II.—The Graptolite-bearing Rocks of Victoria, Australia.

By T. S. Hall, M.A., Melbourne University.

(PLATE XXII.)

Introduction.

THE area occupied by Lower Palæozoic rocks in Victoria is an extensive one, and is pretty equally divided between Ordovician and Silurian, the part occupied by Cambrian being small. According to Dr. A. R. C. Selwyn, formerly Director of the Geological Survey of the Colony, the total area amounts to somewhere about 30,000 square miles in extent,[1] and although in this estimate he included all areas occupied by these rocks provided the cover was not more than 350 feet in thickness, it will still leave us with a large extent of country over which graptolites may be found.

The earliest record of the occurrence of these fossils in Victoria is on a map of Selwyn's published in 1856, where it is stated in a note that graptolites were found for the first time in Australia by C. D. H. Aplin in May, 1856, at a locality indicated on the Saltwater River near Keilor, about ten miles north-west of Melbourne. No identifications have ever been made from these beds, which yield a few species of Monograptidæ in a poor state of preservation.

Very shortly after this graptolites were found in the Lower Ordovician rocks of Bendigo. In an essay contributed to the Catalogue of the Victorian Exhibition of 1861, Professor McCoy recorded from various localities several species which included Diplograptidæ, Dichograptidæ, and Dicranograptidæ, as well as *Monograptus ludensis*, which showed that even thus early almost the whole range of graptolite-bearing rocks had been examined.

In a similar essay by the same author published in 1867, a few additional forms were noted.

The first decade of Sir F. McCoy's "Prodromus of the Palæontology of Victoria" appeared in 1874, and contains the earliest figures and descriptions by which we can judge of the accuracy of his previously published determinations. The plates seem to have been printed off several years previously, for Professor James Hall, in his "Graptolites of the Quebec Group," says that he received a plate from Professor McCoy in 1861, and which from his remarks would appear to be one which was not published till 1875. Two years later, in his fifth decade, Professor McCoy issued figures and descriptions of a few more of these fossils. In 1874 Mr. R. Etheridge, jun., published figures and descriptions of several forms which he identified with known species, the date of his paper in the *Annals of Natural History* and of McCoy's first decade being almost simultaneous.

With regard to the determinations contained in these and other early papers, it may be stated generally that, as was the case of

[1] Intercolonial Exhibition Essays, 1866–7: "Notes on the Physical Geography, Geology, and Mineralogy of Victoria," p. 13.

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many of those of Britain before Professor Lapworth undertook his work of revision, they are in very many cases unreliable. The causes that led to this in the British records have been clearly enunciated by Professor Lapworth, and though it must always appear ungracious to reject any of the work of the pioneers of Australian palæontology, to whom we owe so much, yet the ground must be cleared before a stable structure can be raised. The minute differences on which it has been found advisable to separate the species in this difficult group were not then generally recognized, and we find many of our graptolites identified with forms from which we now regard them as even, it may be, generically distinct. In the case of those forms where the method of branching and the habit is a guide there was, of course, less liability to confusion, and here the specific identifications are of value, but it is extremely doubtful, on the other hand, whether any of the Diplograptidæ have been correctly determined, and a great number of those forms referred to *Didymograptus* (*sensu stricto*) are probably incorrectly identified. One feature, however, must not be overlooked, and this is that the records have in many cases been made from exact localities; and this in the case of Sir F. McCoy's papers, owing to his official connection with the Survey, is of peculiar value, as the precise position from which the fossils came is recorded both by him and on the geological maps, and we are thus frequently enabled to check the records in a very effective way.

During the past seven years I have published several papers on the group as represented in Victoria, and two have also appeared by Mr. G. B. Pritchard, most of them having been printed in the Proceedings of the Royal Society of Victoria.

In a paper dealing with the occurrence of Lower Silurian (i.e. Ordovician) graptolites in New South Wales, Mr. W. S. Dun[1] gives a list of the more important Australian literature referring to the group.

Sequence.

The general sequence of the Victorian graptolites may be correlated with that of the Northern Hemisphere, but experience has shown that it is unsafe to push the analogy too far, and that the only safe method is that of detailed stratigraphical work. Thus we find forms here associated which elsewhere are separated by intervening zones; and, on the other hand, forms elsewhere associated may be here separated. A form which I have named *Leptograptus antiquus*,[2] and which, though not perhaps a typical member of the genus, is certainly not a *Didymograptus*, occurs on the same slabs as a *Bryograptus*. *Didymograptus bifidus*, again, which in Europe and America is characteristic of Upper Arenig, dies out in Australia long before *Phyllograptus typus* has disappeared, and is also survived by a *Clonograptus* and two or three species of *Dichograptus*. At Lancefield, where our lowest Ordovician rocks occur, *Clonograptus flexilis* and

[1] Records of the Geological Survey of New South Wales, vol. v (1897).
[2] Proc. Roy. Soc. Victoria, new ser., vol. xi (1899), p. 164.

