LATE CENOZOIC OUTLIERS IN WEST CORNWALL

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INTRODUCTION

Recent excavation and drilling has revealed three small sedimentary bodies lying between 25 m and 145 m O.D. The sediment size ranges from rounded cobbles to sands. These are assumed to be Late Cenozoic in age as Tertiary outliers are known in west Cornwall. These include St. Agnes Beacon, St. Agnes; Polcrebo in the Parish of Crowan on the Carnmenellis granite; Crousa, near St Keverne on the Lizard (Walsh *et al.* 1987, Jowsey *et al.* 1992); Splattenridden near St. Erth (Wilson 1975); Tregutha Farm near Marazion and Angew Farm near Gwithian (Goode and Taylor 1988); and the St Erth beds (Mitchell *et al.* 1973); Lower Penhallow near Veryan; and possibly of the same age, a deposit lying at Pendarves near Camborne (Leveridge *et al.* 1990). The known and new' deposit locations are shown in Figure 1.

DESCRIPTION

1. *Porkellis*

North-west of the village of Porkellis on the Carnmenellis granite and centred on [SW 6870 3430] three small deposits (Figure 2) of similar composition were encountered during drilling investigations for placer cassiterite. The basal unit is comprised of a of high percentage of well-rounded monomict coarse cobbles of granitoids of up to 0.20 m in size (Photo. 1), hosted in minor orange ferruginous clays and silts. The cobble bed is up to 2 m thick and lies adjacent to an cliff-like erosional feature at an elevation above 130 m O.D. Interestingly these cobble deposits have a very low tin content unlike the adjacent Quaternary periglacial fluviatile, predominantly subangular to angular gravels, infilling the valley which suggests that they are of very local origin. Unfortunately, due to the method of drilling the sediments were not observed in an undisturbed state. These are overlain by a periglacial diamict (head) of clay bound angular granitic gravels.

2. *Trewirgie*

The deposit at Trewirgie, [SW 6970 4125], was exposed during extension of the local cricket club playing field cut into the side of a hillside (Figure 3). The exposure at 145 m O.D., lies on a flattened. north-trending spur cut into Devonian metasediment about 800 m north of the Cam Brea granite outcrop at Buller Hill. The spur extends for five kilometres from a height of 229 m O.D. at Buller Hill in a north-north-westerly direction to 46 m near Bridge, [SW 685 448], on the Portreath river. Four distinct breaks in slope may be identified on this spur, at 61 m, 91 m, 122 m, and 183 m O.D. Several of these heights have been equated in the past with a number of suggested erosion surfaces of probable Tertiary origin, for example, Gullick (1936), Pounds (1945), Balchin (1964), and more recently Everard (1977). Most of the erosion surfaces at these altitudes are characterised by the lack of recognisable deposits upon them, one exception being the well-known site near St. Agnes Beacon which is found approximately nine kilometres to the north, [SW 707 505]. The site at St.Agnes has been described many times over the past 200 years and most recently in an extensive paper by Walsh *et al.* (1987).

Thus the current description of the Trewirgie site near Redruth at 145 m O.D., first noted by one of the authors (James, 1990), is significant for the number of identifiable lithological units that were exposed in the temporary section. The original exposure (Figure 4), just north of the Cam Brea granite/Devonian metasediment contact, extended for more than 150 m in an east-west direction at the southern end of the Redruth Cricket Club ground about five metres from the boundary wall. A series of three 1.5-2.0 m deep terraces were mechanically excavated with the lowest terrace cut down into the Devonian metasediment (`Killas') bedrock. Six lithological units overlying the metasediment bedrock have been identified and are shown in long section in Figure 4. Detailed examination and analysis of a reduced section of circa 50 m in width was possible with careful recording of the units by a levelling survey from nearby bench marks together with an extensive photographic record.

