falklandicus M.* and S., *Leptocoelia flabellites* (Conrad), *Orbiculoidea baini* (Sharpe), and *Spirifer antarcticus M.* and S., are noteworthy in all localities.

The characteristic species of the antarcticus-community.

	Parana, Brazil (Sandstones).	Parana, Brazil (Shalee).	Matto Grossa, Brazil.	Bolivia (Icla).	Argentina.	Falkland Islands.	Bokkeveld Beds (South Africa).
Calmonia signifer Clarke	PCCPC PCPC PCPPC CCPPC CCP CCP CCP CCPC	A C C P C C C A C C P P P P P A	 P P C P P 	·· P C C P ·· ·· A ? ·· ·· P A ·· ·· P A ·· ··	·· P ·· ·· ·· ·· ·· ·· ·· ·· ·· ·· ·· ·· ··	·· A ·· ·· P C ·· ·· C C C C C ·· ·· ·· ··	P P P P P P P P P P C C P A A

A = abundant; C = common; P = present.

In discussing the *antarcticus*-fauna after a detailed survey of the occurrences in Brazil, Western Argentina, and the Falkland Islands, Clarke concluded that "the entire assemblage . . . bears a special and distinctive impress which is characterized as *austral* in contrast to the *boreal* aspect of homotaxial faunas north of the equator. These distinctions consist of specific resemblances without identities; in parallel developments affording different resultants; in invasions of generic structures more or less clearly disturbing generic agreements; and in irregular outgrowth of species distinctions on generic foundations common both to the north and the south." (1913, pp. 7–8.)

Again, "The special traits of this austral fauna appear, with present knowledge, to have been derived by inheritance from a Silurian stock which served as ancestors to both the southern and northern faunas; together with this inheritance are the variations which seem to have been induced by the influence of the geographic isolation, due to the birth of a pre-Gondwana continent wholly cut off by the sea from the northern land." (1913, p. 9.)

Clarke's thesis could be elaborated by further quotations referring to particular generic groups, but the above, it is believed, illustrate his views correctly and fairly.

Kozlowski (1923, pp. 102-5) appears to be in agreement with Clarke's interpretation so far as the Formation d'Icla is concerned.

Reed, in his revision of the Bokkeveld beds of South Africa, comes to the same general conclusions. The Bokkeveld fauna is typically "austral." He remarks, "It must also be emphasized that, although the affinities of many of the species are with Lower rather than Middle Devonian forms in Europe, there are no identical species, and a recognizable European element is conspicuous by its absence." (1925, pp. 216–17.) The same author states, "The general uniformity and absence of differentiation of the sedimentary and of the faunistic facies of the beds is a remarkable feature throughout the whole austral region." (1925, p. 199.)

Clarke, Kozlowski, and Reed have presented a strong case, which would appear to be unassailable.

It is granted that the *antarcticus*-fauna is remarkably uniform in its characteristic fossils over a very wide area, and that the facies of the strata is also very uniform over the same area. That these facts are to be explained by isolation and parallel developments from a common Silurian ancestry is another matter.

It may be urged first that these authorities have stressed differences rather than resemblances.

With regard to the Trilobita the "austral" groups are certainly distinct from the northern types of the same age to a great extent. But this does not in itself imply isolation. The Phacopids in particular are highly organized, and apparently easily affected by environmental changes. A high degree of localization of generic types is to be expected from these forms. The Homalonoti on the other hand are more widely distributed. The *herscheli*-group, for example, is present in New Zealand, and the *noticus*-group in North America and Western Europe.

When the Brachiopoda are studied the evidence for isolation breaks down completely. If one considers only the characteristic species tabulated above, this is clear. The "austral" spiriferids Sp. antarcticus, Sp. iheringi, and Sp. kayserienus belong to the geographical species-group of Spirifer hercyniae Giebel, of which, as has been shown in the systematic part of this work, members occur in Western Europe, North America, and New Zealand. Leptocoelia flabellites (Conrad) occurs very abundantly in the Oriskanian of North America, and in New Zealand. Chonetes falklandica M. and S., belongs to a group common in North America, Western Europe, and New Zealand. Leptostrophia concinna (M. and S.) is of the explanata-type, and this group too, is cosmopolitan.

In view of these facts isolation cannot be considered to have been the cause of the peculiarities of this "Austral" fauna.

It may be suggested that the *antarcticus*-fauna represents a part of the cosmopolitan Lower Devonian fauna, and that the differences between it and the Western European or the North

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American faunas are due to the impress of a different set of physical conditions. The *antarcticus*-fauna is widespread in the "austral" area because that set of physical conditions was stable over a wide area.

In terms of the current stratigraphical nomenclature the Ponta Grossa series of Brazil, the Formation d'Icla, of Bolivia, and the Bokkeveld beds of South Africa are referable to the Lower Emsian of Western Europe.

Strata comparable with the Siegenian and Taunusian horizons of Western Europe do not seem to be represented by fossiliferous strata in the "austral" province. For this reason it seems incorrect to state, as Clarke does, that the peculiarities of the "austral" fauna are due in part to parallel developments from Silurian ancestors common to the north and to the south.

The Rio Maecuru Fauna of the Lower Amazon.—In South America at Rio Maecuru, in the Lower Amazon, there is a Lower Devonian fauna described by Rathbun (1878), Clarke (1890, 1899), and Katzer (1896, 1897, and 1903). The work of the German geologists has been summarized by Schuchert (1906), and the fauna discussed and listed by Clarke (1913). The assemblage appears to differ rather markedly from that of the "austral" antarcticus-fauna. The writer has not access to information concerning the characteristic fossils of the fauna.

UPPER SILURIAN AND LOWER DEVONIAN ANIMAL COMMUNITIES IN EASTERN NORTH AMERICA.

The treatment of the faunas of this area which follows is based solely upon literature and, for this reason, must be regarded as purely tentative.

