Porth Neigwl, Gwynedd

[SH 270 274]

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Introduction

The coastline of Ll■n (the Lleyn Peninsula, north-west Wales) is characterized by both hard rock and weaker till cliffs, and a number of distinctive beaches. Between the mouth of the Mon Glaslyn and the Menai Strait, there are some 18 sand, shingle and cobble beaches that are bounded by rocky headlands. Those along the south-eastern coast are the best-developed set of zeta-curve beaches associated with strong wave refraction on the coastline of England and Wales, but almost all are affected by coastal protection works. Aberdaron Bay (about 6 km to the west) and Porth Neigwl (Hell's Mouth) are more symmetrical in form than the others, Porth Neigwl in particular facing almost directly into the dominant south-westerly Atlantic swell (see (Figure 4.1) for general location and (Figure 4.39)). It is a rare example of a cliff-beach system on the coast of Great Britain confined by long headlands where waves and swell are little affected by refraction (Guilcher, 1958). As a result, the predominantly till cliffs have developed a plan-form that is controlled strongly by the dynamic relationship between south-westerly swell and waves, and the strength of the till (Figure 4.39). The narrow beach is usually subdivided into a lower beach, formed mainly of sand, and an upper beach dominated by cobbles and boulders. A common feature of the beach is a series of bars aligned at an acute angle to the beach itself. Beach cusps are also a characteristic feature. The beach is unusual amongst British west-coast beaches in having no associated dunes (Steers, 1946a). Some controversy surrounds a possible emerged (raised') beach at the western end of the locality (Whittow, 1957, 1960, 1965; West, 1972; Campbell and Bowen, 1989), where there may be present-day cementation of the beach (West, 1972).

Description

The Porth Neigwl (or 'Hell's Mouth') coastline is about 11 km in length and comprises three main elements; (a) a narrow beach, below (b) cliffs of glacial sediments, which lie between (c) cliffs of Cambrian and Ordovician bedrock.

The western side of the bay is formed by cliffs up to 60 m in height, cut partially into sandstones and partially into glacial sediments that rest upon the bedrock slope. The cliff runs SW—NE; this area is the most sheltered part of the bay. There is a narrow cobble and boulder beach. The main beach faces southwards at its western end but gradually curves to face southwest at its eastern end. The cliffs are over 30 m in height at its western end, but are more usually about 18 m high. Between [SH 276 268] and [SH 283 263] they are only 10 m in height. The cliffs are cut mainly into thick blue-grey and brown Irish Sea till, but east of [SH 283 263], there is a higher proportion of gravels in the cliff. Holocene peat and sands are also exposed in the cliffs (Campbell and Bowen, 1989).

Along the eastern side of the bay, the cliffs are cut mainly in Cambrian Hell's Mouth Grits, and attain a height of over 110 m. The lower parts of the cliffs are almost vertical, but, owing to the strata dipping at between 30° and 45° into the cliffs, only limited development of very narrow shore platforms has occurred. There is little evidence of active erosion in the cliffs of this part of the bay. Rockfalls are infrequent and small in magnitude. The till cliffs that form the central part of the bay are, by comparison, easily eroded and have retreated rapidly, undermining cliff-top tracks and fields.

The beach itself is formed by an upper berm composed mainly of cobbles derived from the erosion of the cliffs, and a lower finer-grained beach, which has a maximum width of about 100 m. Two regular features of the beach are well-developed cusps and small bars on the lower beach, which are aligned sub-parallel to the beach itself. They normally merge with the beach at their western end, and they disappear and reform over time depending upon the wave conditions.

Waves usually approach the beach from the south-west because of the effect of the restricting headlands, but the fetch varies between over 4000 km to the south-west to much shorter distances to the south and south-east (80 and 50 km respectively; (Figure 4.39)). Waves approaching from these directions are less strongly refracted than those of the long Atlantic swell, but there is some sheltering of the eastern corner of the bay under south-easterly conditions. The western corner of the bay, in contrast, is very exposed to the south-east waves and by refracted south-westerly waves. Despite these modifications of wave approach, wave energy appears to be often spread evenly along the whole beach and the similar plan of both the cliffs and the beach reflects this.

Interpretation

Guilcher (1958) described Ll■n, and Porth Neigwl in particular, as one of several examples where the coastline has become irregular as a result of the exhumation of the underlying rock surface from beneath a cover of drift. The broad outline of the bay results from the rapid retreat of the glacial infill between the two headlands to east and west, but there is no direct relationship between cliff height and cliff retreat along the glacial cliffs. The rapidity of erosion is such that cliff-top streams have been unable to keep pace with the rate of retreat and so hanging, truncated, valleys into which streams have incised their lower courses have developed (for example at [SH 269 274]). Similar features have been described elsewhere in the present volume (see South-west Isle of 'Wight and the Dorset Coast GCR site reports), and there is considerable debate about their origins (Flint, 1982). Unlike the truncated valleys in the area around Hartland Quay (see GCR site report), the valleys at Porth Neigwl are most akin to those of the south-west Isle of Wight and tesitify to the local rapidity of cliff retreat. This contrasts with the evidence discussed below concerning cementation of the beach.

