On some Tertiary Rocks in the Colony of South Australia: With Notes on the Fossil Polyzoa and Foraminifera, by G. Busk, Esq., F.R.S., F.G.S., W. K. Parker, Esq., Mem. M.S., and T. Rupert Jones, Esq., F.G.S.

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Quarterly Journal of the Geological Society 1860; v. 16; p. 253-260
doi:10.1144/GSL.JGS.1860.016.01-02.34

The author next described the granite, gneiss, and slaty rocks along a section extending from the River Murray and Kangaroo Range across Mount Barker and Mount Lofty towards Adelaide, and noticed the mode of occurrence of the ores of copper, iron, lead, &c., in these rocks. Lastly, he noticed and explained the occurrence of calcified stems of trees standing in the position of their growth in the sand-dunes of the Gulf of St. Vincent, near Adelaide.

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4. *On some* Tertiary Rocks *in the* Colony *of* South Australia. By the Rev. Julian E. Woods, F.G.S. *With Notes on the* Fossil Polyzoa *and* Foraminifera, by G. Busk, Esq., F.R.S., F.G.S., W. K. Parker, Esq., Mem. M.S., *and* T. Rupert Jones, Esq., F.G.S.

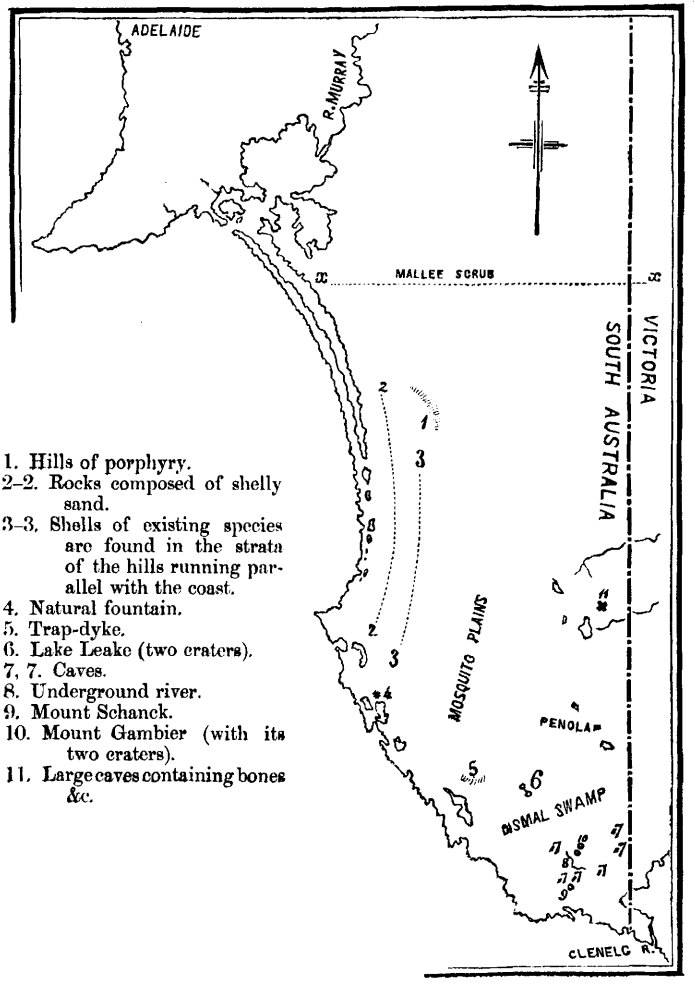
I propose to submit to the Society a description of an extensive Tertiary deposit in South Australia, which has never received more than a passing notice from any who have previously called attention to it. The beds to be described occupy so great a tract even of the large colony of South Australia, that they will, I am sure, eventually call forth a minute examination from those more competent than myself. If there were any probability of a geological survey of the place, under Government-auspices, I would not step forward to do what would then be better done in a much shorter time. But there is no probability of this. Victoria, alone, of all the Australian colonies, as far as I am aware, employs a geological surveyor; and of course he will not be permitted to extend his investigations far beyond the boundaries of that colony. As therefore there is no likelihood of any organized scientific inspection of the country I am about to describe, I venture to submit to the Society my own imperfect observations on facts which it may prove useful for science to be in possession of meanwhile.

