WEST COAST OF ORKNEY

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Introduction

High-cliff coastlines are a feature of much of the Atlantic coast of the Orkney Islands. The 20 km stretch of cliffs between Rora Head, at the south-west tip of the island of Hoy, and the Hole o'Row, mid-way along the exposed west coast of the Mainland (see Figure3.1 for general location and Figure 3.11), provide some of the best examples in Europe of Old Red Sandstone cliffs and associated features. Lithology and structure are major geomorphological controls and the cliffs and associated forms of west Orkney are good examples of the control exerted by geology on coastal landforms. The rich variety of cliff and cliff-related forms along this coast include steep and overhung profiles; sea-stacks; arches; caves; geos and shore platforms, all reflecting the dominant geological control of horizontally bedded, fractured and faulted, sandstone and flagstone.

Figure 3.1: High-cliffed coast of Great Britain, showing the location of the sites selected for the GCR specifically for coastal geomorphology features of hard-rock cliffs. Other coastal geomorphology GCR sites that include hard-rock cliffs in the assemblage are also indicated.

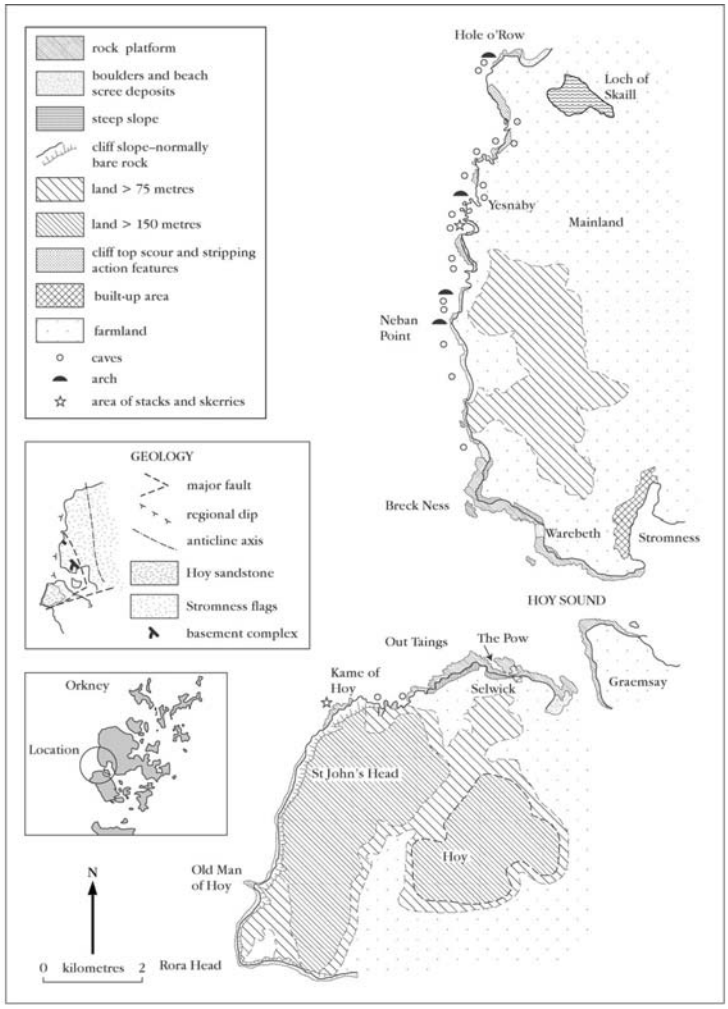

Figure 3.11: Coastal features of the West Coast of Orkney. Erosion of the Hoy Sandstone and Stromness flags (inset) has produced an impressive coast of steep cliffs, caves and stacks. (Modified from unpublished work by W. Ritchie.)

The most characteristic feature of the Orkney climate is the frequency of strong winds. The prevailing winds are from between west and south-east for 60% of the year. Winds greater than 8 m s^{-1} occur for over 30% of the year and gales occur on average for 29 days per year. Along the south-west coast of Hoy, a combination of deep open water and exposure to prevailing winds produces a high-energy wave climate. Within Hoy Sound, conditions are more sheltered, especially from the north and south-west but on the outer coast of Mainland and Hoy during westerly and northerly storms, wave conditions are more severe. Because the sea floor falls steeply away from the west to 60 m, the coast is exposed to relatively high wave energies. Spring tidal range in the western Orkney Islands is 3 m (UKDMAP, 1998).

