Field excursion to the area of St. Austell Bay between Carlyon Bay and Par, 2nd January, 2002

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Bristow, C.M. and James, H.C.L. 2002. Field excursion to the area of St. Austell Bay between Carlyon Bay and Par, 2nd January, 2002. *Geoscience in south-west England*, **10**, 373-376.

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Introduction

This field excursion visited the coast of St. Austell Bay, starting from the Cliff Head Hotel, which was the venue for the conference, and exploring the coast eastwards as far as Par Harbour. The area was partially covered by a previous Ussher Society field excursion (Shail, 1995). On that occasion the emphasis was on the Lower Devonian sedimentation and magmatism and the Variscan tectonics between Spit Beach and Fishing Point. For the 2002 excursion the emphasis switched to the Quaternary deposits and coastal processes, although some of the features seen on the 1995 excursion were revisited and rediscussed. Although the main party did not actually visit the fossil locality at the west end of Carlyon Bay beach or the intertidal zone east of Fishing Point, both localities were visited by smaller groups during the conference. Much of what was seen on this excursion has not been described in modern geological literature.

Formation of Carlyon Bay beach

From the Cliff Head Hotel the party walked to a viewpoint (SX 055522) overlooking Carlyon Bay beach (Figure 1, locality 1). Carlyon Bay (Crinnis) beach, as we see it now, was formed over a relatively short period of about 100 years. High tides reached the base of the cliffs up to about 150 years ago. The source of the sand which forms the present beach was the china clay industry. Carclaze pit discharged its raw clay slurry via an adit to Phernyssick, where sand and residue were removed and thrown into the adjoining stream, to be carried by it down Sandy Bottom, where further waste sand was tipped into the stream. The sand-bearing stream then continued on through Holmbush and across Par Moor, where some sand was extracted for a concrete blockworks adjacent to the former Heavy Transport depôt. If the stream had continued on its natural course down the valley to where Par Harbour is now, it would have rapidly filled the harbour area with sand. So an adit was constructed in the early 19th century, at the same time as the harbour was built, to carry the stream under the present-day golf course to discharge into the sea at Carlyon Bay. This caused large quantities of sand to arrive in the bay and wave action distributed it to form a beach 1.25 km long (Everard, 1962).

China clay waste sand ceased to be put into the stream over 50 years ago and the beach has therefore ceased to have large-scale sediment replenishment. Erosion by wave action and the stream flow onto the beach, together with some eastwards drift towards Spit Beach, may therefore be gradually removing the

