NOTES ON CERTAIN TERTIARY AND POST TERTIARY DEPOSITS

On Flinders, Barren, Badger, and other Islands in Bass' Straits, by Robert M. Johnston.

[*Read 9th April*, 1878.]

SAND DUNES AND ELEVATED BEACHES.

Hitherto the more recent shell deposits upon the islands of Bass' Straits have been briefly referred to by various writers as "elevated beaches." Strzelecki groups the following formations under that head, viz.:—

1. Formation at Lake King, Gippsland.
2. Ditto between Cape Liptrap and Portland Bay.
3. Green Island, Bass' Straits. (100 feet high.)
4. Formation, south-west point of Flinders' Island.
5. Ditto, 10 miles south of Cape Grim. (100 feet high.)
6. Ditto at Table Cape. (70 feet high.)

Mr. Gunn also refers to the "raised beaches":—

7. At Hunter's Island, near Woolnorth, and several islands in Bass' Straits.

Recent investigations have shown, however, that most of the formations thus alluded to are not, properly speaking, "raised sea beaches." They are, for the most part, the remains of the floor of a vast but shallow sea of supposed miocene or oligocene age.

The Rev. J. E. Tenison-Woods, in a paper recently read before the Fellows of the R.S. of New South Wales, states:—

"To sum up all the evidence which has been gathered on this subject, we may say that our tertiary formations probably range through all the various miocene periods which are represented by different deposits on other portions of the globe. We may certainly conclude that the whole of the central parts of South Australia, the north of Tasmania, and the islands of Bass' Straits, were under the sea during that epoch. There is quite sufficient evidence to show that we have tertiary rocks of a lower horizon than the miocene. My own opinion is that the Muddy Creek beds, and those of Table Cape, Tasmania, should be classed as upper oligocene. I conclude this from the small per centage (8 per cent.) of recent species, the relations of the fossils, and the general facies."

There is also abundant evidence to show that this ocean floor has been slowly elevated above the level of the waters in which it was formed; and although this upward movement may not have been uninterrupted in one locality, yet there is

no doubt but that it has continued up to a very recent period, if it be not now going on. The extent of this movement also proves its slow and steady character; and that it has not been produced by a sudden alteration in the relations of sea and land is fully established by the sections exposed at Table Cape, on the islands in Bass' Straits, and in the various sections lying between Cape Leuwin and Cape Howe. If we turn to New Zealand we have there evidence of the movement in a direction southward and eastward ; and we may be sure it is far within the mark when it is stated that the upward tendency of the floor of the ocean in the southern portion of Australia must have affected not less than 3,900,000 square miles of the earth's surface. This is quite contrary to the popular notion which represents Australia as a vast, aged continent, which, in its inert senility, is slowly disappearing below the waters of Oceania. No doubt the exposure of such a large extent of palæozoic rocks in Australia, together with the great number of salt lakes and salt pans in the tertiary districts, may have given some color of foundation to this wide-spread impression.

The vertical movement of the earth's crust is often confused with other influences which help in determining the boundaries of land and sea. For example: the continuous action of rivers hollow out channels, and cause extensive deltas to be formed, which may conceal, to a great extent, the actual vertical movement. The natural waste around our coasts permitting a horizontal advance of the sea may often be mistaken for a sinking of the land ; and the gradual wearing away of some rocky headland, or the effect of the prevailing winds, may produce such extensive modifications, in the shape of sand dunes on land and sandbanks in the sea, as to make it very confusing to those who are not skilled in tracing cause and effect in geology. Even to the latter the signs are not always so apparent that they can at once be recognised. It requires a patient examination of particular districts, and a careful collation of what, often at first sight, may seem conflicting evidences.

These observations are sufficient to explain the local encroachment of the sea on our North-West Coast (as reported to this Society many years ago by Mr. Gunn), and to show that a local encroachment of the sea may be in perfect harmony with a slow vertical movement of the land upward.

The following islands were recently visited by me :— Waterhouse, Swan, Barren, Long, Flinders, Green, Kangaroo, and Badger. The various islands are under lease to different persons. Barren and Badger are now the homes of the half-castes. The original home of the aboriginals, " The Settle-

ment," on Flinders' Island, is the property of Mr. Gardiner, of Launceston, who has also a lease of the whole island.

