EVIDENCE OF RECENT SUBMERGENCE OF COAST AT NARRABEEN.

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[With Plates XXXVIII., XXXIX.]

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I. Introduction.—In view of the general physical features of the coast line of New South Wales for some distance to the north and south of Sydney, as well as of evidence supplied by bores and shafts in the neighbourhood of our coastal areas, it seems clear that one of the most recent movements of the coast line had been a negative one, that is sea level had risen in relation to the land. To state it otherwise, there had been recently a positive movement of the ocean.

In a paper contributed to the Royal Society of New South Wales by Messrs. R. Etheridge, J. W. Grimshaw, and T. W. E. David, a description was given of a submerged forest at Shea’s Creek, near where Cook’s River enters Botany Bay. The trees of this submerged forest grew at a depth of 15 feet below high water, being in position of growth with numerous roots extending out over 12 to 15 feet from the parent stem. The trees all belong to species which are now found in the immediate neighbourhood. In places the old forest was found to pass into a bed of peat. Three aboriginal tomahawks were discovered in association
with these peat beds. The peat beds and trees were covered by estuarine beds containing an abundance of marine shells. Reference was made in the same paper to the discovery of the skeleton of a large Dugong a little above the horizon of the submerged forest, the bones showing evidence of having been hacked by stone tomahawks.

The evidence thus supplied was conclusive as to recent submergence in the neighbourhood of Botany Bay of at least 15 feet. The evidence about to be given shows at Narrabeen a probable recent submergence of over 50 feet.

II. Evidences of recent submergence deduced from general physical features.—It has long ago been pointed out by the late Rev. W. B. Clarke, the late Government Geologist, Mr. C. S. Wilkinson, Mr. E. C. Andrews,¹ and one of the authors,² that the numerous deep inlets along the coast, such as those of Lake Macquarie, Tuggerah Lakes, Broken Bay, Port Jackson, Botany Bay, Port Hacking, etc., were distinct evidence of recent coastal submergence. As the result of the submergence the old land valleys, such as those of Cook's River, Parramatta River, Hawkesbury River, etc., were betrunken through the lower ends of the valleys being drowned, as the consequence of the sea water creeping further and further inland as the subsidences progressed.

The physical features along our coast, particularly those of the Narrabeen Lagoon and its neighbourhood, show that this submergence, though recent from a geological point of view, must date back many hundreds of years, probably many thousands of years into the past. This is obvious from the large amount of reclamation work accomplished

¹ Proc. Linn. Soc. N. S. Wales.
² T. W. E. David, Summary of our present knowledge of the Structure and Origin of the Blue Mountains of New South Wales. This Journal, xxx, 1896, pp. 33-69, pl. i-iv.
by the wind, the waves, and the currents along the coast line near Narrabeen. In places the old estuaries, as at Narrabeen and Dee Why, have been converted into lagoons through the pushing out of sand spits chiefly from their southern ends and directed northwards. In other cases as at the Curl Curl Lagoon, about two miles northerly from Manly, the reclamation is so mature that all the old lagoon is now obliterated through silting, with the exception of the comparatively small area occupied by the modern Curl Curl Lagoon.

A glance at the geological map of Sydney and its neighbourhood, including the County of Cumberland, recently issued by the Geological Survey of New South Wales, shows that the rocky hill of sandstone between the Freshwater and Curl Curl Lagoons, in recent times formed an island previous to the complete silting up of the old estuary which separated it from the main land. The same remark applies to the Quarantine Ground near Manly, as well as to that long strip of sandstone cliff and hill which stretches from South Head to Ben Buckler near Bondi; obviously this area has in recent times been an island before the Strait, now occupied by the silt beds of Rose Bay and the sand hills of Bondi, separated it from the mainland of Bellevue Hill and Bondi. Still further north in the neighbourhood of Lake Macquarie and the delta of the Hunter the general configuration of the country supplies conclusive evidence of recent submergence. Lake Macquarie itself is obviously an old drowned valley, and so is the Hunter estuary between Newcastle and Port Stephens.