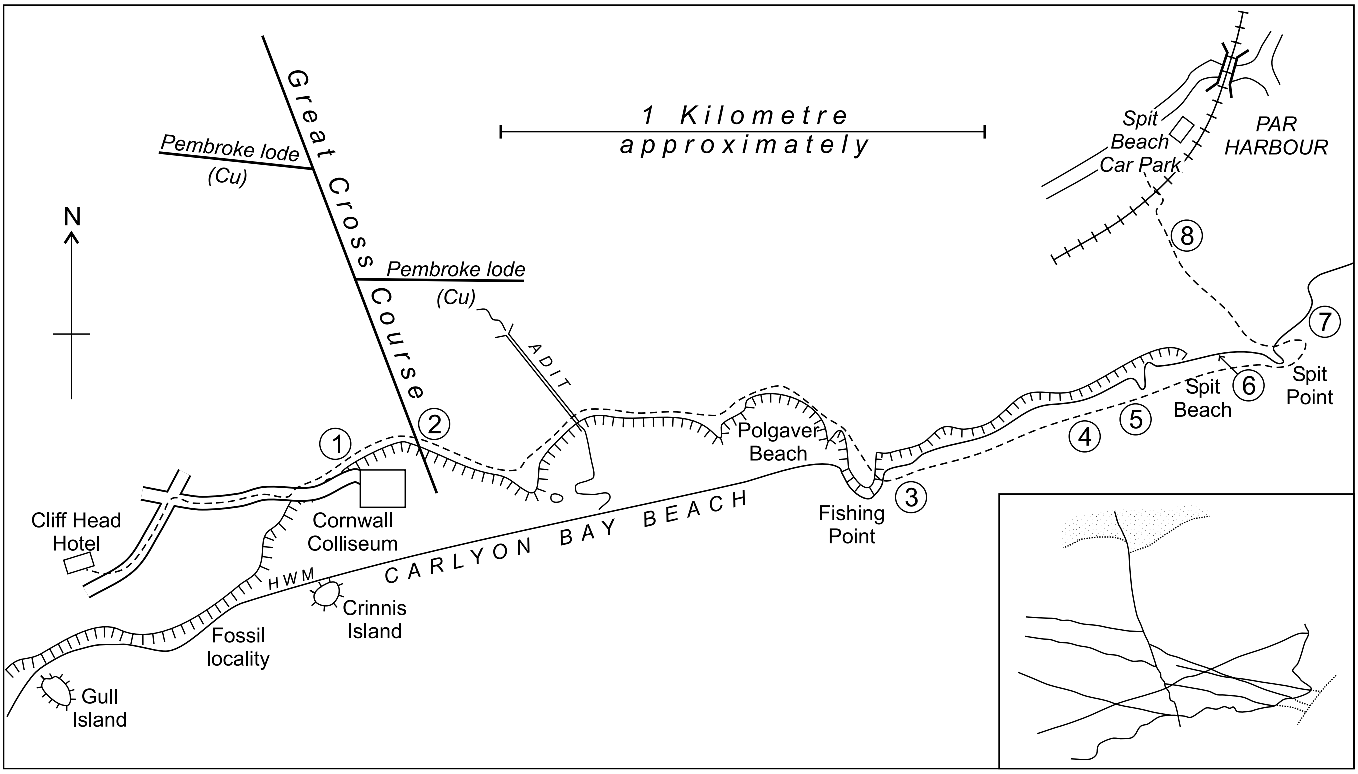

Figure 1. *Sketch map of the route taken on the field excursion, a tracing of the line drawing by De la Beche (1839) of 'The Great Cross-course' is shown in the inset. Numbers refer to localities mentioned in the text. The distance from the Cliff Head Hotel to Spit Point is about 2.5 km.*

Figure 2. Wedge failure in the cliffs directly in front of the Carlyon Bay Hotel.

artificially constructed beach. However, the coarse nature of the sand (in part gravel by particle size definition) and its angularity make this beach more stable than it would be if it had been constructed of normal fine beach sand. The sand level on the beach varies because of large-scale movements from west to east and vice versa, depending on prevailing winds, particularly storms. Observation over many years indicates that the sand levels at Fishing Point in the east can vary by as much as 3-4 m. Because of the overall tendency for an eastward drift, a small part of the area at the west end of Carlyon Bay beach which was given planning permission for development about 15 years ago now lies permanently within the area affected by wave action during spring tides.

Cliff stability

There have been many cliff failures along this stretch of coast. A planar failure along slaty cleavage dipping at 45° towards the sea, just below the viewpoint, affected the access road down to the beach and blocked it a few years ago. A wedge failure at the west end of the beach some years ago narrowly missed causing injury and/or loss of life. The resulting unstable cliff had to be made safe by blasting to bring down unstable masses of rock. In each case many thousands of tons of material were involved. Just to the west of Carlyon Bay (Figure 2, SX 052519) there was a quite spectacular wedge-type failure a few years ago and a further wedge failure occurred about 8 years ago about halfway between Fishing Point and Spit Beach. The predominant mechanism of cliff recession in this area is probably wedge failure. Extensive mine workings in the area between Carlyon Bay beach and Charlestown have probably also helped to weaken the cliff.

Crinnis Island

The proper name for the area where the Carlyon Bay hotels are is 'Crinnis'. This is derived from the Cornish 'Caer Ennis', meaning the camp or fortified settlement on the island. It is possible that the present small stack on Carlyon Bay beach (SX 056520) was much larger when the name 'Caer-ennis' originated, and supported a small settlement in what would have been a superb defensive position. It is equally possible that the name could refer to a larger 'island' about 0.5 km farther west called 'Gull Island'(SX 050518). If either supposition is correct, it suggests a cliff recession rate of about 2 m a century, assuming that the camp on the island existed at about the time of Christ. A small area of raised beach caps Crinnis Island; the bench on which this raised beach sits can be seen to slope steeply seawards.

Fossil locality

A fossil locality at the west end of Carlyon Bay beach (see Figure 1) was pointed out to the main party from the clifftop viewpoint and photographs of the more interesting fossils were shown; later a small party of palaeontologically inclined members of the society visited the location. At the locality (SX 053519-054520) the slates and siltstones of the Lower Devonian Bovisand Formation are exposed at the base of the cliffs in a series of intertidal benches. In spite of the intense deformation, recognisable fossils can be found. Over the last 20 years, one of the authors (CMB) has found a considerable number of fossils between the west end of the beach and Gull Cove, including spirifers with well preserved internal spires, solitary corals, crinoid stems and ossicles, and an orthoceratid and conulariid (the last two kindly identified at the time by the late Prof. M.R. House). This locality is mentioned as 'organic remains' on the first edition of the Ordnance Survey one-inch map (Sheet 96). Notes by Harley (1970) accompanying the re-published sheet suggest the geological details were added around 1838. Peach (1841) mentions that slates at Apple-tree Cliff and Gull-rock Cove yielded 'Encrinites' and 'Turbinolia'. Collins (1893, 1896) records a considerable number of fossils from 'Crinnis', notably crinoids ('Cyathocrinus'), an orthoceratid and a solitary coral. Collins lived at Crinnis House, only about 0.5 km north of the locality, up to his death in 1916. Curiously, Collins does not mention the spirifers, although these are the most conspicuous member of the fossil fauna nowadays.