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C. rigidus are found in association with *Bryograptus*, while in Europe and America *Bryograptus* is a Cambrian form, and indicates an age to which its Victorian associates forbid us to refer it here. In the Northern Hemisphere, again, *Clonograptus flexilis* is associated with forms which characterize the next higher horizon with us. The case of *C. rigidus* is also striking, for though in America it is, according to Ami,[1] associated with *Loganograptus*, yet with us the latter genus does not appear till *Phyllograptus typus* and closely allied species have become extinct. These are all striking forms, and although it is of course not impossible that mistakes in identification have been made, yet figures and descriptions of Australian forms referred to these species have been published by McCoy and myself, with the exception of the members of the tuning-fork graptolites.

The stratigraphical evidence on which these statements are founded does not rest on merely a single set of outcrops, for, with the exception of the Lancefield beds, the field relations of which have not yet been worked out, as the conditions are unfavourable, their relative position has been studied in two or three places.

To prove a negative is, of course, not an easy task, and it may be objected that the non-association of some of the forms I have quoted is only due to imperfect collecting. For instance, I have placed the Castlemaine rocks as a whole above those of Bendigo, and both above those of Lancefield, and have never seen *Clonograptus flexilis* anywhere but at Lancefield, where *C. rigidus* occurs as well. A species related to the latter, which, however, I believe to be distinct, ranges up into the lower Castlemaine zones, but never as high as beds which contain *Loganograptus Logani*. This statement is founded on several years' collecting in fairly rich beds at Castlemaine and Bendigo, as well as on the examination of several collections made at the latter place by others, so that the evidence in favour of the facts being as I believe them to be is strong.

The numerous localities at which graptolites occur in Victoria and the vast area over which they are spread render the hope of anything like a complete account of them for some time to come quite out of the question, and all that can be done at present is to give a brief outline of what has been done towards elucidating their sequence. There is not at present sufficient evidence available to do more with the Ordovician rocks as a whole than to divide them into Upper and Lower, the upper division being characterized by the presence of Dicranograptidæ.

The most thorough collecting that has been done is in the older beds of the Lower Ordovician, and even here large areas are almost untouched. The younger beds of the series have not as yet yielded many forms in a sufficiently well-preserved condition for description, while those from the Upper Ordovician occur at widely scattered localities, and the collections made are small and poor. Still worse is the case of the Silurian forms, for they come from some half-a-dozen localities and afford little more than a record of *Monograptus* and *Retiolites*.

[1] Geol. Surv. Canada, Ann. Rep., vol. iii (1887–8), K, p. 116.

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Main Divisions of the Graptolite Beds.

Lower Ordovician.

1. *Lancefield Series.*—The blue black shales of this locality yield a fauna which I have dealt with in some detail elsewhere.[1]

The species recorded are: *Bryograptus Victoriæ*, T. S. Hall; *Bryograptus Clarki*, T. S. Hall; *Leptograptus antiquus*, T. S. Hall; *Didymograptus Pritchardi*, T. S. Hall; *Didymograptus Taylori*, T. S. Hall; *Tetragraptus decipiens*, T. S. Hall; *Clonograptus flexilis*, J. Hall; *Clonograptus magnificus*, Pritchard; *Clonograptus rigidus*, J. Hall; *Clonograptus rigidus*, var. *tenellus*, Linnars; *Phyllograptus* ? sp.; *Dictyonema Macgillivrayi*, T. S. Hall; *Dictyonema pulchellum*, T. S. Hall.

There is at first sight a strange intermingling of genera here, but the species are all associated in one small excavation, and no separation of the beds is possible. From the occurrence of *Bryograptus*, which is fairly common, the beds must be regarded as the oldest of our graptolite-bearing rocks yet found, while from the presence of the other associated genera they cannot, I think, be regarded as Cambrian, but must be looked on as Ordovician.

2. *Bendigo Series.*—As far as is known, the greatest development of these beds is in the Bendigo district, where our richest auriferous quartz veins occur. A similar fauna is also found at Chewton, Daylesford, Tarilta, Newstead, Spring Plains, Upper Loddon, and near Lancefield.

Minor subdivisions in this thick series will doubtless be made, but at present no salient differences have been noted between the faunas of the various exposures. The fauna is rich, and at Bendigo is usually fairly well preserved, though the beds are often indurated and much cleaved. Many new species are as yet undiagnosed, and several of the old records of *Didymograptus* (*sensu stricto*) are probably incorrect. I have not seen any Diplograptidæ from the rocks of this series, though two species have been recorded from Bendigo. As the family is represented in younger rocks a few miles to the north of the town, in what is known as the Whipstick Country, it is probable that they came from there, the term Bendigo having been used in a loose geographical way. In any case the specific record is open to doubt.

