THE GEOLOGY OF POLDARK MINE

AND ITS

SURROUNDING AREA.

by

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INTRODUCTION

Poldark Mine [SW682315] is situated close by the hamlet of Trenear, 600 metres northeast of the village of Wendron and some 13 km (8 miles) south of Camborne in southwest Cornwall. It lies within the southwestern quadrant of the Carnmenellis Granite (see Figure 1), which is emplaced into metamorphic rocks (slates of the Mylor Slate Formation) of Upper Devonian age.

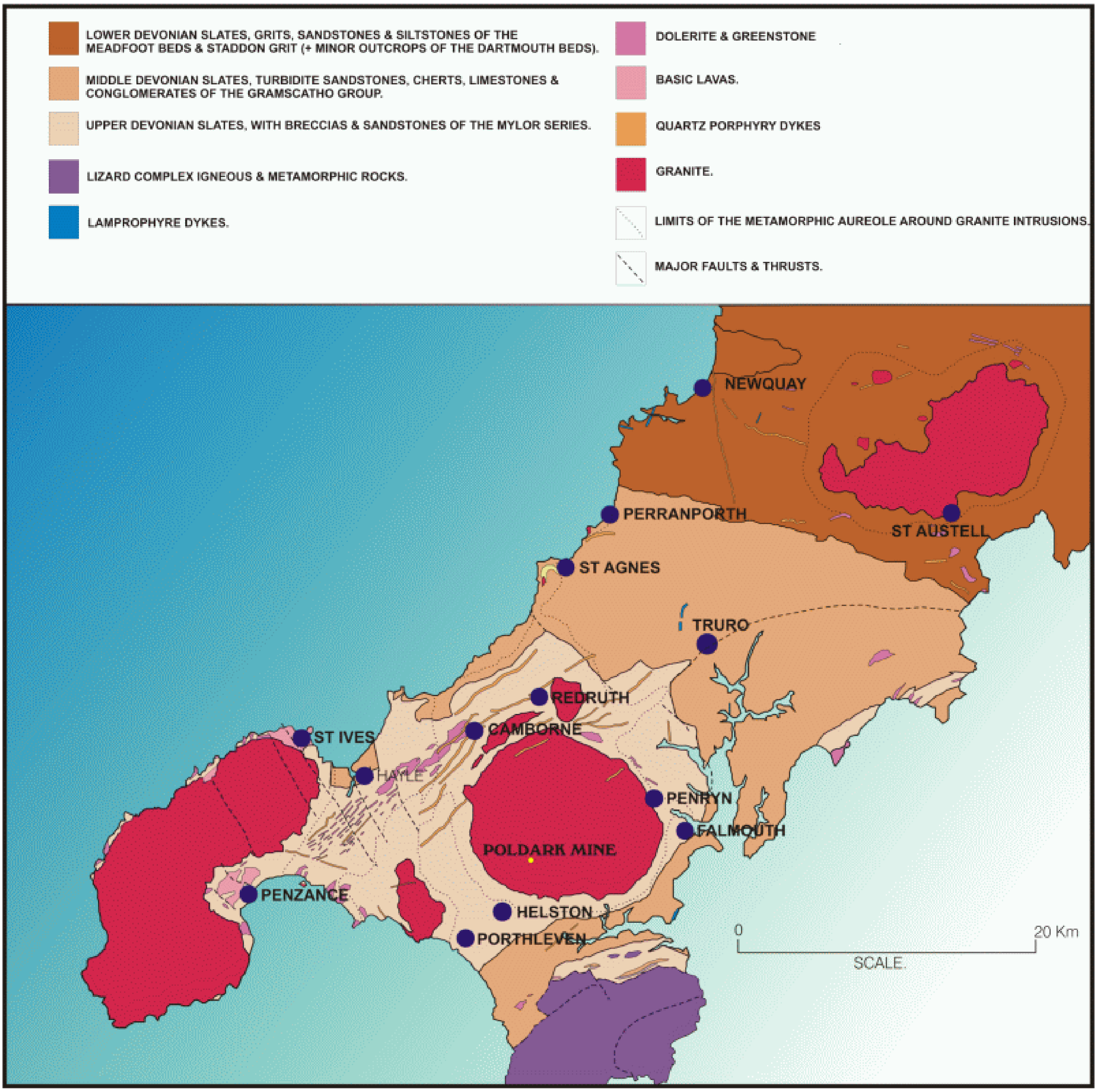

Figure 1. *The geology of southwest Cornwall (after BGS 1:250,000 sheet 50N 06W, Lands End).*

Southwest Cornwall is an area of physical contrasts (see Figure 2). The granite moorlands form the high ground, reaching a maximum height of 252 m above sea level on Carnmenellis and Land's End (at Watch Croft, west of St Ives), with the hills of Carn Brea and Carn Marth (satellites of the Carnmenellis Granite) reaching 225 and 235 m above sea level respectively.

