THE OCCURRENCE OF GIGANTIC MARSUPIALS IN TASMANIA.

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It had hitherto been generally believed that the gigantic marsupials were restricted to the continent of Australia, and did not occur in Tasmania. Jack and Etheridge (1) mention their wide distribution on the continent, and Professor Stirling (2) is of the opinion "that this great marsupial appears to have had an immense range, and to have probably wandered over the whole Continent of Australia." R. M. Johnston (3), who is better acquainted with the geology of Tasmania than anybody else, states that "in Tasmania no remains of the extinct marsupials, such as Diprotodon, Nototherium, and Thylacoleo, have as yet been found either in the ossiferous cavern breccias or in the older alluvial beds."

It seems rather strange that nobody took the view that remains of such animals ought also to occur in Tasmania. Howitt (4) had already, in 1898, expressed the opinion that Tasmania was connected with the mainland in geologically recent times, and Hedley (5), in 1903, holds the same view. Jack and Etheridge had, in 1892, shown that Diprotodon existed in Queensland in post-pliocene times, and as, according to all writers, this animal roamed all over the continent, it would appear very remarkable that it should have avoided the south-east corner of Australia, viz., Tasmania, when during that time the present island formed still a part of the continent.

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(1) Geology and Palæontology of Queensland and New Guinea, 1892, page 668.

(2) Fossil remains of Lake Callabona. Mem. Roy. Soc. South Aust., 1900, Vol. I., Pt. II.

(3) Geology of Tasmania, page 325.

(4) On the Origin of the Aborigines of Tasmania and Australia. Report on the seventh meeting of the Australasian Association for the Advancement of Science, Sydney, 1898, page 723-758.

(5) The effect of the Bassian Isthmus upon the existing marine fauna. A study in ancient geography. Proceed. Linn. Soc. of N.S.W., 1903, Pt. IV., Pag. 876-883.

Consequently, the discovery of remains of a gigantic marsupial in Tasmania should not have created the general surprise they did. When, in 1910, the news that bones of a gigantic marsupial had been discovered in the Mowbray swamp, near Smithton, became known, the discovery was at first somewhat discredited. However, confirmation soon came, and the remains were purchased by the Launceston Museum from their discoverer, Mr. Lovett. Mr. Scott, the Curator of the Museum, has since described them under the name of Nototherium tasmaniense (6), but I am somewhat doubtful whether a new species is justified. After having seen the wonderful remains of Diprotodon australis in the Adelaide Museum, I think a more careful comparison of the Tasmanian remains with those from South Australia should have been made before a new species was created. More weighty reasons for the establishment of a fourth species, in addition to the three already known, should have been advanced, than those given by Mr. Scott; in fact, if we consider that both N. inerme Owen and N. dunense De Vis. differ so little from Nototherium Mitchelli Owen that they are probably nothing more than varieties, the characteristics on which this fourth species, N. tasmaniense, is established, are altogether unsatisfactory. However that may be, it matters very little whether Nototherium tasmaniense is identical with N. Mitchelli or not, or if even the generic determination be uncertain. The main fact that the remains of a gigantic marsupial, which belongs either to Nototherium or Diprotodon, have been found in Tasmania, is indisputable.

Early in 1911 I had an opportunity of visiting Smithton, and, thanks to the kindness of Councillor S. Moore of Smithton, I was able to examine the exact spot where the remains were found. The Mowbray Swamp is about 1-2 miles west of Smithton, and, apparently, fills up a shallow depression of the surface. Probably it represents an old river course, which once had an outlet to the sea, but which subsequently became blocked up by sand. At present the "swamp" is divided from the sea by a narrow strip of sand, on which low dunes are rising towards the coast. There is hardly any natural fall from the swamp towards the sea, and the vegetabilic mould, or, better said, peat, which fills up the depression, is completely waterlogged. The thickness of the peat layer is not exactly known yet, but along the edge of the swamp, where drainage work has been intensive, it reaches about 25ft. to 30ft. To me it seems very probable that the deepest point of the firm bottom,

(6) The Tasmanian Naturalist, 1911.

on which the peat rests, is below sea level, and this would account in some way for the sluggishness of the fall. When drained this peat forms a rich agricultural soil, and it is during the course of such drainage works that the remains were discovered on Mr. Lovett's farm.