The various islands of the group present nearly the same features botanically and geologically. With the exception of the mountain chain on Flinders' Island, running north and south—(the highest peak, Strzelecki, 2,550 feet); a few isolated conical peaks of recent igneous origin (the Patriarchs and others, 300 to 400 feet); Mount Monro, on Barren Island; and Chappell Island—the land is low lying, nowhere rising above 100 feet. The prevailing rock on all the islands is granite, through which a dark blue close-grained rock has been most curiously intruded—sometimes in continuous dykes and veins, at other times interspersed in a sort of network—in such a manner as to leave the observer in doubt whether the granite or the dark blue rock is the later of the two. The granite is frequently porphyritic. Crystals of *black tourmaline* are occasionally found several inches long, and over one inch in diameter. The largest crystals hitherto obtained have been got on Long Island. The surface of the larger islands—where not composed of loose sand dunes and vast brackish lagoons—is covered over with an impenetrable scrub of *Banksia*, *Callistemon*, and *Melaleuca*; and the saline herbs and shrubs of the order *Chenopodiacea* give a most singular character to the vegetation of all the islands. On the low coast flats *Mesembryanthemum æquilaterale* forms a continuous carpet. The half-castes are very fond of the ripe fruit of the latter, and of *Solanum laciniatum*. These fruits are pleasant, and of a sweetish-acrid taste when fully ripe, but are of a most nauseous taste when partially so.

The accompanying sections, giving the relation of the various rocks, will give a better conception of their geological character. A section of one island—say Green, Barren, or Flinders—may be taken as a type of the whole. If we take the rocks in a descending order—after passing through the humus, or the sand dunes now forming the surface of the low coast lands—we would find the following order :—

1(A). Consolidated sandstone, replete with shells of two or three small species of *Helicidæ* and other land shells. Sometimes 60 and 70 feet thick.

2(B). Elevated consolidated sea beaches and sandbanks, composed principally of the shells of species now existing. Average elevation, 40 to 50 feet above present sea level.

3. Turritella limestone, composed of the more or less perfect remains of shells not now existing.

4. Metamorphic schists, abutting upon the granite.

5. Granite.

Rocks 1 to 4 are all more or less unconformable to each other, and they abut against the granite axis on the eastern and western sides.

THE HELICIDÆ SANDSTONE.

This formation is of particular interest. It is found upon nearly all the islands up to a height of 100 feet, and for the most part it lies directly upon the granite. It varies in character from a coarse gritty sandstone, with minute worn fragments of marine shells, to a close-grained cherty or arenaceous limestone. It is found on Barren Island, forming a more or less precipitous coast line of horizontal strata, at intervals, between a point opposite Doughboy Island and Thunder and Lightning Bay. On Badger, Chappell, Green, and Kangaroo islands it is the prevailing rock, and invariably is found to lie directly upon granite or the upturned edges of mica-schist rock. The weathered portions present a curiously rough and honeycombed appearance, and frequently give out a sonorous metallic tone when struck by the hammer.

The most characteristic feature, however, is the imbedded remains of various species of *Helicidæ*, together with certain species of *Succinea*. In certain layers of calcareous clay—evidently the sediment of some ancient brackish lagoons—occurs a species of *Bithynella* in the greatest abundance. I believe the shell to be closely allied to the existing fresh water shell, *B. legrandi*.

In some places the remains of two small species of *Helix* seem to compose 20 per cent. of the mass of the rock. They are very similar to species now found in myriads in the shallow hollows filled with dead leaves in the drift sand of the dunes now forming. In communicating these facts to Professor Ralph Tate, he replied that "in the S.E. coast of this colony (South Australia)—and particularly I noted that the sandstones of Cape Northumberland (100 feet or more in height), were consolidated blown sand; in them I found two species of *Helices*. The two species of *Helices* from Cape Northumberland (both occur living on the spot) are among those you sent me."

It is, therefore, of much interest to find that the sand dunes, consolidated, enclosing certain species of *Helix*, should have such a wide range. In a dried-up lagoon, evidently of more recent date than the sand dunes, I found a species of *Physa*, and a species of *Pomatiopsis*, or *Blanfordia*. Of these and the other shells found in the consolidated sand dunes Professor Tate makes the following observations:—

PLEISTOCENE FOSSILS.

(From Badger Island.)

PHYSA TENUISTRIATA.	At any rate, a South Australian species.
BLANFORDIA STRIATULA.*(?)* *(Pomatiopsis.)*	Shows some characters which, if permanent, would justify its separation from the South Australian called as above. Mr. Woods gives no reason for its removal from this genus. It may be a *Pomatiopsis.*

(From Cape Barren Island.)

PALUDESTRINA SP. *(B. legrandi(?)* Woods.)	Occurs in the River Torrens, at Adelaide.
SUCCINEA STRIGATA.	Living species also sent from sand dunes now forming on the islands.
HELIX DIEMENENSIS. (Cox apparently.)	
Do. SP., allied to *H. Penolensis.* (Cox.)	

