The Industrial Landscape

Introduction
The past economy of Cornwall was based on a diverse range of industries, including metal mining, fishing, china clay production, wool cloth manufacture, quarrying and ship building.

Of these the extractive industries are by far the most visible in the landscape. The transformation of the countryside made by the granite and slate quarries, china clay works and, in particular, the tin and copper mining industries are a most striking aspect of Cornwall’s archaeological heritage.

Cornwall’s rich mineral resources have been exploited on a large scale since medieval times. Large reserves of tin coupled with local innovations in mining practice meant Cornwall dominated the world market until the 1870s. Likewise by the early nineteenth century Cornwall was the pre-eminent copper producer in the world. China clay has been quarried and refined in Cornwall for around 200 years and remains a major industry. Cornish granite was exported all over the world; some of London’s bridges are made from it, and Cornish slate has been quarried and exported from the medieval period.

The landscape of the medieval tin industry represents the most extensive remains of pre-1700 mining in Britain. During this period a substantial amount of tin produced in Cornwall came from tin streaming, a technique which involved washing away lighter sands and wastes from tin-rich gravels to leave the heavier tin ores which were then collected and smelted. Streaming was carried out on a massive scale and countless valleys were turned over for tin.

The remains of medieval tin streaming at West Moor, Altarnum. The use of water for washing tin-rich gravels has gouged a deep cutting in the moorland. Unwanted waste material has been piled up to form a characteristic pattern of banks within the cutting. Photo © Cornwall County Council Historic Environment Service
In some places streamworking was not feasible and the tin ore had to be dug from dry ground. One widespread feature of the early mining industry are lode-back workings. These are lines of shallow shafts strung out along lodes and interconnected by underground tunnels. Lode-back workings represent the beginning of the move underground which led to the more familiar deep tin and copper mines based on shafts and engine houses.

An aerial view of the landscape around Polberro, St Agnes showing the effect of intensive mining for shallow deposits of tin. Photo © Cornwall County Council Historic Environment Service

The period from 1700 to the early part of the twentieth century was the hey-day of Cornish mining. Technical advances in steam pumping marked the Industrial Revolution in Cornish mining. This development in technology made deep mining possible by the end of the eighteenth century.

The steady growth in copper and tin production resulted from exploitation of deep ore deposits based on underground mining and the replacement of small scale tin-blowing by coal-fired (reverberatory) smelting. Copper mining grew from the early 1700s and between 1750 and 1850 it was the most important mineral in the region. The production of arsenic was pioneered in Cornwall during the later nineteenth century. For a time Cornwall was the largest producer of tin, copper and arsenic in the world.

The impact of the industry on the landscape was large-scale and the speed of its decline has left a well-preserved relict mining landscape. Its legacy includes thousands of mine shafts, numerous engine houses and the widespread remains of tin and arsenic processing.
The Great Flat Lode, Carn Brea. The mineral veins, or ‘lodes’, in this area are among the richest in the county. Along its length is found the finest surviving group of engine houses on a single mineral seam anywhere in the world. Photo © Cornwall County Council Historic Environment Service.

The production of china clay remains a major extractive industry in mid-Cornwall. In the early part of the nineteenth century, clay production was a localised small scale industry. Extracting the clay was very labour-intensive, output was restricted by the slow drying process, and there was no developed transport infrastructure in the St Austell area (the main centre of china clay production).

After 1820, during the copper mining boom around St Austell, new harbours were built, some connected by rail to the industrial hinterland, and the industry was transformed around 1850 with the adoption of pan kilns to dry the clay. By the turn of the twentieth century more than half a million tonnes of china clay were being produced annually in Cornwall.

Well-preserved remains of early twentieth century china clay workings at Glynn Valley, Cardinham. Photo © Cornwall County Council Historic Environment Service
Cornwall has a rich variety of high quality stone which has been widely exploited, both for local use and for export all over the world. The main rocks quarried are granite and slate, although others such as greenstone, elvan, serpentine and soapstone are also exploited. Local variations in geology are a principal contributory factor in the diversity of local architecture and the industry has left a legacy of abandoned pits and quarries all over the county.

Dean Quarry, St Keverne. A large quarry on the Lizard coast where greenstone is still quarried for use as roadstone. Photo © Cornwall County Council Historic Environment Service

Buried Wealth

Introduction
Cornwall’s rich mineral resources have been exploited on a large scale since medieval times. Large reserves of tin coupled with local innovations in mining practice meant Cornwall dominated the world market until the 1870s. Likewise by the early nineteenth century Cornwall was the pre-eminent copper producer in the world. During the last decades of the nineteenth century the production of arsenic as a by-product of tin and copper mining was pioneered in the county.