An attempt is made, first, to correlate certain faunas from the arenaceous facies of Maine with those of psammo-pelitic facies in Western Europe; second, to correlate the Maine faunas with those from strata of calcareous facies in Maryland. Thus indirectly the Western European faunas are correlated with those of a totally distinct environment in Maryland. In Maryland the strata in question all belong to the open-water calcareous type, and the faunal succession there offers a standard upon which an international classificatory scheme can conveniently be based.

Communities in the Chapman Sandstone, and Moose River Sandstone of Maine.—Williams and Breger (1916) have monographed the fauna of the Chapman Sandstone, and, in part, have described the fossils of the related, but distinct, Moose River Sandstone.

The characteristic species of the Chapman Sandstone are Chonetes striatissima W. and B., Ch. novascotica Hall, Spirifer sparsus Clarke, Sp. concinnus Hall, Sp. cyclopterus Hall, Rensselaeria mainensis Williams, Dalmanella planoconvexa (Hall), Tellinites (Koenenia) gibbosa Goldf. var. kayseri Beushausen, Actinopterella radialis (Clarke), A. aroostooki (Clarke), Myalina maureriana W. and B., Anodontopsis maccoyiana W. and B., and Tentaculites schlotheimi Koken.

Of these species Chonetes novascotica is equivalent to Ch. sarcinulata (Schlotheim); Rensselaeria mainensis to R. strigiceps (Roemer); Spirifer cyclopterus to Sp. hystericus (Schlotheim); and Tentaculites schlotheimi to T. scalaris Schlotheim.

The four Western European species are all characteristic of the *hystericus*-fauna of Upper Siegenian age in Belgium and Germany.

The conclusion therefore that the Chapman Sandstone community is a "disguised" hystericusfauna is strongly suggested. It may be termed the cyclopterus-fauna from Spirifer cyclopterus Hall.

The Moose River Sandstone, on the other hand, judging from the selected species described by Williams and Breger, is clearly younger.

The characteristic fossils are Leptostrophia perplana (Conrad), Spirifer murchisoni Castelnau, Spirifer gaspensis Billings, Antispirifer harroldi W. and B., Leptocoelia flabellites (Conrad), and Follmannella mainensis (Clarke). The Leptostrophia is clearly of the explanata (Sowerby) type and, in the writer's opinion, distinct from the Middle Devonian species to which it is referred. Spirifer murchisoni is compared with Spirifer primaevus (Stein.), but appears to be more closely related to Sp. hercyniae Giebel. Spirifer gaspensis Billings is admitted by the authors to be "equivalent to and identical with S. hercyniae Giebel."

The association of the *explanata*-type of *Leptostrophia* and the hercyniae-type of *Spirifer* indicates that the Moose River Sandstone is equivalent to the *hercyniae*-fauna of Lower Emsian age in Western Europe. The Moose River Sandstone community may be termed the *gaspensis*-fauna from the *Spirifer* of that name.

Lower Devonian Communities in the Gaspé District.—The palæontology of this area has been studied at length by J. M. Clarke (1908). The sequence is as follows :—

At the top-

1. Gaspé Sandstones.

2. Grande Greve limestones. (Hydraulic limestones, grey impure limestones with or without chert.)

3. Bon Ami beds. (Calcareous shales and limestones.)

4. St. Alban beds. (Grey limestones and calcareo-argillaceous shales.)

The characteristic fossils of the Gaspé Sandstones are Tentaculites cartieri Clarke, Rensselaeria ovoides gaspensis Clarke, Leptocoelia flabellites (Conrad), Spirifer gaspensis Billings, Chonostrophia dawsoni Billings, and Chonetes hudsonica Clarke.

This community is essentially that of the Moose River sandstone, and the latter is equivalent of the Lower Emsian *hercyniae*-fauna of Western Europe. Williams and Breger (1916, p. 299) correlated the Moose River sandstone with the Oriskany sandstone of New York, and the Gaspé sandstone of Gaspé Peninsula.

The characteristic fossils of the Grande Greve limestones are Rensselaeria ovoides gaspensis Clarke, Eatonia peculiaris Conrad, Meristella champlaini Clarke, Spirifer murchisoni Castlenau, Spirifer plicatus (Weller), Sp. cyclopterus (Hall), Leptostrophia magnifica Hall, Hipparionyx proximus Vanuxem, Rhipidomella musculosa Hall, and Chonetes canadensis Billings.

This community is essentially the same as that in the Ridgely Member of the Oriskanian of Maryland. The facies is the same in Maryland and in Gaspé.

Clarke has not indicated the characteristic fossils of the Bon Ami and St. Alban beds.

Oriskany Formation of New York.—In New York the Oriskany Sandstone formation is well known. Clarke (1900, p. 78) has described the formation as a series of arenaceous lenses (in strike section) connected by thin sheets of quartzitic sandstone. The rich fauna has been described by Hall (1859) and Clarke (1909).

The characteristic species are Tentaculites elongatus Hall, Rensselaeria ovoides (Eaton), Leptocoelia flabellites (Conrad), Meristella lata Hall, Spirifer arenosus (Conrad), Hipparionyx proximus Vanuxem, and Leptostrophia magnifica Hall. Also important are Diaphorostoma ventricosum (Conrad), Actinopteria arenaria (Hall), Beachia suessana (Hall), Eatonia peculiaris (Conrad), Coelospira dichotoma Hall, Spirifer murchisoni Castelnau, (in the opinion of the writer the affinities of this species which equals S. arrectus Hall (1859, pl. 97) are with S. hercyniae Giebel, rather than with S. primaevus Steininger), Chonetes rostrata Hall, Chonostrophia complanta Hall, Anoplia nucleata Hall, and Rhipidomella oblata Hall.

With other North American arenaceous faunas this has much in common. In particular it recalls the communities characteristic of the Moose River sandstone of Maine, and of the Gaspé sandstones of Gaspé. It is distinct from the assemblage characteristic of the Chapman sandstone of Maine. On the other hand, many of the characteristic species of this Oriskany sandstone are also characteristic in the Grande Greve limestones of Gaspé, on the St. Lawrence River, and in the Oriskanian of Maryland.