III. Evidence supplied by bores, shafts, etc.—In addition to the case of Shea's Creek already quoted, probable evidence of recent submergence of the coast line was afforded by the trial shaft for the North Shore Bridge made between Dawes' Point and MacMahon's Point. At a depth
of about 90 feet below high water mark, in sinking by means of a caisson at this spot, highly carbonaceous clays, with abundant remains of plants, mostly in a fragmental condition, were found to underlie the sandy shell-bearing estuarine beds, of the type commonly met with on the bottom of our harbour. This section was examined at the time by Mr. H. Stanley Jevons and Professor David, and it appeared to them that these loamy muds with plant remains were strong evidence of the harbour at the time of their formation having its water surface much lower than at present. In other words, these loamy beds are evidence of recent submergence of Port Jackson to the amount probably of 90 feet. Then, too, in sinking the cylinder to form a pier of the present Hawkesbury Bridge, on the side nearest to Mullet Creek, the trunk of a large tree was struck by the shoe of the cylinder, and the cylinder in consequence was carried so much out of plumb that it had to be built up anew from below the level of low tide up to the base of the bridge. The horizon, where this timber was struck, is about 109 feet below sea level. Obviously this is not conclusive evidence of submergence, but is very suggestive of the surface of the estuary having been very much lower than it is at present at the time when the Hawkesbury River was able to roll down in flood time and embed in its flood silts these large logs.

In sinking the shaft for the Stockton Colliery numbers of stumps of large trees associated with coarse water-worn river gravel and shingle were struck at a depth of about 160 feet below sea level. Obviously these river gravels could have been laid down only under conditions where the level of the Hunter River approximated to the present level of that gravel; this implies a submergence there of 150 to 160 feet. A continuation of these gravels has been traced to still greater depths at the Anna Bay Bores and at the bore recently put down by the Perpetual Trustee
Company north of the Cemetery, 3 miles beyond Stockton, Newcastle. The last mentioned bore proved the old estuarine beds of the Hunter to lie there at a depth of over 200 feet below sea level. Also it may be mentioned that in the case of the remarkable washaways in the Borehole Seam, which led to some loss of life at the Ferndale Colliery some years ago, we have an example of an old channel of the Hunter River eroded out of the Borehole seam at a spot where that seam is now 100 feet below sea level. The existence of a bed of recent peat with erect stumps of trees in position of growth at Fingal Bay near Port Stephens, the said peat bed being traceable to below the level of low tide, is evidently good evidence that this submergence is probably still in progress.

With a view to seeking further evidence on the subject of this recent coastal submergence, through the kindness of the Under Secretary for Public Works, Mr. J. Davis, M.I.C.E., a small hand-boring plant was placed at the disposal of the authors on 1st August, 1904. With the help of about twenty of the University students, under the superintendence of the authors, an attempt was made to put a bore down close to the bridge at Narrabeen Lagoon, at the spot shown on Plate 38. Considerable difficulty was experienced in forcing the lining pipes, by hand, down through the quick-sand, and the first bore had to be abandoned without any definite evidence being obtained. The second bore proved more successful, for at a depth of 52 feet below the surface, and about 49 feet below the level of high water, clean sea sand with shells, which up to that time had been the dominant material in the bore, suddenly gave place to a dark carbonaceous sandy clay. The general section of the bore is shown on Plate 39. It will be noticed that these dark clays at about 57 feet below the surface contained a number of Gasteropod shells of shallow water habit.
At 62 feet numbers of roots of trees and charcoal were met with embedded in a carbonaceous sandy clay, and at a total of 65 feet a perfect cone of Casuarina was brought up by the sand pump. At 56 feet the formation became a dark peaty sand, probably of terrestrial or lacustrine origin; at 71 feet this gave place to dark peaty sand passing downwards into sharp clean sand, with occasionally white quartz pebbles, one-third to one-quarter inch diameter associated with fragments of plants. The last 4 feet of the boring was in coarse gravelly sand with pebbles of Hawkesbury sandstone up to 1 inch in diameter, with occasional fragments of lignite.

As the bore progressed we were careful from time to time to test the water which came up in the bore for saltiness with a view of deciding to what depth the layer of freshwater bearing sand extended. We were somewhat surprised to find that the water in the sands was fresh to a depth of about 14 feet below high water. This is obviously due to the fact that there is a considerable mass of water bearing sand forming a broad and high bank on the seaward side of the bore; this bank rises to a height of about 35 feet above sea level, and it is no doubt the slow movement under hydraulic pressure of the water from this sand bank seawards that forces back the salt water. We were informed by residents in the neighbourhood that after a prolonged drought the top of the salt water zone comes within about 4 feet of the level of high water.

