On the Tertiary Deposits of Australia.

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The subject of Australian tertiary geology has not, as far as I can learn, occupied much of the attention of the Royal Society of New South Wales. Owing to the very extensive development of the palæozoic, metamorphic, and volcanic rocks on the eastern cordillera of our continent, the tertiary formations have escaped attention; yet they are certainly an important element in our geological history, and deserve a speedy elucidation at the hands of naturalists in New South Wales. The marine cainozoic rocks of Australia cover at least a fourth part of its surface. The interest they possess, not only for ourselves but for Europe, can scarcely be overstated. As far as they have been studied they have revealed facts which are of almost startling importance to the science generally, and lately some of the discoveries will materially modify long received conclusions. This will appear as I proceed with the following paper, which I intend as a brief *résumé* of the present state of Australian tertiary geology. Such an epitome has long been wanted, not only by men of science, but by the public generally. The time is not far distant, let us hope, when a popular exposition of Australian geology can be prepared. The materials are sufficient, or nearly sufficient. While awaiting this, what I here bring before the notice of the Society may serve as a contribution to the subject, and I am encouraged to the task by the fact that most of what I shall state is new to the public.

Before I refer to what has been done, I beg to draw attention to the special interest the subject has for the natural history of New South Wales. There can be no question that tertiary formations are extensively developed in this Colony. They are no doubt chiefly volcanic or alluvial, with drifts and travertine of various ages; but their nature and position have not been studied—the marine formations have hitherto absorbed all the attention of geologists in Australia. This has not been owing alone to the special attractions they must ever have and the facilities for their study, but also because no satisfactory attempt at the correlation of strata can ever be made until something like a basis has been established by fossils of the relative position of marine strata. But as on the east and south sides of Tasmania, so in New South Wales, tertiary marine strata are not known. This is a significant fact, which has a far more important influence on our geological history than is supposed. But while marine strata are not visible, volcanic strata, freshwater deposits and drifts, all clearly tertiary, are abundant. No attempt, or at least no successful attempt, has been made to classify them. It is possible that nothing short of an actual and careful survey would reveal the age and relative position of these rocks, yet something might be done even by amateurs. That all our volcanic rocks possess features of their own, by which they may be recognized almost as surely as if they contained fossils, is a probability which investigation is daily raising to a certainty. In Victoria the miscroscopical and analytical researches of Mr. Ulrich have revealed astonishing facts. Already the augitic and hornblendic rocks are found to arrange themselves chronologically, and, as far as the learned and industrious mineralogist has gone, show an important bearing on the question of auriferous rocks. It may be said to be almost established that no volcanic emanations belonging to different periods, *e.g.*, the miocene and pliocene, will be found to have the same mineralogical characters. This then of itself would simplify the question of our tertiary volcanic geology, and when once taken in hand will not leave us long to wait for valuable conclusions. In the meantime I draw attention to the subject as a most interesting and untrodden field for observation, and I trust that my remarks on tertiary Australian geology may induce observers to stray into a field where an easy and abundant harvest awaits them.

Tertiary marine strata cover the whole or very nearly the whole southern portions of the Australian continent, from about the 125th to the 145th meridian of east longitude. There are interruptions to these beds, more or less; on the east side the formations get more and more narrowly confined to the sea, until they disappear altogether. On the Australian Bight they are uninterrupted, and extend very far from the coast line. They are all very rich in fossils, very well preserved in some cases, and in others masses of casts and broken shells. The peculiar character of these shells will be dealt with presently.

The interruptions to the continuity of the tertiary beds are of much interest. Throughout their course on the level country they are continually broken into by islands of red granite rocks, which are nearly the only elevations in the vast sandy plains of the deserts. Besides these small interruptions there are mountains, notably two large ones. The first, on the eastern side, is the South Australian chain, beginning at Cape Jervis at the mouth of St. Vincent's Gulf, and terminating in what was formerly erroneously regarded as the horseshoe bend of Lake

Torrens. A little further on the eastern side of this range the tertiary beds succeed in unbroken plains to the valley of the Murray. A little to the east of the boundary between South Australia and Victoria the country becomes singularly overlaid by basalts of middle tertiary or later tertiary origin, while a remarkable dome-like area of tableland forms an extensive interruption of some two or three thousand square miles in extent. This is apparently lower mesozoic, cut through by the Wannon and Glenelg Rivers. To the east it is again interrupted by the supposed lias or trias ranges of the Grampians and Victoria ranges. The tertiary rock still maintains its prevalence near the coast, and probably no more complete series of the deposits can be found anywhere than between Warrnambool and Cape Otway. This latter feature is the projecting portion of a range which forms a remarkable interruption, but at Geelong and on the western side of Port Phillip the tertiary formation again appears. The spur of the Dividing Range which abuts upon the sea at Wilson's Promontory is probably the final barrier to the tertiary beds, though some of them may yet be traced close to the sea in Gippsland.

