AGE RELATIONSHIPS BETWEEN LOW LEVEL ROCKY SHORE PLATFORMS AND THE HIGH COASTAL SLOPES IN JERSEY AND THE SURROUNDING AREAS

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Recent research along the coastal cliffs and embayments of Jersey has revealed new aspects of the geomorphology of the rocky shore platform and its relationship with the steep slopes that link it to the island plateau above. Specifically, a rockhead platform meets a 10-30 m high, near vertical cliff at approximately 8-10 m above Jersey Datum (J.D.= ±0 m Ordnance Datum; likewise Guernsey Datum: G.D.), slopes down-towards mid-tide levels becoming ever more deeply dissected. Generalised contours of this platform show it to be distinct from a lower tidal rockhead platform which is comparatively smooth over large areas as it undergoes continuing contemporary abrasion. This lower platform is generally separated from the higher one by low cliffs, less than a metre high at mid-tidal levels, but two to three metres at the base of the backing cliffs. Both of these platforms are shown to antedate the Last Cold Stage (Devensian) head at a number of localities and this relationship is taken to represent the general situation, not only in Jersey, but throughout the other Channel Islands and adjacent coasts of Armorica. Whether either, or both, of these two platforms are older than Marine Oxygen Isotope Substage (MOIS) 5e (Ipswichian) as well is not known. However the considerable age of the numerous and wide intertidal shore platforms of the Channel Islands and adjacent coasts of Amorica makes a greater age quite possible.

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INTRODUCTION

The southwestern and northern coasts of Jersey (For locations see Figures 1 and 2) are characterised by an alternation of embayments and headlands cut mainly into granites though with substantial stretches eroded out of largely acid volcanic rocks and a conglomerate. These embayments were partially filled with periglacial deposits of head and related Last Cold Stage (Devensian) sediments. These are now partly eroded away, e.g. Beauport and Bonne Nuit/Giffard bays, or almost completely stripped out, Grève au Lançon, Grève de Lecq (Figure 2). The nature of the bedrock and its varying structural components have been instrumental in controlling most of the hard rock erosional detail (Renouf, 1986, 1993), but the major composite slopes linking the low level shore platforms to the island plateau (Figure 3) are considered to have reached their present form by the interglacial high level sea of MOIS (Marine Oxygen Isotope Stage) 5e before the cold stage deposits of the Devensian began to accumulate.

In terms of present day erosion of the bedrock in the different embayments, all the rocks are characterised by strong but variably developed and orientated jointing, with faulting also common at varying scales (Renouf, 1986, 1993). The sedimentary and volcanic rocks were strongly folded during the Cadomian orogeny which ended some 400 ma ago (see Bishop and Bisson, 1989; Helm, 1984; Lees and Roach, 1993). In this paper, the situation at Grève au Lançon (the beach at Plemont) is examined and is contrasted with sites found in Bonne Nuit/Giffard bays. Reference is made to other Jersey and Channel Island localities and a number of sites on the adjacent coasts of Armorica (Brittany and Lower Normandy).

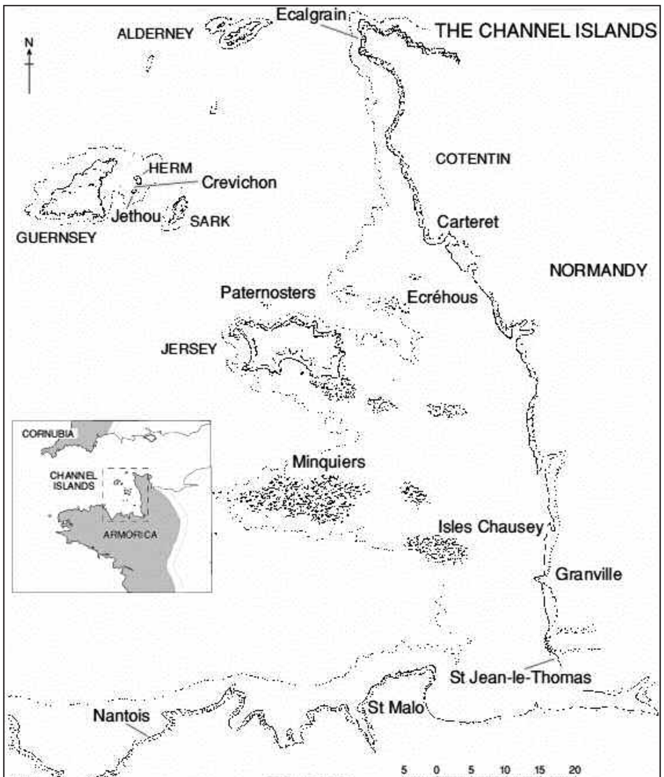

Figure 1. *The Rybot hachure map of the Channel Islands to show localities referred to in the text and the extensive, mostly intertidal, reefs (e.g. Minquiers, SE Jersey).*

