QUATERNARY EXPOSURES IN WHITSAND BAY, SOUTH-EAST CORNWALL: DOWNDERRY AND WIGGLE CLIFF.

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INTRODUCTION

The extensive Quaternary deposits, exposed in coastal sections in Whitsand Bay, South East Cornwall have received little attention in the recent literature.

A thick sequence of raised littoral and possibly aeolian sands capped by a veneer of soliflucted head is described from the east of the Bay between Wiggle Cliff and Polhawn Cove, near Rame Head. Here, the great extent of unconsolidated *in situ* sands above a relict abrasion platform is considered to represent a transition from intertidal littoral to back-beach aeolian sediments associated with sea-level regression, probably during the late Ipswichian / early Devensian. Upper sand deposition is considered likely to have been penecontemporaneous with early solifluction.

Further west at Downderry, relict littoral sands and gravels, now below the modern beach, occur beneath a stony clay unit. This clay is topped by an unusual stratified head sequence occurring beneath the more typical Main and Upper Head units. Clay horizons, interbedded with head, coarsen towards the top of the stratified sequence where they become dominantly loessic. The Upper Head, both here and at Wiggle Cliff, is characterised by the sporadic occurrence of small well-rounded local and exotic clasts apparently absent from the main soliflucted head.

Both sites warrant further investigation, the aeolian sands and loessic horizons especially lending themselves to luminescence dating and so constraining further early Devensian sea-level fall and the onset of periglaciation in southwest Britain.

LOCATION AND BACKGROUND

Though much work has been done on the raised beaches and coastal solifluction terraces of south-west Britain *(e.g.* Mottershead, 1977; Taylor and Beer, 1982; James, 1995; Scourse, 1996) much of the south-eastern Cornish coast has been neglected, more perhaps through inaccessibility than through any dearth of exposures. Whitsand Bay, to the west of Rame

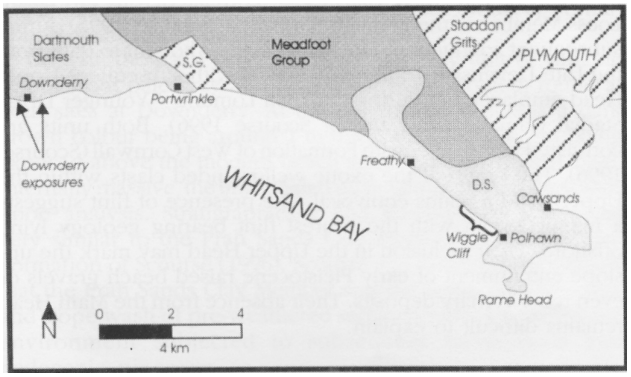

Figure 1. *Map of Whitesand Bay: geology and site location.*

Head [SX 418 417], cut into the Lower Devonian rocks of the Dartmouth Slates, Staddon Grits and Meadfoot Group (Figure 1), extends 25 km westwards and possesses several laterally and vertically extensive raised beach-solifluction terrace sequences backed by a degraded fossil cliff.

Ussher (1907) was the first to note such features in Whitsand Bay, describing the head sequences along the southeast coast. Since then little work has been conducted in the Bay save that of Harris (1987) whose detailed description of clast size, roundness and fabric within an isolated remnant of coastal head formed part of a more general discussion on argillaceous and non-argillaceous periglacial slope deposits in Southwest Britain. The Downderry sequence has been subject to investigation from a coastal protection and engineering viewpoint (Coard *et al,* 1987; Sims and Ternan, 1987, 1988). Sediments from Downderry have also been sampled to assess their suitability for luminescence dating although no results have been published to date H. Murton pers. corn., 1998).

WIGGLE CLIFF - POLHAWN COVE [SX 416 502-SX 420 494]

The coastal section at Wiggle Cliff extends c.1100m northwestwards from Polhawn Cove [SX 420 494] to Wiggle Cliff [SX 416 502] in the far east of Whitsand Bay near Rame Head. The exposure is particularly vegetated but an accurate stratigraphic investigation was possible, the section being accurately levelled and surveyed using EDM equipment (Figure 2).