The following species occur, amongst others: *Didymograptus bifidus*, J. Hall; *D. gracilis*, Tqt.; *D.* cf. *decens*, Tqt.; *D. caduceus*, Salter; *Tetragraptus fruticosus*, J. Hall; *T. serra*, Brong.; *T. quadribrachiatus*, J. Hall; *Dichograptus octobrachiatus*, J. Hall; *Phyllograptus typus*, J. Hall; *Goniograptus Thureaui*, McCoy; *G. macer*, n.sp. (vide infra).

A mere inspection of the list hardly brings out the character of the fauna, as a good deal depends on the relative abundance of certain forms. *Tetragraptus fruticosus* and *Phyllograptus typus* are very abundant, while *Didymograptus bifidus* is very rare and

[1] Proc. Roy. Soc. Victoria, new ser., vol. xi, 1898 (1899), pp. 164–178, pls. xvii, xviii, xix.

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perhaps indicative of the higher beds of the series. *Didymograptus caduceus*, again, is rare and small, and it is interesting to notice, as we pass up through a long series of rocks above those of Bendigo, that it increases in relative numbers, and at the same time gradually attains a much larger size, till it reaches its maximum near the horizon of the uppermost Castlemaine beds, where it crowds the rocks to the almost entire exclusion of other forms. It then enters on the period of its decline, is but sparingly represented by stunted forms at Darriwill, and perhaps ranges up into the Upper Ordovician.

3. *Castlemaine Series.*—The rocks which form this series overlie the Bendigo beds conformably. The change in fauna is slight, but *Tetragraptus fruticosus*, so characteristic of the older beds, is absent, and *Didymograptus bifidus* becomes abundant at the base of the Castlemaine rocks. I have subdivided the rocks into several minor zones,[1] but need not here consider the details. The summit of the series has not been clearly marked off from the beds which succeed it, as they are not known to come into contact.

In the lowermost beds *Didymograptus bifidus*, J. Hall, as just stated, is abundant, but soon disappears. *Phyllograptus typus* long persists, and is survived for a short time by *P. angustifolius*, J. Hall. Species of *Diplograptus* appear in the higher beds, but not, apparently, in the lower. A species of *Clonograptus* occurs in the lower beds, but soon disappears. *Loganograptus Logani* puts in an appearance in the highest zones and ranges up into the Darriwill Series.

Though the position of *Didymograptus bifidus* and its allies would appear to be somewhat lower, relatively, than what it is in the Northern Hemisphere, yet if it be true, as has been suggested by Nicholson and Marr, that the 'tuning-fork' group is phylogenetically connected with *Tetragraptus fruticosus*, then its position in beds so closely associated with those in which the latter species occurs is no more than we should reasonably expect to find. The really striking point is that it should die out so soon with us, and characterize rocks that are closely connected by their fauna with the Lower Arenig and not with the Upper. Although we seem to be able to trace the descent in a general way of the 'tuning-fork' group from the *Tetragraptus fruticosus* group, still we are unable, I venture to think, to descend from generals to particulars.

The late appearance of *Loganograptus* is of interest. As it is one of the species figured by McCoy in his "Prodromus of the Palæontology of Victoria," and was stated to occur commonly at Castlemaine, I was naturally on the look out for it, and for a long time in vain. I found it at last about a mile to the south of the town, where I made a prolonged search for it, on the strike of McCoy's locality, which is in the centre of the town and inaccessible. It is never associated with *Phyllograptus typus*, which does not range as high as the beds in which *Loganograptus* first appears. *Dichograptus octobrachiatus* has also disappeared, after having long

[1] Proc. Roy. Soc. Victoria, new ser., vol. vii (1894), pp. 55–88.

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persisted, while the commonest associate is *Didymograptus caduceus*, which is represented by the large variety characteristic of the higher beds of the Castlemaine Series. In Canada the only species given by Ami[1] as associated with it are *Rouvilligraptus Richardsoni* and *Goniograptus Thureaui*. The former species has not been recognized in Australia, while the latter is confined to a lower horizon, not passing up into the Castlemaine Series. In the Skiddaw Slates it would also appear that the position of *Loganograptus* is lower in the series, for Miss G. L. Elles,[2] in her table of suggested phylogeny, puts down *Dichograptus octobrachiatus* and *Tetragraptus quadribrachiatus* as derived from *Loganograptus Logani*. Genealogical trees are notoriously difficult to draw up in biology where there is great danger of confusing the different collateral branches. The question suggests itself as to what is the real order of the appearance of these forms. Migration, one would think, must produce apparent inversions in widely separated regions, and it will be evident that several such inversions actually do occur in the case of our graptolites, or, in other words, that we find in Victoria forms associated which are not found together in the Northern Hemisphere, and *vice versâ*. That the general phylogeny of the graptolites may be traced out on the lines indicated by Nicholson and Marr,[3] and so ably elaborated by Miss Elles, there can be but little question, but the task of elaborating the details is complicated when we take into consideration the possibility that the succession of life in any particular set of beds may not be the true one. The general succession of the graptolites in Australia and the Northern Hemisphere is the same, but there are undoubtedly differences in details.