Observed relationships between littoral rock platforms and the coastal slopes above

Grève au Lançon

Grève au Lançon is a sandy beach which extends from low water to the base of 15 to 30 m, near vertical, cliffs. These cliffs are often deeply cut into by gullies and caves (Figure 4). In front of the cliffs in the intertidal zone, towards the western end of the bay, a low cliff rises out of the sand at mid-tide levels to a *c.* 8 m level dissected rock platform. This platform meets the near vertical cliff line at a notch locally expanded into small caves (Figure 5). This is the rocky surface widely referred to in the past as the 25 foot shore platform (Mourant, 1933). To the west of the steps down to the beach, a stream descends a V-shaped valley and drops vertically 20 m to mid-tidal levels below (Figure 6); waterfalls such as this, with drops up to 30 m, are a common feature along all the coastal cliffs of Jersey and the other Channel Islands. A range of examples of waterfalls and associated features occur between Grève de Lecq and Grève au Lançon (Figure 2).

The situation at Plemont can be summarised as follows (Figure 7). A contemporary low angle, mid-tidal, sandy beach extends from low tide at – 5 m J.D. to the base of near vertical 20-30 m cliffs at the top of which there is a marked change of angle with gentler slopes leading upward to the island plateau, here at *c.* 80 m J.D. The contemporary mid-tidal sands also meet the fossil 8 m rockhead platform in a low cliff varying in height from 2 to 3 m. In turn the 8 m platform intersects the 15-30 m near vertical cliffs along a line of notches occasionally expanded into small caves. No sediments survive on the 8 m platform here. Unsorted local diamictites (head) occur on the higher coastal slopes between spines or ridges of rock outcrop.

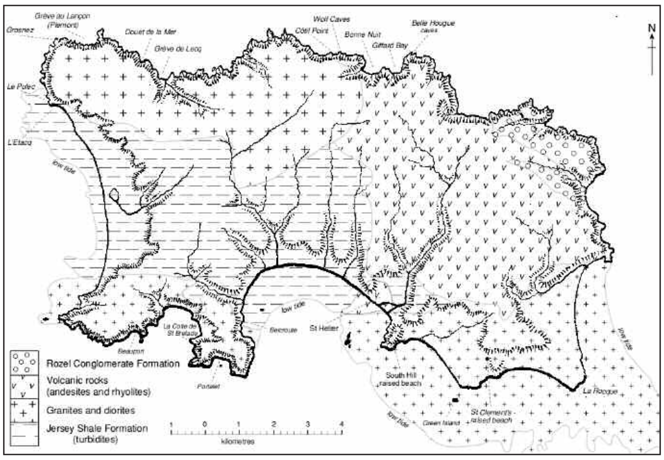

Figure 2. *The Rybot hachure map of Jersey which locates the steep slopes linking littoral platform and island plateau. The map has been annotated to show (1) the outline geology and (2) the places referred to in the text.*

The various features described above refer to those coves and embayments where Last Cold Stage (Devensian) head deposits are either not found or occur only on the upper slopes between the lower 15-30 m cliffs and the island plateau. Where substantial head deposits survive, it is usually in the larger embayments such as those of Bonne Nuit and Giffard bays on the north coast, although Beauport, a smaller bay on the southwestern cliffs also has thick and extensive head deposits.

