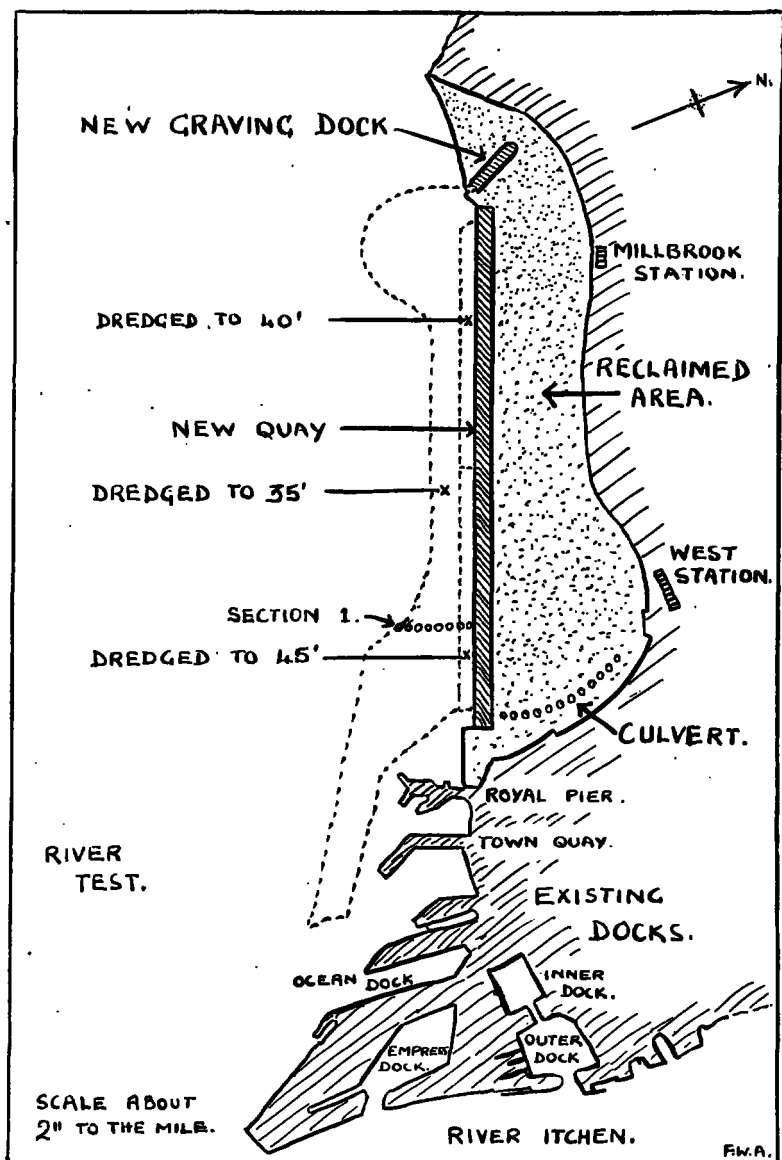




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THE NEW DOCKS EXCAVATIONS, SOUTHAMPTON

By F. W. ANDERSON, M.Sc.

DURING the earlier stages of the construction of New Docks at Southampton a large number of excavations and borings were made into the Bracklesham Beds underlying the peat, gravel and river mud of the River Test. These new docks, which are being built by the Southern Railway Company, are situated on the east bank of the Test and lie north of the existing docks. There is to be a large quay, 7,000ft. long, which will cut across a bay of the river which stretches from the Royal Pier to Millbrook Point. This will mean the draining of some 400 acres of mud-banks lying within the bay, and filling in the drained area with tipped material, thus making a large area of reclaimed land stretching from the new quay wall to the West Station.

Also, an approach channel is to be dredged from the existing deep channel near the Ocean Dock to and alongside the new quays. At the western end, near Millbrook Station, two new graving docks are proposed, one of which is now in the course of construction.