The detail of the bay results mainly from the longshore movements of sediments within a swash-aligned system (see Chapter 5). Furthermore, water movements are strongly constrained by the confining headlands. Waves are little affected by refraction within the bay except along the foot of the two headlands, but reflection from the headland cliffs, especially to the east, may produce complex wave patterns.

The beach is notable for the very common occurrence of large beach cusps along its length. Cusp development has been attributed to edge waves, in which cusp spacing is related to interactions between the edge-waves and the incident waves (Darbyshire, 1982). The regularity of beach cusps has been described by many coastal scientists (see for example Komar, 1976; Pethick, 1984). Bowen and Inman (1969) suggested that the rhythmic beat of the incoming waves on the water of the near-shore zone creates a secondary set of waves at right angles to the incoming waves. The combination of incoming waves and edge waves produces a regular series of undulations in wave height along the beach. The resultant differences in wave-energy distribution produce the regularly-spaced cusps.

In Porth Neigwl, the lack of variation of the direction of wave approach means that cusps are likely to be broken down or change their wavelength mainly as a consequence of variations in the period of incoming waves rather than any directional change. They are, as a result, a common characteristic form on this high-energy beach. However, reflection from the eastern wall of the bay also produces waves that travel obliquely across the bay at regular intervals. Waves travel into Porth Neigwl from comparatively deep water, in contrast to many other similar beaches which are related to south-westerly swell (see, for example, GCR reports for Carmarthen Bay and the English Channel sites such as South-west Isle of Wight and Loe Bar). The site provides an excellent field-study site for future research into the effects of interference of reflected waves with incoming and edge waves. Because of the limited refraction and deep water close inshore, it also provides a good site for investigation of wave behaviour and beach and cliff responses to rapid sea-level rise.

Porth Neigwl contrasts with the other beaches of Cardigan Bay in lacking any significant development of cliff-top dunes. Some swash-aligned beach-cliff systems develop small cliff-top dunes that are maintained by wind transport from both the beach and the cliff-face. There is no evidence of this process here. The rate of cliff erosion and the narrowness of the beach inhibit intertidal drying and so wind action is insignificant. There is also no evidence of an offshore source of beach sediment. It is one of the best examples in England and Wales of a high-energy beach with local sediment feed. Although it has a similar wave regime to the south-west facing flint shingle beaches of the English Channel, it differs from them in

having deep water dose to the shore and in depending entirely on erosion of the cliffs for its sediment supply.

In one other aspect, this site is unusual. It is the site where cementation of beach materials was thought first to have occurred in an emerged beach situation (Whittow, 1960), but was later shown to be part of the present-day beach (West, 1972). Whittow (1957, 1960, 1965) described a shelly conglomerate as a postglacial (Holocene) emerged beach, although he recognized that a wave-cut notch could not be seen because of the masking effect of landslips in the till that formed the cliff above the site. He also noted that coastal shelly drifts terminated inland at a height of about 3 m against a steep rock cliff, which he suggested might represent the old sea cliff of the Great Interglacial (Hoxnian) emerged beach. West (1972) demonstrated that inorganic calcite had been deposited in the western part of the beach, but gave no evidence of it being a Holocene emerged beach. Campbell and Bowen (1989) accepted this interpretation. It is unusual to find present-day beach sediments cemented in this way, but there is evidence from elsewhere (for example, east of Dover) that it can take place beneath debris from cliff falls.