Other and minor interruptions there undoubtedly are, but generally it may be said that a great semi-circular basin of tertiary rocks occupies the southern portion of the Australian continent, much in the way originally represented on the very clear sketch map of the geology of Australia by the late Mr. Jukes. A more detailed map has been recently given to the public by the Victorian Government, on which the same general features are given, but the detailed information attempted is not so reliable. Many of the places marked there as silurian in South Australia are really occupied by tertiary rocks, notably the eastern side of the shores of St. Vincent's Gulf, north of Willunga.

Various attempts have been made at some kind of classification of these beds, but no satisfactory system has yet been adopted, and it may be doubted whether the materials are as yet extensive enough for the purpose. Professor Duncan is of opinion that the whole of the deposits should be included under the general title of cainozoic, until the existing fauna shall be well enough known to admit the percentage system to be applied. This also will require a far better knowledge of the fossils than we have at present. The fauna of different beds in widely separated localities show that the results obtained so far are somewhat perplexing. Yet there are certain characters which seem to prevail. In order to understand these, I must give an account of what has been done towards the classification of Australian marine tertiary fossils. Strezelecki was the first in the field, but this only resulted in the determination of a single species. The next attempt was that of Professor Busk in 1859 (*Proceedings Geological*

Society). This was confined to Polyzoa. My humble efforts followed in 1862 (*Geological Observations in South Australia*), but this resulted in little more than a few figures and names. Professor Duncan immediately afterwards took the corals in hand, and in a series of papers in the *Geological Society's Proceedings*, threw great light on the nature and affinities of our fossil corals, from materials supplied by myself. In 1865 I published figures and descriptions of several of the more remarkable *Brachiopoda* occurring in the Mount Gambier formation, with a few *Echinodermata* and some conchifera (*Pectinidæ*). These were published and the figures lithographed by me in the Proceedings of the Adelaide Philosophical Society. In 1869 *Dr. G. C. Laube, in the Sitz. d. k. Akad. d. Wissen. Wien* (*Vienna*) *B. lix. Ab.* 1, 1869, *p.* 193, figured and published a very extensive catalogue of the *Echinodermata*, naming a number of new species from the Murray River beds. Shortly afterwards Professor M'Coy commenced the publication of his decades of Australian Palæontology, which left nothing to be desired in the figures or descriptions of the species named. But as the decades include other besides tertiary fossils, the descriptions, so far, do not describe many species; all, however, of the highest interest. In 1874, during a missionary visit to Tasmania, the Council of the Royal Society there placed at my disposal for classification a number of fossils in the Society's Museum, collected by Dr. Milligan, Mr. Stephens, and Mr. R. M. Johnston. The collection showed me at once that the great tertiary formation of Australia extended to the north-west portions of Tasmania. Among well recognized forms I saw many new and interesting species all new to science, and I therefore described them, the figures being executed by that accomplished natural-history artist, Mrs. Charles Meredith. Subsequent investigations by Mr. Johnston enabled him to write several most interesting papers on the deposit, all of which appeared in the Proceedings of the Royal Society of Tasmania; and at the same time he placed so valuable and so complete a series of fossils at my disposal that I was enabled to make a very full comparison of the Tasmanian beds with those of Australia. In all, I succeeded in settling the characters of from seventy to eighty fossils new to science, only very few of which have been hitherto found in Tasmania alone.

In the meantime the Geological Survey of Victoria has been very active, and a series of reports and papers have appeared with important papers on the fossils, from Professor M'Coy and Baron von Müller. Mr. Etheridge, jun., of the English Geological Survey, has also taken an active interest in the matter, and two valuable papers have appeared. In the first (*Geological Society's Proceedings*) he has described a new *Hemipatagus*—*H. Woodsii* (*Lovenia*, var.?), and then given a complete *résumé* of all that has been published on the subject of the Australian fossil Tertiary Echinodermata. In the second (*Annals of Natural History*) he has described some new *Brachiopoda*. But a most valuable accession to our Australian geologists has been in the arrival of Professor R. Tate, of the Adelaide University. He has entered upon his labours with a zeal and industry which bids fair soon to place him far in advance of all other observers in Southern Australia. Already his syllabus of the lectures given shows that he has made important discoveries, and in his private correspondence with myself has made known facts of the highest interest, to which I may refer just now. I may mention, also, that in my correspondence with T. Davidson, the most eminent of British, nay of European palæontologists, in his particular department (the Brachiopoda), I have forwarded all the fossils I could meet with belonging to this most interesting order. I take this opportunity of stating that from no scientific man have I ever met such kindness and courtesy. Trouble seems nothing to him, and his brilliant talents and vast knowledge are cheerfully at the service of the youngest amateurs. His observations on the Brachiopoda are full of interest, and I would place them in full before the Society, but that I know Professor Tate is preparing a monograph for publication on the same subject, which will shortly be accessible to all.