The Castlemaine Series has been best studied in the district whence its name is taken, and it there includes, as far as I have seen, all the beds above the Bendigo Series, which is but slightly exposed on the main anticline which passes through Chewton.

The group includes rocks occurring at Castlemaine, a large area in the Bacchus Marsh and Coimaidai Districts,[4] Gisborne, and perhaps a considerable part of the intervening country, as well as an area in the Whipstick, north of Bendigo.

The fauna includes *Didymograptus bifidus*, J. Hall; *D. Murchisoni*, Beck; *D.* cf. *decens*, Tqt.; *D. extensus*, J. Hall; *D. caduceus*, Salter; *Tetragraptus serra*, J. Hall; *T. quadribrachiatus*, J. Hall; *T. proiectus*, n.sp. (v. infra); *Dichograptus octobrachiatus*, J. Hall; *D. octonarius*, J. Hall; *Clonograptus*, sp.; *Phyllograptus typus*, J. Hall; *P. angustifolius*, J. Hall; *Loganograptus Logani*, J. Hall; *Goniograptus macer*, n.sp. (v. infra); *Dendrograptus*, sp.; *Diplograptus*, spp.; *Climacograptus*, sp.; and perhaps *Trigonograptus*, as well as many forms as yet unidentified.

4. *Darriwill Series.*—The only locality at which these rocks are known is in the parish of Darriwill, where graptolites were found by

[1] Geol. and Nat. Hist. Surv. Canada, new ser., Ann. Rep., vol. iii, pt. 2, K, p. 116.
[2] Q.J.G.S., vol. liv (1898), p. 537.
[3] Geol. Mag., 1895, pp. 529–539.
[4] Proc. Roy. Soc. Victoria, new ser., vol. x, 1897 (1898), pp. 202–3.

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Wilkinson in 1864. The fauna differs from the typical Castlemaine one by the almost entire absence of *Didymograptus caduceus*, and the appearance of *Lasiograptus* and *Glossograptus*. *Trigonograptus* and several species of *Didymograptus* and *Climacograptus* occur, while *Tetragraptus serra* and *Loganograptus* still persist. Sir F. McCoy records *Tetragraptus Headi*, but judging by the figure and description I am inclined to doubt the identification.

The beds are very rich, and many new forms are present, but the rocks at the only fossiliferous localities known are so much weathered that further elucidation of the fauna is rendered difficult.

This series appears to mark the close of the Lower Ordovician, as in the succeeding rocks Dicranograptidæ put in an appearance.

Upper Ordovician.

No stratigraphical work has yet been done in the Upper Ordovician beds, so that in the present state of our knowledge it will be unwise to attempt any correlation based on the occurrence of a few stray forms the vertical range of which we cannot positively state.

Rocks rich in graptolites, but in a very bad state of preservation, occur on the Saltwater River about twenty miles north of Melbourne. There are present *Cœnograptus gracilis*, apparently, as well as *Dicranograptus ramosus* and several species of *Dicellograptus* and of Diplograptidæ.

A somewhat similar fauna has recently been found near Matlock on the Woods' Point Road,[1] whence I have identified *Diplograptus foliaceus*, Murch., and perhaps *Dicellograptus Morrisii*, Hopk. Diplograptidæ are also represented. The rocks of this area have long been considered Silurian from the occurrence of *Cardium Gippslandicum*, McCoy, the only fossil known from the district. Elsewhere this *Cardium* is associated with an *Orthoceras*, identified by McCoy as *O. striatopunctatum*, Münst., and so considered by him to be of Silurian age. As the age of the graptolites is Ordovician beyond a doubt, the fact of the occurrence of Silurian rocks in the neighbourhood may be questioned till better evidence is forthcoming, though of course the Ordovician may be a small inlier.

The age of the rocks in North-Eastern Victoria was long in doubt, but the discovery by Mr. Ferguson[2] of what proved to be Upper Ordovician graptolites at three widely separated localities showed that a great part of the area must be occupied by rocks of that age. I have identified *Dicellograptus elegans*, Carr., and *Climacograptus bicornis*, J. Hall, from Wombat Creek, where Diplograptidæ are also represented. At Tungamah we get *Diplograptus pristis*, His., and perhaps *Dicellograptus sextans* and *Dicellograptus ramosus*, all, however, badly preserved. From Walwa Creek come *Dicellograptus anceps*, Nich.; *Diplograptus pristis*, His.; *D. truncatus*, Lapw.; *Climacograptus bicornis*, J. Hall. From Eastern Gippsland a few forms, also belonging to the Upper

[1] Proc. Roy. Soc. Victoria, new ser., vol. x (1897), pp. 13–15.
[2] Id., vol. x, 1896 (1897), pp. 183–6.

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Ordovician, have been doubtfully recorded,[1] the condition of the specimens rendering specific identification impossible, though I consider the generic character of the fossils sufficiently clear.