The fertility of the soil can be judged by the fine timber that grows on the swamp, but a great deal of clearing and, above all, draining will have to be done before the soil can be used to its full extent.

The clearing has revealed a very peculiar feature of the surface. Everywhere, where the bush is lighter, small conical mounds, rising abruptly from the surface, will be noticed. Generally these are not of great height; the highest I saw was about 30ft., but the majority are not more than 10ft. high. These mounds look like little volcanoes, and the likeness appears greater still, as on the top there is a crater-like opening filled with water, in which gas bubbles constantly rise. The water flows over the edge, down the slope, and the immediate neighbourhood of such a mound is particularly swampy. In order to prevent this, and to regulate the outflow, several of these mounds have been opened by a trench, extending right into the centre. This trench has not only revealed the existence of a pipe, reaching from the bottom to the top of the mound, but it also permitted its structure to be studied We see that the mounds consist of body of peat, which rises above the general surface, and dips from the centre in all directions. On the surface of this cone layers of calcareous tuffa are observed, while layers of fine mud, containing numerous shells of fresh water mollusca, are seen to be interstratified with the peat.

There is only one explanation to account for the existence of these cones, the vegetabilic matter in the depth of the swamp is still decaying, and as the result of the decomposition gases are liberated. These gases rise and lift the peat till it assumes the shape of a bubble, which eventually bursts. The gases have now a free exit, but the pressure is still sufficient to make the water rise to the top, where it flows over.

It was, of course, of some importance to ascertain the nature of the gas rising in the water, whether it be sulphuretted hydrogen, a hydro-carbon, or carbonic acid. Sulphuretted hydrogen is easily detected by its unpleasant smell. The entire absence of such smell proved that the gas could

not be sulphuretted hydrogen (7). The gas was, apparently, not combustible, as a lighted match applied to the bubbles had no effect, but when I put it into the bottom of the pipe of a cone which had been opened by a cut, just over the point where the bubbles rose, it went out immediately. This proves, in my opinion, that the gas must be carbonic acid, which, being heavier than air, collected at the bottom of the narrow pipe, and slowly flowed out along the trench. The water is quite cold; unfortunately, I had no thermometer to measure its temperature, but even in January it was cool. This proves that it cannot rise from a great depth. To all appearances the water is of good quality; it has no taste whatsoever, and is of crystal clearness. However, when exposed to the air for some time, scuds of brownish colour commence to form. These indicate a considerable percentage of iron, which becomes oxydised when the water is exposed to the air. The presence of some iron salt is proved by another observation. A piece of peat which was taken from the ditch where the bones were found became, after being dry, completely covered with whitish crystals. These crystals proved by their sweetish, astringent taste to be sulphate of iron.

Considering the large quantity of the efflorescence, sulphate of iron must be present in considerable quantities, and this accounts for the ferruginous scuds forming when the water is exposed to the oxydising influence of the air.

The water must also contain a considerable amount of carbonate of lime, as proved by the deposit of tuffa.

Whether water that, though, apparently, perfectly tasteless and quite clear, contains so large a percentage of iron and lime is a good drinking water, and not injurious to health, remains to be seen.

The peat is composed of rotten vegetabilic matter, in which trunks of large trees are irregularly embedded. It appears that most of the vegetabilic matter is too decomposed to allow for a determination, yet trunks of fern trees could be distinctly recognised. A great deal of inorganic substance, probably sand and clay, is mixed with the organic matter, and when dug it represents a black substance, of, rather, heavy weight, which might be used as fuel.

