

RAISED BEACHES AND MARINE GEOMORPHOLOGY

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CONTENTS

I	Introduction	283
II	Raised Beaches	285
	1. The <i>Patella</i> raised beach	287
	(a) The Platform	287
	(b) Beach material	288
	(c) Overburden	289
	(d) Age	289
	2. The higher raised beaches	292
III	Coastal Morphology	292
IV	Shore Platforms	293
V	Cliff Profiles	301
VI	Depositional Forms	303
	1. Beaches	303
	2. Sand Dunes	303
	3. Spits	304
	4. Barriers	305
	5. Estuarine silting	306
VII	Conclusions	306
	References	306

I. INTRODUCTION

"As about four hundred and seventy-two miles of coast, exclusive of estuaries and minor irregularities, are in the district under consideration exposed to the action of the sea, considerable facilities are afforded for the study of this action, more especially as the rocks brought within its influence are very different, and the conditions under which they are exposed are also variable." With these words De la Beche (1839) underlines the great geomorphological variety of the coastal 'golden fringe' of the south west peninsula. Yet a review of the literature since 1839 suggests that much remains to be done in the way of coastal studies, for the emphasis has been on the evolution of the inland morphology. The most comprehensive account of coastal geomorphology is undoubtedly that by Steers (1946). Valuable regional evaluations have been contributed by Balchin (1946), Arber (1949) and Robson (1950), and local studies made by Robson (1948), Clarke (1959) and Bird (1963), among others. The topic at present being most actively studied is that of cliff-profiles (Arber 1949; Savigear 1962; Orme 1962).

Cliffs dominate the coastal scene but often do not exceed about 200 feet for long distances, particularly on the south coast. Some of the highest sheer cliffs are on the exposed north Cornish coast, where they rise to 400 feet near Morwenstow. Usually, however, an inclined, and often vegetated bevel intervenes between the true cliff and the edge of the coastal plateau. In many areas where there are rapidly alternating rock types and structures the coastline is crenulate, as along the north of the Penwith peninsula, but uniform rock and structure tend to produce long relatively smooth stretches of cliff and beach, as in Watergate Bay. Much of the north coast has been described as 'mature, cliffed', but the estuary-penetrated south coast would appear to be in an earlier stage of the marine cycle, although some coastal smoothing has occurred at Loe Bar and Hallsands.

Depositional forms are fewer than on some other parts of the British coastline, but include areas of sand dunes along the north coast (Hayle, Perranporth, etc.) and shingle barriers at Loe and Hallsands on the south coast. Extensive estuarine silting has occurred in certain areas, especially adjacent to mining regions, as at Par.

The coastline of Devon and Cornwall is best described as compound, being a mixture of emergent and submerged forms. Both Balchin (1946) and Robson (1950) emphasise the essentially emergent nature of the coast, submergence intervening as a relatively minor, late episode.

Several factors have contributed to the present-day shape of the peninsula. King (1954), from a study of the off-shore geology, suggests that much of the general coastline of western Britain is controlled by the position of the margins of Triassic basins, which suffered further downwarping in later periods. Removal of part of the softer infilling of these basins has left upstanding the more resistant rocks of the peninsula.

Arber (1940, 1949) notes that both the north and south coasts are divisible into a few broad embayments, separated by the major headlands and has discussed the application of Lewis' (1938) theory of shore-line curves to their shape and orientation.

Bays in the process of adjustment to the trend of the dominant waves become asymmetrical, with a large smooth side facing the dominant waves. Arber quotes as examples the great bays of the south coast, the eastern sides of which (facing the south west) are comparatively smooth, with blunted headlands, whereas the western sides are much indented into minor bays and separated by angular promontories.

An examination of raised beaches and "fossil cliffs" shows that much of the present detailed coastal outline is not the result of modern erosion, but has been inherited from the past. Marine erosion during the Middle and Upper Pleistocene (Orme 1962), at times when sea-level was little above the present, produced a coastline much like the modern one. There has been remarkably little erosion since the formation of this "fossil coast" and over long distances the ancient and modern coastlines run parallel or coincide. Only in north Cornwall has the old coastline been overrun for a long distance. It is appropriate, therefore, to commence our discussion of coastal geomorphology with an account of the raised beaches.

Raised Beaches and Marine Geomorphology

II. RAISED BEACHES¹

Extremely fresh and well-preserved rock platforms at heights ranging from near present High Water Mark to about 60 feet O.D. are to be found at a number of localities around the coasts of south west England (Fig. 1). Rounded boulders and pebbles often rest directly on the platforms and there is little doubt that these features are of marine origin² and related to former higher sea-levels. The term "raised beach"³ has been used without discrimination for both beach and platform, and this has led to much confusion in the literature. There is considerable uncertainty as to the number and age of the platforms and beaches and the climates prevailing at the time of their formation.

Borlase (1758) figured and described the raised beach at Porth Nanven as early as 1758 and in 1817 Hennah (1817) noted the raised beach at Plymouth Hoe. By 1828 twenty-one occurrences of raised beach had been recorded between Pendeen Cove and Mousehole, and a number of sections are described by De la Beche in his 1839 Geological Memoir. Valuable early accounts include those by Austin (1851) and Prestwich (1892). Probably the most comprehensive review is to be found in the relevant One-inch sheet memoirs of the Geological Survey (see bibliography). There are numerous references in the volumes of the Royal Geological Society of Cornwall, e.g. Carne (1827, 1865), Worth (1887), Wünsch (1895), Robson (1944). Later workers, among them Arkell (1943), Green (1943), Steers (1946), Wright (1937) and Zeuner (1953) have discussed at length the interpretation and dating of the raised beaches.

Exposure to powerful wave attack favours the formation of shore-platforms and it is not surprising that some of the best surviving examples of raised platforms are to be found on exposed headlands. During later and lower sea-levels, however, an exposed location is likely to lead to the erosion of a raised platform and its beach cover, and so the majority of surviving examples are to be found "in sheltered bays and nooks". Around the Lizard peninsula, for example, traces of raised beaches are far more common on the sheltered east than on the exposed west.

Correlation of isolated remnants of raised beaches and platforms has been rendered more difficult by failure to refer heights to a standard datum and to state precisely what has been measured. Heights have been referred to High Water Mark, High Water Level, or even 'the present beach', none of which can be accurately re-discovered by later workers. It is often difficult to tell whether measured heights refer to the rock platform or the top of the overlying beach. The most valuable measurement is, of course, the height of the raised platform/cliff junction, but this is rarely exposed. Some variation in the measured height of a raised platform and beach is to be expected because of the pronounced seaward slope. Differential erosion

¹For the purposes of this account, the term "raised beach" refers chiefly to features below about 65 ft. O.D. but brief reference is made to features up to 150 ft. O.D.

²One or two early workers claimed the boulders as downwash material, e.g. Carne (1827).

³Early workers in the South West, e.g. Wünsch (1895), were firmly convinced that land movements were responsible for the elevation of the beaches, hence the term "raised beach".