I will now proceed to notice how far the investigation of the fossils has thrown light upon Australian geology, and what relation our tertiary beds bear to similar formations in Europe. And first as regards the term tertiary. We do not pretend by that term to recognise many of the fossils here as identical with what are known as tertiary fossils in Europe. The formations which make up that group are thus classified because they contain either a certain percentage of species still existing, or because by their general contents they make a gradual approach in their typical organisms to the fauna and flora of the present day. Now in Europe the knowledge of the existing fauna, though hardly complete as far as marine life is concerned, is sufficiently so to enable naturalists to say with tolerable accuracy what percentage of fossils in any given bed belong to species which still exist. But in Australia our knowledge of marine life is almost confined to what is called the littoral zone. And to make this partial knowledge still more disadvantageous, I have not met many, or indeed I may say any truly littoral species, in all the tertiary beds I have examined. Neither have we any formation preserved to us, as far as I have been able to ascertain, which can be called the remains of a coast or littoral deposit. This circumstance renders us unable to apply the percentage test, and thus deprives us of those opportunities of classification, or rather correlation, with European deposits which would justify the employment of such terms as oligocene, miocene, &c. This Professor Duncan has pointed out, and has suggested the employment of the word cainozoic as a general term to distinguish those lower tertiary beds which contain the commencement of our modern fauna or new life. While quite agreeing with the learned professor in this, my long acquaintance with all the tertiary formations and my familiarity with the fossils induce me to offer a few suggestions which I think may carry our knowledge a little further. If we cannot apply the percentage system, we can, at least, form general conclusions from superposition, distribution, &c., as to the chronology of the series—if I may so speak. And it seems to me that we must not entirely disregard what I may term a family likeness in the deposits. We must remember that at the present day the existing fauna of widely separated seas, which have scarcely any species in common, have a general resemblance, in the prevalence of certain genera in certain habitats. Thus I suppose there are no seas where some forms of *Littorina*, *Patella*, *Trochus*, *Buccinum*, *Cardium*, *Pectunculus*, and *Mytilus* do not inhabit the rocks and sands. And some of the species bear so close a general resemblance that it is only after a careful comparison we can see specific differences. Now, we ought to see a similar general resemblance in the faunas of very widely separated areas which belong to the same epoch; and this, in fact, we do see, and, as far as my observation goes, almost justifies us in correlating our deposits with similar formations in Europe. I believe, however, that it is a generally received opinion that, as we go further back in time, so we find a wider range for species, until in the earliest deposits we find little specific variety all over the world. It is not quite so certain, however, that where widespread specific identity begins to fail, that close affinity still shows the influence of the former rule. It seems to me, however, that it is so, and it has an important bearing on facts which I now adduce. At present in Australian seas we have a series of molluscan provinces, all united by one general Australian *facies*, yet all with distinct characters peculiar to each. To any one conversant with Australian conchology it would be easy to tell at a glance to what province any given collection of shells belonged. For my own convenience I have been accustomed to divide the Australian seas into five molluscan provinces outside the tropics. These are,—1, Sydney, or Eastern; Victorian, or South-eastern; 3, Adelaide chain; 4, the Tasmanian; 5, South-western; the latter ranging from Port Eucla to Cape Leuwin. Now each of these provinces has species of its own and species in common. Observation as yet will not permit us so far to say with certainty how many of the species now identified are no more than local varieties. However, we can be certain that for those species which have a wide distribution, we see a great difference between specimens gathered in different provinces. Take for instance *Mytilus latus*, Lamk., or the common Australian mussel, which is one of the few shells common to Australia and New Zealand. In the latter place it is a large and often partly yellow shell. In Tasmania it is a brilliant olive green, changing with age into a dull purple. In New South Wales it is a tumid shell of dull olive, and in Victoria it is of the Tasmanian colour and shape, though with peculiarities of its own. This is by no means so favourable an instance as the less known *Patella tramoserica*, which has received a good many names from naturalists in its time. But from those or other instances that might be alleged, we find pretty certainly manifest at the present day local differences of form, character, &c., in otherwise identical species. Now it seems to me that there is not the same variety in our tertiary beds, and that this greater or less variability in remote districts might be made to form a valuable guide to the chronology of the deposits. One thing, however, is certain, which is that the species common in our tertiary beds have a much wider range than any species have now. To prevent the fact being applied too far, let us bear in mind that the deposits are not littoral, but rather that of the laminarian zone. 2nd. That colour, which is an important element in estimating variety in existing shells, is absent from the fossils. 3rd. The tertiary area at our disposal for investigation, though wide, is not nearly so extensive as the area of the provinces enumerated by me. Still, making all those deductions, my observations incline me to the conclusion that we have in our tertiary formations a much greater uniformity in marine life, and species more constant in character, than what is witnessed in the present Australian seas. This fact may seem of small importance in estimating our chronology, but I venture to submit that it is a clue which will lead in the end to valuable data. Whether we could ever hope by its aid to erect sub-divisions in our tertiary formations may appear doubtful, yet it must be of importance until the percentage system can be applied.

