KINGSDOWN - DOVER

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Introduction

The cliffs between Kingsdown and Dover (see Figure 4.1 for general location) show an excellent example of structural controls on coastal cliff-form. These cliffs, broken only by the deep valley and bay at St Margaret's, rise to between 30 m and 110 m OD. Retreat of the cliffs has been about 0.2 m a^{-1}, but this takes place mainly as large slides affecting the whole cliff face. A well-developed platform extends to below low-tide level. Beaches are formed mainly of clasts of rounded chalk and a mixture of rounded and angular/unrounded flint. Little evidence now remains of a former fringing beach that extended from Dover to Kingsdown. The present beaches depend upon the contemporary erosion of cliffs and platforms. When major cliff-falls occur, boulder-sized debris usually forms a protecting rampart with the smaller chalk cobbles and flints being added to the beaches (Figure 4.22).

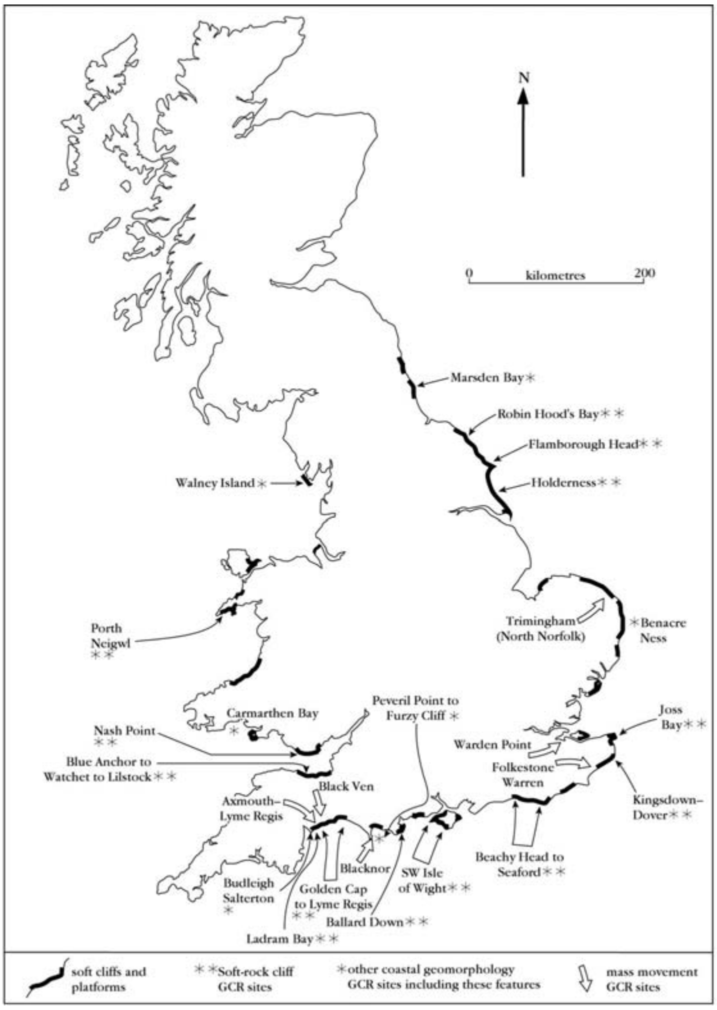

Figure 4.1: Location of significant soft-cliffed coasts and platforms in Great Britain, indicating the sites selected for the GCR specifically for soft-rock cliff geomorphology. Other coastal geomorphology sites that include soft-rock cliffs and sites selected for the Mass Movements GCR 'Block' that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