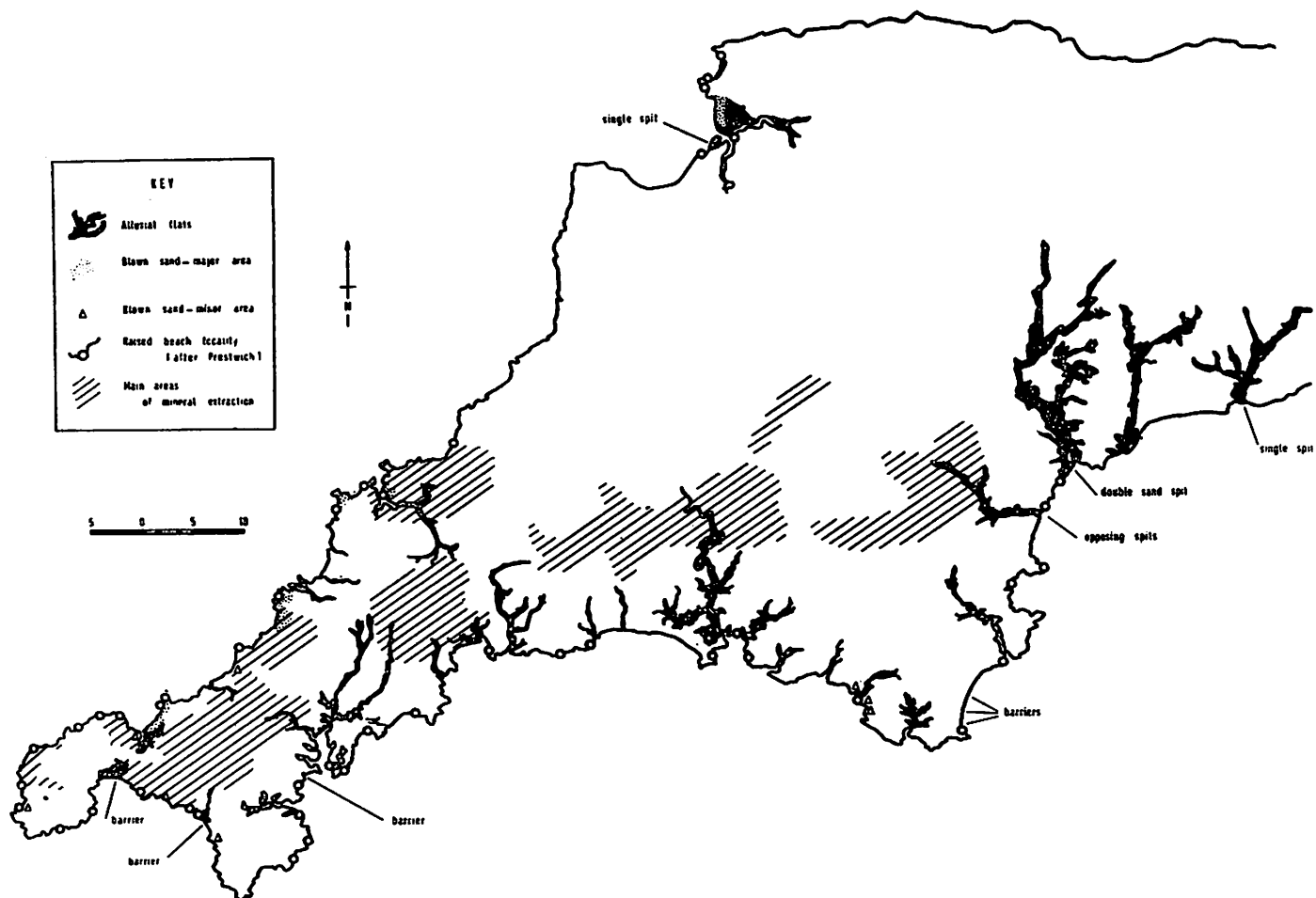


Fig. 1. Distribution of Depositional Forms and Raised Beach Localities.

Raised Beaches and Marine Geomorphology

in a given area results in the same platform outcropping at different heights, and at any one exposure erosion will reveal successive sections at progressively higher levels. Ordnance Datum should obviously be used in all height measurements.

At the present time it is extremely difficult to be certain of the number of raised platforms and beaches in south west England, and to correlate the numerous exposures. In the Padstow area for example Clarke (1963) records Pleistocene and Holocene strandlines at the following levels: 150 ft., 120 ft., 100 ft., 88 ft., 65 ft., 50 ft., 25 ft. and 15 ft. O.D. The majority of recorded exposures however lie between mean sea-level and about 25 ft. O.D. and there appears to be general agreement that the most widespread raised beach rests on a rock platform that rises to about 25 ft. O.D. at its junction with the old cliff. This is often referred to as the *Patella* raised beach. Sections of this platform in front of the old cliff-line will, of course, be below 25 ft. O.D., but it is probable that locally there are two lower platforms cut into the *Patella* platform: at c. 14 ft. O.D. (Zeuner 1953; Orme 1962) and 6 to 10 ft. O.D. (Orme 1960). Some of the best examples of these lower stages are found in south Devon (Lannacombe).

Problem platforms and beaches within this height range are the so-called "10-foot" fossiliferous beach near Barnstaple and the Torbay raised beaches (Hughes 1887; Rogers 1946). The former, although apparently at the same height as the *Patella* beach, is of a different age. The latter is an important link between the south west raised beaches and that at Portland but authorities differ on its relationship to the *Patella* beach.

Higher raised beaches, resting on platforms cut in solid rock or Head deposits, occur in several areas, with a concentration in the 50-60 ft. O.D. range (Robson 1944). Arber (1960) has described surfaces cut into Head deposits at 50 ft. and 100 ft. O.D. on the banks of the Taw near Barnstaple. A raised beach at 50 ft. O.D., on a Head platform, has been described at Trebetherick Point (Arkell 1943) and strandlines noted by Clarke in the Padstow area have been listed above. Round (1944) has described beaches at 50 ft. and 100 ft. O.D. in the Marazion area, and there is a well-known 65 ft. beach (resting on a 50 ft. O.D. rock platform) at Mousehole. Hendriks (1923) has referred to raised beaches at 100 ft. and 160 ft. O.D. at Helston and Porthleven respectively.

1. The *Patella* Raised Beach

(a) THE PLATFORM. Most raised platforms and beaches lying between 5 and 25 ft. O.D. have been regarded as remnants of this stage, but some exposures may, in fact, be parts of the 14 ft. or 6 to 10 ft. O.D. platforms. This beach is said to skirt about 1,000 miles of the British and French coasts. The platform-cliff junction is about 25 ft. O.D., although this is rarely to be seen, with the beach material banked against the old cliff rising to 40 ft. O.D. (cf. the Plymouth Hoe sections). Green (1943) puts the mean sea-level of the *Patella* beach at about 30 ft. O.D.

The seaward limit of the raised platforms is often difficult to locate as the landward. At Lannacombe Mill it appears to terminate close to the present low tide level,

but an alternative view is given in the Padstow Geological Memoir (1910) "... what we see is only the upper edge of the raised beach platform the rest of it is below the sea. Judging from the submarine contours this platform may be of considerable extent . . ." In other words, the raised platform may have a steeper gradient than the modern one, which is essentially a bench cut into it.

Prestwich (1892) was one of the first to map and summarize the distribution of raised beaches in the south west peninsula. He notes that the first trace west of Portland is in the cliffs east of Dawlish and numerous exposures are found along the little eroded south coasts of Devon and Cornwall. The beach hugs the exposed Land's End peninsula and continues up the north coast, the long stretch without traces being from Pentire Point to Hartland Point ; here modern erosion has over-run the beach and its cliff.

The *Patella* raised beach and its cliff closely parallel the modern shore, penetrating estuaries such as the Camel and Carrick Roads (post-dating their main excavation), but is apparently absent from the Hayle estuary. The modern sea-level has made little headway in eroding these ancient features.

The platform, with or without beach, may be found in section only, overlain by Head or other deposits, as near Looe, or it may have been swept clear of its superficial burden, forming a well-developed shelf a few feet above the modern platform, (Pl. 1). Here it is so rarely reached by the sea that it is overgrown with lichen and drift. Arkell (1943) noted that the raised platform is more worn and freer from 'snags' than is the present one, with the inference that the sea stood much longer at the higher level. It tends to be wider where coastal slopes are gentle and the rocks relatively soft.

(b) BEACH MATERIAL. The thickness and composition of the beach deposits vary greatly. Thus at many places around the Land's End peninsula the raised beach is only a few inches of shingle beneath a thick mass of Head, but at Porth Nanven it is 20 ft. thick and consists of enormous granite boulders. At Prah Sands and several other localities the beach is cemented into a ferricrete by compounds of iron and manganese and is very resistant to wave attack. In Gerran's Bay modern caves follow the same lines of weakness as old ones, so that the cemented shingle of the old cave floor forms the roof of the modern one.

Occasionally, as in Gerran's Bay, it is recorded that the raised beach is composed of material identical with that on the modern beach, but it is not uncommon to find "foreign rocks" present. Chalk flint is often found and on both the north and south coasts erratics, possibly brought by ice-floes, are to be found. Those in the raised beach in Fistral Bay are well known and more occur further north. The largest, found on the modern beach but presumably derived from an older one, is the Giant's Rock west of Porthleven, a 50 ton mass of microcline gneiss.

The ancient cliff behind the *Patella* raised beach is for many miles the modern cliff also, but there are numerous localities where it is completely masked by Head and other deposits, so that its form and inclination cannot be seen.

