# On the OCCURRENCE of a SUBMERGED FOREST, with REMAINS of the DUGONG, at SHEA'S CREEK, NEAR SYDNEY.

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[With Plates VIII. - XI.]

[*Read before the Royal Society of N. S. Wales, August 5, 1896.*]

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## I.—References by Previous Observers to Movements of the Australian Coast.

Evidence proves that changes have taken place, in comparatively recent geological time, between the relative levels of land and sea on the East Coast of Australia. The evidences may be divided into two classes, according as they show (*a*) a negative movement (subsidence) of the land or corresponding positive movement of the sea, as the case may be—[For this the term submergence will be used in this paper]—(*b*) a positive movement (elevation) of the land, or a corresponding negative movement of the sea.

(1) *Submergence.*—As this paper relates to submergence, evidences of submergence may be taken first. Darwin was in favour of the view that the Great Barrier Reef of Australia was evidence of submergence, though he does not supply many details.[1]

[1] Journal of Researches, 2nd Edit., 1845, p. 474.

He states in a later publication[1]:—"If instead of an island, as in the diagram, the shore of a continent fringed by a reef were to subside, a great barrier-reef like that on the north-east coast of Australia, would be the necessary result; and it would be separated from the main land by a deep-water channel, broad in proportion to the amount of subsidence, and to the less or greater inclination of the bed of the sea."

Prof. J. D. Dana and Commodore Charles Wilkes, U.S.N., were also of opinion that the Barrier Reef of Australia was evidence of subsidence. They state[2]:—"The coral reefs indicate an extensive subsidence along the east and north-east coasts of New Holland." On the following page they estimate the subsidence as not less than five hundred feet. On the same page is also adduced some evidence of elevation—"On the eastern coast there are occasional elevated beaches or deposits of shell and some appearances of terraces." Prof Dana dwells specially on evidence of a raised beach on the Illawarra Coast of N. S. Wales, between Bulli and Wollongong, about ten feet above sea-level. The fact, however, should here be mentioned, that subsequent researches show that this ridge is rather a storm-beach with midden remains than a true raised beach. Professor Dana in a later publication[3] repeated his statement, that the existence of barrier reefs on a coast is evidence of subsidence.

The Rev. W. B. Clarke was of opinion that a subsidence had taken place along the east coast of Australia, as proved by the following statement[4]:—"Whilst marine deposits of Tertiary age are found along the west coast of Australia, and along the southern coast from Cape Leeuwin to Cape Howe, there are no known *marine* Tertiaries in any part of the coast of New South Wales and Queensland up to the Cape York Peninsula; and the reason of

[1] Structure and Distribution of Coral Reefs, 2nd Edit. 1874, p. 135.

[2] U. S. Exploring Expedition, 1838–42, Vol. x., Geology, 1849, p. 533.

[3] Corals and Coral Islands.—J. D. Dana, 1872, p. 319.

[4] Remarks on the Sedimentary Formations of New South Wales. By the Rev. W. B. Clarke, p. 7, 4th edit. By Authority, Sydney, 1878.

this may be, that, as indicated by phenomena before pointed out by me, but which on this occasion cannot be further dwelt upon, the eastern extension of Australia has been probably cut off by a general sinking, in accordance with the general Barrier Reef theory of Mr. Darwin."

Perhaps the most important statement on this subject is that made by Mr. C. S. Wilkinson, the late Government Geologist of New South Wales. He says,[1] with reference to Port Hacking, near Sydney:—"It will thus be seen that this locality is over a very deep portion of the coal basin. The eastern portion of this basin has been apparently faulted and thrown down beneath the waters of the Pacific Ocean, the precipitous coast, and a line about twenty miles east from it, marking approximately the lines of dislocation. The deep soundings immediately beyond this would seem to favour this view, so that here the bed of the ocean probably consists of the old land surface which once formed the continuation of that upon which the City of Sydney now stands, and which has been faulted to a depth of over 12,000 feet; the length of the faulted area is not known, but it probably does not extend along the coast beyond, if so far as, the north and south limits of the Colony."

"The abrupt eastern margin of the Blue Mountains, up which the Great Western Railway ascends at Lapstone Hill, near Emu Plains, marks the site of a similar though not so extensive fault, by which all the country between it and the coast was thrown down to its present level—the depression being so great that the ocean water flowed into the old river valleys, one of which forms the beautiful harbour of Port Jackson. We have evidence that these faultings probably took place towards the close of the Tertiary epoch; for no marine Tertiary deposits are known along this portion of the coast of Australia, whereas in New Guinea on the north, and in Victoria on the south, the marine Miocene beds occur at elevations up to eight hundred feet above the sea. Had

[1] Mineral Products of New South Wales etc., p. 52. By Authority, Sydney, 1882.

this low lying country along the east coast of Australia then existed, it must have been covered by the Miocene Sea, and doubtless some portions of the Miocene strata of that period would have escaped denudation, and have remained as those have which are seen in Victoria and elsewhere; but it is very probable that until or during the Pliocene period it stood at a much higher level and extended some distance beyond the present coast line. Then again the Tertiary deposits throughout east Australia show that the valleys draining the Great Dividing Range have been chiefly eroded since the Miocene period, for we find deep valleys and ravines cutting through later Tertiary formations; therefore, the sinking of the land traversed by any of these valleys, such as that of Port Jackson, evidently took place in comparatively recent geological times, and may have been contemporaneous with the extensive volcanic eruptions of the Upper Pliocene Period during which the southern portion of Victoria especially was the *locale* of great volcanic activity."

In 1886, Mr. Walter Howchin, F.G.S.,[1] recorded evidence of a supposed land surface submerged about twenty-six feet below sea-level, (high water) at Glanville, near Adelaide. The evidence is in the form of a crust of travertine capped by brown clay. In the absence, however, of land fossils, the evidence, as the author points out, is inconclusive.

Reference has been made by one of the authors to the occurrence of black loam and peat extending from about sixteen feet to thirty-six feet below low water at Narrabeen lagoon, about nine miles northerly from Sydney.[2] This is probable though not conclusive evidence as to submergence, as the peaty loam may possibly have been originally deposited below sea-level. Further evidence as to submergence along the eastern coast of Australia has been quoted by the same author in his Presidential Address for 1896 to this Society.

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[1] Trans. Roy. Soc., South Australia, Vol. IX., 1886-7, pp. 31 – 35.