The top of the metasediment (Unit 7), here found at c.145 m O.D., presents an undulating, strongly weathered surface dipping towards the west along the local dip of the granite/killas boundary. The range of

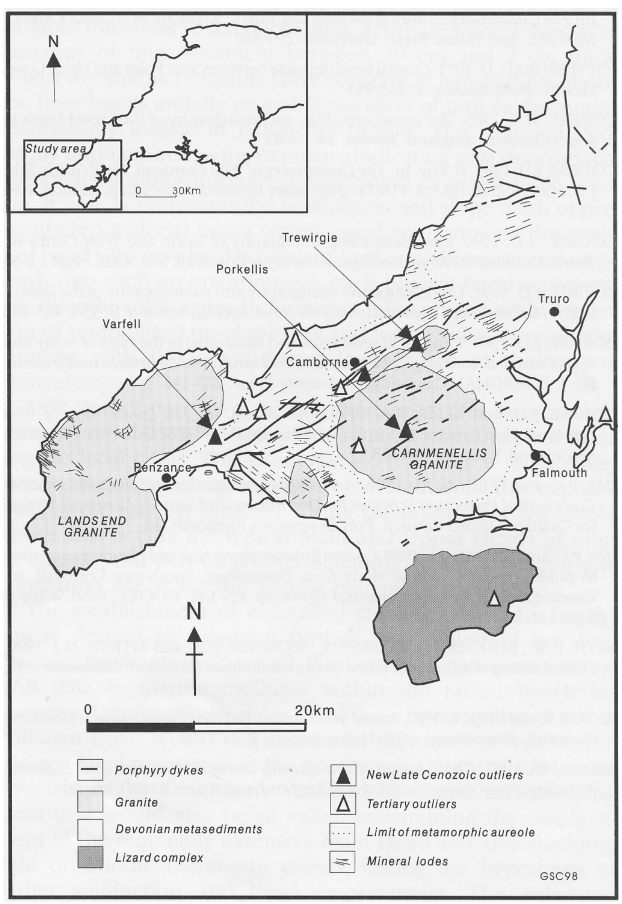

Fig. 1 Map showing new Late Cenozoic outliers in west Cornwall

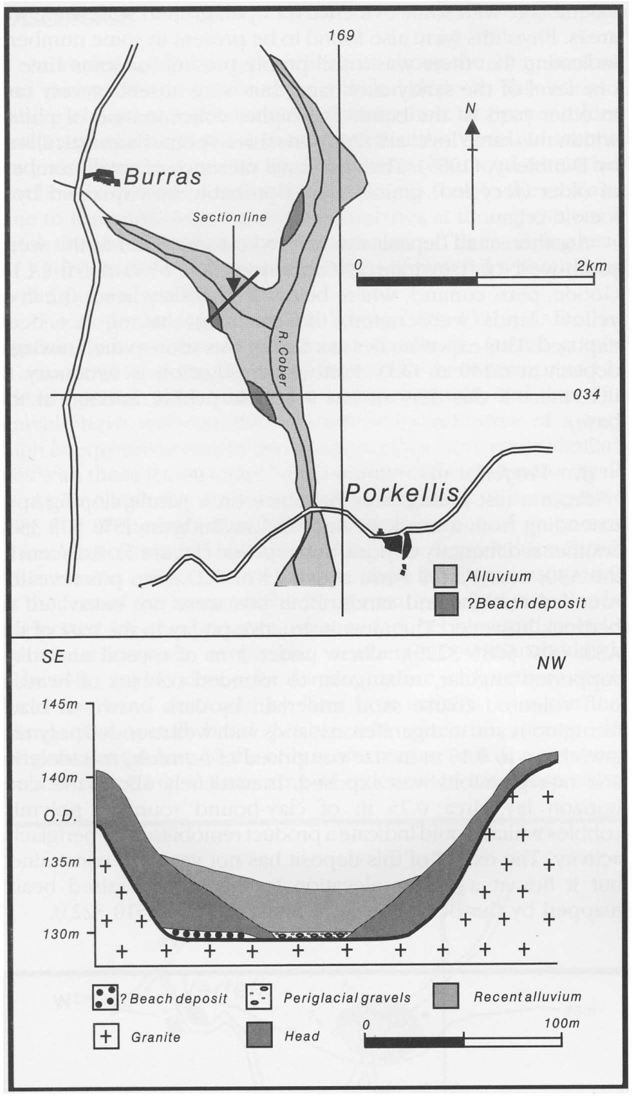

Fig.2 Location map and cross-section of Porkellis deposit

relief of the bedrock surface is c.0.7 m. with northward trending gullies preserved within this surface. A thin but persistent layer of manganese coated pebbles and sand (Unit 5) overlay the undulating surface of the killas throughout the width of the section. The maximum thickness of this unit was 0.05 m and the pebbles were of local origin, that is metasediment and vein quartz. A size distribution of this thin basal unit showed that 44% was greater than 0.005 m. The gravel contains cassiterite and the size distribution and tin content are discussed in Camm and Croot (1994). SEM examination of quartz grains in the gravels (Photograph 2) indicated that most had 'V' shaped chatter marks which are probably diagnostic of marine surf action (Krinsley and Doornkamp, 1973).