The oldest portions of our tertiary beds, as far as we can judge from the contained fossils, appear to be about Schnapper Point, Mount Martha, and Western Port. Here the blue clays, and the general appearance of the contained fossils, forcibly remind one of the eocene beds of West Barton, in Hampshire; and as Professor M'Coy has long ago pointed out, there is a good deal more than mere external resemblance. Some of the fossils closely imitate in character the fossils known in the English beds by what the learned professor has termed "mimetism." The resemblance is so close that some might even suppose the identity of the fossils. This is especially seen in *Voluta antiscalaris*, M'Coy, and

V. anticingulata. But these fossils, it must be added, are also found in newer formations, such as Table Cape in Tasmania, and Muddy Creek in Western Victoria. The general character of the Mount Martha and Schnapper Point beds is first in the beautiful state of preservation in which the fossils occur. The most delicate markings and fine edges are as fresh as if they were just dredged up from the deep. The clay in which they are found is of a light blue or ash grey colour. *Foraminifera* are not common, at least not so common in this finely levigated mud as in many of the higher beds. *Polyzoa* are also the exception. Pedicillate corals are, however, numerous, few of existing species, but of characters similar to those now living in the Japanese and China seas. There are none peculiar to this formation, at least as far as the beds have been explored, and that, it must be admitted, is only slightly. An undescribed *Nisso*, and a beautifully marked *Pleurotama*, also caught my attention, as well as a *Fusus*, so like the beautiful and delicately spined *F. pagodus* of the Philippines, that it has, I believe, been named *Fusus pagodoides* by Professor M'Coy.

Above those beds, and not separated from them by any very clear line of demarcation, we find a series of different deposits of some thickness and very wide spread. The characteristics differ in different localities. In the Geelong beds, and then westward from Cape Otway to Warrnambool, we meet with clays and muds, sometimes intercalated with plant remains, and a long succession of horizontal or slightly inclined stata. The precise number of the beds exposed has not been clearly ascertained, but they represent a very long series of deposits and an extensive period in our tertiary geology. To the north of Warrnambool they are found at a place called Hamilton, or around it, in the form of light brown clays, very rich in fossils. They are overlaid in places by a thick hard rock of ferruginous or ochreous limestone, entirely composed of polyzoa and the fragments of shells. The whole district is overlaid by much later outpourings of volcanic matter, so that the tertiary rocks become hidden, but there is little doubt that they are underneath, as, when wells or shafts are sunk to any depth, if they pierce through the basalt, the polyzoan limestone is reached. Now and then we find outcrops of granite, but even there traces of the tertiary formation appear. At a creek near Harrow, in Western Victoria, about 600 feet above the sea, we find, on the slopes of the granitic formation, a thin clay of a few inches thick, full of highly ferruginous fossils. These are hard and glazed, and have evidently owed their preservation to their ferruginous character, since the beds wherein they were deposited have entirely disappeared, and the fossils lie entangled in the grass, which is almost rooted in the granite. They are all of species common in the

Geelong beds, such as *Cucullæa corioensis*, *Pecten yahlensis*, (Tenison-Woods); *Cassidaria reticulospira* (M'Coy); *Placotrochus deltoideus* (Duncan).

Not very long ago it would have been difficult to name many of the fossils found in this immense series of deposits, but since the labours of M'Coy, Laube, Duncan, Etheridge, already referred to, and my own humble efforts, so large a number of the organic remains have been arranged and classified that it would be quite beyond the limits of this paper to give even a list of names. I propose, however, with the permission of the Society, to publish subsequently in the Proceedings a list of the names, authorities, and exact references where they may be found, as an easy aid to palæontological researches, which is very much required.

In Tasmania we find the same deposits, but under different conditions. The matrix is rather a muddy gravel than clay, and contains fragments of what are evidently the remains of a basaltic rock. There are also an immense number of rounded quartz grains, and the whole formation suggests the proximity of some granitic and basaltic rocky shore. The fossils are not different from those of Victoria, but only different from the character of the fauna in the same locality now. In describing over, I think, ninety fossils from those beds, I did not meet half-a-dozen similar to those now existing on the coast, and those only of shells which are now of rare occurrence. *Fissurella concatenata* (Crosse) is a case in point, and one or two which are doubtfully referred to European forms still existing, or of miocene age. Corals abound throughout the formation, whether in Victoria or Tasmania. One form, *Placotrochus deltoideus*, seems to prevail everywhere, and is very common; but no characteristic eocene form, such as *Turbinoli*. *Balanophyllia* is a genus which is richly represented, but the species in Tasmania are different, and one closely allied form, *Dendrophyllia*, has two species departing very widely from any known forms. In Victoria no reef-building coral was found, but in Tasmania I discovered a *Heliastræa* (*H. tasmaniensis*, Dunc.) to be not uncommon, together with a *Thamnastræa* (*T. sera*, Dunc.) not hitherto found in Australia. The general conclusion forced upon palæontologists by the fossils is that the seas were then much warmer than they are now. The types approach nearer to the fauna of the Philippine Islands and China Seas than anything now living near Australia. It is true that two or perhaps three species of *Trigonia* are found, but these are rather abnormal forms. The strictly Australian ones, such as *Elenchus*, *Cominella*, *Bankivia*, *Trochocochlea*, *Phasianella*, *Thalotia*, *Siphonaria*, &c., are not represented even generically, except a doubtful *Thalotia*.

