ON THE SUBMERGED FOREST AT WESTWARD HO! BIDEFORD BAY.

BY INKERMANN ROGERS.

(Read at Newton Abbot, 28th July, 1908.)

To the south of the estuary of the Taw and Torridge lies a tract of land differing somewhat from that to the north. In place of shifting sandhills an extensive grassy plain, known as Northam Burrows, about six hundred acres in extent, runs up to the low range of hills formed of Upper Carboniferous (Upper Culm Measure) sandstones and shales. This level tract of grass-land is protected from the inroads of the sea by a natural breakwater, known as the Pebble Ridge. The pebbles of which the ridge is formed vary much in size, and are composed of the hard bluish grey, and greenish grey, carboniferous sandstones derived from the waste of the cliffs.

Having had many opportunities of examining the rocks on the shore of Bideford Bay, whilst searching for fossil plant remains, I have frequently met with beds of sandstone of precisely the same texture and colour. There cannot, therefore, be any doubt that the pebbles, which may be seen in every stage of manufacture, are derived from these beds, which extend westward to Hartland Point.

Seaward of this ridge there is a fine expanse of firm sand, broken only at its southern end by the outcrop of large beds of blue clay and peat, containing roots, trunks, and branches of trees. These peat beds are known as the Submerged Forest of Westward Ho!

Some interesting observations have been made recently by Mr. Clement Reid, F.R.S., F.G.S.,[1] regarding the forma-

[1] *First Report of the Royal Commission on Coast Erosion*, Vol. I, Part I, Appendix No. XII (B), 1908.

tion of Bideford Bay. He gives a clear idea of the condition of things when the land extended many miles further westward than it does at the present day. Mr. Reid says that

"the great prominence of Hartland Point does not appear to be sufficiently accounted for by any exceptional hardness of the rocks. A study of the orographical features suggests that the Point may be merely a relic of the high watershed which stretches north-westward across Devon from Dartmoor to Hartland, and at one time was probably continued across to Lundy Island. The rivers Taw and Torridge run parallel to this ridge, so that Bideford Bay probably represents the low ground of their combined valleys which once continued much further westward. The great depth and width of Bideford Bay seem to be due to the occurrence of soft secondary strata over its floor. Bideford Bay is also margined in places by other loose and easily destroyed deposits, such as raised beaches and submerged forests, and where these occur the coast is wasting somewhat. Masses of peat from below the sea-level are torn up and thrown upon the beach at Westward Ho!"

The first recorded exposure of the forest bed was in the winter of 1863–4, as mentioned by Townshend Hall.[1] He states that there were no less than

"seventy to eighty stems of large trees, all standing upright in the position in which they grew, though broken off at a height of two or three feet from the roots."

One stem which he selected for examination was six feet in circumference.[2] The amount of material removed by the sea at that time seems to have been enormous. Mr. Hall remarks that

"although the pebble ridge is described by Risdon and Westcote previous to 1630, no reference is made to the occurrence of the Submerged Forest on the Northam side of the estuary, nor does there appear to be any local tradition relating to it. The denudation in the winter of 1863–4 may, therefore, be regarded as a starting-point for the literature on the subject."

From this time onward the peat has undergone a steady process of denudation by the wave action, for whereas in

[1] *Quart. Jour. Geol. Soc.*, Vol. XXXV, Proc., p. 106, "The Submerged Forest of Barnstaple Bay," 1879.

[2] T. M. Hall, *Note on the Discovery of Flint Implements at Croyde and Northam, North Devon*, February, 1865. Privately printed. See also T. M. Hall, *The Geology of North Devon*, 1865.

1879 it was four feet thick, there is now only about one foot of the bed remaining. There is, however, some evidence still of the forest growth, for a number of prostrate stems and branches of trees can be seen embedded in the remains of moss, leaves of Iris, masses of twigs and leaves, consisting chiefly of the oak and hazel (the nuts of which, as well as acorns, are most abundant), rootlets, and decayed vegetable matter. During the spring of 1904, I unearthed the trunk of an oak, eighteen inches in diameter and twenty-two feet in length, which, including the branches, must have once measured thirty or forty feet. Its top lay towards the land as if it had been blown down in that direction. Two large roots of trees were then still *in situ*, at the extreme western end of the bed, but they have since disappeared. All the rootlets of the stumps were present and still covered with bark, and thus the evidence is perfectly conclusive that they originally grew on the spot in which they are found. The stumps, though retaining internally the appearance of sound wood, were quite charred at their surface, and were throughout so soft and brittle that they could be cut through with a spade or broken by a slight blow. Owing to their softness, they had been worn down almost to the level of the peat.