Upper Silurian and Lower Devonian Faunal Communities in Maryland, North America.-This summary is based entirely upon the excellent monographs of the Maryland Geological Survey (Lower Devonian, 1913; Silurian, 1923)(1).

The succession in Maryland is as follows :---

- 1. Oriskany Formation-
 - (a) Ridgely Member.
 - (b) Shriver Member.

2. Helderberg Formation-

- (a) Becraft Member.
- (b) New Scotland Member.
- (c) Coeymans Member.
- (d) Keyser Member.

3. Cayugan Formation-

- (a) Tonoloway Member.
- (b) Wills Creek Member.
- (c) McKenzie Member.

The Ridgely Member is composed of calcareous sandstones, which pass in places into arenaceous limestones. The characteristic⁽²⁾ species are Leptocoelia flabellites (Conrad), Spirifer intermedius Hall, Sp. cumberlandiae Hall, Sp. arenosus (Conrad), Beachia suessana (Hall), Eatonia peculiaris (Conrad), Rhipidomella musculosa (Hall), Platyceras gebhardi Conrad, Edriocrinus sacculus Hall, and Dalmanella planiconvexa (Hall). The following species are also abundant: Rensselaeria marylandica (Hall), Oriskania lucerna Schuchert, Spirifer murchisoni Castelnau, Leptrostrophia magnifica (Hall), and Hipparionyx proximus Vanuxem.

The community agrees essentially with the gaspensis-fauna detailed above.

The Shriver Member, or Lower Oriskany(3), consists of dark siliceous shale containing large quantities of black impure chert in the form of nodules or layers of nodules. The characteristic fossils are Leptocoelia flabellites (Conrad), Pholidops tumida Schuchert, Chonetes hudsonica Clarke, Spirifer murchisoni (Castelnau), Metaplasia pyxidata (Hall), Meristella lentiformis Clarke, Spirifer tribulis Hall.

Cobleskill, Rondout, and so-called Manlius limestones of south-eastern New York the fauna is much smaller, the species that continue into the overlying formations are only six in number, and the proportion of species derived from the underlying formations is greater in comparison to the total number of species in the fauna. Furthermore, the change in the fauna eliminates the members of the genera upon whose presence is here based the assignment of the Keyser to the Devonian. In the New Jersey and south-eastern New York area the pronounced faunal change occurs at the base of the Coeymans limestone." (Swartz, 1929, pp. 50–1.)

In view of these facts, I submit that Swartz has not presented a very convincing case.

²) The characteristic species of the Oriskanian and Helderbergian are indicated by Swartz, and others (1913, pp. 133-90.)

(3) This fauna is described in greater detail from Becraft Mountain by Clarke (1900).

⁽¹⁾ Since this section was written F. McK. Swartz (U.S. Geol. Survey, Prof. Paper 158-C, 1929) has published his observations on "The Helderberg Group of Parts of West Virginia and Virginia," and has included some interesting notes on the "Position and Nature of the Silurian-Devonian Boundary in the Appalachian Basin" (pp. 48-51). Swartz agrees with the earlier conclusions of Ulrich (Bull. Geol. Soc. Amer., 22, 1911, p. 590) and Reeside (U.S. Geol. Surv. Prof. Doc 1001 (U.S. Geol. Surv. Prof. 2014) and the place of the Silurian Conception of the place of the second state of the s Paper 108, 1917, pp. 193-99) that the Silurian-Devonian boundary should be placed at the base of the Keyser limestone. This is somewhat lower than the writer places it in this work.

Swartz bases his conclusion mainly on the presence in the Keyser of members of important Devonian genera—viz.: Chonostrophia, Rensselaeria, Beachia, Meristella, Actinopteria, and Aviculopecten. (p. 50.)

Now, it is significant from the writer's point of view that but two of these six genera-viz., Meristella and Renselaria—are represented by characteristic—i.e., abundant species; furthermore these two genera only appear in the Upper or Favosites-zone of the Keyser. The remaining four genera seem to be quite unimportant. Actinopteria

the Upper or Favosites-zone of the Keyser. The remaining four genera seem to be quite unimportant. Actinopteria is represented by "one fragmentary specimen, found in the upper part of the Keyser limestone" (p. 58); while Chonostrophia, Beachia, and Aviculopecten are not mentioned in Swartz's faunal lists from the Keyser (pp. 35-37). It is obvious that the palæontological evidence for Swartz's conclusion is quite inadequate. That the stratigraphical evidence is weak appears from Swartz's own work. In this connection the following paragraph is of particular interest :--". . The Keyser of Maryland and the Virginias contains a large fauna, with a considerable number of species that continue into the overlying Coeymans, New Scotland, and Becraft limestones, and a lesser number derived from older deposits. The pronounced faunal change is found at the Tonoloway-Keyser contact in this area. "As the Keyser is traced northward through central Pennsylvania the number of distinctly Helderberg species is diminished, and in the apparently equivalent Decker, Rondout, and so-called Manlius limestones of New Jersey and Cohleskill. Bondout, and so-called Manlius limestones of south-eastern New York the fauna is much smaller the species

This may be termed the *tribulis* sub-fauna from the last-named species, but is not essentially distinct from the *gaspensis*-faunas.

The Becraft member of the Helderbergian in Maryland is an arenaceous limestone interbedded with much black chert.

The characteristic species are Spirifer concinnus Hall, Rensselaeria subglobosa Weller, Spirifer cyclopterus Hall, Rhipidomella assimilis (Hall), Schuchertella woolworthana (Hall), and Edriocrinus pocilliformis Hall. Also abundant are—Meristella arcuata (Hall), Rhipidomella oblata (Hall), Uncinulus vellicatus (Hall), and Leptaena rhomboidalis (Wahlenberg).

This appears to be the equivalent of the cyclopterus-fauna of the Chapman sandstone.

The New Scotland Member consists of limestones with white cherts, and subordinate shales. The characteristic species are Schuchertella woolworthana (Hall), Spirifer perlamellosus Hall, Spirifer macropleurus (Conrad), Leptaena rhomboidalis (Wahlenberg), Dalmanella perelegans (Hall), Meristella arcuata (Hall), Rhipidomella oblata (Hall), Chonostrophia helderbergiae Hall and Clark, Dalmanites pleuroptyx (Greene), Anoplotheca concava (Hall), and Spirifer cyclopterus (Hall).