Bonne Nuit/Giffard bays and the accumulation of Last Cold Stage (Devensian) deposits

At the close of MOIS 5e, the sea began to recede. At this moment the coastal situation in the Channel Islands would have been somewhat similar to that prevailing now in that a high interglacial sea level had existed for at least several thousand years allowing erosion of pre-Ipswichian deposits, notably older heads and loesses. However, it is possible that fewer bays would have been backed by soft deposits, since the higher sea level of the Ipswichian would have encouraged greater landward erosion. This would have led to more situations comparable to that described for the contemporary one at Grève au Lançon. Some pre-Ipswichian cold stage deposits have survived locally under special conditions, e.g. in the Palaeolithic cave shelter at La Cotte de St Brelade (Callow and Cornford, 1986; Keen *et al.*, 1996), the basal sediments of the Belcroute and Portelet sections (Keen *et al.*, 1996), and further away at Ecalgrain (Van Vliet Lanoë *et al.*, 1986) on the Cotentin coast northeast of Jersey (Figure 1); additionally a range of proven Ipswichian deposits are known to rest on the 8 m platform in places, e.g. Belle Hougue Cave (Keen *et al.*, 1981), while similar age marine sediments are likely elsewhere, e.g. Le Pulec.

The first known effects, in Jersey and the surrounding region, of the receding sea are recorded in the local accumulation of wind blown sand against the bases of some cliff slopes with the reddish sands above the 8 m raised beach at Belcroute being the best example in Jersey (Keen *et al.*, 1996). This feature is further illustrated in Bonne Nuit Bay where remnants of a much wider cover of sand remain trapped against low rocky remnants at the extreme ends of the bay. Surviving exposures of 8 m raised beach deposits are limited to a small section at the eastern end of Bonne Nuit Bay but are better exposed below the head in the centre of Giffard Bay to the east.

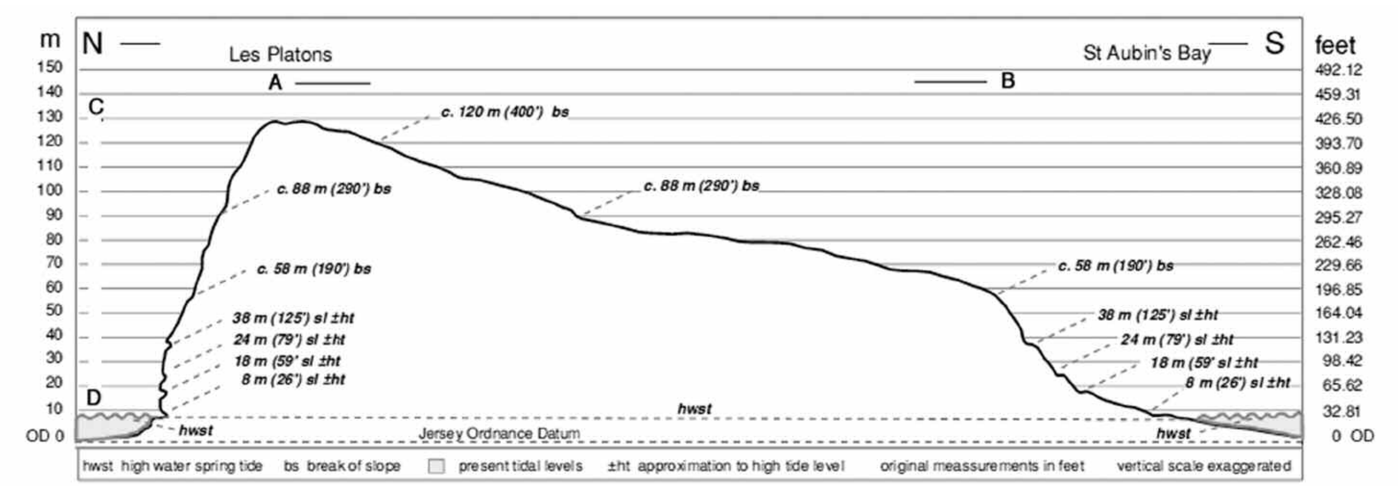

Figure 3. *North to south profile of Jersey to show the coastal platform, the island plateau and the steep composite slopes that join the two. Main breaks of slope and identified former sea levels are also shown. Based on work by, among others, Mourant (1933), Hanson-Lowe (1938) and Renouf (1986).*

Figure 4. *Part of Grève au Lançon showing current erosion into the base of the old cliff line with gully and cave developed. See Figure 7 and text for full explanation.*

Figure 5. *Part of Grève au Lançon showing the old ±8 m platform rising from the beach and extending back to the level of the cave base at a slightly higher level. See Figure 7 and text for full explanation.*

Figure 6. *The hanging valley seen descending from top right of the picture ends abruptly at between 20 and 30 m above Grève au Lançon in an under cut waterfall (shadowed). See Figure 7 and text for full explanation.*

As the climate continued to deteriorate, the sea receded further from the present shorelines and an increasingly larger area of the western Channel was exposed until, at the extreme sea level retreat of the Devensian some 18 Ka ago, the shoreline extended into the Western Approaches. Thus the Channel Islands during much of the Devensian cold stage were in a continental location and, though not glaciated, experienced a periglacial climate similar to that of present day tundra regions (Hallégouët andVan Vliet Lanoë ,1986; Lautridou and Coutard, 1995). A number of geological processes were at work at various times during this cold stage.