The first important dock construction in Southampton was that of the Outer Dock opened in 1842. This was followed by the Inner Dock, the Empress Dock and four graving docks. The Empress Dock, which was opened in 1890, was the first of the large excavations which have yielded so much valuable information to the Geologist. Until the new quays were constructed the deepest dock was the great Ocean Dock opened in 1912 to accommodate the enormous Atlantic liners: it has a depth of 40ft. at low tide.

Fortunately the excavation of the Empress Dock, from 1887 to 1889, was carefully watched by that indefatigable observer T. W. Shore, the originator, and for many years the secretary of the Hampshire Field Club. Mr. Shore published a detailed account of the excavations in the *Proceedings* of the Hampshire Field Club in 1889. (*The New Dock Excavation at Southampton*, by T. W. Shore, F.G.S., F.C.S., and J. W. Elwes, *Proceedings Hampshire Field Club*, 1889, pp. 43-56.)

The present workings have been closely watched by Professor W. Rae Sherriffs and myself since the beginning of the excavations and we are grateful for this opportunity to place on record the valuable information thus acquired.

My best thanks are also due to the Southern Railway Engineers, Mr. Wentworth-Shields and his staff, who have offered every

facility to observe the construction of these docks and collect data and specimens. The greater part of the sections accompanying this paper was constructed from information supplied by him.

The Bracklesham Beds at Southampton.

The Bracklesham Beds form part of the Eocene deposits of Hampshire ; they rest on the Bagshot Sands and are capped by the Barton Clay.

Eocene	{	Barton Sands.
		Barton Clay.
		Bracklesham Series.
		Bagshot Sands.
		London Clay.
		Reading Beds.

Upper Cretaceous—Upper Chalk.

It is, however, a difficult matter to separate the Bracklesham Beds from the Bagshot Sands, and even more difficult to separate them from the Barton Clay into which they pass gradually and imperceptibly. Even in the Isle of Wight, where excellent coast sections are available, the exact boundary is uncertain and difficult to trace. In general the Bracklesham Series differ from the Bagshot Sands in that they commonly contain a large amount of glauconitic material, giving usually green sands. There are also laminated clays or loams, with a high proportion of carbonaceous material, and white and grey sands. These beds, the green sands in particular, yield a large number of marine fossils. They increase in thickness from west to east, having a thickness at Bramble Hill of about 200ft., increasing to 320ft. at Netley, and in Southampton Water are probably about 400ft. thick. Southampton is built chiefly on the Bracklesham Beds, the Lower Bagshot Sands and London Clay appearing from underneath them at Lord's Wood, Bassett (just north of Red Lodge), and in the Itchen Valley at St. Denys. They are, however, generally obscured by the Pleistocene and more recent deposits and exposures are rare, hence the great value of such extensive sections as the new dock workings afford.

The docks excavations have been made entirely within the Bracklesham Series and the superficial deposits. The earliest excavations yielded many fossils, and according to the Rev. Osmund Fisher ("On the Bracklesham Beds of the Isle of Wight Basin," *Quart. Journ. Geol. Soc.*, vol. xviii, pp. 65-94, 1862) the beds then disclosed are equivalent to the beds containing *Nummulites laevigatus* seen at Selsey and at Bracklesham Bay. That is to say only the lower part of the Bracklesham Series is present, and the

beds are below the fossiliferous strata of Brook and Bramshaw. The deposits are mainly greenish-grey loamy sands or clay with much glauconite, and a seam of flint pebbles.

T. W. Shore reported on the Empress Dock Excavations, which exposed extensive sections of Bracklesham Beds lying underneath ancient river and estuarine deposits and well below sea level, as follows :—

(a) Dark clay, generally green-tinted, and more or less sandy, extending over the northern half of the excavations, apparently unfossiliferous.