The existence of similar land shells in the dunes now being formed is hardly necessary to guide us to the conclusion that the *Helicidæ Sandstone* has been formed in a similar way, and under similar conditions. Everything points in the same direction. The minute fragments of shells, which are the chief cementing principle in the sandstone, are certainly marine; and I have frequently, in the associated coarser grits, obtained the somewhat worn body-whorl and aperture of the shells *Bittium granarium* and *Truncatella tasmanica*, species which now exist in the greatest abundance on the shores of the various islands.

The shells may now be classed as follows :—

FOSSIL—HELICIDÆ SANDSTONE.

HELIX STANLEYENSIS (Petterd)	Still existing.
Do. PICTILIS (Tate)	Ditto.
Do. WELLINGTONENSIS (Cox)	Ditto.
SUCCINEA AUSTRALIS (?)	Ditto.
BITHYNELLA NITIDA (Mihi.)	Doubtfully distinct from an existing form.

SUB-FOSSIL—BED OF OLD LAGOONS.

POMATIOPSIS BADGERENSIS (Mihi.)	May only be a variety of existing species.
PHYSA TENUISTRIATA (?)	Identical with Sowerby's *P. eburnea.*

OYSTER BED DEPOSIT.

On the same horizon as the *Helicidæ Sandstone* we may include the oyster bed deposit of Flinders' Island. This deposit is situated on the banks of the River Arthur, about two miles inland from its mouth. It is about thirty feet above high water level, and a fine exposed section shows that it is composed principally of regular layers of an enormous species of mud oyster, with which is associated *Venus aphrodinoides*, and species of *Rissoa*, *Fusus*, *Alaba*, etc., etc., all existing species. Enormous gum trees grow over them. The regular layers of heavy unbroken shells preclude the idea that they have been carried any distance, whether by wind or water. They plainly indicate that the estuary mud or sand in which they lived has been slowly elevated into its present position.

RAISED BEACHES.

These are found more or less concealed by the overlying *consolidated sandstones* on Badger and Green islands. The shells are all littoral, and are, when found, in consolidated masses. On Badger Island this old beach of shells lies against, and firmly adheres to the metamorphic schists.

The species are numerous, and seem to be identical with those now existing on the shores of the islands. These beaches are invariably about 40 or 50 feet above present sea level, and sometimes nearly a mile from the present shore line. On the east coast of Badger and Flinders there appears to be intermediate shell accumulations below the recently-formed sand dunes. In them I have frequently picked up *Pectunculus laticostatus*, slightly bleached and worn, together with *Cucullea corioensis;* but whether they now exist in the immediate neighbourhood or not I am not yet prepared to say. I never could pick one up on the margin of the sea that was not more or less worn or bleached, and it is possible they have been washed out of the older sands, upon which the sea may have encroached. It is clear, however, that both *P. laticostatus* and *C. corioensis* must have existed up to a very recent period on the east side of Flinders' Island.

There may, however, be a slight difference in the number of radiating ribs. Although I made allowance for the worn edges, there seemed to be fewer ribs upon those found by me on the islands named as compared with the fossil species at Table Cape. I am not sure whether the New Zealand existing species have invariably 29 ribs, like our Table Cape fossil species. It would be interesting to know. The sandhills on the east side of Flinders are protected by the native grass, *Spinifex hirsutus*. Their globose spiny heads are perpetually being blown out, wheel-like, to sea. When the long spine

penetrates the smooth sand, the whole head is speedily covered over by the drift ; and if the situation be sufficiently removed from the waves, it erects a barrier to further drift inland. There is reason to believe that the *Helicidæ Sandstone* was similarly protected.

I was much impressed with the numerous evidences of the recent elevation of the land, on taking a knapsack excursion, on foot—in company with my friend, Mr. T. R. Atkinson—from Badger Corner to Cameron's Inlet: *i.e.*, along the south and east coast of Flinders' Island. The country, for miles inland, consists of a series of sand hillocks, in ridges more or less parallel with the coast line. These ridges may be said to form a species of network along the eastern coast of Flinders' Island, the interspaces consisting of brackish or salt water lagoons, or the bottoms of recently dried-up lagoons. Some of these salt water lagoons are very extensive. The Pot Boil Lagoon and Cameron's Inlet still maintain a connection with the sea at full tide by a very narrow shifty inlet, but it is evident that they are but existing examples of the mode by which the other basins have been cut off from the receding sea. Their connection will also soon be closed up. Recent shells—particularly *Ampullarina fragilis*—are found round the margins of the inland salt water lagoons. On sinking through the turf of *Saliera radicans*, in search of water—(there are no fresh water streams on the eastern coast)—I passed through layers of decomposing seaweed three feet below the surface, some distance inland.