This may be called the macropleurus-fauna from the Spirifer of that name.

The Coeymans Member in Maryland consists of massive, blue, crystalline limestone. The characteristic fossils are *Gypidula coeymanensis* Schuchert, *Atrypa reticularis* (L.), *Schuchertella woolworthana* (Hall), *Leptaena rhomboidalis* (Wahlenberg), *Stropheodonta arata* (Hall), and *Dalmanites pleuroptyx* (Greene).

This may be termed the *coeymanensis*-fauna from the first-named species. This community is closely related to that of the New Scotland Member.

The Keyser Member is formed of massive nodular limestones in its lower part, and is more shaly and thin-bedded above. It contains important coral and stromatoporoid reefs. Thickness, 270 ft. to 290 ft.

The Keyser Member contains two faunas, which it will be well to distinguish. The upper unit, consisting of shales with limestones, is characterized by the species *Rensselaeria mutabilis* (Hall), *Schuchertella prolifica* Schuchert, *Meristella praenuntia* Schuchert, *Tentaculites gyracanthus* (Eaton), and *Leperditia altoides* Weller.

The "reef-knoll" facies of the same age has the following characteristic species: Cyathophyllum schucherti Swartz, Favosites helderbergiae var. praecedens Schuchert, and Stromatopora constella Hall.

The lower part of the Keyser Member-the Chonetes jerseyensis Zone-consists of nodular limestones. It, too, contains a normal fauna and a fauna of "reef-knoll" facies.

The normal fauna contains the following characteristic species: Chonetes jerseyensis Weller, Camarotoechia litchfieldensis (Schuchert), Stenochisma deckerensis (Weller), Cladopora rectilineata Simpson, Spirifer modestus Hall, Sp. vanuxemi var. prognostica Schuchert, Camarocrinus stellatus Hall, and Gypidula coeymanensis var. prognostica Schuchert.

The "reef-knoll" fauna is characterized by Favosites pyriformis Hall, Syringostroma centrotum Girty, S. barretti Girty, Aulopora schohariae Hall, and other species.

The community in the Upper Keyser Member may be termed the *mutabilis*-fauna; that of the lower part the *jerseyensis*-fauna.

The Tonoloway Member of the Cayugan Formation consists of interbedded limestone and calcareous shale. Thickness, 600 ft. The fauna consists essentially of ostracods. Apart from this group, the characteristic species are *Hindella congregata* Swartz, *Rhynchospira globosa* (Hall), *Stenochisma lamellata* (Hall), *Camarotoechia litchfieldensis* (Schuchert), *Spirifer vanuxemi* (Hall), *S. corallinensis* Grabau, *Schuchertella rugosa* Swartz, *Hormatoma rowei* Swartz, and *Tentaculites gyracanthus* var. marylandicus Swartz.

This community may be termed the vanuxemi-fauna from the Spirifer of that name.

Pre-vanuxemi faunas in the Cayugan need not be detailed. They contain no Devonian species in their characteristic fossils.

Fauna.	Maine.	Gaspé.	New York.	Maryland.		
C. commerce	Magan Brunn	Gaspé Sandstone	0	Ridgely		
GASPENSIS	SANDSTONE	GRAND GREVE LIMESTONE	ORISKANY SAND- STONE	SHRIVER	ORISKANIAN	
Cyclopterus	Chapman Sand- stone		na ta ang s	BECRAFT		
MACROPLEURUS			· . ·	NEW SCOTLAND		
COEYMANENSIS				Coeymans	Helderbergian	
MUTABILIS	2.0	• 1.		UPPER KEYSER	5 5	
JERSEYENSIS				Lower Keyser	e a e	
VANUXEMI				TONOLOWAY	Cayugan	

CORRELATION OF NORTH-EASTERN AMERICAN AND WESTERN EUROPEAN COMMUNITIES.

As far as comparison with Western European communities is possible, the characteristic fossils of the arenaceous horizons represented by the Moose River sandstone, the Gaspé sandstone, and the Oriskany sandstone of New York, suggest the *hercyniae*-fauna of Lower Emsian age. This correlation is based chiefly on the presence in these American strata of Spirifers of the *hercyniae*-type (Sp. gaspensis, Sp. murchisoni), and of Leptostrophias of the *explanata*₁type (L. magnifica and its varieties).

[•] It has been shown that the fauna of these American arenaceous horizons is essentially similar to that of the calcareous Oriskany strata in Maryland. Of the twenty-four species cited as characteristic of one or other of the arenaceous horizons, seven occur in the calcareous Oriskanian of Maryland.

If these conclusions are legitimate, then an important fact emerges. The gaspensis-fauna of calcareous facies in Maryland is the equivalent of the *hercyniae*-fauna of psammo-pelitic facies in Western Europe.

This correlation across the facies may be carried a stage further. The Chapman sandstone fauna of arenaceous facies has been shown to be the equivalent of the hystericus-fauna of psammo-pelitic facies in Western Europe. The Chapman sandstone community, further, contains certain of the characteristic fossils of the cyclopterus-fauna of the calcareous Becraft Member of the Helderbergian of Maryland (notably Spirifer concinnus and Sp. cyclopterus). Hence the hystericus-fauna of Europe is represented in the calcareous facies of Maryland by the cyclopterusfauna.

In the horizons of calcareous facies in Maryland below the Becraft—*i.e.*, in the New Scotland, Coeymans, Keyser, and Tonoloway—Emsian and Upper Siegenian elements among the characteristic fossils become rarer and rarer. In the New Scotland Member such elements are Schuchertella woolworthana (Hall), Rhipidomella oblata (Hall), and Spirifer cyclopterus (Hall). In the Coeymans Schuchertella woolworthana (Hall) is the sole representative. In the Keyser and in the Tonoloway they are totally lacking.