(b) Similar green sandy clay, containing abundance of fossils, especially *Sanguinolaria*, occupying most of the remainder of the dock area. This bed and the successive ones were well exposed in the deepest drainage trenches. A rather bright green sandy clay with a small proportion of black grains (glauconitic), small nodules of ironstone, thin patches of lignite, and occasional pebbles ; fossils abounding in a high state of preservation, many of them having a reddish tinge. *Sanguinolaria hollowaysii* occurs in pairs in the position in which it lived, with *Voluta spinosa*, *Pseudoliva ovalis*, *Cardita planicosta*, *Crassatella sowerbyii*, *Solen obliquus*, *Natica mutabilis*, *Voluta selseiensis*, *Mesalia multisulcata*, a small *Pectunculus*, and many of the small species which occur in the sand above. The fossils are scattered rather thinly throughout, not forming beds.

Towards the south side and highest part of the green sand appears *Cytherea striatula*, and the matrix presently loses its sandy character.

(c) A bed of clay in which this species appears in myriads with *Bifrontia landunensis* (?) and a small *Pisania*. A few small shelly concretions occurred in this bed, some of which showed the shells on the surface finely preserved.

(d) Above this clay lies a bed of small oysters (*O. tenera*) in a more sandy matrix, and on this a local patch of slightly clayey sand, of light puce grey tint, weathering a yellowish brown, with a considerable proportion of fine black grains, and abundance of small shells, *Cytherea striatula*, *Mesalia fasciata*, *Crassatella sowerbyii* (immature), *Corbula cuspidata*, *C. longirostris*, *Cardita elegans*, *Tellina* (?), *Pisania*, *Arca modioliformis*, *Arca laevigata*, *Lutetia parisiensis*, *Bifrontia landunensis*, *Tellina plagia*, *Pectunculus pulvinatus*, *Turbinolia*.

The present excavations have yielded information from four sources :—

1. A deep culvert intended to take the drainage water which previously flowed into the bay, through the reclaimed area within

pipes and so to the sea at the eastern end of the new dock wall.

2. A series of borings along the site of the dock wall. A source of accurate information from which the section accompanying this paper was largely constructed. (Section 2.)

3. Excavations for the pylons which constitute the new dock wall, the material being removed by grabbing.

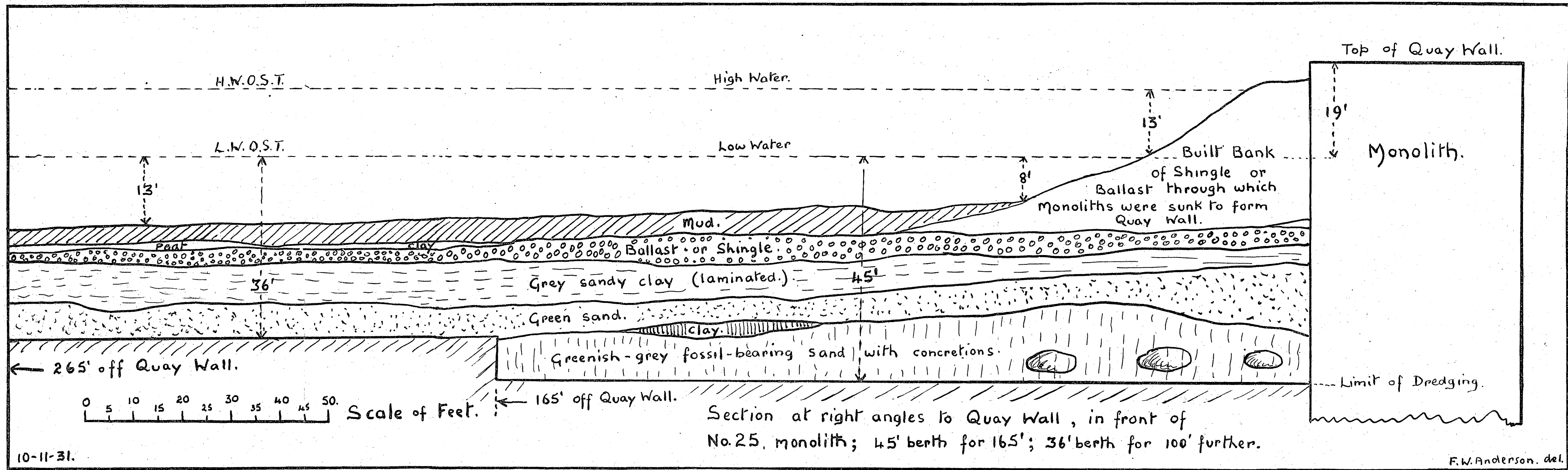
4. The enormous excavation for the new graving dock at Millbrook.