A distinctive unit of varying thickness, averaging 0.5 m (Unit 4) was found above the thin layer of pebbles of Unit 5. The gravels at the base of Unit 4 were up to 0.3 m thick and extended across the whole of the original 150 m wide section. They were largely of rounded vein quartz and discoid killas pebbles in a sand matrix, but contained no molluscan material. The remainder of Unit 4 consisted of clasts of Devonian metasediment, hornfels, vein quartz together with rounded clasts of microgranite and one sample of a fine-grained basic igneous rock. Scattered throughout the eastern end of the unit were occasional large rounded cobbles of killas and coarse-grained granite. Two examples of the latter were thoroughly chemically weathered and such was their degree of disintegration that it was impossible to remove them from the section. In addition, small sand lenses and larger sandy

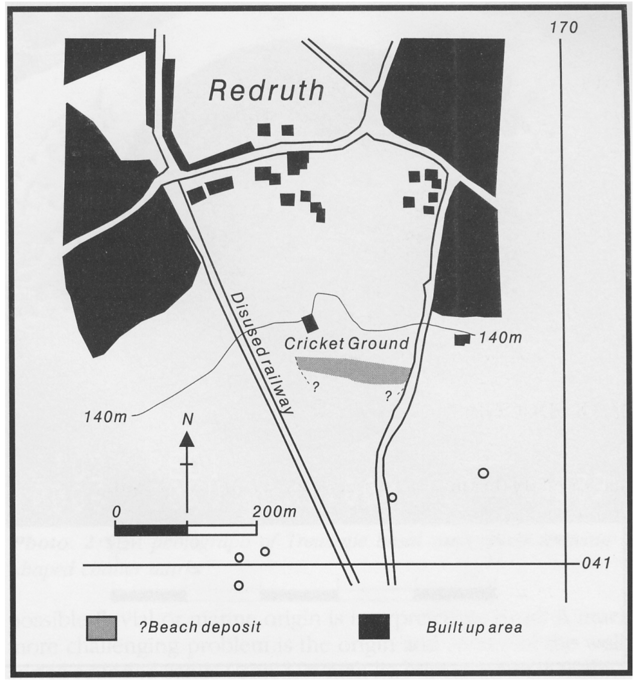

Fig.3 Location Map of Trewirgie deposit

clay lenses occurred throughout Unit 4. One particularly thick clay unit (0.2 m), located in a depression of the eastern end of the original exposure (Unit 6), was subsequently sampled for organic material by Dr. C. Hunt of Huddersfield University. Identification of the pollen at this stage suggested a grassland assemblage with some evidence for open ground with some wet areas. Above Unit 4, a distinctive sandy gravel unit (Unit 3) with a maximum thickness of 1.2 m extended across the whole exposure in an east-west direction with a dip towards the west apparently consistent with the Devonian bedrock surface. The top of this unit attains an altitude of 147.2 m O.D. in the east declining to 145.6 m O.D. in the west. Granulometric analysis of the sands showing them to be well sorted medium-fine sands and their almost spherical shape was revealed through SEM examination. A series of fractured ferricrete and manganese pan layers, often in the form of involutions, were also found near the base of Unit 3. Finally occasional angular clasts of killas, often vertically inclined, were found in the upper part of this unit. These clasts are believed to have been derived from an overlying 0.5 m thick unit of head (Unit 2) which capped the sandy gravel unit. Observations of the fabric of Unit 2 suggested a downslope movement from the south.

