

COUNTYBRIDGE QUARRY, THE LIZARD PENINSULA, CORNWALL – HISTORICAL AND GEOLOGICAL SIGNIFICANCE OF AN ABANDONED QUARRY

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Countybridge Quarry, a Cornwall County Geology site (RIGS), is an abandoned serpentinite quarry that started in the 19th Century as one of a number of small local quarries, and subsequently became one of the larger quarries in the region. Together with the adjacent Trevassack Quarry, it was the principal and effectively the last source of serpentinite building material in the 20th Century on the Lizard Peninsula. The quarry exploits a narrow band of tremolite serpentinite, overlain by loess, which formed the overburden in the quarry and was removed to still well-preserved spoil heaps. The resulting loess section, designated as the type section of the Goonhilly Member of the Lizard Loess Formation has been cleared and re-examined. This re-examination, which has been extended to include other abandoned quarries on the peninsula, suggests that the sharp, locally brecciated, contact between the overlying loess and the under-lying serpentinite bedrock is in all probability a periglacial shaved surface and that the loess of the Lizard Plateau was not immune from periglacial processes, as is often assumed.

Quantitative age data for vegetation re-colonisation within the quarry have been estimated and the long lasting damage done by vehicle tracks to areas with vulnerable thin loessic soil covers is highlighted. The principal ecological importance of the quarry, i.e. the direct link with geodiversity, is the presence of magnesium carbonate secreting stoneworts in the flooded parts of the quarry and miner bees in the upper loess unit.

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INTRODUCTION

Countybridge Quarry is one of 4-5000 abandoned pits and quarries (Owens, 2000) in Cornwall, most of which have yet to be audited, let alone assessed for their intrinsic conservation value. An audit of such pits and quarries on the Lizard Peninsula was undertaken in 2006 by Cornwall RIGS Group with support from Cornwall County Council Historic and Environment Service, using different vintages of Ordnance Survey (OS) maps, backed up by geological field checks. A total of 300 plus quarries and pits were identified within the area, half of which were developed in serpentinite bedrock (Figure 1). As an initial step to assess their ecological, geological, and historical (industrial archaeological) significance and hence conservation value, a pilot study which included an archaeological assessment (Kirkham, 2008) was undertaken on Countybridge Quarry, a Cornwall County Geology Site (RIGS), with support from Natural England's Aggregate Levy Sustainability Fund (ALSF). The quarry has a history, dating back at least to the 1880s, contains a nationally important loess section, and has been abandoned for the last 30 years. It was included as access land under the Countryside and Rights of Way (Crown Estate) Act in 2000 and is therefore accessible by the public. This paper describes the results of the study, with emphasis on their direct /indirect geological significance and historical interest.

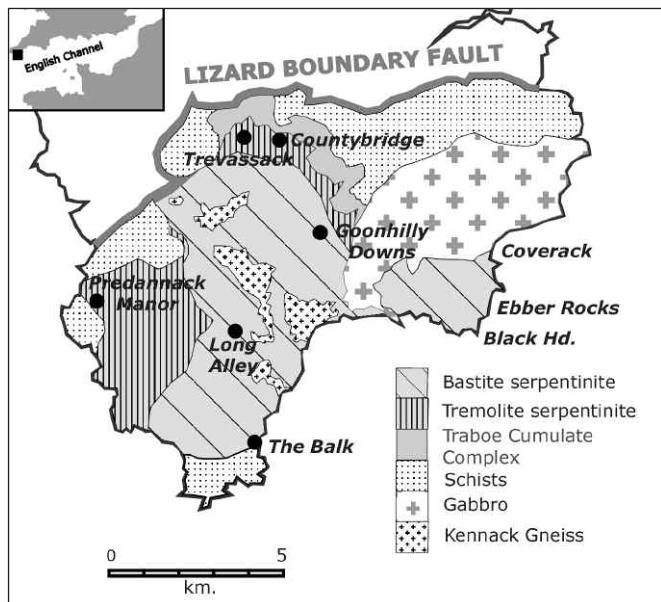


Figure 1. Sketch map of the geology of the Lizard ophiolite, modified and adapted from Flett (1946), with localities mentioned in the text.