It is a remarkable circumstance of the fauna of these beds that there has been discovered at Table Cape, Tasmania, one almost perfect skeleton of a wallaby, *Halmaturus* (?), imbedded in a soft yellow sandy clay full of marine fossils. They are principally small *Turritellæ, T. Warburtoni, mihi,* and others. There is nothing whatever to lead one to suppose that the animal was not deposited at the same time as the shells. It may have been carried out to sea by a flood from some coast stream, or it may have been dropped into the sea by a bird of prey. There it lies, however, firmly imbedded among the fossils, a land animal among marine shells. I was not able to ascertain whether the remains could be referred to any existing species. The specimen lies in the Museum of the Royal Society at Hobart Town, where unfortunately there are no marsupial skeletons for comparison. It seemed to me to be the remains of an animal stouter in proportion to its length than any we are acquainted with now. The fossil is of great interest, because first of all it points out the great antiquity of the marsupial fauna of Australia; and secondly, will serve as a guide to the interpretation of some of our cave remains.

At Portland, nearly on the western limit of Victoria, we have a commencement of a newer tertiary formation, known as the Mount Gambier or Polyzoan limestone. It is quite different in character from the lower strata we have been considering, and has been fully described in two publications of mine—viz., "*Geological Observations in South Australia,*" and "*Two Lectures on the Geology of Portland*"—both of which are now in the Society's library. It has also been continually noticed in the reports of the various geological surveyors to the Mining Department of Victoria. I shall not therefore describe it now, but refer to some features which have not been previously noticed. First of all the deposit is distinguished by the abundance of *Polyzoa* and *Foraminifera,* of which, indeed, it is principally (nay almost entirely) composed. The greater part is a kind of marble, very loose and friable, which seems to be composed of broken foraminiferæ. The other fossils may be easily enumerated. They are few and far between, and may be said to comprise *Echinodermata, Brachiopoda,* and *Pecten,* and even these are scarce, except one urchin. This is *Lovenia Forbesii* (Woods and Duncan).* This lies on strata a few inches thick, with no other fossil, showing how curiously they must have flourished in the days of their existence. Now that we have the deep-sea dredging as a guide in estimating the conditions of life at great depths on the ocean floor, we easily understand what we see here. Sometimes the dredge of the "Challenger" would come up full of one kind of echinidæ, as if there was nothing else to be found. Here we see a similar thing in former times. There are also a few

* This fossil urchin was first named by me as *Spatangus,* but subsequently described by Professor Duncan as *Hemipatagus.* The same Professor has recently shown (in Q. Jour. Geo. Soc., 1877, p. 56), by a careful examination of many specimens, that the fossil is a *Lovenia.*

little belts of *Terebratula compta* (Sow.) The deposit is evidently one prevailing at great depths, and very different from its fauna from what we see at the same depths now. In Portland there is a good opportunity for observing the sequence of the tertiary beds and the volcanic outpourings. Tertiary marine strata and recent basaltic rocks are regularly intercalated. Some of these volcanic rocks have evidently been poured out under the sea, and there are two recent craters still visible in the midst of the waves, namely, what are called the Lawrence Rocks and Lady Julia Percy Island. The latter is about seven miles from the shore, and is a crescent-shaped island of almost tabular elevation entirely composed of volcanic ejectamenta. I propose, however, to give a paper on the tertiary volcanic phenomena of Australia, and therefore will not pursue this subject further.

The tertiary beds are found almost universally, unless where interrupted by the volcanic rocks, granite hills, or islands, as we may call them, until the Great South Australian chain or Adelaide Range is reached. They are, however, very much concealed near the coast by very recent pliocene and pleistocene deposits. The beds exposed on the banks of the Murray have never been submitted to a detailed examination by an experienced palæontologist until Professor Tate has taken them in hand. Some of his conclusions have been communicated privately to me; but I refrain from saying more on the subject, as the public will soon hear of them from himself. The same remark must apply to the tertiary beds on the western slopes of the Adelaide chain, about the mouth of the Onkaparinga River. These beds have been long known to me as containing quite a different series of organisms. They seem to me as older than even the Western Port beds; but my opportunities for examination were very limited. Professor Tate informs me that he has found characteristic upper mesozoic fossils among them, though he regards the beds as tertiary.

