

RAISED BEACHES OF WEST CORNWALL AND THEIR EVOLVING GEOCHRONOLOGY

H.C.L. JAMES

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The presence of a series of low level raised beaches along the Cornish coast is well known since the early work of Borlase and De la Beche. They overlie shore platforms and are overlain by terrestrial sediments. Earlier attempts to date the former marine sediments through the use of long-distant altitudinal and lithostratigraphical correlations are reviewed. The results of the application of modern geochronometric techniques to date the Cornish raised beaches are discussed.

H.C.L. James, Department of Science and Technology Education, University of Reading, Bulmershe Court, Earley, Reading, RG6 1HY.

Establishing a chronology for the Pleistocene raised beaches of south-west England has been one of the most contentious issues in the study of coastal Quaternary deposits in the region. Arkell (1943) proposed the first comprehensive stratigraphy for the coastal Quaternary deposits of west Cornwall, placing the raised beach at Trebetherick Point within the Penultimate interglacial. Mitchell (1960) favoured a Hoxnian age. Other workers, Zeuner (1945) and Guilcher (1949) preferred a Last (Monastirian) Interglacial date. These differences in opinion largely reflected the lack of datable material within the raised beaches and they could be dated only by reference to the overlying matrix-supported diamicton known as Head.

Most attempts to date raised beaches since 1945 were based upon altitudinal correlation with respect to estimates of interglacial sea levels, for example, by Fairbridge (1961). The difficulties of establishing a common datum point related to HWM were illustrated when attempts were made to correlate platform and raised beach heights over long distances and even across oceans (James, 1974). Thus, to be realistic, unless there is more information available for a raised beach other than its altitude, then it is not possible to date it.

Attempts to obtain a relative date for the raised beaches of western Britain based on ^{14}C age estimates of marine Mollusca found within overlying glaciogenic sediments (John, 1970) were dismissed by Mitchell (1972) as unreliable and the use of this technique for such material in raised beaches is probably best limited to Holocene beaches. Since the early 1980s, a number of newly developed geochronometrical techniques have been applied to raised beach material. Amino-acid racemization (AAR) techniques, details of which may be found in Miller and Brigham-Grette (1989), have been used globally over the past decade. This approach, based on the ratios between the amino-acid L-isoleucine and its diastereomer D-alloisoleucine, is used to give a relative index of age. The L-isoleucine epimerizes to D-alloisoleucine on death of the mollusc. This ratio increases from zero in a recently dead specimen to an equilibrium ratio of $1.3 \pm 1/0.05$ (Miller and Brigham-Grette, op.cit.). The length of time needed to reach equilibrium is dependent on species and integrated palaeo-temperature.

The application of AAR to molluscs collected from three sites in west Cornwall, Godrevy [SW 581 429], Newquay [SW 799 624] and Trebetherick [SW 927 782] by Davies (1984) and Bowen *et al* (1985) (Figure 1) produced broadly similar results for Godrevy and Newquay. Davies concluded that the Newquay and Godrevy raised beaches may be correlated with Oxygen Isotope (OI) stage 7. The lower ratio for the single sample from Trebetherick (Bowen *et al.*, op.cit.) suggests OI Substage 5e.

However, the results from Davies (1984), although internally consistent, were produced with an earlier preparation method that gave higher ratios than the current preparation method used in Bowen. Thus a reinterpretation of the Davies ratios could make most of them IO substage 5e in age. In addition, the earlier data of Davies were not standardised to any particular species while the later set were, to *Patella vulgata* (note, *Littorina littorea* is currently used as standard, (Bowen, 1994).

Uranium-series disequilibrium techniques applied to flowstones and stalagmites and stalactites from raised platforms (Gray and Ivanovich, 1988) require the presence of suitable material. Samples of carbonate cemented sandrock from Godrevy were collected by the writer in order to apply U-series dating techniques, but unfortunately the texture proved to be too coarse with uneven style of cement. Hence the material acted as an open system thereby permitting leaching of the uranium to take place rather than as a closed system which is desirable if the U-series disequilibria is to be used as a geochronometer (M. Atkins, pers. comm.). Ideally a number of different geochronological techniques should be used to provide independent corroboration for the estimated dates. Keen *et al.* (1981) illustrated this by using AAR and U-series in dating the Mollusca and associated travertine within the raised beach material found in Belle Hougue cave in north Jersey.