Raised Beaches and Marine Geomorphology

(c) OVERBURDEN. Many sections on the coast of the peninsula reveal only Head, sometimes 30 or 40 feet thick, on the rock (Pl. 2 and 3) but occasionally the overburden is more complex (Steers 1946). Arkell (1943) in one of the most detailed expositions of a Cornish raised beach ever made, determined the following general sequence at Trebetherick Point, probably the most important raised beach site in the south west peninsula:

- | | |
|--|-----------|
| 7. Holocene blown sand. | Low S.L. |
| 6. Head and pebbly solifluxion deposit. | |
| 5. Trebetherick boulder bed. | High S.L. |
| 4. Main Head. | Low S.L. |
| 3. False-bedded sand and sand-rock (wind blown). | |
| 2. Raised beach. | |
| 1. Rock platform. | High S.L. |

Other workers consider that the sand (bed 6) is current bedded (Dewey 1935), and of marine origin. Arkell postulates a marine origin for the Trebetherick boulder bed, regarding it as a high sea-level, post-dating the *Patella* beach and the main Head deposits of the south west. There is no general agreement upon the origin of the boulder bed, which is thought by some to be of fluvial origin (Arkell 1943, discussion).

(d) AGE. The ages of the *Patella* raised beach and the platform upon which it rests are not known. Zeuner (1952), has made the general point that the erosion of a rock platform could precede the deposition of the overlying beach deposits by a considerable period of time. He regarded beach deposits as accumulated during a regressive phase and "... successively younger the further seaward they lie from the ancient shore, although deposition is continuous and therefore seemingly contemporaneous."

Arkell (1943) has emphasised the general freshness of the appearance of the raised platform, concluding that it should be dated as no older than is strictly necessary.

The barrenness of the beach and the presence of (?) ice-rafted erratics points to its accumulation during a cold period, as Ussher noted (1879). Yet there are records of temperate fauna (Reid 1906).

Wright (1937) dated the *Patella* raised beach as pre-glacial, because its presumed equivalents in Gower and Southern Ireland are overlain by early glacial deposits. It is now generally regarded as of infra-glacial age, as both beach and platform obviously preceded one or more glaciations, but the platform seems too fresh to have been cut before any glaciation affected the British Isles.

Green (1943) attempted a geomorphological solution of the problem. He concluded that the *Patella* beach (with which he included the Hope's Nose and Portland raised beaches) had largely overrun, and hence post-dated, his lower Taplow surface (sea-level 50 ft.) He therefore equated the raised beach with his Muscliffe Terrace stage (sea-level 28 ft. O.D.) and the Late Monastirian phase of Zeuner (1953).

Zeuner (1953) related the *Patella* raised beach to a Late Monastirian sea-level (7.5 metres) and included with it the Hope's Nose, Croyde and Saunton raised beaches. The Portland raised beach he excluded from this stage, dating it as Main Monastirian or early Last Interglacial (18.0 meters sea-level). It should be noted that Baden Powell (1956) on faunal evidence, equates the Torbay and Portland beaches. Arkell's (1943) account of the Pleistocene deposits at Trebetherick Point introduces yet another element into the discussion, namely the age and origin of the Trebetherick Boulder Bed. On the basis of its regular stratification and the presence of the larger boulders near the old cliff Arkell considered it to be marine, although a fluvial origin has also been suggested. He dated it as Wolvercote Interglacial and as evidence of a 50 ft. O.D. sea-level. The Boulder Bed rests on a platform cut in the Main Head, which in turn overlies the bedded sands and the *Patella* raised beach. Its presence implies the complete submergence of these largely unconsolidated deposits but apparently for only a brief period, as they were not removed. In Arkell's view the paucity of fauna and presence of erratics (presumably carried by ice-floes) in the *Patella* raised beach point to cold water conditions, possibly during a period of waning cold during the melting and retreat of an ice-sheet. He concludes that it may have been formed during a prolonged still-stand at the very end of the Mindel glaciation, and was followed by a temporary fall of sea-level, during which the overlying blown sand was accumulated. The Main Head he dated as of Riss age.

Subsequently, in the light of further work, Arkell (1945) reclassified the Cornish and South Coast beaches, as follows (more in accordance with Green's views) :

Upper Head	)	
Trebetherick Boulder Gravel	)	Würm (Last Glaciation)
Lower Head	)	
Portland Beach	)	
Barnstaple Beach and Blown Sand	)	Riss-Würm
Trebetherick Blown Sand	)	(Last Interglacial)
10 ft. or <i>Patella</i> Beach	)	End of Riss
	)	(Penultimate Glaciation)
Bembridge Beach	)	
Goodwood Beach	)	Mindel-Riss
	)	(Penultimate Interglacial)

Arber, on the evidence of erosion levels cut in Head in the Barnstaple area, claims that the Main Head cannot be as recent as Last Glaciation in age and concludes that Arkell's original dating of events was the correct one (see below).

Orme (1962) considers that the 25 ft. O.D. raised platform of north Cornwall is of pre-Saale age but points out that in many areas, e.g. Lannacombe, one can only say that the platform pre-dates the last major solifluxion. On the basis of work both

Raised Beaches and Marine Geomorphology

in the south west and in Ireland, he postulates that sea-level returned temporarily to a height at or near the Cromerian level during the Hoxne and Ipswichian Interglacials. Transgression above this level, such as occurred during Hoxne times and the regressions characteristic of the glacial phases he regards as abnormal oscillations about a common level. This view contrasts with that of Zeuner, who postulates that the sea-levels fell during successive interglacials.

Stephens (1961) has recently re-examined some Pleistocene sections in Cornwall and Devon, and offers the following chronology, which is given more fully in his paper.

Upper Head	Würm (Last Glaciation)
No trace of main deposits	Interglacial
Fremington boulder clay and	Riss (Penultimate Glaciation)
Main Head	
Raised beach	Interglacial
Large erratics reach coast	Mindel (Ante-Penultimate Glaciation)
Rock platform cut	Early Pleistocene

He argues for the existence of a series of wave-cut platforms of early Pleistocene age, overlain by a single raised beach, containing erratic material and with associated sand dunes. Platform and beach are clearly of different ages and as the Fremington boulder clay overlies the equivalent of the Raised Beach, it cannot have been responsible for the coastal erratics found at Croyde and Saunton.

The so-called "10-foot" raised beach at Saunton has, in contrast to the *Patella* beach, a rich warm-climate fauna, and yet rests on the same rock platform as the *Patella* beach, contains similar erratics and is overlain by the Main Head. Arkell (1943) suggests that both beaches belong to the same interglacial and that the Saunton beach records a second sea-level oscillation within it, during which the materials of the old 10-foot beach were re-worked and re-deposited with a warm fauna, the heavy erratics remaining on the platform.

The rock platform beneath the Fremington (?) boulder clay lies 15 to 20 ft. above High Water Mark and has been correlated with that beneath the *Patella* raised beach (Maw 1864). Stephens (1961) refers to well-rounded gravel beneath the Fremington clay, and equates it with the coastal raised beach. Zeuner (1945) agrees with Dewey (1935) that the clay is a true boulder clay and argues that as there is no evidence of ice trespassing on the '25 ft.' beach anywhere in Devon, the Fremington moraine must be older than this beach and dating from the Penultimate or some earlier glaciation. Arber (1960) favours the latter age.

Both Zeuner (1953) and Orme (1962) agree that in south Devon a lower and later platform can be traced, at about 14 ft. O.D. Zeuner dates it as Epi-Monastirian, and related to a rise in sea-level four or five meters above the present during the First Interstadial of the Last Glaciation. Sea-level has risen to a similar height at least once during the Post-glacial, re-activating the platform and sweeping it clear of its deposits.

Orme's 6-10 ft. raised platform, recorded only at Lannacombe, may be a local phase or may only represent an eroded portion of the 14 ft. platform.

2. The higher raised beaches

Arkell's (1943) original dating of the Trebetherick Boulder Bed (50 ft. O.D. sea-level) placed it in the Riss Würm Interglacial, and he accounted for the many erratics present in this high sea-level beach by suggesting that they came from high Tertiary platforms drained by the Camel river system, rather than from ice-floes. He equated it with the Start, Torbay and Portland raised beaches, and with the Croyde and Fremington erratics.

Bull and Green (Arkell 1943, discussion) questioned the correctness of this dating in relation to the *Patella* beach, pointing out that during a period much longer than that which has elapsed since the last glacial advance, the sea is assumed to have stood nearly 100 ft. above its present level. Yet it left neither trace on the cliffs rising above the *Patella* raised beach, nor marine or estuarine deposits upon the raised beach itself.