(7) Mr. Moore has, however, informed me that there are certain springs which emit such a smell.

Imbedded in the peat are irregular streaks and layers of a soft calcareous mud, full of the shells of fresh water molluscs.

At Mr. Lovett's farm a trench of about 10ft. depth had been cut, and partly imbedded in such a shell layer were found the bones of, apparently, two individuals, a larger and a smaller one. Unfortunately, Mr. Lovett had not noted the position of the bones when they were found, but there is no doubt that they were not washed together by running water; at least, those of the bigger animal belonged to one individual. This fact is so far of importance, as it proves that the animal must have perished where it was subsequently found. If this view is correct, there is every probability of finding further remains, because it is not very likely that the specimen found was the only one that existed.

I collected a large number of the shells, because their determination must be of the greatest importance in fixing the age of the strata in which the remains of this marsupial were found. As I have been able to compare the specimens with the types in the Tasmanian Museum, Hobart, the specific identification is correct. I found:—

(1) Vitrina (Paryphanta) Milligani, Pfeiff.
(2) Helix (Flammulina) Hamiltoni, Cox.
(3) Bulimus (Caryodes) Dusfresnii, Leach (eggs only).
(4) Succinea australis Fer.
(5) Physa tasmanica, Ten. Woods.
(6) Bithynella nigra, Quoy and Gaimard spec.
(7) Cyclas tasmanica, Ten. Woods.
(8) Pisidium tasmanicum, Ten. Woods.
(9) Ostracodum gen. et spec. indet.

The occurrence of Physa tasmanica, some 8ft. from the surface, associated with the remains of a gigantic marsupial, is of particular interest. Tennison Woods (8), who first described this species, states that it is so similar to Physa fontinalis, of Europe, that it is almost impossible to distinguish the two species. He was, therefore, at first inclined to consider Physa tasmanica as an imported variety of Physa fontinalis. The discovery of Physa tasmanica in the beds of the Mowbray Swamp has now conclusively proved that it is an indigenous, and not an imported,

(8) Pap. and Proceed. Roy. Soc. Tasmania, 1875, pag. 74.

species. If it were imported the gigantic marsupials would have existed a considerable time after 1803, because we must assume that it took some time before Physa fontinalis spread from the southern part of the island to its north-western corner. I do not think that anybody would accept such an absurd theory, and we can, therefore, take it as granted that Physa tasmanica is autochthonous.

On the other hand, if Physa tasmanica and Physa fontinalis are really so similar that they are hardly discernible the problem becomes very interesting. I hardly think that anybody will assume that Physa fontinalis migrated from the temperate zone of Europe, through the tropics of Asia into temperate Tasmania, without the slightest morphological change; in fact, if such a migration actually took place it would be more probable that the Tasmanian form would be widely different from its European ancestor—unless we believe that having passed the tropics, and reached the temperate zone, it assumed again the shape and form of that, living in the temperate zone on the northern hemisphere.

If such a theory were possible, or even probable, it would revolutionise our entire view of the geographical distribution of animals; but I think that before it could even be seriously discussed further proof would be required.

I rather feel inclined to think that the similarity of the two species represents one of the numerous examples of convergency of form, developing under the influence of the same climatic conditions. After the disappearance of the glaciers in Tasmania, certain molluscs developed the same tendency towards a certain form, as did similar molluscs in Europe under similar climatic conditions. This is, however, a problem which is outside the province of this paper.

With the exception of Bulimus (Caryodes) Dufresnii, the largest land snail of Tasmania, whose eggs could unmistakably be recognised, and Helix (Flammulina) Hamiltoni all other species occur in enormous numbers. All these species live at present in Tasmania, and range amongst the commonest species. With the exception of the three species, all the others are fresh water molluscs, but Vitrina Millegani, Helix Hamiltoni, and Bulimus Dufresnii like a moist, cool habitat.