As with much of the hard rock upland coast of Britain, there have been few detailed geomorphological studies of the Orkney coastline. Nevertheless, the nature of the cliffs and associated features have been described in more general terms (Steers, 1973; NCC, 1978) and Hansom and Evans (1995) have examined the nature and development of the famous sea stack called the 'Old Man of Hoy'.

Description

The GCR site has three main sub-units (Figure 3.11):

1. The west coast of Hoy, from Rora Head to Kame of Hoy.

2. The north-west coast of Hoy, from Kame of Hoy to The Pow.

3. The west coast of Mainland, from Breck Ness to Hole o'Row.

The cliffs from Rora Head to Kame of Hoy are high, steep, and in places, vertical. The highest cliffs occur in the north at St John's Head, but no part is less than 50 m high. A narrow (40–70 m-wide) intertidal shore platform, with a cover of fallen boulders, is a common feature along much of this stretch of coast. The Old Man of Hoy, one of the tallest and most spectacular sea stacks in Britain (Figure 3.12) towers 137 m above the sea surface yet is only a few metres wide at the top. Its sides are composed of vertical or overhanging walls that fall sheer on all sides. The pinnacle itself is separated from the adjacent cliffs by a 60 m-wide chasm whose base is strewn with debris, which presumably has fallen from a collapsed arch (Hansom and Evans, 1995).

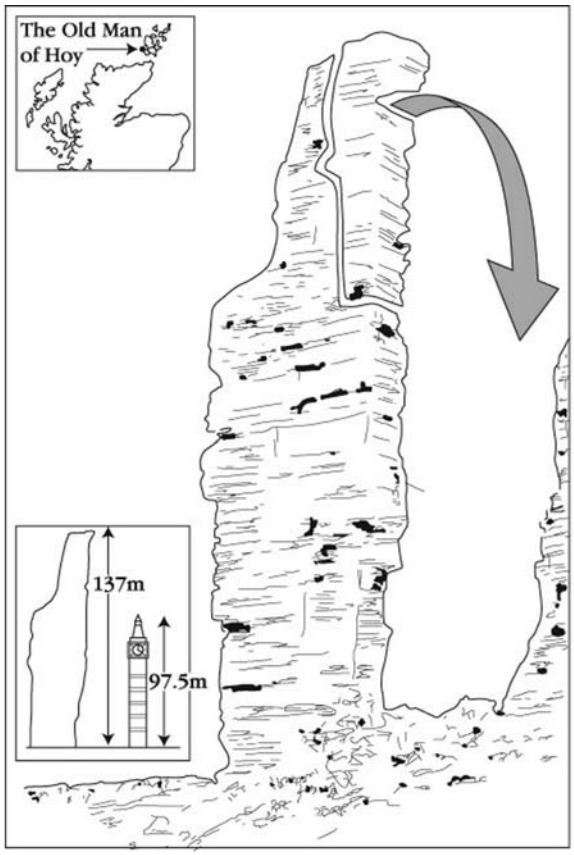

Figure 3.12: The Old Man of Hoy, West Coast of Orkney, showing incipient failure cracks. London's 'Big Ben' is shown for scale in the inset. (After Hansom and Evans, 1995.)

To the north of the Old Man, the cliffs of St John's Head rise vertically to 335 m. The rock is composed of alternating beds of relatively soft, sandy and pebbly sandstone with occasional beds of harder grey flagstone, bestowing upon the cliffs a slab-like, notched and often overhung profile. These variations in hardness, the near-horizontal bedding, combined with the multiple joints, cracks and faults common in sandstones and flagstones are important factors explaining the spectacular vertical cliffs, caves and stacks of this coastline. The cliff forms are dominated by blocky shapes and cut by deep steep-sided geos and ravines that often bisect headlands. Weathering has etched out vertical chasms in the cliffs along joint planes and near Kame of Hoy the coastline is extremely rugged with many minor sea stacks and inlets. Near the Old Man, a few near-horizontal platforms have been cut into the sandstone, but elsewhere the shore platforms are gently sloping at 10–20°.