The characteristic shells exposed by the destruction, by the wind, of the inland sand dunes, are as follows:—

Bankivia varians	Most abundant.
*Philine aperta...	Common.
*Trigonia margaritacea	Abundant.
*Pectunculus rubens (Axinia radians?)	Ditto.
* ,, roseus (,, obligans?)	Ditto.
,, laticostatus	Ditto.
Arca trapezia	Ditto.
Leda crassa	Ditto.
*Cardium tenuicostatum	Ditto.
Cucullea cainozoica	Ditto.

Those marked with an asterisk are certainly now existing in the neighbourhood; but I could only get the others in a bleached and worn state along the shore, and it is very doubtful whether they are now living in the immediate vicinity.

I picked up a living specimen of *Turbo circularis* near to Cameron's Inlet. Professor Tate informs me that it is "a very rare South Australian form, and hitherto only recorded

from St. Vincent's Gulf." The new locality for this species will be interesting to conchologists.

RECENT BASALTIC TUFFS.

Basaltic tuffs, similar to the tuffs at Breadalbane, occur in the neighbourhood of the Samphar Rivulet, Badger's Corner. The beds are in some places stratified; and in them, and strewed along the shore, occur numerous trunks of fossil wood in a silicious state. The structure shows it to be somewhat allied to certain trees found by me in the lignite of Breadalbane. It certainly has no relation to the Pine family. Probably it may be allied to Casuarina, the structure of which it closely resembles.

TURRITELLA LIMESTONE.

Near to the Patriarchs, on Flinders' Island, at a place called the "Heathy Valley," occurs a limestone of which, through the kindness of Mr. Peter Gardiner, I have obtained some specimens, together with interesting particulars as regards distribution.

The limestone is entirely composed of the remains of shells. From their general appearance I judged, at the first glance, that they belonged to our wide-spread tertiary system; and I was confirmed in this supposition by the discovery, among the specimens, of the well-known forms—*Cucullea (Pectunculus) cainozoica* (Tenison-Woods), and *Nucula tumida*—so abundant in the Table Cape beds. The majority of the shells, however, present a different facies to those found at Table Cape, and the deposit will require to be carefully examined before we can determine its exact position in the tertiary series. The characteristic shells are :—A small species of *Turritella*, of the *T. Warburtonii* type; and a small nacreous turritella-like shell, of about 10 whorls spirally grooved, four grooves on each uniformly convex whorl. This last shell may yet be classed among the *Elenchus* group, to which, I think, it has some affinity. I have described these two species in a separate note, and I send specimens with this paper.

On nearly all the beaches of the various islands I have picked up waterworn pieces of fossil limestone, which may yet prove to be associated with the *Turritella Limestone*. The waterworn fragments washed ashore on Swan Island, from the sea bottom in the immediate neighbourhood, are very numerous. I infer that the kelp adheres to them, and during stormy weather they are by this means drifted on the beach. On breaking open some fragments on Swan Island I detected *Trivia europea*, together with one or two forms common to the Table Cape beds. It is remarkable, however, that in all

these fragments I could never trace a single specimen of the two characteristic shells belonging to the *Turritella Limestone* of Flinders' Island. I incline to the opinion that the *Turritella Limestone* may yet turn out to be the lowest member of the tertiary system hitherto found. I intend, at the earliest opportunity, to examine this deposit more minutely.

I have been informed by the Rev. Canon Brownrigg that a white fossiliferous limestone is exposed on the road from the shore to the Lighthouse, on Kent's Group. If the Lighthouse Superintendent were applied to for his kindly assistance, a number of specimens might be obtained for the Society's Museum, and for the use of those who may wish to study the subject. Perhaps some of the Fellows may have business relations there. If so, a box of specimens might easily be obtained by the first vessel which trades between Hobart Town and Kent's Group.

General.

From the foregoing remarks it is evident that there remains a great deal to be done before we can speak positively of the relations of the various beds belonging to the tertiary and post tertiary systems of Australia and Tasmania. The discovery, by Professor Tate, of *Salenia* and *Belemnites* in the Aldinga beds, is very significant. From this and other considerations the Rev. J. E. Tenison-Woods inclines to the idea that the Aldinga series may be "passage beds between our tertiary and secondary rocks." Be this as it may, it is clear that in South Australia, Tasmania, and the Bass' Strait islands we have a series of beds which form a complete chain of evidence, telling of the persistent elevation of the ocean bed from the earliest tertiary period to the present hour—a period sufficiently vast to encompass the extinction of nearly 92 per cent. of the organisms which first inhabited our tertiary seas, and to witness the introduction of a new series of species to take the places of those which have disappeared.