Loess deposition

On a regional scale the north coasts of France and the Channel experienced lengthy periods of loess accumulation. In Jersey, loess forms a veneer over most of the island plateau to a depth of 50 cm or more (Keen, 1978). It is also found to a lesser extent on the main cliff slopes descending to present shore platform levels. A good example is the distinctive lens up to a metre or more thick within the head deposits backing Beauport (Figure 8) but the granulometry of most heads record a silt fraction which is considered to be loessic in origin (Franklin, 1973). Saltwater saturated loesses presently under study are also found on the extensive shore platforms around the islands, e.g. Green Island and La Rocque in Jersey and, more recently, between the islands of Jethou and Crevichon off the east coast of Guernsey (Sebire, 2004).

Head deposition

The principal Devensian deposit of steep slopes around the shores of the Channel Islands, adjacent coasts of France is the rubbly head. Mottershead (1971) provides one of the few detailed descriptions of head in his work on Devon in South-West England; many of the features he describes match those recorded here. During the cold and wet periods of the Last Cold Stage, there was enhanced weathering and erosion of the fossil cliff slopes separating the shore platforms from the island plateau. Fragments of various sizes broke away from exposed rock surfaces through the action of frost, and accumulated lower down the slopes in a number of ways. Free fall occurred on vertical rock faces to form scree slopes. This scree, together with other rock fragments breaking clear on less steep slopes, would have become bonded by the tundra vegetation to some extent but was subject to continual down slope movement through slumping and intermittent mud flows and localised streams. Any soils that developed were incorporated into these downward movements.

Depending on the nature of the climate at the time, the height of the cliff slopes, and on the amount of rock exposed in the cliffs, varying amounts of rock debris accumulated. The relative proportions of coarse and fine debris subsequently affected the flow characteristics of the head when infiltrated by water or subjected to erosional agents particularly on exposed cliff faces.

The thickness of head accumulation was strongly influenced by the height of the slope summit, the slope direction and its steepness. As Figure 7 shows, the lower 10 to 30 m of the bedrock slopes linking the shore platform with the island plateau is almost always a near vertical cliff. The first accumulations during the Devensian must have been by free fall over these cliffs on to the abandoned platform below; not all the material would have been fresh rock scree, some soil would have initially slipped down from the higher slopes and over the edge to form colluvium. Where the rock debris comprised sufficiently large and numerous fragments, the resulting head was clast supported as at Beauport (Figure 8) where coarse head against the rock cliff has clear voids near the base. Most voids were subsequently filled, either by directly blown, or downward infiltrating loess as in this example. Matrix supported head occurs where the rock debris was finer and there was sufficient loess and soil. Occasional discrete lenses of loess are also found within the head, often several metres long and up to a metre thick. The head deposits contain fewer large blocks and are less clast supported the further they are away from the originating cliff (Mottershead, 1971) as illustrated by the sections at Beauport (Figure 8) and Nantois in the Baie de St Brieuc (Monnier *et al.*, 1997).

A modelled sequence of events based particularly on Bonne Nuit/Giffard bays is shown in Figure 9 and this is considered to be widely applicable in the Channel Islands and adjacent areas, e.g. St Jean-le-Thomas south of Granville (Figure 1). However, where proven pre-Ipswichian deposits occur, as at Ecalgrain and the Belcroute, Portelet and La Cotte de St Brelade sections, more complex interpretations are needed. In summary, during the Last Cold Stage there were considerable climatic and depositional variations but the final outcome was the infilling of the gap between the shore platform and the higher slopes. This created a prism of head composed of a thin veneer near the plateau summit thickening downwards into the main body of material to thin again when traced outward at an ever decreasing angle several hundred metres from the base of the fossil cliffs (e.g. St Jean-le-Thomas and Nantois).

