SOUTH-WEST ISLE OF WIGHT

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OS Grid Reference: SZ493755–SZ306852

Introduction

The south-west coast of the Isle of Wight (see Figure4.1 for general location) is geomorphologically rich in features of interest. It contains examples of most of the cliff types undergoing active erosion described from other GCR sites. The site demonstrates well how coastal processes have produced different cliff forms related not only to variations of lithology and geological structure, but also variations in the intensity of coastal processes and the timescales over which coastal evolution occurs.

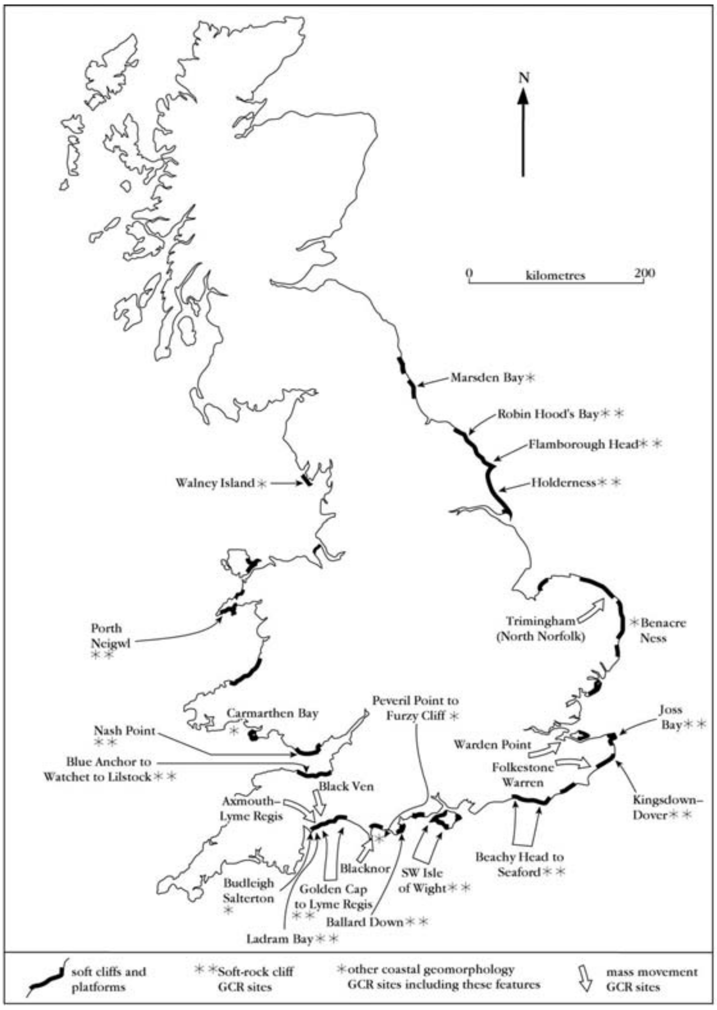

Figure 4.1: Location of significant soft-cliffed coasts and platforms in Great Britain, indicating the sites selected for the GCR specifically for soft-rock cliff geomorphology. Other coastal geomorphology sites that include soft-rock cliffs and sites selected for the Mass Movements GCR 'Block' that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

Much of the coast of the Isle of Wight is affected by rapid retreat and landslides. Damage to property remains a constant hazard and stabilization has been a priority on the urbanized parts of the coast (Clark *et al*., 1993). However, the GCR site area is mainly unprotected, except at Freshwater Bay.

The site extends from Chale in the east (SZ 493 755) around the Needles (its westernmost point at SZ 289 849) to Alum Bay (SZ 306 852; see Figure4.15) and crosses outcrops of

Chalk, Upper Greensand, Gault, Lower Greensand and the Wealden exposed on both sides and in the core of the Brighstone anticline. The general plan of the coastline is controlled by the relative resistance of the Chalk in the west and the Upper Greensand in the east, and the effectiveness of the prevailing and dominant south-westerly wave systems in maintaining the alignment of the shoreline. There are many, small irregularities associated with locally resistant outcrops, and the beaches comprise both locally derived materials and some residual flints. Erosion has been rapid, so that small streams have been unable to keep pace with continually steepening gradients. 'Chines' (small coastal gorges) and waterfalls are common.