GEOLOGICAL AND GEOMORPHOLOGICAL SETTING

Countybridge Quarry lies near to the northern edge of the Lizard Ophiolite Complex within 1 km of the Lizard Boundary Fault and exploits the tremolite serpentinite zone that lies between the central mass of bastite serpentinite, dominating the Lizard plateau and the marginal belt of dunite/amphibolites, now known as the Traboe Cumulate Complex (Figure 1). The tremolite serpentinite is overlain by a 1 m thick loess section, which, before quarrying of the underlying serpentinite took place, was removed with the overlying soil and vegetation cover. Roberts (1985) first described the Countybridge Quaternary section and proposed it as the stratotype section of the Lizard Loess Formation, widespread in south Cornwall and believed to be derived from Devensian outwash in the Irish (Catt and Staines, 1982) and Celtic Sea (Scourse, 1999). In 1999 the section was formally designated as the formal stratotype of the Goonhilly Member of the Lizard Formation, i.e. the massive settled loess facies as opposed to remobilised head-loess (Campbell *et al.*, 1999) which essentially corresponds to the earlier non-mixed and mixed loess of Roberts (1985).

Geomorphologically the boundary between the serpentinites and Traboe Cumulate Complex forms a pronounced break in slope to the north and northeast immediately south of the Lizard Boundary Fault. Countybridge Quarry straddles this break in slope, and as a result affords vistas of the china clay pits to the east, Carnmenellis and Tregonning Hill to the north, and the Penwith Granite and the iconic Ding Dong Mine to the west, enhancing the aesthetic value of the site.

HISTORY OF QUARRY

Countybridge Quarry has been known under a variety of names – Countybridge (Flett, 1946; Holyer, 1996), Blue Stone, Telstar, Kemp's (Roberts, 1985; Campbell *et al.*, 1999) and Phillips Rocks. James Kemp was the operator of the quarry between 1959 and 1974. The quarry is shown on the 1st edition of the OS 1:2500 map (1880) as one of a number of small quarries in the area located on the slope bounding the Lizard plateau. The name Countybridge is derived from a small settlement immediately north and down slope of the quarry shown on this map. Air photographs taken in 1946 indicate a major upslope southward and westward expansion occurred (Figure 2) after the 1907 2nd edition of the OS 1:2500 map (Kirkham, 2008). The name Phillips Rocks Quarry, used in all legal documents from 1946 onwards, probably derives from this period. Flett (1946) photographed well-developed gable jointing in the quarry faces during this period probably in 1937–38 when he re-examined the principal exposures of the Lizard during his preparation of the 2nd edition of the Geology of the Lizard and Meneage Memoir (Flett, 1946). However, our research indicates that a number of serpentinite quarries (Balk, Long Alley and Predannack Manor) supplied hardcore for the runways of the RAF Predannack airfield, which became operational in May 1941. It is therefore not clear whether the quarry expansion predated or occurred as part of the WW2 airfield construction activity, which is regarded by Smith (2000), as one of the biggest and most ambitious building projects ever completed in such a relatively short space of time – the number of airfields in the UK trebled during WW2.

After 1946 the quarry again expanded southwards and westwards where it was deepened. The loess overburden was dumped in spoil heaps on the adjacent Goonhilly Downs immediately to the west, now part of Natural England's Lizard Nature Reserve. Two distinct phases of dumping can be recognised on the 1946 and 1977 aerial photographs (Kirkham, 2008). The earlier phase occurred as a result of WW2 or expansion. It was during the later phase that the current loess section was exposed. Vehicle tracks, associated with these dumping activities, are still clearly visible on modern aerial/internet satellite photographs and exhibit crosscutting relationships.

As well as producing roadstone and aggregate, Countybridge and the adjacent Trevassack tremolite serpentinite quarry were the principal and effectively the last sources of serpentinite building material in the 20th Century on the Lizard Peninsula, replacing earlier use of bastite and dunite serpentinites, used from the 15th Century onwards. Tremolite serpentinite building material is distinctive and readily identifiable in the area.

As a result of its proximity to the expanding Goonhilly Earth Satellite Station immediately to the south, the quarry ceased operations in July 1974. The deeper parts then flooded, as shown on an OS map surveyed in 1975 and confirmed in the 1977 air photograph. The first records of stoneworts (charophytes) at Countybridge date from this late 1970s period (ERCCIS, 2008). These green algae are often the first plants to colonise newly dug or cleared ponds and ditches, and in chalk/limestone areas secrete calcium carbonate onto their outer surfaces. On the Lizard, which is one of the key areas in Britain for stoneworts (Stewart, 1996), magnesium derived from the serpentinites substitutes for calcium (Gainey, 1997).

