

# THE POST-GLACIAL MARINE TRANSGRESSION IN N. IRELAND— CONCLUSIONS FROM ESTUARINE AND 'RAISED BEACH' DEPOSITS: A CONTRAST

GURDIP SINGH\* & A. G. SMITH

Department of Botany, The Queen's University, Belfast, N. Ireland

## ABSTRACT

Studies of the raised beaches in Co. Down have suggested a water level of + 30 ft. (9.2 m.) I.O.D. in the Atlantic period (c. 8,000-5,000 B.P.).

Stratigraphical, palynological and radiocarbon investigations of estuarine deposits in Co. Down indicate that the maximum of the Post-glacial relative sea-level rise was shortly before 3,000 B.P. when high-water reached to 12 ft. (c. 3.6 m.) above present mean sea-level. The regression since the maximum is apparently of the order of 4 ft. (c. 1.2 m.). These findings stand in contrast to earlier tentative conclusions from open coast 'raised beach' studies that the sea rose at its maximum to c. 22 ft. (6.46 m.) above mean sea-level before 5,000 B.P.

**D**EDUCTIONS as to the relative height of sea-level at the maximum of the Post-glacial marine transgression in Co. Down, N. Ireland have so far been made only from the geomorphological evidence of the 'raised beaches' on relatively open coasts (STEPHENS & COLLINS, 1960). These beaches were almost certainly formed, at least in part, at times of exceptionally high water during storms. Thus a large incalculable element enters into the deductions. It is equally difficult to make precise deductions as to past sea-levels from estuarine deposits since they are liable to have undergone compaction and compression, as well as erosion at both transgression and regression. The emphasis of the present work was, therefore, on basins containing quiet water estuarine deposits with a related beach formed farthest inland under conditions presumably not so seriously affected by storms.

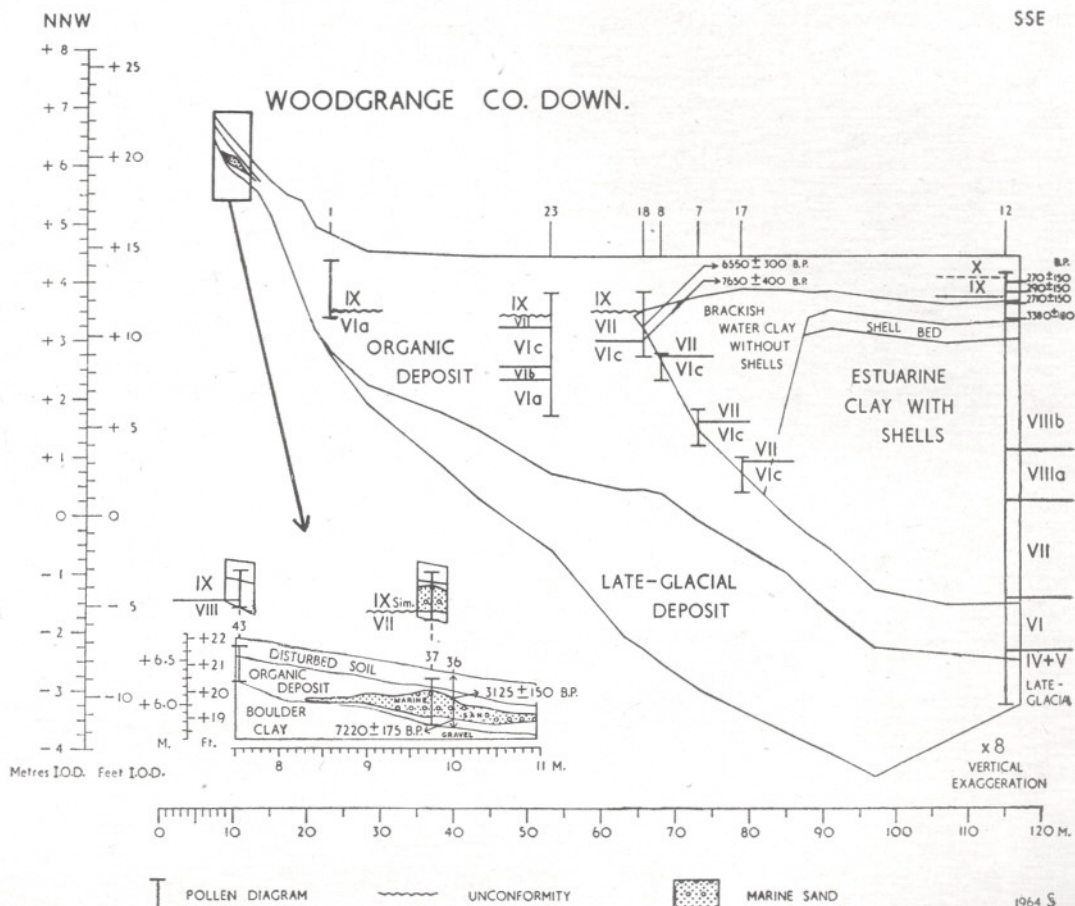
In Text-fig. 1 an outline levelled section is given, showing the stratigraphy of one of the innermost inter-drumlin blind arms of the Quoile estuary at Woodgrange, near Downpatrick, Co. Down. The section is constructed from borings and an excavation.