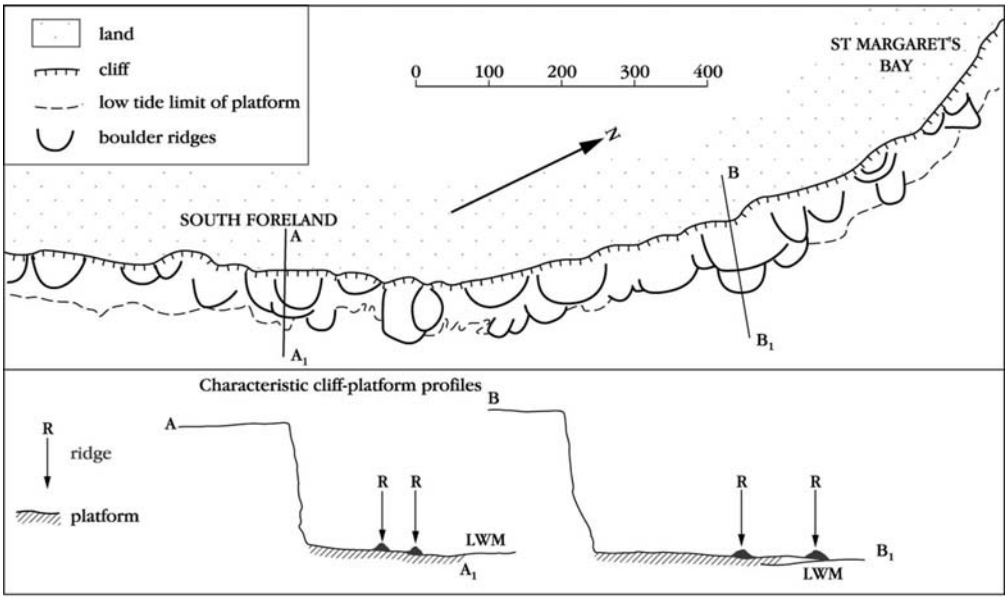

Figure 4.22: Sketch map of boulder ridges, South Foreland to St Margaret's Bay within the Kingsdown to Dover GCR site. Characteristic cliff-platform profiles through A–A1 and B–B1 are shown in the lower part of the diagram.

Research on the Kingsdown to Dover site has focused on the nature and processes of cliff retreat (May, 1964; May and Heeps, 1985; Hutchinson, 1980, 1983; Birch, 1990; Leddra and Jones, 1990) and the relationship between cliff-form and major structures in the Chalk (Middlemiss, 1983). Like many such cliff sites, it is referred to bySteers (1946a) and Bird (1984). Comparable surveys have been made of other Chalk cliff sites in England and Wales (see GCR site reports for Flamborough Head, Joss Bay, Ballard Down and Peveril Point to Furzy Cliff) and on the Normandy coast (Precheur, 1960).

Description

The vertical cliffs between Dover and Kingsdown are currently undergoing the most active change in England and Wales. They are cut through the Upper Chalk of the*Micraster cortestudinarium* and *Micraster coranguinum* biozones. Unlike the high Chalk cliffs at Beachy Head, for example, they are generally a simple near-vertical face up to 110 m in height. Erosion rates have increased in recent decades. Cut across the eastern end of the North Downs, their height reflects mainly the gradual slope of the Chalk landscape towards the north-east. Thus, between Dover and St Margaret's Bay the cliffs reach heights of 110 m, although at the Dover end of the site they also have lower faces where the cliffs are cut into coombs such as that at Langdon Bay. North of St Margaret's Bay, the alignment of the cliffs is closer to that of the strike and so they reflect more closely the dip of the Chalk surface, falling gradually to a height of about 30 m at Kingsdown.

Middlemiss (1983) describes the relationship between the structure of the Chalk and the failures of the cliffs. Between Kingsdown and the windmill at South Foreland, 300 measured joints fall into four main groups.

1. Striking at about 300°: major strike joints.

2. Striking at about 205° to 210°, dominantly vertical or very steeply dipping: tensional dip joints complementary to the first group.

3. Striking at 205° to 210° with dip angles between 50° to 70°, and

4. Striking at about 280°.

Middlemiss demonstrated that cliff-form corresponds both in plan and profile with the attitude of the jointing. Group (1) and (4) joints that are roughly perpendicular to the coastline in plan view are often important as the sites of caves and minor changes of the cliffline (e.g. Ness

Point and White Fall). Almost every length of the cliffline is related to at least one group of joints, with groups (2) and (3) dominant (Figure 4.23).

Figure 4.23: View looking north of St Margaret's Bay, Kingsdown to Dover GCR site. (A) Small, fringing beach of flint, mostly derived from recent cliff falls; movement alongshore is restricted by fall debris; (B) large toe of a slide extending beyond low-water mark; (C) cliff being eroded where previous rock fall has been completely removed; (D) vegetated slope that developed behind a former slide toe and debris; these features then protected cliff-foot bedrock from erosion; (E) typical upper cliff profile above debis slopes. (Photo: V.J. May.)