It is evident from the large size of the trunks of the trees that the oaks, of which the forest was mainly composed, must have grown some distance from the ancient coastline, since the westerly winds from the Atlantic at the present time prevent the free growth of vegetation in all unprotected positions on the coast. The direction of the prevalent gales, however, is proved to have been very much the same as now, for most of the trees lie prostrate with their heads pointing towards the east. The ten-fathom line, considered by Sir Henry de la Beche [1] to be roughly the boundary of the land at that time, may be taken to represent the sea margin with tolerable accuracy.

The lower part of the blue clay is full of small pebbles and angular fragments of Culm Measure rocks. At a point between tide limits, where these fragments appear, flint flakes have been found, struck off by the hand of man in the manufacture of flint implements. In this

[1] *Report on the Geology of Cornwall, Devon, and West Somerset*, p. 420, 1839.

locality it is clear that man had once lived on the old land-surface before it was submerged, and that the remains of his handiwork had dropped in the angular detritus which may be of sub-aerial and glacial origin. This view has been borne out recently by the researches of Mr. Thomas Young, M.R.C.S.[1] The numerous instances of forest ground, at or below the present sea-level, afford ample proof that the land once stood relatively higher than it does at the present time. At present there are not along our whole southern coast any woodlands immediately adjoining the sea nor even many single trees of any magnitude. Moreover, many kinds of trees do not well support the sea air.[2] Conclusive proof of submergence, within comparatively modern times, has been brought forward by Mr. Pengelly in his paper "On the Submerged Forest of Torbay."[3]

From time to time I have obtained portions of the peat, which I have searched carefully for the seeds of plants that grew there during the forest era. I found a number which I submitted to Mr. Clement Reid, F.R.S., F.G.S., and he kindly identified the following species :—

Cornus sanguinea. Linn. (Dogwood).
Ranunculus flammula. Linn. (Lesser Spearwort).
Rubus fruticosus. Linn. (Blackberry).
Aster tripolium. Linn. (Sea aster).
Atriplex patula. Linn. (Common Orache).
Sueda maritima. Dum.
Scirpus Tabernæmontani. Gmel.
Sambucus nigra. L. (Elder).
Ruppia maritima. L.
Eleocharis palustris. ? Br.
Carex, sp.
Viola (Violet).
Alnus glutinosa (Alder).

Mr. Reid remarks that *Ruppia* is a characteristic salt-marsh plant, always growing entirely submerged in brackish water, and that the whole assemblage of plants suggest a brackish-water marsh, such as may occur behind a shingle beach. The flint implements, which were also

[1] *Trans. Devon. Assoc.*, Vol. XXXVIII, p. 261, 1906.
[2] Lord Avebury, *The Scenery of England*, 1904.
[3] *Trans. Devon. Assoc.*, Vol. I, p. 30, 1865.

submitted to Mr. Reid, he regarded as being distinctly Neolithic.

On closely examining the blue clay it was found to contain enormous quantities of the shell *Hydrobia ulvæ*. Estuary shells and flint flakes are sometimes met with in the "head," which bars the progress of the sea further inland.

In addition to the vegetable remains and flint flakes, the contents of the peat and the surrounding clay prove that the forest was over-run by wild animals. Mammalian remains, besides those occurring in the "kitchen-midden" deposits, are also dispersed over the whole area of clay for a distance of 1400 yards northward outside the Pebble Ridge. The forest growth appears to belong to the Neolithic division of the prehistoric period, a conclusion supported by the presence of animals, originally domestic, which were introduced by the Neolithic tribes, such as the Celtic shorthorn and the sheep and goat, as well as by the absence of the Pleistocene mammals.[1]

During the winters of the past five years I have collected a quantity of mammalian remains, which were submitted to Dr. Chas. Andrews, F.R.S., and he has kindly determined for me the following :—

MAMMALIAN BONES FROM THE SUBMERGED FOREST, WESTWARD HO!