With reference to the various organisms obtained from this bore, Mr. C. Hedley, F.L.S., has examined the Mollusca and other Invertebrates, and reports:—

(1) The species are all recent.
(2) And are all components of the mud fauna.
(3) They belong to between tide marks and to the zone immediately below low water.
"Such forms as Balanus and Ostrea indicate rocky ground within a short distance. Nassa, Pyrazus and Cantharidus are suggestive of a mangrove swamp dry at low tide. These might, however, be washed thence down to the bed of the stream. So I would prefer to dwell on the evidence of Spisula and Chocloodesma, and consider that at the period of deposition the horizon of these shells was the bed of a muddy estuary about 15 to 20 feet deep. Nothing of the ocean beach fauna appears. The fossils point decisively to the fact that the sea had not free access to the spot. If, when the 50 feet horizon was deposited, the land had stood higher than the sea, obviously the shells would have been fluviatile or terrestrial, not the mangrove fauna produced. On the contrary, if then the land stood as low or lower than it does now, and if the sea had free access to the spot, another fauna would have prevailed there. Conclusion, the environment of these specimens was exactly the condition of the present Narrabeen Creek. An hypothesis, that the creek maintained its level relative to the sea, by raising its bed with sediment and so balancing subsidence against accumulation, would agree with the condition and position of these shells."

In regard to the roots of trees and other fragments of fossil wood, many of these were found to be distinctly charred, probably as the result of a bush fire. Certainly the conversion into charcoal is not due to ordinary decomposition, such as brings about the conversion of wood into lignite. Some of the fragments recovered by us from the bore were a couple of inches in thickness, and 4 to 5 inches long. This wood having been sectioned for microscopic examination, Mr. J. H. Maiden, Director of the Botanic Gardens, was good enough to examine the sections, and he reported that on examination he could not detect the medullary rays characteristic of the Proteaceae or Casuarina
and considers that "it is probably Myrtaceous or Leguminous, probably Eucalyptus."

From this report it is clear that the species of wood all belong to recent types. The evidence of the roots and other remains of plants, taken in conjunction with that of the estuarine shells, is in the opinion of the authors conclusive proof that we have here a very definite piece of evidence of a recent subsidence of the coast line to the amount of about 50 feet. This subsidence, from the evidence quoted earlier in the paper, appears to have been somewhat widely extended, inasmuch as the area from Port Hacking to Port Stephens can certainly be included in the submerged area, that is a belt of coast about 90 miles in length.

Tide gauge observations at Fort Denison are unfortunately, up to the present, not very reliable, but as far as the evidence goes it is insufficient to justify the statement that our coastline at the present moment is undergoing an appreciable depression or elevation. The evidence collected by Mr. H. S. W. Crummer, shows that at Vaucluse and parts of Middle Harbour crusts of Cirripedia and Balanidæ are found there a few feet above the level of high water. It is possible that these indicate a slight upward joggle of the coastal plain. The evidence, however, cannot be implicitly relied upon in view of the fact that older conditions along the coast line, and the shape of the shore line, lead to the waves at times splashing up higher than at others. It is quite sufficient for the growth of Cirripedia and Balanidæ that they shall be bathed by the waves at least every high tide.

It is to be regretted that with the appliances available we were unable to carry the bore below the 70 feet level. It is highly probable that further traces of submerged land or swamp surfaces would have been met with at these
deeper levels, surfaces corresponding with the old level of the Hunter River channel near Newcastle. If the subsidence is still in progress it must be exceedingly slow, at all events if it extends as far inland as the great earth fold at Glenbrook to the west of Penrith. Accurate measurements taken by Mr. G. H. Knibbs, with a dumpy level, show that if movement at all is taking place in the way of the hinging down of the coastal strip between Penrith and the sea it must be something of the order of $\frac{1}{10}$th to $\frac{1}{50}$ths of an inch in the year.

We would venture to suggest, with a view to the further elucidation of the question whether our coast at present is rising or falling, that a number of bench marks might be made along the coast, carefully levelled to, as was suggested at the Meeting of the Australasian Association for the Advancement of Science at Dunedin in 1904.

Our thanks are specially due to the Under Secretary for Works, Mr. Davis, M. Inst. C.E., for having so kindly placed the boring plant at our disposal, and also to the students of the University who rendered splendid service in the practical work of boring.

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