The north-west coast of Hoy between Kame of Hoy and The Pow is a transitional coastline, between the high cliffs at Kame of Hoy and the lower, north-facing cliffs with platforms at the north-east of the island. The 1.1 km stretch east of the Kame contains some of the steepest coastal slopes in Orkney and there are excellent examples of high plunging cliffs with no shore platforms. This zone also marks the junction between the Old Red Sandstones to the south and the grey Caithness Flagstone Group to the north. These flagstones consist of rhythmic sequences of thinly bedded siltstones, shales and finely laminated sandstones and so, apart

from the stretch of high cliffs east of the Kame, most of the remaining coastline towards The Pow consists of low cliffs, degraded terraces ranging from*c.* 5–10 m high, and some well-developed shore platforms, particularly at the Taing of Selwick. At Selwick, the rocks dip to the west, imparting to the 60 m-wide shore platform a well-defined ribbed appearance where the eroded fronts of the beds run north towards the water's edge. Numerous small-scale intertidal fissures and cracks have been excavated by the waves, some have been abraded by boulders and many of these have become lodged in fissures in the shore platform. The lower-lying areas of shore platform have become buried by accumulations of sand and gravel, for example at The Pow.

The west coast of Mainland between Breck Ness and Hole o'Row consists of a dramatic series of almost vertical cliffs reaching up to 60 m in height, within which the effects of erosion are well developed, with a great variety of geos, caves, arches, stacks and cliff forms. The underlying geology is the Caithness Flagstone Group but some basement granitic and gneissic rocks outcrop as inliers, the largest of which lies to the south of Yesnaby. This stretch of coast is typical of Orcadian cliffed coastline, in detail highly irregular but, in general, lacking substantial embayments. The cliff tops are lower than on Hoy at between 20–60 m, but occasionally reach 100 m above sea level, particularly in the north where the coastline intersects the generally rising relief of the landward plateau. The cliffs are mainly vertical or overhanging with a distinctive notch at wave level where the flagstones have been quarried by waves. The notch is best-developed where narrow sloping platforms front the cliffs and allow broken waves to impact on the cliff foot, such as at Alga Bar and Brough of Bigging. On the lower cliff tops, wave spray erosion is well developed and many cliff top areas have been stripped of their soil and drift cover up to 40 m inland. Gravel is rare along this stretch of coast, except occasionally within the heads of geos and at Billia Croo, where a small gravel beach occurs.

In general the shore platforms are steeply dipping and narrow, tending to occur as projections from the cliff foot rather than as a continuous fringe along the coast. In detail the platforms are controlled by intertidal outcrops of relatively more resistant flagstone beds. In the steeply dipping strata, these present coherent intertidal ramps (30°) over which waves surge to finally break on the cliff. The intertidal shore platforms have smooth seaward ramp surfaces whereas the landward surfaces are stepped and crenulated. Excavation of these landward steps is often well-advanced enough to have resulted in separation from the original platform to form offshore skerries. In some places deep water extends to the foot of vertical plunging cliffs, for example at Black Craig.

The variety of geos, caves, arches and stacks that occur along this coastline tend to be triangular or rectangular in form, rather than slot-shaped, reflecting the cross-cutting joint and faulting pattern of the flagstones. The stacks and arches at the Castles of Yesnaby and Qui Ayre are rectangular in plan and are known locally as ‘castles' (Figure3.13). Both narrow towards the base where arches have been eroded. At Qui Ayre, the arch is so large that the roof appears unstable. Variations in lithology and geological structure again are major controls on the coastal landforms and the resultant differential erosion and exploitation of weaker strata, joints, fissures or dykes are responsible for much of the meso- and micro-topography. To the south of the Hole o'Row wave and spray erosion is both active and effective (Steers, 1973) on the cliff face and the base of the cliffs and spray and wind erosion is important at the top of the cliffs. In summary, this is an actively evolving cliff coastline that encompasses, in a relatively small area, a consistent suite of cliff-type features developed in a uniform sequence of sedimentary rock.