To the south of South Foreland, there has also been a number of large falls in recent years, where the cliffs turn increasingly towards the west. The Chalk is greatly jointed but the cliff patterns have not been described in the same detail as those in Middlemiss's paper. Where recent falls are absent, the cliff has a basal notch and a very steep profile (Figure 4.24). The platform in these areas is free of small chalk debris, but has small pockets of flint, both rounded and angular, the latter derived directly from the platform. Platform surfaces are generally of two types. The first of these is co-incident with tabular flint horizons in the Chalk and follows their dip so that flint forms the surface of the platform. The second type is steeper, lacks a flint surface and cuts directly into the Chalk. Both types of platform are dissected by sub-parallel channels up to 0.4 m in depth. There is considerable biological activity in the erosion of the platforms, with borers such as piddock *Pholas* spp. riddling the surface layer to depths of several centimetres. Substantial lengths of the site, in contrast, have platforms that are cloaked by debris. This is often boulder-sized and sufficiently stable to carry a cover of algae. Much of the large debris is derived from frequent rockfalls that affect this coastline.

Figure 4.24: Langdon Bay. (a) Boulder rampart residue from earlier debris tongue; (b) in the foreground, talus from a clif failure is seen; in the background, residual boulder fields from flow-type failures are present; (c) parallel ridges bounding a large flow-failure that left the platform comparatively clear of large debris. (Photos: V.J. May.)

Middlemiss (1983) identified four main areas north of South Foreland where falls have been particularly frequent:

1. South Foreland (TR 363 434) and the cliff immediately to the north-east. The structure of the cliff is determined by three sets of joints striking at 303°, 233° and 202°.

2. At Leathercote Point (TR 374 451) and for about 300 m northwards to The Cut (TR 375 454), where master joints striking at about 301° and 232° are the major factors.

3. At White Fall (TR 378 457), where two small faults, striking at about 301° with a throw to the north of about 1.5 m, are intersected by a major joint striking at 232° and dipping at 70° to the south-east. Middlemiss suggested that the presence of about a 1.5 m thickness of calcareous downwash at the top of the cliff may be a contributory factor here.

4. East of Hope Farm (TR 376 462) and for 400 m northwards, where major joints determine the structure of the cliff. An additional set of joints striking at about 342° affect the outline of an embayment (TR 379 465). The valley bottom deposits of Hope Farm Valley, some 2–3 m of residual gravel and calcareous downwash, which not only cap the cliff but also fill several large solution pipes, may play a contributory role.

At the northern end of the site, joint-controlled channels cut into the platform are filled by angular flint and chalk mixed with rounded, oxidized, flint shingle together with shelly fragments in a chalky matrix. This is characteristic of the deposits occurring beneath chalk debris fans that preserve, albeit temporarily, the existing beach sediments beneath. The chalky matrix comprises the fine-grained materials at the base of the fall and may include fines that have washed through the debris above or have been derived by erosion of the overlying debris. These deposits are spatially associated with the remnants of a large talus fan at the cliff foot that has mostly been destroyed. Although the sub-debris sediments are normally ephemeral, their presence emphasizes the variability of sources for the beaches.

Interpretation

The rate of retreat of these cliffs is moderate, but in recent years retreat has accelerated.May (1966) reported the average cliff-top retreat over a period of 84 years from 1873 to 1957 as 6 m between St Margaret's and Kingsdown, and 16 m between St Margaret's and Dover.May (1971a) expressed cliff-top retreat at South Foreland as about 0.19 m a^{-1} between 1817 and 1962. Hutchinson (1972) compared chalk falls on the Kent coast in general between 1810 and 1970 with the number of days with air frost and effective rainfall. Falls tended to co-incide with, and to follow, periods of maxima of air frost and to follow periods of maximum water surplus. Bird and May (1976) stated that between Dover and Walmer there had been intermittent recession of the cliffs by rockfalls, which occur most frequently during the winter and are associated with periods of high average numbers of days with air frost.May (1964) described a state in which large falls produced extensive debris slopes that were sufficiently long-lived to develop a stable vegetation of chalkland grasses and coastal plants. The debris survived for several decades, sometimes in excess of 50 years. However, such longevity of debris no longer appears to be the case. Almost without exception the cliffs fall abruptly to a distinct junction with a platform, which is about 200 m in width. Where present, the beach is narrow and formed of rounded chalk and both rounded and angular flint. There is no evidence, apart from in the northernmost part of the site, of the once-continuous fringing rounded flint shingle beach described by Austen (1851). The construction of the harbours at Dover and Folkestone during the second half of the 19th century prevented any continuing supply from the south-west. Hutchinson *et al*. (1980) recorded the links between this interruption to the littoral drift and major changes at Folkestone Warren, but there has been no comparable record for the coastline east of Dover except at the northern end of the site. The effect has been less dramatic but no less important. Furthermore, the construction of groynes at St Margaret's and the former Royal Marines firing range at Kingsdown virtually prevent any supply of flint from the erosion of the present-day cliffs to reach the beaches at Walmer and Deal. The site is thus characterized by reduction in a protective lag deposit of flint shingle and depends for its basal protection entirely on the contemporary products of cliff-falls. These are now insufficient in volume to provide other than localized protection since much of the Chalk is dissipated by attrition. Residual boulder arcs reduce wave energy but do not provide the cliff foot protection that the 19th century beaches previously offered.