The formation which is the subject of my observations extends westward and southward from the River Murray. The line *x x* across the map marks the northern boundary of the district with which I am acquainted (about 290 miles long, by an average breadth of 70 miles). This is all occupied with the tertiary limestone, excepting some small patches of post-tertiary deposits. A line of trap-rocks almost exactly follows the boundary-line of the two colonies; and then the tertiary beds reappear and continue to Port Fairy in Victoria, about 60 miles from the boundary.

The whole formation, and indeed the whole country laid down on the map, is remarkably level and horizontal throughout; the only exceptions being some few ridges, which never rise more than 200 feet above the plains, four extinct craters, and half a dozen hills raised by trap-dykes. The latter are in the southern portion of the district. In the north, on the edge of the Mallee Scrub (*Eucalyptus dumosa*), there are two or three ranges of porphyry rocks, forming chains of small eminences, some 50 feet in height, which run about east and

Sketch-map of a Part of South Australia.

[To illustrate the Rev. J. E. Woods's paper on the Tertiary Strata of that District.]



west for 100 miles, terminating in a volcanic district on the River Warmon, Victoria, about twenty miles over the boundary. With these exceptions the country is an immense plain, with a gradual rise from the sea. In the extreme south of the district are some extinct volcanos. To the north of these there lies an immense chain of swamps, the principal of which is called the Dismal Swamp—a large series of marshes about thirty miles long by ten broad. To the north of this again is a ridge of limestone (Tertiary), bordered on each side by swamps or sandy flats, to Penola, where the Mosquito Plains commence, and then continue right to the edge of the Mallee Scrub. No change of the level occurs as far as the Mallee is known. There can be no doubt that there is a continuation of the same flats, and most probably of the same formations, as far as the River Murray, a distance of 134 miles; but, as the scrub is nearly impenetrable from the tangled nature of the brushwood, and quite so for want of water, the geographical and geological features are not known. The cliffs of the Murray to the north are of the same description of rock as that found lower down near Penola. The Mosquito Plains are a series of swamps, which are shallower than those further north, and the water in them dries during the summer. This makes them available for pasturage, but the land is very inferior.

Before proceeding to describe the tertiary rocks, let me remark, in reference to the country, that there are two kinds of soil met with. The more common is a sand-peat, with stringy bark (*Eucalyptus Fabrorum*) and a fern (*Pteris esculenta*) as the only plants, besides the usual scrub-growth of Australia. The sand is found on examination to consist of rounded particles of pink felspar and white or transparent rounded grains of quartz, mixed with carbonate of lime and black loam. The other kind of soil is generally of a chocolate or black colour, with limestone-rock cropping out. It generally supports good grass and trees of the *Eucalyptus*, *Banksia*, and *Casuarina* class, besides many beautiful Acacias. Both these kinds of country pass into another; but, as a general rule, the sandy scrub is found on very level ground, and the well-grassed soil on that which is undulating. I shall now proceed to describe the formation which is universal in the district.

Immediately under the surface-soil, which is always of small depth, a white limestone is reached, of a compact texture, and containing no fossils. In some places it is only a few feet thick; in others, some twenty or thirty feet; and again in other localities it is entirely absent. Whenever caves are found, such as I shall hereafter have occasion to describe, they are always immediately under this non-fossiliferous bed; and where this is absent, I do not remember to have seen any caves.