[2] Annual Report Department of Mines, 1890, p. 236. Report by T. W. E. David. By Authority, Sydney, 1891.

(2) *Elevation of Coast* (or negative movement of ocean).—References to papers on the above subject have already been given by two of the authors elsewhere.[1] A brief summary will here suffice. Reference has already been made to the supposed raised beaches of the Illawarra District of New South Wales, noticed by Professor Dana during the United States Exploring Expedition under Commodore C. Wilkes, U.S.N., 1838 – 42.

In 1846, Captain Stokes quoted evidence of elevation near Cape Upstart, in the following words[2]:—"I will, myself, here adduce what may be deemed an important fact; and which, if allowed its due weight, will go far to weaken the arguments brought forward in favour of subsidence of the north-east coast of Australia. I found a flat nearly a quarter of a mile broad, in a great sheltered cove, within the Cape, thickly strewn with dead coral and shells, forming, in fact, a perfect bed of them—a raised beach of twelve feet above high water mark. . . . . Had it been on the seaward side of the Cape, I might have been readier to imagine that it could have been thrown up by the sea in its ordinary action, or when suddenly disturbed by an earthquake wave, but as the contrary is the case, it seemed impossible to come to any other conclusion than that an upheaval had taken place."

In 1847, Professor J. B. Jukes described small sandy flats of coral conglomerate, never extending more than fifteen feet above high water mark, at intervals along the north-east coast of Australia.[3]

In 1859, Mr. Ludwig Becker adduced evidence to show a rising of the shores of Hobson's Bay, Port Phillip, as shown by the readings taken by Mr. R. L. J. Ellery on the tide gauge at Williamstown near Melbourne.[4] Mr. Becker estimated the rise of the coast near Melbourne at four inches a year.

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1 Rec. Geol. Sur. N. S. Wales, Vol. II., pt. i., 1890.—Raised Beaches of the Hunter River Delta. By T. W. Edgeworth David and R. Etheridge Junr.. pp. 37 – 52, pl. 3. By Authority, Sydney.

2 Discoveries in Australia, etc., 1846, I., p. 332

3 Narrative of the Surveying Voyage of H.M.S. "Fly," 1847, I., p. 58.

4 Some facts determining the rate of upheaval of the South Coast of the Australian Continent.—Trans. Phil. Inst., Vict. 1859, III., p. 7.

In 1862, the Rev. J. E. Tenison-Woods corroborated Mr. Becker's observations, as to a rising of the southern coast of Australia, and on the evidence partly of the shallowing of the soundings, since they were taken by Flinders in 1802, partly from the occurrence of marine shells on the shores of coastal lakes now fresh, but evidently formerly salt, concluded that the rising affected the whole coast from Melbourne to King George's Sound.[1]

In 1869, Dr. Alexander Rattray published his opinion that in the Cape York district there was evidence of a recent elevation of the coast. He says[2]:—"Equally interesting is the evidence that the north-east, if not the whole of the east coast of Australia, is slowly rising, to be found in the gradual shoaling of the channel between Hinchinbrook Island and the mainland, (Lat. 18½° S.) which is due to all appearance, neither to silting up nor to the growth of coral—in the presence of waterworn caves in the sandstone cliffs of Albany Island and those of the mainland opposite, now well above high water mark—and in the existence along many parts of the coast, especially towards the northern end of the peninsula, of extensive tracts of level country now covered with sand dunes bearing a scanty vegetation stretching inland, and on either side to the base of lofty hills now ten, fifteen, or twenty miles off, but which had once closely bordered the sea, the whole looking as if they had once been under water."

In 1890 two of the authors published an account of some well developed and extensive raised beaches near the apex of the Hunter River Delta near Maitland, N. S. Wales. The marine shell beds nowhere attained a greater elevation than that of fifteen feet above high water.[3]

In 1892, Mr. E. J. Statham, Assoc. M. Inst. C.E., described certain shell heaps and shell beds near the mouths of the Clarence, Richmond and Brunswick Rivers.[4] He states,[5] "These layers are to

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[1] Geological Observations in South Australia, 1862, p. 205.

[2] Q.J.G.S., Vol. xxv., 1869, p. 302. [3] *Op. cit.*, p. 46.

[2] Journ. Roy. Soc. N. S. Wales, Vol. xxvi., 1892, pp. 304–314. [3] *Op. cit.* p. 306.

be found at levels usually from four to ten feet above high water, and are important as indicating that the east and south coasts (if not the whole insular mass of Australia) are rising, further support to which conclusion is afforded by the fact of nearly all the streams and estuaries having bar entrances, which in some instances become entirely blocked up until a passage is opened by land floods."

In 1894, Mr. G. A. Stonier, F.G.S., described a raised terrace of auriferous black sand, six feet above ordinary high water mark, near the Evans River in the Lismore District, New South Wales.[1] The following year Mr. J. E. Carne, F.G.S., described similar terraces at a level of a few feet above high water, at Jerusalem Creek in the same district.[2] Mr. Carne, however, states:—"Whether the slight elevation of the surface of the black rock represents an elevation of the land or depression of the sea bed, or simply an accumulation of sand thrown up by stormy conditions, sufficient data are not yet to hand to enable a determination to be arrived at."

(3) *Stability.*—The paper by Mr. T. E. Rawlinson, C.E., on the coast line formation of the Western District of Victoria,[3] does not bring forward evidence either as to elevation or subsidence, but is rather in favour of stability in the *level* of the coast line in recent geological time. He says,[4] "The formation of the land and its three distinct coast lines as described indicate considerable changes of coast, and these changes must have occurred *since the upheaval of the land to its present level.*"—(The italics are ours). He concludes that the land has gained on the sea in southern Victoria in recent geological time, chiefly through accumulation of shell sand, and not through elevation of the sea floor. R. Daintree referring to the eastern coast of Queensland, states that "little

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[1] Annual Report Department of Mines, N. S. Wales, 1894, p. 130. By Authority, Sydney, 1895. [2] *Op. cit.*, p. 151, 1895, published 1896.