Consideration of the processes of deposition for the Trewirgie deposit suggest that, with the possible exception of the thin pebble unit overlying the undulating killas surface and the sandy clay horizon, that all of the overlying deposits were soliflucted from the higher ground to the south during the Pleistocene period. The underlying killas surface is interpreted as a former erosion surface, possibly marine in origin, as indicated by the corrasion features, that was subjected to significant chemical weathering prior to the deposition of the killas "brash" or "Old Head" unit. This distinctive unit, which largely consists of fractured clasts of local rock together with a significant proportion of rounded clasts of killas as well as the described granite cobbles appears to have been soliflucted downslope. Whether the rounded cobbles were marine or fluvial in origin prior to the solifluction phase is difficult to determine because of the disturbed character of this unit. However, further evidence for a periglacial climate is the fact that many of the clasts, including the cobbles, are found in a vertical position. The sandy clay unit with its pollen spectra in a shallow depression suggests a former wash unit. A possible marine origin for the basal rounded gravels within the overlying gravelly sand unit is indicated, together with subsequent reworking and solifluction as well as the truncation of the sandy clay unit. The

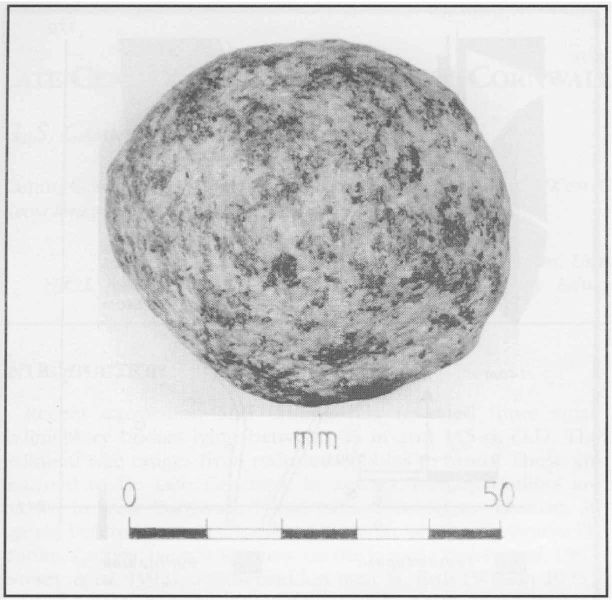

Photo. 1 Photograph of weathered cobble from Porkellis deposit. (from Camm and Hosking 1985)

well sorted sands were undoubtedly aeolian in origin, and then also soliflucted as shown by the presence of angular killas clasts in the upper part of this unit. In addition, the presence of involution and other cryoturbatory phenomena within the sands indicates frost disturbance. Finally, the thin layer of head sealed in the underlying units.

Identification of the pollen at this stage, by Dr.C. Hunt, Royal Holloway and Bedford New College, suggests a grassland assemblage with some evidence for open ground with some wet areas. Phyoliths were also found to be present in some numbers, indicating that there was a soil profile present for some time at one level of the sandy clay band, but were absent or very rare in other parts of the band. The higher concentration of pollen within this same level also supports this hypothesis as articulated by Dimbleby, (1985). The additional presence of small numbers of older (recycled) grains, would probably be explained by a loessic origin.

Another small deposit was observed some 6 km to the west-south-west of Trewirgie at Camborne, [SW 6530 3964] (A.J.J. Goode, pers. comm.), where below 2 m of slaty head, 0.2 m of yellow sands were noted, the basement having not been exposed. This exposure lies at a similar elevation to the Trewirgie deposit at c.140 m O.D. Further investigation is necessary to determine if this deposit has a cobble/pebble horizon at the base.

3. *Varfell*

From a test pitting near Penzance on a gentle sloping spur extending from a break in slope below Ludgvan [SW 505 330], another sedimentary deposit was exposed (Figure 5). Adjacent to the A30, near Varfell Farm above 25 m O.D., two pits revealed rounded cobbles and sands. Both pits were not excavated to bedrock however. The most instructive pit lay to the east of the A30, (SW 5085 3225), where under 3 m of topsoil and clay-supported angular, subangular to rounded cobbles of head, a buff coloured coarse sand underlain by dark brown to black ferruginous and manganiferous sands with well rounded polymict gravels up to 0.15 m in size comprised of hornfels, metadolerite and rare granitoid was exposed. Immediately above the sand horizon lay circa 0.75 m of clay-bound rounded polymict cobbles which would indicate a product remobilised by periglacial activity. The extent of this deposit has not yet been constrained but it lies at a higher elevation to the second raised beach mapped by the BGS (Penzance Sheet 351/358 (510 322)).