I find that at a meeting of the Geological Society of London, February 7, 1877, a paper was read from Professor Tate, on new species of *Belemnites* and *Salenia*, from the middle tertiaries of South Australia. The fossils were named by him *B. senescens* and *S. tertiaria.* They were obtained at Aldinga, where, he said, the fossils were for the most part identical with those of the Murray River beds. The *Salenia* was hitherto supposed to be extinct, and a characteristic mesozoic form, but a living species had been dredged up by the "Challenger." In the discussion which ensued, the President, Professor P. Martin Duncan, remarked upon the interest attached to the discovery of this Belemnite, which added another to the curious examples of the survival of older forms of life in Australia. He thought it could hardly have been derived from secondary strata. The *Salenia* was evidently tertiary, and, as it was somewhat cretaceous in its aspect, added another to the cretaceous forms which had outlived the cretaceous period. This and similar discoveries showed the impossibility of comparing Australian and English strata on purely palæontological data. Mr. J. S. Gardiner remarked, in connection with the discovery of cretaceous forms still living in modern times, that American cretaceous beds may be like our eocene. If a Belemnite lived on into the tertiary period, this might give quite another reading to those supposed cretaceous beds, whose determination rests mainly upon their flora. Mr. A. W. Waters said that two years ago he exhibited to the Society Belemnites from Ronca. Since then it has been shown that in the deposit at Ronca there are boulders from older beds, so that although his Belemnites are not rolled, and he regarded them as probably tertiary, the evidence must be considered incomplete. These *Belemnites* were like liassic forms, but very unlike those discovered by Mr. Tate. The Rev. J. F. Blake said that Professor Tate's specimens were more like oolitic than cretaceous forms, and they certainly did not belong to the genus *Belemnitella*. The carrying on of cretaceous forms into tertiary times favours the idea of a non-uniform deposition of beds, and a more continuous succession of life in Australia than in Europe. Professor Rupert Jones said that in 1857 *Belemnites* found in a tertiary deposit north-west of Germany were exhibited at the meeting of the Naturalists' Association at Bonn. Professor Seeley remarked that it was impossible from the material before the Society to determine the species to which the *Belemnite* belonged. The characters were not sufficiently clear to show whether it was a true *Belemnite*, or might form a distinct but allied genus. He agreed with Mr. Gardiner with regard to the resemblance of American cretaceous shells to those of the English tertiaries. Professor Duncan reminded Mr. Blake that there is a sharply defined cretaceous formation in Australia.

If I should venture to suggest anything in this matter, it would be that our tertiary formations are older than the period hitherto assigned to them. I do not think either that our cretaceous formation, which is near the equator and remote from these beds, is quite so clearly defined as imagined; neither is it safe to say that the southern analogues would be so very different from our lower tertiary beds, though I am far from saying that they would be the same. They may, however, be nearer to each other than is at present believed.

Westward of the Onkaparinga and Aldinga beds we have the tertiary formation well represented in some parts of Yorke's Peninsula. At Kadina, Moonta, and the Wallaroo mines generally, fossils are found at a small depth below the surface, mostly Echinoderms (*Arachnoides australis*, *Lovenia Forbesii*). These are well known forms of the Murray River beds, and perhaps they occupy the same geological horizon. They completely, or almost completely, cover the cupriferous veins, which are in true hornblendic or dioritic dykes. The deposit seems widely spread on Yorke's Peninsula.

Westward of these deposits we have the thick fossiliferous formation of the great Australian Bight, which extends for 300 leagues in an unbroken wall, abutting on the ocean at heights ranging from 300 to 600 feet, and all one mass of fossils. I believe this to be a geological phenomenon almost unequalled in extent and peculiarity on the surface of the earth. All the fossils I have seen from these beds have been familiar forms from Victorian or South Australian beds. I should imagine, from the description of the beds themselves, and the fossils submitted to me, that they were nearer to the Mount Gambier formation than those of the river Murray. I have however, never seen a good series of fossils from the cliffs of the Australian Bight, and no doubt they would be of the highest interest, and modify many of our conclusions made. I cannot help thinking that there has been no slow upheaval in the case of the Australian Bight. The cliffs, sometimes 600 feet high, abut upon the ocean without any sign of that wearing process which surely slow and gradual upheaval would cause. There is very strong, nay conclusive evidence, that the close of the miocene period, or rather the dawn of the existing fauna, was ushered in by extensive volcanic disturbance; and this, no doubt, caused very great changes of level and upheaval, some of which was clearly sudden and extensive. It is difficult to interpret the facts in any other way. It seems to me pretty clearly established that the whole central parts of the coast of Southern Australia were almost suddenly upheaved from the sea.

I now append a few notes on the *Brachiopoda* of the tertiary in Tasmania which has formed the subject of my inquiries for some time past. I accompany it with an outline sketch to assist in understanding some of the species to which I refer. I have submitted all the specimens to Mr. Thomas Davidson, Professor M'Coy, and Professor Tate, and I append after each species their remarks.

A *Rhynchonella cœlata*, M'Coy MS.: Rounded trigonal, with a strong mesial fold, with many fine imbricated ribs. "From several miocene beds in Victoria."—M'Coy. "A most beautiful species, very closely related to *R. nigricans*, from New Zealand. Some examples in external shape cannot be distinguished, but I have not observed on any recent *R. nigricans* such prominent and strongly marked imbricated striæ. The fold and sinus seems more strongly marked on the fossil form. The ribs also seem smaller and more delicate than on real *nigricans*."—T. Davidson. "Aldinga, one specimen."—Professor Tate.