[3] Trans. and Proc. Roy. Soc. Vic. Vol. XIV., pp. 25–34, 1878. [4] *Op. cit.*, p. 31.

upheaval of this portion of Australia has taken place since the last volcanic disturbances terminated."[1]

From the evidence above quoted it is clear that in comparatively recent geological time there has been a relative change in the level of land and sea along the east and south coasts of Australia of about fifteen feet, and this amount of alteration seems so constant as to incline us to the opinion that it may be due, as so ably advocated by Suess in his classic work, "Das Antlitz der Erde," rather to a negative movement of the ocean than to a positive movement of the land. On the other hand, Darwin, Clarke, and Wilkinson, have brought forward arguments, to which we think much weight should be attached, to show that in late Tertiary, perhaps even in Post-Tertiary time, there has been a considerable submergence, perhaps due to subsidence of the lithosphere, along the east coast of Australia. In comparing the conflicting evidences as to submergence and elevation along the east coast of Australia, the fact which has been well emphasized by Suess should always be borne in mind, viz., that in case of oscillatory movements even when the positive movement has greatly preponderated, it is chiefly as a rule, the traces of the negative movement that survive.[2] Positive movement (of the ocean) submerges old beach lines and hides them from view, with a covering of sediment, whereas raised beach lines are exposed to view and are not easily obliterated.

## II.—Shea's Creek.

(1) *The locality as it was before the Canal was commenced.*—Previous to the cutting of the present canal and the artificial raising of the level of the surrounding land, the area referred to in this paper was mostly a salt water swamp, through which crept the sluggish malodorous Shea's Creek. Shea's Creek rises to the east of Redfern in some low sandy hills, and can be traced thence for a distance of three and a half miles south-south-west, until its estuary joins that of Cook's River, half a mile below the Cook's

[1] Quart. Journ. Geol. Soc., Vol. xxviii., 1872, p. 273.

[2] Das Antlitz der Erde, von Eduard Süess, Vol. ii., p. 691, 1888.

River Dam, and about half a mile north of the point where the estuary of that river enters Botany Bay. For the greater part of its course it was little more than a ditch, and was tidal for about a mile and a half above the point where it joined Cook's River. Its course throughout is almost entirely over alluvial deposits, derived from the denudation of the low hills of Triassic rocks (Wianamatta Shales and Hawkesbury Sandstone) which lie to the north-west, north, and north-east. It is the alluvial flats which lie on either side of the tidal portion of Shea's Creek, which constitute the salt swamps referred to above. The surface of the swamp is covered by rank grass and salsolaceous plants with a thin belt of swamp oak *(Casuarina)* along its western margin.

(2) *General Geological Conditions.*—A glance at the geological sketch map accompanying this paper (*Plate* 8) shows that these alluvials form a somewhat delta-shaped area, about three and a half miles long from its apex to its seaward termination, and four miles wide measured along the shores of Botany Bay. To the west of the present canal area, and at a distance of about half a mile at right angles to Shea's Creek, the alluvials are sharply bounded on the south-west by Hawkesbury Sandstone, and farther north-east by the Wianamatta Shales. Eastwards their boundary is lost under the hills of blown sand in the neighbourhood of the Waterloo and Botany swamps and Randwick. The excavations for the Shea's Creek canal prove that these alluvials occupy the site of what has once been a large indentation of Botany Bay.

(3) *The Section exposed at Shea's Creek.*—The portion of the Shea's Creek canal excavations, specially examined by us, extends from the dam five hundred and fifty feet, measured horizontally, above Rickety Street, as far as the site of a second dam to the north-east, a further distance of 2,150 feet. The bottom of the canal is being carried to a uniform depth of ten feet below low water, and is one hundred feet wide at the bottom, and two hundred feet wide at the top. The mean rise and fall of the tide is about five feet, so that at mean high tide there will be a depth of fifteen feet of water in the canal when filled. The

alluvials on either side have had their surface artificially raised with material excavated from the canal, as shown on the sections accompanying this paper, (*Plate* 9, fig. 1.) As the original level of the swamp was there at, or a trifle below, that of mean high water, and as the canal has been excavated to a depth of fifteen feet below mean high water, it follows that a section of that thickness (fifteen feet) is exposed to view in the banks, wherever they have been cut down to the full depth, and have not yet been concealed by the fascine work and stone pitching with which the sides of the canal are being lined, from three feet below low water to the top of the embankment.

The nature of the strata observed by us is shown on figs. 1 - 2, of *Plate* 9. (*a*) The uppermost stratum is a bed of sandy peat from nine inches to one foot in thickness, obviously of recent origin. (*b*) Next in descending order are layers of blown sand, with interstratified peaty partings, the whole having a thickness of about three feet. The outcrop of these beds is stained yellow and orange by a superficial film of sulphate of iron and alum. (*c*) A well marked horizon follows where marine shells are plentiful especially *Anomalocardia trapezia*. The bed was traced by us almost uninterruptedly from the dam above Rickety Street for nearly half a mile north-east. The shells are imbedded in sandy clay. A few varieties only, and all belonging to living species, are represented. The bed is two feet thick, and at its base is from one foot below mean low water to about two feet above. (*d*) A second layer of peaty loam passing in places into true peat with roots of various trees, and a few stumps of Swamp Mahogany underlies the shell bed just described.

On the longitudinal section the stump of a tree (No. 3 Stump) is shown on the horizon of this bed. *No. 3 Stump* was in pieces when seen by us. It was surrounded with sand containing partings of peaty matter, covered with a thin sandy clay. This stump was one foot seven inches above low water mark and possibly not *in situ*. The exterior showed traces of perforation by a boring amphipod, *Sphæroma verrucauda*, Dana. An allied species *S.*

*quoyana*, M. Edw., perforates sandstone rocks between tide marks; both are met with in Port Jackson. The stump belonged to the Swamp Mahogany, *Eucalyptus botryoides*, as determined by Mr. R. Baker of the Technical Museum. Near the preceding, we observed another stump, (No. 4) on the horizontal section.

Although the above stump was perhaps not *in situ*, numerous horizontal roots of trees were observed by us on this horizon, undoubtedly *in situ*, and the layer of peaty loam in which they occurred was very persistent. (*e*) Below the second well marked peat horizon is a bed of unctuous, plastic, dark bluish-grey clay, sandy in places, and occasionally showing vertical rootlets passing through it. The bottom of this bed rests, at about from nine to ten feet below low water, on the submerged forest, and a thick bed of peat, developed chiefly at the north-east end of the section. Marine shells are very plentifully and rather irregularly scattered through it, being most abundant near its upper surface, and, (towards the south-west end of the section) they form an irregular bed composed almost entirely of shells, and about two feet in thickness, extending from four to six feet below the level of low water.