The relationship at Bonne Nuit/Giffard bays between the rocky shore, the head and the backing cliffs

Two distinctive rockhead shore platforms may be found on the Bonne Nuit Bay foreshore and are distinguished by their form and height above Jersey Datum. The first consists of remnants of a deeply dissected rock platform (Figure 10) which rises sharply in small cliffs (from less than 0.5 m low down the beach to almost two metres near the high tide) above the present, gently shelving mid-tidal rock platform which forms the second. Remnants of the deeply dissected higher platform occur further offshore (e.g. the Cheval Rock). The lower,

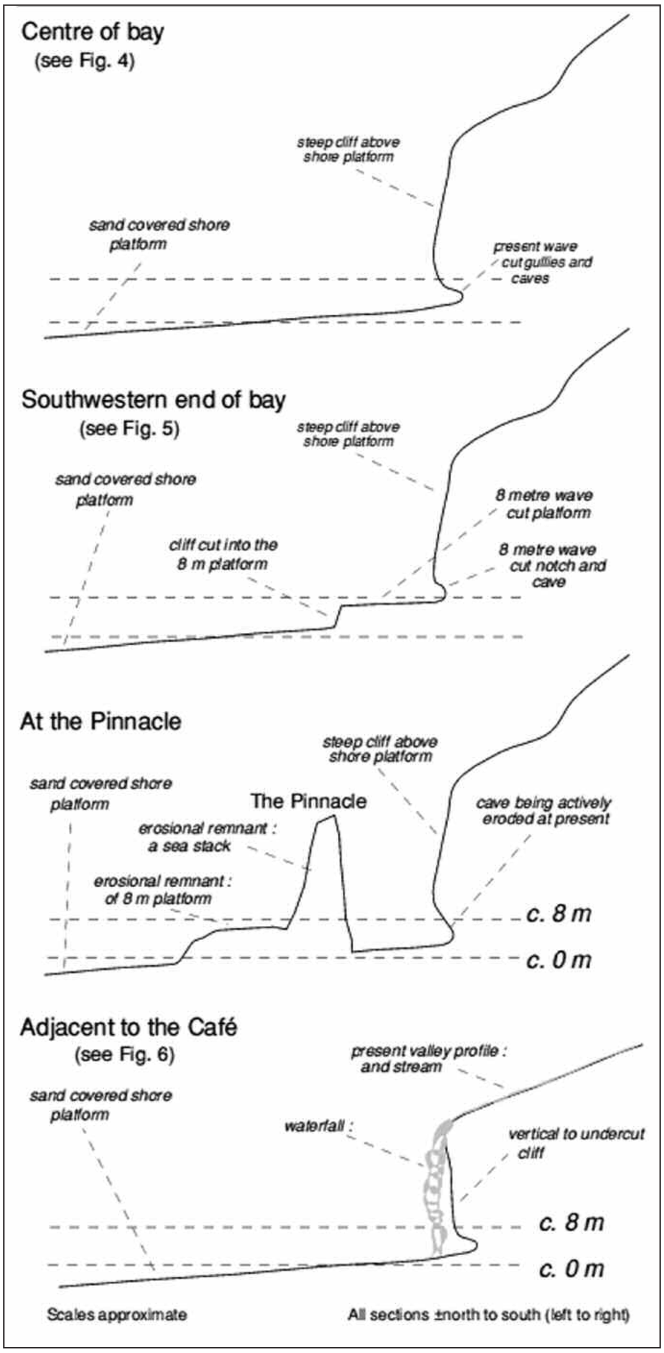

Figure 7. *Series of sketch profiles of beach to cliff at Grève au Lançon to demonstrate the main erosional features and their relationships. See text for full explanation.*

Figure 8. *Eastern end of head section at Beauport showing clast supported coarse head against the jointed rock and much paler loess-rich lenses where the person is working.*