The raised abrasion platform cut into the Devonian Dartmouth Slates varies between 4 m on and 8 m OD, being generally higher in the east. This platform is considered to have been retrimmed during successive high interglacial sea-level stands. The wave-cut platform is generally overlain by a clast-supported bouldery facies (unit la) of rounded and subrounded dominantly local slate and vein quartz boulders with much unconsolidated interstitial sand. This bouldery facies is confined to the western two thirds of the exposure. Unit la is never more than 1.5 m thick and is overlain by unconsolidated sands. In the eastern third of the exposure the bouldery facies is replaced by a variable unit of clast-supported cobbles and gravels (unit lb). Typically subangular to well rounded, lithologies are dominated by local slate and vein quartz, often indurated and exhibiting manganese and ferric oxide staining (Figure 3). These basal cobbles and gravels are interbedded with sandy horizons at their top where unit lb passes into the overlying sands of unit lc. Exotic clasts occur in both subunits, typically granitic erratic boulders in unit la and flint and sandstone clasts in unit lb. A granitic boulder, recently exhumed by erosion from the base of unit la is situated on the wave-cut platform at Wiggle Sandways [SX 418 501] whilst another granitic erratic and a red grit boulder are found at the back of the modern beach at [SX 497 420]. Another large red grit boulder also occurs in the active beach at the western end of Polhawn Cove [SX 495 421]. Erratics such as these have been noted from many locations around the Cornish coasts such