5. An examination of the material brought up by the dredger used for deepening the approach channel has made it possible to construct a section at right-angles to the line of the dock wall. (Section 1.)

The lowest bed exposed is a stiff brown laminated clay with its upper limit approximating to Dock Datum (*i.e.*, 87.75ft. below O.D.). This bed was reached in all the borings along the Quay Wall and the pylons have been sunk until they rest on this very solid clay; this again forms the base on which the graving dock is being built. The bed is composed of thin layers of clay divided by very thin layers of an extremely fine clean sand containing mica. The clay is usually a deep chocolate brown in colour, but in places, with the admixture of more sand, it becomes almost grey. The sand is generally white or grey in colour but is occasionally distinctly green. Organic material is present as small lumps of lignite, with which nodules of pyrites are commonly associated. Tufa and peat are also present in lenticular beds of soft sand within the clay.

This bed would appear to approximate to the base of the Bracklesham Series. It was not actually seen in the excavations of 1889 *in situ* but was reached by a boring under the north wall of the dock, here described as being a "dark green clay, burning red, and a very stiff brownish grey clay, burning white, variegated with green and blue streaks, with lignitic material." A boring between High Street and French Street of which details are given in the Geological Survey Memoir for Southampton (*Mem. Geol. Survey*, No. 315, by Clement Reid, 1902, p. 64) showed brown clay 79ft. thick at a depth of 173ft., overlain by green sands; and a brown clay very similar in character, with peat, pyrites and lignite was seen in a pit near Chandler's Ford Railway Station, in 1895 (*Mem. Geol. Survey*, No. 315, p. 23).

One would suggest that this brown clay represents the basement clay overlying a thin pebble bed at the base of the Bracklesham series as exposed in Bracklesham Bay, and the laminated sand clay at the base of the section in Whitecliff Bay, *i.e.*, Fisher's bed "1," and bed "6" of Prestwich's section. (Rev. O. Fisher, "On



the Bracklesham Beds of the Isle of Wight Basin," *Quart. Journ. Geol. Soc.*, 1862, p. 73.) On the other hand the graving dock borings show that this clay is underlain by further green and grey sands which cannot easily be distinguished from those above. The clay is followed by 16-20ft. of grey laminated sandy clay, containing in places lenticles of clay, from which no complete fossils have been obtained but which in places contains masses of broken shell fragments. This apparently represents bed "2" (Fisher) of the Whitecliff section, though there it is only 10ft. thick. This bed is exposed in the graving dock excavation and in all the borings along the Quay wall. Above come bright green sands, with, in places, a considerable amount of clay. They are apparently unfossiliferous, and very variable in thickness, but averaging about 30ft. They contain small streaks of white and brown marl in places, and nodules of pyrites disseminated throughout. The characteristic colour is due to a green colouring matter which may be washed out by shaking the sand with water, leaving a light grey sand as residue. This bed was the lowest reached in the excavations of 1889 (Shore's bed "a") and corresponds to bed "3" (Fisher) of the Whitecliff section where it is described as "Alternating beds of green sand and finely laminated clay, weathering grey and brown; with thin seams of lignite . . . 18ft." This bed was met with in all the borings along the quay wall and in the graving dock section.