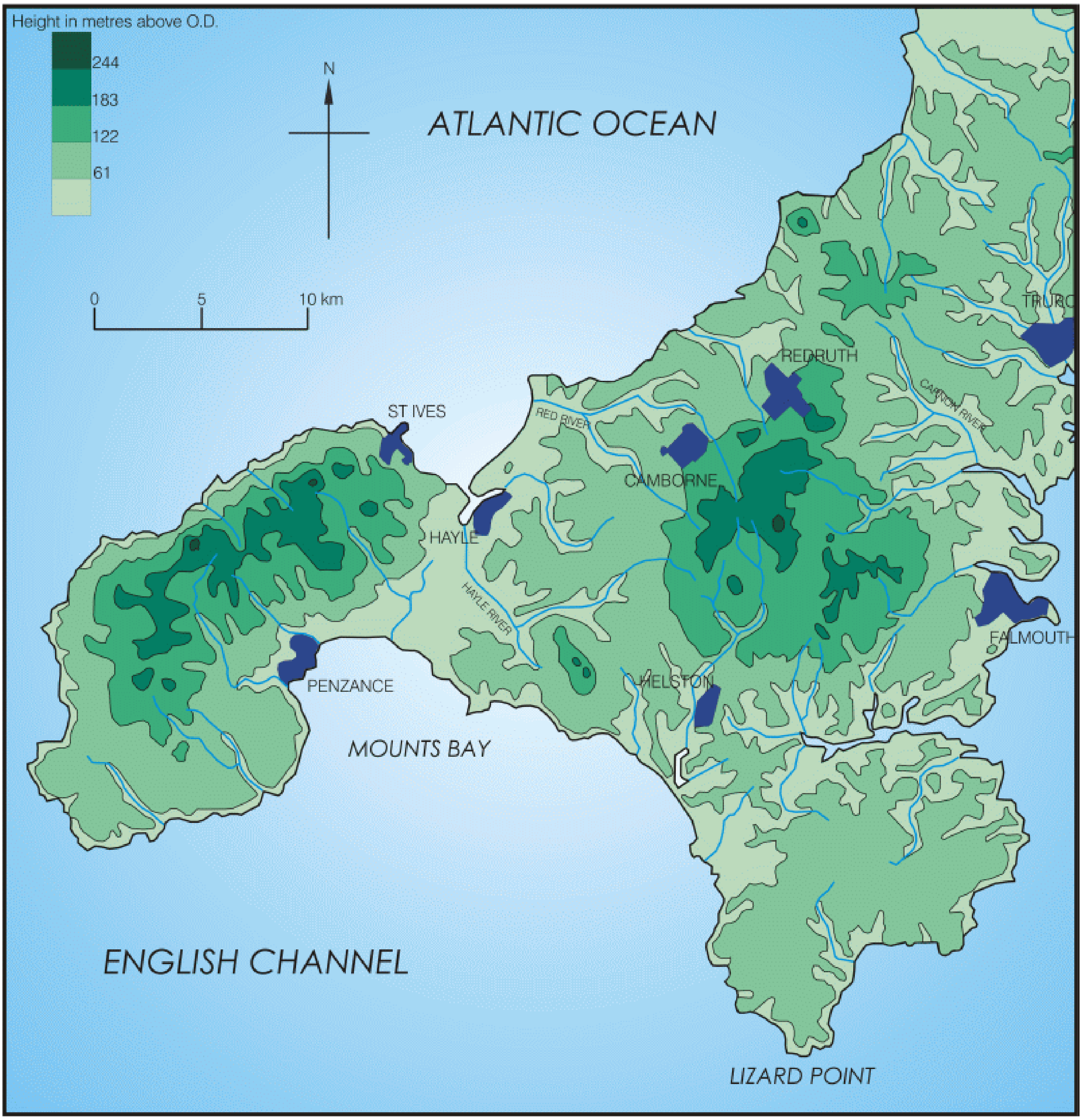

Figure.2. *The physiography of southwest Cornwall.*

Away from the moorlands the land falls away to form high cliffs along the north coast and gentle rolling lowlands along the south coast (around the Carrick Roads in the Falmouth district, cliff heights reach an average of only 10 m above sea level). Large bays (Mounts Bay and Hayle Bay) lie behind the Land's End Granite, and to the east the basins of the Truro, Tresillian and Fal rivers form a landscape of steep-sided wooded valleys and open farmland on the floodplain.

The main industries of the area are agriculture and tourism. Much of the upland areas are used for pastureland and the growing of cereal animal feed for the dairy industry, the lowlands area given over to cereal and vegetable production with seasonal flower and fruit farming. The extensive beaches, landscape and clement climate are major draws for tourists and much of the areas workforce are engaged in the tourism and support industries.

The old industries of the region, fishing and mining, are now in decline or extinct. The fishing fleet, based primarily at Newlyn, is much reduced and faces an uncertain future. The last mine, South Crofty, closed in 1998, bringing to an end some 3000 years of mining in the region. At its peak in the mid 19th century some 50,000 people were directly employed in the industry. Today many mining remains are being preserved for the future as part of Cornwall's mining heritage and as tourist attractions; Poldark Mine falls into both of these groups.

THE GEOLOGY OF POLDARK MINE: PART ONE – GEOLOGICAL HISTORY.

Poldark Mine is over 200 years old; tin streaming in the Cober Valley goes back perhaps 4000 years, but the history of the area around Poldark goes back over 400 million years to a time when Britain lay well south of the equator and Cornwall lay beneath the sea.

During the Devonian Period Britain lay roughly at the latitude of the Tropic of Capricorn (23.5° S), in the southern desert belt occupied by the Kalahari Desert in modern Namibia. Britain was part of a supercontinent called Laurasia (North America, Greenland, Northern Europe and European Russia). The hot desert landscape passed southwards into an ocean called the Rheic Ocean and the coastline ran from London, across south Wales and on into southern Ireland. Cornwall lay deep beneath the sea and was crossed by a series of marine basins in which muds and sands were deposited. These basins (called rifts, where the crust is being stretched) were also the sites of much volcanic activity. On submarine platforms around Plymouth limestones were deposited in clear shallow waters in which coral reefs formed.

On the south side of the Rheic Ocean the great landmass of Gondwanaland (Africa, Antarctica, Australia, India and South America) was advancing northwards, being pushed towards Laurasia by immense tectonic forces. Throughout the Devonian Period the Rheic Ocean was shrinking as the two continents came closer together. In Cornwall the crust was still being stretched, in fact it was stretched to the point of breaking and at one point some dense basic crust (that forms the crust beneath the oceans) was formed, that later became part of The Lizard in modern Cornwall (see Figure 3).