On the east side of the cutting at position of No. 1 Stump, the bed is at least seven feet thick. The contained shells are strictly of an estuarine character, such as may now be met with in any of the muddy arms of the Parramatta River or sandy beaches connected therewith. A very similar bed of shells was excavated a few years back at Long Cove Creek, between Leichhardt and Dobroyd, Ashfield, the lithological character of the deposit being very similar to that of the present bed.

The organic remains so far obtained from this horizon, Shea's Creek, are as follows:—Annelida: *Polydora ciliata*, Johnston (borings). Echinodermata: *Salmacis Alexandri*, Bell. Pelecypoda: *Anomalocardia trapezia*, Deshayes; *Clementia papyracea*, Gray; *Tapes undulata*, Lam.; *Tapes turgida*, Lam.; *Tellina deltoidalis*, Lam.; *Tellina* sp.? *Dosinia circinaria*, Deshayes; *Circe scripta*, Linné; *Pecten fumatus*, Reeve; *Pecten tegula*, Wood; *Spisula*

*parva*, Petit; *Ostrea Angasi*, Sowerby; *Ostrea cucullata; Nucula Strangei*, A. Adams; *Cryptodon globosum*, Forskal; *Cardium tenuicostatum*, Lam.; *Mytilus hirsutus*, Lam.; *Potamides eben-inus*, Bruguiere; *Lampania australis*, Quoy; *Natica Strangei*, Reeve; *Natica plumbea*, Lam.; *Natica conica*, Lam.; *Bulla australis*, Quoy & Gaimard; *Bittium granarium*, Kiener; *Nassa jonasi*, Dunker; *Calliostoma decorata*, Philippi; *Trochocochlea zebra*, Wood; *Liotia clathrata*, Reeve; *Risella lutea*, Q. & Gaim.; *Urosalpinx Hanleyi*, Angas; *Triton olearium*, Linn.

The mollusca do not call for any special mention, they are a mixture of both muddy-inlet and sandy-beach loving forms, such as one would expect to find in a deposit that must have undergone alterations of deposition. The Echinoderm is a deep water species, and in all probability was simply washed in.

Much interest attaches to the borings of the Oyster-boring Worm *Polydora*. In 1890, Mr. T. Whitelegge, of the Australian Museum, was deputed to investigate a disease that appeared amongst the oysters of New South Wales, on behalf of the Fishery Commissioners. It appears from his researches[1] that a marine worm, determined as above by Prof. W. A. Haswell, bores into and infests the shells of the oysters. The death of the oyster is then brought about by the decomposition of the mud after the death of the worms. At the time these investigations were made it was supposed by the oyster farmers and others to be a new disease, at any rate, so far as New South Wales was concerned, but we now find evidence of its existence at the remote period to which the deposition of bed (*e*) is to be referred. A few stumps of trees were also noticed enclosed in this bed. (Stumps Nos. 4 and 6 on longitudinal section *Plate* 9).

*No. 4 Stump* was a very large one, much eaten by boring on the outside, the borings, however, extending but a very short distance into the wood. This appeared to be *in situ*, the level of the top of the roots being three feet four inches below low water

[1] Aust. Mus. Records, 1890, I., No. 2, p. 41.

mark, the roots descending three feet. It was situated as near as possible in the middle of the canal, 2,100 feet north of Rickety Street Bridge. The roots rested on six inches of loamy sand passing down into a grey unctuous clay. This stump belongs to the Mahogany, *Eucalyptus* sp.

*No. 6 Stump* was also apparently *in situ*, its top being six feet eight inches, and the roots about two feet lower, below low water level. Remains of a Dugong, which will be described presently, were found in this bed, and unearthed in the presence of two of us. Four tomahawks have also been obtained from this bed, as we are informed, and our information leads us to the opinion that it is almost certain that they were obtained *in situ*. These also will be described presently.

(*f*) At the base of the estuarine blue clays is the horizon of the third peat bed, from a few inches up to five feet in thickness. Its upper surface is from ten feet to seven feet below low water. At the north-east end of the canal excavation, shown on the plan, and next to the upper dam, a very large number of tree stumps, as we are informed by Mr. W. Trickett, the overseer of the work, were unearthed, the majority being ten feet below low water. Of these, all but about three had been removed at the time of our visit (Nos. 1, 2, and 5). This submerged forest is also reserved for detailed description.

(*g*) Below the third peat horizon is white running sand, with thin bands of brown peaty sand, extending to a depth of at least three feet. Canal excavations have not gone below this depth, but bores put down for the foundations of the Rickety Street Bridge showed that the strata underlying (*g*) are as follows :—

8 ft. 6 in. Sand and mud.

12 ft. 0 in. Blue clay resting on Hawkesbury Sandstone.

(4) *Remains of the Dugong.*—One of the most important discoveries in connection with the Shea's Creek excavation is the discovery, by some of the workmen employed, of the bones of a Dugong. These were unearthed partly in the presence of one of us, near the junction of the two main tramlines running from

Rickety Street Bridge, at about seven hundred and sixty feet from the latter and fifteen yards from the western bank of the canal as now constructed. They were entombed in sandy clay, near the top of the estuarine clay marked (*e*), and just above the shell bed. They were five feet six inches to eight feet six inches below the present high water level, and a total depth of four feet six inches to seven feet six inches below the swamp surface level, previous to excavation. The bones were thus distributed through a thickness of about three feet of the sandy estuarine clay. The bones are those of *Halicore dugong*, Gmelin, sp., and were found confusedly heaped together. Although representing only a portion of the skeleton, we see no reason to doubt that they all belonged to one and the same individual. The following table shows the number found as compared with that of those of the living Dugong. The skull was recovered on two different occasions, the skull on one, the mandible on the other. The shoulder girdles, paddles, and pelvic bones are wholly wanting.

| Name of Bones. | Dugong according to Flower.[1] | Shea's Creek Bones. |
|---|---|---|
| Cervical Vertebræ | 7 | 1 |
| Thoracic ... ... | 19 | 17 |
| Lumbar ... ... | 4 | 3 |
| Caudal ... ... | 27 | 5 |
| Ribs ... ... | 38 | 26 |

[1] Flower, Osteol. Mammalia, 3rd ed., 1885.