It is difficult to recognize Middle and Lower Siegenian elements in the New Scotland and Coeymans of Maryland, but it is significant that the cyclopterus-type of Spirifer first appears in the Coeymans, where it is locally abundant, and becomes characteristic in the New Scotland and Becraft. In Western Europe the equivalent Spirifer hystericus appears in the Taunusian and is most characteristic of the Upper Siegenian. In the Tonoloway the Spirifers belong to the type of vanuxemi (Hall). This species is, as Williams and Breger (1916, pp. 91-93) have pointed out, ancestral to the cyclopterus-type. Sp. vanuxemi is represented in Western Europe by Sp. mercuri Gosselet from the Schistes de Méricourt (Downtonian), and the Schistes de Mondrepuits. This is most significant, and suggests the correlation of the Tonoloway with the Lower Gedinnian (Downtonian).

The above discussion suggests the following correlation between the calcareous facies of Maryland and the psammo-pelitic facies of Western Europe.

Maryl	and.	Western Europe.		
Fauna.	Horizon.	Fauna.	Horizon.	
Gaspensis Cyclopterus {Macropleurus Coeymanensis Vanuxemi	Ridgely.Shriver.Becraft.{New Scotland.Coeymans.Keyser Member.Tonoloway.	Hercyniae Hystericus {Primaevus Sedgwicki Mercuri	Lower Emsian. Upper Siegenian. {Middle Siegenian. Taunusian. Non-marine. Lower Gedinnian.	

The Keyser Member, therefore, becomes the time equivalent of the non-marine Upper Gedinnian with the lyelli-fauna.

If these tentative correlations be substantiated, and this will necessitate very careful field work in both North America and Europe by the same authority, then the problem of finding a complete Upper Silurian – Lower Devonian sequence of strata of the open-water calcareous facies is solved. In order to determine whether a rigid, natural boundary can be fixed between the Silurian and the Devonian, the above correlations are assumed to be true, and Maryland is taken as a standard area.

It then becomes clear that the sequence of faunas is transitional and gradual. The Tonoloway fauna has much in common with that of the Keyser. The Keyser fauna foreshadows that of the Coeymans, and so on up to the Oriskanian. There is no clear-cut faunal break where the facies is the same. This was to be expected on a priori grounds.

The conclusion, therefore, is inevitable that the problem of the Siluro-Devonian boundary has no real significance. From the point of view of faunal chronology there is no boundary.

However, for the general convenience it is desirable to fix an artificial limit, and this limit must be chosen with reference to faunas of the open-water marine habitat. Three possibilities are suggested. First the limit may be chosen to coincide with the incoming in force of the *explanata-hercyniae* faunas—*i.e.*, at the base of the Oriskanian of North America, or between the Emsian and Siegenian in Western Europe. Second, the limit may coincide with the incoming of the *cyclopterus-hystericus* faunas—*i.e.*, between the Coeymans and the Keyser in Maryland, or at the base of the Taunusian in Western Europe. Finally, the limit may be determined with reference to the incoming of the *mercuri-vanuxemi* faunas—*i.e.*, below the Tonoloway in Maryland, or below the Lower Gedinnian (Downtonian) in Western Europe.

Now the *hercyniae*-fauna cannot be separated logically from the earlier *primaevus* and *sedgwicki*-faunas in Western Europe; and the Coeymans, New Scotland, Becraft, Oriskanian succession in Maryland is a natural grouping. The first possibility, therefore, has nothing to recommend it.

Again the *mercuri*-fauna of Western Europe is the end point of a normal, marine succession, which forms a natural unit. In Maryland also the Tonoloway has much in common with the preceding Cayugan horizons. The third suggestion also has little in its favour.

The conclusion is therefore that the second case—a limit determined by the incoming in force of the faunas associated with the *cyclopterus-hystericus* type of Spirifer—offers the most practical solution.

In Maryland, then, the base of the Devonian is placed beneath the Coeymans Member of the Helderberg Formation. In Belgium and Germany the lower limit of the Devonian lies at the base of the Taunusian. In Northern France (Liévin) the whole sequence is referred to the Silurian. In Great Britain the Downtonian is referred to the Silurian. It is not yet possible to state that the upper limit of the *lyelli*-fauna corresponds to the lower limit of the Taunusian, therefore the Dittonian may prove to be of Siluro-Devonian age.

LOWER DEVONIAN CALCAREOUS STRATA IN BOHEMIA, HARZ, ETC.

In the above discussion no mention has been made of the pre-Oriskanian faunas of New York, nor of the Lower Devonian calcareous facies in the Harz, nor of the Lower Devonian - Upper Silurian sequence in Bohemia.

In New York the Becraft, New Scotland, and Coeymans are essentially similar lithologically and faunistically to their correlatives in Maryland. The relation of pre-Coeymans units in New York—Manlius, Rondout, Cobleskill, &c.—to those of Maryland is a thorny problem, concerning which American geologists—Weller, Ulrich, Hartnagel, and others—present most discordant views.

The sequence in Bohemia, although classic, is, in fact, imperfectly known, and, without personal studies in the field, little of value from the present point of view could be gleaned from the literature. The question of the Harz faunas is bound up with that of Bohemia.

It is for these reasons that Maryland was selected as the unit of comparison for faunas of the calcareous facies.

SUMMARY.

The major conclusions of this report are :---

A. Concerning the Reefton beds of New Zealand-

- (1) The Reefton beds of New Zealand contain a Lower Devonian marine fauna closely comparable in its characteristic fossils with that of the Upper Siegenian of Western Europe. Lower Emsian horizons may also be present. Also a small fauna, restricted to strata of calcareous facies, and consisting chiefly of Tabulate and Rugose corals, is comparable with the Middle Devonian faunas of Eastern Australia.
- B. Concerning Lower Devonian animal communities and the base of the Devonian System-
 - (1) Lower Devonian marine faunas of the same age can be subdivided into a number of characteristic animal communities, each of which seems to have existed under, and to have been bounded by, a distinct set of physical conditions.