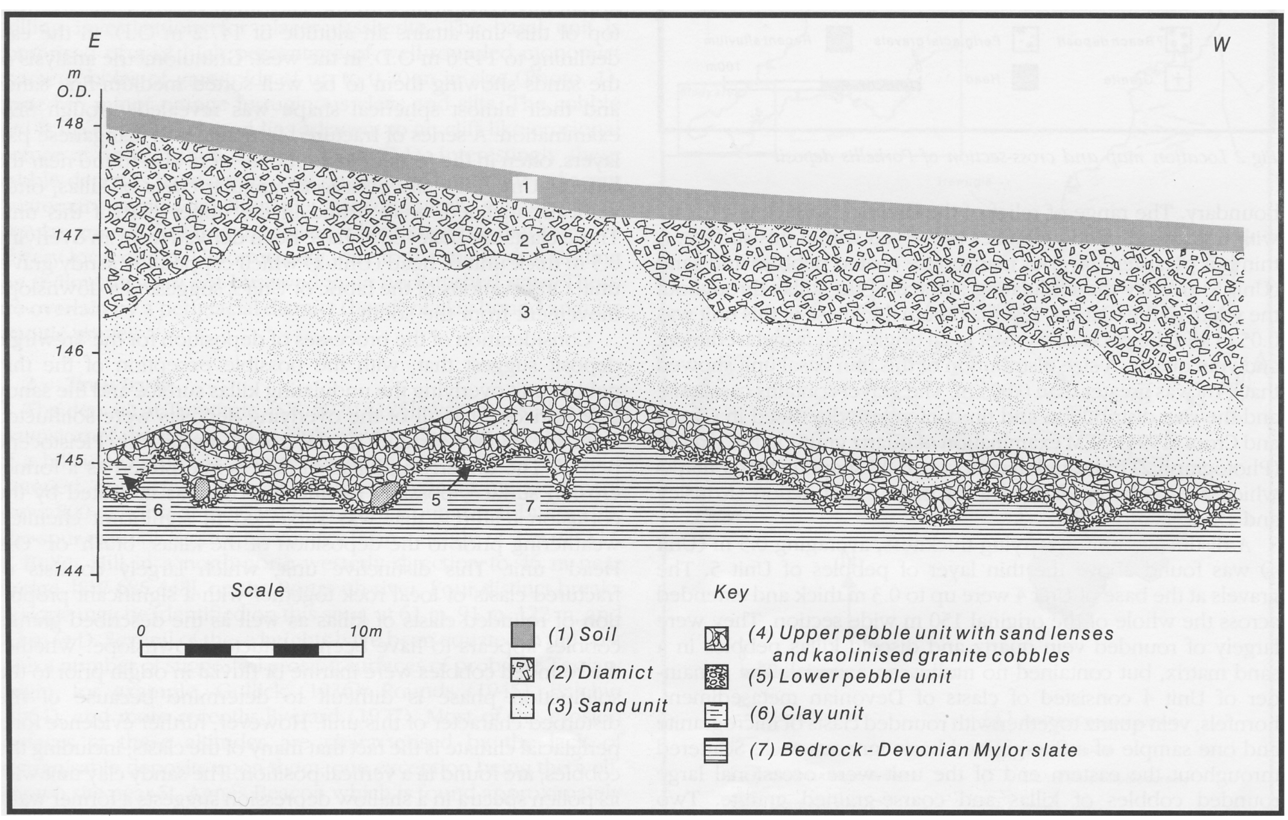

Fig.4 Cross-section of Trewirgie deposit

DISCUSSION

At Varfell Farm the deposit lies just above the 25 m contour and the sediments appear to be a littoral deposit. This lies at a similar elevation to Pliocene deposits to those at Spattenridden and Tregurtha Farm and it is assumed that the Varfell sediments may also represent similar aged sediments. The total extent has not been constrained and although two pits, one to the east and one to the north-west delineate boundaries at those positions it is felt that the deposit may be more extensive. The overlying head of 3.0m or more would conceal this type of material without deep drilling or excavation.

