ROBIN HOOD'S BAY

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Introduction

The coastline of the North York Moors is one of the most scenically dramatic in England and Wales. It transects a large part of the Jurassic succession from the Lower Lias (Lower Jurassic) strata at Saltburn-by-the-Sea in the north to the Corallian (mid-Upper Jurassic) deposits at Filey in the south. Few parts of this coast have been examined geomorphologically in detail, except for the cliffs and shore platforms around Robin Hood's Bay, where well-developed platforms cut across outcrops of Liassic shales. The cliffs mainly comprise till resting on the Lias and are subject locally to considerable mass-movement and rapid cliff-retreat. Much of the geomorphological interest in the site arises from the platforms and their relationship to the cliffs. Robin Hood's Bay contrasts with other ‘active platform' sites: first, it is affected exclusively by the North Sea wave climate; second, it has been subject to glacial and postglacial processes prior to sea level reaching its present position, and third, it is close to the point along the east coast where isostatic stability rather than uplift or subsidence is predominant.

Studies of shore platforms have been a major focus of geomorphological research since the 1960s (e.g. Agar, 1960; Trenhaile, 1972, 1974a,b, 1983; Trenhaile and Layzell, 1981; Robinson, 1977a–c; Sunamura, 1983) and this GCR site has been among the most frequently examined in such studies. It forms an essential member of the network of ‘active platform' GCR sites because, although Liassic shales are represented elsewhere at other GCR platform sites, no other North Sea site includes such a marked relationship between upper till cliffs and an underlying pre-glacial bedrock platform that is currently being reworked. In addition Robin Hood's Bay is by far the most studied site, particularly because of the contrast between this site and others in the ‘active platform' network in England and Wales (Trenhaile, 1974b). It has been identified as the only location in 225 km of platformed coast with a continuous platform extending around a well-defined headland–embayment sequence (Trenhaile, 1974b). Unusually, the rate and nature of erosion in a cliffed coast with extensive platforms has been the focus of attention (Agar, 1960; Robinson, 1977a–c).

Description

Robin Hood's Bay lies between NZ 956 051 and NZ 908 037 on the north-east coast of Yorkshire (see Figure 4.1 for general location). Its main feature of interest is its well-developed platform cut across the geological structure known as the ‘Robin Hood's Bay Dome' comprising Lower Lias shales (Figure 4.6). The bay is backed by low cliffs in the shales overlain by extensive deposits of till. The southern boundary of the site lies at South Cheek where the Peak Fault is crossed by the platform and exposes a small area of ferruginous shales. From calculations for four points around the bay, Agar (1960) estimated that the coastal retreat rate varied from a maximum of 0.305 m a^{-1} to a minimum of 0.046 m a^{-1}. Here, as elsewhere along the north Yorkshire coast, bays were retreating more rapidly than headlands (Table 4.3). In addition, there was a considerable difference between the rates of retreat of the till and the Lower Liassic strata at the cliff foot.