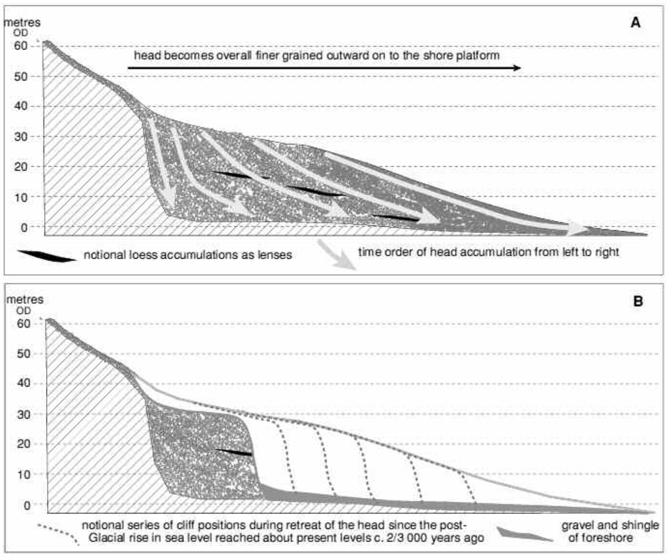

Figure 9. ***A.*** *During the Last Cold Stage (Devensian), the slopes linking the island plateau and the current foreshore levels were eroded and the material fell and slumped down the hillsides to accumulate as head below. From time to time loess accumulated in small lenses and also more generally infiltrated the fabric of the head.* ***B.*** *After the end of the Devensian the sea level rose over a period of several thousand years until it reached the down slope tip of the head which it then eroded back to an irregular time scale as shown by the notional stages above.*

shelving platform forms wide (up to two hundred metres) gullies across the mid-tidal to low-tidal foreshore and is frequently swept bare of sand, gravel or shingle during a continuing abrading process. Above mid-tidal levels the platform is generally covered with gravel and shingle, although platform and shingle remain at a lower level than the dissected platform.

Dissection of the higher platform and abrasion of the lower one are processes that are currently active. However, both of the platforms are seen to pass beneath the head cliffs at the back of the beach and must therefore pre-date the head and be pre-Holocene in age. The same relationship is seen in the adjacent Giffard Bay. At Grève au Lançon, although the mid-tidal, bedrock platform is not well exposed, it can be shown to reach the base of the dissected fossil 8 m platform and to extend deep into the caves cut into the base of the near vertical cliffs above. Once the two platforms are recognised then they are seen to be present in almost every coastal embayment around the islands where bedrock is exposed.

Figure 10. *Flat mid-tidal rockhead platform in the middle of Bonne Nuit with a veneer of shingle and gravel. Rising above the platform are two degraded remnants of the ±8 m rock head platform the one to the right notched by current erosion. The mid-tidal platform passes beneath the steep cliffs of head at the high tide level. The skyline to the right shows the bedrock volcanic rocks rising towards the island plateau.*

Summary

Two important erosional features on the foreshores of Grève au Lançon and Bonne Nuit/Giffard bays are common to both of the embayments. These are firstly, a 8 m hard rock shore platform characterised by: (1) notching and the local development of small caves at its junction with a 10 to 30 m high, nearly vertical, bedrock cliff which forms the base of the island's coastal slopes. (2) an increasingly dissected form down-beach with generalised contours of its surface indicating it belongs to a single feature. (3) Isolated local heads (nautical terminology) of rock rising to the 8 m level but separated from the 8 m dissected platform and occurring at lower tidal positions or beyond (e.g. the Cheval Rock in the middle of Bonne Nuit Bay). (4) Being overlain by Devensian head and associated deposits where the relationship can be proven.

Secondly, there is a more mid-tidal, hard rock shore platform which: (1) Extends in those embayments lacking head deposits from the present low tide up-beach to the base of backing 10 to 30 m high, nearly vertical cliffs where it often passes into quite deep caves, e.g. 20 to 30 m+ at Grève au Lançon. (2) Passes beneath any Devensian head in those embayements where that is preserved and where the relationship between the two can be observed. (3) Has relatively smooth lateral and up- and down- beach profiles, although local, small scale breaks in slope and notches on the latter are not uncommon. (4). Interfaces with the remnants of the 8 m dissected platform by small vertical cliffs that increase from less than a metre high at lower tidal levels to several metres in the upper tidal zone. (5). Extends in many places into the joints and gullies of the dissected 8 m platform (this relationship is particularly well shown in the rather inaccessible sections between the Wolf Caves and Côtil Point, Figure 2). (6). May be the same platform that underlies the pre-Ipswichian loessic deposits at such localites as typically represented by the Belcroute section (Keen *et al.*, 1996).

Discussion

At least by the close of MOIS 5e, the steep coastal slopes linking the general shore platform around Jersey to the island plateau (Figure 3) were in existence. This situation applies generally to the other Channel Islands and adjacent coasts of Armorica. These slopes ended downward in a near vertical fall of 30 to 40 m. (Figure 4) onto one or the other of two hard rock platforms at 8 m J.D. and at mid-tidal levels.