A complete pollen diagram was made for a point [ref. no. BB'-4 (SINGH, 1964), one of a series of borings at 90° to the line of the present section] 20 m. SW of point 12. For the sake of clarity the levels of the pollen zone boundaries have been transferred to point 12, which shows a similar stratigraphy, and to this extent only the figure is schematic. Fig. 1 also shows the levels of the pollen zone boundaries for six shorter pollen diagrams progressively closer to the margin of the basin. The inset large-scale diagram (TEXT-FIG. 1, lower left) shows the zonation of two further pollen diagrams and two C-14 dates related to an excavated sand layer intercalated in organic deposits on the drumlin surface.

Above the basal Late-glacial deposits the basin is largely filled with estuarine clays virtually disappearing landwards and intercalated in fresh water organic deposits. The marginal part of the estuarine clay is without shells and was presumably deposited under relatively quiet conditions. The transgression contacts at points 12, 17, 7, and 8 date from late in zone VIc (Late Boreal; time, datable roughly to 8,000 B.P.). Finds of hystrichospheres in zone VIa, of marine diatoms and pollen of shallow salt-water plant, *Ruppia*, in zone VIc, before the lithological transgression contact show, however, that in the earlier part of the Boreal period high tides occasionally brought salt-water into the basin. The next transgression contact at point 18, which is at a higher level (by c. 90 cm.) than the transgression contact at point 8, shows an early Atlantic date [early zone VII; cf. 6,550 ± 300 B.P. (LJ-903); TEXT-FIG. 1]. Thus the threshold of the basin (now at +c. 6.5 ft. = +c. 1.98 m. I.O.D.<sup>1</sup>) was lower than

1. I.O.D. (Irish Ordnance Datum) is some 8 ft. (2.4 m.) lower than the English Datum (DIXON, 1949).

\*Now at: The Birbal Sahni Institute of Palaeobotany, Lucknow, India.



TEXT-FIG. 1—Outline section, constructed from 23 borings and an excavation, of the superficial deposits of an innermost arm of the Quoile estuary at Woodgrange, near Downpatrick, Co. Down, N. Ireland. The extent of 9 pollen diagrams from the numbered points is indicated by the height of the 'I'-shaped line, and the levels of the pollen zone boundaries by the horizontal lines. The levels of the pollen zone boundaries shown for point 12 are transferred from a point (ref. no. BB'-4; Singh, 1964), with similar stratigraphy, offset by 20 m. at 90° from the line of the section to the SW of point 12. To this extent only the figure is schematic. The zone system employed is that of Mitchell (1956), except for the zone VI-VII boundary, where Jessen's (1949) criteria have been used. (The notation IX Sim. is used for the upper part of the pollen diagram from point 37 since it is much influenced by local conditions and the zonation is not supported by the C-14 date which is considered to be a more reliable guide to the age of the deposit). The diagrams from points 12, 17, 7, 8 & 18 cross a lithological transgression contact. The unconformity depicted at points 18, 23, 1 & 37 is deduced both from stratigraphical and pollen analytical evidence though the slight lithological hiatus at points 23 & 1 is not represented in the figure. The inset diagram (lower left) shows in detail a section through a raised beach discovered by excavation of a subdued notch on the drumlin surface in line with the section of the basin deposits.

the level of the transgression contact at point 18 (+c. 12 ft. = +c. 3.6 m.) and the transgression progressed further after the first entry of the sea into the basin. Nevertheless, just as marine influence can be seen as early as zone VIa before the lithological transgression contact in the

deeper part of the basin, the presence of hystrichospheres in late zone VIc and early zone VII at point 18 [cf. 7,650 ± 400 B.P. (LJ-904); TEXT-FIG. 1] suggests that it was under occasional marine influence before estuarine clay deposition began.