Arkell (1945) later re-dated the Boulder Bed as of Würm age.

The Mousehole raised beach (65 ft. O.D.) Arkell (1943) tentatively dated as Boyn Hill interglacial, but Green (1943) classes it as Lower Taplow. Arkell (1943) suggests that the 100 ft. and 160 ft. O.D. fragments near Porthleven may also be of Boyn Hill age.

Arber (1960) has traced two Pleistocene erosion platforms in the Barnstaple area, both cut into the Main Head, and related to Last Interglacial sea-levels at 100 ft. and 50 ft. O.D.

III. COASTAL MORPHOLOGY

With very few exceptions the coasts of Devon and Cornwall are retreating under wave attack " . . . but a major view does not suggest especially active erosion under modern conditions " (Balchin 1946). Early workers seriously over-estimated the rate of erosion. Whitley (1848) estimated the rate at one foot in three years in the Manor of Tehidy, and Budge (1846) argued that all traces of the raised beach platform would be obliterated within a few hundred years, an event which the full span of post-glacial time has failed to bring about in many areas.

Whitley (1850) was one of the first to discuss the 'outline' of Cornwall in terms of structure and marine processes. To him lithology was primarily responsible for the great headlands and bays, and he quoted the greenstone of St. Ives, the granite of Cligga Head and the trap of Trevoise Head as examples of the former. He was also aware (as was Boase 1832) of the importance of minor structures in marine erosion, as is shown by his paper on the Penwith peninsula.

This theme has been elaborated by several workers and it is now well established, as Balchin (1946) has amply demonstrated, that there is " . . . a fairly intimate relationship between the structure and morphology . . ." so far as the cliff coasts of Devon and Cornwall are concerned. Robson (1948) has examined and classified

Raised Beaches and Marine Geomorphology

the Land's End coast on this basis, and Wilson (1952) has contributed a valuable paper on the Tintagel area. He shows that geological structure — bedding, jointing, faulting and, to a lesser extent, rock-type — have not only had a considerable effect on the shape of the cliffs, but have also guided the marine attack on the coast. The evolution of most of the coastal features, when seen in plan or profile, has been controlled "by the local geological structure". Clarke (1959) has described the Padstow peninsula and the details of coastal morphology, such as the origin of blow-holes.

The result of cliff-retreat is the formation of rocky shore platforms, a discussion of which now follows.

IV. SHORE PLATFORMS

Hawkins (1827) noted the effect of ". . . the heavy swell and boisterous swell of the Atlantic . . ." on the cliffs of Cornwall, resulting in ". . . long reaches of rocks which are exposed to our view at low water (marking) the extent of these depredations . . ." Since his time there has been little interest in the shore platforms¹ of the south west peninsula and the following is a summary of work now in progress.

Shore platforms are found on every rock type outcropping along the coast, but are usually partially buried by beach material, especially at their critical junction with the cliff-face. The investigations have been concerned first with accurate measurement of transverse platform profiles from cliff-face to low water and related to Ordnance Datum (Fig. 2), and secondly with the processes that shape the platforms.

The distribution of the platforms is shown in Fig. 3. No two platforms are alike, and yet all share certain characteristics. In some areas the shore platform is composite or stepped and obviously incorporates portions of raised platforms, as at Harris's Beach, Lannacombe, where two or three main levels occur. The highest, which is exposed beneath a low head cliff, occurs at about 24 ft. O.D. This level extends for only fifteen feet from the cliff and then steps down to a level at about 15 ft. O.D. This extends for a further seventy-five feet and then there is another step down to a level at 0 ft. O.D. and this continues to Low Water Mark, a further hundred and fifty feet. These platforms are developed on mica schists and gneisses. At Kenneggy Downs on Devonian Slates and at Trebetherick Point on Upper Devonian Slates a similar development occurs.

Since the present Mean Spring Tides on the south coast reaches to a height of only 8 to 9 ft. O.D., and on the north coast only 10 ft. O.D., in the localities quoted, the 15 and 24 ft. levels must be attributed to higher stands of the sea. Along much of the coast of Devon and Cornwall however, the shore platforms rise well above the height of present mean Spring Tides without any step developed. This is particularly so on the north coast where fourteen of the twenty-six localities surveyed conform to this pattern. On the south coast it is a less regular feature but occurs at

¹This term is free of the genetic implications of 'abrasion platforms' or 'wave-cut platforms'.

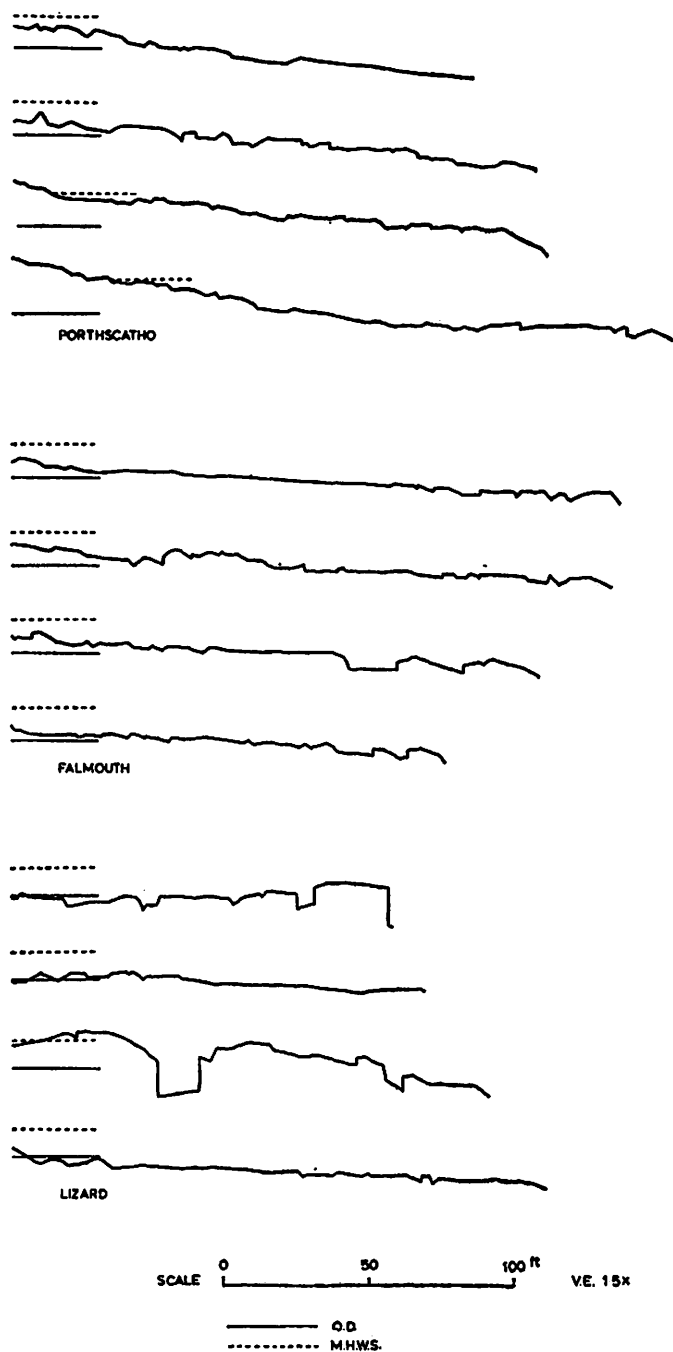


Fig. 2. Profiles of shore platforms showing the surface form, the relationship between the platform and Ordnance Datum, and the position of Mean High Water Spring. At Portscatho two profiles show the existence of a raised portion of platform.