Above the greensands are about 10ft. of grey and green sandy clays, extremely fossiliferous; *Sanguinolaria hollowaysii* being the most abundant fossil in the lower part of the bed, and *Cardita planicosta* and *Nummulites laevigatus* being found in great abundance in the upper part, particularly in the extensive excavations of the graving dock where these fossils could be collected by the hundred. *Turritella imbricata* is also to be found at this horizon but is much less common. *Sanguinolaria* is most abundant in the spheroidal calcareous concretions which occur at this level and are usually much better preserved than when found in the surrounding sand. The concretions are very numerous and of large size, averaging 3 to 4ft. in diameter, and caused a considerable amount of trouble to the engineers when the pylons were being sunk on account of their extreme hardness. They are generally to be found at the base of the grey sandy clay but some have been found at higher and slightly lower levels. A large heap of these "boulders" have been placed on the Royal Pier with a label describing their locality and mode of formation, and two specimens from one of the earlier excavations are to be found in the entrance to the Castle, Winchester, though I have been unable to trace any published record of them being found prior to the present extensions.

This bed is apparently bed "b" (Shore) of the 1889 section and compares very closely with bed "4" (Fisher) of the White-cliff Bracklesham where it is described as "Calcareous, clayey, green, and iron sand, with numerous shells in seams. The base seems washed into the next bed . . . 52 feet." Here are also recorded *Nummulites laevigata*, *Turritella imbricata*, and *Cardita planicosta*, although, apparently, *Sanguinolaria hollowaysii* is absent.

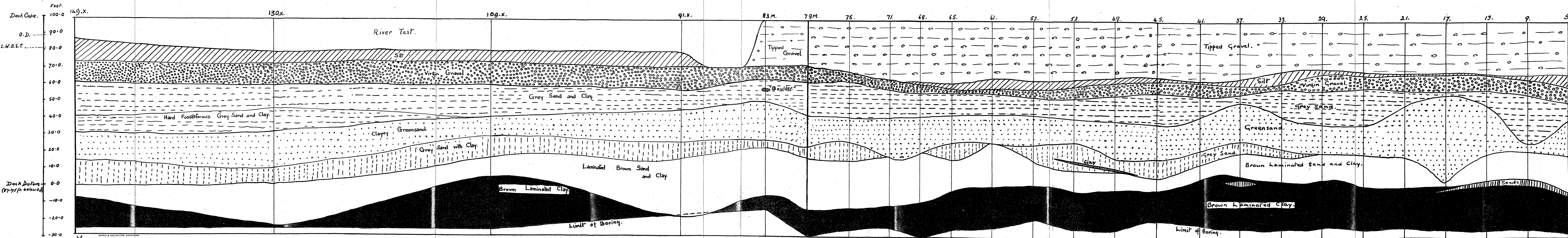
The fact that the fossils are more numerous and better preserved in the concretions than in the surrounding sands, though belonging to the same species, suggests that these concretions are simply masses of the sand which have been cemented *in situ* by the deposition of Calcium carbonate from circulating water, and that the Calcium carbonate was most probably derived from the solution of fossil shells at higher or lower levels in the bed. This bed, which is the highest of the Bracklesham series exposed in the present workings, is found underlying gravel all along the quay wall and at the graving dock where an enormous area of this bed has been removed.

It seems most likely that only about a third of the whole Bracklesham Series has been encountered during the progress of this work on the New Docks, about a hundred feet of strata.

Alluvial Deposits.

Above the Bracklesham Series lie alluvial deposits filling up the valley of the Test and Southampton Water. They consist of gravels, marl and peat overlain by the muds of the present-day river, and were laid down at a level very much below that of the existing Test. Indeed, at the beginning of the period when these deposits were laid down the land must have been at least forty feet above its present level, and Southampton water could have been nothing more than a narrow river, unaffected by the tides, running between lowlands and marshes. These marshes are now represented by the deposits of peat and tufaceous marl, the so-called "malm," which in so many places overlies the basement gravel.