No. 1. *Waldheimia imbricata, nobis, W. macropora,* M'Coy, MS. "Called so from pores which separate it from *W. flavescens,* to which I drew attention many years ago when printing that name. I do not, however, know how it can be separated from Davidson's *W. Garibaldiana.*"—Professor M'Coy. "This species has much the character of *W. flavescens* or *Australis.* I have not a good collection of Australian recent species of *Brachiopoda,* but have one that has a good deal of general similarity to this fossil from Table Cape, Tasmania, but none that has exactly the same shape. It would be well to compare with *W. flavescens.* It is a new but allied species, and has also a little resemblance to my *W. Garibaldiana,* although I think not the same species. The sub-pentahedral elongated shape is remarkable, but it is difficult to guess at the variations a species may assume by the inspection of a single specimen."—T. Davidson. "The commonest Brachiopod in the middle beds of the Murray cliffs."—Prof. Tate.

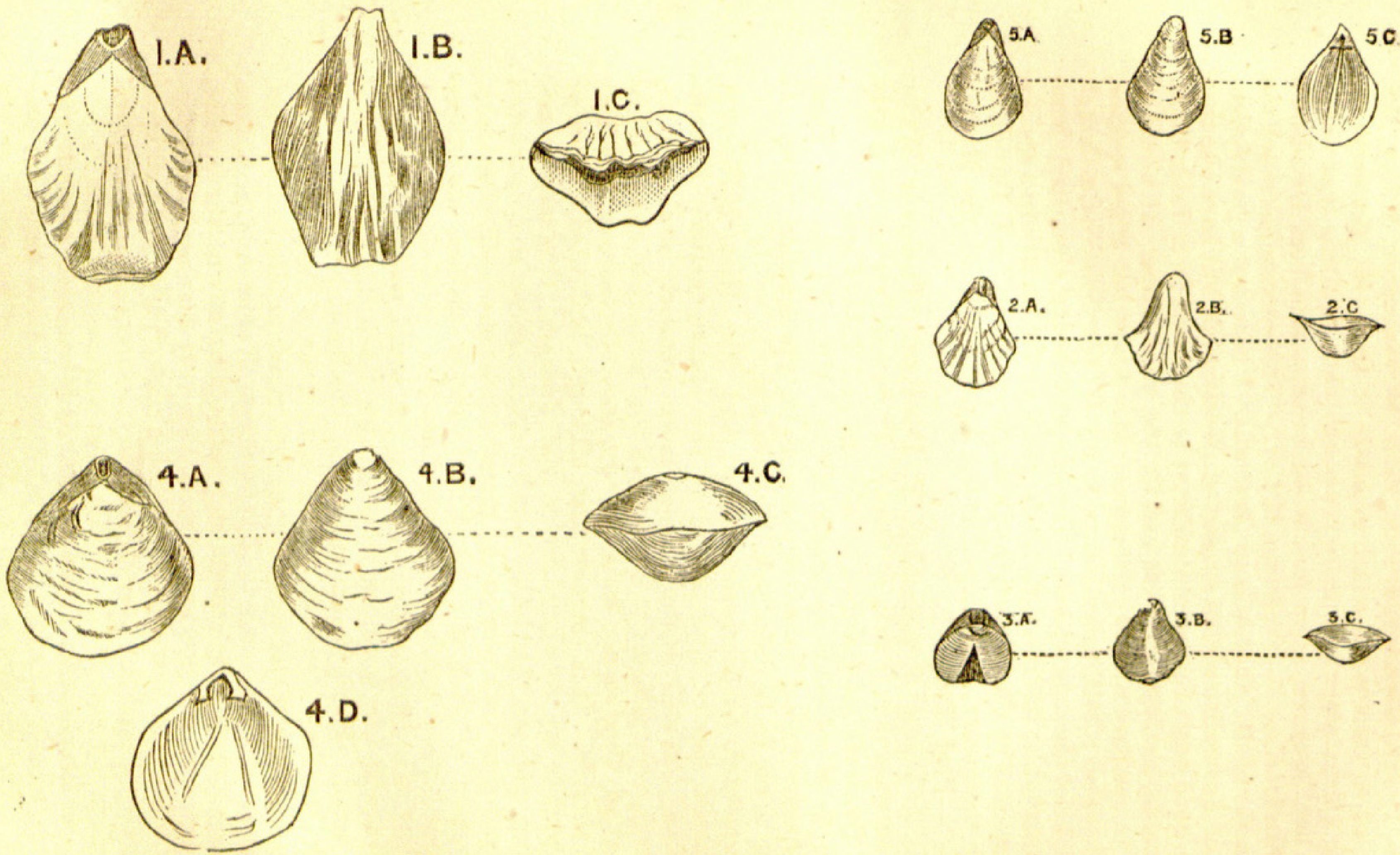
No. 2. Young of preceding, T. Davidson. Professor M'Coy did not recognize it with certainty. Professor Tate thinks it may be a *Terebratulina* common to Aldinga and Table Cape.

No. 3. *Waldheimia corioensis,* M'Coy, MS.: "I do not know this species with a broad depression on the smaller valve. It seems to me to be quite new."—Davidson.

