PART 1 SOUTH

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GEODIVERSITY OF SELECTED QUARRIES IN CORNWALL IN THE CORNUBIAN OREFIELD

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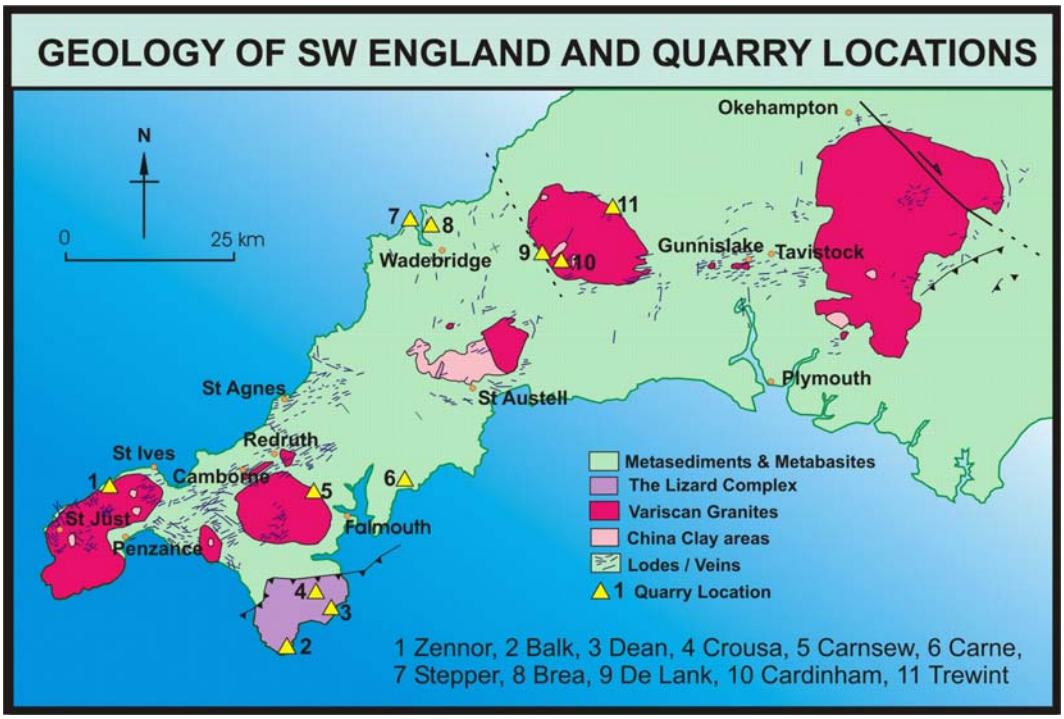
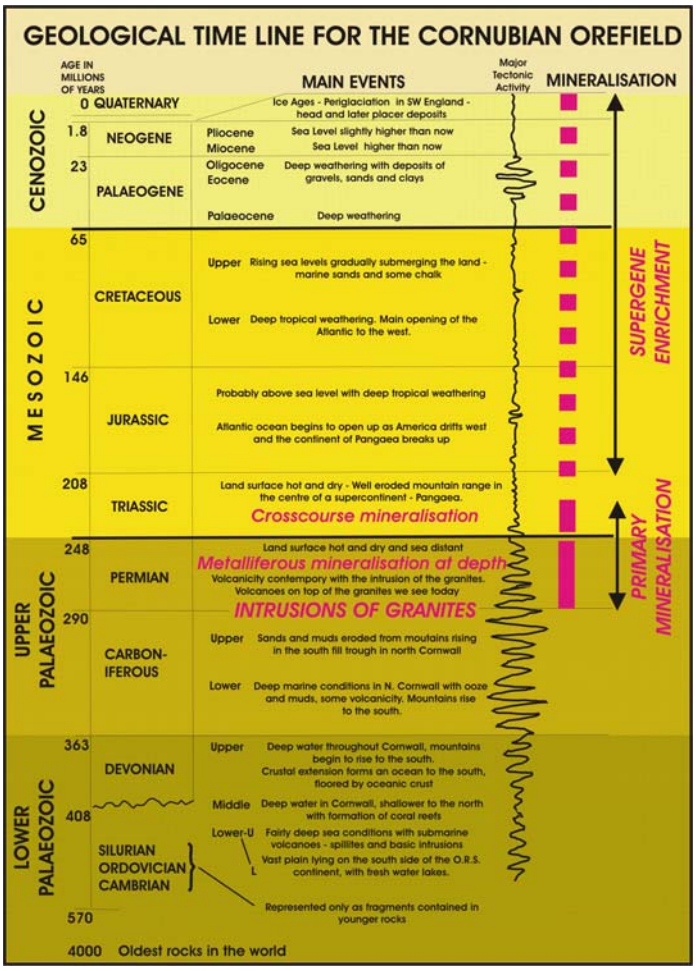
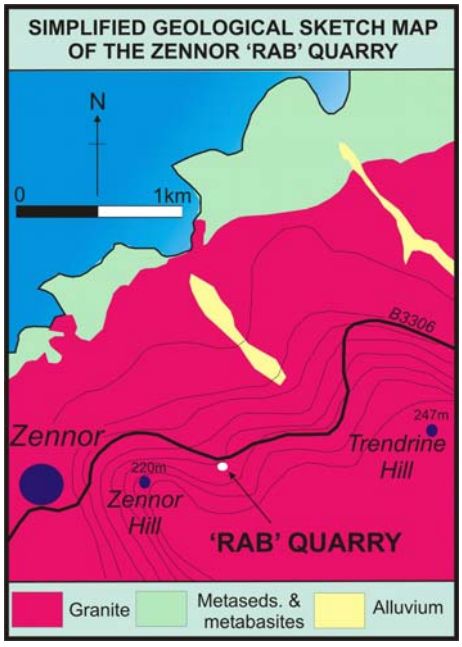