The Porkellis deposit, which lies at circa 130 m O.D., has similar characteristics to one found on the St. Austell granite (Camm and Hosking 1985) and these have been interpreted as 'beach' gravels lying adjacent to a degraded relic cliff line. The gravels have well-rounded characteristics indicative of a very high energy environment and in appearance have many similarities with those found today below granite cliffs in west Cornwall.

At Trewirgie the outlier is more complicated. It is suggested that this of marine origin, through the presence of an ancient shore platform at 145 m O.D. backed by a degraded fossil cliff. This erosion surface has an average slope of 2°, increasing to 9° at the foot of the former cliff A former marine origin may also be supported by the presence of rounded pebbles and cobbles which, at intervals, overlie the weathered Devonian bedrock. However, any evidence for former marine sedimentary structures has been destroyed by later frost activity. Thus the thin manganese-coated basal pebble unit extending across the original section may be the only in situ marine unit. The overlying pebble unit (Unit 4) consisting of redeposited local material

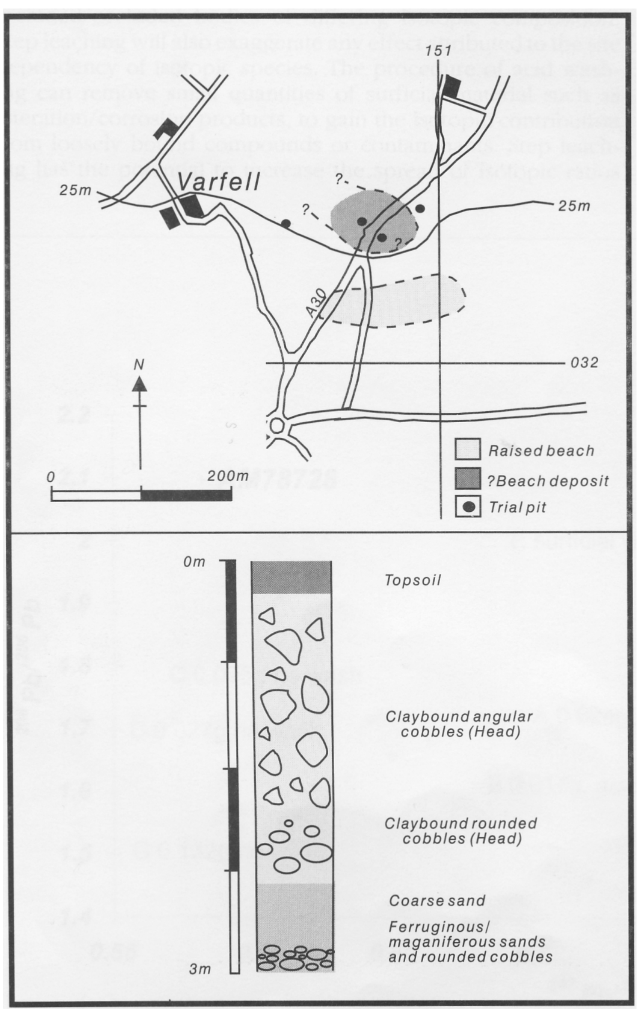

Fig.5 Location map and section of Varfell deposit

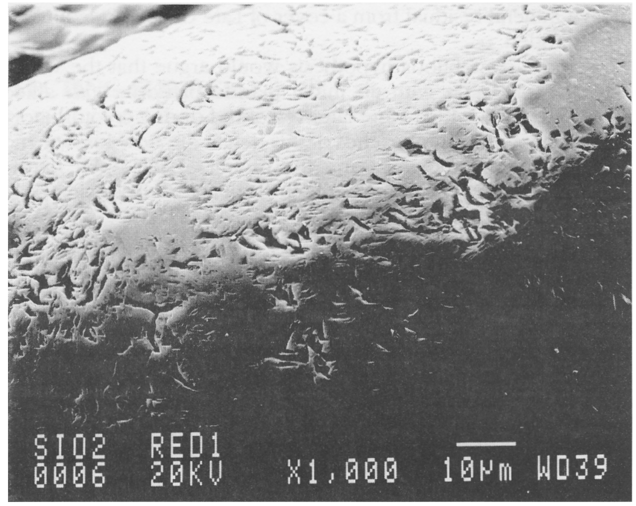

Photo. 2 SEM photograph of Trewirgie basal sand grain showing V shaped chatter marks