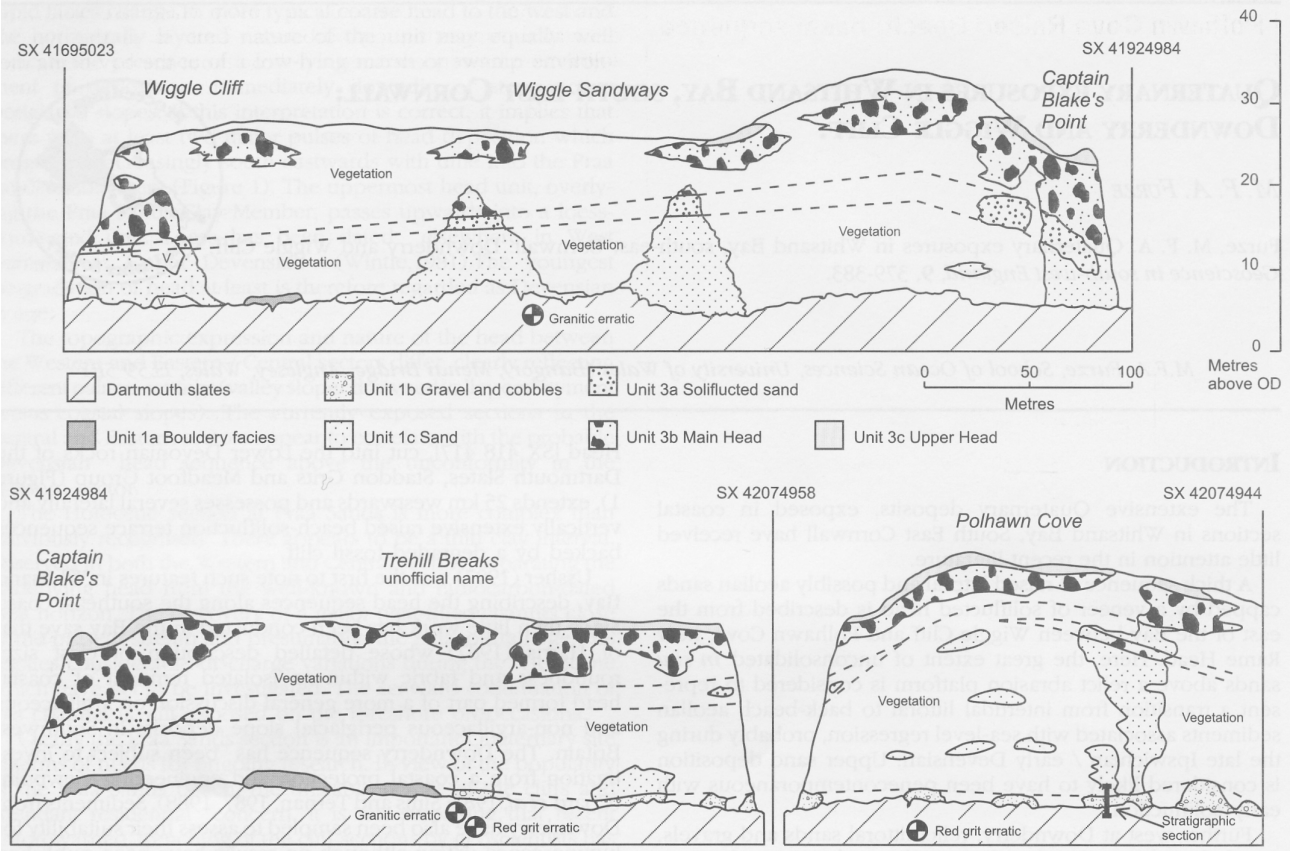

Figure 2. *Wiggle Cliff - Polhawn Cove levelled stratigraphic section.*

as the 'Giant's Rock' at Porthleven. Iceberg rafting is considered the principal emplacement mechanism with subsequent reworking upon the abrasion platform. Mottershead (1977) favours an Anglian age for emplacement.

Unit lc consists of unconsolidated massive and laminated sands with sporadic gravel and granule lenses. Approximately 3 m thick at the Wiggle Cliff end of the section, the unit attains a thickness of an astonishing 15 m at Polhawn Cove at the eastern end of the section, perhaps the greatest thickness of coastal Pleistocene sands in south-west Britain. Sand grains are generally rounded and subrounded and fine upwards. Unit lc grades into unit 3a over most of the exposure, however at Polhawn Cove a band of solifluction breccia 1.20 m thick occurs towards the top of unit lc, preceded by an increasing number of small angular clasts of local provenance occurring within the fine planar-bedded sands. A further 2 m of stony fine sand occurs above this head horizon before the contact with unit 3b, the Main Head, proper. The sands of unit lc are considered to be *in situ* littoral and back-beach aeolian sediments representing a transition from intertidal to supra-tidal conditions during a regressive sea-level regime. These raised beach deposits are correlated with similar units around the Cornish coast of Ipswichian OI Stage 5e age corresponding to the Godrevy Formation of Scourse (1996). The increasing occurrence of angular clasts and the inclusion of a bed of apparent solifluction breccia towards the top of the unit suggests that aeolian deposition was occurring pene-contemporaneously with solifluction during the later stages of sand emplacement. Unit 3a, above the unconsolidated sands, though absent from Polhawn Cove, is a well-consolidated silty sand with included small angular local clasts, often vertically orientated. The sand fraction is very similar to that of the underlying unit lc, unit 3a grading into the overlying head of unit 3b. This is thought to represent soliflucted littoral and aeolian sands with the admixture of up-slope slate clasts and slope wash sediments with subsequent cryoturbation.