Immediately under the bed which I have described come the fossiliferous limestone; but there is no abrupt line of demarcation between them, for the one passes insensibly into the other. This rock is composed of fragments of *Bryozoa*, sometimes so finely comminuted as only to show here and there small fragments of organic structure, imbedding occasionally the *Terebratula compta*, and fre-

quently the *Spatangus Forbesii*. At other places all organic traces are lost, and the rock appears like white chalk, of an extremely friable texture; or, again, the beds appear composed entirely of *Bryozoa*, huddled together in a very confused manner, but always forming strata. The most common fossils are the *Psileschara subsulcata* (nov. gen. et spec.), Busk, *Melicerita angustiloba* (sp. n.), Busk, *Cellepora Gambierensis* (sp. n.), Busk, which must have been, from its constant recurrence, the prevailing Bryozoan of the period, several *Escharæ*, *Celleporæ*, *Membraniporæ*, *Lepraliæ*, and other *Bryozoa*, of which a list has been drawn up by Prof. Busk, F.G.S., and appended to this paper. Two species of *Pecten* also, and some Echinoderms*, are not uncommon; and casts of Univalves also occur. The only fossil which I am able to identify as occurring in beds at home is the *Nautilus ziczac*, which is frequently met with. The specimens I have sent with this paper are not all equally abundant in the same strata,—some prevailing more in the lower, while others are more common in the upper beds.

In a spot near Mount Gambier, where the falling in of a large cave has given origin to a deep circular pit, about 100 feet wide and 90 deep, a complete section of the beds is exposed. It is here seen that, in addition to distinct lines of stratification which occur about every 14 feet, there are regular zones where particular fossils are associated. At the first bed (14 feet) little is seen but small *Bryozoa* with *Terebratulæ*. In the next (10 feet), less *Bryozoa* and some Bivalves. The next (12 feet) is almost exclusively composed of a species of *Pecten*, and the branched *Cellepora Gambierensis*. The beds seem to alternate thus to the water-line (there is water at the bottom of the pit), except that a *Retepora*? and the *Spatangus Forbesii* are more common lower down in the deposit.

I cannot assert that this arrangement is found throughout the district, but fossils are found in much the same way at the caves on the Mosquito Plains, seventy miles distant (marked on the accompanying map), where a fine section is exposed to view. It appears to me that the whole deposit has been formed in deep water, from the detritus of a large reef, which may have existed at some distance from the beds, as these appear to have been slowly spread out along the sea-bottom. This would appear from the chalky texture of the rock, which, when soft, must have been a white pasty mass, occasionally enclosing some fragmentary fossils which had escaped the general attrition. The large *Cellepora Gambierensis* is never in an upright position, but always broken and interstratified in the mass.

The general resemblance which the whole formation bears to the European Chalk is very singular. With the exception of well-defined strata and a rather more plentiful supply of fossils, the cliffs might easily be mistaken for chalk-cliffs; and then the usual sand-pipes (sometimes going to great depths) and rows of flints make the resemblance most striking. The flints just mentioned are generally black, occurring in regular layers, from 14 to 20 feet apart; and one layer

* *Eupatagus*, *Echinolampas*, and *Clypeaster*.—Ed.

is frequently found immediately over the water-level. Sometimes, however, the flints are white; but this is seldom the case; and both black and white varieties contain fossils, most commonly Bryozoans and Sponges.

