

STANNIFEROUS PALAEOVALLEY SYSTEMS IN MOUNT'S AND ST. AUSTELL BAYS, SOUTH COAST OF CORNWALL

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INTRODUCTION

Shallow geophysical surveys and boreholes off the south Cornish coast revealed palaeovalley systems. These channel-like structures extend for over 5 km offshore beyond the 30 m isobath in both Mount's and St. Austell Bays. During the Pleistocene eustatic regression, temporary fluctuations around mean sea level occurred as the ice-caps advanced and retreated. It was during these regressions that the palaeovalleys were formed. The shallow palaeovalleys were incised by fluvial erosion into an abraded surface, either of marine or terrestrial origin, or a combination of both. Valley cross-sections in many instances have a box-shaped profile which may indicate that downcutting commenced in periods of permafrost. Valleys are also asymmetric in cross section. Channel infill indicates multiple cut-and-fill events with polymict, clay-bound, sandy and poorly sorted angular to subangular gravels, forming three terraces. Valley bottom infill is overlain by minor peat and extensive fluvioestuarine silty clays and later by a thin veneer of active marine sandy gravels during Holocene transgression.

BACKGROUND AND LOCATION

Numerous stanniferous placers, both autochthonous and allochthonous, are known on the peninsula of Cornwall while others occur offshore (Camm and Hosking, 1984; 1985). The majority of these bodies are small and were only ever of minor economic importance. During the 19th Century valley systems on the south Cornish coast had been worked below sea level, in some cases in the intertidal area, for placer tin deposits in the Par and Pentewan Valleys (Colenso, 1829; Smith, 1817; Rashleigh, 1802, 1822; Hawkins, 1822; Symonds, 1874). In the course of exploration for placer tin deposits, research indicated the possibility of buried river channels extending offshore. This had been indicated by a geophysical survey in Mount's Bay in the 1960's (Ong, 1966). Detailed geophysical surveys of Mount's and St. Austell Bays during 1980-85 confirmed that palaeovalley systems extended offshore and were mainly the continuation of rivers draining to the coast (Figure 1). The study locations covered an area of 96 km² in Mount's Bay and 52 km² in St. Austell Bay. Wide fence drilling on close centres, using a vibrocore drill with rotary head, provided data on the valley infill and basement rock.

GEOPHYSICAL AND DRILLING METHODS

A reconnaissance geophysical survey of 280 line km of acoustic profiling on an 800-100 m grid was conducted in both bays utilising *Boomer* and *Sparker* systems. A more detailed *Uniboom* survey was conducted later on a 200 x 200 m grid. Fence drilling with an interval of 1600 m between fences and 50 m borehole intervals was conducted using a 100 mm diameter vibrocore drill with rotary head. Fence positions were designed to test the length of the channels, and to test both above and below confluences. The first fence drill position was

in the centre of the channel with drill holes placed at either side to determine the channel margins. A total of 128 boreholes were drilled, with positioning by *Artemis* ensuring accuracy to ± 5 m. Samples were retained inside the core barrel in an undisturbed state. The rotary head with core cutter made drilling into bedrock possible, ensuring recovery of a complete sample of the overburden geology.

GEOPHYSICAL INTERPRETATION

Detailed profiles indicated that the palaeovalley systems ranged from a few tens of metres to up to 200 m in width. Cross sections are either V-shaped in the case of minor channels, or flat bottomed or box-shaped in the main channels (Figure 2). Interpretation suggests that the channel infill consisted of three sedimentary units; (1) a thin upper layer; (2) the main channel infill and (3) a basal layer. The main layer was an acoustically homogeneous lithology of estuarine silty clay, but the upper and basal layers showed numerous internal echo traces suggestive of gravel horizons. In Mount's Bay the main palaeovalley, St. Michael's Channel, has a smaller tributary, the Penzance Channel to the west (Figure 1). This appears to end abruptly on a presumed marine abraded platform with no apparent connection to the Marazion River valley on land. Traversing southwards the bottom gradually deepens from -20 to -45 m below the lowest astronomical tide (LAT). The upper reaches of the Penzance Channel are ill-defined, but may be connected to the small streams draining the Penzance-Newlyn area. Sediments covering the seaward dipping rockhead further offshore to the south may represent periglacial head. This head overlies a generally level surface at between -45 and -50 m. This is likely to be wave-cut platform which is covered by a several metre thick sheet of coarse elastic sediment. At this point the layer appears to merge with the interpreted gravels at the bottom of the St. Michael's Channel.