Units 3b and 3c cap the whole section along its entire length. Both units are solifluction breccias, the lower unit 3b being the thicker. Clast dominated and often coarsening upwards suggesting a possible inversion of the weathering profile (Scourse, 1987; Ballantyne and Harris, 1994), unit 3b is internally variable in clast size and colour reflecting variations in the up-slopë source material. It is considered to be equivalent to the Main Head of the southwest. Unit 3c corresponds to the Upper Head, differing from unit 3b in being generally much thinner, never exceeding 2m, and in being matrix dominated. The contact with the lower unit is often marked by a minor lag of angular gravel and pebbles. Clasts are smaller than those in the underlying unit, being marked by the sporadic occurrence of well rounded small quartz and flint pebbles, some appearing to have been frost shattered. These rounded pebbles are absent from the underlying unit 3b. The matrix is dominated by silt grade material, appearing loessic. Such a sequence is common around the southwest, Mottershead (1971, 1977) detailing very similar deposits in South Devon. The high loessic component within the Upper Head is considered to be due to reworking and inclusion of Late Devensian loess (correlated with the Lizard Loess Member of the Penwith Formation; Scourse, 1996) during subsequent solifluction. The Main Head is thought to date from the Late Devensian Dimlington Stadial with subsequent Upper Head emplacement during the Loch Lomond / Younger Dryas Stadial (James, 1981a and b; Scourse 1996). Both units are correlated with the Penwith Formation of West Cornwall (Scourse, 1996). The origin of the exotic well-rounded clasts within the Upper Head remains equivocal. The presence of flint suggests a marine origin with the nearest flint bearing geology lying offshore. Their inclusion in the Upper Head may mark the up-slope entrainment of early Pleistocene raised beach gravels or even relict Tertiary deposits. Their absence from the Main Head remains difficult to explain.

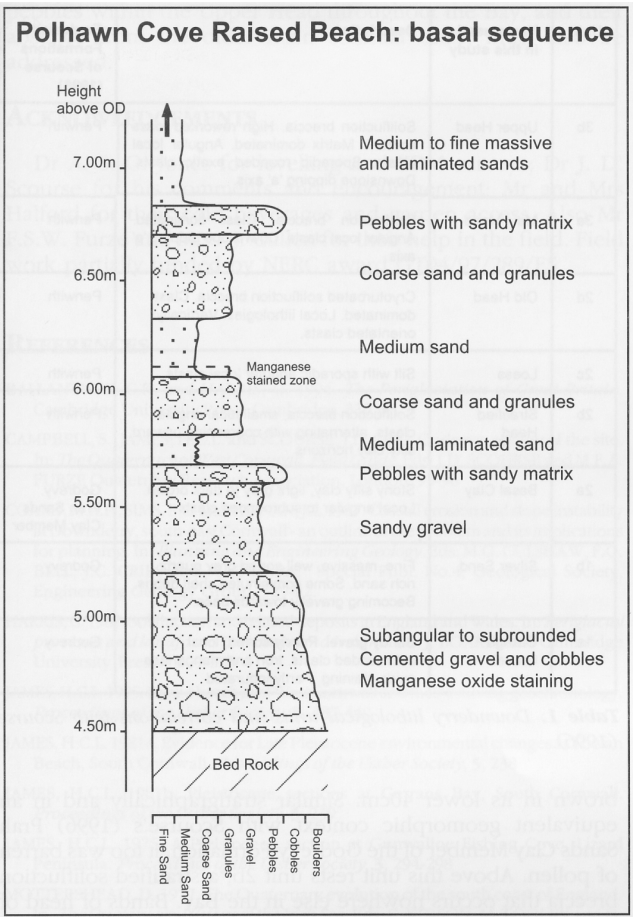

Figure 3. *Polhawn Cove. Unit 1b Basal Gravel stratigraphy.*

DOWNDERRY EAST [SX 321 538] AND WEST [SX 313 540]

Two sites are detailed from the extensive solifluction terrace at Downderry, the western site [SX 313 540] 200 m west of the "Inn on the Shore" public house and approximately 1 km west of the eastern site [SX 321 538], 800 m east of the pub. The eastern site is now obscured by sea defences though construction enabled inspection of the basal sequences below modern beach level. Both sites were also proved using a wing auger below the beach surface.

At Downderry East (Figure 4) five stratigraphic subunits were found (Table 1). A unit of orange gravel (unit la) rests on bedrock at 0.6 m on. Approximately lm thick, local subrounded matrix supported gravel clasts and coarse sands appear to be bedded, with iron and manganese oxide staining giving the unit its orange colour. Well consolidated and partly indurated, it occurs only in the eastern exposure. It is considered a littoral deposit of uncertain age corresponding to the Godrevy Formation of Scourse (1996).