The Great Cross-course

The line of the Great Cross-course intersects the cliffs at SX 057523 (Figure 1, locality 2). This was shown in a diagram in De La Beche (1839) and also referred to by Henwood (1843). The 1839 diagram by De La Beche (Figure 1, inset) must be one of the earliest representations of a strike-slip fault. Dines (1956) reports that the total dextral displacement is 228 m, based on the movement on the Pembroke Lode (Cu). There may be an additional pre-granite movement on the fault; some highly sheared and contorted Bovisand Formation slates exposed in a reef at LWM (SX 059521) on the line of the fault may be an indication of this. The fault zone is mainly occupied by a soft clayey gouge material ('fluccan') and is not mineralized, apart from extensive iron staining. The fault continues northwestward towards Bodelva china clay pit, the site of the Eden Project, where it displaces the granite margin (Mueller *et al*., 1999). Some small depressions on the golf course may be connected with this fault.

Fishing Point (SX 067522, Figure 1, locality 3)

We descended via a path which, beneath the modern soil, cut through a section of orangy-brown earthy material with a few angular fragments of slate, about 1 m thick. This material is similar to loess found in many places on the south coast of Cornwall. It grades down into a material with a greater abundance of angular slate fragments which has more the character of head, which is several metres thick. This, in turn, rests on a raised beach less than 1 m thick, with well rounded quartz vein clasts up to 4 cm in diameter. This suggests a sequence of events commencing in the last interglacial with the raised beach being formed at a time when sea level was about 8 m higher than present, followed by a period of cold, presumably the Devensian glaciation, which led to the formation of the head, followed by a period of very dry cold, giving rise to the loess, before the Holocene transgression and climate amelioration set in. Greater thicknesses of raised beach and head are seen towards the Spit Point end of the section. Descending onto the underlying rocks, the bluish-grey slates and siltstones of the Lower Devonian Bovisand Group (the old Meadfoot Group) were seen. These have a regional dip to the southeast. A recumbent fold with well developed axial planar cleavage, together with a sill of dolerite with a chilled margin were seen on the top of the point and an agglomerate was seen on the west side of Fishing Point at beach level (this is only seen when the level of sand on Polgaver Beach is low). The clasts in the agglomerate are up to 20 cm in diameter, many look as if they were lithic fragments, but some are drawn out parallel to the

Figure 3. *Raised beach at the west end of Spit Beach capped by a considerable thickness of head, with a layer of loess about 0.5 m thick under the present day soil. See text for further details.*

bedding, more than would be expected if this was due to purely tectonic effects, suggesting they were plastic at the time of deposition, possibly indicating that this was emplaced as a hot pyroclastic flow. Although highly altered, the lithic clasts look as if some were originally vesicular, and others were possibly coarse grained igneous rocks. The vent which produced this coarse debris cannot have been far away, a line of basic intrusives stretching from Black Head towards Trewoon could possibly represent magma chambers associated with this volcanicity. Due to a strong southerly wind, the party was unable to traverse from Fishing Point eastwards towards Spit Beach along the intertidal zone at the base of the cliffs, although a small party later in the conference did manage to make the traverse. The main points of interest in this area are the volcanics (Shail, 1995), notably volcaniclastics, including tuffs, tuffites, agglomerates and hyaloclastites, and the structures in the Bovisand Formation slates, siltstones and volcanics. About half way between Fishing Point and Spit Point there is a thrust fault with associated drag folding and the sheets of hyaloclastite frequently show repeated dislocations by fracture cleavage.

Spit beach – hyaloclastites

Descending onto Spit Beach the Bovisand Formation could be seen to contain increasing amounts of volcaniclastic rocks as one traversed westwards towards Fishing Point. Some look as if they could have been lapilli tuffs or even crystal tuffs. There is also more agglomeratic material. One of the most puzzling lithologies to be seen is a series of yellow sheets, up to 1 m thick, which look as if they are intruding the Bovisand muddy sediments. In one of the sea caves (SX 072524, Figure 1, locality 5) a dolerite can be traced laterally changing into one of these yellow sheets. These sheets appear to be hyaloclastites developed from the intrusive dolerite magma, although the original glassy fragments are now likely to be altered to clay minerals, together with accompanying changes in chemistry. Similar sheets are seen along strike on the north coast at Holywell Bay, possibly there is some connection with the Start-Perranporth Line. Hyaloclastites are also reported from the volcanic rocks in the Bin Down Formation, about three miles north of Looe on the recently mapped (1998) Plymouth Sheet 348. The Bin Down Formation is enclosed by sediments assigned to the Whitsand Bay Formation (the old Dartmouth Group), just below the base of the Bovisand Formation.