Eleven quarries with a wide geographical spread, both heritage and active, have been chosen to illustrate the geodiversity of aggregate quarries in Cornwall. Rocks exploited by quarrying have ranged from sands deposited in an early ocean and dislodged during continental collision, an old ocean floor thrust up and now exposed, submarine volcanoes, created deep in the heart of a mountain chain, eroded and accumulated during a period of tropical to semi-tropical conditions to deposition during the last Ice Age. The age range is from 490 million years to those just over 10,000 years, and rock types vary from ultrabasic, basic, acid igneous to metamorphic and sedimentary.



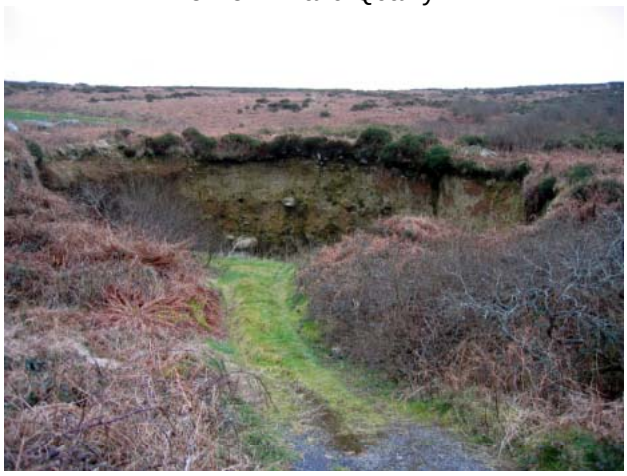
ZENNOR "RAB" QUARRY

The Zennor "rab" quarry lies under the small tor of Zennor Hill, to the east next to the B3306 in West Penwith in the Land's End Peninsula. There are many small "rab" quarries in West Penwith beside the roads skirting the granite. "Rab" is a colloquial word meaning subsoil of weathered rock, mainly applied to areas of granitic rocks. The quarry lies in a topographic hollow below the hill and is shown on the first edition six-inch ordnance survey map which indicates an early age as it was probably being used as a source of ready aggregate for the local roads.



The small quarry has a face approximately four metres high and is composed of a fine gravely matrix of decomposed granite with the occasional large boulder. During the Cenozoic Cornwall was subjected to deep chemical weathering of the bedrock, which resulted in the decomposition of the feldspars leaving the more resistant components of quartz and black tourmaline. During the Pleistocene or Ice Age period Cornwall was subjected to permafrost or periglacial conditions. During freeze-thaw conditions the weathered material would move down slope under the influence of gravity to accumulate in valley systems or topographic hollows. This material is known as head. The small excavation near Zennor is in such material, some of which may also represent hill wash, or mass wasting, at the very end of the cold conditions as the climate ameliorated.