Silurian.

The Saltwater River, in its course south from the Dividing Range, passes over the boundary between the Ordovician and Silurian formations. The river-valley is cut deeply through the great basaltic plain of Western Victoria, which here reaches almost its eastern limit. As is usual in such gorges, the basaltic detritus deeply masks the hill-sides, and outcrops of older rocks are isolated and small, so that whether the junction is conformable or not has not been settled. The question has been avoided on our geological maps by colouring Ordovician to the border of one sheet and beginning the next with Silurian. In the north-east of the colony, however, at Wombat Creek, there is, according to Mr. W. H. Ferguson, of the Department of Mines, an unconformable junction with a conglomerate at the base of the Silurian. The graptolites from the lower beds which he obtained, and which were submitted to me by the Department, are, as mentioned above, of Ordovician age. The fossils from the upper series over the conglomerate were sent to Mr. R. Etheridge, jun. They were in a very imperfect state, but from an examination of them Mr. Etheridge says[2] that he is "inclined to regard the specimens . . . . as of Upper Silurian age," Upper Silurian being used in the sense in which Silurian is used in this paper. There would appear from this, then, that there is a physical unconformity between the two formations in Victoria. That an unconformity exists was long ago asserted by Dr. Selwyn,[3] the statement being based on the difference in the average amount of dip in the two formations, and not on any observed contact. Mr. R. A. F. Murray, lately Government Geologist of the Colony, says that "the precise lines of junction of the two groups have not yet been so nearly ascertained as to enable it to be stated that they are stratigraphically unconformable."[4] Mr. Ferguson's observations, however, would seem to settle the point.

As previously mentioned, the earliest known graptolite locality in Australia lies near the township of Keilor, where Aplin found specimens in 1855. There are one or two species of Monograptidæ present, none of which I find well enough preserved for description, and *Diplograptus* is possibly represented. About a mile from the locality just mentioned another outcrop occurs, which contains a few examples of *Monograptus*, but which is chiefly noticeable as being the spot where *Retiolites Australis*, McCoy, is found, and which has not hitherto been found elsewhere.

The records from other localities are not very satisfactory. I have identified *Monograptus priodon*, from Macclesfield, and *M.* cf. *dubius*,

[1] Geol. Surv. Victoria, Prog. Rep., vol. ix (1898), pp. 126–8.
[2] Ibid., p. 126.
[3] Intercolonial Exhibition Essays, Melbourne, 1867, p. 12.
[4] "Geology and Physical Geography of Victoria," p. 43.

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Suess, from South Yarra, while a few other badly preserved examples of *Monograptus* have also been found at this last locality. From Alexandra a large number of specimens of the same genus have been obtained, all apparently of the one species, but all so badly preserved that no useful purpose would be served by either recording them as old species or describing them as new. It is worthy of remark, however, that no sign of Diplograptidæ has been found at this locality, so that we may perhaps assume that the beds are not very near the base of the formation.

The record, then, of Silurian forms is meagre in the extreme, for we can do little more than assert their presence in the formation, and must await the advent of better material before reliable definite statements can be made.

The absence of many characteristic genera, both Ordovician and Silurian, from our records must be regarded as apparent rather than real. The Lower Ordovician beds are the only ones that have been examined in any detail, while the Upper Ordovician rocks, hitherto worked, are either badly jointed mudstones or highly indurated slates, in which graptolites merely appear as a glaze on the surface.

Other Australasian Localities.

With regard to other Australasian graptolites the information is as yet meagre.

Tasmania has apparently yielded a single specimen, which was identified as *Diplograptus nodosus*.[1] I have elsewhere[2] given reason for supposing that a *Diplograptus* was found, and for the worthlessness of the specific identification, and for the correlation with Victorian beds founded upon it.

New South Wales has recently afforded some Upper Ordovician forms as recorded by Mr. W. S. Dun.[3] Dicranograptidæ and Diplograptidæ are common, but badly preserved. *Phyllograptus* is doubtfully recorded from the same beds, and Mr. Dun kindly showed me the specimen, which, however, I am inclined to regard as one of the Retiolitidæ. *Phyllograptus* certainly does not range as high. These forms come from the south-east corner of the colony, but similar forms have since then been found as far north as the latitude of Sydney, and throw considerable light on the age of a series of slates and sandstones hitherto tentatively regarded as Silurian.

In New Zealand Lower Ordovician graptolites occur, and Sir James Hector[4] gives a few rough woodcuts of some of the forms, but does not identify any of the species. Frech[5] gives a few records, which are all of Lower Ordovician forms, and I have examples of *Didymograptus bifidus* from Nelson.