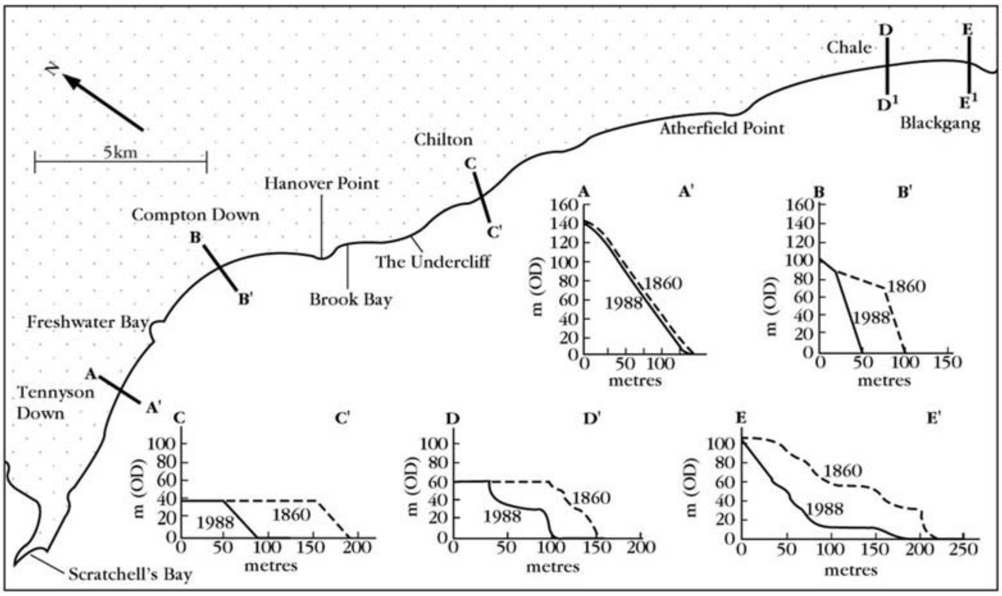

Figure 4.15: Variations in the rates of cliff retreat from Blackgang to the Needles (to the west of Scratchell's Bay), Isle of Wight. Cliff profiles for sections A to E are shown. (After Hutchinson, 1984.)

The cliffs vary in height from about 15 m in Brook Bay to over 145 m at Tennyson Down. At Freshwater Bay, the former Yar Valley is truncated and coast protection works have been constructed, but elsewhere interference with the beach system and its feeder bluffs has been negligible. The structural impact of variations in dip and rock strength is well exemplified in the stacks at Freshwater Bay and the Needles, as well as in the differential erosion of the Chalk itself along Tennyson Down.

Platforms are poorly developed on the Chalk coast, the cliff foot being masked by extensive boulder accumulations. However, parts of the coast intersecting the Greensand and Wealden strata have large platforms, for example at Hanover Point, whose seaward extensions affect wave refraction locally. This is one of six major south-west facing beach systems in the English Channel. It is distinctive by reason of its rapid retreat and the differential feeding of sediment to it, as well as a limited flint content. Flint is important only on the beach between Atherfield Point and Blackgang where major landslides feed the beach. The Chalk cliffs in the north are very slow to change; they feed very small quantities of flint into the beach, except at Scratchell's Bay and on the northern side of Tennyson Down.

Research has focused on the cliff processes, with increasing emphasis on the landsliding (Lyell, 1835; Steers, 1946a; May, 1964; Hutchinson, 1965, 1987, 1991; Hutchinson *et al*., 1981; Barton, 1990, 1991; Clark *et al*., 1993; Bromhead *et al*., 1991; Chandler, 1991; Hutchinson, 1991), and the development of chines (Englefield, 1816; Lyell, 1867; Bristow, 1889; Bury, 1920; Cotton, 1941; Steers, 1953a; Flint, 1980, 1982).