Spit beach and Spit Point - Quaternary

The raised beach and associated Quaternary deposits at Spit Beach were briefly mentioned by Ussher (1879) and Rogers (1910) but, as far as the authors are aware, there have been no modern investigations of these deposits. At the extreme western end of Spit Beach (SX 072524, Figure 1, locality 4) there is an excellent section (Figure 3) which shows a raised beach, probably deposited in a gully, capped by a considerable thickness of head. The head appears to consist of two or three distinct layers, with the ubiquitous overlying layer of loess about 0.5 m thick under the present day soil. The lower part of the raised beach contains clasts up to 0.5 m long, many of these are of felsitic elvan, which is curious, as the nearest elvan in St. Austell Bay is 5 km to the south-west at Phoebe's Point. There are also no known elvans in the catchment areas of the Carclaze stream or the Par River, in spite of extensive underground mining in both areas. The elvan clasts are similar to the Pentewan elvan, exposed in the cliff at Polrudden Cove. They might have been derived from an offshore reef, now destroyed by marine erosion. This raises the possibility that the form of the coast in the last (Ipswichian) interglacial was significantly different to the present form. A well developed wave-cut notch at the base of the cliffs was seen nearby. Continuing eastwards the main section of raised beach is exposed (SX 072524-075525). This rests on a sloping platform, in the west it is at about 8-9 m above O.D., sloping down eastwards to 6.6 m. The raised beach is up to 5 m in thickness and consists of alternations of sand and pebbly layers, with clasts up to about 10-15 cm in diameter. Some of the clasts have brown iron-rich haloes surrounding them, suggesting iron had migrated out from the clast into the surrounding sediment. These clasts may have been gossan or lode material from the intense Cu mineralization in the surrounding area. The raised beach would have formed a spit separating the inundated river valley to the north from the sea. If the present day eastward drift of sediment in the bay also prevailed at the time the raised beach was being formed, this would have helped to build the spit. To the west of Spit Point, the 2-3 m thick raised beach at its distal end reveals sub-rounded clasts which display a distinctly vertically inclined macrofabric similar to that previously recorded in Alderney (James and Worsley, 1997), Guernsey (Gurney *et al.,* 1998) and northern Brittany (Renouf and James, 2001). One of the most interesting features seen was a relic ice wedge indicative of former permafrost conditions (SX 074525, Figure 1, locality 6 and Figure 4). With dimensions of 0.8 m at its greatest width and more than 0.75 m in depth, it is comparable to similar features recently found at Godrevy and Tregunna (Scourse, 1987), both on the north Cornish coast, and at Towan Beach (James, 1981) on the south coast, and also on Guernsey (Gurney *et al*., 1998). On the east side of Spit Point (SX 076525, Figure 1, locality 7) a low cliff about 3-4 m high showed the raised beach to be much thinner (about 10-15 cm) and at present day HWM. It is possible that this raised beach is not a continuation of the one further west and belongs to a different episode of beach formation. The raised beach is covered by 3-4 m of head and loess. Although not particularly clast-rich, the flat clasts, where present, tend to be vertically inclined and occasionally in plume like structures. The head and loess have clearly been disturbed by periglacial action and may

Figure 4. *Ice wedge at the back of Spit Beach – see text for details.*

have originated some distance upslope.

'Poth' buried valley

The stream from Carclaze contained an exceptionally rich layer of alluvial tin at the base of the infill in the buried valley, which descended to about 10-12 m below O.D. by the time it reached the area of the Spit Beach car park (SX 074529, Figure 1, locality 8). This infill chronicles the Holocene transgression, and the sequence in 1792 at 'Poth' (probably about one hundred metres west of where the car park is now) was described by Philip Rashleigh (1802) in an illustration in his 'Description of British Minerals'. The tin ground varied in thickness from 0.3 m to 2 m and was overlain by a layer of peat with branches, bones of deer and ox horns in it, which was, in turn, overlain by sand containing sea shells, indicating a rapid inundation of the 'Poth' valley by a rise in sea level. A further layer of peat indicated a return to non-marine conditions and the upper part of the sequence was a light coloured mixture of clayey, micaceous and sandy sediments, possibly deposited in the period since tin streaming began in Bronze Age times. The infilled valley can be traced offshore descending to well below current sea level (Camm, 1999). After the open pit workings were overwhelmed in a storm in 1801, the tin ground was worked underground under Par Beach by means of iron shafts up to 20 m deep sunk in the intertidal area through the Holocene sediments.

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