[1] Thureau, "Report on the . . . Lisle Goldfield": Tasmanian House of Assembly Journal, vol. xliii (1882), No. 146.
[2] Rep. Aust. Ass. Adv. Science, Sydney, 1898, p. 401.
[3] Records Geol. Surv. New South Wales, vol. v (1897), p. 124.
[4] Cat. N.Z. Geol. Exhibits, Ind. and Col. Exhib., 1886, p. 82.
[5] Lethæa Palæozoica, Bd. i (1897).

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Remarks on some of the Forms, with Descriptions of New Species.

Monograptus, sp. (Pl. XXII, Fig. 1.)

The specimen figured shows the characters of the genus, but is too imperfect for specific description, and the figure is merely given as evidence of the occurrence of the genus in our beds.

Locality. — Keilor, from the locality where Aplin first found graptolites.

Didymograptus gracilis, Törnquist. (Pl. XXII, Fig. 2.)

Acta Univ. Lund, vol. xxvi, pt. 2, iv, p. 17, pl. i, figs. 9–12.

Hydrosome slender. Sicula about 1·3 mm. long and very narrow, with a very delicate virgula, which is traceable for about 0·7 mm. Branches extending at 180° and apparently arising at very different levels from the sicula, the left side of which projects as an acute tooth. The left branch is given off from about its middle, the right branch appearing to rise at the level of the aperture. Dorsal edge of the branches convexly swollen opposite the middle of each theca. Thecæ about seven in 10 mm.; slender; outer edge slightly concave, apertural edge straight and facing somewhat inwards, the two edges forming an acute denticle.

Törnquist says that he had an example showing the hair-like virgula, but that he was subsequently unable to find it.[1] It is clearly visible in the figured specimen. Breadth of branch about 0 3 mm.; width of thecæ at aperture about the same.

Locality.—Bendigo; exact locality unknown.

Leptograptus antiquus, T. S. Hall. (Pl. XXII, Figs. 3, 4.)

Locality.—Lancefield.

Tetragraptus projectus, n.sp. (Pl. XXII, Figs. 5, 6.)

Primaries in a straight line, about 1 mm. long. Secondaries diverging at an angle of 90° from each other, rigid, narrow, about 1·5 mm. broad, and may be more than 6 cm. long. Central disc oblong, with straight sides, slightly curving outwards at the angles to embrace the secondary branches. Length parallel to the direction of the primary branches, 7 mm.; breadth, 5 mm. Sicula not visible. Thecæ eight in 1 cm.; short; slightly expanding; apertural margin slightly concave, forming an angle of about 105°; outer margin concave, inclined at 50° to 55°. Amount of overlap not clearly shown in the only specimen found, and cannot be traced further than is shown in the enlarged figure (6).

The narrowness of the secondary branches and the prominent thecæ distinguish the species from all others to which I can find reference.

Locality.—A single specimen, both sides preserved, from the slate quarries five miles west of Gisborne, associated with the large form of *Didymograptus caduceus*, *Tetragraptus serra*, *Diplograptus*, sp., *Climacograptus*, sp., and apparently *Phyllograptus typus*.

[1] Loc. cit., p. 17, footnote.

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Dichograptus octonarius, J. Hall. (Pl. XXII, Fig. 7.)

The tertiary branches at a little more than 1 cm. from the sicula are from 2·5 to 3 mm. broad. Thecæ eleven in 1 cm., slightly expanding, curved, inclined at about 30° in the middle part of their length, and at nearly twice that angle near their aperture. Apertural margin strongly concave, forming an angle of about 150°, and making with the outer margin a prominent denticle. The species seems somewhat more lax in habit than *D. octobrachiatus*, and specimens are common in the middle beds of the Castlemaine district, which lie in very similar positions to that figured by Hall in his "Graptolites of the Quebec Group."

Locality.—The figured specimen is from Victoria Gully, Castlemaine.

Clonograptus rigidus, J. Hall, var. *tenellus*, Lns. (Pl. XXII, Fig. 8.)

The figured specimen shows a common form in the Lancefield beds, where it is associated with the typical form, as described by Hall. *C. rigidus* and *C. tenellus* cannot, I think, be separated, and the extremes are connected by a long intermediate series at Lancefield.

Goniograptus macer, n.sp. (Illustration, p. 450, Figs. 9, 10.)

Syn. *Loganograptus Logani*? R. Etheridge, jun. (*non* J. Hall): Ann. Mag. Nat. Hist., 1874, p. 4, pl. iii, fig. 12.

Id., McCoy (*non* J. Hall): Prod. Pal. Victoria, Dec. i, p. 19 (loc. B *b*, 29, specimens in the National Museum, Melbourne).

Goniograptus, sp., T. S. Hall: Proc. Roy. Soc. Victoria, N.S., vol. vii, 1894 (1895), p. 72.