We must, therefore, assume that the beds in which Nototherium tasmaniense was found are of quite a recent age; in other words, that the gigantic marsupials must have lived in Tasmania up to quite recent times. The

simultaneous occurrence of higher organised mammals, which have become extinct, and lower organised mollusca, which are still flourishing, is of the greatest theoretical importance. It proves conclusively that lower organised animals are much less susceptible to changes than higher organised ones. The lower organism is, apparently, better fitted to adapt itself to changes than the higher one; changes which resulted in the complete disappearance of the gigantic marsupials had not the slightest effect on the molluscs. On the other hand, this simultaneous occurrence of extinct mammals and living molluscs conclusively proves that in determining the age of certain beds from fossils alone, we must be strictly guided by one class only. It has been proved over and over again that the results as to the age of certain beds derived from the study of, say, the echinoderms, are somewhat at variance with those derived from the study of molluscs; and, again, those derived from the study of pelecypoda and gastropoda differ from those obtained from the study of cephalopoda. Generally, the lower classes are indicative of a somewhat older age than the higher classes, because they are more persistent than the latter.

The present land and fresh-water molluscan fauna must, therefore, have already been in existence when the gigantic marsupials roamed over the Australian Continent, and when Tasmania was still connected with the mainland. It would, however, be completely wrong to argue that it must be of great age, because these giants have since died out.

Stratigraphically, the beds in the Mowbray Swamp are also of very recent age; in fact, they were formed when the present physiographical features of Tasmania had been practically formed, except that in all probability the elevation of the swamp above sea level was then higher than it is now.

It almost seems significant that the remains of the gigantic marsupials were discovered in such a part of Tasmania that probably was connected longer with the mainland than others, but this is, perhaps, merely accidental. For the present we are unable to say whether the gigantic marsupials had a wider distribution in Tasmania, or whether they were restricted to the northern part. So far no remains have been found at other localities, and R. M. Johnston, the indefatigable geological explorer of Tasmania, would have most probably discovered them had they existed. However, this does not prove that they do not

exist; the numerous silted-up lakes and tarns of the highlands of Tasmania may still contain many a surprise.

However, for the present we are forced to assume that the distribution of the gigantic marsupials in Tasmania was limited, and restricted to the northern parts; in fact, it almost appears as if they had just arrived from the mainland, when they commenced to die out, without finding time to spread further. It is certain that the migration from the mainland must have taken place at a time when Tasmania was still connected with the mainland; in fact, the occurrence of the gigantic marsupials is a further proof—if such was required—of the existence of a land bridge between Tasmania and Australia. It is absolutely impossible to understand how the gigantic marsupials could have otherwise reached Tasmania, unless we assume that they originated spontaneously in Australia and Tasmania.

Further, unless we assume that the gigantic marsupials existed in Tasmania a long time after the separation of the island from the continent, we must conclude that this event took place in very recent times. But, what is more, the gigantic marsupials must have already been extinct before the arrival of the Tasmanian aborigines, because there is not a tittle of proof that they were known to them. Thus the separation of Tasmania and Australia must have taken place so recently that the theory advanced by me in a previous paper is fully borne out (9).

The sequence of events in the most modern geological times of Tasmania may be summarised as follows:—

Later Post Glacial Period.	Fresh water and land Molluscan Fauna the same as at present. Flora the same as at present.	(*a*) Last stage of the isthmus between Tasmania and Australia.	1. Immigration of the gigantic Marsupials (?) 2. Extinction of the gigantic Marsupials. 3. Immigration of the Tasmanian Aborigines about 7,000 years ago. (Probably commencing rise of temperature.)
		(*b*) Destruction of the isthmus between Tasmania and Australia.	Subsidence of the surface, probably accompanied by volcanic eruptions along the north coast of Tasmania. (Younger volcanic period (?)
Present Period.		(*c*) Complete replacement of the old isthmus by the sea.	1. Immigration of the Aryan race, 1803. 2. Extinction of the Tasmanian Aborigines, 1878. 3. Exclusive population of Aryan origin in Tasmania since 1878.