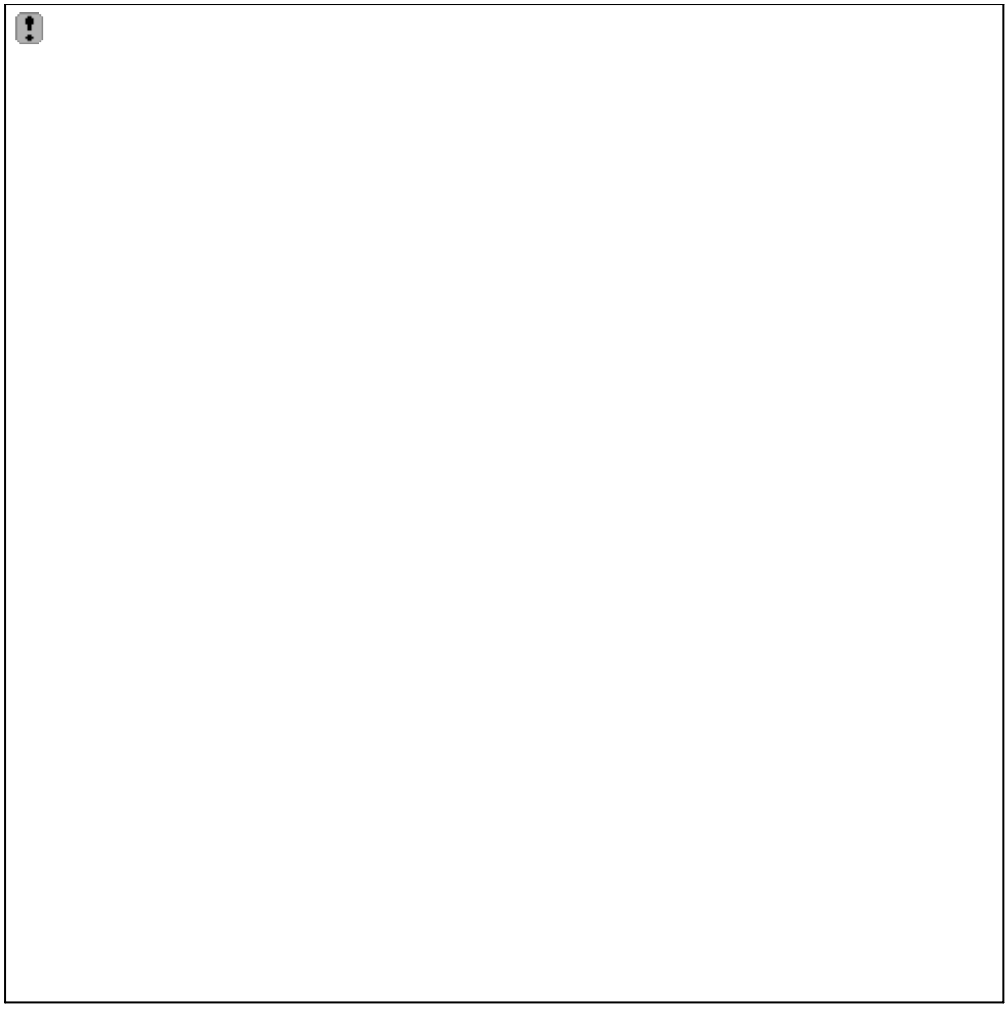

Figure 3.13: The spectacular arch at Qui Ayre, Yesnaby, West Coast of Orkney, is one of several arches and columnar stacks in the area in various stages of development. (Photo J.D. Hansom.)