Hydrosome slender. Primary branches about 1 mm. in length, and forming an angle of 180° with each other. Secondary branches diverging at about 90° from each other, and then bending in a zigzag manner at intervals of about 1·5 mm., and giving off tertiary branches from the salient angle. Tertiary branches form two to four in number. After giving off the final tertiary branches the secondary branches as well as the tertiaries may reach the length of 30 or 40 mm., and are fairly rigid. Sicula about 1 mm. in length, slender, and very slowly tapering. Thecæ eight or nine in 10 mm., overlapping by half their length. Apertural margin slightly concave, forming an angle of about 110° with the axis of the branch. Outer margin inclined at about 25° to the axis of the branch, gently curving towards the distal extremity.

Though the species is fairly common, the delicate nature of the hydrosome rarely allows of its being found in a well-preserved condition, and the thecæ are usually invisible in specimens in slate.

Under the name of *Goniograptus*, sp., I have previously dealt with this species, and shown that it has been confounded with *Loganograptus*, which occurs only in higher beds, the two forms never being associated. The species is evidently congeneric with *Dichograptus Kjerulfi*, Herrmann.[1]

[1] See Geol. Mag., 1886, pp. 13 et seq.

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In the above description I have regarded the secondary branches as giving off tertiaries on alternate sides, instead of treating it as a case of dichotomy, that is, I look at it as showing what botanists term sympodial branching. In this I follow the view of McCoy in his description of the type species, *Goniograptus Thureaui*. In a simple species, such as the present, the distinction may appear trivial, but in the type species, and still more so in an undescribed member of the genus in the National Museum, Melbourne, simplicity is certainly gained by this manner of considering the branching. A similar mode of branching occurs, of course, in *Thamnograptus*.

Locality and Horizon.—It occurs throughout the Bendigo and in the lower members of the Castlemaine Series. In the former it is associated with the stouter and much more copiously branched *G. Thureaui*, which is confined to these beds.

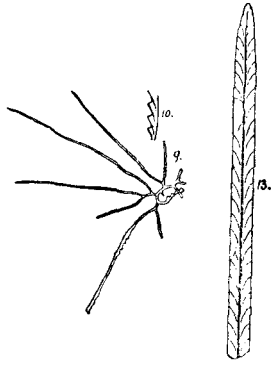

FIG. 9.—*Goniograptus macer*, n.sp.
,, 10.—The same, thecæ enlarged.
,, 13.—*Trigonograptus Wilkinsoni*, n.sp.
} (Reduced to one-fourth nat. size.)

Bryograptus Victoriæ, T. S. Hall. (Pl. XXII, Figs. 11, 12.)

This species is fairly common at Lancefield, and indistinct specimens, with more branches developed than I have figured, occur, but I have shown a well-preserved form. It occurs on the same slabs with the *Leptograptus* figured above, as well as with most, if not all, of the species recorded from that locality in this paper.

Trigonograptus Wilkinsoni, n.sp. (Illustration supra, Fig. 13.)

Hydrosome straight, parallel-sided, gently curving to a blunt point at the distal end. Thecæ inclined at about 30°, gently curving outwards to the margin of the polypary, which they do not indent; about six and a half in 10 mm., opposite to one another. Virgula very distinct, straight, not traceable quite to the distal extremity. Breadth of hydrosome nearly 3 mm., greatest observed length (broken) 4 cm.

The species seems very distinct from those already described by the small number of thecæ in a given length. In general form it

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approaches closely to Hall's figures of *T. ensiformis*, but the thecæ are opposite, and not alternate, and are gently curved. One specimen shows the proximal, or sicular end, to be more abruptly rounded than the distal.

Locality.—Sutherland's Creek, Darriwill, close to the spot marked "W.L.S.I." on Wilkinson's map.

DESCRIPTION OF PLATE XXII.

FIG. 1.—*Monograptus*, sp., enlarged.
,, 2.—*Didymograptus gracilis*, Tqt., enlarged.
,, 3.—*Leptograptus antiquus*, T. S. Hall.
,, 4.—The same, showing thecæ enlarged.
,, 5.—*Tetragraptus projectus*, n.sp.
,, 6.—The same, showing thecæ enlarged.
,, 7.—*Dichograptus octonarius*, J. Hall; thecæ enlarged.
,, 8.—*Clonograptus rigidus*, J. Hall, var. *tenellus*, Lns.
,, 11.—*Bryograptus Victoriæ*, T. S. Hall.
,, 12.—The same, enlarged.

(Unless otherwise stated, the figures are of the natural size.)

III.—On a New Species of *Lepracanthus* from the Yorkshire Coal-measures.

By Edgar D. Wellburn, L.R.C.P. & S.E., F.R.I.P.H., F.G.S., etc.

Genus Lepracanthus, Owen.

Geol. Mag., Dec. I, Vol. VI (1869), p. 481.

Lepracanthus rectus, sp. nov.