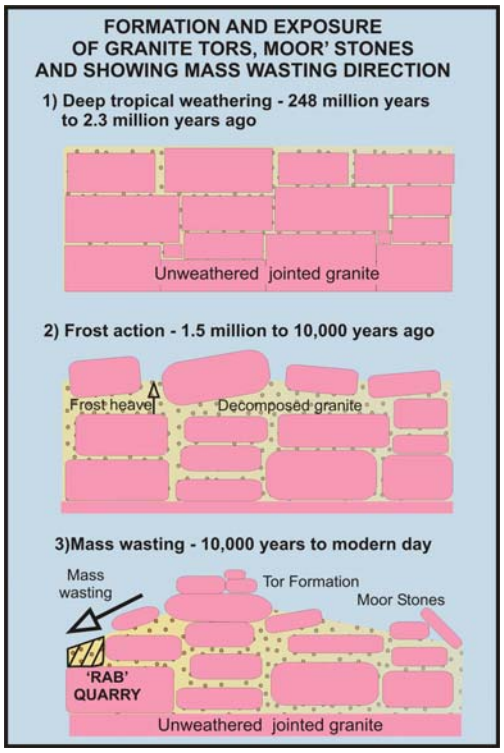
Zennor Hill and Quarry

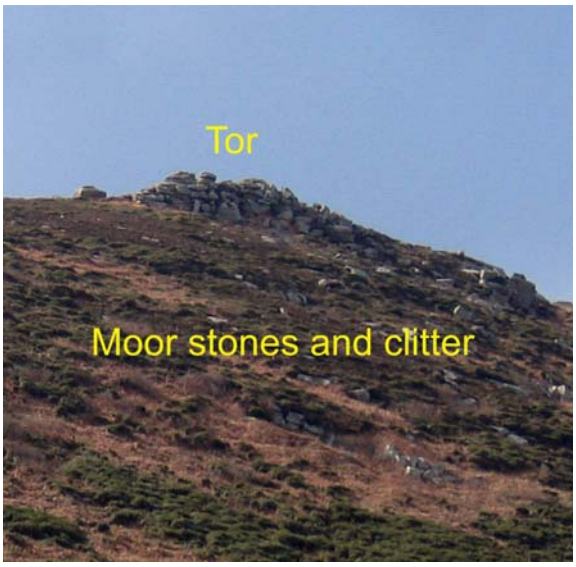

Zennor “Rab” Quarry

Quarry face

Gravel matrix

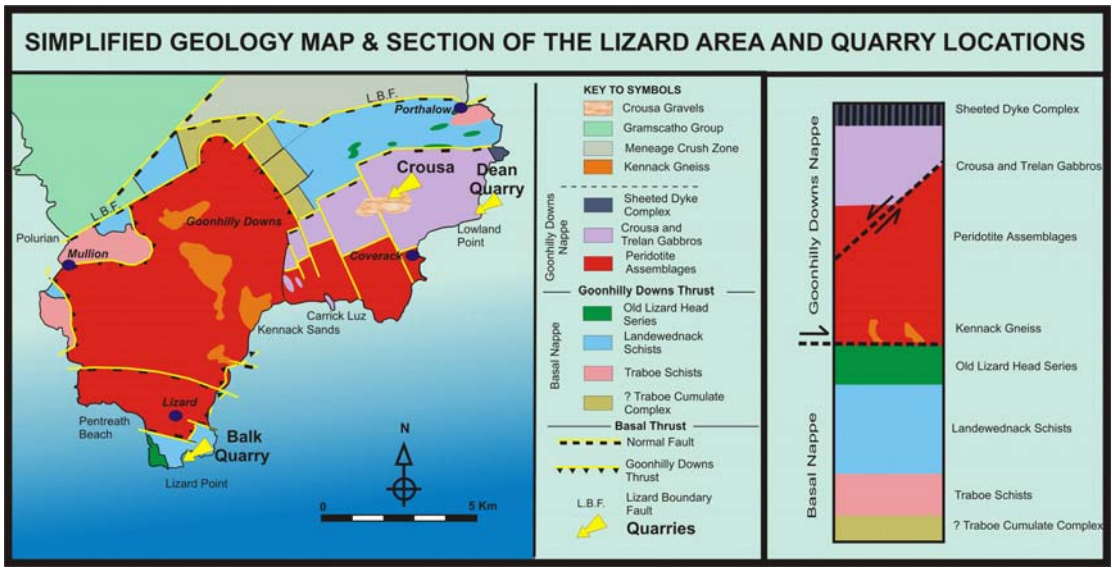
The process of deep tropical weathering, exploited the jointing liberating granite blocks. During the period of permafrost the action of frost heave in freeze-thaw conditions would heave blocks out of the ground, fracture rock and lead to the blocky material moving down slope during a periglacial event known as solifluction. This frost heave would produce Tors, moor stones, a clitter slope of broken rock, and as the climate changed to more temperate conditions producing a hill wash or mass wasting product.





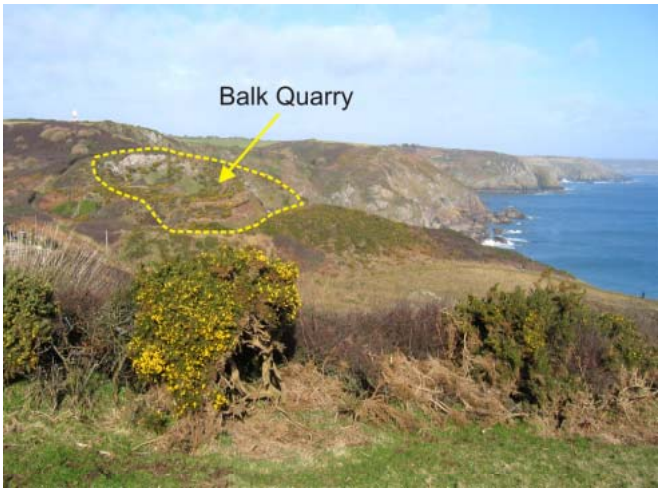
THE LIZARD AREA

On the Lizard, the most southerly point in Britain, rocks from an old ocean floor have been thrust up during continental collision. This collection of rocks is known as an ophiolite. The ophiolite sequence, from bottom to top, includes peridotite, gabbro, basaltic dykes, and pillow basalt. Oceanic sedimentary rocks frequently overlie this sequence. Here quarries have worked some of the rocks for aggregate and ornamental stone. The Lizard is dominated by an old erosion surface upon which there is a remnant of comparatively recent age in geological terms of an unconsolidated sedimentary rock. Three quarries illustrate the geodiversity from this complex.

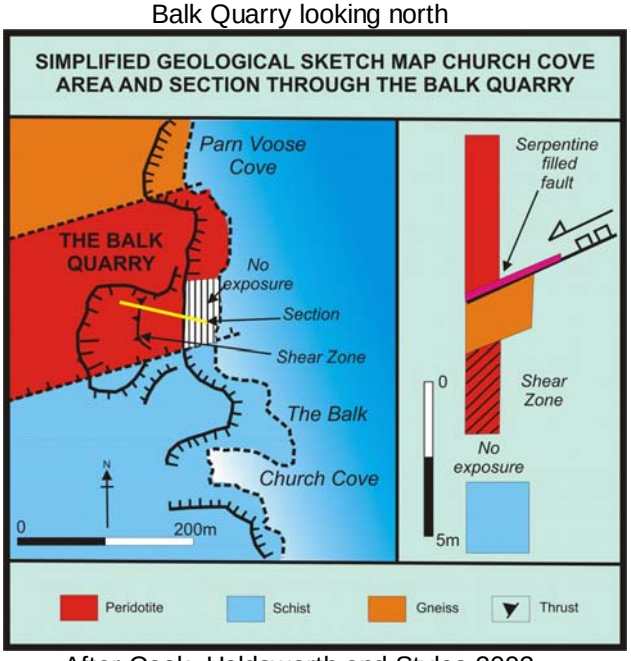


BALK QUARRY

Balk Quarry is situated to the east of the Lizard Head on the edge of the cliff near Church Cove. It is predominantly in serpentine, a highly altered peridotite, an ultramafic rock which makes up the Earth's mantle. Peridotite contains less than 45% silica and consists mainly of the mineral olivine with pyroxene. Hot water or hydrothermal solutions passing through this rock have altered it to serpentinite, a highly coloured rock for which the Lizard area is famous. The quarry is cut by a low angle fault or thrust exposing gneiss, and on the south side a faulted contact between the altered peridotite and sedimentary rocks, now highly metamorphosed to schist. White veins of calcite cross-cut some of rocks illustrating that hydrothermal fluids have moved through the rocks.