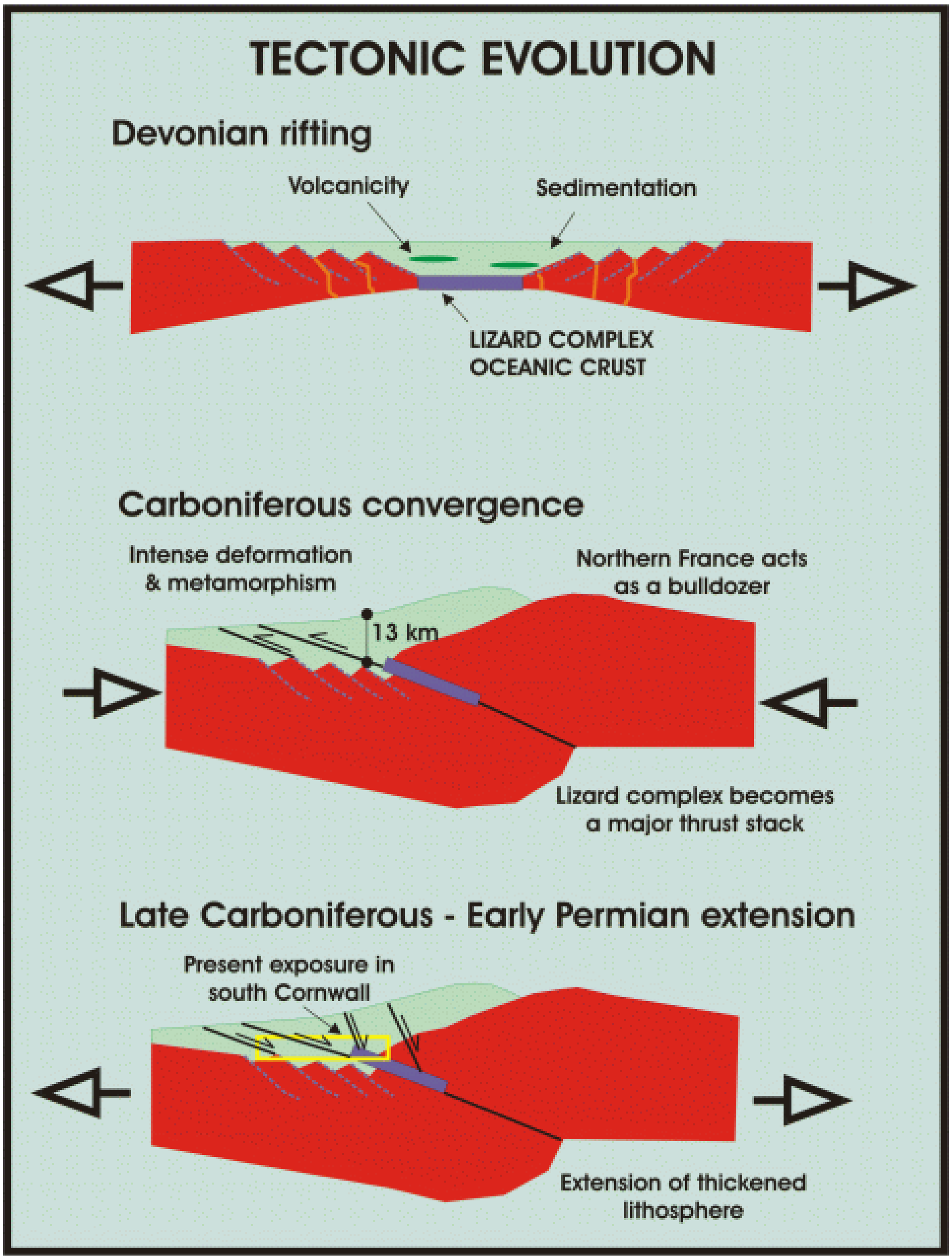

Figure 3. *The evolution of the crust across Cornwall from 400 – 280 million years ago (drawing by Simon Camm).*

Eventually the two continents collided to form the supercontinent of Pangaea, by the end of the Carboniferous Period (286 million years ago). The basins across Cornwall, full of muds, sands and volcanic rocks, were compressed and folded as the ocean closed to form an E-W trending fold mountain belt called the Variscan Orogenic Belt. The sediments were buried, folded and heated, metamorphosing the muds into slates within the heart of the mountain belt. However, once the collision was over the mountain belt began to collapse back upon itself as the crust was stretched once more. The rapid thinning of the crust (from about 40 km thick to 30 km thick) caused the upper mantle, beneath the crust, to melt a little. Molten rocks from the mantle penetrated through the crust along faults, forming rocks called lamprophyres. This, together with heat rising from the mantle, heated up the already warm crust to such a point where it began to melt as well. The molten magma from within the crust rose along near-vertical fractures to collect in the upper crust, eventually cooling to form the granites of Cornwall and Devon between 293 and 272 million years ago (see Figure 4).