of possible fluvial or marine origin is interpreted as Head. A much more challenging problem is the origin and source of the well-sorted rounded sands (Unit 3) which lie beneath the 0.5 m thick Head which caps the section. The well-sorted nature of these sands suggests an aeolian origin. The presence of angular shale clasts within the sand unit suggests that this unit was finally emplaced by mass movement. The formation of the pan layers found only in the lower part of the sand unit is most likely to have occurred whilst the sands were in their present position. The source of these sands can only be subject to conjecture at this point and the only record of a similar deposit at a comparable height is the Upper Sands (Benson Member) of the St. Agnes formation described by Walsh *et al.*

CHRONOLOGY

With the exception of Unit 6 (Sandy Clay), all the units above Unit 5 for the Trewirgie site show clear signs of reworking and cryoturbation, that is Pleistocene periglaciation. The presence-of Cedrus pollen in the clay infill of Unit 6, if not re-worked, would indicate a pre-early Pliocene age, while the presence of Gramineae pollen and Compositae (Ligulifiora) further suggests a post Oligocene age since they evolved in the Late Oligocene. Hence a Miocene date would therefore be appropriate. Consideration also needs to be given to the present altitude of the Redruth site and the original location of the rounded clasts within units 4 and 5. If marine processes caused the rounding of the metasediment and particularly the granite cobbles, prior to their subsequent solifluction then this site is unique in retaining beach material at this altitude in Cornwall. As mentioned in the introduction, various erosion surfaces have been mapped in south-west England and Wales, but remarkably few deposits associated with these surfaces have been recorded. It therefore appears probable that Neogene deposits have been fortuitously preserved and subsequently exposed at Trewirgie following a series of solifiuction events during the Middle to Upper Pleistocene period.

The basal pebble bed deposit at Trewirgie, with quartz grain surface textures showing chatter marking, suggests a high energy environment. Combined with the north-south trending eroded gullies, would appear to reinforce that it is of marine origin. Other work elsewhere in the county (Camm and Hosking 1985) supports the existence of a component of placer cassiterite with high sphericity and extensively chatter-marked. Marine action is again suggested. Additionally, fine cassiterite is present in stream sediments covering large tracts of Cornwall a considerable distance away from the parent source (Hosking and Orbital 1966) which would require some method of transportation. It is possible that these were transported by long shore drift during a marine high stand (Dunlop and Meyer 1973) and

Represent the heavy mineral residual from a cover of Late Cenozoic sediments now eroded.

A more contentious hypothesis would argue that the whole site is Pleistocene with an initial marine platform with allied beach deposits which were later reworked during cryoturbatory phases. However, no beaches of this height are now known and the issue of neotectonics and the timing of the uplift of the erosion surfaces resulting perhaps from hydro-isostasy would need to be further investigated.

Walsh *et al* (1987) ascribe an Oligocene and Miocene age from fossil evidence for sands and clay formations lying around St. Agnes, and an aeolian and colluvial origin. They also argue that the surface they lie on is an old land surface formed by a tropical or subtropical environment forming an etchplain of pre late Miocene age. They conclude that the surface could not have been eroded by marine action assuming that any deposits lying on the surface would have been totally eroded. However they quote earlier historic information (Davies and Kitto 1878) which indicated a 4.8 m high buried 'sea cliff' and pinnacles on the noth-west side of the St. Agnes Beacon and a bed of pebbles, often containing cassiterite at the base of the St Agnes deposits (Reid and Scrivenor 1906). This view poses a question as to the genesis of the Porkellis and Trewirgie deposits, and the surface upon which they lie on, as they appear to be of marine origin. Recent work in St. Austell Bay and Mount's Bay shows offshore Quaternary fluviatile deposits preserved on the floor of both bays (Camm and Dominy 1998).

It is interesting to note the Late Cenozoic outliers in west Cornwall lie to the souh-west of the Start Perranporth line (Bristow 1996). Late Cenozoic age deposits may be more extensive than previously thought and are probably concealed by a thick mantle of Pleistocene periglacial head. Further exploration is required at suitable sites to test for them, especially adjacent to the 'cliff like erosion features forming embayments.

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