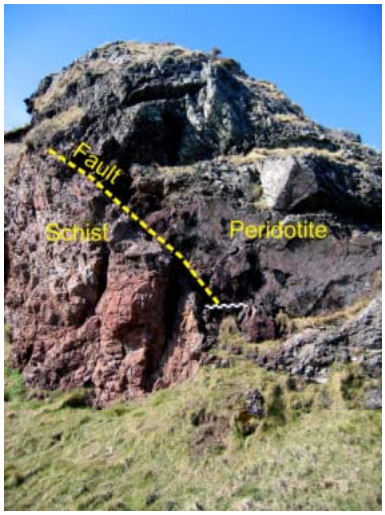
Balk Quarry looking north



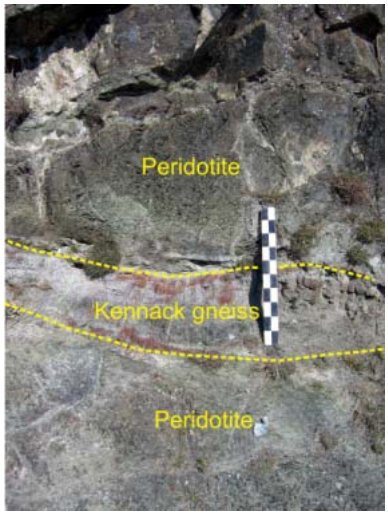
After Cook, Holdsworth and Styles 2002

Peridotite altered to serpentinite

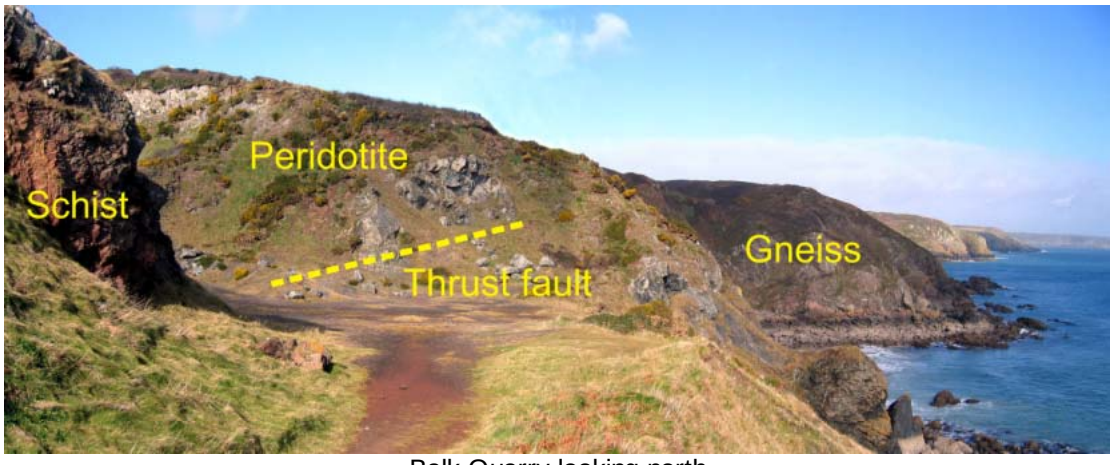

Calcite veins



Faulted contact between schist and peridotite

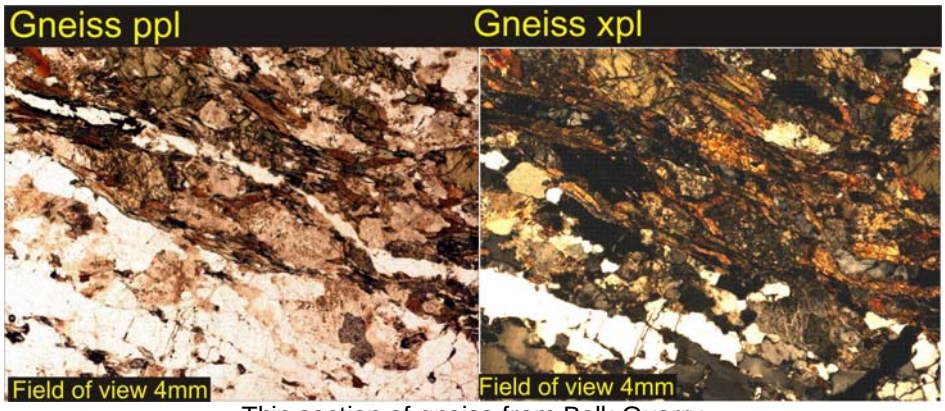


Sheared Kennack gneiss between peridotite



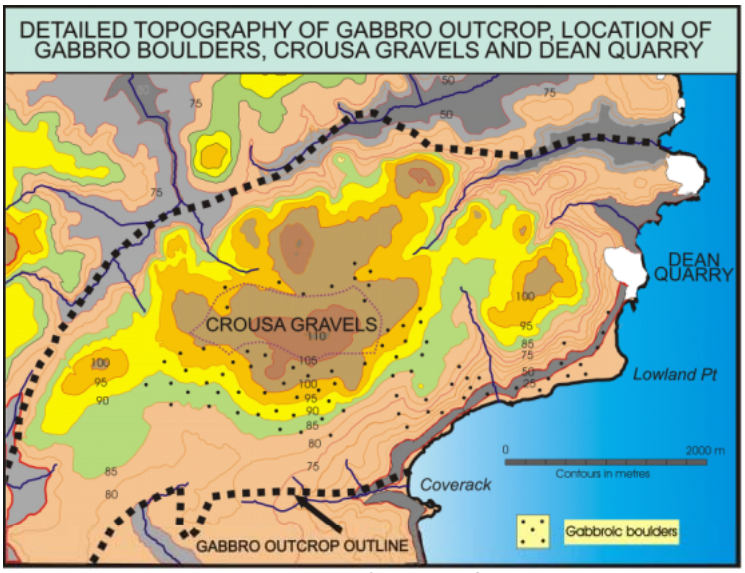
Balk Quarry looking north

The quarry was originally worked for the ornamental stone for cutting at the workshops at the Lizard village. During the early part of the Second World War however there was a great need for aggregate for the production of runways for hastily erected airfields for the defence of this island. To this end as an expedient any quarry with a suitable stone was commandeered. Although the highly altered peridotite is not the best in terms of hardness it is presumed that the hard gneissic rocks exposed by the thrust may well have been suitable for this purpose. The aggregate was used for the construction of the Predannick airfield, which is still evident on the Lizard peninsula.



Thin section of gneiss from Balk Quarry

DEAN QUARRY



Courtesy of Dr.P.Ealey