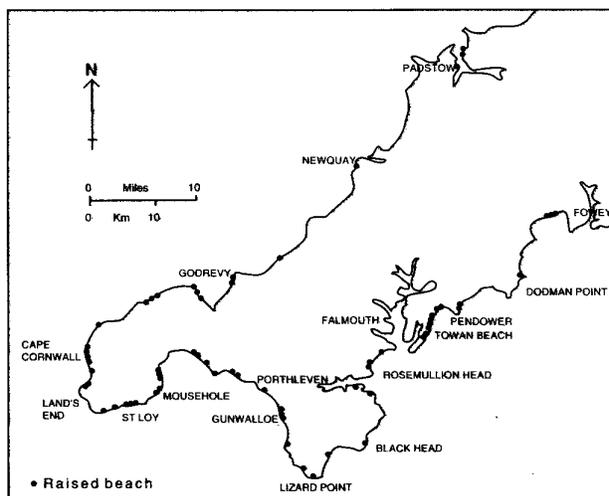


Figure 1
The Pleistocene raised beaches of west Cornwall

Thermoluminescence (or TL) techniques may be applied to non-fossiliferous as well as fossiliferous sediments (Aitken, 1985). Much of the arenaceous raised beach deposits, particularly in south Cornwall, together with the loessic material of west Cornwall are suitable. In principle, a TL age involves measurement of the luminescence (laboratory induced) and determination of the palaeodose, that is:

$$\text{TL apparent age} = \text{palaeodose/dose rate.}$$

Wintle (1981) used TL techniques to obtain Late Devensian dates for the loessic materials overlying the matrix-supported diamicton in the Scilly Isles and west Cornwall. Most of the earlier TL experiments on Quaternary sediments were concentrated upon clay and silt size materials (Wintle and Catt, 1985) but the potential for work on sand-sized quartz from beach sediments using Luminescence techniques is being investigated (Wintle, pers. comm.).

Figure 2 demonstrates a characteristic Quaternary succession of west Cornwall. The raised beach overlies the raised shore platform. Clearly this platform is at least as old as the overlying raised beach and probably considerably older. Large "erratics", whenever present, are always found at the base of the raised beach deposits in direct contact with the underlying platform.

The question of the number of separate low level raised beaches in west Cornwall and in surrounding regions is sometimes difficult to resolve as it is unusual to find them in close association. At least two distinct low level raised beaches have been identified in the West Country, at Portland (Davies and Keen, 1985) and Torbay (Mottershead *et al.*, 1987). These, like that identified earlier at Swallow Cliff, Middlehope, (Gilbertson and Hawkins, 1977) all fall within the altitudinal ranges suggested for west Cornwall.

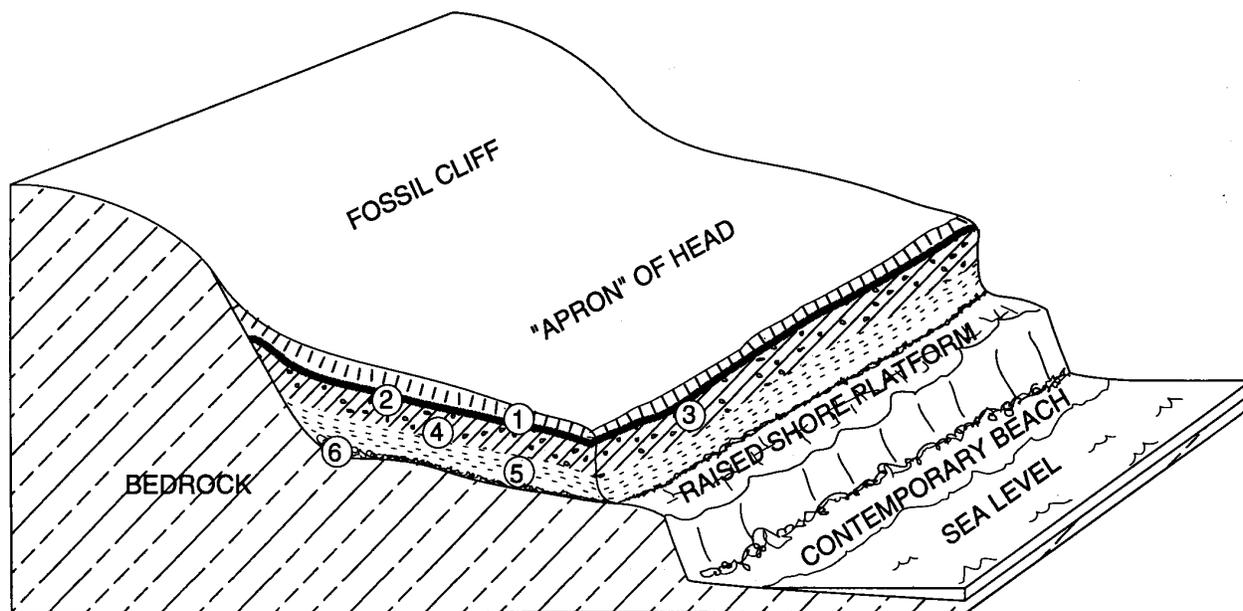
With access to bench marks, precise levelling of the notch at the raised beach/old cliff junction suggests three specific levels in west Cornwall. The established levels for the relict notches are:

- 4.4 m above O.D.
- 12-13 m above O.D.
- 20 m above O.D.