Tin was in demand for use in pewter, bronze and to make tin plate on which the canning industry was built. Copper was needed for shipbuilding, in the brewing and distilling industries and for the telegraph cables which criss-crossed the world. The English brass industry was based on Cornish tin and copper. Arsenic was used in the dyes of the Lancashire cotton industry and demand grew when it became a popular insecticide in the late nineteenth century.

China clay is used in the making of porcelain and more recently as an ingredient in paper, cosmetics, plastics, paints and pharmaceuticals and Cornish china clay
production remains a major industry. Cornish granite was exported all over the world; some of London’s bridges are made from it.

Tapping into Cornwall’s mineral wealth led to the creation of thriving and prosperous settlements throughout the county. It also created burgeoning ancillary industries such as foundries and engineering, and the development of a transport network including tramways, railways and industrial ports.

Charlestown. One of the best examples of late eighteenth and early nineteenth century industrial harbours in Britain. Photo © Cornwall County Council Historic Environment Service

**Metal & Stone**

Cornwall’s naturally occurring metal ore deposits were produced nearly 400 million years ago when molten rock formed submarine lavas and intrusions on the bed of a Devonian sea. Episodes of major earth movement caused by continents colliding subjected these rock formations to folding and faulting, and mudstones became slates. Between 300 and 270 million years ago continental collision generated enormous heat and pressure which melted the crust and formed granite, a coarse crystalline rock, deep in the earth.

Pressure forced granite masses upwards and they intruded into the rocks above them. The economically important mineral veins – known as lodes in Cornwall – were formed shortly after the intrusion of granite. The intense heat from the granite caused water to circulate in fractures in the rock, dissolving metal salts present there. As the water cooled it deposited metallic ore minerals along fissures and faults. Fifteen different metals and a great variety of minerals were produced; the most important being tin, copper and arsenic.
A similar process of water circulation affected some parts of the granite, breaking down feldspar crystals in the granite to produce kaolin or china clay. Kaolinised granite is found mainly in the Hensbarrow area to the north of St Austell. It is often weak and decayed in character.

Some rocks found on the Lizard Peninsula are even older than the granites, dating from the Cambrian era 600 million years ago. Most have been altered by subsequent pressure or heat. Among the economically important rocks on the Lizard are greenstone and serpentine. Greenstone is a term used to describe a number of igneous rocks (rocks formed molten volcanic magma) and is found in places in West Penwith and in North Cornwall as well as on the Lizard. Serpentine is a mineral produced when a volcanic rock, peridotite, became altered. It is a highly decorative stone when polished.

**Early Exploitation**
Cornish stone has been an important resource since the earliest times. Six thousand years ago during the Neolithic period axes were being made from high quality greenstone dug from Cornish quarries. These axes were exported from Cornwall and have been found as far away as East Anglia. Prehistoric stone circles and megalithic chambered tombs were built from massive granite stones found lying on the moors. Bronze Age farmers in the Cornish uplands used moorstone taken from the surface to build their homes and to divide up the land into fields.

*Map showing granite outcrops in Cornwall and the location of the principal mineral lodes (seams).*
Tin and copper reserves were certainly exploited in prehistory. The upper part of a copper vein or ‘lode’, above the water table, is subject to oxidisation. This process produces colourful copper-rich minerals, such as red oxide (cuprite) and blue and green carbonates (azurite and malachite, among others). These are very obvious, for instance as bright green staining in the cliffs around St Agnes, and would have been easily recognised.

Similarly the unusually heavy, dark-coloured pebbles from deposits of tin ore (cassiterite) would not have escaped notice. Where tin lodes were exposed, geological erosion caused cassiterite to break away and to lie on the surface as coarse, tin-rich gravel. These tin gravels were then washed downslope. They either settled a short distance downslope from the parent lode as eluvial deposits, or accumulated in the bottom of river valleys to form alluvial deposits. In both cases the deposits formed layers of varying lengths known as tin streams. These streams of tin are often several metres deep and wide.

Where lodes of tin were exposed at surface (1) tin-rich rocks were weathered and washed downslope where it lay as eluvial tin (2). Some accumulated as concentrated deposits of alluvial tin in river valleys (3).

Although any early tin mining will have become obscured by peat growth or by later workings there is a wealth of evidence pointing to the quarrying or mining of metals in Cornwall from the earliest times. The classical author and historian Diodorus Siculus, describing the inhabitants of the pre-Roman South West, wrote that

*The natives work the tin, treating the bed which bears it in an ingenious manner. The bed, being like rock, contains earthy seams, and in them the workers quarry the ore, which they melt down and cleanse of its impurities.*

Diodorus also recounts how the finished tin was taken for export to northern Europe.
The archaeological record presents a picture of extensive use of the tin resources at this time. A number of tin ingots dated to the late Iron Age and Romano-British periods have been identified in Cornwall; pebbles of stream tin and evidence of metalworking are commonly found at Romano-British settlement sites.