Along part of the eastern side of the coastal strip of the Lizard are a number of quarries. Quarrying of the hardrock was made more accessible as there is a relic or paleo-cliff line. This formed during a period when sea levels were higher during the Pleistocene during interglacials in the last Ice Age. Additionally, quarried rock could be exported by sea. One of these is Dean Quarry exploiting a basic rock known as gabbro, which is mafic (dark coloured) coarse-grained and igneous. Gabbro has the same chemical composition as basalt (lava), has a specific gravity c.3.0g/cm^3, and forms in large slow-cooling intrusions and is an essential part of the oceanic crust in mid-ocean ridges. Gabbro has no quartz and is composed of calcium plagioclase feldspars, pyroxene and minor olivine.

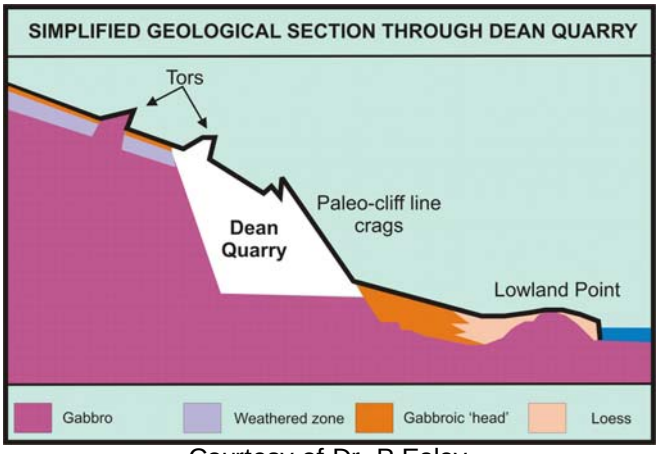

Dean Quarry looking north west from Lowland Point

Boat loading at Dean Quarry

Gabbro with basaltic dykes

Gabbro aggregate

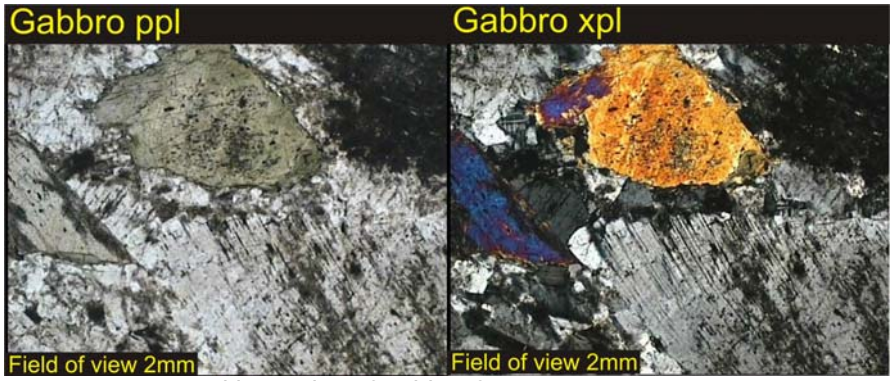
The quarry has a number of benches, the lowest of which is approaching sea level. The uppermost bench is being removed because the rock is not suitable for aggregate, as it has been extensively weathered. In the quarry jointing in the gabbro is evident in sub-parallel fractures.