Description

The site can be divided into eight sections (Figure 4.15), as follows.

1. St Catherine's Point to Blackgang Chine, forming the western part of the Undercliff, which

rises to over 180 m in height. The steep upper cliffs comprise mainly Upper Greensand, underlain by Gault Clay and Lower Greensand, all dipping gently to the south-east. There have been many large landslides (Hutchinson, 1965).

2. Blackgang Chine to Atherfield Point. Cliffs that are undergoing very active erosion at the eastern end give way westwards to steep fairly stable cliffs in the Ferruginous Sands. Two chines break the cliffline. This is the only substantial fringing flint-shingle beach within the site.

3. Atherfield Point to The Undercliff (Brighstone Bay) is dominated by active cliffs in the Atherfield Clay and the Wealden beds. The rate of cliff retreat has been estimated at greater than 1 m a^{-1} (May, 1964). Chines are distinctive features both here and in the next two segments of the coast.

4. Brook Bay, which is cut mainly into the Wealden Marls (Wessex Formation). Its eastern side is marked by an undercliff of slipped blocks up to 7 m thick known as ‘Roughland'. On its western side, the cliffs are about 16 m in height. The dip of the strata is to the south.

5. Hanover Point to Freshwater Bay. The cliffs vary in height from about 15 m at Hanover Point to over 80 m at Compton Down. The dip is towards the north and so there is a gradual transition from the Wealden Marls and Shales (Wessex and Vectis formations) through the Lower Greensand to the Chalk at Compton Down. This is a very active coastline and the coast road at Compton Down is so seriously threatened that complete realignment has been considered (Barton, 1990). Chalk from the eroding cliffs is transported south-eastwards towards Hanover Point, but is virtually absent within 1 km of the Chalk cliffs.

6. Freshwater Bay forms a small semi-circular bay between relatively resistant Chalk headlands. Stacks and caves have formed on either side of the bay, but erosion of considerably altered chalk along the former valley side as well as the risks of flooding of the Yar Gap have led to the construction of a sea-wall within the bay. There is a small beach of flint shingle, much of which is angular or subangular.

7. Tennyson Down (South) is formed entirely of high, steep, Chalk cliffs rising to over 140 m. There is a very narrow beach mainly of boulders and cobbles, and falls of rock appear to occur only occasionally. However, much of the cliff top is deeply broken by large tension cracks and extensive falls could occur at any time.

8. Scratchell's Bay to Alum Bay includes the world-famous stacks of ‘The Needles' (Figure 4.16). As well as their aesthetic appeal, they have been widely reported in the literature as being of interest geomorphologically. For example, Lyell (1835) reported falls of some of the pinnacles in 1764 and 1772, and Huxley (1884) included a sketch of them. Scratchell's Bay to the south has a narrow beach of flint and chalk shingle, but there is limited beach development along the northern side of Tennyson Down. This is, however, a very active Chalk cliff, up to 100 m in height, which continues inland at the southern corner of Alum Bay. This part of the site demonstrates well the contrast between the purely sub-aerial products of erosion of the non-marine cliffs and the combined marine and sub-aerial product of the sea cliffs to the west.

Figure 4.16: The Needles and Scratchell's Bay, Isle of Wight, with narrow flint and chalk beach fed by contemporary rockfalls. (Photo: J.E. Gordon.)

Interpretation

The following aspects of the coastline have attracted specific attention in the geomorphological literature.

1. the rapidity but differential nature of cliff erosion;

2. the landslides;

3. the development of the chines;

4. the sources and transport of sediment (Figure 4.17).