In 1984 British Telecom (BT), the owners of the adjacent Goonhilly Earth Satellite Station, bought the quarry, which was sold in 2006 to a private individual. The Goonhilly Earth Satellite operations are currently being phased out. By 2006, the quarry and its overburden dumps had reverted to nature, enhancing its aesthetic appearance and ecological value.

The quarry was designated as a Cornwall County Geological Site (RIGS) in 1997 for its mineralogy (native copper and steatite breccias, Holyer, 1996). It was realised subsequently that Countybridge and Kemp's Quarry, mentioned in Quaternary literature (Roberts, 1985; Campbell *et al.*, 1999) were one and the same and that more importantly the quarry was also the national type section of the Goonhilly Member of the Lizard Loess Formation.

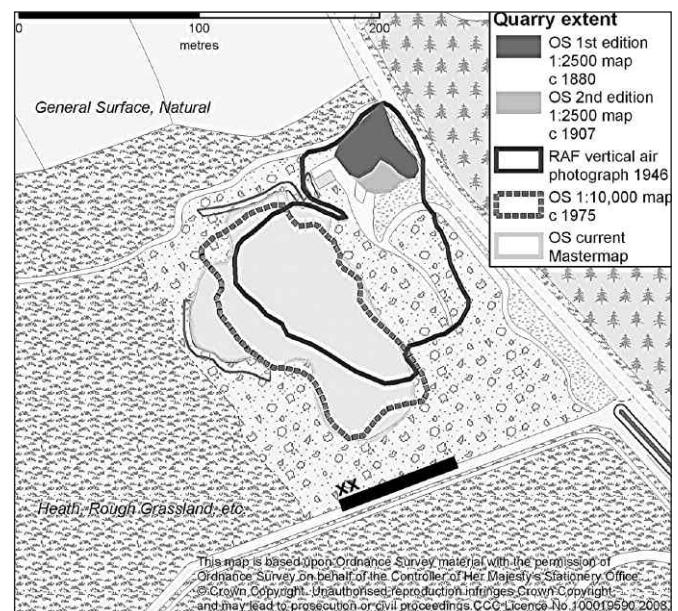


Figure 2. Historical development of Countybridge Quarry (courtesy of Cornwall County Council Historical Environment Service), with location of loess section (heavy black line) and trenched segment (XX) added.