The Rev. J. E. Tenison-Woods, recently, in a paper read before the Linnæan Society of New South Wales, draws particular attention to the remarkable variability of the various species of the genus *Trochocochlea*. In giving the synonomy of *Trochocochlea australis*, viz. :—

T. concamerata (Gray.) | *T. striolatus* (Quoy, G.)
Monodenta australis (Lam.)—

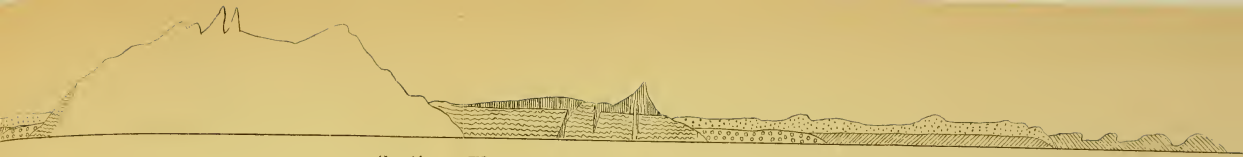
He states—"Turn over any flat stone at low water, and the under side will be found covered with it (*T. striolatus*—Quoy), of almost every size, shape, and color within the limits of the shell's character. I have seen some specimens more than an inch in diameter, some almost conical, some depressedly

turbinate, some white with green spots, some black and yellow on diagonal lines, and some dull olive with few yellow spots. . . . . It is a remarkable fact that the larger shells of these species are found in Southern Tasmania, and they become smaller, more decidedly ornamented, and highly coloured as they approach the tropics."

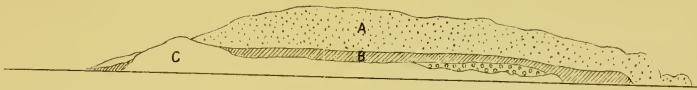
When we take into consideration the remarkable variability, under slightly different conditions, of various species at the present hour, and the vast period during which such changes have taken place in the facies of our Australian marine fauna, as to have caused the disappearance of 92 per cent. of the original tertiary species, it seems to me a difficult thing to assert that Australian geology has no reasonable evidence to offer in favour of evolution. To me—while making every allowance for the persistency of the lower forms of life, and of one or two particular types—the evidence of Australian geology appears to be in perfect harmony with the theory of evolution as represented by its best exponents.

As I understand the theory, original change of form (not hereditary change) only follows material change of the conditions affecting the immediate environment of particular organisms, whether vegetable or animal. There is reason to believe, therefore, that, as regards the lower organisms of the ocean which survive, the external conditions affecting them have not undergone any material alteration since the early epoch when the *Trilobite* peopled the depths of the ocean. Evolution, therefore, is in perfect harmony with facts which disclose the persistency of particular types. I am also fully convinced that it would be unscientific to look upon Australian fossil forms as in some manner independent and distinct from the past life of the world elsewhere. In the world's life-history the fossil forms of Australia are as purely colonial (as regards completeness and origin) as the European races of animals and plants which, within the last century, have occupied its surface.

It seems to me unwise to restrict our attention to the few widely isolated fragments of the past life of the world, as represented by Australian geology, when we take into consideration the evolution hypothesis—which rests upon the whole past changes of life on this earth of ours.



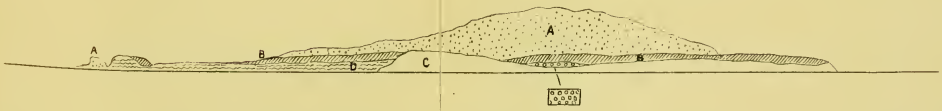
I Section Flinders' Island. (South Side.)



II Section Green Island.

A. Consolidated Sand dunes.
B. Elevated Sea Beach.
C. Syenite.

Syenite.
Basalt.
Elevated Beach replete with shells of existing species.
Consolidated Sand dunes. with shells of Helicidae,
Metamorphic schists.
Turritella Limestone.
Recent and Consolidated Sand dunes.



III Section Badger Island.

A. Consolidated Sand dune, replete with shells of Helicidae, Bythinia, Succinea.
B. Elevated Sea Beach, with remains of existing species.
C. Syenite.
D. Metamorphic schists.

Ideal Sections from Originals,
By R. M. JOHNSTON.
Drawn by T. R. ATKINSON.