The two pollen diagrams (at points 23 and 1) landwards of the main spread of the estuarine clay both exhibit an unconformity (indicated by a wavy line). In each case, at approximately the same level as the pollen analytical unconformity, the organic deposit has a small clay content and it is apparent either that during the later part of the Atlantic period and through pollen zone VIII<sup>2</sup> there was no deposition, or that the deposits were subsequently eroded. At point 1 deposition of organic material had ceased after zone VIa due to a general fall of lake level for which there is evidence not recorded here.

The sand layer (TEXT-FIG. 1, inset, lower left) discovered by excavation beneath a subdued notch in the slope of the drumlin above the general level of the basin deposits is intercalated in highly humified organic deposits. The sand contains a few well rounded small (gravel-sized) pebbles, marine diatoms, pollen of *Ruppia* and numerous seeds of *Juncus gerardi*. It follows that the sand was laid down under salt-water conditions; moreover, it appears very probably from the *Juncus gerardi* seeds that it accumulated under the influence of high spring-tides. The mean level of the sand layer is approximately + 20 ft. (+c. 6.1 m.) I.O.D. Stratigraphical and microfossil analysis of three other basins in the area having thresholds ranging from + c. 20 ft. (+ c. 6.1 m.) to + c. 27 ft. (+c. 8.2 m.) I.O.D. show that salt-water has not entered them. Thus it is reasonable to suppose that the sand layer at Woodgrange represents the highest limit of the spring-tides at the maximum of the relative sea-level rise.

The dating of the sand layer depends on both pollen analytic and radiocarbon evidence. The pollen diagram from point 37 (bracketing the sand layer) is influenced by local conditions but the organic deposit below the sand is referable to (probably early) zone VII and it has given a confirmatory C-14 date of  $7,220 \pm 175$  B.P. (I-1198). A sudden change in the pollen frequencies at the boundary between the lower organic deposit and the sand suggests that there is an erosional unconformity between the two

layers. The virtual absence of *Ulmus* and *Pinus* pollen and the presence of *Plantago lanceolata* pollen shows that the sand layer almost certainly dates from post-Atlantic times (i.e. after c. 5,000 B.P.). Taken at its face value the pollen diagram indicates that the sand and the upper organic deposit belong to zone IX. According to Mitchell (1956), zone IX opens with the beginning of Christian times in Ireland and the zone VIII-IX boundary has been dated by C-14 assay to c. 300 A.D. (MCAULAY & WATTS, 1961). The C-14 date of  $3,125 \pm 150$  B.P. (I-1199) for the lowermost part of the organic deposit in contact with the sand, however, does not support the attribution of these layers to zone IX. Since the upper part of the pollen diagram is much influenced by local conditions the C-14 date is presumably a more reliable guide to the age of the deposits. The sand layer may well have been deposited only just before 3,000 B.P.

The present general height of the Woodgrange flat (+c. 15 ft. = +c. 4.6 m. I.O.D.) is such as to suggest that, were it not for the barrage, it would be inundated by the sea at high spring tides, which, measured at the new barrage across the Quoile estuary, rise to an average of + c. 16 ft. (+c. 4.87 m.) I.O.D. This deduction is supported by a map drawn in 1710 (anonymous), before the building of the barrage which shows the Woodgrange flat as being outside the area of permanent marine influence. It is thus clear that there was some regression after the maximum of the relative sea-level rise as represented by the sand layer at + 20 ft. (6.1 m.) I.O.D. In the basin deposits the cessation of shell deposition in the upper part of the estuarine clay too indicates a certain amount of recession of salt-water conditions. The C-14 date of  $3,380 \pm 180$  B.P. (LJ-908) from the lowermost part of the brackish water clay (without shells), overlying the shell bed (TEXT-FIG. 1), approximately tallies with the C-14 assay of  $3,125 \pm 150$  B.P. (I-1199) obtained from the bottom of the upper organic deposit in contact with the marine sand in the raised beach deposits. The above C-14 date (LJ-908) may, thus, be taken as a confirmatory evidence, coming independently from estuarine clay deposits in the basin, to the effect that the maximum of the relative sea-level rise in Co. Down was completed only just before 3000 B.P. The

2. Throughout this paper unless otherwise stated the pollen zone scheme of Mitchell (1956) is used except in the case of the zone VI-VII boundary (the Boreal-Atlantic transition,) where Jessen's (1949) criterion is employed.