This conclusion is best illustrated by the faunas of Lower Emsian age. Apart from certain cosmopolitan groups, the characteristic fossils of this age differ according to the facies of the strata containing them. Four main Lower Emsian communities are recognized—viz., the fauna of the Oriskanian of Maryland in calcareous strata; the gaspensis-fauna of the Moose River sandstone of Maine in arenaceous strata; the antarcticus-fauna of South America, the Falkland Islands, and South Africa in argillaceous strata; and the hercyniae-fauna of Western Europe in psammo-pelitic strata.

C	0	RI	REI	.AI	NIC)N	T	AB	LE.

Western European Fauna.	South Devon and Cornwall.	Ludlow.	Lievin.	Ardennes.	Germany.	Maine.	Maryland.	North American Fauna.
Hercyniæ	n s La s	ta a st		Emsien Inférieur (Ahrien)	UNTERKOBLENZSCHICHTEN	Moose River Sandstone	Ridgely Shriver	Gaspensis
Hystericus	ş *			SIEGENIEN SUPÉRIEUR (Hunsrückien Supérieur)	Herdorfer Schichten	Chapman Sandstone	Becraft	Cyclopterus
PRIMÆVUS .	LOOE BEDS			Siegenien Moyen (Hunsrückien Inférieur)	RAUHFLASEB SCHICHTEN		NEW SCOTLAND	MACROPLEURUS
SEDGWICKI	- X			SIEGENIEN INFERIEUR (TAUNUSIEN)	Tonschiefer Horizont (Taunus Quarzit)		COEYMANS	COEYMANENSIS
Tarat ta		L.O.R.S.	SCHISTES DE VIMY		······		Knygpp	Manual Tananana
LYELL	10	(DITTONIAN)	Schistes de Pernes	GEDINNIEN SUPERIEUR	a	- ¹⁰ - 11	IXEYSER	MUTABILIS-JERSEYENSIS
MERCURI		(DITTONIAN) TEMESIDE GROUP (DOWNTONIAN)	Schistes de Pernes Psammites de Lievin Schistes de Méricourt	GEDINNIEN SUPERIEUR			TONOLOWAY	Vanuxemi
MERCURI		(DITTONIAN) TEMESIDE GROUP (DOWNTONIAN) UPPER LUDLOW GROUP	Schistes de Pernes Psammites de Lievin Schistes de Méricourt Couches de Drocourt Calcaire D'Angres	GEDINNIEN SOPERIEUR			TONOLOWAY [Not studied.]	Vanuxemi
MERCURI		(DITTONIAN) TEMESIDE GROUP (DOWNTONIAN) UPPER LUDLOW GROUP DAYIA SHALES	Schistes de Pernes Psammites de Lievin Schistes de Méricourt Couches de Drocourt Calcaire d'Angres Calcaire de Liévin	GEDINNIEN SUPERIEUR			TONOLOWAY [Not studied.]	VANUXEMI

Siluro-Devonian Boundary.

[To face page 58.

- (2) The chief condition governing the distribution of these Lower Emsian faunas appears to have been the degree of clearness of the water. It is, however, impossible to assess the value of such factors as salinity, temperature, and competition.
- (3) Where the physical conditions are identical, even in widely separated areas, the characteristic fossils of strata of the same age are identical or closely related. The most striking example of this fact is found in the close agreement of the Reefton mudstone-sandstone facies fauna with that of identical facies in the Upper Siegenian of Western Europe.
- (4) Certain Lower Devonian types appear to have had a wide range of physical stability, and occur in strata of various facies. The most noteworthy examples are Leptocoelia flabellites (Conrad), and the species-groups of Spirifer hercyniae Giebel, and Leptostrophia explanata (Sowerby).
- (5) These types, of great physical stability, are of great importance in that they allow of correlation from facies to facies.
- (6) In any one area it is possible to define a chronological succession of characteristic animal communities in Lower Devonian strata. When, as is often the case, members of a species-group occur in successive communities the evolutionary stages in that species group have significant stratigraphical importance. Thus in Western Europe the species-group of Spirifer hercyniae Giebel contains the lineage hystericus ≥ primaevus ≥ hercyniae ≥ paradoxus. Each of these species is characteristic of a definite community. S. hystericus, which appears first in time, does not however become characteristic until after the period of dominance of the primaevus-type.
- (7) In Western Europe there is nowhere a complete marine succession ranging from strata of undoubted Silurian age to strata of undoubted Devonian age. Non-marine faunas separate the Lower Gedinnian marine fauna from the Taunusian marine fauna. Hence if the international use of the term Devonian is to be preserved, and if a faunal classification is to be based upon the succession of the open-water type of marine faunas, then the limit between the Silurian and the Devonian cannot be defined with regard to the Western European sequence.
- (8) A complete succession of strata with marine faunas of the open-water type, ranging from Silurian to Devonian, occurs in Maryland, in North Eastern America. In Maryland the succession of characteristic fossil communities is gradual. Where the facies is stable, therefore, there is no faunal break between the Silurian and the Devonian.
- (9) For general convenience it is desirable to fix an artificial limit between these two periods.
- (10) The base of the Devonian is fixed to agree with the incoming in force of the faunas associated with the cyclopterus-hystericus type of Spirifer.

In Maryland, then, the boundary between the Silurian and the Devonian lies at the base of the Coeymans Member of the Helderberg Formation; in Western Europe, at the base of the Taunusian or Lower Siegenian.

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APPENDIX.

ON THE SEQUENCE OF DEVONIAN STRATA EXPOSED IN THE LEFT BRANCH OF LANKEY CREEK, NEAR REEFTON.

THESE notes are the result of a brief visit to Reefton made in January, 1930.

Lankey Creek is a tributary entering the Inangahua River about three miles east of Reefton. It cuts through a belt of Devonian rocks nearly a mile in width, which is faulted on both east and west against the greywackes of the Aorere Series of pre-Devonian age. The main or left branch of Lankey Creek flows in a south-westerly direction, and, since the strike of the Devonian strata is approximately north and south, with a westerly dip of high angle, successively lower horizons outcrop as the creek is traced towards its source.