The whole of the bones are in an excellent state of preservation, and are more or less fossilised, particularly the ribs, which nevertheless still retain a portion of the original animal matter. The structure of the bone substance of the ribs is very dense, and is with difficulty scratched with a knife on a fractured surface. The ribs in a recent Dugong are very heavy proportionately, dense and hard. A comparison of thin sections respectively of the ribs of this Dugong and of those of a recent Dugong shows that their mineralogical condition and structure are in both cases almost identical. We see no reason to doubt the identity of this Sirenian with the existing Dugong, and although unquestionably repre-

senting a large animal, it is not of greater size than the Dugong is known to attain.

The present southern limit of the Dugong is probably Wide Bay. although it was formerly to be caught in Moreton Bay. Its occurrence on the coast of New South Wales is very rare, indeed the late Mr. Gerard Krefft said, "the Dugong is not found on the coast of New South Wales,"[1] but Dr. E. P. Ramsay states that it has been "occasionally observed as far south as the Tweed and Richmond Rivers."[2] About two years ago Mr. Harry Stockdale, exhibited, at the Hotel Australia, a Dugong, which Mrs. Chinnery of Hunter Street, of whom the Dugong was purchased, informs us was caught in Broken Bay.

The late Mr. A. W. Scott, speaking of the Dugong's habits, says[3]:—"It is only the shallow waters of unruffled inlets and creeks, the sheltered mouths of rivers, the bays and the straits between proximate islands, that afford the necessary quiet, and the abundant submersed marine aliment essential for a permanent residence." This "aliment" is described by Macgillivray, as a slender, branchless, cylindrical, articulated seaweed, of a very pale green colour.[4]

Macgillivray gives[5] the following description of the method employed by the Cape York natives to capture the Dugong:—"When one is observed feeding close inshore, chase is made after it in a canoe. One of the men standing up in the bow is provided with a peculiar instrument used solely for the capture of the animal in question. It consists of a slender peg of bone, four inches long, barbed all round, and loosely slipped into the heavy, rounded, and flattened head of a pole, fifteen or sixteen feet in length; a long rope an inch in thickness, made of the twisted stems

[1] Australian Vertebrata—Fossil and Recent, 1870, p. 6.

[2] Cat. Exhibits N. S. Wales Court, Gt. Internat. Fisheries Exhib., London, 1883, p. 53.

[3] Mammalia, Recent and Extinct, 1873, p. 52.

[4] Voy. "Rattlesnake," 1852, II., p. 25.

[5] *Loc. cit.*, pp. 24–25.

of some creeping plant, is made fast to the peg at one end, while the other is secured to the canoe. When within distance, the bowman leaps out, strikes the Dugong, and returns to the canoe with the shaft in his hand. On being struck, the animal dives, carrying out the line, but generally rises to the surface and dies in a few minutes, not requiring a second wound, a circumstance surprising in the case of a cetaceous animal, six or eight feet in length, and of proportionate bulk. The carcass is towed on shore and rolled up the beach, when preparations are made for a grand feast. The flesh is cut through to the ribs in thin strips, each with its share of skin and blubber, then the tail is removed and sliced with a sharp shell as we would a round of beef."

On the other hand, Mr. J. K. E. Fairholme,[1] says, the Dugong was captured by the blacks in Moreton Bay "by placing large nets across through which they knew the animals would pass from the feeding grounds."

Except on one of two hypotheses the presence of these bones in the Shea's Creek deposit is difficult of explanation, viz., either that the Dugong had strayed some considerable distance from its accustomed feeding ground, or else a carcase had floated in from seawards and become stranded. It could hardly have frequented such an inlet as Shea's Creek must then have been for feeding purposes, if the resemblance of the deposit to those now accumulating in the Parramatta River, and elsewhere under like conditions be any criterion for "Dugongs are much more strictly marine than Manatees, and their food is therefore chiefly restricted to sea-water algæ."[2] If, however, it be admitted that this Dugong was stranded alive at Shea's Creek, or at any rate at that part of Cook's River Estuary now represented by that odoriferous locality, the natural inference is that conditions more akin to those of the north-east Queensland coast existed there at that period.

(5) *Traces of Man's Presence.*—(*a*) *Tomahawks.*—On the north side of the second dam, 2,700 feet from Rickety Street, two

[1] Proc. Zool. Soc., 1856, pt. xxiv., p. 353.

[2] Ogilby, Cat. Austr. Mam. (Austr. Mus.), 1892, p. 63.

tomahawks were found in the first sump hole at a point opposite the middle of the dam, and one to the south-west, at the present site of the pump. Recently a third was found in a heap of mullock on the bottom of the canal on south-east side of the same dam. The two tomahawks from the first sump were six feet below low water, and therefore eleven feet below mean high water mark. One of these has come into our possession, and differs in no way from the oblong ovate type used by the aborigines, and is now exhibited.

(*b*) What appears to be a far more interesting piece of evidence of man's presence around Botany Bay at this epoch of its history is afforded by the Dugong bones, particularly the ribs. Many of these are scarred transversely and obliquely with deep scratches and cuts, especially at their distal ends. These incisions are most certainly not of recent execution, nor can we conceive any fortuitous circumstances, such as contact with sharp rock surfaces, that would produce them. They present the appearance of cuts and scratches that would be made by the direct blows of a sharp-edged stone tomahawk. The cuts are in themselves curved, with the central portion deeper than the sides, such as one would expect to be caused in the manner suggested. (See *Plates* 10, 11.) The esteem in which the Dugong's flesh was held by the blacks of the north-east coast is well known, and has been already referred to, and we are informed by Mr. R. Grant of the Australian Museum, that he has seen Dugong bones on the Queensland coast, with similar markings, that he knew had been handled by the aborigines. There is, therefore, the probability that at the time this Sirenian was stranded, and before the final geological changes had taken place that brought about the present aspect of the Botany and contiguous swamps, man was an inhabitant of the locality. One other item of evidence there is—the burnt off stumps in the forest bed, although this is of a much less conclusive nature.

(6) *The Submerged Forest.*—As already mentioned, a very large number of stumps of trees were found, chiefly just to the south-west of the northern dam. The greater number of these were *in*

*situ*, just as they grew when their stems were attached. A few were lying over on their sides. At the time of our examination, only about three trees were still left *in situ* on this horizon, viz., Stumps 1, 2, and 5, as shown on the longitudinal section, (*Plate* 9).