Interpretation

In common with cliffs elsewhere in Scotland, the cliffs of Orkney are likely to be inherited features that have persisted over several changes in sea level (Sutherland, 1984; Hansom, 1988; Trenhaile, 1997). However, cliffs and stacks are also affected by present-day erosional wave processes, and features such as stacks are clearly ephemeral features (Hansom and Evans, 1995). There is no doubt that erosion is active on the west coast of Orkney (Steers, 1973; NCC, 1978; Hansom and Evans, 1995), however, the rate of erosion and thus the amount of cliff recession is unknown. The historical development of the Old Man of Hoy gives an insight into the rate and type of active erosional processes affecting these ancient cliffs. As late as the early part of the 19th century this famous stack had an arch on its landward side (Steers, 1973). The arch has since been lost and all that remains is a perceptibly thicker part of the column indicating where the arch was at one time attached.Hansom and Evans (1995) trace the historical development of the Old Man further. Maps dated*c.* 1600 and 1750 do not portray the Old Man as a stack but as a headland. However, by 1819, the headland had been eroded into a stack and arch with the twin legs that gave the ‘Old Man' its name. Early in the 19th century, a severe storm washed away one of the legs (Miller, 1976) creating the free-standing stack. This pattern of ongoing erosion continues today and in 1992 a 40 m-long crack had opened up in the top of the south face leaving a large overhanging block that will eventually collapse. From the above it is apparent that the Old Man is a relatively young feature (less than 250 years old) and in geological terms a mere infant. It seems reasonable to assume that many stacks may have similar development patterns but variable life spans depending on exposure, structure and lithology. Certainly the dynamic nature of the processes that have shaped the Old Man will also lead to its eventual demise (Hansom and Evans, 1995).

However, as erosion proceeds, other sea stacks will undoubtedly be eroded from the cliff face. Indeed, Steers (1973) noted a high pillar at Bre Brough, which had almost separated from the cliffs. In spite of this detail it remains difficult to estimate a rate of cliff recession from such intermittent activity.

It is recognized that active erosional processes, combined with variations in lithology and geological structure, have produced a unique variety of cliff and cliff-related landforms on the west coast of Orkney (Steers, 1973; NCC, 1978). For example, the coastline of Hoy is dominated by beds of red and yellow Hoy Old Red Sandstone that rise vertically above a pedestal of dark basalt lava (Kellock, 1969). Ritchie (1984) describes the lower Hoy beds as being soft and friable and the overlying beds to be harder forming prominent outcrops. Undercutting of such beds leads to sequential failure of beds above and the development of a vertical profile. The large stacks at the Castles of Yesnaby and Qui Ayre are rectangular in plan but both narrow downwards and have arches eroded through their base, an indication of marine erosion being more active than subaerial failure. Indeed the arch at Qui Ayre is now so large that it will soon fail and result in complete separation of the stack from the host cliff.

Variations in lithology and geological structure are major controls on the cliffs of Orkney and the resultant differential erosion and exploitation of weaker strata, joints, fissures or dykes are responsible for much of the meso- and micro-topography. Much of the detail depends directly upon marine erosion of joints, bedding planes, faults and dykes of igneous rock intruded into the sedimentary strata. The rock in contact with such dykes is often removed fairly easily, leaving impressive features such as the natural arch at the Hole o'Row. The diversity of caves, arches, stacks, geos and vertical cliffs along this short stretch of coast provide an excellent field site to study the development of erosional features and further our current understanding of coastal processes and forms on hard upland coasts. Although, to date, little research has been carried out on Orkney cliffs, the research potential is immense and the range, size and physical attributes of this spectacular coastline, together with its high wave-energy, justify its inclusion here.

Conclusions

The exposed Atlantic coastline of the west coast of Orkney is of national geomorphological importance. The 20 km stretch of coast includes some of the most spectacular and dramatic cliff forms in the British Isles, with numerous geos, inlets, caves, arches, stacks and excellent examples of the relatively rare phenomenon of cliff-top scouring. Although sea stacks are familiar features of many hard rock coastlines in Scotland, few are more spectacular or famous than the towering monolith of sandstone, the Old Man of Hoy, which reaches a height of 137 m. The scientific importance of this site lies in the range of spectacular cliff forms displayed over such a short stretch of coastline and the clear influence that geological structure plays upon their form. The evidence of contemporary coastal retreat is also very clear and there are opportunities in Orkney to establish the retreat rate of these sandstone cliffs.

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