Exposures of the 20 m above O.D. level raised beaches are now fragmentary in extent and generally inaccessible. The 12-13 m above O.D. beach is normally restricted to the more resistant and exposed granite outcrops of the Land's End peninsula with occasional exposures elsewhere, for example, Trebetherick. By far the most extensive raised beach is that at 4.4 m above O.D. which is particularly well preserved in sheltered non-granitic coastal areas along the south coast. However, as noted in James (1968), the heights of the notches can vary by 1-2 m from individual headland to bayhead beach and a number of intermediary heights have been obtained.

The contact between the raised beach and the overlying head ranges from a distinct planar unconformity as may be seen at Towan Beach [SW 869 328] and Bream Cove [SW 791 285] to an irregular contact with load structures penetrating into the underlying sand unit, for example, Godrevy Rocks [SW 581 429]. Elsewhere, the overlying diamicton may be seen to interdigitate into the raised beach, for example, Gunwalloe Fishing Cove [SW 654 223], which would appear to indicate that emplacement of the basal diamicton was contemporaneous with the final deposition of the raised beach.

Bream Cove, located between Rosemullion Head and Maen Porth south of Falmouth, has an extensive raised beach overlying a raised platform eroded from steeply seaward dipping beds of the Portsatho



- 1 Sandy soil - derived from Holocene wind-blown sand
- 2 Silty (occasional loessic layers)
- 3 Matrix supported diamicton (head)
- 4 Littoral sand unit (semi-lithified to form "sandrock" on north coast)
- 5 Conglomerate
- 6 Sub-angular - sub-rounded boulders (including "erratics")

Figure 2
Block diagram to illustrate Late Quaternary coastal stratigraphy of west Cornwall

Formation. This formation consists principally of alternating grey sandstone flags and buff-weathering slates (Leveridge *et al.*, 1990). The notch between the raised platform and fossil cliffline was precisely levelled to 4.73 m above O.D. and it can be observed discontinuously for up to 200 m north to The Hutches [SW 792 287]. The 300m long exposure of raised beach only exists on the southern side of the cove where the valley from Nansidwell opens out into the cove and has been totally eroded from the narrow remnant of raised platform which survives to the north as noted above.

There are a number of different facies within the raised beach at Bream Cove, where a basal unit of largely flat discoid clasts of local slate in a medium to coarse-grained cemented sand lies directly upon the platform. This 30cm thick basal unit passes upwards into well-sorted ferruginous sands 1.8 m thick with occasional 1-2 cm diameter rounded quartz clasts randomly scattered throughout. This is often