The gravel, as may be seen from the accompanying sections, is of a fairly uniform thickness of about 10 feet, and has been proved in all the sections, *i.e.* in the borings, culvert, berth dredgings and in the graving dock. Two animals at least are known to have existed at this period, for an antler of the Reindeer was recovered from the Empress Dock excavation, and a tooth of the mammoth has been dredged from a ballast hole at Weston, 12 feet below the surface of the gravel. This gravel, which is often called "ballast" or "shingle," consists chiefly of subangular



flint in a coarse sandy matrix, and in the greater part of the river bed is overlain directly by river mud, though near the shore, in the culvert, there were extensive deposits of peat and clay.

The culvert excavation showed irregular masses of peat interbedded with and, in places, underlain by a calcareous clay or marl. The clay contains a large amount of vegetable matter and numbers of shells, with occasional pockets of the bright blue mineral Vivianite ($\text{Fe}_3 \text{P}_2 \text{O}_8$). A long list of the fresh-water mollusca found in the marl in 1889 will be found in a paper by J. T. Kemp, M.A., in the *Proceedings* of the Hampshire Field Club for that year.

Specimens of the peat were sent to Dr. T. W. Woodhead, M.Sc., F.L.S., of the Tolson Memorial Museum, Huddersfield, who, with the assistance of Mr. B. J. Rendle, of the Forest Products Research Laboratory, was able to identify the following plants :—

1. Oak ; wood, twigs, bark and leaves.
2. Hazel ; wood, bark, leaves and a very large number of nuts.
3. Birch.

In addition Mr. Shore found remains of the bulrush (*Scirpus lacustris*), the bog myrtle (*Myrica*), and the bracken fern (*Pteris aquilina*), with sedges and heaths. Clement Reid, in material sent him by Mr. Whitaker, found also the buttercup (*Ranunculus* ?), the blackberry or raspberry (*Rubus*) and the elder (*Sambucus nigra*).

Bones of several animals have been found from time to time in the peat and associated marl. *Bos primigenius* and *Cervus elaphus* (Red Deer) have been found in the present excavations, and in addition, from the 1889 excavations, Mr. Shore records bones of the horse, boar and hare. The marl also contains a large number of small rounded tufaceous concretions, such as are to be found in the marl of the Itchen alluvium.

In the opinion of Mr. Clement Reid, the peat and marl are of Neolithic Age, and Neolithic flint implements have certainly been found in the peat. Dr. Woodhead says that the remains he has examined from the peat are very similar to what are found in deposits of Atlantic Time.

Overlying the peat, marl and gravel is about 6 feet of modern river mud, dark blue in colour and containing the remains of such animals as are at present living in Southampton Water. In places, as is shown in the quay wall borings, the normal sequence has been disturbed by a large stretch of tipped gravel which overlies the mud, most of it being, I believe, material derived from the earlier docks excavations.

The work is still going on, and this account therefore must be regarded as only preliminary. The graving dock excavation

and the large number of borings still being made in connection with it will provide further information which is not to hand at the time of writing, and which must remain over to be embodied in a further account at some future date.

PLATE.

- Fig. 1. *Cardita planicosta*, from the fossiliferous grey sand, Graving Dock, Millbrook.
- Fig. 2. Cervical vertebra of *Bos primigenius*, Peat, from the Culvert.
- Fig. 3. *Sanguinolaria hollowaysii*, from a concretion, fossiliferous grey sand, Quay Wall.



FIG. 1.

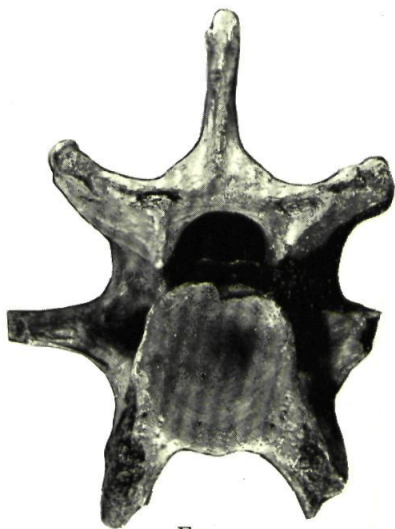


FIG. 2.



FIG. 3.

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