Courtesy of Dr. P.Ealey

Dean Quarry looking north east

Jointing



Thin section of gabbro from Dean Quarry

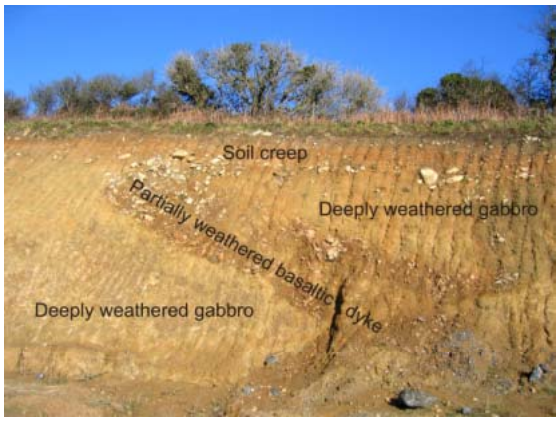
The weathering profile in the upper part of the quarry illustrates the production of tors. During the Cenozoic deep weathering exploited

zones of weakness such as fractures and jointing in the rock to allow penetration of weakly acidic water. Feldspars were attacked and converted to clays. Those areas of rocks that had little fracturing were resistant to attack and gradually became exposed either as Tors or Crusairs (moor stones) that are now seen on the Lizard where there are gabbro rocks. Later during the Pleistocene during periods of periglaciation, material was transported downslope as head. At Lowland Point below Dean Quarry there is both evidence of head material formed during periglacial activity as well as wind-blown fine silty-clays known as loess, which were deposited during the same time period.

Weathering of gabbro

Deep weathering

Incipient Tor formation



Preferential weathering

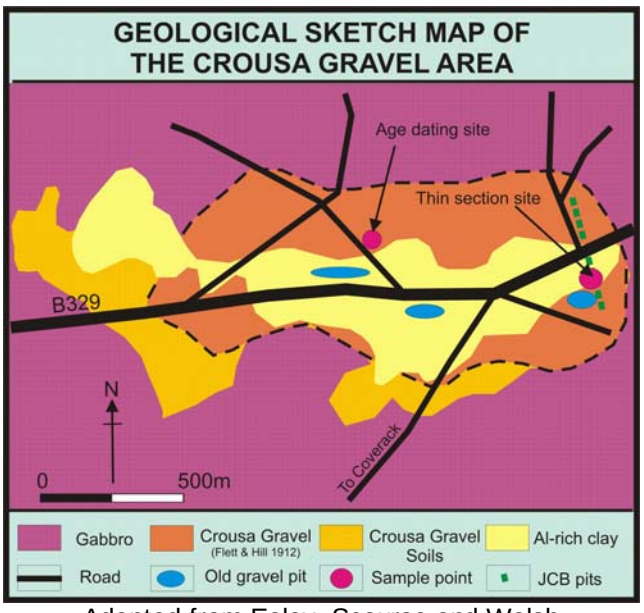
CROUSA

The Crousa gravels have been somewhat enigmatic in their origin and dating. The gravels are mainly quartz-rich, sub-rounded to sub-angular in shape with in some cases interbedded clays. They had been exploited from small pits for mainly road building in the 19th century and are shown on the first edition six-inch ordnance survey map, and were commented on in 1842. Little remains of the past quarrying activity although the remains of one small pit with public access is still extant.

Small pit in Crousa gravels

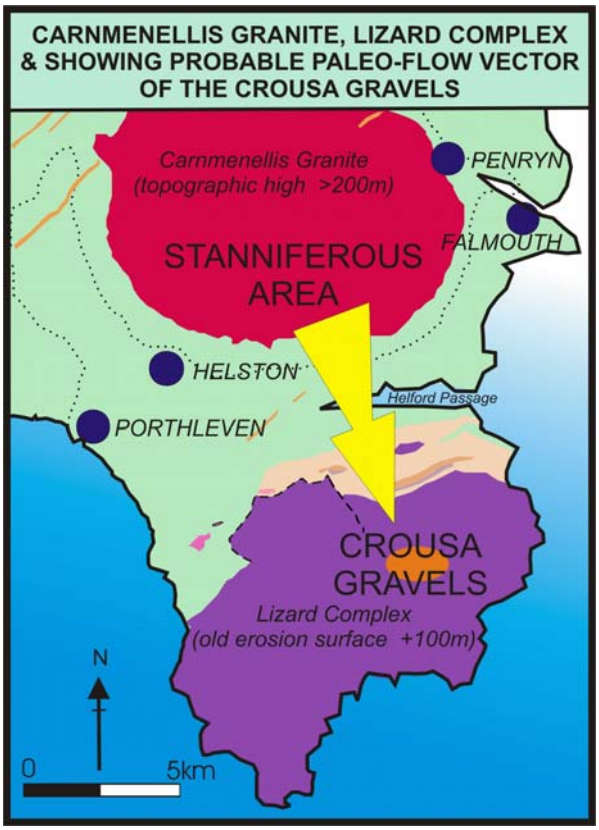
Crousa gravel

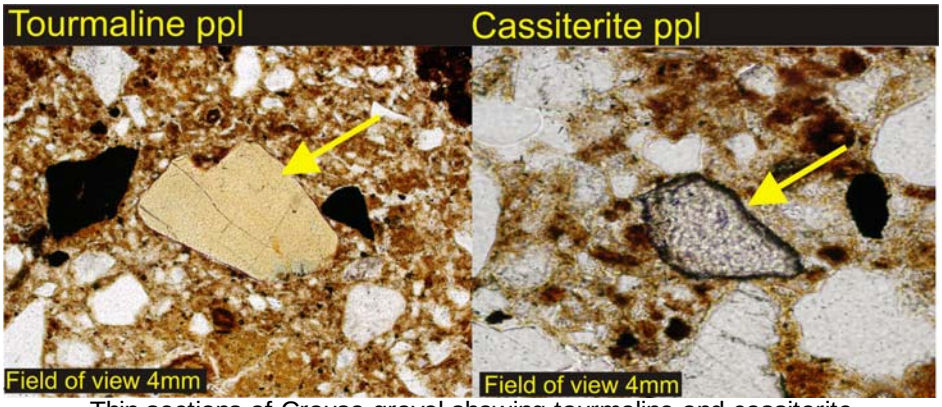
The gravels are reported to be up to 12 metres deep from a more recent survey by the BGS (1992) and cover an area most probably 1.5 kilometres long by 600 metres wide. A debate had ranged over the dating of the gravels but a sample collected in 1985 indicated a Tertiary age from fossil pollen samples.