*No. 1 Stump* lay at the bottom of the canal, and had a large "buttress," the roots spreading out in their natural position, some with rootlets attached at least six inches long by two inches in diameter. The root rested on and was implanted two feet in dark clayey sand, above the top of the stump was one foot of peaty material, and then the estuarine bed (*e*), there six feet thick. Mr. E. F. Pittman, the Government Geologist, traced one of its roots by digging for fully six feet from the centre of the stump—the root extended horizontally and slightly downwards—and satisfied himself as to the stump being really *in situ*. The root was still over four inches thick at the furthest point to which it was traced. This stump is ten feet below low water, and belongs to the Swamp Mahogany, *Eucalyptus botryoides*.

*No. 2 Stump* showed evidence of having been burnt off at the top, and the roots also appeared charred. It belongs to Honeysuckle, *Banksia (B. serrata)*. The subsequent discovery of the cones by Mr. R. Baker, proves the existence of this species in the submerged forest. It is also ten feet below low water, and is *in situ*.

*No. 5 Stump*, occurring at the same level, was also dug around by us to make sure that it was *in situ*, and the roots were found to radiate for at least four feet from the stump. This stump belonged to the Mahogany, *Eucalyptus (? E. resinifera)*. Mention should also be made of the fact that during the early part of the work, Mr. A. S. Patison, surveyor in charge at Shea's Creek, followed one root belonging to a stump in the bottom of the canal near the upper dam, for twenty-one feet. The stump to which it belonged had a diameter of two feet six inches. No doubt, therefore, exists in our minds as to the stumps described above being really *in situ*, and Mr. E. F. Pittman, the Government Geologist concurs with us in this opinion.

## III.—Deductions.

(1) *As to Submergence.*—It is not our purpose to enter here into a discussion of the general question as to whether evidence, such as that afforded by the submerged forest, points to a downward movement of the land or to a rise in the level of the ocean. A very brief summary, however, of general views held on the subject of beach lines will perhaps be not out of place. Of late years eminent geologists, notably Suess, have argued that, in the case of raised beaches and submerged land surfaces, the evidence points rather to an alteration in the level of the ocean than to a definite upward or downward movement on the part of the earth's crust. Among causes which affect the general level of the ocean or distort its surface may be mentioned the following:—

i. Development of ice masses at the Poles.
ii. Bending of the earth's crust.
iii. Lateral attraction of continental masses.
iv. Sedimentation.
v. Position of the shore with regard to the tide wave.
vi. Inflow of freshwater.
vii. Difference in density of the ocean water at different localities due to varying conditions of evaporation, rainfall, and currents.
viii. Direction of prevalent winds.
ix. Hydration of the lithosphere.

With reference to (i.) Lord Kelvin[1] has shown that the alteration in sea level, during an ice age, in a non-glaciated hemisphere, (on the assumption that the glaciation of the Northern and Southern Hemispheres was alternate) would amount to, (certain other premises being granted) as much as three hundred and twenty to three hundred and eighty feet. Mr. Warren Upham[2] has calculated that during the maximum glaciation of the Ice Age in the Northern Hemisphere, the sea surface over the whole globe may

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[1] Popular Lectures and Addresses, p. 330.

[2] The Ice Age in North America—G.F. Wright, 1889, p. 579.

have been reduced by as much as one hundred and fifty feet, while Mr. R. S. Woodward[1] has estimated that gravitation towards the ice in the Northern Hemisphere would further depress the ocean in the tropics and in the Southern Hemisphere to the amount of from twenty-five to seventy-five feet, while it would raise the level near the borders of the ice-sheets to counter-balance approximately the depression due to the diminution of the ocean's volume, and would lift portions of the North Atlantic and of the Arctic Sea, perhaps two or three hundred feet higher than now.

With regard to (ii.), Suess states that, if Krümmel's formulæ be taken for the cubic capacity and depths of the oceans, and that if it be assumed that the shores of the ocean were everywhere vertical and that the Greek Levantine Sea and the Black Sea did not exist, and then the depressions were to be formed in which the Black Sea and Greek Levant now lie, there would be a eustatic negative movement of the ocean to the amount of four mètres. In order, therefore to produce a change in level of the sea surface equal to that of which we have evidence at Shea's Creek, it would be necessary for a rise to have taken place in the ocean floor sufficient to displace more water than now lies in the Black Sea and Greek Levant.

With regard to (iv.) Sedimentation, it would be necessary to denude a thickness of ten mètres off the whole area of the land, and deposit it in the sea in order to produce an elevation in the sea surface of four mètres. At the rate of one foot in 50,000 years, this would occupy a period of 1,637,000 years, a period of time vastly in excess of that needed for the production of all the phenomena observed at Shea's Creek.

Suess[2] states that a strong argument against "Raised Beaches" being attributable to movements of the solid crust of the earth rather than to changes in sea-level, is that that they appear to be wholly independent of such folding movements as the earth's crust

[1] United States Geological Survey, Sixth Annual Report pp. 291 – 300, and Bulletin No. 48, "On the Form and Position of the Sea-Level."

[2] Das Antlitz der Erde, Suess, Vol. II., p. 509.

can be proved to have undergone in the past, and is probably still undergoing in the present.

Whether the change of level at Shea's Creek be due to the movement of the land or that of the water is uncertain, but there is evidence, at all events, of an alteration in the level of the land and sea in recent geological time to the amount of about fifteen feet, as the trees found *in situ* by us at a depth of fifteen feet below high water all belong to genera which do not flourish below the level of high tide. This is probably one of the most important pieces of evidence yet obtained in any part of Australia to prove submergence in recent geological time.

With regard to the question as to whether the submergence is still in progress, the fact might here be mentioned that Mr. G. H. Knibbs, L.S., and one of the writers, with the view of possibly obtaining some evidence as to whether the coastal strip between the eastern escarpment of the Blue Mountains and Port Jackson is still subsiding, have levelled carefully across the hinge of the fold which forms the inland boundary of the depressed area. Marks have been cut in the rock, and Mr. Knibbs proposes to to relevel between the marks three or four times a year. Possibly some results may be obtained in the course of a few years, and might tend to throw light on the question, as to whether the crust is subsiding or the ocean rising in the neighbourhood of Botany Bay.