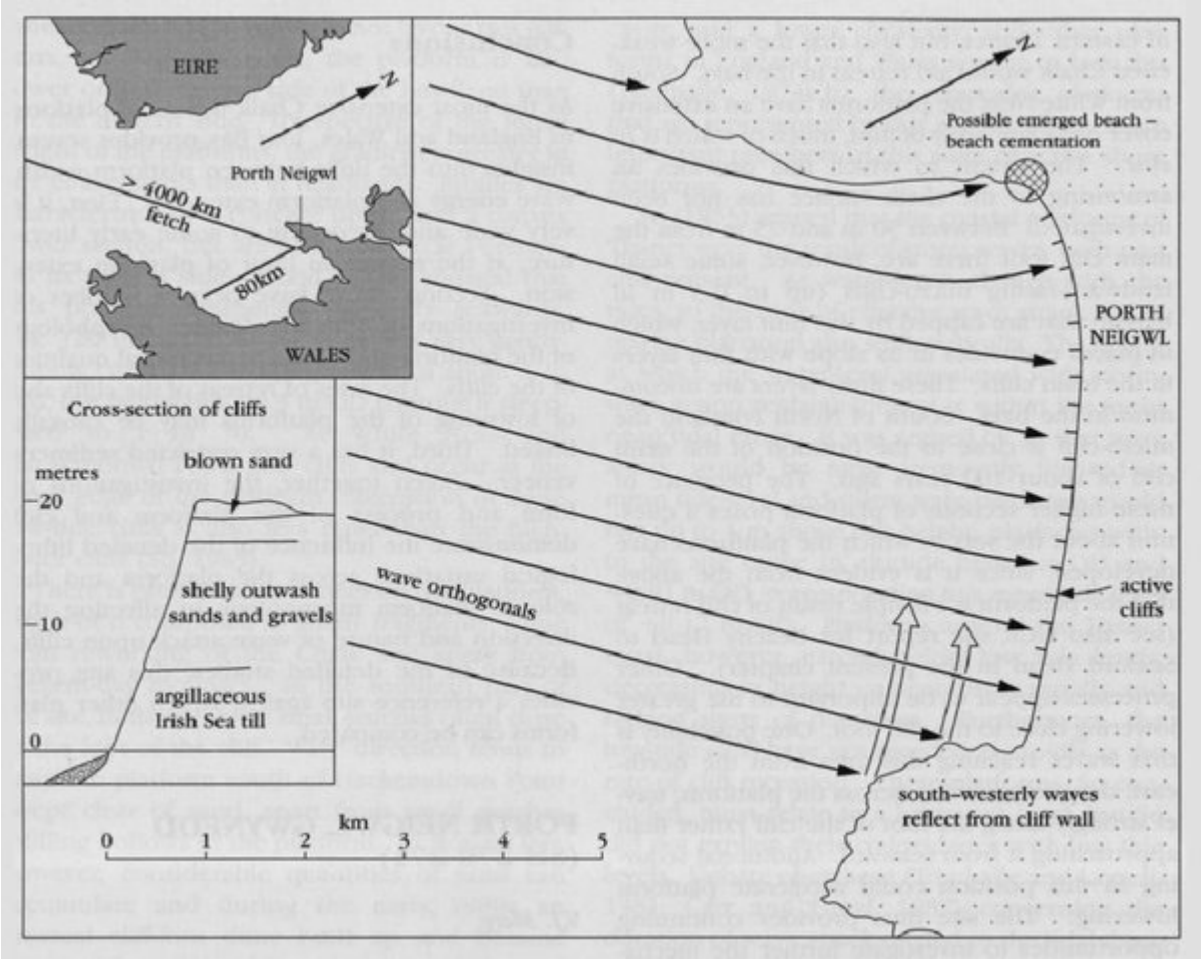
Whittow (1965) also suggested that the presence of the emerged beach indicated that the till cliffs could not have retreated more than about 800 m since the end of the transgression about 6000 years BP There are, as yet, no ^{14}C or amino-acid dates for the cemented material. The presence of hanging and incised valleys indicates that the rate of retreat of the cliffs has been faster than the rate of down-cutting, but this does not provide evidence of either the rate of retreat or the magnitude and frequency of retreat events. West's (1972) re-interpretation of the cemented material as contemporary suggests that retreat has taken place at marked intervals, for sufficient time must have passed without disturbance of the beach to allow cementation to take place. In this respect, the site poses interesting and as yet unanswered questions about the nature, magnitude and frequency of retreat of the till cliffs in this very high-energy environment. There is no other site on the coastline of England and Wales where contemporary cementation has been reported in a comparable location below cliffs. For this reason alone, the site is of considerable scientific importance.

Conclusions

Porth Neigwl is a rare example of a cliff-beach system, confined by long headlands, in which waves and swell approach from deep water and are little affected by refraction. Porth Neigwl is one of the few beaches on the coastline of England and Wales where waves travel in deep water sufficiently close to the shoreline to be little affected by refraction.

The till cliffs are retreating rapidly, but despite ample supplies of coarse sediment, the beach remains very narrow. This locality is an excellent example of a very high-energy environment that lacks intertidal platforms (contrast with Nash Point, for example — see GCR site report in the present chapter). It is also of considerable interest because it is probably the only recorded site of possible contemporary cementation of a cliff-foot beach in England and Wales.

(Figure 4.1) Location of significant soft-cliffed coasts and platforms in Great Britain, indicating the sites selected for the GCR specifically for soft-rock cliff geomorphology. Other coastal geomorphology sites that include soft-rock cliffs and sites selected for the Mass Movements GCR 'Block' that occur on the coast are also shown.



(Figure 4.39) Wave refraction and reflection in Porth Neigwl. Wave orthogonals show the direction of travel of waves and are drawn at right angles to the wave crest. Open arrows are also orthogonals for reflected waves.