Unit 2a, the basal clay, is a stony silty clay unit of variable colour from pale grey to dark brown, often mottled, found at both sites at Downderry. At the eastern site it attains a dark brown colour being around 1 m thick, the upper 30 cm being exposed above the modern beach surface during August 1998. Internally massive, the unit yielded no pollen or other microfossils upon analysis. Stratigraphically and lithologically it appears very similar to the Prah Sands Clay Member of the Godrevy Formation of Scourse (1996). Scourse and Kemp (1999) suggest that the Prah Sands Clay Member was the result of solifluction and slope wash of pre-weathered sediments into a waterlogged environment subjected to subsequent freeze-thaw and pedogenic processes.

A solifluction breccia composed of large blocky local clasts 2.7 m thick sits above unit 2a. Many clasts are vertically orientated suggesting cryoturbation. Unit 3a is the typical solifluction breccia encountered throughout the bay being the same as the Main Head at Wiggle-Polhawn. Unit 3c, the Upper Head is also the same as for the Wiggle Cliff exposure, including the occurrence of exotic rounded clasts.

The date of emplacement of unit 2d, the cryoturbated solifluction breccia, is equivocal. However, based on stratigraphic arguments and correlation with similar sequences in the southwest an estimate can be made. The Upper Head, unit 3c is particularly loessic similar to many other sites in Cornwall. It seems likely that Upper Head development occurred during or subsequent to the delivery of loessic material to the area with solifluction and slope wash incorporating the fine aeolian silts into the matrix of the breccia. In the west of the county the Lizard Loess Member (Roberts, 1985) which occurs in a similar stratigraphic context (Scourse, 1999) has been dated by TL techniques to 15,900±3180 yr BP (QTL-1e; Wintle, 1981) and the genetically and stratigraphically related Old Man Sandloess Member of Scilly (Scourse, 1991) also analysed giving two TL dates of 18,600±3700 yr BP (QTL-1d and 1f; Wintle, 1981) and two optical dates of 20,000±7000 (738al)