It might naturally be expected that in such loose and soft deposits water would more or less undermine the rock and cause subterranean hollows. Accordingly we find that the whole district is more or less honeycombed with caves. Sixteen, and perhaps more, are known, of very considerable extent; but the smaller ones abound in different localities, confined, however, to the higher ground, or where the country is undulating, for I cannot call to mind a single instance where they have been found on level flats. The most remarkable of all are those situated on a high ridge on the northern side of the Mosquito Plains (see Map, p. 254). There are three very close to one another, the entrance to which is a round aperture, about 6 feet wide, on the summit of the ridge on which they occur. The first cave is about 200 feet long, divided into three large halls, from which there are occasional passages leading into extensive side-chambers. At the end of the last cave the passage ramifies into several smaller tunnels, which, though too narrow to admit of actual examination, are supposed to be continued for a long distance. The direction of the caves is nearly north and south, that is parallel with the axes of the ridge. The entrance is at the southern end. At the termination of the first chamber in the large cave, there is a large stalactite, which almost entirely blocks up the passage into the next. At the foot of this, on the side of the entrance, there is a very extensive deposit of bones. These occupy just such a position as to lead one to conclude that they had been deposited from a current of water flowing from the entrance towards the narrow end. To such a stream the immense stalactite would act as a dam, only allowing the water to pass through a narrow passage at each side. I must state, however, that there is but slight internal evidence of such a stream, excepting perhaps that the walls of the cave are somewhat undermined all round the first chamber; and a stream running strongly enough to bring down bones might be expected to leave more evident marks of its former existence. But, if a stream did hollow out the caves, there must have been a period during which its flow was stopped; for the large stalactite bears evidence of having been formed in small columns at first, and a current of water would have prevented their formation, and have eroded them away much faster than the drippings from the limestone could repair the damage done. Supposing the great stalactite to have been formed during a time when water was not running, its existence easily accounts for the deposit of bones at its foot; for it would act as a barrier to the stream.

The bones in question are mostly of extinct species, closely allied to those of animals at present inhabiting the locality, but many times larger. The most common are those of a rodent somewhat resembling, in the form of the skull, the dentition, and the markings on the molars, our existing domestic Mouse, though it is many times larger.

I have also identified the skull-bones of nine existing insectivorous Marsupials, and one Bat, all of the size of existing species. There is one thing more in this cave which deserves notice: it is the body of a native which lies in a crevice of one of the inner chambers. The remains are perfectly shrivelled and dry, and the skin tough like leather, broken through in some places and showing the bones underneath. It was partially imbedded in stalagmite some time since; but, having been moved by some settlers, there is no such appearance visible now. At first sight one would imagine the remains to be of great antiquity, but in reality they are very modern. It is only fourteen years since the man died in the spot where his body is now seen. He was shot in a quarrel between the settlers and aborigines, and was known to have crept to the place where he died, in order to escape pursuit. I cannot help thinking that the fact of human remains becoming almost fossilized by being imbedded in stalagmite is rather a valuable one. Dr. Lund, who found some bodies in a similar state in caves in South America, took from that circumstance the idea that the Indian race must have been in America much longer than we supposed. Would not the fact to which I am drawing attention modify the supposition of such immense age?

Close to this cave there are two more; neither of which, as far as I am aware, have ever been examined. One of them is 30 feet deep, and the other 60; and there is no means of descending into them without pulley and ropes, which are not easily procured in the unfrequented part of the Australian bush in which the caves are situated. Next in importance to the above are a series of caves in the vicinity of Mount Shanck, and between that and Mount Gambier. (The two most southerly craters marked on the map.) Some of them do not run very deep, but others have never yet been explored. They all resemble each other in one particular, and that is in the possession of water at a depth varying from 70 to 100 feet, dependent on the height of the eminence upon which they are. One is just like a round hole, about 100 feet in diameter; and the passage to the bottom is by a winding footpath to the water's edge, 75 feet below the surface. The cave then seems to shelve away to a great depth; but no more is positively known than that at about 10 feet from the side the soundings are 60 feet. At another cave very near this the descent is very sudden, so that the water stops further progress very near the entrance, and it is so deep as to appear of a deep sea-blue. The cavern is seen to continue in a fine arched passage, high above the water-level, to a distance far beyond what has ever been explored. In a cave at Mount Shanck the water is so deep that no bottom could be found with 120 feet of line. In every one of the above, and in many more that I have not described, the water is beautifully clear, and where deep of a sea-blue.