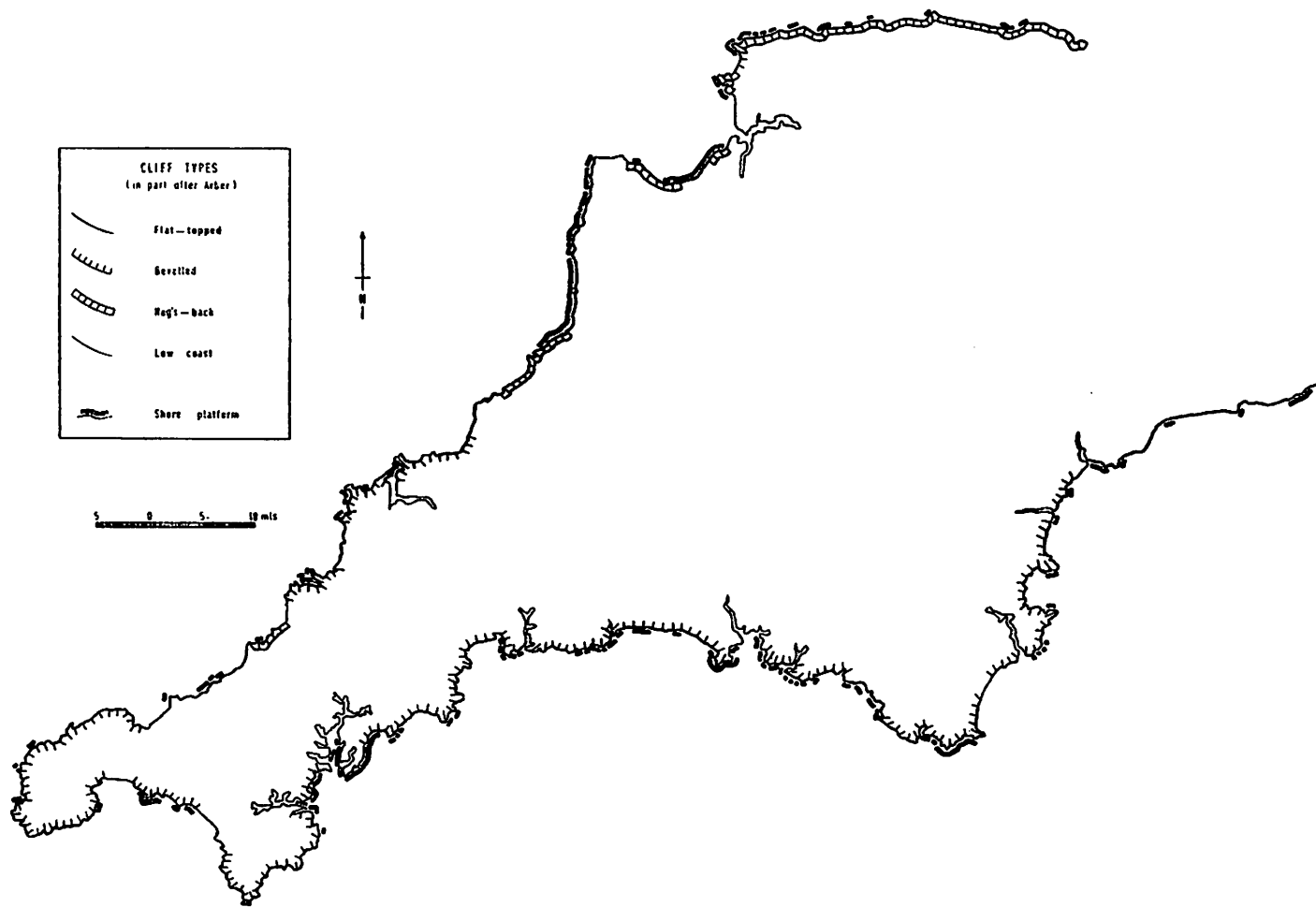


Fig. 3. Distribution of Cliff-types and Shore Platforms.

four localities. The diagnostic feature of a 'raised' platform therefore, is not necessarily a stepped profile, although there is usually an increase in gradient between the two levels. A further distinction between the two levels is a change in colour and in vegetation. The higher levels are usually much lighter on colour and support a sparse vegetation of halophytic plants especially *Ameria maritima* and *Plantago maritima*, whilst the lower level is darker in colour and is colonized by marine algae.

The same data used to draw the profiles can also be used to plot a height range diagram. By superimposing upon this the Mean Spring and Neap Tidal range, derived from the Admiralty Tide Tables, certain features emerge (Fig. 4). Three groups of platforms can be distinguished; those having a raised facet which are represented as extending above the mean Spring High Water Mark; those which have no raised facet but rise to the mean Spring High Water Mark; and those which do not reach this mark so that the spring high tides reach the solid cliff. Of these three groups perhaps the most interesting is that which rises to the Mean Spring High Water Mark. There are nine such localities shown on this diagram and at most of them it can be demonstrated that erosion is active at the present. For example at Trevaunance Cove near St. Agnes there has been a recent cliff fall due in part at least to undercutting at the base which has partially obscured the platform on the eastern side of the bay. Another example of contemporary erosion can be seen at Green Cliff two miles south west of Westward Ho! Here the raised beach and platform so well developed at nearby Westward Ho! has been completely destroyed and the modern platform abutts against the solid rock cliff.

On the south coast perhaps the best example can be seen at Corbyn's Head, Torquay. The rocks here are of New Red Sandstone age and are less resistant to erosion. Only where the platform is protected from attack by the south westerly storms does it rise to the height of the Mean Spring Tides. On the exposed flanks of the headland it is cut much lower. This was a feature of most of the other localities where New Red Sandstone occurred. At Sidmouth, Exmouth and Dawlish the platform was exposed only on the headlands as deposition of sand in bays obscured it and in all these cases the platform was below the Mean Neap High Water Mark (Fig. 4). The abundance of sand present in the bays and the near vertical, unvegetated lower part of the cliff all suggest active erosion on these softer rocks. The only localities on the north coast where this occurs are Heddons Mouth and Lynmouth where the platforms are cut into Lower Devonian rocks. At Heddars Mouth there is an abundance of coarse sand which has abraded the platform and lowered it to its present level. At Lynmouth much abrasive material has been brought to the coast by the East and West Lyn, and this together with the products of marine erosion, has likewise helped to lower the platform.

Although the height of the cliff/platform junction varies considerably from one locality to another, on a smaller scale there is also a difference in height between the junction in small bays and their enclosing headlands. In most cases where resistant rocks occur the platform developed upon the headland rises higher than that within the bay. At Hele Bay, east of Ilfracombe, the cliff/platform junction on the headland