In St. Austell Bay a major palaeovalley system was mapped. The depth of the channel bottom varies from -3 to -44 m below LAT. The major channel, named Par Channel, is evidently an offshore continuation of the Par River (Figure 1). To the west the channel is joined by three minor tributaries without any apparent connection to onshore river valleys. Downstream it has a braided pattern until it forms a single linear channel. The Pentewan Channel, which forms a confluence with the Par Channel offshore to the south, is the seaward continuation of the St. Austell River valley (Figure 1). At least three terraces cutting into bedrock were interpreted from the geophysical profiles. This was later confirmed by drilling. A thick layer of sediment is present close to the coast on the westerly side of the bay. The lower part of this layer, up to 10 m thick, is possibly periglacial head. Both the St Michael's and Par Channels extend over 5 km from the present coastline and continue beyond the study area.

CHANNEL INFILL

Vibrocore drilling produced three lithological types; (1) active marine sandy gravels, underlain by (2) fluvio-estuarine silty clays

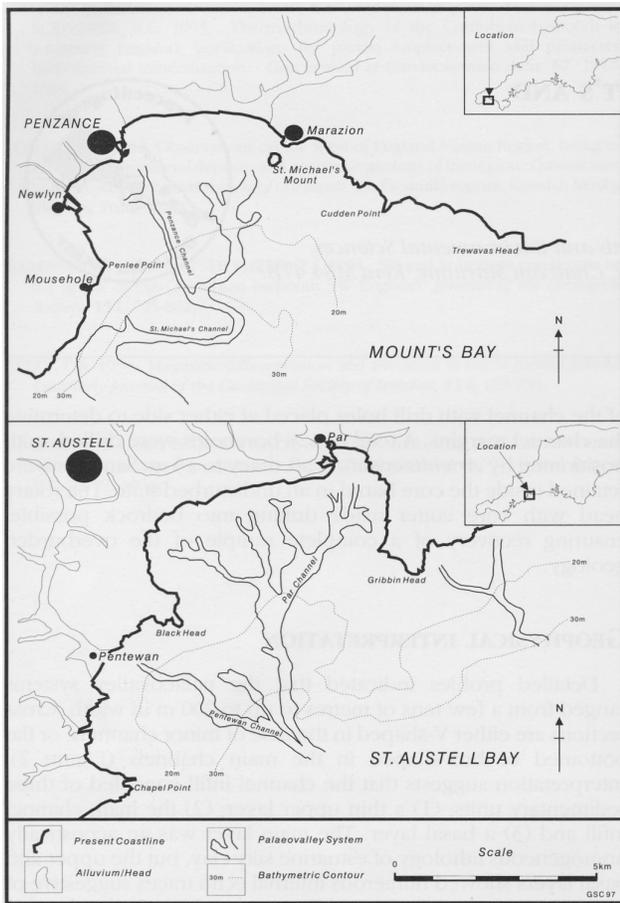


Figure 1. Palaeovalley locations - Mount's Bay and St. Austell Bay.

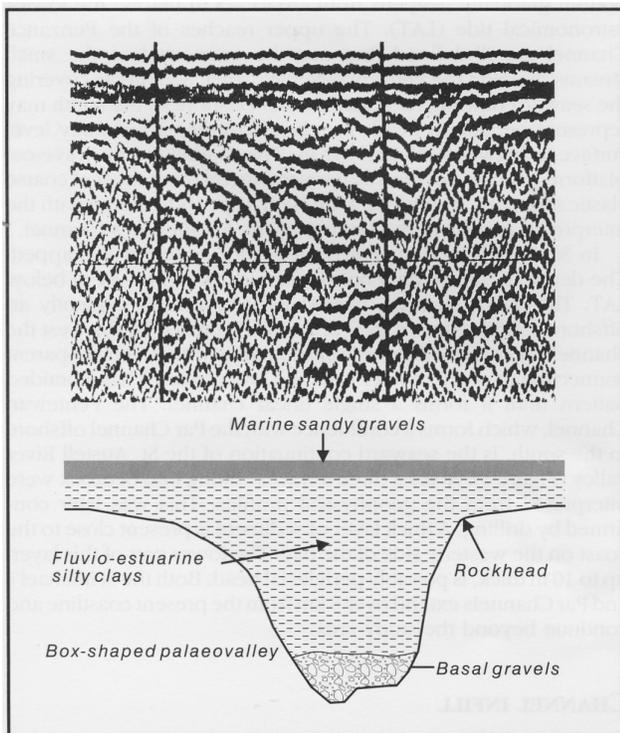


Figure 2. Sparker profile and seismostratigraphy of infilled valley.