At certain seasons of the year (I have been informed) a distinct motion is perceptible; but I have been only able to verify this in one instance. This was at a short distance from Mount Gambier, where an extensive subterranean passage occurs. The opening to it is narrow and perpendicular, and from above the water is just discernible. Upon one

occasion a boat was lowered down to this, and a party of settlers floated along the surface for half a mile; and, though they then turned back, they alleged that the passage was as wide as ever and could have been followed to a much greater distance. On this body of water a distinct current is perceptible after the rainy season, and doubtless this is one of many underground rivers by which a large tract of country, unprovided with any other means of drainage, gets rid of its surface-water. This may be the cause of all the caves; but why they should always occur on the higher ranges and not upon the flats, does not appear very clear according to such a theory.

There are other facts which tend to show that some parts of the country are being drained by underground channels. Thus in certain localities on the Mosquito Plains all the wells are observed to have a distinct current to the north-west. Again, I noticed, in following the current of a large overflowing swamp, that the water disappeared at the foot of a limestone-ridge (in which there were only a few crevices) and became lost. Now at a place on the coast, N.W. of the Mosquito Plains (Lake Eliza, marked on the map), and at two places near the sea, south of the caves at Mount Gambier, natural fountains are found, where the water rises from holes in the rock in a fountain of some height, which must send up many gallons of water per minute. There may be many others which are not known, for the coast has been but little explored. At all events the existence of a chain of freshwater lakes along the coast, containing much more water than can be accounted for by the annual fall of rain, would seem to indicate an underground drainage; for it is known not to come along the surface. The channels made by the passage of this water will certainly become caves, should the land be hereafter sufficiently upheaved to leave them dry.

I have never been able to find bones in any caves but those of the Mosquito Plains, except in one or two shallow ones, where, though imbedded in stalagmite, they were all of existing species; and the aperture was always in such a position on the roof that animals, bounding across them, would be most likely to fall in. I met with one curious instance of how caves of this description might become full of animal remains. In exploring one near the coast, which had never been entered before, I crept along a gallery which led into a large chamber, in the centre of the roof of which there was a round hole about 2 feet wide. Underneath this was seen a large heap of Kangaroo bones; and skeletons were distributed about the chamber. On coming to the surface I found that the hole was almost perfectly concealed by grass, that an animal might jump into it without suspecting the existence of an aperture. Some might be killed immediately, and so leave their bones on the heap, while others would struggle about the chamber and leave their skeletons around.

I have now enumerated a few of the remarkable features of this extensive district, in which, though nearly 10,920 square-miles in extent, there are only one or two small patches where the deposit differs from the formation which I am led to believe is of an Eocene

character. These exceptions are,—first, a deposit composed of fine particles of sand and broken fragments of shells such as would arise from detritus brought along by a deep sea-current. The rock is stratified in a manner which fully bears out such a view. I believe that this formation covered nearly, if not quite, the whole of the limestone, but has afterwards been washed away by denudation, to which its friable texture would render it extremely liable. There is always more of it near the coast, and there in some places it is 200 feet thick. Elsewhere it is only in patches lying on elevated spots of ground, and apparently much water-worn.

A ridge of coarse limestone follows the line of coast; and in this, as well as in the limestone some few miles further inland, fossils abound; but they are all of species at present inhabiting the coast. This is the result of upheaval which appears from observation to continue to this day. It is worthy of notice that volcanic emanations occurred during the period of upheaval; and it would appear probable, from shocks of earthquakes that are occasionally felt, that the cause of them is yet in existence.

Note on the Fossil Polyzoa *collected by the* Rev. J. E. Woods *near* Mount Gambier, South Australia. By George Busk, Esq., F.R.S., F.G.S., &c.

The *Polyzoa* included in this collection belong to fifteen or sixteen genera, of which four are probably new; and the number of species is about thirty-nine or forty, of which at least thirty-six seem to be undescribed. Among them are several very peculiar and characteristic forms, especially in the genus *Cellepora*. Taken as a whole, these fossil forms exhibit such generic and specific types as to render it probable that the formation in which they are found corresponds, in point of relation to the existing state of things, with the Lower Crag of England, although the collection contains but one or two species which can be referred, and those even doubtfully, to any belonging to the Crag. It is remarkable, however, that it presents a second species of *Melicerita*, which genus is peculiar to that deposit. Of the characteristic *Fasciculariæ* and other *Theonidæ* of the Crag no trace exists in the present collection. The most characteristic form is a large and massive *Cellepora*, for which I propose the name *Cellepora Gambierensis*.