Cervus elaphus (stag). Antler, teeth, fragment of jaw with teeth, anterior end of mandible, scapula, metapodial (cannon bone), end of humerus, cervical vertebræ, astragalus (ankle bone).

Bos longifrons (Celtic shorthorn). Horn core, mandibular rami, maxilla with teeth, eight odd teeth, ulna, femora, vertebræ, auditory region of skull.

Equus (horse). Upper molar, tibia of small horse.

Canis (dog). Fragment of upper jaw, mandible, ossa innominata, fibula, humerus, ulna, rib.

Ovis (sheep). Cranial portion of skull, tibia wanting epiphysis, metatarsal, os innominatum (young), dorsal vertebræ (?).

Capra (goat). Upper molar.

Sus (pig). Anterior portion of maxilla with canine and premolars, distal end of tibia, young ulna, teeth.

Homo (man). Young clavicle (collar bone).

[1] W. Boyd Dawkins, *Early Man in Britain*, 1880.

Dr. Andrews remarks that

"all seem to have belonged to domestic animals. The ox seems to be certainly the Celtic shorthorn (*Bos longifrons*), while the small sheep is a characteristic Romano-British, which has been described from many places where it has been found with Roman and earlier remains."

I may state that in regard to these remains, only those which were actually *in situ* in the tenacious blue clay, and which required to be excavated, were collected. In my experience no mammalian or other remains are ever seen on the shore free from the clay.

Without doubt the most notable feature in connection with these fossils is the discovery of definite human remains. This is the first record of the kind from this locality.

The origin of the submerged forests, which occur at intervals all along the coast and at the mouths of many of the larger rivers, is a matter of much interest. By some change of level these ancient forests have been submerged and buried under tidal deposits. How did this change of level come about? Only two causes can be assigned. It must have been due either to the rupture of a barrier, previously excluding the sea-water, or to actual sinking or subsidence of the whole of the estuary. The first of these suppositions is that which most readily appeals to the popular mind, but when we consider the great extent of the barrier required, the absence of any traces of it, and the great depth below high water at which the forest remains occur, it is difficult to suppose that such a barrier, even if it existed and wholly excluded the tide, could have produced dry land at such a low level. The effect would be the production of a lake, or, at the most, a morass. On the other hand, a more simple explanation is that a subsidence has taken place over a considerable area, and to the depth of about forty feet. That strong reasons exist supporting this view has been made quite clear by Mr. Pengelly.[1] We have no distinct evidence to show whether the subsidence was sudden or gradual, but analogy would lead us to suppose that the latter was true. If a gradual subsidence of this kind has occurred in comparatively modern times, geologically, the question

[1] *Trans. Devon. Assoc.*, Vol. II, 1868.

remains, Has it ceased, or is the land in places still subsiding? Dr. Andrew Wilson, F.R.S.E., declares that

"the southern coasts of England, as well as that of Ireland and the north coast of France, are in a state of depression. While the western coast of Norway and also the Swedish coast in the Gulf of Bothnia may be said to exhibit evidences of rising, the most southernly part of Sweden is actually proved to be at the present time subsiding. The south coast of Greenland is also an area which is marked by depression. The evidence indeed points to the fact that for four hundred years, at least, the coast of Greenland has been sinking. Tracing the north African coast we find evidence of rising extending from Gibraltar to Tripoli, but from the latter point onward to the Red Sea we have evidence of sinking."

It would appear, therefore, that change of level is still going on at the present day.

I do not propose to describe the raised beach which extends a mile westward along the cliffs, except to remark that investigation has shown that it appears to contain nothing more than a few flint nodules and pebbles of Culm Measure sandstone precisely similar to those lying on the modern beach. The effects of long-continued marine denudation (forming a reef-like ledge of rock along the shore, extending seaward for some distance at low water) cannot be better studied on any other part of the coast.