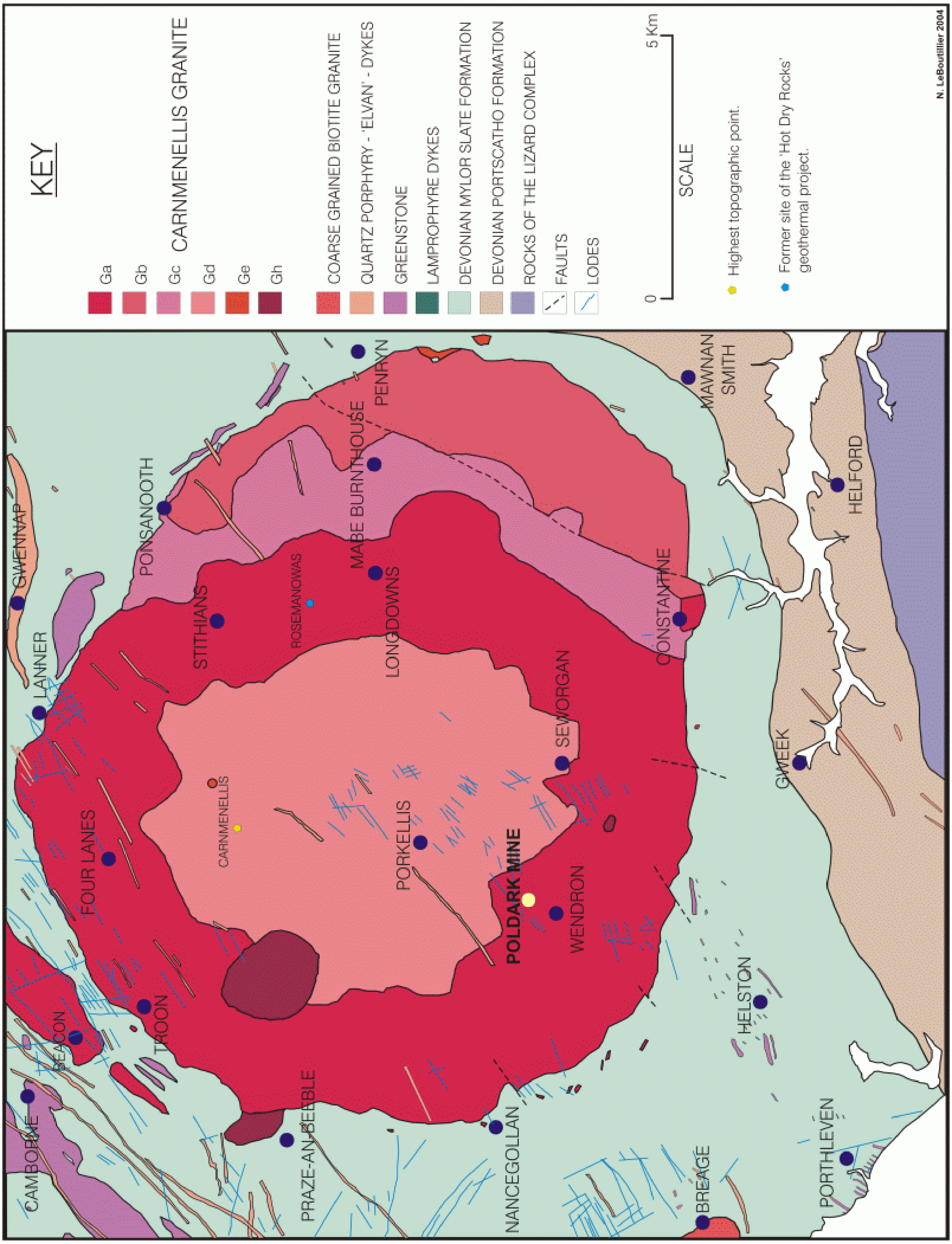

Figure 10. *A geological map of the Carnmenellis Granite. After BGS 1:50,000 sheet 352.*

As the granites began to crystallise (about 4 km below the present land surface), the elements that couldn't be accommodated within the main granitic minerals (quartz, feldspar and mica), including many important metals such as tin, copper, tungsten and zinc, became concentrated in fluids within the granite. Eventually the pressures within this 'fluid reservoir' became so great that they fractured the solid granite above. The fluids then escaped into these fractures at very high speeds, temperatures and pressures, rapidly crystallising to form the mineral veins, or lodes, for which Cornwall is famous. This cycle of mineralisation happened many times, with higher temperature tin giving way to copper, zinc and lead, and then low temperature silver and cobalt mineralisation. As the overall stresses acting on the crust changed over time, so did the orientation of the mineral lodes and these can be grouped by the direction they trend in and the minerals that they carry.

Later erosion has worn away the rocks covering the granites and has left them exposed. As the granites were worn down and the mineral lodes with them; the heavy ore of tin, cassiterite, began to collect in the gravels within the river valleys. These gravels eventually formed the deposits of tin worked by the early tin streamers across Cornwall, including the valley in which Poldark Mine now stands.

THE GEOLOGY OF POLDARK MINE: PART TWO – WHEAL ROOTS.

Poldark Mine (see Figure 5), originally known as Wheal Roots, worked between 1790 and 1810, though few details of its history are known. The mine workings succeeded tin streaming in the adjacent valley, which can be dated back to prehistoric times. The early tin streamers worked the tin-bearing gravels in the valley and would have exposed the lodes from which the tin ore came during their work, though they wouldn't have bothered to work them until the easily-won alluvial ores were exhausted (probably during the 17th Century). It appears that the lodes cut in the banks of the stream were originally worked by opencast methods (as were several other tin deposits across Carnmenellis), before underground mining began. The workings are fairly extensive and include the main adit level, a number of shafts and three stopes (the largest of which extends above and below adit level and is pumped out to allow access. Flooded workings continue below the main stope, to an unknown depth. The mine sett was taken over by the nearby Wendron Consols in the 1830's, but there is no record of any further work being undertaken at Wheal Roots, apart from the use of the stamps and dressing floors for processing tin ore. The mine provides excellent exposure of main-stage blue peach lodes, as well as earlier and later phases of mineralisation.