(2) *Evidence as to the Geological Antiquity of Man.*—A second deduction, perhaps more interesting than the first, may be drawn from the Shea's Creek section, with reference to the geological history of man in Australia. As already stated, the bones and skull of the Dugong exhibited, show conclusive evidence of having been hacked by human agency, the cuts being exactly of the kind as would be produced by blows from a blunt edged implement such as a stone tomahawk. We may look upon it as an established fact therefore, that this Dugong was cut up and no doubt eaten by the Aborigines. We have been unable to obtain any evidence to show that the Aborigines in the neighbourhood of Sydney ever

fed upon the Dugong, and we should be glad of any information bearing on this subject. The date of this ancient Dugong feast at Shea's Creek cannot be stated in terms of years. As regards the downward limit in time we have the evidence of the shells and of the trees, all of which belong to existing species. The date of the feast cannot therefore be moved back below the limits of Post-Tertiary time. In view of the probable specific identity of the species of the Dugong now discovered with existing species, it is questionable whether it is likely that the date can be carried back into Pleistocene time.

As regards the upward limit, the following considerations suggest themselves :—The uppermost of the bones discovered lie at a level of six inches below low water, and the lowest at three feet six inches below low water. It might be argued from this that the animal was stranded in shallow water at low tide and cut up in the shallow water by the Aborigines at a time when the general level of the ocean was much as it is at the present day. The occurrence, however, of the peaty horizon (*d*) just six inches above where the remains of the Dugong were found seems to preclude this hypothesis, as the evidence shows that after the skeleton had become silted up in the estuarine beds, swamp conditions extended over the spot, as shown by roots of shrubs, found in this peaty horizon. It would obviously have been impossible for such shrubs to grow below sea level, and they would have been at least five feet below mean high tide, unless the level of the ocean has risen since the burial of the Dugong, as must obviously have been the case.

The evidence seems to point rather to the following conclusions:—The Dugong having been captured and killed by the aborigines, its body was towed or dragged in the water during flood tide until the water became too shallow to tow it any further inland. It may then have been taken into water about three feet deep or less, and as the lowest of the bones are a trifle over three feet below present lower water, the level of present low water probably represented the level of high water at that period ; in other words

the general level of the ocean may have risen five feet with regard to the level of the land since the death of the Dugong. The carcase was probably for the most part carried off by the Aborigines piece-meal, and as there would have been enough flesh on the bones to admit of their cutting and coming again, the feasting would probably have been prolonged for more than one day. Hence it is all the more probable that the carcase of the Dugong would have been taken to near high water mark, where it would have been comparatively safe from any but human carnivores, than have been left to the tender mercies and maws of the sharks, as it would have been had it been allowed to remain at low tide level. The skeleton, after being stripped of its flesh, was covered over with mud by the wash of the tide, and sediment brought down by, perhaps, the ancestor of the modern Shea's Creek, and the spot having been temporarily reclaimed by the silting, it was possible for swampy vegetation to overspread the spot, and this actually happened. Then followed a slight subsidence of the land or rise of the ocean during which the mud and shells were brought in which form bed (*c*) above the peaty horizon (*d*). This movement continued until the peaty horizon (*d*) was gradually carried five feet below the level of mean high water. During this time the sand forming bed (*b*) was accumulating, the peaty horizons in it perhaps marking pauses in the relative movement of ocean and land surfaces. If these inferences are correct, we are led to the somewhat startling conclusion that Neolithic man may have inhabited Botany Bay when the ocean level was about five feet lower than at present.

If the four stone tomahawks found at Shea's Creek were *in situ* as there seems every reason to suppose, and if they had not worked down in the silt, (and it is all but impossible that they could have worked down through the peaty layer (*d*) into the position in which they are said to have been found), they would show that man, sufficiently civilised to manufacture such implements, inhabited this region at perhaps even a more remote period, one of the tomahawks having been found close to the horizon of the

third peat bed (*f*) about seven feet below the level of low water. The burnt stump in the submerged forest is possible, though not certain evidence, of the presence of man.

Previous to this discovery evidence as to the geological antiquity of man in eastern Australia was of a very meagre character. It has already been summarised by one of the authors, Mr. R. Etheridge, Junr.[1] Briefly stated the evidence is as follows:—

A. *Direct.*—(1) In New South Wales a human molar tooth, more or less fossilised, was found by Mr. Gerard Krefft, a former Curator of the Australian Museum, at the Wellington Caves in the cave earth, associated with the remains of extinct animals, *Diprotodon* and *Thylacoleo*.[2] There is, however, some doubt as to whether this tooth really occurred *in situ* in the cave breccia containing the bones, or whether it may not have been introduced subsequently through a crack into the breccia. The Scotch verdict of "not proven" is considered to apply to this case.

(2) In the Hunter River district, sandstone beds covered by about thirty feet of alluvial material are said by Bennett to show axe-marks produced by the Aborigines, when grinding their stone tomahawks.[3] These axe-marks, however, need not necessarily have been very old, as the Hunter and Paterson Rivers frequently change their courses rapidly during floods, and so a bed of sandstone, which may, previous to a flood, have been exposed in the bank of the river at the summer level, may become covered with twenty feet or more of alluvium, if during the flood the river should suddenly change its course.

(3) On the Bodalla Estate a stone tomahawk was dug up at a depth of fourteen feet, under alluvial deposits, as referred to by Mr. C. S. Wilkinson.[4]

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[1] Proc. Linn. Soc., N. S. Wales. Vol. v., 1890.—Has man a Geological Antiquity in Australia, pp. 259 – 266.

[2] *Op. cit.*, p. 263, and Geol. Mag. 1874, I., p. 46.

[3] *Op. cit.*, p. 261, and Bennett, History of Australian Discovery and Civilization, p. 263, (8° Sydney, 1867).

[4] Notes on the Geology of New South Wales—Department of Mines, Sydney, 1887, p. 90. (4° Sydney, 1887, By Authority).

(4) At most sheltered spots along the coast of New South Wales where shell life is abundant, as along the shores of coastal lagoons and estuaries, there are to be seen mounds of shells, accumulated by the Aborigines, and consisting of the shells of edible molluscs, fragments of charcoal, bones of fish etc., together with skinning knives made of flakes of hard rocks, bone needles, stones for opening and cracking shells, etc. From the position of some of these shell mounds, on the edges of swampy flats formed of silt brought down by rivers into what were probably open estuaries at the time that the Aborigines gathered shells there, it is evident that the shell mounds must be of somewhat ancient date.

(5) Sand dunes—Remains of some antiquity, of human workmanship, have been discovered in some of the sand dunes of Victoria, as described by the late C. S. Wilkinson,[1] and one of the writers.[2] These remains consist of flint chips, a sharpened stone tomahawk, and several bone spikes or needles. In view, however, of the rapid rate at which dunes form and drift these may not necessarily have had a very high antiquity, though as they were lying beneath sand dunes at least two hundred feet high, they must have been tolerably ancient.