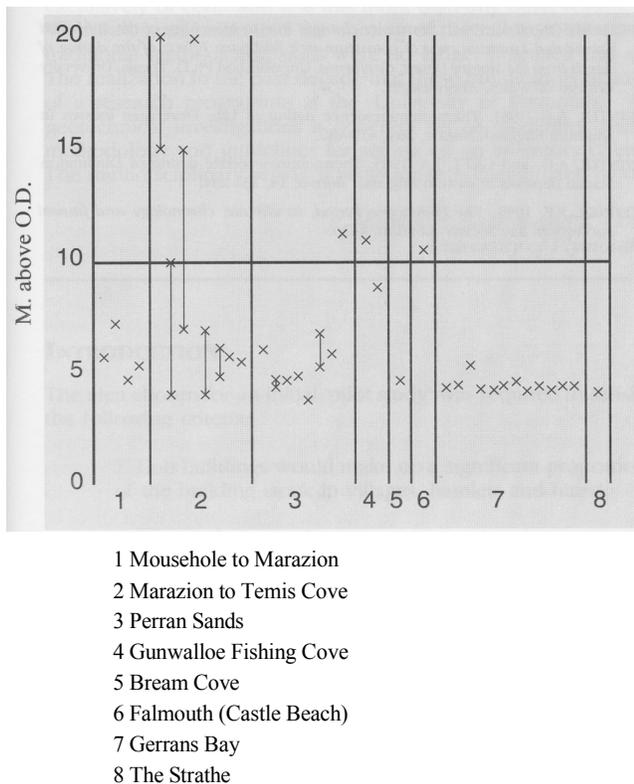


Figure 3a
The height range of raised beaches in west Cornwall

succeeded by 1-2 m of well rounded 1-2 cm quartz clasts with occasional small rounded slate clasts. As with the underlying units, this beach shingle is also indurated, this time with manganese (IV) oxides. There is a sharp erosion boundary, marked by occasional 20cm long rounded slate clasts, between the ferruginous sand and the overlying beach shingle. The shingle passes into a further 3 m of iron-stained medium to fine-grained sands, in turn overlain by a matrix-supported diamicton.

Recent developments in luminescence techniques have centred around Infra-Red Stimulated Luminescence methods (IRSL) whereby individual feldspar grains within raised beach deposits may be dated (Richardson, 1994). Luminescence dating can be applied to the feldspars and quartz grains that make up the body of sand. They are thus more relevant for dating the emplacement of beaches or dune ridges.

A pilot project based upon samples from the raised beaches of west Cornwall was initiated in April 1994 and preliminary IRSL results support an OI substage 5e date for the Godrevy and Newquay sites on the north coast and a similar date is indicated for the first time

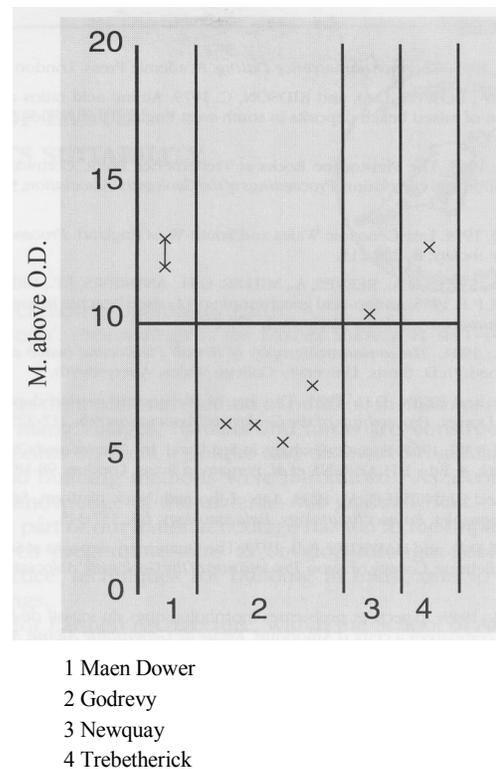


Figure 3b
The height range of raised beaches in west Cornwall

for a site on the south coast of Cornwall at Bream Cove near Falmouth (Richardson, pers. comm.). It should be noted that most of the samples for which IRSL results are at present available (Richardson and James, in prep.) were taken from the base of the sand unit(s) overlying the basal conglomerate. These dates match the AAR results for shell taken from a similar stratigraphical position at sites along the coasts of north Cornwall and Devon as tabled in Bowen *et al.* (1985).

In conclusion, first, the age of the raised beaches based on AAR geochronology from the north coast initially suggested that the basal elastic raised beach contains shell of CH stage 7 age at Godrevy and Fistral using the earlier AAR preparation method (op. cit.) but revised to substage 5e using current preparation method and the preliminary IRSL results (Richardson, pers. comm.) indicate CH substage 5e for the overlying marine sand units at these sites. AAR ratios from Mollusca within the basal conglomerate at Trebetherick also suggested sub-stage 5e (Bowen *et al.*, 1985). The IRSL results for Bream Cove on the south coast confirm for the first time similar dates for the raised beaches in that locality. It is therefore suggested that the raised beaches of south-west England, like those in Gower, South Wales (Bowen *et al.*, op.cit.) are largely OI Substage 5e in age but contain remanié material of stage 7 as may be found at Horton in Gower (Bowen, 1994). Early indications for the presence of raised beaches in southwest England of at least two different ages were signalled in Andrews *et al.* (1979) with their associated implications for different sea-levels.

Second, the raised beaches may be grouped within specific height-range bands which might represent separate interglacial sea-levels. Third, a possible time stratigraphy may be linked with Quaternary sites in south-west England, South Wales and Channel Islands. The presence of different aged raised beaches on the same raised shore platform illustrate the complexity of Quaternary sea level change and the possibilities of reworking of material from beaches of different ages. Thus, "Without a sure means of dating individual beach fragments, sea level sequence will only be clarified slowly." (Keen, 1993, p.17.).

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