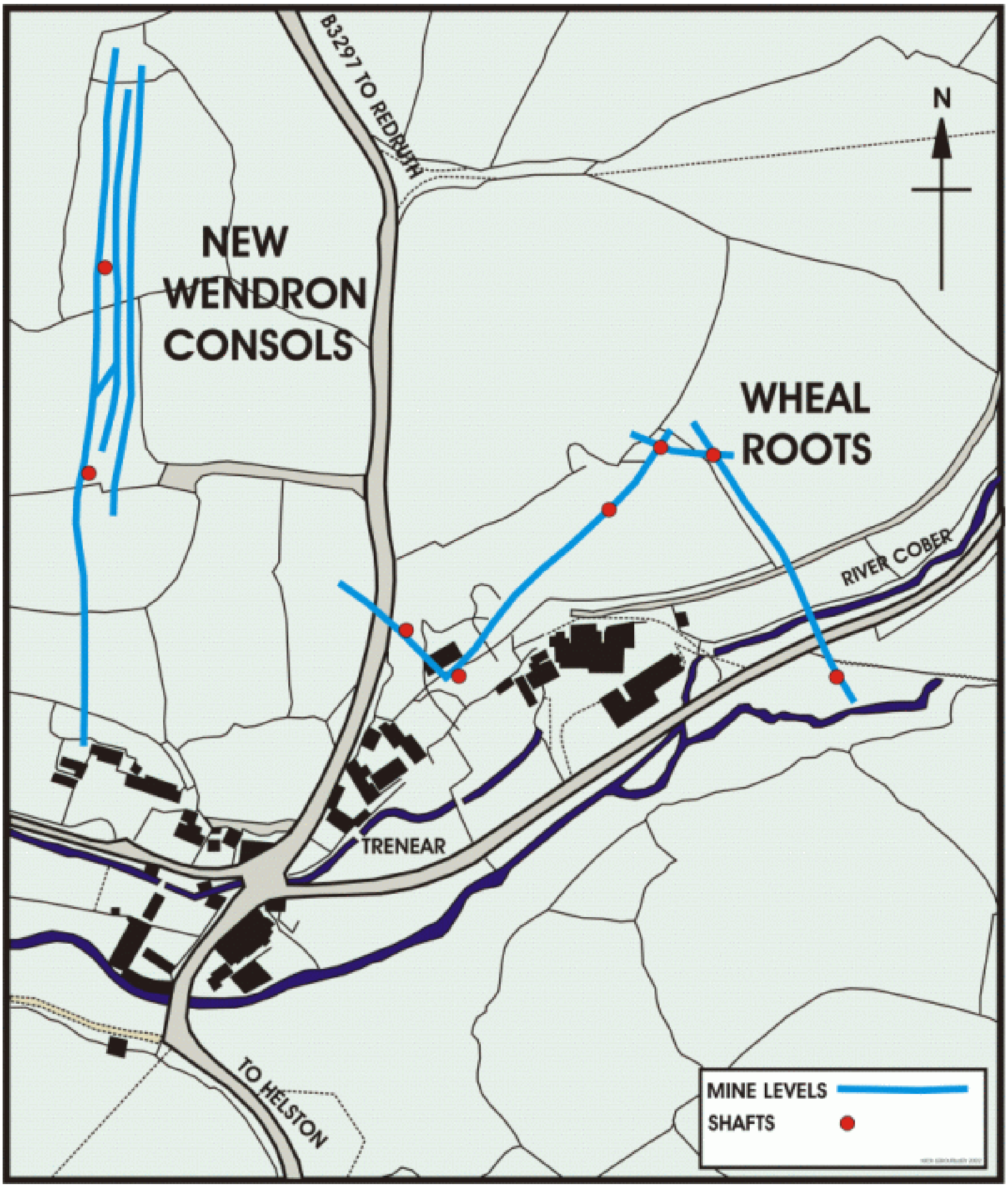

Figure 5. *A sketch map and plan of the location and workings of Wheal Roots. After Hamilton Jenkin, 1978.*

The main lode/vein trend is ENE-WSW (see Figure 6). The earliest phase of mineralisation is in the form of fine, millimetre-scale, schorl (tourmaline) veins, which occur as fracture infills and as coatings on joint planes. These veins trend around ENE-WSW (050°-080°, dipping NW) and also (primarily as joint coatings) NW-SE (120°-122°, dipping NE). The more numerous ENE-WSW set form a 'lode zone,' several metres in width, within which the main-stage blue peach lodes were emplaced.