B. *Indirect Evidence.*—This evidence would argue a much greater antiquity for man in Australia than the above quoted direct evidence. It is chiefly twofold. (1) The existence of man in Tasmania argues that he crossed from the Australian continent thither probably either before the formation of Bass Strait, or, at all events, if he crossed in canoes, at a time when Bass Strait was far narrower than at present, as neither the Victorian nor Tasmanian Aborigines had any knowledge of the art of building sea-going canoes, as far as we are aware. If the first arrival of man in Tasmania took place at the most recent time when Tasmania was united to Victoria, it must date back certainly many thousand years. There is, however, good ground for supposing

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1 Report on the Geology of the Cape Otway District, 1865, p. 2.

2 R. Etheridge, Junr., Trans. and Proc. R. Soc. Victoria, 1876, Vol. XII., pp. 3, 4; and Records Geol. Survey N. S. Wales, 1889, I., pt. i., p. 15.

that Tasmania was already disunited from the mainland before the advent of man into that island, because the dingo did not find its way into Tasmania, and the dingo was probably introduced into Australia by man. At the present there are not only no dingoes in Tasmania, but not even the slightest vestige has been found of the remains of fossil dingo in Tasmania. The conclusion therefore, may be provisionally drawn, that Bass Strait was already in existence at the time of the advent of early man and his canine companion, the dingo, in Australia. He perhaps crossed into Tasmania by means of small canoes, but not judging the dingo to be an agreeable cabin companion left him behind.

(2) The Tasmanian Aborigines never advanced beyond a Palæolithic stage in the manufacture of their stone weapons, always producing a cutting edge by rough chipping, never by grinding. By far the larger number of the known stone implements of the Australian Aborigines are on the other hand of a Neolithic type, and mostly very neatly fashioned by grinding. This great difference in the manufacture of their stone implements implies that the Tasmanian Aborigines must have been long isolated from the Australian Aborigines.

(3) The next piece of indirect evidence is based on the assumption, (a very probable one,) that the dingo was introduced into Australia by man. If this be the case, it follows that to whatever period the date of the dingo can be pushed back, the date of man in Australia can be equally extended back into the past. Remains of dingo have been discovered in association with those of various extinct animals in a cave at Gisborne, Mount Macedon, and also from Pliocene deposits near Colac, Victoria, as well as from the Wellington Cave bone breccias with *Diprotodon* in New South Wales. The complete skeleton of a dingo has also been discovered under a depth of sixty-two feet of basalt tuff from an extinct volcano at Tower Hill, near Warnambool in Victoria. There is not even a legend among the Aborigines of man having seen alive any of the extinct animals, such as the *Diprotodon*, with which the remains of the dingo have been found to be associated at the above

mentioned localities. At a time when the dingo was contemporaneous with such huge herbivores as the *Diprotodon* and the *Nototherium*, the climate of Australia must have been far more humid than at present, so that the Central Plains supported a dense growth of vegetation surrounding swamps which are known in the neighbourhood of Lake Eyre to have been infested with crocodiles. A great lapse of time is needed to account for this great change in the physical geography of Australia. We may conclude, therefore, that man, if contemporaneous with the earliest arrived dingoes, has probably a considerable geological antiquity in Australia, that he may have witnessed the volcanic eruptions in Victoria and South Australia, and that he may have crossed Bass Strait in his canoes at a time when that strait, now about one hundred miles wide, was in the condition of one or more narrow channels. It is, however, of course at present by no means certain that the dingo was introduced into Australia by man, and any conclusions based on such an assumption must therefore be looked upon as only provisional and tentative.

That aboriginal man may have witnessed some of the latest volcanic eruptions in Victoria is rendered probable by the remarks of Mr. James Dawson, who makes the following statement[1]:—"An intelligent Aboriginal distinctly remembers his grandfather speaking of fire coming out of Bo'ok"—a hill near the town of Mortlake in Western Victoria—"when he was a young man. When some of the volcanic bombs found among the scoriæ at the foot of Mount Leura were shown to an intelligent Colac native, he said they were like stones which their forefathers told them had been thrown out of the hill by the action of fire."

With the exception of the meagre direct evidence just described, the evidence obtained at Shea's Creek, as far as we are aware, is the best direct evidence hitherto obtained to show that the existence of man in eastern Australia can probably claim something approaching to a geological antiquity, as is implied by the fact

[1] Australian Aborigines, 1881, p. 102.

that the Pacific Ocean and the Australian land have changed their respective levels by as much as fifteen feet, since the existence of Neolithic man at Botany Bay.

We desire to gratefully acknowledge the courtesy of Mr. Cecil W. Darley, M. Inst. C.E., in placing his offices at our disposal and allowing his officers to assist us; and we are also indebted to him and to Mr. McLachlan, Under Secretary for Mines and Agriculture, for the loan of the stone tomahawks dug up at Shea's Creek. We also acknowledge the services rendered us during our exploration of Shea's Creek by Mr. A. S. Patison, the surveyor locally in charge of the work, and by Mr. W. Trickett, the overseer, and for much important information communicated to us by them. We are under a special obligation to Mr. J. Jennings of the Australian Museum for the naming of the shells, and to Mr. R. Baker of the Technical College for determining the various kinds of timber taken from the different stumps of the submerged forest. We also beg to thank Mr. W. F. Smeeth for his preparation of the microscopical sections of the Dugong bones, which has proved no light task, and to Mr. Whitelegge of the Australian Museum for the photographs exhibited showing the excavation at Shea's Creek. We also have to thank Mr. Halligan for kindly supplying sections of the Rickety Street Bridge bores, and Mr. H. E. C. Robinson for preparing the enlarged diagrams to illustrate this paper.

## CORRIGENDA.

Page 159, line 8, delete 'and Commodore Charles Wilkes, U.S.N.'
" line 9, for 'were,' read '*was.*'
" line 10, for 'They state,' read '*He states.*'

David, Tannatt William Edgeworth, Etheridge, Robert, and Grimshaw, J W. 1896. "On the occurrence of a submerged forest, with remains of the dugong, at Shea's Creek near Sydney." *Journal and proceedings of the Royal Society of New South Wales* 30, 158–185. https://doi.org/10.5962/p.359241.

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