Raised Beaches and Marine Geomorphology

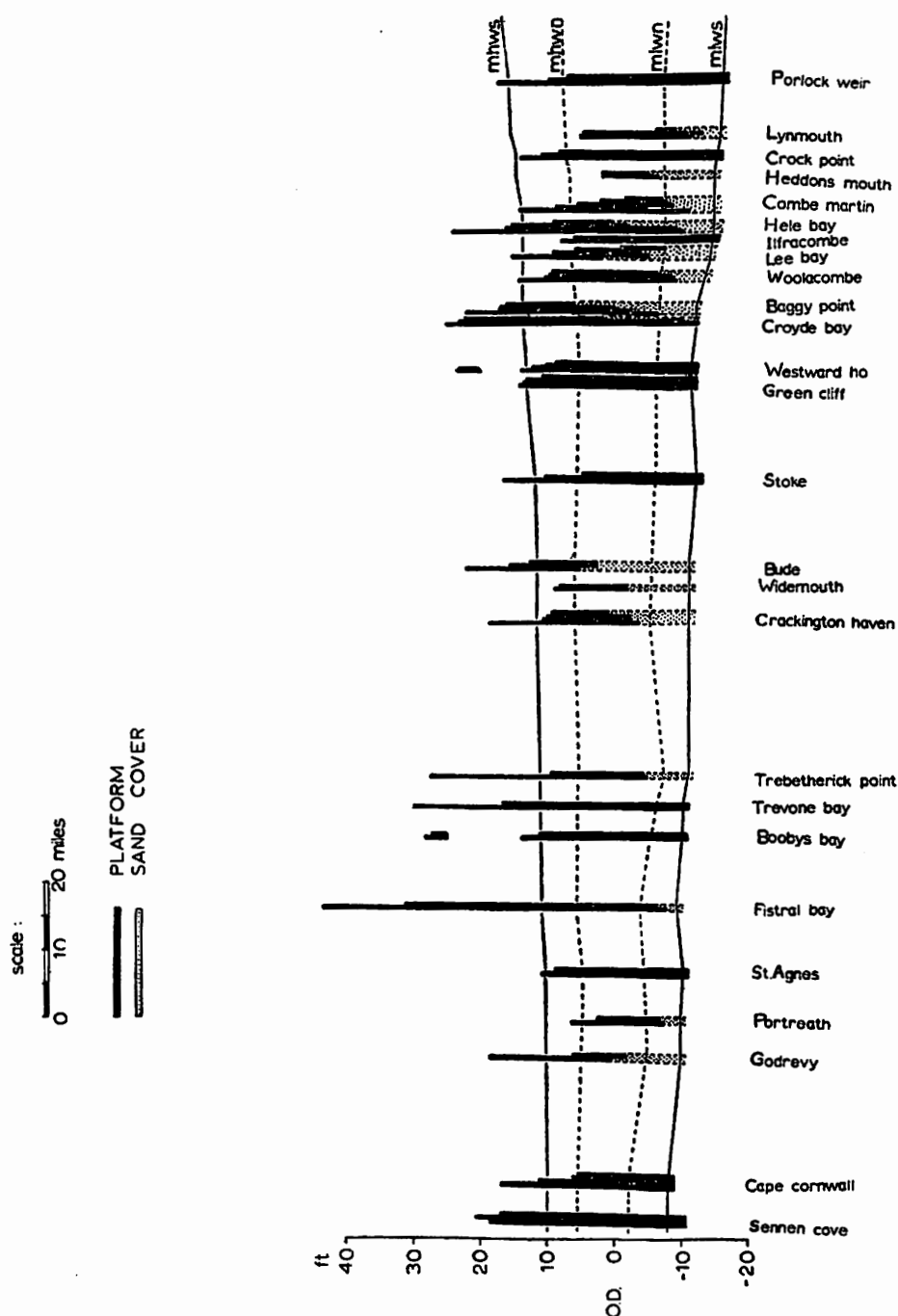


Fig. 4. Diagram illustrating the relationship between the height range of the platform and the mean positions of High Water Spring, High Water Neap, Low Water Neap and Low Water Spring.

is at 24.8 ft. O.D. and in the bay centre it is at 9.7 ft. O.D. The platform length also varies. On the headland it is only about 190 ft. long whereas in the centre of the bay it is 360 ft. in length. Because of this the slope of the platform at the headland is far steeper than that in the bay. At Crackington Haven on the Culm Measures the same features can be demonstrated. At the headland the platform rises to 18.8 ft. O.D. but in the centre of the bay only to 7.6 ft. O.D.

In contrast to these general features of shore platforms which apply widely over Devon and Cornwall, the detailed features, which are due to an interaction of several processes and to the more detailed structural and lithological factors, are more difficult to study and interpret.

The geology of the platforms, in its widest sense, would seem to be the basic influence upon the detailed form of the platforms. This includes the lithology, the thickness of the bedding, the intensity of jointing, hardness, the strike and dip of the rocks at the coast and the intensity of folding and faulting. Lithological differences are picked out by differential erosion and this can be demonstrated on the platform at Westward Ho! and at Gorran Haven. At Westward Ho! igneous intrusions are exposed in the platform and remain as low ridges up to four feet in height. At Woolacombe large vertical quartz veins bedded with, and cutting across, the Morte Slates are left as upstanding ridges up to five feet high while the surrounding softer slates are furrowed out in the most fantastic fashion.

Bedding planes and joint planes are also important to the detailed relief of the platforms, for it is along these lines of weakness that erosion tends to be concentrated. Thus massively bedded and poorly jointed rocks suffer less rapid erosion than a well bedded and strongly jointed rock, other things being equal. The Land's End Granite is a massively jointed rock with a very poor platform development, whereas at St. Agnes (Trevaunance Cove) the platform is well developed upon well bedded Lower Devonian rocks. Similarly, at Corbyn's Head in Torbay, where thinly bedded New Red Sandstone outcrops, erosion has worked along the bedding planes and joints, giving a generally tabular nature to the platform.

The hardness of the rocks is a further factor to be considered, but one which is difficult to assess. This is undoubtedly another reason why granite platforms are so poorly developed. In general terms, the dip of the rocks does not affect the platforms to any great extent. However, in detail differences can be seen. Gently dipping beds give rise to a continuous or stepped platform while steeply dipping or vertical rocks give rise to a corrugated surface such as can be seen at Woolacombe. In highly contorted rocks, because planation is never complete, small-scale structures inevitably remain as surface features. This is most clearly seen in many areas of the Culm Measures and it is well demonstrated at Crackington Haven where a small monoclinal flexure gives rise to a step two feet high.

The geology therefore, has a considerable influence upon the character of the platform. Generally softer rocks give rise to wider platforms than harder ones and only on the latter are the 'raised' platforms preserved. Since wave attack along lines of weakness is one of the main agents of erosion, the degree of dip, jointing and

Raised Beaches and Marine Geomorphology

bedding are important factors in the development of the platforms. Other things being equal, erosion is favoured in those areas where the rocks are gently dipping, well bedded and striking parallel to the shore, or where they are steeply dipping, well bedded and striking perpendicular to the shore. Where steeply dipping rocks strike parallel to the shore the platforms are much narrower. This is illustrated by comparing Widemouth, where the rocks strike perpendicular to the shore and the platform is wide, with Ilfracombe where the rocks strike parallel to the shore and the platform is much narrower.

So far it has been implied that the process of attack is uniform. This however is not the case as the platforms are being driven back and lowered by the interaction of several processes. These include wave-quarrying, abrasion, pot-holing, solution attack and spray weathering. The presence of animal and plant organisms is also of some significance.

In most areas wave-quarrying is the most important factor to be considered. The process is essentially that of large masses of water being thrown against irregularities in the platform and the compression of air trapped in the joints and bedding planes. This process can operate anywhere between low and high tide, so the whole platform can be subjected to its influence, and it is particularly important that at high tide when the waves break on to the cliff. Most erosion is accomplished during storm periods; for most of the time the sea is geomorphologically idle. Even so, erosion accomplished by this process would seem to far exceed that of the other processes combined. The effects of wave-quarrying are easily recognised, the two dominant characteristics being the angularity of the platform surface and the occurrence of freshly exposed rock faces. These features are well displayed on the Culm Measures.

Abrasion is of more limited importance and can only occur at all where an abrasive, in the form of sand, shingle or rock debris, is present (Pl. 4). Only the New Red Sandstone rocks break down to give an abundance of abrasive material, and in these areas the platforms are frequently lower than elsewhere (Fig. 4) and are more planed and smoothed. This process tends to be concentrated along lines of weakness so that the joint pattern is etched out. This is most clearly seen at Sidmouth but it is true to a lesser degree in every other area where an abrasive occurs.

In the non-sandstone areas there is a tendency for abrasive material to be concentrated in a zone at the cliff-foot and it is in the yard or so seaward of this where most abrasion occurs, under normal sea conditions. During storms, the zone in which abrasion can occur is considerably widened. It may occur down to a limit of 30 feet below low tide level but during storm periods it would seem to be particularly effective in attacking the cliff/platform junction. Despite this a notch seldom develops at this junction, indeed the most extensive notching occurs on the sides of stacks perpendicular to the shore (Pl. 5). This suggests that a sawing motion, due to the movement of material back and forth under the influence of the tides is far more important than direct frontal attack. The latter often produces slight undercutting at the base of the cliff, but it is seldom the smooth concave curve implied by the term

'notch'. Notching occurs on the sides of stacks in several areas on the north Cornish coast and can be especially well seen at Perranporth and along much of Culm coastline.

Wave-quarrying and abrasion are the most significant processes operating in the south west. Of the minor processes, which tend to lower rather than widen the platform, perhaps the most spectacular is pot-holing, which is more common on the north coast than the south. Pebbles and sand are whirled around in a small depression, usually at the foot of a step in the platform, and slowly wear a round or elliptical hole in the rock surface. These occur on almost every rock type and vary in size from a few inches to about four feet across and up to two feet deep. They are usually isolated features as at Coombe Martin but may coalesce and so lower the surface considerably. At Woolacombe, for example, the pot-holes are separated by knife-edge ridges.

Another minor process is spray weathering (Pl. 6), but this is only effective on the raised portion of the platform and the cliff above high spring tide level. Spray splashed on the rock dries and the salt, crystallizing in minor cracks, expands and flakes off pieces of rock. Irregular pits about two inches deep honeycomb the rocks, occurring on vertical and horizontal surfaces. They are best developed on the former, especially where a vertical face exposes the bedding planes to splashing by the waves. At Godrevy this can clearly be seen where the 'raised' platform is completely pitted by this form of weathering. It occurs in many areas on both the north and south coast being particularly in evidence at Wembury and at Hope's Nose, Torquay.