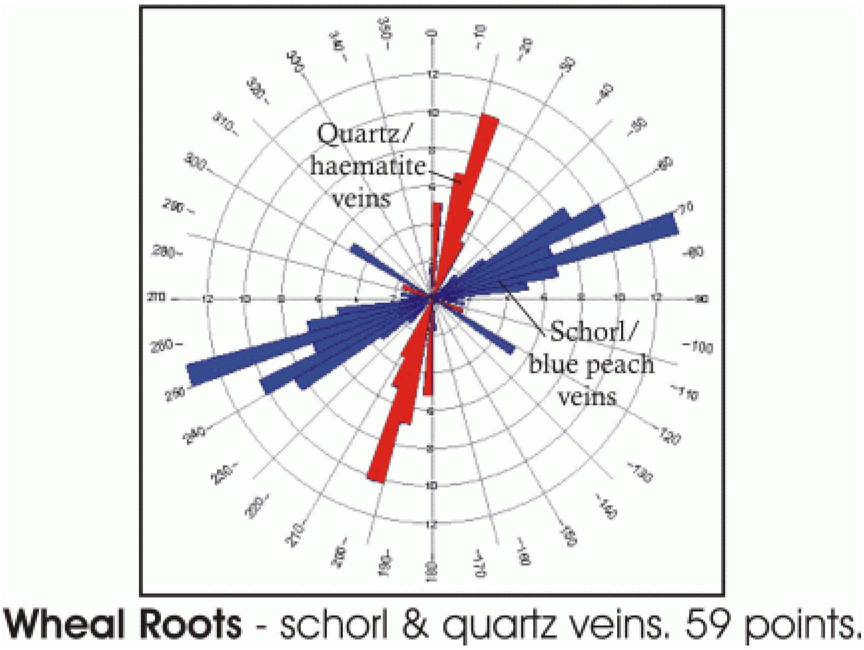

Figure 6. *A rose diagram of lode and vein orientations at Wheal Roots.*

Three worked lodes and a number of subsidiary structures (some of which were trialled) occur within the mine. The lodes have very different characteristics, although they are all tourmaline-dominated structures. The caunter lode worked in the adit (see Plate 1) trends 078°/60°/NW and reaches up to 0.90 m in width (pinching and swelling along both dip and strike). The lode is composed of blue peach, with a central quartz leader (2 cm in width); the lode margins are generally sharp, but in places diffuse and irregular; on the footwall the lode passes into granite directly, on the hangingwall tourmalinised (schorl) or kaolinised granite is apparent on the margin before this passes into unaltered granite. It would appear that the main-stage mineralisation reactivated an earlier schorl-lined fracture (with associated tourmalinisation of the wallrocks) and overprinted the earlier mineral infill (now present only as a relict structure on the hangingwall) while also replacing the granite at the lode margins. Later reactivation of the host fracture is evidenced by the late quartz (with minor haematite) leader. While being a strong structure in terms of its width and strike length, no visible cassiterite was seen in the lode. A spot sample, analysed for tin only, showed the grade to be 0.20% Sn over the whole width of the lode.

The Middle Lode and North Lode (the most extensively stoped and developed), trending parallel 060°/70°/NW, are more diffuse in nature and consist largely of replaced granite (with obvious relict textures) which has been extensively tourmalinised by both black and , later, blue tourmaline. North Lode appears to consist of swarms of irregular anastomosing blue peach veins and veinlets (up to 1 cm in width) within which stronger (to 25 cm), but discontinuous blue peach veins occur. Some of these can be seen on the walls of the stope, the most prominent being by the sump at the base of the stope. These pass laterally into thin fractures with altered (tourmalinised and sericitised) margins, the alteration extending for a few cm on each side. Little of the lode remains in the main stope, which reaches well over 1 metre in width, so it is difficult to ascertain the true character of the lode.

Plate 1. *A Blue peach lode – Adit Lode -, Wheal Roots. The lode is dipping at about 65 degrees to the north and is trending roughly E-W. The quartz leader (centre) is evidence of later, low-temperature, reactivation. Rule (25 cm) for scale.*

Middle lode is exposed within an ancient stope (see Plate 2), which appears to come close to the surface. The exposure in the old stope is curious in that the narrow lode (0.20 m) has been worked in a stope reaching well over a metre in width in places; such massive overbreaking of waste granite would have required the ore to be washed, cobbed (broken by hammer and all the granite removed from lode material) and hand-sorted prior to stamping. In addition the lode is very pale and weak (the tourmalinisation is not particularly pervasive and relict granite textures are readily visible); XRF analysis (see Table 3) showed it to be carrying only 91 ppm Sn, a fact that would not have gone unnoticed at the time, given the relative sophistication of vanning and assaying techniques practiced on the mine during the 18th Century.