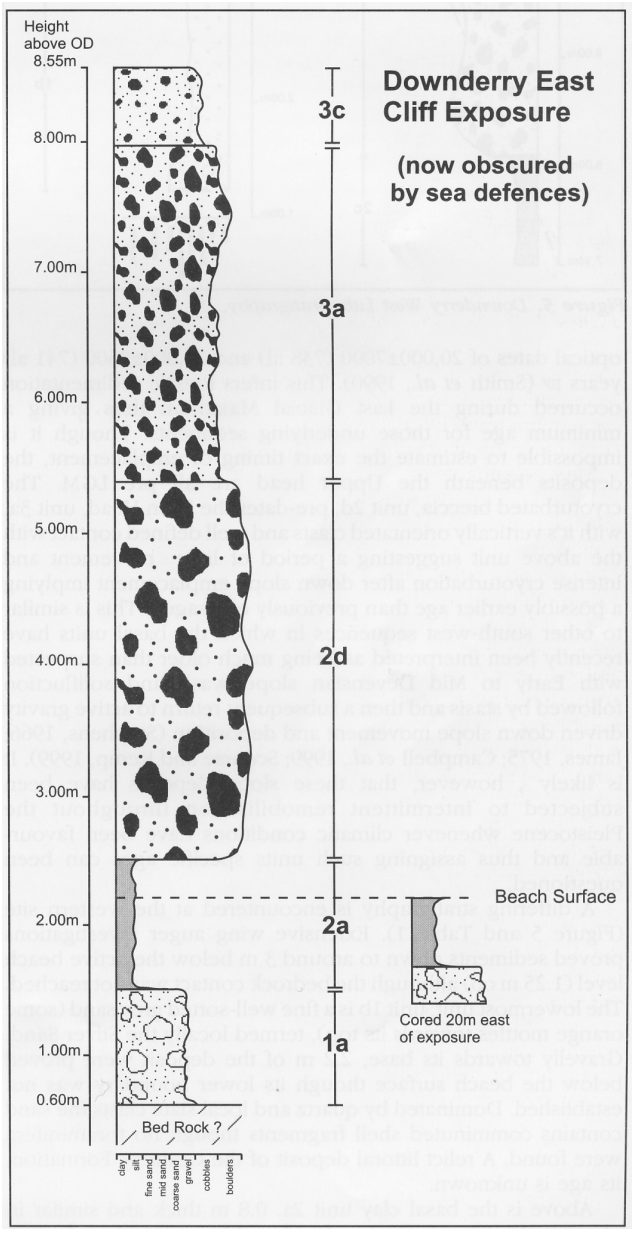

Figure 4. *Downderry East Lithostratigraphy.*

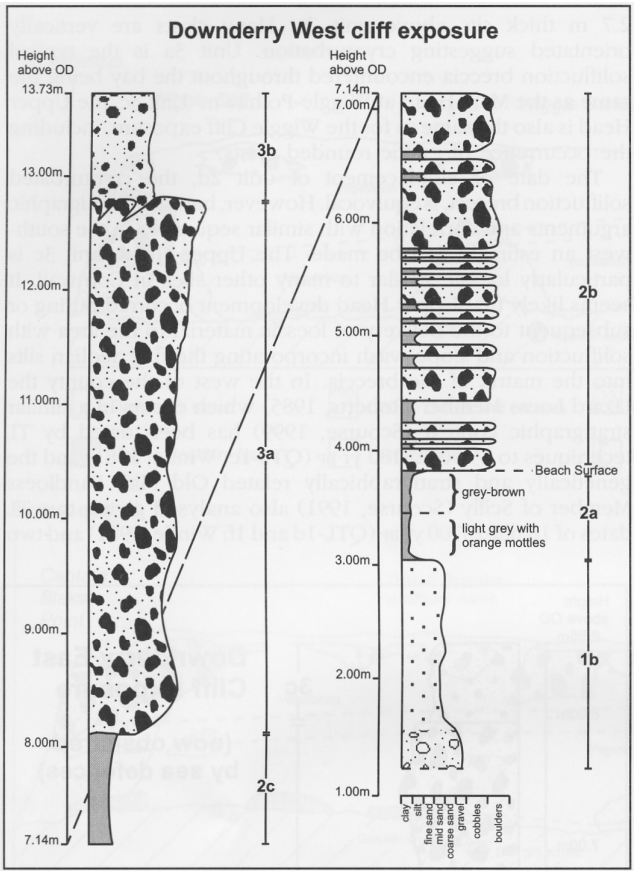

Figure 5. *Downderry West Lithostratigraphy.*

Unit	Name used in this study	Description	Equivalent Formations of Scourse (1996)
3b	Upper Head	Solifluction breccia. High reworked loess content. Matrix dominated. Angular local clasts. Sporadic rounded exotic clasts Downslope dipping 'a' axis.	Penwith
3a	Main Head	Solifluction breccia. Clast dominated. Angular local clasts. Downslope dipping 'a' axis.	Penwith
2d	Old Head	Cryoturbated solifluction breccia. Clast dominated. Local lithologies. Vertically orientated clasts.	Penwith
2c	Loess	Silt with sporadic angular local clasts	Penwith
2b	Stratified Head	Solifluction breccia, small local angular clasts, alternating with coarsening upward silty clay horizons.	Penwith
2a	Basal Clay	Stony silty clay, light grey to dark brown Local angular to subrounded clasts	Godrevy. Prah Sands Clay Member
1b	Silver Sand	Fine, massive, well sorted grey quartz rich sand. Some comminuted shell debris. Becoming gravelly towards base.	Godrevy
1a	Orange Gravel	Sandy gravel. Poorly sorted, local subrounded clasts. Iron and manganese oxide staining. Partly indurated	Godrevy