(9) The Antiquity of Man in Tasmania. Pap. and Proceed. Roy. Soc., 1910. See also Noetling, Das Alter der menschl. Rasse in Tasmanien. N J.M.G P., 1911. Beilageband XXXI., page 303.

The fact that in Tasmania the gigantic marsupials occur together with the recent molluscan fauna and the recent flora is of the greatest importance with regard to the determination of the age of these animals in Australia.

On the authority of the late Professor Tate, the beds which contained the remains of Diprotodon australis in Lake Callabona (S.A.) were declared to be of pliocene age. I have not been able to ascertain how Tate arrived at his view of the age. Professor Stirling found only one species of mollusca, viz., Potamopyrgus spec., and some specimens of plant remains, two of which could be identified with living species. I almost presume that for no other reason than because they contained the remains of extinct animals these beds were considered as Pliocene, as they were undoubtedly younger than those Tate considered as Eocene and Miocene. Tate's views as to the age of the tertiary beds in Australia are, however, no longer tenable. The Eocene disappears entirely, and most of the strata he thought to be of Eocene age have to be considered as Miocene; in fact, if not of still younger age. I cannot enter here into the discussion of this question; all I can say is that Tate's view of the pliocene age of the Diprotodon beds is not supported by unshakable palæontological evidence. Whatever their age may be, in Tasmania the Nototherium occurs in beds that, without doubt, are of post-glacial age.

In view of the above fact, it is remarkable to note that as far back as 1892 Jack and Etheridge (10) have expressed a similar view with regard to the remains of Diprotodon in Queensland. On page 608 the authors say:—"On the other hand, in Queensland there is no evidence that they went back to the tertiary epoch, although it is quite possible that they did. Such direct evidence as we have, consisting of the association of the mammalia with fresh water and land shells of species still living, would lead to the conclusion that the former (viz., the gigantic marsupialia) were in the Queensland area, confined to the post-tertiary deposits."

If the authors, however, state that "There is abundant evidence to show that in the southern colonies the extinct mammalia existed in pliocene times," I am afraid that they were somewhat influenced by Tate's views. I do not deny that it is possible that the gigantic marsupials first appeared in pliocene beds, but the evidence on the strength

(10) The Geology and Palæontology of Queensland and New Guinea. 1892, pag. 608.

of which these beds were declared to be Pliocene is not very convincing. On the whole, I do not think it very probable that these giants lived all through the Pliocene, the Pleistocene, and the late post-glacial epoch, up to times which, according to the European standard, might be termed prehistorical. I have come to the conclusion that the gigantic marsupials, in particular Diprotodon and Nototherium, existed during the cold Pleistocene period, when enormous glaciers covered a large portion of Tasmania and the Australian mountains. The giant marsupials were not exactly Arctic animals, but they preferred a cool, pluviose climate to a warm and dry one. When with the general rise of temperature the glaciers melted away the giant marsupials probably followed the receding glaciers, and they kept longest in those parts where the glaciers remained for the longest time, viz., in Tasmania. With the complete disappearance of the glaciers, the giant marsupials also became extinct.

It is noteworthy that Jack and Etheridge hold somewhat similar views. They assume that the changes of climate which followed the subsidence of the land were sufficiently great to have a disastrous effect on the now extinct fauna (11). It matters very little whether we attribute the changes of the climate to the disappearance of the glaciers or the subsidence of the land, which latter, in my opinion, took place in post-glacial times. Messrs. Jack and Etheridge, as well as myself, concur in the view that the extinction of the giant marsupials was the result of climatic changes; only that I go a little further, and assume that the gigantic marsupials were the representatives of the glacial period in Australia, in the same way as Rhinoceros tychorhini (the woolly Rhino) and Elephas primigenius (the mammoth) characterised the pleistocene glacial period in Europe.

(11) L.C. pag. 609.