The submarine forest is not the only locality in the neighbourhood in which flint flakes occur. In the neighbourhood of Fremington I have found a deposit of them on the left bank of the river Taw, near Yelland Farm, about four hundred and forty yards north of the L. and S.W. Railway. The flakes were scattered over a shingle beach bordering on the mud, and were associated with large quantities of cockle and other shells. Several hundred flakes have been collected from this spot, and among them were a large number of rudely shaped implements, showing secondary work, besides a barbed arrow-head and many well-made scrapers.

Animal remains have also been found in the raised beach situated in the left bank of the Taw, at a spot about eight hundred yards west of Fremington Pill. Dr. Chas. Andrews has identified the *radius* of *Bos longifrons* from this place.

APPENDIX ON THE HISTORY OF NORTHAM BURROWS.

THE earliest known reference to Northam Burrows is found in Risdon's *Survey of Devon* (1630). He states that a "goodly plain presents itself to your view, called the Burroughs, lying full upon the sea, defended from the rage thereof by a ridge of chesell." Early writers have made various statements regarding the area of Northam Burrows. Vancouver (*General View of the Agriculture of the County of Devon*, 1808) estimates it at "1800 acres, two hundred acres of which are subject to be covered by spring tides." Lysons (*Magna Britannia*, 1822) states that "on the coast adjoining Northam burough a large sandy tract of about 800 acres, is a remarkable bank of pebbles, of great height, about a mile in length." There are, however, good grounds for belief that in the early part of last century the area was considerably more than 1000 acres. Watkins (*History of Bideford*, 1792) remarks that "on Northam Burrows there is a beach of pebbles about three miles, of very considerable breadth and depth, so that although they have been used as ballast, and for paving, the number is not perceptibly diminished. Within these few years the sea has lost considerably on the north side and gained on the opposite shore. Many acres on Northam Burrows have thus yielded to its encroachments." Since that time the sea has made steady inroads. From a survey and map made for Northam Parish by Mr. Cuming, 1855, it appeared that sixty-five acres had then been already lost, and that ninety-six acres more had been rendered valueless. The Rev. I. Gossett, Vicar of Northam, in a pamphlet entitled *A Proposal for Securing the whole of Northam Burrows from the Encroachments of the Sea* (1861), drew the attention of the parishioners to the probability of losing the Burrows entirely unless something were done. He had two maps prepared showing the amount of land lost and damaged. One of these maps was placed in the Vestry Room at Northam, and the other in the National Schoolroom at Appledore. It was shown that during the six years, 1855–61, eighty-seven acres had been destroyed. On the north-east side of the Burrows the encroachment of the sea had been very rapid. Graysand Hill had been washed away for a distance of nine hundred feet. The flow of the water behind, and the sweep of the tide around the south end of the hill, much reduced it in length. Mr. Nicholas Whitley (July, 1861) received instructions to make a survey of the Burrows and report to the Burrows Committee thereon. He stated that "the remains of the ancient pasture land may be traced far out beyond the present high-water mark towards