THE spine is 40 mm. in length, by 5 mm. in width at the junction of the inserted and exserted portions; from this point the spine gradually narrows to a moderately fine point at the apex. The posterior margin is nearly straight, the anterior one gently curved, the curve being more marked distally. The lateral surfaces meet in front at a moderately acute angle, the spine being much laterally compressed. The posterior surface is concave, and each margin is armed with the usual well-marked recurved denticles. The sides of the exserted portion are ornamented with a longitudinal series of ganoine-coated, tuberculated ridges. The tubercles are squarely shaped, and are arranged in a close series, even in the proximal portion of the spine. In the distal two-thirds there are five such ridges, but in the proximal third they are increased by intercalation to seven. Their direction is as follows:—The anterior one forms a prominent keel on the anterior border, the next two run to the tip more or less parallel to that border, one runs close to and parallel with the posterior border, another runs to the apex between these two sets, and, lastly, on each side of this ridge are intercalated two shorter ones. The inserted portion is well marked, and the line of demarcation between this and the exserted portion runs upwards and backwards, cutting the anterior and posterior margins at an angle of 45 degrees.

The present spine, for which I propose the specific name *rectus*, differs from *L. Colei*, Owen, in that it is straighter and more robust,

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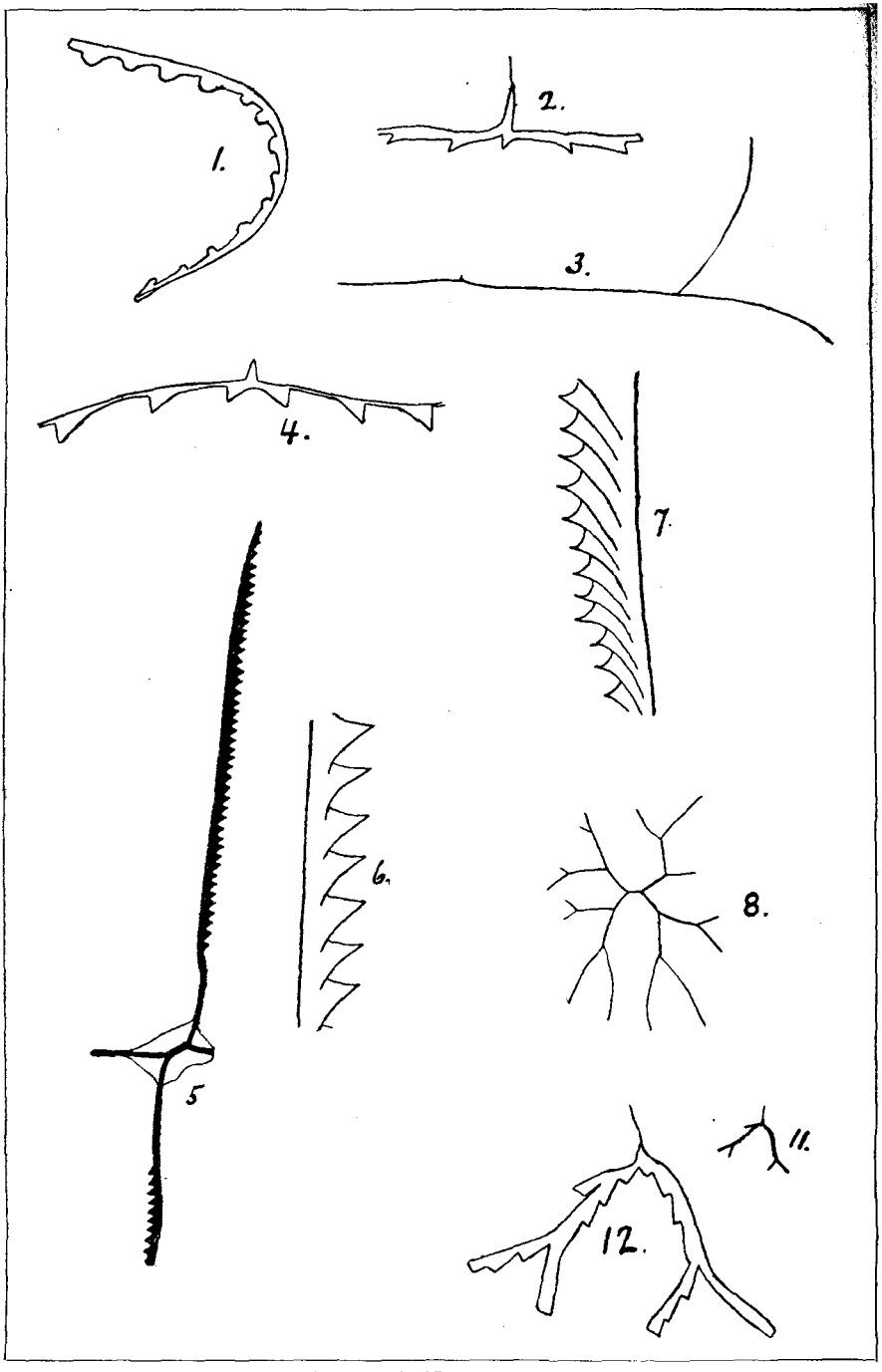

Graptolites of Victoria, Australia.

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