Where the steep coastal slopes are replaced by lower relative relief as in the northern Guernsey lowland, the relationships between these shore platforms and higher levels is not so clear, since there are no cliffs as high as 38 to 40 m. G.D. (See Keen, 1978 for a summary). However, the 38 to 40 m cliffs around Jersey's coasts are widely notched at 18 m; a single occurrence of a notch and raised beach at 38 to 40 m is known at South Hill (Figure 2 and Keen, 1993) and another former sea level is recorded between 20 and 24 m at St Clement (Dunlop, 1911 and recent surveying by the authors). Since the 38-40 m high coastal cliffs were already in place by at least the end of the Ipswichian to allow head accumulation against them, the local sea levels at 18, 20-24 and 38 to 40 m O.D. must also precede the Ipswichian; there is also no oxygen isotopic evidence for such high stands of the sea as late as the Ipswichian; a pre-Ipswichian age of sea levels at 18 m O.D. and above is widely accepted. However, what the present results emphasise is the contrast that exists between the minor notching of the cliffs during the 18, 20-24 and 38-40 m events and the extensive platforms at shore level (Figure 3). There is no similarity between the two sets in terms of the length of time required for their formation. Such considerations raise again the question as to how long it takes marine —or other— erosion to create a rock platform more than tens of metres wide in hard rocks such as granite and other plutonic rocks. Certainly the duration of the Holocene high sea level —the present height reached no earlier than 4500 bp— has not been able to more than marginally modify two already existing hard rock platforms; furthermore the degree to which even the dissection, for instance, of the 8 m platform seen on present shores around Jersey and the other islands, is the result of Holocene sea action remains very uncertain. It seems rather that the sea is occupying an existing topography and barely even trimming it. For example, significant quantities of unconsolidated head deposits still exist within the reach of high tides and storm conditions (e.g. Beauport, Bonne Nuit/Giffard bays, Ecalgrain).

Conclusions

Along most of Jersey's northern and southwestern cliffs, the island plateau is linked to the shore platform by way of steep slopes that end in near vertical cliffs for their last 10 to 40 m. The top of these basal steep cliffs is at about 38 to 40 m J.D. (Figure 3). There is a known notch with associated pebble deposits at this height on South Hill in Jersey and ongoing survey work is revealing many possible degraded cliff features at this position around the northwest cliffs between L'Etacq and Grève de Lecq and elsewhere. At present, neither the age, overall form, nor significance of the features at this level is known, although their presence marks a major division of the slopes linking island plateau to shore platform.

The near vertical basal cliffs, when in bedrock, are notched by former sea levels, with or without associated deposits, at least at 20 to 24 m (St Clement) and 18 m J.D. Elsewhere, and northern Guernsey is a good example, there may be evidence of more extensive erosional platforms at such levels although, at present, it has not proved possible to advance beyond the work done by Keen (1978). However, when the sea was at these heights, and where the steep drop to present shore platforms existed, the power of the sea to erode the cliff was limited by the deep water immediately in front of it. Present storms on the northwest cliffs by Grosnez, for instance, have comparatively little effect, since the waves battering the cliff lack any abrasional material (sand, stones or larger boulders) and have only a slight effect as the result of water impact or leverage alone. This may account for some of the differences between the cliff environments of Jersey's north coast and areas, such as northern Guernsey, where the greater areas of shallow water would have increased the effectiveness of breaking waves and generated more abrasional material. However, in spite of this, known notches at c. 18 m are not usually associated with areally extensive beach deposits.

At least two widely occurring, low-level, hard rock shore platforms on Jersey's north coast are identified and shown to extend into the base of the hard rock cliff (notching and caves). The higher of the two meets the back shore cliff at about 8 to 10 m J.D. and is variably associated with notches, caves and mostly undated sediments. From the high tide levels, this platform slopes down towards mid-tide becoming increasingly dissected. At tidal levels and immediately offshore, heads of rock occur at the 8 m height and these are considered remnants of this platform. The lower of the two extends up-beach from the low tide usually as wide, rather smooth, rocky platforms between outcrops of the higher platform into which it extends along fault or joint bounded gullies.

Where Devensian head deposits back the embayments, both of these shore platforms are seen to extend beneath them. Thus, in a number of localities, a pre-Devensian age is the minimum for the origin of both of the platforms. These two relationships can be identified extensively around the Channel Islands and adjacent coasts of Armorica.

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