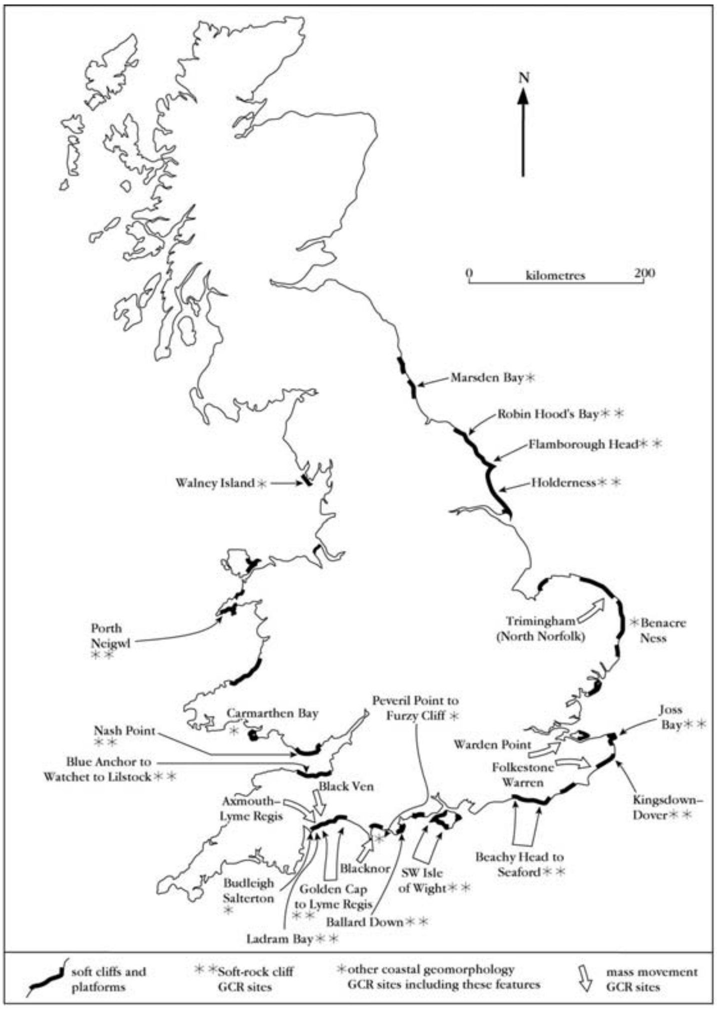

Figure 4.1: Location of significant soft-cliffed coasts and platforms in Great Britain, indicating the sites selected for the GCR specifically for soft-rock cliff geomorphology. Other coastal geomorphology sites that include soft-rock cliffs and sites selected for the Mass Movements GCR 'Block' that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

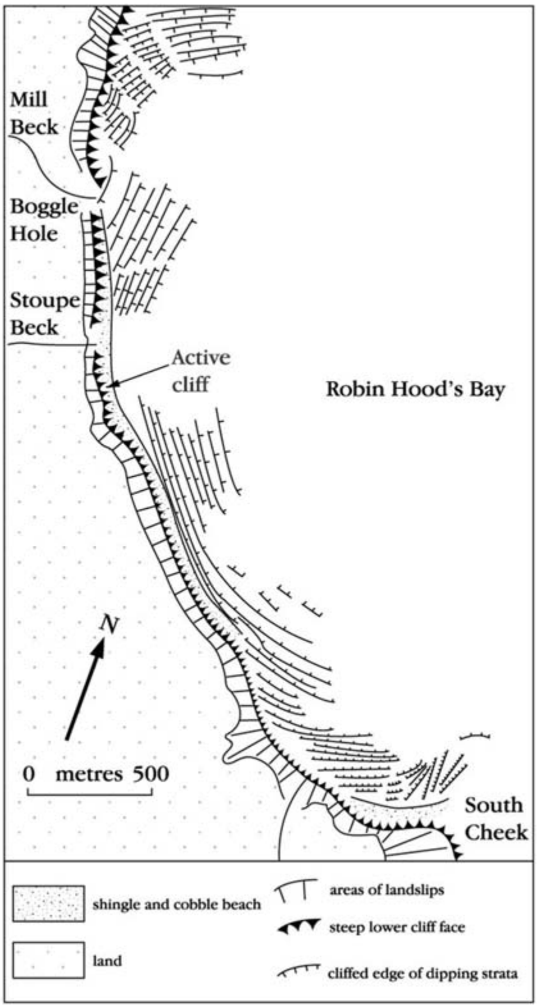

Figure 4.6: Pattern of seaward-facing micro-cliffs on the landward-dipping strata (the strike of the strata is indicated) on the low-gradient intertidal platform in Robin Hood's Bay.