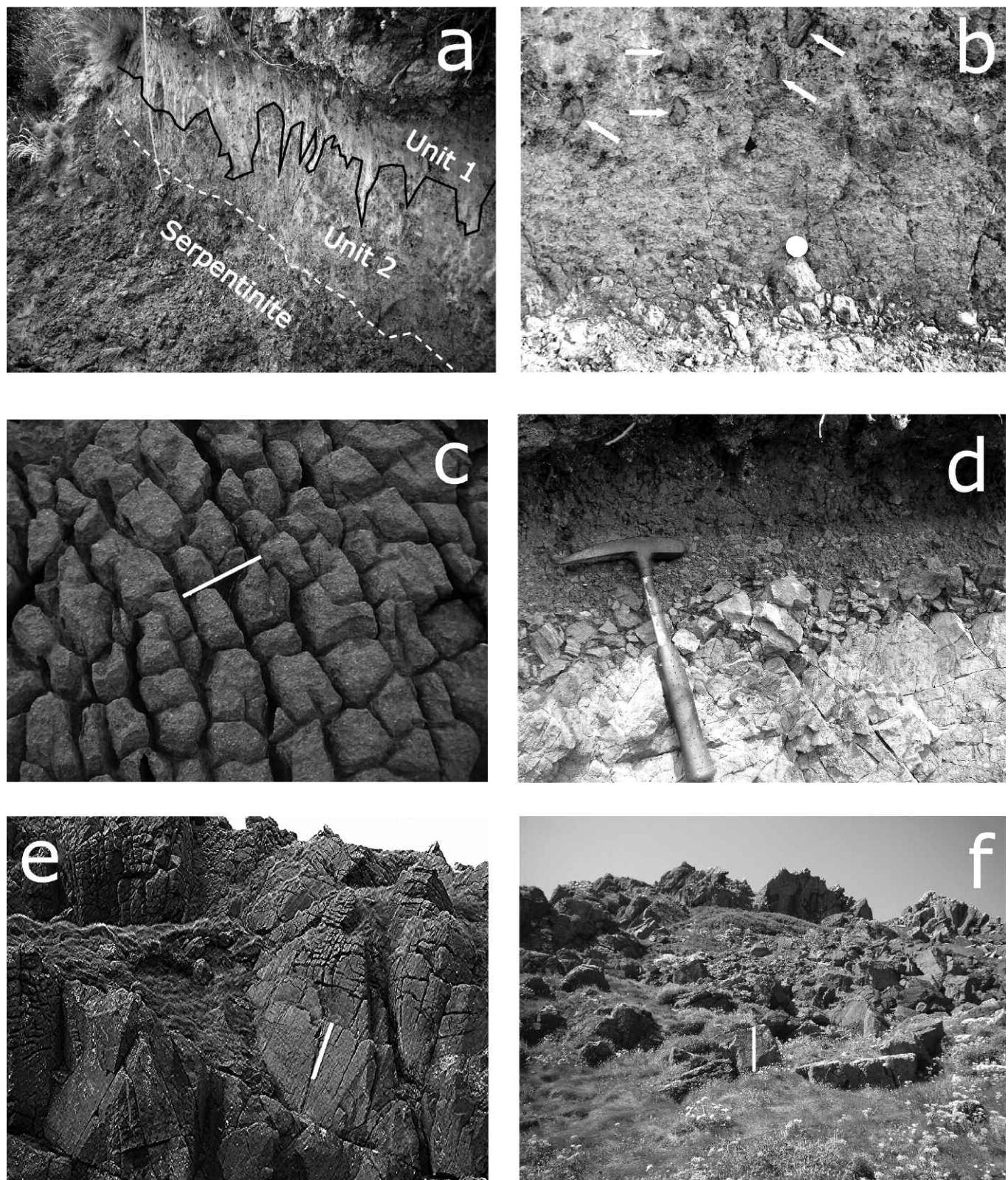


Figure 3. (a) Trenched section with sampled section located by tape. (b) Vertical inclined clasts (arrowed) within and at base of Unit 2. Coin scale = 2 cm. (c) Reticulate weathered serpentinite, Ebber Rocks (NGR SW 781 167). Pencil for scale. (d) Predannack Manor Quarry section (NGR SW 666 172), showing basal serpentinite breccia, overlain by two loessic soliflucted units. (e) Solution free joint planes exhumed from beneath 4 m thick loess wedge on Black Head coastal slope (NGR SW 779 169). 1 m scale bar. (f) Typical coastal slope block field, Black Head (NGR SW 778 162). 1 m scale bar.

COUNTYBRIDGE QUATERNARY SECTION

The loess and underlying serpentinite are exposed in a 2 m high cliff at the back of a 15 m wide upper bench in the southernmost part of the quarry. The cliff exposure extends over a 70 m length and abuts the southern boundary fence of the quarry (Figure 2). This face dates back to the later phases of the quarry operations, which ceased in 1974. An oblique aerial photograph, taken in 1977 shows a relatively fresh cliff face. However, by 2006 the exposures in the cliff section were intermittent due to local slumping and colonisation by bramble, gorse, grass and heather. The western third of the section was virtually inaccessible, due to the growth of gorse, willows and brambles on the upper bench. This area was cleared by tractor and mechanical flail as an integral part of the project.

Trenched section

A 10 m long section has been trenched at the western end of the Quaternary exposure. This area was selected because it did not immediately abut the boundary fence and any destabilisation caused by the trenching was unlikely to impact on that fence. The thickness of the loess section is in the order of 1 m, which is bounded by an upper humic zone (24 cm thick) and a 25-30 cm thick basal brecciated (Murton, 1996) serpentinite zone, overlying more massive bedrock. The humic zone comprises a basal soil, overlain by loessic overburden on which mixed heath has formed. Two distinct units with an irregular contact were identified below the overlying humic and above the basal serpentinite zones (Figure 3a):

Unit 1. 24-59 cm. White to orange massive silt, with abundant miner bee holes, and penetrated by roots from above. White vertical streaks are clearly visible in the lower part of the unit.