The watershed is heavily bushed, the creek deeply excavated throughout most of its length, and the lower part and spurs free of bush are generously clothed in tangles of bracken and blackberry. These obstacles make it difficult to determine a detailed succession.

The sequence in the creek is frequently obscure for distances that vary from a few feet to several chains, but many of the gaps can be filled in by examination of the sides of a track which follows a disused coal-race that runs parallel to the creek.

Fossils were first discovered in Lankey Creek by Theodore Ranft in, or prior to, 1872. Collections were made by McKay in 1873; by McKay and Cox in 1876; and by the former during 1882. The most detailed account of the stratigraphy is that of McKay. (*Rept. Geol. Explor.* during 1882 (1883), pp. 104–118.) J. Henderson (1917) added supplementary data, but did not provide more than a generalized sequence of the Devonian strata. Although large collections have been obtained from Lankey Creek, no attempt has hitherto been made to collect from individual lithic units, or from horizons within such units. The object of the recent visit was to try to establish the exact place in the succession of the species described above from the material collected by earlier . workers.

The highest beds observed containing fossils outcrop on the track beside the coal-race on the north side of the creek immediately west of the limestone quarry on the same side. Here the beds are weathered felspathic sandstones indistinguishable in hand-specimen from similar rocks of the The fossils are poorly preserved casts and are few in number. Aorere Series farther to the west. The following have been determined : Chonetes sp. ind., "Spirifer" sp. ind. (not "S." cf. hercyniae, nor "S." cf. hystericus), and Meganteris cf. neozelanica n. sp. These greywackes appear to lie directly upon a coralline limestone. McKay, in discussing Lankey Creek (or Gully), stated that the limestone "has blue Spirifer slates seemingly above and below it." (1883, p. 111.) I am unable to confirm this statement, but it should be noted that Henderson, in referring to the same locality, stated "seemingly overlying the limestone in this locality are argillite and greywacke containing Devonian fossils, but otherwise indistinguishable from the beds of the Aorere Series so abundantly developed in the [Reefton] Subdivision. This locality, however, is traversed by a powerful fault, and the true position and thickness of the rocks are matters of doubt. Similar argillite occurs with the intensely faulted Devonian rocks of Rainy Creek, and since they are there in the same relative position it is probable that they are part of the general succession and overlie the limestone." (1917, pp. 73-74.)

More evidence is required to settle this point, but the presence of *Meganteris* cf. *neozelanica* suggests a Lower Devonian age, whereas, as noted below, the limestone is almost certainly Middle Devonian.

The highest horizon of which the position is palaeontologically and stratigraphically definite is a dark-blue limestone with which are intercalated bands of argillite. The limestone in the left branch of Lankey Creek strikes N.-S. and dips 80° W. The rock is quarried on both sides of the creek, and is burnt for lime. It is found also *in situ* in the creek-bed. The thickness is approximately 60 ft. to 70 ft. Fossils occur abundantly in bands in the limestone, but as a rule are difficult to extract. They also occur as casts in the weathered argillites. Corals are abundant, as also are various dendroid organisms, including *Favosites* and bryozoa. Brachiopoda are found somewhat commonly, but I did not collect any material sufficiently well preserved for exact determination. A species of "Spirifer" is most common. Casts of *Fenestella* are noteworthy, and fragments of crinoids abound.

This limestone was also examined in the right branch of Lankey Creek, where it is richly fossiliferous. *Eridophyllum bartrumi* n. sp. is very abundant. The same horizon is described by McKay (1883, p. 108) from the right bank of the Inangahua River, one mile east of Lankey Creek,

5-Pal. Bull. No. 14.

The corals so far determined from this limestone are "Cyathophyllum" dunstani Eth. fil., Eridophyllum bartrumi n. sp., Favosites murrembidgeensis Jones MS. Allan.

In addition there are several undescribed species of corals and some bryozoa.

P. G. Morgan (N.Z. Geol. Surv. Bull. No. 22, 1919, p. 208) cites some analyses of this Devonian limestone. The percentage of $CaCO_3$ varies from 84.81 to 87.50.

Beneath the limestone is a thickness of some 700 ft. of blue argillites of fine texture; these beds weather brown. The succession is exposed intermittently along the track beside the coal-race on the north side of the Creek. The argillites are fossiliferous in most outcrops, but, apart from certain definite horizons to be noted below, the fossils are comparatively rare. Certain species occur sporadically throughout, and of these *Chonetes maoria* n. sp. is most noteworthy.

Four horizons or bands, each characterized by a great abundance of a single species, can be recognized, but one of these could not be found *in situ*.

About a chain along the track from the quarry, the rocks contain a great abundance of *Meganteris* neozelanica n. sp., which is here not in any way distorted. Fine specimens can be obtained from weathered slabs. In the unweathered argillite this species retains its shell, but can only be extracted with difficulty. With this species are found *Proschizophoria* cf. provulvaria (Maurer) (common), Eatonia parki n. sp. (rare), and Acrospirifer cf. hystericus (Schlotheim).

Some 30 ft. lower in the sequence a narrow band occurs crowded with rather crushed specimens of *Chonetes maoria* n. sp.

About 90 ft. below the band of *Meganteris neozelanica*, just before the track and race cross a small stream, is an horizon with large, well-preserved specimens of *Acrospirifer* cf. *hercyniae* (Giebel). This species occurs in immense numbers, and with it are *Chonetes maoria* n. sp. (not uncommon), and *Meganteris neozelanica* n. sp. (rare).

A fourth horizon, known only from isolated boulders, but certainly derived from the argillites, contains a profusion of *Leptostrophia reeftonensis* n. sp., and less commonly *Acrospirifer* cf. hystericus (Schlotheim) (moderately abundant), *Chonetes maoria* n. sp. (common), and *Proschizophoria* cf. provulvaria (Maurer) (rare).

Near the base of the argillites a band of poorly preserved, iron-stained casts of very distorted *Meganteris neozelanica* n. sp. was recognized. The species is abundant.

The striking feature of the argillites is the presence of comparatively thin bands containing an amazing abundance of a single species associated with a few other species in insignificant numbers. In this respect the Reefton occurrence is very similar to that in the classic area of Belgium and Germany.