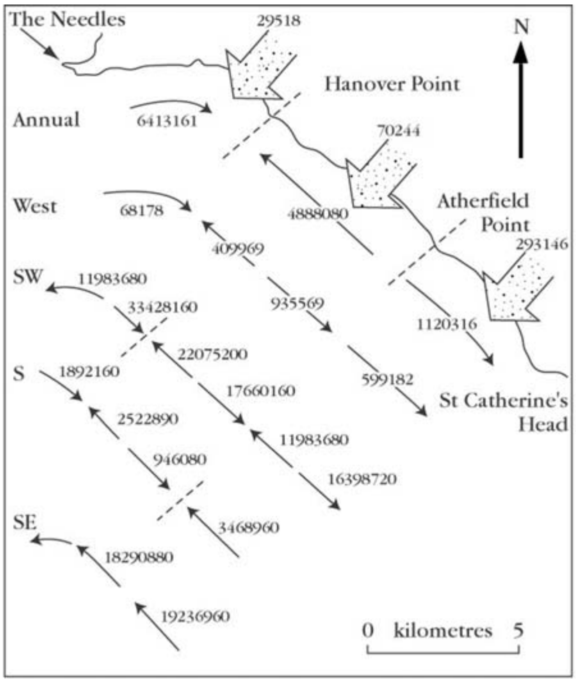

Figure 4.17: Sediment inputs from cliff retreat (m3 a–1) annual longshore potential sediment transport and variations with wind direction. See text for explanation. Total sediment input = 392 908 m3 a–1 (After Davies, 1997.)

The rapidity and diversity of erosional processes around the coastline of the Isle of Wight is especially well demonstrated along its south-western coast. May (1964) summarized the main features and estimated that rates of cliff retreat during the previous 100 years ranged from 0 to more than 2 m a^{-1}. The resistance of the intertidal area and the cliff foot to erosion are particularly significant, for it can be shown that the more resistant layers (such as the Perna Bed hard band and the 'Pine Raft' at Hanover Point) not only form platforms but also reduce rates of cliff retreat. Thus headlands have formed at Hanover Point and Atherfield Point where the cliffs are formed in materials that are intrinsically weak. Their existence as headlands owes much to the greater relative resistance of the cliff foot and intertidal platforms. Much of the cliff consists of easily eroded materials, and so variations in the resistance of the cliff foot or platforms associated with these slightly harder bands play a very important role in the overall outline of the coast.

Hutchinson (1965) reconnoitred the documented landslides of the Isle of Wight indicating that this site contained 13.5 km affected by rockfalls, 0.6 km affected by seepage erosion, about 4.25 km affected by base failures, and 5.5 km affected by slope failures and mud-flows (Figure 4.18). Only 5.1 km comprised relatively stable, soft rocks. The main concentration of base failures occurs at the eastern end of the site around Blackgang (Figures4.18 and 4.19). The largest landslide recorded in the Isle of Wight took place in February 1799 when about 40 ha subsided by as much as 10–12 m (Anon., 1887; Cooke, 1808; Webster, 1816). Hutchinson (1965) regarded the movement, known as the 'Gore Cliff landslip', as a renewal of movement in the ancient failed mass forming the Undercliff. The slide has been affected by several subsequent movements. Colenutt (1928) described a large toppling failure at Gore Cliff that blocked the road. Hutchinson (1987) suggested that the continuing severe toe erosion, the narrowness of the Undercliff and the opening of joints behind Gore Cliff, indicate that a period of renewed regression was approaching. Bromhead *et al*. (1991) showed that the 1978 landslide was the most recent in a series that had affected the coastline between Rocken End and Blackgang Chine during the last 200 years. It had a basal slip surface controlled by bedding about 18 m above the base of the Gault Clay and re-activated earlier slides. The large landslides that form the Undercliff result from the interaction between marine erosion initiated during the Holocene transgression and the seaward-dipping synclinal structure and detailed lithology of the Cretaceous rocks (Hutchinson, 1991).