Unit 2. 59-93 cm. Silt, darker brown in colour, with abundant oxidised serpentinite clasts, locally vertical (Figure 3b) and with thin dark grey coatings. The base clearly shows vertical clasts derived from the underlying brecciated zone.

Unfortunately the precise location of Robert's (1985) section was not documented. Clearly it was in the vicinity of the newly trenched section described here (GPS derived NGR SW 72145 21864), as its thickness is comparable and the thickness of the loess section decreases towards the east, as does the ground surface. Roberts (1985) recorded a thinner soil horizon (16.5 cm), a thicker (58.5 cm) massive silt, with serpentinite clasts in the lower 20 cm (our Unit 2), underlain by a thin (19 cm) clay unit (our Unit 2). The irregular contact within the loess section does not appear to have been apparent in the 1980s.

Laser granulometric analysis of the <2000 µm fraction was undertaken on four samples from the newly trenched section with two samples from each unit (Figure 4). Unit 1, which equates to the Goonhilly Member of the Lizard Formation, is characterised by 14-15% sand, 72.4-74.7% silt and 8.0-10.2% clay, with grain size modes of 45.8-50.3 µm. These figures are very similar to those obtained by Catt and Staines (1982) for unmixed loess on the Lizard. The corresponding figures for Unit 2 are 6.6-11.1% sand, 76.5-78.4% silt, and 12.4-15% clay. The upper sample has a mode of 31.5 µm at the lower limit of modal ranges for Lizard loess reported by Catt and Staines (1982) and Staines (1984). The basal sample is bimodal with modes of 23.8 and 5.9 µm. These results indicate that the lower unit is indeed finer grained as Roberts (1985) noted, but not clay as he described and interpreted as a weathering product, i.e. soil, of the underlying serpentinite. It is possible, but unlikely, given the planar appearance of the loess-serpentinite bedrock contact where it is exposed over 70 m that there are local pockets of clay. Sieving of a bulk sample from the basal part of the lower unit revealed a far larger >2000 µm fraction than was present in our samples or field observations, suggesting the

loess content has been thoroughly mixed with serpentinite or other debris. The presence of vertical clasts up to 5 cm (as measured along the long axis) within the lower unit strongly suggests freeze-thaw processes. Similarly inclined clasts at the base of the unit could as well be the result of ground ice, common in the slates in Cornwall (Scourse, 1987) – tremolite serpentinite is strongly foliated. The markedly irregular contact between the lower and upper unit has all the appearance of periglacial involutions that have involved the whole section. In this interpretation the root marks in the upper unit and underlying bleached zones are considered as roots following the path of least resistance. An alternative interpretation (Brigitte van Vliet-Lanoë, personal communication) is that the irregular contact between the two units and bleached vertical zones are part of a fragipan soil horizon, characterised by a polygonal/prismatic structure, outlined by the vertical bleached zones, and reflecting former permafrost conditions (van Vliet and Langohr, 1981).

The basal serpentinite zone beneath the loess section is fractured to a far greater degree than can be explained by the well-developed joint system in the rest of the quarry. These joints have a metre to decimetre, not centimetre, spacing as observed in the brecciated zone. The brecciation is in marked contrast to the more characteristic serpentinite weathering patterns described by Flett (1946), i.e. etched appearance of the foliation and 'reticulate weathering' (Figure 3c) which he attributed to the network of cracks, resulting from expansion during the serpentinisation process, and subsequent widening and deepening by the solvent action of atmospheric waters.

Loess sections in other serpentinite quarries

As part of this investigation, the loess sections identified in other serpentinite quarries as part of the preceding audit were investigated. At Trevassack and the Goonhilly Downs pit, that Roberts (1985) also described, the lower unit is characterised by oxidised serpentinite clasts as seen at Countybridge. At Predannack Manor, brecciation of the underlying serpentinites was clearly identified (Figure 3d), overlain by two distinct clast-bearing loess units. Laser granulometric analyses of these two units are very similar, with grain size modes of 45.8 µm, 23.9% sand, 68.2 % silt, and 7.9% clay. The clay content is similar to that obtained from Unit 1 at Countybridge, the silt content is slightly lower, and the sand content is higher not surprisingly given the field observations, and the significant >2000 µm clast content in these samples, retained before the <2000 µm grain size analysis.