Adapted from Ealey, Scourse and Walsh

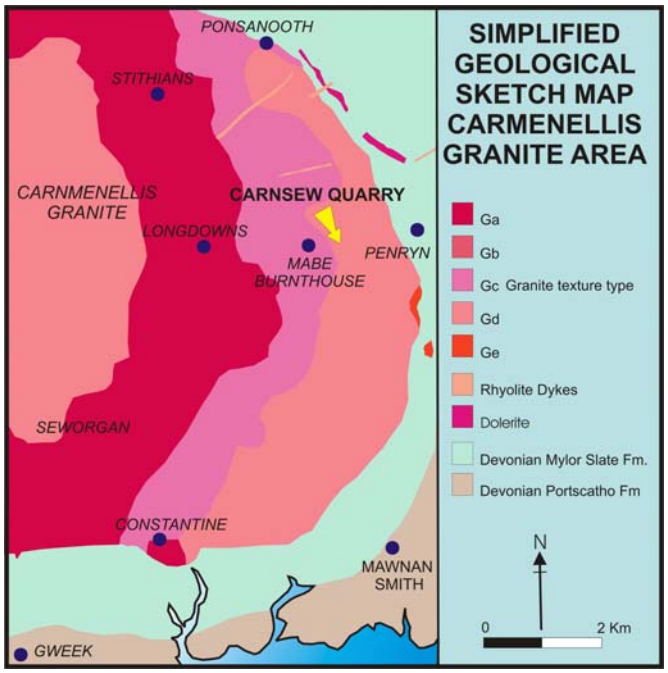
The gravels, although predominantly quartz-rich also contain quartz-tourmaline cobbles; other rock cobbles have been extensively weathered to clays. The bedrock of gabbro is also reported to be deeply weathered. The gravels are stanniferous as they contain cassiterite, which would indicate a source to the north with deposition taking place before the formation of the Helford Estuary. The gravels have now been exhumed, possibly having been preserved in a small graben (rift) fault system (Dr. P.Ealey pers. com.).





Thin sections of Crousa gravel showing tourmaline and cassiterite

CARNSEW QUARRY



Carnsew Quarry is situated on the eastern edge of the Carnmenellis granite. Granite is a coarse grained acidic igneous rock, primarily composed of quartz, feldspar and biotite mica and has a density of around 2.7 g/cm^3. The granite in Cornwall has been derived from the melting of sedimentary rocks during mountain building and occurs as small stock like masses connected at depth to a batholith. The granite of the Carnmenellis mass is made up of five main textures indicating that the emplacement was not a single event but occurred over a passage of time. Carnsew Quarry exploits a medium grained variety of the Carnmenellis granite.

Panoramic view of Carnsew Quarry looking west

The granite is heavily jointed and is exploited by a series of benches. In the fresh rock the sub-vertical joint sets can be clearly seen but near the surface sub-horizontal joints become evident as well. These sub-horizontal joints, often called off-loading joints, are the result of the removal by erosion of the rock above and as a consequence they are not confined by the weight over them and can therefore expand upwards with the formation of this new set. Weathering processes can exploit both the sub-vertical and sub-horizontal sets.

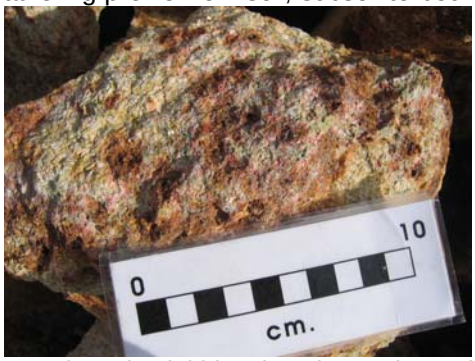
Sub-vertical joint set

Sub-horizontal joint set

At the top of the quarry the weathering profile is clearly evident. Deep chemical weathering commenced in the Cenozoic and is responsible for the china clay deposits elsewhere in Cornubia. Mineralization is often associated with granites and this is also the case with the Carnmenellis mass at Carnsew. Sulphides, predominantly iron pyrite, occur in some of the granite at this point. The weathering activity has attacked the sulphides producing more acidic water from the sulphate released causing a deeper and more intensive alteration of the feldspars to clays and also attacking the biotite micas releasing the iron.

The crushed rock from the quarry is sold as aggregate, some of which is exported to as far away as the Republic of Ireland.

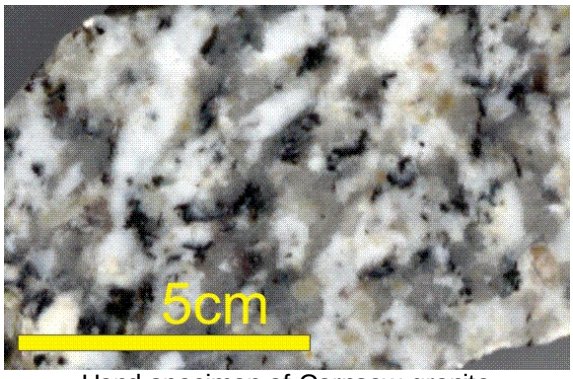
Weathering profile from soil, subsoil to bedrock