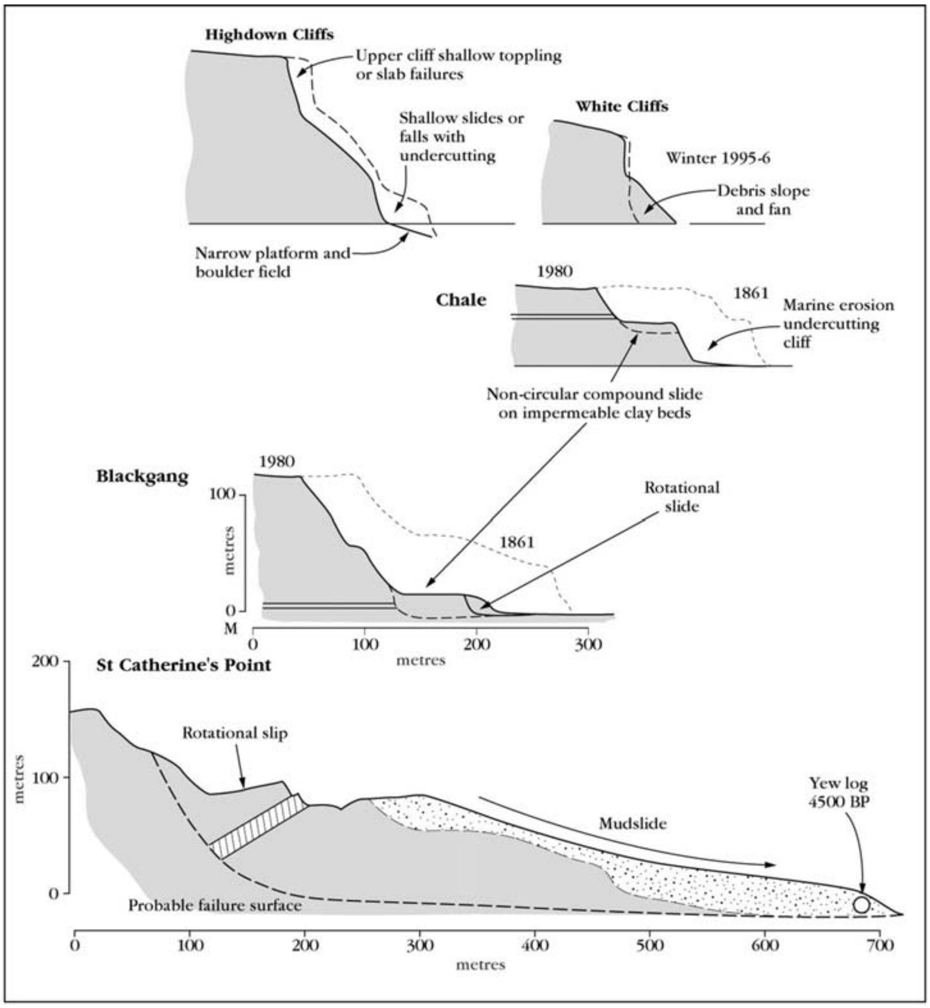

Figure 4.18: Differences of failure in the cliffs of south-west Isle of Wight, ranging from large rotational slides to shallow failures. (After Hutchinson, 1984.)

Figure 4.19: Characteristic slope failures at Compton Down, looking west, showing shallow slides in chalk rock. (Photo: V.J. May.)

To the north-west, seepage erosion appears to have been most important in giving rise to benches in the cliff profile. Fitton (1847) suggested that less permeable beds within generally more permeable strata would encourage water from these beds to undermine the cliff. As a result, the cliff is characterized by an upper active cliff, a bench and a lower sea-eroded cliff. The upper cliff and the sea cliff retreat at different rates, and the rates of recession trebled from the 19th to the 20th centuries. Hutchinson *et al*. (1981) and Hutchinson (1987) describe the processes in detail, as follows. The upper scarp of the Ferruginous Sands cliff at Walpen collapses as a result of seepage erosion in fine layers in the Foliated Clay and Sand. The resulting debris moves across the undercliff bench, usually obliquely, by compound slides and by rotational slips in its seaward edge. Mudslides and stream action also carry debris across the undercliff. As the bench surface dips below sea level towards the south-east, the bench is broken by deep-seated base failures.