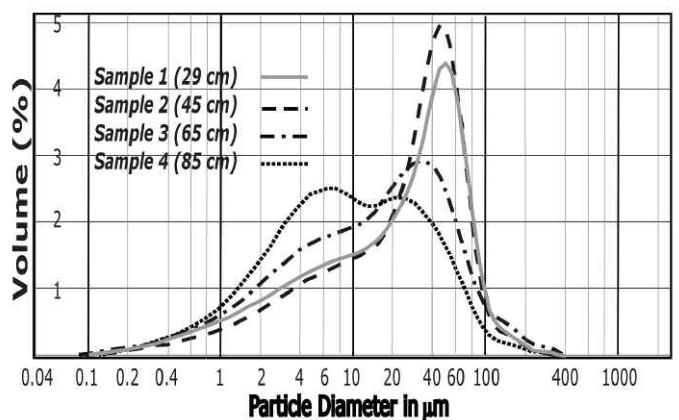


Figure 4. Grain size distribution (<2000 µm fraction) of Countybridge Quarry loess section samples.

DISCUSSION

The Quaternary section at Countybridge comprises a lower finer grained clast-rich unit and an upper relatively unmixed loess unit with a marked irregular contact between the two, previously unreported and almost certainly of periglacial origin. Whether this was due to freeze thaw involutions in the active layer or represents a former permafrost table and if so clearly of regional significance (James, 2004), can only be resolved by a detailed pedological study.

The topography of the Lizard Plateau is more irregular than is generally recognised from road or coastal views. Rather than a single plateau it comprises a series of upland plateau-like blocks bounded by broad slopes, often associated with valleys. The fact that Countybridge Quarry straddles a major break in slope and other quarries investigated with similar clast-rich sections occur on such slopes indicates that solifluction cannot be ruled out. The lower unit at Countybridge Quarry could be a soliflucted deposit and not the result of mixing of loess with the underlying brecciated serpentinite and clay soil by frost heave as Roberts (1985) suggested.

The sharp, locally brecciated, contact between the overlying loess and serpentinite bedrock, observed in all quarries, appears slope related and is in all probability a periglacial shaved surface (Te Punga, 1957). The basal brecciation resembles that described by Williams (1987), Murton (1996), and Murton *et al.* (2003) from the chalks of southern and southeast England. As a corollary of this interpretation, it is postulated that the solution process involved in reticulate weathering is principally active in temperate/interglacial climatic conditions. This is supported by observations of interpreted interglacial reticulate weathered blocks in the periglacial diamicsts on the coast, and at a unique outcrop near Black Head where the bedrock faces previously buried by loessic material, pass upwards into reticulate weathering on the same fracture plane (Figure 3e). Although the exhumed fracture face exhibits etched foliation surfaces, reticulate weathering has yet to develop. The ubiquitous presence of periglacial block fields (Figure 3f) on the coastal slope between Coverack and Black Head backed by joint bound crags suggests active ground ice fragmentation under periglacial conditions. Reticulate weathering developed on the resulting fracture faces in more temperate climate conditions. The Lizard serpentinites appear to have been more susceptible to ground ice action than the adjacent gabbro (Figure 1) and south-west granites to which they are often compared (Catt and Staines, 1982; Scourse, 1987), primarily because of the common massive nature of these three rock types. The Lizard serpentinites, however, do not weather deeply to produce coarse granular products like gabbro and granite.

The Countybridge Quarry loess overburden dumps, although covered by heath, are a good example of well-preserved former working practices. Using the data of Kirkham (2008) the time scale for vegetation re-colonisation of overburden dumps has been estimated. The older dumps were completely re-vegetated over a period of 31 years and the younger dumps over a period of not more than 23 years. Attention is drawn to the damage done to the thin complex loessic soil profiles of the Lizard Peninsula by vehicle tracks during quarry operations at Countybridge. Tracks ranging from 20-60 years old can still be identified on aerial/satellite photographs. The long lasting environmental impact of vehicle tracks on soil profiles needs to be considered and consequences assessed in all operations (agricultural, civil and military construction, forestry, heath land management, etc), not just quarrying.

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