The cliffs are about 50 m in height in the northern part of the bay where they are cut by two steep-sided valleys, Mill Beck and Stoupe Beck (see Figure4.6). These are cut mainly in till. Although the Lias forms the lower part of the cliff, it is commonly masked by debris from the landsliding clays above it, and by a storm beach of shingle. South of Stoupe Beck, the cliffs rise steadily to reach a maximum of 107 m at the southern end of the bay. Here the Lias forms most of the slope, with near-vertical lower cliffs comprised entirely of Lower Lias rocks. The Peak fault runs through South Cheek, with the result that the southern part of the cliff is dominated by Toarcian rather than Pliensbachian shales. Agar (1960) did not measure change here although his paper suggests that erosion was substantially less than elsewhere in the bay.

The platform is distinguished by a series of curving ridges and troughs that reflect the differential erosion of the shales and the structural form of the Robin Hood's Bay Dome (Figures 4.6 and 4.7). Trenhaile (1974a) suggests that the platform on the northern side of the bay is concave in form, a feature that he attributes to ramp development. However, rather than having a truly concave form, the platform is made up of two elements. The ramp is related to harder material forming the upper part of the platform. Elsewhere in the bay, linear forms up to 500 m in width are more characteristic of the platform (Trenhaile, 1974b) and extend for considerable distances offshore with a gradient of about 1 in 100 to depths of about 40 m (Agar, 1960).

Figure 4.7: Shore platform at Robin Hood's Bay looking east from Mill Beck (see Figure 4.6 for location). (Photo: J.D. Hansom.)

Interpretation

The broad geological structure of the Robin Hood's Bay Dome has not affected the macro-morphology of the platform cut across it, whereas the micro-morphology of the platform is strongly dependent upon the structure across the Dome (Figure 4.7). In contrast to the platforms between Watchet and Lilstock (see GCR site report for Blue Anchor–Watchet–Lilstock in the present chapter), this site does not have a well-developed ‘washboard' surface but demonstrates well how spatial arrangements of the micro-morphology are controlled by the varying dip and strike of the beds of the outcrops. In detail this may affect the refraction of waves, especially at lower stages of the tide. In turn this affects the transport of sandy sediment within the intertidal zone. The development across a very complex structure of platforms that display similar characteristics to those cut across simpler ones gives this site an important place in the debate about shore-platform development.

Most writers have concentrated on the development of the cliffs and the platform, rather than the links between the platform and geomorphological processes. The single exception is Robinson (1977c, see below). Agar (1960) used his measurements of cliff erosion in combination with an assessment of the degree to which the upper cliff had changed in postglacial (Holocene) times to judge the development of the coastline over the past 10 000 years. He regarded present-day conditions as ‘optimal', i.e. the sea breaking on the gradually sloping foreshore and attacking the vertical face of the cliffs at high tide to develop a cliff-foot notch. Erosion rates could thus be interpreted as being maxima. Agar argued that a slightly lower sea level would result in the action of the waves being concentrated on the platform and having a much less important role in coastline retreat. A higher sea level would similarly have only a limited effect because waves would be reflected from the vertical cliffs. Taking account of the contemporary interpretations of the curve of sea-level change, he argued that apart from a short period around 7000 BP, the past few centuries are the only postglacial period ‘in which favourable conditions for formation of the present foreshore have existed' (Agar, 1960, p. 422). Extrapolating from the measured rates of retreat, he argued that most of the local erosion has occurred only during the last six centuries. As a result, many profiles, including those of South Cheek, would have been affected by only limited postglacial erosion. Their upper slopes were not regarded by Agar as contemporary forms, but as probably of last interglacial age. Both the discussion following Agar's paper and later comments cast doubts on his interpretation of the coastal features.

Straw and Clayton (1979) consider that if Agar is correct then the present coastline must approximate in location to that of the Ipswichian (Eemian) interglacial. They cite the resistance of the rocks to marine erosion and recognize the difficulty of ascribing the platform solely to late Holocene marine erosion. They thought it inevitable that the platforms must have been prepared during preceding interglacial periods. However,Robinson (1977c) was not convinced by the view that many of the platforms have been reworked and that notches revealed beneath the till show that the platforms are at least Weichselian in age. Robinson counters by arguing that many of the features are recent, some less than 200 years old, and that much of the alleged pre-Weichselian glacial form has been buried by postglacial landslipped material that has then been removed, exhuming the pre-talus surface.