North-westwards from Atherfield Point, the cliffs are marked by many slides, some shallow, others more deep-seated and giving rise to ‘staircases' of slipped blocks, but they have received rather less attention in the geomorphological literature than the cliffs around Blackgang. The cliffs towards Alum Bay also warrant much fuller examination, not only because of the threats to roads at several points, but also because there is considerable evidence in the cliff-top tension fissures, particularly on Tennyson Down, that major cliff failures could occur (Figure 4.21). At Compton Down, the chalk cliffs are undergoing more active erosion than any other part of the chalk section of this coastline. Cliff failure occurs in massive units that give rise to open fissures behind the cliff edge (Figure4.20; Barton, 1990).

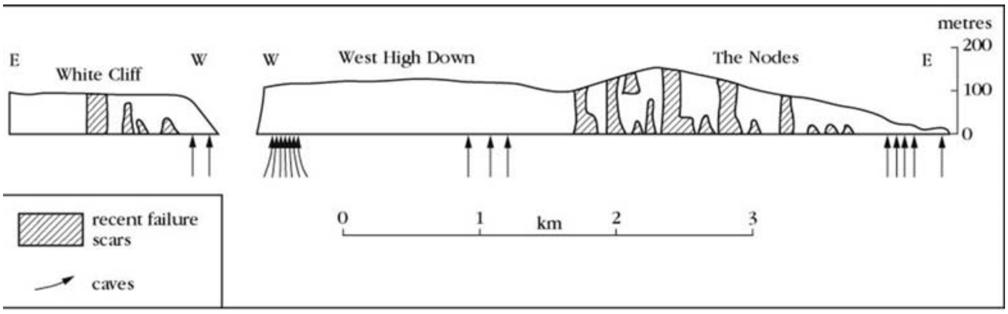

Figure 4.21: Cliff-face failures west of Freshwater Bay. (Based on British Gas aerial survey, February 1996.)

Figure 4.20: View looking east from Compton Down where chalk pebbles typically survive for little more than 1 km owing to their erosion during longshore drift. Well-developed cusps commonly characterize this beach. (Photo: V.J. May.)

Explanations for the origins of the chines range from landsliding (Lyell, 1867), enlargement after rainfall (Gardner, 1879), wind erosion (Englefield, 1816), and spring-sapping (Bristow, 1889). Bury (1920) concluded that they were formed recently, but did not suggest their probable age. In his view, where the rate of headward erosion was faster than that of cliff retreat the chines were lengthening. The valley-within-a-valley form he attributed to the role of much larger volumes of water forming the upper open valleys whereas the chines were the result of present-day conditions, the size of the chines being a function of their present-day small streams, which misfit the larger upper valleys. He argued that the different levels were a result of changes of sea level, a view supported by Steers (1953a). Flint (1980, 1982) concluded, in contrast, that they are a function of basin characteristics (stream power and geology) and cliff retreat-rate, not the result of cliff retreat alone. The critical drainage basin area for the maintenance of a base-levelled chine varies with rock type. In sands, this area is about 2.5 km^2, in marls 0.64 km^2 and in shales greater than 0.73 km^2. Below these values, stream power decreases, waterfall height increases and the chine is removed by cliff retreat

(Flint, 1980). Landsliding is not a primary agent in initiating chines. Flint (1980, 1982) refuted Bury's (1920) view that the different levels of the chines were due to sea-level changes alone.