The following fossils were found in situ in the argillites: Acrospirifer cf. hercyniae (Giebel) (abundant), Acrospirifer cf. hystericus (Schlotheim) (common), Chonetes maoria n. sp. (abundant), Eatonia parki n. sp. (rare), Leptostrophia reeftonensis n. sp (rare)(¹), Meganteris neozelanica n. sp. (abundant), Proschizophoria cf. provulvaria (Maurer) (common).

The sequence immediately below—*i.e.*, upstream from—the argillites is not very clear until the base of the quartzite bluff is reached. On the track unfossiliferous argillaceous limestone is exposed, but its relation to the strata above and below is obscure. There are no outcrops in the creek, but some distance below the fall over the quartzite, in a dry creek channel on the north side of the creek, some 40 ft. of black or dark-blue limestone is found *in situ*. Intercalcated are thin bands of black, greasy-looking mudstone. These rocks strike N.-S., and dip 80° W. No fossils were observed.

These beds overlie a thick series of quartzites. The upper member, over which the creek forms a picturesque fall, is a pale grey to flesh-coloured rock with numerous stringers of quartz. It forms high precipices on either side of the creek. The strike is still N.-S., but the dip is slightly less, being 70° W. This rock overlies dark-red cherty quartzites, which in turn succeed a great thickness of bluegrey, rather coarse-grained quartzites. The latter appear to be faulted against the greywackes of the Aorere Series.

The total thickness of the quartzite series must exceed 700 ft. No determinable fossils were collected.

No great precision can be claimed for the thicknesses cited, and it is quite possible that more detailed work will prove that the sequence detailed is incomplete.

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EXPLANATION TO PLATES.

PLATE I.

Fig. 1. Homalonotus (Digonus) expansus Hector. Lectotype. Locality 129. Lower Devonian. $\times 1$.

Fig. 2. Dechenella (Eudechenella) mackayi n. sp. Holotype. (?) Middle Devonian. $\times 2$.

Fig. 3. Homalonotus (Digonus) cf. expansus Hector. Locality 130. Lower Devonian. × 1.

Figs. 4, 5. Homalonotus (Burmeisteria) huttoni n. sp. Holotype. (Canterbury Museum.) Lower Devonian. × 1.

Fig. 6. Chonetes maoria n. sp. Holotype. Lower Devonian. Locality 130. $\times 2$.

Figs. 7, 8. Chonetes nigricans n. sp. Locality 129. Lower Devonian. Fig. 7 (juvenile), \times 3; fig. 8 (holotype), \times 2.

Figs. 9, 10. Leptostrophia reeftonensis n. sp. Paratype (fig. 9) and holotype (fig. 10). \times 1.

PLATE II.

Figs. 1-3. Acrospirifer cf. hercyniae (Giebel). Lower Devonian. (Fig. 1, normal example; fig. 2, a specimen of the assimilis Fuchs type; fig. 3, a distorted specimen from the National Museum collection, Melbourne). × 1.

Figs. 4, 5. Acrospirifer cf. hystericus (Schlotheim). Lower Devonian. (Fig. 4, sculpture from a specimen in the Auckland University College collection, $\times 2$; fig. 5, $\times 1$.)

Fig. 6. Leptocoelia flabellites (Conrad). Lower Devonian. \times 2.

Fig. 7. "Spirifer" chapmani n. sp. Holotype. (?) Lower Devonian. Type in the National Museum, Melbourne. $\times 2$.

Fig. 8. Lingulidiscina ranfti n. sp. Holotype. Lower Devonian. Type in the National Museum, Melbourne. \times 2.

Figs. 9, 10. Meganteris neozelanica n. sp. Fig. 9, holotype; fig. 10, paratype. Lower Devonian. \times 1.

Fig. 11. Eatonia parki n. sp.' Holotype. Lower Devonian. \times 1.

Figs. 12, 13. "Spirifer" benson in sp. Holotype. (?) Lower Devonian. (Fig. 12, \times 3; fig. 13, \times 6.)

Fig. 14. Camarotoechia mackayi n. sp. Holotype. (?) Lower Devonian. \times 3.

PLATE III.

- Figs. 1, 2. Acrospirifer hercyniae (Giebel). Unterkoblenschichten, Oberstadtfeld, Eifel, Germany. Coll. R. S. Allan. × 1. (Compare pl. II, fig. 1.)
- Figs. 3 and 5. Meganteris neozelanica n. sp. Lower Devonian. Juvenile. (Fig. 3, \times 3; fig. 5, \times 1.)

Figs. 4 and 7. Proschizophoria cf. provulvaria (Maurer). Lower Devonian. × 1.

Fig. 6. Goniophora hendersoni n. sp. Holotype. Lower Devonian. Type in Auckland University collection. $\times 1$.

Fig. 8. Echinocaris sp. ind.

- Fig. 9. Palaeoneilo sp. ind. Lower Devonian. Figured specimen in National Museum, Melbourne. \times 1.
- Fig. 10. Grammysia (Grammysioidea?) sp. ind. Lower Devonian. Figured specimen in National Museum, Melbourne. × 1.

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Fig. 13. Platyceras sp. ind. Lower Devonian. \times 1.

PLATE IV.

Fig. 1, 2. Lioclema (?) reeftonensis n. sp. Holotype. Middle Devonian.

Figs. 3, 4. Fistulipora cf. trifoliata Schluter. Middle Devonian.

Figs. 5, 6. Favosites murrumbidgeensis O. A. Jones MSS. Middle Devonian. Figured specimen collected by Professor J. Wanner, and presented to the New Zealand Geological Survey.

PLATE V.

Figs. 1-3. Eridophyllum bartrumi n. sp. Holotype. Auckland University collection.

SYSTEMATIC INDEX.

NAMES of genera and species in black type are those described in the present volume. Names in ordinary type represent synonyms or genera and species to which only passing reference is here made.

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PLATE I.



E.T. TALBOT, del.

PLATE II.



PLATE III.



E. T. TALBOT, del.

PLATE IV.



PLATE V.