The effects of chemical erosion are more difficult to demonstrate, although it undoubtedly occurs over the whole area. There are two points to be considered: the chemical effects of sea water upon the platforms, and the chemical effect of plants and animals. Sea water solution is best seen on limestones which occur only in the Torbay district which does not have well developed platforms. However, it is probable that salt water also affects the other rocks of south west England and it is hoped that future work of a quantitative nature will demonstrate this fact.

Marine algae and animals are generally widely distributed on the platforms and these undoubtedly increase the pH value of the water in the rock pools in which they live. Animals, especially molluscs but also fish, expel carbon dioxide in the process of respiration and marine algae also give off carbon dioxide during the hours of darkness. This all helps to encourage the breakdown of the rocks. This is accelerated during the summer when the rock pools are left at low tide and the temperature in them rises considerably. The water becomes saturated with such elements as calcium and magnesium and is then flushed out by the next high tide. So the process continues.

On many platforms marine algae form an almost complete blanket and this indicates that wave-quarrying and abrasion is limited. This is the case at Looe. However, if the seaweeds, especially the wracks (*Fucus*) and other varieties attaching themselves by means of a holdfast, are torn away, they take with them a sliver of the rock to which they are attached. This occurs quite extensively during storm

Raised Beaches and Marine Geomorphology

periods and must make some contribution, however small, to the lowering of the platform.

It is clear from this study that there are important differences between the north and south coasts of the peninsula. Erosion is greater on the north coast, which is shown by the more continuous development and greater width of the shore platform on the north coast. On the Culm Measures there is a continuous development of platform from Hartland Point to the Cambeak, a distance of about 25 miles, whereas on the south coast the most extensive development is between Pendower in Gerrans Bay, and Porthmellin Head south of Portscatho, a distance of only five miles.

There seems to be no specific height relative to the tides to which the contemporary platforms develop, some rising to mean high spring tide level, but others are below this or even below mean high water neap tide level. Likewise, the width of the platforms is not governed exclusively by the amplitude of the tidal range. For example at Widemouth the platform is nearly 700 ft. wide where the tidal range is 22 ft., whereas at Lynmouth the platform is only 200 ft. wide although the tidal range is 30 ft.

V. CLIFF PROFILES

It has already been noted that the cliffs of the south west peninsula are relatively low, often not exceeding 200 ft., and that a vegetated surface of gentler inclination (the coastal bevel) often intervenes between the cliff-top and the edge of the lowest coastal plateau. In recent years there has been a revival of interest in cliff profiles but it is worth recording that as far back as 1827 Hawkins perceived that sub-aerial denudation contributed to the shaping of cliffs and that the coastal bevel was characteristic of long stretches of coast. He further observed that the bevel was formed at a time when the 'original outline' of the peninsula was being shaped.

Orme (1962) has emphasised the poly-cyclic and poly-genetic origin of the cliffs of south west England, which often consist of a 'fossil' cliff (perhaps formed in the Middle or Upper Pleistocene) truncated, intersected or overrun by a recent cliff. The result is a considerable variety of cliff profiles.

Arber (1949) describes the following basic profiles : (Fig. 3).

(1) The almost vertical cliff face, abruptly terminating the inland plateau (e.g. 440 ft. high at Morwenstow).

(2) At the other extreme the long, steep vegetated slope descending to sea-level, only the base being subject to wave attack (e.g. the Great Hangman, rising to 1,024 ft. within 300 yds of the shore).

(3) An intermediate type, in which a vegetated slope curves in a bevel from the level surface above to the vertical cliff below ; the curve may be concave or convex (e.g. the Lizard, Land's End).

On the basis of the above, Arber proceeds to the following classification of cliff profiles in north Devon and north and west Cornwall :

Hog's-backed cliffs. These are largely dependent on geological structure and develop where the strike approximately parallels the coast, the dip being either seawards or landwards (Balchin 1946). In Orme's view (1962) hog's-backed cliffs largely preserve the 'fossil' cliff element. They are found on coasts protected from the dominant wave attack, e.g. east of Morte Point.

Bevelled cliffs. The depth of the sea-cut face in proportion to the slope ('fossil' cliff) above is dependent upon the exposure to wave attack. The bevel is clearly of sub-aerial origin but is not being developed under modern conditions. The bevel tends to be concave on granites, but elsewhere is broadly convex (see below).

Flat-topped cliffs. These are vertical cliffs developed on very exposed portions of the coast and are actively retreating, having presumably consumed all traces of the 'fossil' cliff. They tend to develop where the coastline cuts across the strike (Balchin 1946).

Arber has summarised the various theories on the origin of the coastal bevel and a recent paper by Bird (1963) outlines the most commonly accepted view, as it applies to the Dodman area. The bevel is regarded as a former sea cliff degraded under periglacial conditions when sea-level was much lower, some harder masses, e.g. quartz, remaining as tor-like protrusions. As sea-level rose during the Flandrian transgression the lower slopes were undercut, particularly on the exposed western side of the Dodman.

Orme (1962) has described in some detail the abandoned and composite sea cliffs of the south west. He notes that they are well preserved in schists between Start Point and Bolt Tail, in the Land's End granite, and in Devonian slates and grits throughout the peninsula. Rocks of intermediate hardness preserve them in part in the 'bevel', while in relatively weak rocks and on exposed coasts (e.g. Hartland Point to Bude), recent seas have cut back beyond them. He differs from Arber in this emphasis on the importance of rock-type. He relates this 'fossil' cliff line to a prolonged stillstand late in the Hoxne Interglacial. "It was subsequently dissected by Saale congelifraction, partially cliffed during Ipswichian times and again buried by Weichsel head."

Saviegar (1960) regards the coastal bevel (which he re-names the seaward slope) as of composite origin. He observed in West Penwith that the cliffs terminate upwards in a distinct bevel, averaging 50°. Between this bevel and the plateau surface (here the 330 ft. platform) he recognises three morphological units, at mean inclinations of 32°, 27°, and 6°. These four slope units he regards as the main constituents of the seaward slopes, and related to four phases of marine erosion, modified during the production and accumulation of the Head.

In a later paper (1962) Saviegar extends his survey to the Ilfracombe and Boscastle areas, and in proposing a poly-cyclic origin for the seaward slope (coastal bevel), he strongly opposes previous views on its origin. He believes that the bevel is generally rectilinear and angular in form, even on apparently smoothly convex outline, proving on examination to possess angular breaks which separate both slope facets and/or curved slope elements.

Raised Beaches and Marine Geomorphology

The seaward slope forms are believed to have been initiated by successive phases of cliffing (one, two or three phases in the case of the Little Hangman and Great Hangman), each followed by a period of sub-aerial slope modification. The earliest phases are represented by low angle slope facets, the latest by the current marine cliff. Certain facets may be less extensive than others, or absent from certain localities, because they have been erased by the more vigorous growth of steeper facets from below.

Much of the work now in progress on the cliffed coasts of Devon and Cornwall represents a big advance on the earlier, purely descriptive accounts and underlines Balchin's point that comparatively stable cliffed coasts can be as productive of geomorphological problems as coasts of accretion.

VI. DEPOSITIONAL FORMS

1. **Beaches**

Stuart and Simpson (1937), as a result of investigations into the mineralogical composition of beach sand along the north coast, conclude that longshore drift is not great enough to mask its essentially local character. Robson (1950) is satisfied that most of the beach sediment in Cornwall at least is of fluvial, and therefore of local, inland origin. At the same time, he points to the presence of 'derived' constituents, such as the flint that is a conspicuous ingredient of many south coast beaches, and the abundant shell fragments, together with the material that is made available by slow cliff retreat and the gradual erosion of the raised beaches. Most of the minor bays and coves contain beach material, but the amount and quality vary considerably with both time and area. Generally speaking, the quantity is most scanty during the winter months when destructive wave action tends to prevail and in those narrow coves flanked by prominent headlands where longshore drift is minimised and the supply of new material prevented. There is an obvious contrast between these restricted and variable bay-head beaches and the long open sweeps of sandy foreshore that fringe the larger sand dune areas.

2. **Sand dunes**

There is a need to distinguish between the old and the modern blown sand (Rogers 1909). The old sand (regarded by some as being of sub-aqueous origin, e.g. Dewey 1935) is usually brown in colour, consolidated, and frequently observed (as in the Newquay and Gwithian areas) to lie between the normal pebbly raised beach and the later Head deposits. It would seem, therefore, that this sand accumulated during the Pleistocene period, presumably at a time when a relatively low sea-level caused the exposure of an extensive and sandy foreshore.