Two main processes promote the instability in these cliffs, namely wave action along the master joints, and the effects of percolating water within the joints. The latter effect is accentuated, according to Middlemiss, where residual gravel and calcareous downwash form the cliff top, as reservoirs for percolating water. The tendency for falls to follow periods of hard frost suggests a combination of mechanisms for the falls. Water freezing in these zones exerts pressure through its expansion. Alternatively, pressure is exerted by the ponding of groundwater in a joint behind a plug of ice.

Hutchinson (1980, 1983) showed that as cliff height and slide volume increase, a ‘degree of flow' appears in the debris. In falls from the higher cliffs (70–150 m), a ‘chalk flow' can occur, which may carry debris for distances in excess of four times the height of the cliff across the near-horizontal shore platforms. Hutchinson's working hypothesis was that these flow slides occur because high pore-water pressures were generated through the crushing impact of relatively weak blocks of high-porosity, near-saturated, chalk.Leddra and Jones (1990) show that steady-state flows can result from rapid or undrained loading of the Chalk, with the result that debris from high chalk cliffs can flow for considerable distances. The debris produced by cliff-falls, such as those described by Hutchinson, varies in size from fines to boulders over 1 m across. The fines are quickly dispersed by wave action and longshore currents. Shingle-sized debris is commonly rounded within a few days and is worn down to sand-sized fragments over a period of several months. It is often too mobile to attract algal growth. The larger material, however, remains *in situ* for very long periods of time and becomes colonized by algae and molluscs. While these boulders gradually diminish in size, the platform retains a substantial cover, commonly for many years. One fall in 1982 produced a fan of debris across the platform from which much fine debris was quickly removed; the main boulder pattern remains today. On one 1500 m length of the cliffs south of St Margaret's Bay, some 30 residual arcuate forms have been identified (Figure 4.24).

Kingsdown to Dover is an important coastal geomorphology GCR site because it demonstrates:

1. the role of structure in controlling cliff development in a site undergoing comparatively rapid erosion;

2. the significance of relict beaches in retarding recent cliff development;

3. the limited present-day sediment supply from the flint-rich Chalk;

4. the role of cliff-fall debris in modifying the form of the platform and controlling the wave refraction;

5. the role of structural features in affecting platform morphology and the role of flint layers;

Conclusions

At Kingsdown to Dover, vertical cliffs in the Chalk undergoing active erosion rise above well-developed intertidal platforms. Beaches are mainly contemporary in origin and depend upon frequent rockfalls. Boulder ridges occur on many platforms and mark the former extent of cliff-falls. The site is distinguished by the rapidity and nature of the changes within it, and by the relatively simple morphology of the cliffs and platforms. This is an important cliff site that demonstrates well the role of structures in controlling cliff development. This geomorphologically active site is important for understanding the nature of cliff failure and its effects upon platform development, and unlike many similar cliffs it can be shown to have become much more active during the past 100 years as the supply of shingle from the west and the residual protection from the older beaches has diminished. Unlike other Chalk cliff–platform sites, it has a large and active sediment supply but much of the platform is cloaked by boulders that affect wave-energy distributions. Internationally, this is one of a very small number of near-vertical cliffs that have been investigated in some detail. It is also potentially very important for understanding the links between cliff erosion and the supply of sediment to adjacent beaches.

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