List of Genera and Species.

I. P. cheilostomata.

1. Salicornaria, *Cuvier*.
   1. S. sinuosa, *Hassall*.
   2. S. Parkeri, n. sp.
2. Canda, *Lamx*.
   1. C. angulata, n. sp.
3. Onchopora, *Busk*.
   1. O. pustulosa, n. sp.
4. Membranipora, *Blainville*.
   1. M. stenostoma, *Busk*. ?
   2. M. bidens, *Hag*.

3. M. appressa, n. sp.
4. M. Cyclops, *Busk.*

5. Lepralia, *Johnston.*
   1. L. ——, sp.?
   2. L. submarginata, n. sp.
   3. L. subcarinata, n. sp.
   4. L. doliiformis, n. sp.

6. Cellepora, *O. Fabr.*
   1. C. Gambierensis, n. sp.
   2. C. hemisphærica, n. sp.
   3. C. nummularia, n. sp.
   4. C. costata, n. sp.
   5. C. tubulosa, n. sp.
   6. C. spongiosa, n. sp.?

7. Eschara, *Linn.*
   1. E. simplex, n. sp.
   2. E. papillata, n. sp.
   3. E. arcuata, n. sp.
   4. E. oculata, n. sp.
   5. E. bimarginata, n. sp.
   6. E. hastigera, n. sp.
   7. E. inornata, n. sp.
   8. E. ——, sp.?

8. Retepora, *Imperato.*
   1. R. ——, sp.?

9. Psileschara, nov. gen.
   1. P. pustulosa, n. sp.
   2. P. subsulcata, n. sp.

10. Cœleschara, nov. gen.
    1. C. australis, n. sp.

11. Melicerita, *M.-Edwards.*
    1. M. angustiloba, n. sp.

12. Scutularia, nov. gen.
    1. S. prima, n. sp.

II. P. CYCLOSTOMATA.

1. Pustulopora, *Blainville.*
   1. P. distans, n. sp.

2. Idmonea, *Lamx.*
   1. I. Milneana, *D'Orbigny.*
   ?2. I. ligulata, n. sp.

3. Hornera, *Lamx.*
   1. H. Gambierensis, n. sp.?
   2. H. rugulosa, n. sp.?

Note on the FORAMINIFERA *from the* BRYOZOAN LIMESTONE *near* MOUNT GAMBIER, SOUTH AUSTRALIA. By W. K. PARKER, Esq., and T. RUPERT JONES, F.G.S.

A small portion of the deposit has yielded several *Foraminifera*, namely,—

Polymorphina lactea, *J. & W.* Rather large. }
Textularia pygmæa, *D'Orb.* Small. } Not rare.
—— agglutinans, *D'Orb.* Small. }
Globigerina bulloides, *D'Orb.* Small. Common.
Cassidulina oblonga, *Reuss.* Small. Rather common.
Rosalina Berthelotiana, *D'Orb.* (a variety of *Rotalia Turbo*, D'Orb.). Small. Rather common.
Rotalia Ungeriana, *D'Orb.* Rather large. Abundant. }
—— Haidingerii, *D'Orb.* Small. Not uncommon. } Varieties of *Rotalia* (*Planorbulina*) *farcta*, F. & M.
—— reticulata, *Czjeck.* Small. Not rare. }
—— (Anomalina) Rotula, *D'Orb.* Small. Rare. }

The above-named Rhizopods exist at the present day, and for the most part live in rather deep water, at from 200 to 300 fathoms. It would hence appear that the fragmentary *Bryozoa* forming the mass of the deposit were washed down from a higher zone of sea-bottom and mingled with the *Foraminifera* inhabiting deep water.