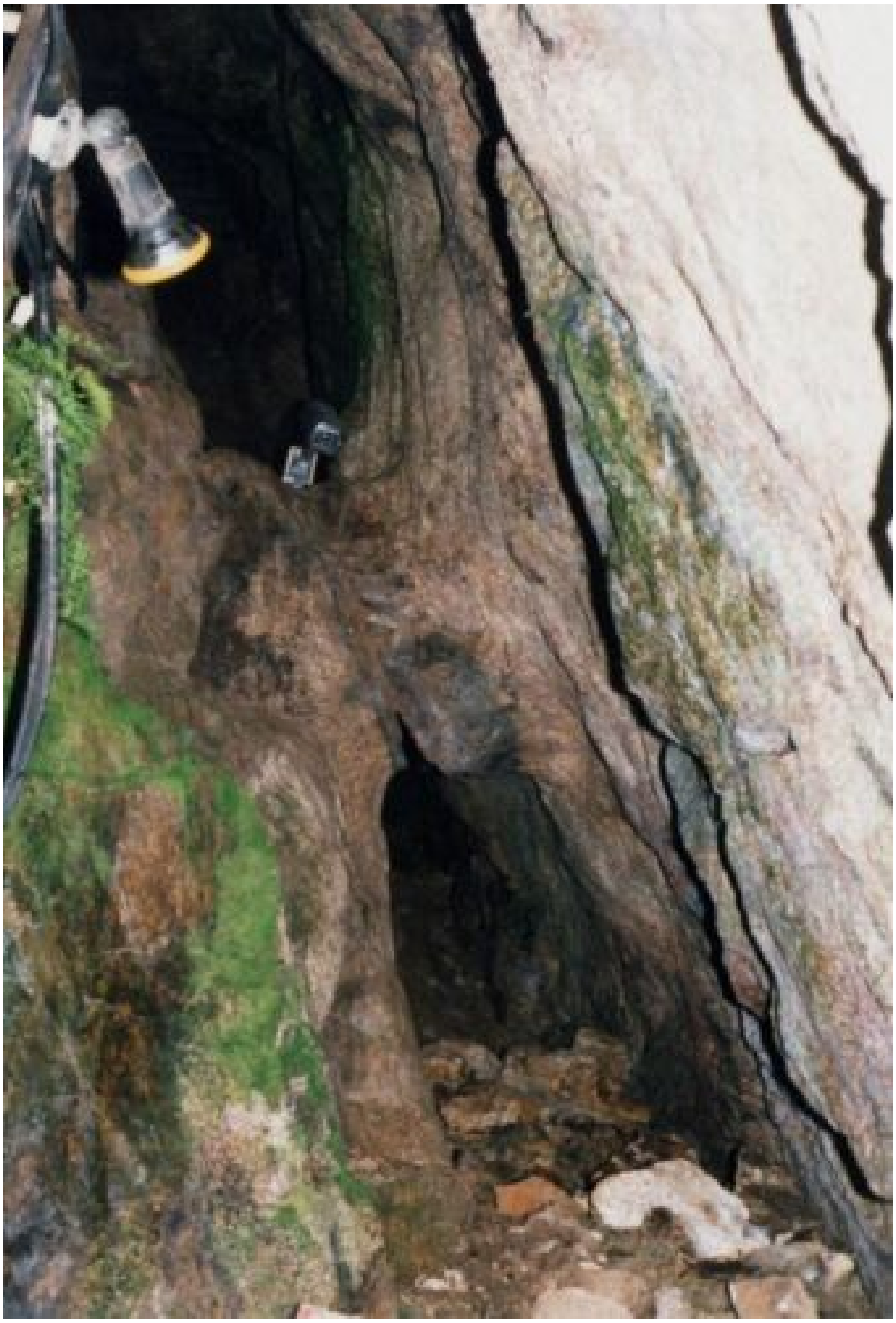

Plate 2. *Middle Lode exposed on pillars within a stope at Wheal Roots. The lode, 20 cm in width, lies along the centre line of the pillars within the stope and consists of variably tourmalinised granite around a fracture (joint) which lies close to the footwall. The contacts vary from sharp to diffuse, the lode appearing to have formed largely by replacement of the host granite.*

The lode characteristics suggest that high-temperature boron vapours (pneumatolysis) played an important part in lode formation, overshadowing true fissure-infill as the dominant formation mechanism. Such a scenario supports the assertion that this area (and central Carnmenellis in general) records only the base of the tin zone and the roots of, now eroded, lode systems; as does the presence of high-temperature specularite in the ore, forming a similar lode assemblage to that seen in central Dartmoor at the base of the tin zone there.

Some of the main-stage structures carry rare slickenlines on internal surfaces. Those trending 060°-070° are characterised by very steep (>80°) oblique slip to true dip-slip slickenlines, while those trending 076°-086° (caunter orientation) are characterised by near-horizontal slickenlines, indicating that the structures belong to two structurally independent episodes.

The lodes and earlier schorl veins are cut by a series of quartz/chalcedony veins (with occasional sinistral offsets that may reach up to 0.35 m) trending NNE-SSW (010°-030°, with the majority around 020°), around N-S and (rarely) ENE-WSW. The quartz veins (normally 1-2 cm in width, but may reach 10 cm) are associated with extensive kaolinisation of the wallrocks and localised iron (haematite) staining. Within the kaolinised areas biotite can be seen to be breaking down, in-situ, to haematite. This material has been remobilised and lines thin fractures around the quartz veins and even within the blue peach lodes and later quartz leaders. These late, low-temperature, veins mark the crosscourse phase of mineralisation at this location. The late-stage clay (argillic) alteration of the granite post-dates the quartz mineralisation, by an unspecified time span.

The main crosscut (Jewson’s Crosscut) displays a large number of these structures. The crosscut is driven along a fault (with subhorizontal slickenlines), which can be seen as a clay-lined fracture about 1 cm wide, running down the drive. In places more than one parallel fracture can be seen and it is better to think of the rock breaking along a series of lines (moving like a deck of cards) rather than a single plane. Veins crossing the fault(s) are variably displaced by distances ranging from 0.50 m to 1.60 m, suggesting that the fault has a long history of movement and has moved between the times that some of the veins in the drive were emplaced. The sense of movement is called sinistral (top sense of shear to the left) and is most likely to have moved in response to N-S shortening of the crust in this area.

XRF analysis (see Table 1) of two lode samples WR01 (blue peach/tourmalinised granite – North Lode, from within the main stope) and WR02 (tourmalinised granite – Middle Lode) show that both lodes are essentially barren (although Hamilton Jenkin (1978) records that samples of lode material taken during the 1970’s when the mine was being prepared for pubic opening, assayed at 17lb of black tin per ton – around 0.60% Sn, but even this value is below the level that most Cornish mines operated under), but this does not preclude the possibility that the lodes were sporadically rich enough in tin to warrant stoping (this can be the only logical explanation for the presence of the North Lode stope below adit level).

The analyses show low levels of tin, copper and all other metals (the majority well above background, but well below economic values), with silica being the most important component. In most respects these analyses are more typical of enriched granite rather than lode material, reflecting the low levels of economic mineralisation at the base of the tin zone.

Wheal Roots: Samples WR01 & WR02 XRF Analysis

Output Results including and taking account of LOF%.

	L.O.F.%	Fe2O3%	TiO2%	CaO%	K2O%	Al2O3%	MgO%
WR01	0.64	3.62	0.00	0.37	0.08	6.64	1.02
WR02	2.39	6.80	0.21	0.27	4.79	13.18	0.47

	Na2O%	MnO%	BaO%	S%	P2O5%	SiO2%
WR01	0.70	0.03	0.02	0.02	0.01	88.12
WR02	0.03	0.12	0.01	0.02	0.15	69.80

Traces ppm.

	Nb	Zr	Y	Sr	Rb	Th	Co
WR01	8	11	<10	42	<10	<10	10
WR02	19	85	71	125	677	<10	20

	V	La	Nd	Ce	Ga	Pb	Sn
WR01	3	7	21	53	12	6	521
WR02	12	24	22	68	31	12	91

	Cu	Zn	As	Ni
WR01	28	53	28	<10
WR02	146	108	151	7

Table 1. *The results of XRF analysis of two samples of lode material from Wheal Roots.*

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MINING TERMINOLOGY.

Cornish geology has a wealth of traditional terms, many relating to the mining industry This terminology was used up until the closure of the last working mine in 1998 and is carried forward in this description of Poldark Mine. A short glossary of the most frequently used terms is set out below:-

Killas. A group term referring to the metamorphosed sedimentary cover rocks (predominantly slates of Upper Devonian age in SW Cornwall), their associated volcanic and intrusive rocks and the later suites of lamprophyre and quartz porphyry dykes; all of which surround the granite plutons. The term was basically used to refer to anything other than granite that was encountered in mine workings; its derivation is unfortunately lost.