Because of the variety of beds, the sources of beach material can often be identified comparatively easily. Apart from Scratchell's Bay, there is no part of the Chalk coastline that has a beach composed solely of flint and chalk shingle. Elsewhere, the beach is minimal or is mixed with shingle and larger material derived from the Lower Greensand. From Compton Down, chalk pebbles indicate a transport direction towards the south-east, but are virtually absent 1 km downdrift from the cliff. Most beaches along the Wealden coastline are sandy, but contain varying amounts of shingle and clay depending on their relationship to the chines and landslides. Most beach material appears to be locally derived and recently produced. East of Atherfield Point, however, the beach is formed of flint shingle. There has been no detailed investigation of the sedimentological characteristics of this anomalous beach. Possible sediment sources to the south-east, but longshore transport has normally been described as being from north-west to south-east. However, Davies (1997) has shown that under south-westerly waves there are three sediment-transport cells with little exchange between them. In contrast, under easterly waves, there is net movement alongshore towards the west (Figure4.17). The bulk of the material entering the beaches is fine-grained sand or clay, and much is transported away from the beach in suspension. There is a marked lack of shingle to the west of Atherfield Point, which acts as a groyne to westerly movement. Alternatively, this beach may represent part of a former larger beach system that extended throughout Brighstone Bay at an unkown distance offshore. Hutchinson (1987) showed that the foot of the Undercliff at the eastern end of the site includes a former sea cliff and platform probably related to a period of relative sea-level still-stand about 7500 to 8000 BP. A period of active landsliding occurring about 4500 BP protected this feature. Of particular interest is the suggestion that the shoreline position at the eastern end of the site was not different from that of today, but with sea level perhaps as much as 7 m lower. The western Yar was already open to the sea, having been cut to a depth of at least –13.4 OD (Nicholls, 1987) during the Pleistocene Epoch.

The south-western coastline of the Isle of Wight stands apart from the other south-west-facing beaches of the English Channel in the rapidity of its retreat (Figure4.17). Although within broadly the same wave conditions as the Seven Sisters in East Sussex, both the mechanisms and the coastal plan of the south-west Isle of Wight differ as a result of the variety rock types and their different responses to sub-aerial and marine processes. Another key difference is that whereas the Seven Sisters display a more-or-less uniform rate of retreat over the 100 year timescale, the south-west Isle of Wight cliffline has retreated at varying rates that have accentuated coastal crenulations rather than reducing them. Finally, the Isle of Wight site can be regarded as the type area for chines in sands and clays, for they are well-developed common features about which a considerable amount is known.

This site is the best example in Britain of a coastline that cuts across an anticline in relatively weak geological materials. Erosion follows the core of the Brighstone anticline, but the variations in rock strength exposed in the cliff and foreshore have produced considerable differential erosion. The importance of the site lies mainly in the range of responses to erosion in different lithologies within the larger scenario of a shoreline that is strongly controlled in its general outline by the dominant south-west wave regimes. In contrast to the coastline of east Dorset, which is either clearly longitudinal (around Lulworth) or has a strong headland–bay pattern (the transverse coast around Swanage), this coastline is one where headland–bay topography is slight, but retains similar amplitudes as it retreats at comparable rates throughout its length.

The relationship between the old landslides at the Undercliff and former shorelines gives this site another distinctive feature. The resistance to erosion of the exposed southern side of Tennyson Down contrasts strongly with the much more sheltered northern side of the headland and demonstrates very well the importance of both structure and lithology. This also deserves more detailed investigation, because of its relationship to sediment supply and the potential for catastrophic change to the southern cliff.

The lack of large-scale anthropogenic interference with the coastal processes makes this site particularly important for investigation of the links between cliff retreat and beach development, especially since the different lithologies of the retreating cliffs provide natural markers for examination of longshore transport processes.

Conclusions

The south-west coastline of the Isle of Wight is dominated by cliff and beach features related to the south-westerly wave climate of the English Channel, but also demonstrates well the effects of differential erosion both where rock-types change and where coastal retreat outstrips the erosional ability of coastal streams. The site includes the Needles and extends from the Chalk of Tennyson Down in the west to the Lower Greensand cliffs of Blackgang Chine in the east. There are rapidly retreating cliffs, well-developed cliff-foot beaches and steep-sided valleys (the chines). This is the type area for chine formation. Differential erosion in relatively weak rocks is affected by more resistant bands, except at the extremities of the site where the Undercliff overlies an older shoreline in the east and the stacks of the Needles and the high cliffs of Tennyson Down resist erosion. Although not as well-recognized internationally as the very active landslide coast east of Lyme Regis, this coast contains examples of all the soft rapidly retreating coastal types that occur in Britain and parts such as the Undercliff are renowned internationally. It is one of the best examples of a coastline that cuts across a major anticline in generally weak materials.

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