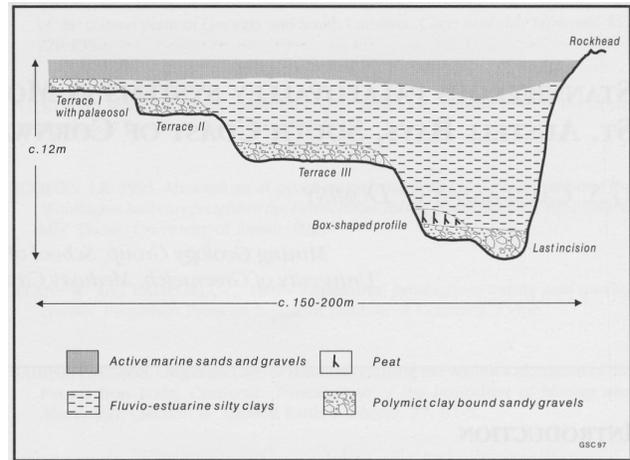


Figure 3. Composite section from St. Austell Bay showing stratigraphy of palaeovalley location.

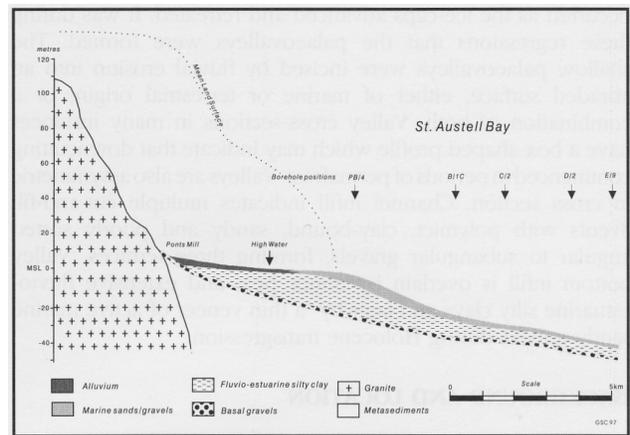


Figure 4. Long section and stratigraphy of the Par Channel (St. Austell Bay)

in turn underlain by (3) a basal polymict clay-bound sandy gravel. Minor peat and organic-rich silts were encountered above the basal gravels. Where intersected, terrace deposits of clay-bound sandy gravels could be distinguished not only by their higher elevation, but also their oxidised appearance indicating palaeosol development. Valley bottom infill of basal gravels had similar characteristics to the terrace deposits, being poorly sorted, angular to sub-angular cobbles with sands in a clay matrix. Detailed descriptions of the stratigraphy are given in Camm (1998). A composite section showing the stratigraphy is illustrated in Figure 3 with a long section of the Par Channel in Figure 4.

DISCUSSION

During gradual regression of eustatic origin, temporary fluctuations around mean sea level occurred as the ice-caps advanced and retreated. These fluctuations may have been from -120 ± 60 metres for global changes (Shackleton, 1987), or -88 m during the Late Devensian for local variations from the glacial-eustatic minimum (Scourse *et al.*, 1990). It was during these falls in base sea levels that the palaeovalleys were formed. The palaeovalleys often exhibit a box-shaped profile in cross section which would suggest that they may have been cut by thermal fluvial erosion during periods of permafrost (French, 1976). This occurred during periods of lower sea level and the cold stages of the Quaternary when the area, now submerged, was exposed to subaerial erosion processes. This palaeo-environment has been noted elsewhere on the south coast of England (Dingwall, 1975;

Jones, 1981; Smith, 1985, 1989; Bellamy, 1995). The narrow V-shaped late incision in the valley bottom probably represents a period of degradation. This equates to the last stages of fluvial development prior to the Flandrian marine transgression when the sea level was at its lowest during the Late Devensian. The original channel, up to 2 km wide in St. Austell Bay, probably represents an early, braided, fluvial system meandering over a flat plain. Yearly, during the summer melts, a reworking and redepositional phase probably took place adding a new component of recently transported material. Large accumulations of fluvial sediment would thus accumulate as a thick sheet over the exposed surface. This is indicated from the geophysical data, with a coarser clastic layer below the veneer of marine sediments. Subsequent falls in base sea level would have led to incision, producing the characteristic valley shape if in permafrost, and the terrace deposits. The three terraces and lower basal unit indicate at least four substantial falls in base sea level. The stanniferous sandy gravels are poorly sorted, angular to sub-angular, clay-bound and composed of granite, tourmalinite, hornfels and quartz. This combined with the angularity of the coarser clasts 8 km away from the likely source, would indicate that part of the transport process was as a debris flow (Camm and Groot, 1994). Spasmodic fluvial high energy discharges or freshet activity induced by season meltwater was also likely (Jackson, 1997). Carbon-14 dating of peats lying above the valley gravel infill from -23 to -33 m below LAT indicate ages from 7,200 to 12,000 years BP (Goode and Taylor, 1988; Tooley, pers. comm.). This suggests that the last incision and gravel infill took place in the Late Devensian, the terraces above representing an earlier phase. Subsequent sea level rise during the Flandrian produced fluvio-estuarine conditions with the deposition of silty clays protecting the early coarser clastic sediments. A thin veneer of active marine sands and gravels was produced as sea level reached its current position.

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