Terebratula gambierensis. Ether. Ann. Nat. Hist. 1875. "A biplicated species approaching to the Italian tertiary *T. pedemontanæ,* but still distinct, being more regularly oval. It is, however, very difficult to distinguish the numerous closely allied biplicated *Terebratulæ* from the Jurassic, Cretaceous, and Tertiary periods. It is singular that, although biplicated species of *Terebratulæ* are so abundant in the Jurassic, Cretaceous, and Tertiary periods, that hitherto not a single species so constructed has been found alive or in the recent conditions."—T. Davidson. "Common at Aldinga. Another variable species, sometimes without biplications."—Professor Tate.

No. 4. *Terebratula vitreoides,* n. s. A small, smooth, orbicular species, with very conspicuous concentric lines of growth. Foramen small. I only figure and name this fossil provisionally, of which Mr. Davidson says, "This is another of those undecided forms that resemble many things described as distinct species. It has some resemblance to *T. vitrea* or to *T. orbiculata,* Sequenza. I would not like to assign it positively to any of the species, although I would not assign to it any very distinguishable features. I think you should publish a description and figures of these very interesting species, not only on account of the species, but of the formation and locality from whence they come."

No. 5. *Terebratula Tateana,* n. s. Small, smooth, without ribs or folds, closely allied to *T. compta* (Sow.) Beak somewhat produced. The specimens sent to Mr. Davidson too small or imperfect for determination.



EXPLANATION OF PLATE.

No. 1. *Waldheimia imbricata:* *a* dorsal valve, *b* ventral valve, *c* front view of margin.
No. 2. Young, sp.? *a* dorsal valve, *b* ventral valve, *c* front view of margin.
No. 3. *Waldheimia coriensis*, M'Coy: *a* dorsal valve, *b* ventral valve, *c* front of margin.
No. 4. *Terebratula vitreoides*, n. s.: *a* dorsal valve, *b* ventral valve, *c* front view of margin, *d* loop.
No. 5. *Terebratula Tateana*, n. s.: *a* dorsal valve, *b* ventral valve, *c* loop.

Discussion.

The Chairman said the paper was particularly interesting to him, and the discussion of the subject brought many things to his remembrance. He was born on the tertiary formation of East Anglia, and had lived for years in the tertiary district of Dorsetshire, as well as on those of the continent. He had also written on the subject of tertiary formations. He would take the liberty of making one or two remarks on the valuable paper just read. First, relating to the genus belemnites as tertiary. In the county of Suffolk, belemnites occur in great abundance *over* the tertiaries. But they so occur with gryphytes as drift in the boulder clay. It now appears, however, that not only is belemnites found to have tertiary species in Australia as well as elsewhere, and that there are a great number of instances in which fossils belonging to one particular epoch have survived to a more recent period. It is the case in parts of India; and in Australia plants assumed to be younger are found in beds of our carboniferous formation. It is in such cases proved that there is a passage from one formation to another without those immense breaks which geologists once thought necessary. He had one other remark to make respecting the coasts of Australia. The great banks of tertiary deposits along the Australian Bight overlie granite. In his "Notes on the Geology of Western Australia" (see Geological Magazine, vol. iii, p. 503 and p. 551), will be found a statement made to him by the late Captain Stanley, R.N., respecting a depth of water off the Bight amounting to nearly four miles, which in his "Notes" he shows to be possible. This might be so, even if elevation has since taken place. Between Cape Howe and Cape York no marine tertiaries have yet been found, though tertiary fossils have been brought from New Guinea. Along the east coast there appears to have been a sinking of the land in places which can be explained, in accordance with the Barrier Reef theory of Darwin, Probably this has been the case in earlier than tertiary times. with the district between Sydney and the elevated area of the Blue Mountains at the back of Penrith, and elsewhere on the coast, and thus notwithstanding elevations, there have been subsidences.

The Rev. W. Scott moved a vote of thanks to Rev. Mr. Woods. This was the first time they had had a paper read by an honorary member.

The motion was carried unanimously, and the Chairman conveyed the thanks of the Society to Mr. Woods.

Rev. Mr. Woods, in reply, expressed the pleasure he felt in having any part in the investigations of this Society. In reference to Mr. Clarke's statement as to the belemnites,—possibly they were derived fossils. It was said that no such interpenetration was admissible. If they were derived, we should expect to find them under different conditions. What he had seen convinced him that it was a mass of fossils accumulated in the sea. It was said there were, in the Bight, fossils found in North Australia. He had noticed one or two tropical forms there. As for the strata, he would hardly be prepared to say they were the same as the Murray cliffs, but the fossils were clearly tertiary. As to the subsidence of the eastern side of the continent, Mr. Clarke was more competent than any other man living to form an opinion. As to the depth found by Captain Stanley, he (Mr. Woods) thought four miles hardly a reliable one in those early days. As far as he had heard, there seemed to be a gradual shelving; but there was evidence of great subsidence, or of upheaval.