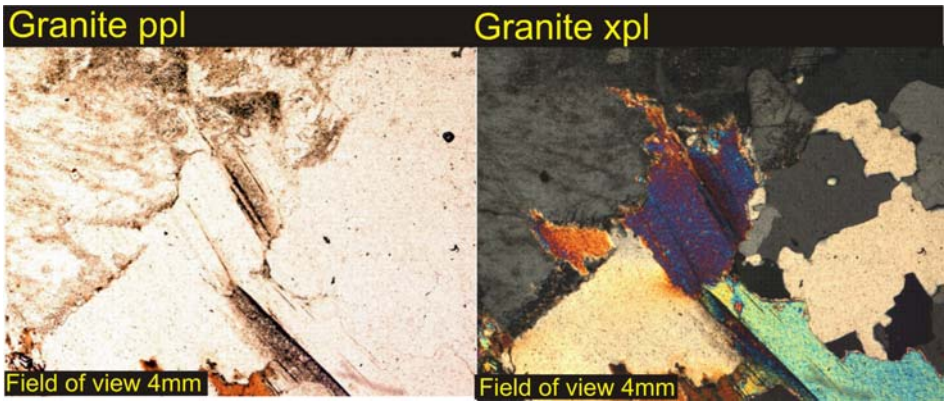
Weathered sulphide ‘clots’ in granite and kaolinization of the feldspars

Weathered granite and decomposition of biotite micas

Granite aggregate



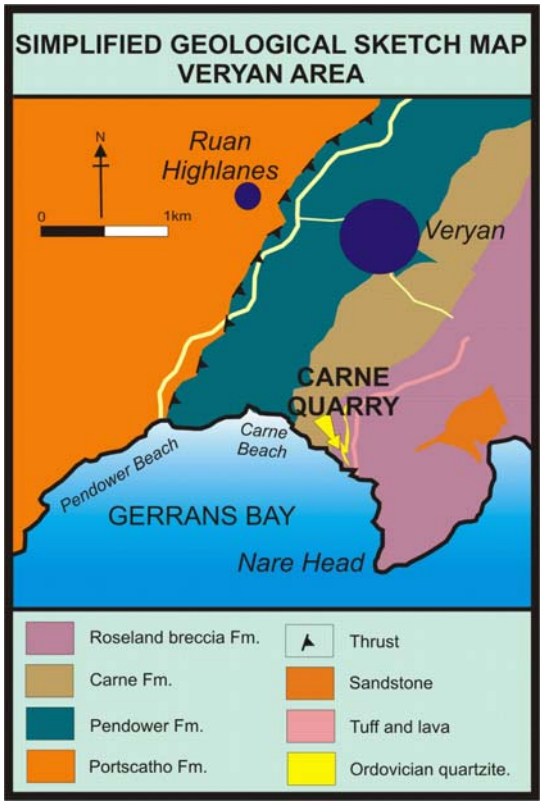
Hand specimen of Carnsew granite



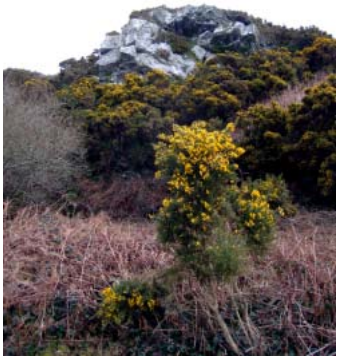
Thin section of Carnsew granite

CARNE QUARRY

The quarry at Carne is probably unique in Cornwall in the age of the rock that was quarried for aggregate. The rock, a very hard quartzite, is Ordovician in age, some 480 million years old, and so one of the oldest rocks in Cornwall. Strictly speaking the rock is incorporated into an olistostrome, which is a mixture of sedimentary rocks types from various sources; this is associated with a thrust that also was resposible for the exposing the Lizard rocks in Devonian times. A number of small quarries exploited the rock.



The thrust was caused by continent collision closing a small ocean and in the process thrust rocks up into a nappe (a sheared rock which falls back on itself) which would then break off to slump under the influence of gravity down one side. Although the majority of the rock is Devonian in age in the area the quartzites are essentially broken fragments of sandstones, which were originally an Ordovician Age seabed. Metamorphism by pressure and heat has now welded the quartz grains of the sandstone into a quartzite. Although quarried initially for building stone the quarries were taken over and expanded in the Second World War for the production of aggregate for the D-Day embarkation points in the Fal Estuary.

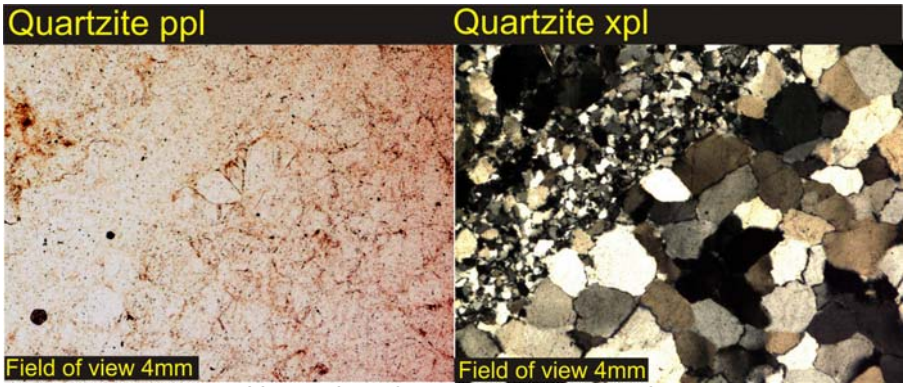

Quartzite quarry ourcrop


Quartzite outcrop near path

Close-up of quartzite


General view of top quarry outcrop


Flooded part of the middle quarry



Thin section of Carne Quarry quartzite