Greenstone. A term used to refer to the metabasic volcanic and intrusive rocks emplaced at the same time, and within, the metasediments. A reference to their dark green colouration, they were also sometimes called *irestone* (iron stone – they were major barriers to mine workings because of their hardness) or *blue elvan*.

Elvan. A term used to refer to the quartz porphyry and rhyolite dykes that intrude the metasediments and granite plutons. Closely associated, in many areas, with mineralisation, the quartz porphyry dykes were occasionally mining targets in their own right. Extensively quarried for building stone; where kaolinised (partly broken down by weathering) they also produced china clay and brick clay.

Fathom. 6 feet or 1.84 metres. The traditional unit of measurement in Cornish mines for horizontal and vertical distances. In use until the closure of South Crofty Mine in 1998.

Lode. A fissure-infill vein carrying metallic ores; usually assumed to refer to 'right running' structures that follow the general vein trend in any given district.

Caunter lode. A mineralised vein that obliquely intersects or counters (*caunters*) the 'right running' lodes (often at angles of around 30°) of any given district. Usually later than the 'right running' lodes (which they fault and displace), the caunter lodes also carry important deposits of tin and copper (etc), but tend to be dominated by lower temperature groups of minerals than the earlier lodes.

Crosscourse. A mineralised fault that cuts and displaces the lodes of any give district at (or around) right-angles to their strike (or trend). Over much of the orefield these wrench faults trend NNW-SSE to N-S. They typically carry a low-temperature infill of chalcedony and quartz and are usually barren; however, some crosscourses carry ores of lead, silver, cobalt, nickel and uranium and were locally important mining targets. Used extensively in mining for the excavation of adits and crosscuts (the infill being softer than the surrounding rock and easier to mine), the structures also lead directly to lodes along strike and were used as pathways and guides (a name used for these structures in the St Just area of Penwith) to these structures.

Fluccan. As above, but carrying an infill of clay instead of a solid infill of chalcedony. They were less used than infilled crosscourses due to problems with ground stability.

Blue peach. A term used to refer to blue tourmaline-dominated lode infill. In the deeper workings of the mines of Penwith and Camborne-Redruth (and across Carnmenellis) tourmaline is the most important gangue (or waste) phase. The microcrystalline tourmaline aggregate infill is usually Prussian blue in colour, hence the name. The ‘peach’ part of the term refers to the presence of cassiterite in the gangue (frequently as bands and clots of fine-grained aggregates) which (with a little imagination and candle light) may approach a peach colour (varying from black, to amber brown, to faintly pinkish). Over time the ‘blue and peach’ has become shortened to blue peach and is synonymous with blue tourmaline-infilled lodes whether cassiterite is present or not (*by oral tradition*; South Crofty Mine).

Green peach. As above, but substituting chlorite (deep green) for tourmaline (*by oral tradition*; South Crofty Mine).

Capel. Mineralised and altered granite on the margins of a lode, impregnated with (usually tin) ore. On some occasions almost the entire economic structure would consist of capel (the Great Flat Lode, south of Camborne is the most famous example), the alteration halo emanating from a small central fracture and spreading into the surrounding granite.

Cockle. A network breccia (rock composed of cemented angular fragments – blasted apart and then sealed back together again) of tourmaline veins and altered granite, impregnated with cassiterite, often forming irregular replacement bodies (from a few metres to many tens of metres across) within granite, called *carbonas*.

Black tin. Cassiterite concentrate, produced by the mines and their ‘finished product’; the final stage before smelting.

Drive. A horizontal excavation within a mine, either on-lode or off-lode; also referred to as a *level*.

Adit. A drive used for drainage purposes, above or at the water table. Water pumped from the deeper workings would be released into the adit system, which would have its escape portal on the banks of a stream or on the coast. Sometimes some of this water was redirected back to the surface workings of the mine to power water wheels and for milling processes.

Crosscut. An off-lode drive, often at right angles to lode strike, connecting the workings on one lode with those of another; sometimes used as an exploratory tool, driving away from (normal to) a known lode in the hope of finding other parallel structures.

Stope. An excavation formed by the removal of valuable parts of a lode. Payable ore values often occur in *shoots* or zones; by blocking out this ground by a series of *drives*, *raises* (vertical or inclined excavations) and *sublevels* (horizontal *drives* between main *levels*) the payable zones can be identified and selectively removed. Stopes vary in size according to the width of the lode, the strike length of the ore shoot and the unsupported/supported strength of the host rock; they vary from a few metres in size to great excavations that span up to 40 metres in width and 100 metres in length and height in a single span. Stopes can be worked from the bottom up (drilling into the back of the lode) as overhand stopes or from the top down (drilling into the floor) as underhand stopes.

Gunnis. A stope that breaches the surface, leaving a linear excavation that extends down into the mine workings (*pleural*, gunnies); also sometimes used to refer to old, empty, stopes after the broken ore has been removed.

Back. The roof and, occasionally, the floor. Thus the roof of a drive is the *back* of the drive and overlying roof in an overhand stope is the *back* of the stope. When lodes are found by surface excavations (such as trenches or trial pits), it is the *back* of the lodes which have been cut.

Pillar. A segment of the lode within a stope that is left behind to support the stope walls and prevent a collapse. Often used in conjunction with timber supports, this method of supporting the stope was widely used in highly jointed or weak wallrocks and became highly important in lodes with gentle dips where the large hangingwall spans required considerable support.

Zawn. A canyon-like inlet on the coast (often very narrow, with very steep or vertical sides) often formed by the erosion of lode structures by the sea. Some of these have been artificially created, or extended, by the removal of lode material during mining.