Skern. This pasture land must have once extended seaward towards Skern, at least a quarter of a mile, on the outside of the present high-water mark and Shingle Ridge. At full tide the Bight of the Skern is open to the full force of the waves from the reach of the Taw; and at ebb tide the set of the current is right on it, causing a strong counter-current very destructive to the shore. The ebb tide also, with a north-east wind, drives the water behind Graysand Hill, which is now reduced to a mere skeleton, and nearly cut through on the north, which, if not strengthened, a channel with a strong current will be shortly formed which on the ebb tide will rapidly take away the loose sand." Mr. Appleton (*Trans. Devon. Assoc.*, Vol. IX, 1877) relates that "in the winter of 1876 the storms and heavy seas told very seriously on the Pebble Ridge, and much land was washed away." During a storm, in the winter of 1874, the pier, which had been erected a few yards west of the Nassau Baths, was destroyed by the force of the waves. Mr. T. M. Hall ("The Submerged Forest of Barnstaple Bay," *Quar. Jour. Geol. Soc.*, 1879) noted the denudation going on between the years 1863 and 1879. He states that "the whole ridge had been driven bodily inwards on two recent occasions in 1877 from 35 to 50 feet; and in February, 1878, from 50 to 70 feet more." Mr. G. H. Spearing ("On the Encroachment of the Sea at Westward Ho! North Devon," *Quar. Jour. Geol. Soc.*, Vol. XL, 1884) says, "For the last nine years the sea has been encroaching on the land near Westward Ho! at the rate of about 30 feet a year. The Appledore side of the estuary has for a long time been subject to erosion." Mr. Spearing illustrated his paper by a map showing the amount of land lost, and the position of the Union Club House before it was destroyed in 1876. According to the Government Ordnance Survey of 1884, the area of the Burrows clear of the tides was 618½ acres. Mr. Wheeler (*The Sea Coast*, 1903) says, "During the winter of 1896 there was a succession of westerly gales, culminating in a very heavy storm from the north-west. The Pebble Ridge was torn down and so lowered that the waves broke over it and inundated the enclosed land. The ridge was forced back 30 feet, exposing the clay bed on which it had rested previously." In October, 1900, I observed the waves breaking through the narrow neck of land on the north side of Graysand Hill. A breach was made twenty-eight yards broad. Since then another breach, thirty-three yards wide has been made some distance further eastward of the first. Mr. Whitley had previously warned the Northam parishioners, in 1861, that this would, in all probability, take place sooner or later, unless they strengthened the defences of Graysand. The lords of the manor and the Burrows Committee, in view of the seriousness

of this encroachment, have recently taken steps to prevent further destruction at this spot, but it appears likely that only a short time will elapse before the waves will be continually breaking through the isthmus into Graysand Lake. If Graysand Hill is once cut off from the rest of the Burrows, it will rapidly disappear altogether. In the winter of 1902 the centre of the Pebble Ridge was driven back some ten to fifteen feet. Of ten houses originally forming Westbourne Terrace, six have been destroyed by the encroachments of the sea. At the last Government Ordnance Survey, in 1903, the area clear of the tides was about six hundred acres. Last year a Sub-Committee of the Royal Commission on Coast Erosion, before whom the writer gave evidence, held an inquiry into the causes and effects of the coast erosion which is still going on.[1] The direction of the sea-current near the coast was proved to be from south-west to north-east by the fact that fossiliferous nodules which lay at one time *in situ* in Cockington Cliff, three miles to the west, have been carried along the shore of the bay and thrown on to the Pebble Ridge where they may now be found. The representatives of the Northam Council pointed out to the Commissioners that it was essential for the maintenance of the ridge that the removal of the pebbles from the shore at any point to the east of Hartland Point should be stopped.

From maps of Westward Ho! in my possession, dated respectively 1863, 1866, 1873, 1884, and 1908, it appears that since the year 1863 the south-west end of the Pebble Ridge has been gradually driven back about two hundred yards. But during the past five years (1903–8) the scouring action of the waves has been somewhat less, and consequently the loss of land here has been much smaller than in previous years, and the position of the ridge has remained almost stationary. The pebbles coming from the west have accumulated in great quantities, and will tend to further strengthen the ridge.

The sheet of water near the sand-hills, locally known as "Sandy Mere," is of comparatively recent formation. This "inland sea," which is not seen in the oldest known photographs of the Burrows, was at first an isolated pool. In 1884 its area was two acres. When, however, the Pebble Ridge, driven back year by year, reached the western edge of the pond, the sea found its way through, and since that time the sheet of water has rapidly increased to its present dimensions of thirteen and a half acres.

That there is a remedy at hand, for preserving the sand-dunes from destruction, is shown by the fact that large areas of sand-waste have been reclaimed elsewhere. The

[1] The inquiry was held at Westward Ho! July 16th, 1907.

only way to fix drifting sand-dunes is to plant them with such plants as will thrive upon them and bind the whole mass together, thus making use of the forces of nature, instead of blindly fighting against them. An excellent example of what may be done is afforded by the coast of Western France, where the shifting sand-dunes are fixed with *Psamma arenaria*, *Elymus arenarius*, *Agropyrum junceum*, etc., together with sand-binding species of sedges, and in this way the reclaimed land is also prepared for gradual afforestation with bushes and trees, thus saving enormous tracts of land and sums of money.