inundation of the deeper part of the Woodgrange basin by salt-water can be seen from the continued deposition of brackish water clays (without shells) in the basin after the maximum of the relative sea-level rise and it appears to have gone on for a fairly long time (*cf.* 2,710 ± 150 B.P.; LJ-907, TEXT-FIG. 1). The actual date of transition from salt-water to freshwater conditions in the basin deposits is obscured by several factors chief among which is the building of the barrage across R. Quoile in 1745 (KNOX, 1875). The short span of zone IX in the main pollen diagram (Point 12) and the C-14 date of 290 ± 150 B.P. (LJ-906) and 270 ± 150 B.P. (LJ-905) of fen-peat from just above the brackish water clay, however, suggest that either the transition from salt-water to freshwater conditions engendered relatively slower deposition of material during zones late-VIII and IX or there was some erosion of the brackish water clay before the freshwater organic deposit was laid. The latter view seems more probable since other erosional contacts at points 18, 23 and 1 are also seen at more or less the same level.

Because of isostatic instability, the area is not suited to an assessment of eustatic changes of sea-level. Nevertheless, the extent of the regression since the maximum of the relative sea-level rise as represented by the sand layer at +20 ft. [(6.1 m.) I.O.D.] does give a minimum measure of the relative uplift of the area; if the present high spring-tide level in the Quoile estuary, + *c.* 16 ft. = + *c.* 4.8 m. I.O.D., can be applied to the Woodgrange flat, then this value is of the order of 4 ft. (1.2 m.). If there have been no eustatic changes since 3,000 B.P. (GOULD and MCFARLANE, 1959), then this figure gives an approximate measure of the uplift of the area. If the eustatic rise had ended by 5,000 B.P. (FISK, 1944, 1951; LE BLANC & BERNARD, 1954; GODWIN, SUGGATE & WILLIS, 1958) then we should have to assume that there ensued a fairly long period of isostatic stability in county Down. If, however, eustatic sea-level rise has continued slowly (SHEPARD & SUESS, 1956; JELGERSMA, 1961; & SHEPARD, 1964), then the figure of 4 ft. (1.2 m.) is clearly an underestimate. On the other hand it has been estimated by some authors that there has been a eustatic fall of sea-level of up to 8 m. in the later part of the Post-glacial period; a more conservative estimate

of 3-4 m. has, however, been given by Kuenen (1954). If this were the case then isostatic depression of the area under consideration would presumably have to be invoked. This is, of course, contrary to the generally accepted view (WRIGHT, 1914, 1937; MARTIN, 1930; STEPHENS, 1957; GODWIN, 1963).

In summary it may be said that the data presented here do not oppose the view that a slow eustatic rise continued even after 5,000 B.P. It may be suggested that in this area isostatic recovery did not overtake such a rise until quite recent times (*c.* 3,000 B.P.). The marine sand layer appears, thus, to be the first true raised beach described in the north of Ireland. It must be recognized, however, that this deduction rests on the assumption that there has been no major change in the tidal range since the sand layer was deposited.

It is evident from this work that the tentative conclusion from 'raised beach' studies that the maximum of the relative sea-level rise in Co. Down was in the Atlantic period (MORRISON & STEPHENS, 1960; MORRISON, 1961) cannot be sustained. Recent radiocarbon dates (Q-632, GODWIN & WILLIS, 1962; Q-770, GODWIN & WILLIS, 1964) suggest, in fact, that the shingle deposits of the 'raised beach' date from after *c.* 5,400 B.P., and that there is an unconformity between these deposits and the underlying Boreal lagoon clays. It is also evident that the estimate for a sea-level rise in Co. Down to levels greater than + *c.* 20 ft. (+ *c.* 6.1 m.) I.O.D. (MOVIUS, 1953; STEPHENS & COLLINS, 1960) can be taken as applying only to the open coast and cannot be extrapolated inland. The conclusion from such extrapolation that the peninsula of Lecale to the SW of the Quoile estuary was probably isolated from the mainland at the maximum of the transgression (STEPHENS, 1958) cannot be upheld.

The disparity demonstrated in Co. Down between conditions on the open coast and in the quiet estuary raises the question as to whether a similar difference might be found on coasts elsewhere.

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Note — I.O.D. (Irish Ordnance Datum) refers to a low-watermark and is some 8 ft. (c. 2.4 m.) lower than the English Datum.