Table 1. *Downderry lithological units and correlations with Scourse (1996).*

and 26,000±9500 (741 al) years BP (Smith *et al*., 1990). This infers loessic sedimentation occurred during the Last Glacial Maximum thus giving a minimum age for those underlying sediments. Though it is impossible to estimate the exact timing of emplacement, the deposits beneath the Upper head are all pre LGM. The cryoturbated breccia, unit 2d, pre-dates the Main Head, unit 3a, with it's vertically orientated clasts and well defined contact with the above unit suggesting a period of little movement and intense cryoturbation after down slope emplacement implying a possibly earlier age than previously envisaged. This is similar to other south-west sequences in which the basal units have recently been interpreted as being much older than suspected with Early to Mid Devensian slope wash and solifluction followed by stasis and then a subsequent return to active gravity driven down slope movement and deposition (Stephens, 1966; James, 1975; Campbell *et al*., 1999; Scourse and Kemp, 1999). It is likely , however, that these slope deposits have been subjected to intermittent remobilisation throughout the Pleistocene whenever climatic conditions have been favourable and thus assigning such units specific ages can been questioned.

A differing stratigraphy is encountered at the western site (Figure 5 and Table 1). Extensive wing auger investigations proved sediments down to around 3 m below the active beach level (1.25 m op) although the bedrock contact was not reached. The lowermost unit, unit lb is a fine well-sorted grey sand (some orange mottles towards its top), termed locally the Silver Sand. Gravelly towards its base, 2.2 m of the deposit were proved below the beach surface though its lower boundary was not established. Dominated by quartz and local slate clasts the sand contains comminuted shell fragments though no foraminifera were found. A relict littoral deposit of the Godrevy Formation, its age is unknown.

Above is the basal clay unit 2a. 0.8 m thick and similar in character to the eastern site, the clay differs in being pale grey brown in its lower 40cm. Similar stratigraphically and in an equivalent geomorphic context with Scourse's (1996) Prah Sands Clay Member of the Godrevy Formation, it too was barren of pollen. Above this unit rests unit 2b, a stratified solifluction breccia that occurs nowhere else in the Bay. Bands of head of variable thickness (max. 60cm, min. 4cm) are interbedded with horizons of finer sediment between 20 cm and 2 cm thick. Whilst the solifluct remains fairly constant in nature throughout, the finer bands initially resemble the clays of unit 2a, becoming increasingly loessic in nature up-profile. The stratified beds gently undulate across the exposure indicating post depositional deformation either through cryoturbation or overburden loading. If unit 2a represents the solifluction and slope wash of pre-weathered material into a waterlogged environment, the stratified head (2b) may be the result of further solifluction and slope wash into such an environment, each breccia band representing discrete solifluction flow events interspersed with deposition of remobilised up-slope clay and loess perhaps contemporaneous with the cryoturbated lower head at the eastern Downderry site.

Unit 2c occurs above the stratified head, this being a bed some 95 cm thick of loessic silty sediment with included small angular local clasts. This is interpreted as being a remobilised loessic deposit perhaps originally derived from the exposed shelf of the English Channel during Devensian low sea-levels. Above this occurs the typical Main and Upper Heads of units 3a and 3b, the two units interdigitating. Again, character and correlation are as for the Wiggle-Polhawn exposures.

The establishment of a detailed chronostratigraphy for the bay is desired to constrain further the timing of key Late Pleistocene events in Cornwall. Further investigation may reveal AAR datable marine molluscs within the raised beach sequences. Luminescence dates from the upper aeolian sands at Polhawn Cove would help constrain the onset of solifluction and sea-level regression in the Southwest. Dating of the loessic layers from the Downderry stratified head and the overlying loess unit would also be of value, constraining the emplacement of the regionally extensive Main Head and also shedding light on Middle Devensian events, testing the hypothesis of earlier solifluction and head emplacement. The enigmatic occurrence of sporadic well rounded vein quartz and flint

pebbles within the Upper Head throughout the Bay, and their absence from the older main soliflual units, must also be addressed.

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