The modern blown sand (Fig. 1) differs in that it is yellow in colour, calcareous rather than quartzose, and it overlies the Head deposits. At Gwithian, on the south side of the Red River near Strap Rocks, old and modern blown sand may be seen close together, separated only by a thin layer of stoney Head. This modern blown sand is much more extensive on the north coast, as may be appreciated by comparing

the large dunal areas of Braunton and Northam Burrows, Penhale and Gwithian Towans with the isolated pockets that occur at infrequent intervals along the south coast. The factors contributing to this greater accumulation appear to be fourfold (Robson 1944): (i) the occurrence of wide beaches of light granitic sand, (ii) the prevailing south-westerly winds are directly onshore, (iii) the gently shelving nature of the offshore zone, and (iv) the mobility of much of the sand due to the abundance of light shell fragments.

Little or no serious work has yet been done on the chronology of these 'recent' accumulations of blown sand. Carne (1825) deduces from the discovery of coins that the deposition of sand in the vicinity of Hayle must have taken place before the final departure of the Romans in the 5th century. There is certainly plenty of archaeological and documentary evidence of the continuing and relentless inblowing of sand through historic times, evidence that awaits a thorough and co-ordinated investigation.

3. Spits

Spits are rare in south west England and there are only three major examples (Fig. 1). Dawlish Warren, the largest, is in fact a double spit. Kidson (1950) believes that the Inner Warren is composed of sand blown from the Outer Warren, a suggestion that is perhaps confirmed by the fact that the inner spit is lowest in the south west and highest in the north east, (the prevailing winds are the south westerlies). The two spits are separated by Greenland Lake, a broad depression formerly covered at high tide but now usually dry. Martin (1872, 1876, 1893) provides some interesting measurements of the erosion of the Outer Warren in the nineteenth century, while Kidson illustrates the seriousness of the erosion on the seaward face during the present century. The outer spit was apparently built of material derived from Langstone Rock and Clerk Point, together with fluvial debris deposited in the estuary. With the steady removal of these headlands in post-glacial times, the supply of material from the south west has so diminished that today it is insufficient for the maintenance of the spit.

At Teignmouth there are two opposing spits. The permanent spit, known as Denn Point, has grown south westwards across the estuary, while the impermanent structure, known either as Teignmouth Bar or the Hook, is regularly built outwards from the Ness at Shaldon. According to Spratt (1856) this second spit undergoes a cycle of change having a period of about seven years, and its growth and subsequent partial destruction may be related to fluctuations in the extent of Denn Point. It is interesting to conjecture whether the origin of these opposing spits bears any relationship to that worked out by Robinson (1955) for apparently similar structures at the entrances to Poole, Christchurch, and Pagham harbours.

The Northam Pebble Ridge is a spit of well-rounded pebbles built northwards from Westward Ho! across the Taw-Torridge estuary, and provides protection to the sand dunes of Northam Burrows that lie behind it. The pebbles are composed mainly of Carboniferous sandstone which is exposed in the cliffs running west to

Raised Beaches and Marine Geomorphology

Hartland Point. Spearing (1884) believes, however, that the pebbles are in fact derived from the erosion of raised beach material immediately to the west of Westward Ho! Like the Outer Warren at Dawlish, there is evidence that this spit is diminishing in size, presumably as a result of both the exhaustion of the source of material and the steady comminution of the present pebbles. There is also clear evidence that the spit is being rolled inland. Rogers (1908) states that the Ridge was driven back by no less than 30 ft. in one year, and that over a period of 45 years the south western end retreated by about 200 yards.

The Doom Bar close to the mouth of the Camel estuary is sometimes and erroneously cited as a Cornish example of a spit. This bank of shell sand is, however, completely submerged at high tide, and must therefore be classified as a 'bar'.

4. Barriers

A number of theories has been propounded to explain the shingle barriers that are to be found along the south coast of Devon and Cornwall (Fig. 1). Ussher (1904) suggests that the barrier at Slapton started life as a spit deflecting the Gara southwards. This proposed southward growth might also explain the spreads of gravel that are to be found on the north side of Slapton Bridge as being fluvial deposits. Worth (1904, 1909, 1923) makes a number of interesting statements about the possible origin of the Slapton barrier and the two smaller features to the south at Beesands and Greenstraight. Firstly, he states that dredging in Start Bay shows that these accretional structures cannot receive any appreciable amount of material from the offshore zone. Secondly, in his opinion the drift of beach material in Start Bay must be balanced, for otherwise the barriers would have disappeared long ago as a result of the pronounced one-way direction of drift. Finally, he states that the presence of flints and other non-local rock types in the shingle necessitates ascribing a considerable age to the structures. Robinson (1961) agrees with and provides more evidence to support Worth's observations. The arguments are also extended to the conclusions (i) that the shingle must have reached the shoreline from offshore during a time of rising sea-level, (ii) that this could only have been at the end of the last glacial period, (iii) that the supply of shingle must have been limited, and (iv) that probably for some time past the amount of shingle has not increased on any of the Start Bay barriers.

It is worth noting that Loe Bar near Helston, and the smaller barriers at Marazion and Swanpool (Robson 1944) also contain large quantities of flint in their constituent shingle. Toy (1934) was perplexed by this occurrence when discussing the formation of Loe Bar. According to him, the flint is simply derived from Prah Sands and is moved eastwards by tidal action. This is apparently counter-balanced by a westward movement of the same shingle during times of strong south easterly winds. As a result of these alternating movements, two opposing spits were built across the mouth of the Cober to eventually form the barrier, the final closing of the estuary being ascribed either to gradual processes or to a single occurrence, such as a tidal wave or storm surge. But this improbable theory does not solve the basic problem of

the source from which the flint shingle came. Surely here is yet another instance where during a period of eustatic rise material has been rolled in against the coast from some distance offshore.

5. Estuarine silting

All the 'rias' of south west England have to some extent experienced silting (Fig. 1). The basic cause of this accretion must have been the post-glacial eustatic rise, which by reducing stream flow would encourage the deposition of fluvial sediment. It is more than likely, however, that other factors of a more local nature have played their part. The great amount of alluvium contained in the estuaries of south east Devon can perhaps be related to the prevalence of softer rocks in this part of the peninsula. Elsewhere exceptional degrees of silting may be related to the effects of tin-streaming, the working of china-clay, and in some cases to obstruction at the estuary mouth by such phenomena as spits, bars, beach material and blown sand. Symons (1877) and Everard (1960) have examined the relative effects of these different processes in the Par estuary, and Whitley (1881) in the creeks of Carrick Roads. Witherick (1963) has collected the manuscript and cartographic evidences that describe the course of estuarine silting in the cases of the Fal and Fowey rivers.

VII. CONCLUSIONS

This review of research on the raised beach and coastal geomorphology of the south west peninsula shows clearly that many topics merit further investigation. Current work on cliff profiles, shore platforms and the processes that shape them is probably the most active field of research at the present time. There is an urgent need for a thorough re-examination of all extant raised beach sections, relating them to Ordnance Datum, in the hope that the complex problems of their age and correlation may be resolved. Remarkably little has been done on the shingle structures, and on the dunes of the north coast. In the case of the latter attention needs to be focussed on the period and conditions of initial accumulation and migration in historic times.

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Raised Beaches and Marine Geomorphology

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PLATE 1. Looe. Showing low head cliffs overlying raised platform and the re-grading of this higher surface to the modern sea level. This lower surface may have been cut at an earlier date when the sea stood at or near its present level.

PLATE 2. Looe. Showing head overlying raised platform. The illsorted character of the head reflects its deposition here from a small stream.

PLATE 3. Wembury. Section showing junction between raised platform and head deposit. The shattering of the top of the (slatey) platform and its alignment in the direction of slope with long axes parallel is well shown as is the pseudo bedding in the head deposit.

PLATE 4. Ilfracombe. A typically abraded surface developed on Middle Devonian Slates.

PLATE 5. Heddons Mouth. A classical notch developed at the cliff-foot. These features are rather unusual and would seem to develop only where material can be dragged back and forth along the base of the cliff. The best development therefore, occurs where the coastline is parallel or oblique to the direction of main storm-wave approach.

PLATE 6. Godrevy Point. Here the raised surface is being attacked by spray weathering which has honey-combed the Mylor Slate. This phenomenon occurs only in the zone where spray is being thrown up; beyond this it dies out completely. The photograph was taken at high tide.

PLATE 1



PLATE 2



PLATE 3