In a wider discussion of shore platforms,Trenhaile (1974b) describes this site as the only location in 225 km of platformed coastline with ‘a continuous shore platform extending around a well-defined headland–embayment sequence'. He also records that the platform gradient increases towards the headlands, especially in the north, typically from about 35' to 2.5°. The headland site is more rugged than the Lower Lias shales of the embayment and is also more exposed to greater wave activity. From such evidence here and on other shore platforms around the coastline of England and Wales,Trenhaile (1974b) concludes that the platform gradient is being maintained in dynamic equilibrium. This appears to cast doubt on the claim that many of these platforms, including the platform at this site, have been inherited from previous forms (Trenhaile and Layzell, 1981). However, they argue that the evidence suggesting that shore platforms are partially inherited features is not incompatible with the evidence indicating that they are at or close to a state of dynamic equilibrium with a morphology finely tuned to their present environments. Despite some debate (Carr and Graff, 1982; Trenhaile, 1982), this argument appears to hold good for Robin Hood's Bay – that the platforms are likely to be be reworked earlier platforms, retrimmed by Holocene seas. Unfortunately neither Agar, nor Trenhaile and Layzell, take sufficient note of the role of debris on the platforms either in its erosional, or its protecting and roughening, role.

Robinson (1977a–c) argued that the morphology of the platforms resulted from the presence of sand debris rather than the nature of the rocks forming the platform. The width of the platform is controlled primarily by the protection afforded to the cliffs by the deposits at their foot (Figure 4.7). Where debris is absent, the platform has a low angle of inclination, characteristically about 1°. Robinson calls this the ‘plane'. In contrast, where there is a beach, the slope is greater, usually up to 15°. This is the ‘ramp'.Trenhaile (1974b) believed that the steeper ramp was produced by harder materials. Robinson identified five erosion processes here:

1. micro-quarrying;

2. the expansion and contraction of clay mineral lattices by hydration and desiccation. He estimated that processes 1 and 2 together lowered the platform by 0.144 cm a^{-1};

3. wave-quarrying, by which removal of small blocks from the cliff foot lowered the platform surface by 2.3 cm a^{-1};

4. corrasion: direct abrasion of the in-situ rock by wave-transported sediment lowered surfaces by 5.79×10^{-3} cm $tide^{-1}$;

5. wedging, in which small sediment particles forced into cracks in bedrock gradually force it apart. This lowered surfaces by 11.05×10^{-3} cm $tide^{-1}$.

Robinson (1974) showed that erosion was more rapid when a thin beach was present, but seasonal variations in wave action also affect the efficiency of erosion of the ramp. In contrast the plane is affected by desiccation and contraction at low water – especially in summer – and expansion at high water. The annual rates of lowering estimated by Robinson's use of a micro-erosion meter are about 1.5 times faster than those obtained by longer-term comparisons of platform levels on the Chalk around the Isle of Thanet (see GCR site report forJoss Bay in the present chapter).

Conclusions

Robin Hood's Bay is a very important site for study of platformed coastline development, because the platform cuts across a complex structural geological structure, the 'Robin Hood's Bay Dome'. Despite the complexity of the underlying structure, the platform displays many of the features observed elsewhere in much simpler structures. Unlike many other platforms, it has been the focus of detailed investigation of the erosion processes, in particular the varying role of beach sediments in either erosion or protection of the platform and cliff foot. It demonstrates well a relationship between headland and embayment in which pre-glacial erosion of the platform may have produced an equilibrium form that is being reworked today. This remains, however, the paradox of this site, for it is not possible to determine the extent to which the platform is being exhumed or reworked. The cliffs are cut both into the Lower Lias bedrock and glacial materials and provide an excellent example of a cliffed coastline where the comparatively recent weaker sediments reveal older features as they are eroded. The erosion of these cliffs is important to our understanding of the late Quaternary history of soft-rock coasts.

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