During the early medieval period there is evidence for export of Cornish tin to the Mediterranean and northern Europe. A wooden shovel used by tinners working in Boscarne tin stream is dated to this period. Clearly the extraction of tin was becoming a large scale enterprise: church bells, whose bronze depended on Cornish tin, were widespread by the time of the Norman Conquest.

**Streams of tin**

**Tin streaming**

By the thirteenth century the Cornish tin industry was already internationally important. The landscape of the medieval tin industry represents the most extensive remains of pre-1700 mining in Britain. During this period a substantial amount of tin produced in Cornwall came from tin streaming, and the industry provided employment and wealth far beyond that to be expected from such a remote and poor agricultural area as Cornwall. The boom years for tin streamers were the 1330s when more than a million pounds (2,200 tonnes) of tin was produced annually. Although tin streaming declined in importance after the seventeenth century it continued as an industry up to the mid 1900s.

Streamworks on Breney Common, Lanlivery. The water-filled pits visible towards the lower centre of this photo were dredged for tin as recently as the 1960s, but the alluvial tin deposits here were being worked at least 800 years ago. Photo. English Heritage (NMR) RAF Photography. RAF 540/994/F21/0081
Countless valleys were turned over for tin. Tin streaming was carried out on a massive scale, as evidenced by the vast man-made landforms on Bodmin Moor, Goss Moor, Hensbarrow, Breney Common and Redmoor, as well as in the valleys draining the mineral rich areas elsewhere across Cornwall.

The removal of millions of tonnes of overburden resulted in rivers and estuaries, such as the Fal, Fowey and Carnon, becoming heavily silted. Tidal limits were progressively pushed downriver so that former ports became marooned amidst salt marsh.

**How Tin Streaming Worked**

Deposits of alluvial tin occur where tin-rich rocks have been broken away by erosion from their parent seam or 'lode', and have accumulated in the bottom of river valleys. These accumulations are known as tin streams.

After the formation of a tin stream, layers of sand and gravel settled on top of it. Over time they in turn were covered by accumulations of peat and leaf mould. These layers of overburden are frequently several metres deep. To reach the tin stream the tinners first had to remove the overburden. This was done by hand and dumps of unwanted overburden were produced alongside or downstream of the working areas.

The technique used to extract tin from these streams is known as tin streaming. Streamworkers took advantage of the fact that cassiterite (tin ore) is denser than the associated minerals which constitute granite. By diverting a stream of water over and through the tin stream, the lighter sands and silts could be washed away in suspension leaving behind the heavier gravels containing tin-rich rocks.

*Tin streaming in Cornwall was similar to that elsewhere, particularly in the Erzgebirge region of Eastern Europe, where it is well documented by contemporary writers such as Agricola (1556). This etching of Agricola shows the removal of overburden and the washing away of unwanted gravel to separate out the heavier tin ore.*
Ramped Workings
Streamers developed a range of methods to separate the cassiterite from the waste, depending on the nature of the tin stream and the elements constituting the overburden; each method produced its own distinctive type of earthwork remains.

Where large amounts of coarse overburden covered the tin stream the heavy wastes were systematically removed by wheelbarrow. This method of dumping waste produced a characteristic pattern of overlapping rectangular mounds. In cross section each mound is shaped like a wedge of cheese, with a shallow gradient leading to a steep scarp.

Streams had to be temporarily diverted from the working areas to allow access to the tin gravels. As the whole width of a tin stream was worked numerous diversion channels were dug, sending the stream first one way, then another. As a result many streamworks have left deep cuttings gouged into the surrounding landscape.

Parallel Workings
In situations where the overburden was shallow or comprised fine material, most of it could be simply washed away saving much heavy labour.

In this type of streamworks water was brought through a channel into the working area and the overburden was washed into the river or a drain where it flowed downstream in suspension. The heavy stones and gravel left behind were piled up to

An example of extensive ramped workings at Tresibble, Restormel. A series of overlapping mounds are arranged on either side of the stream. These mounds or ramps were formed by the practice of systematically dumping wheelbarrow loads of waste as the work proceeded. The length of each dump reflects a reasonable distance over which the waste could be barrowed. Once this distance was reached a new dump was started; hence the overlapping ‘wedges’. The ground was exploited in strips in this way and the workings have scoured the landscape to a considerable depth. English Heritage (NMR) RAF Photography. RAF 540/994/F21/0088
form steep linear banks just downstream from the working area. By dumping waste on the area just worked, the streamers maintained a consistent width to their current working area. This would have been essential for maintaining a steady flow of water at the optimum velocity for the operation. Working upstream in a systematic way the streamers produced a regular pattern of parallel banks of spoil.

Streamworks at Ennisworgey, Restormel. There is a well-defined alluvial working to the south of the stream, towards the left centre of the photo. A diverted channel defines the southern limit of the workings. From this channel water would have been fed into the workings to wash away the lighter overburden into the stream. Heavier waste has been dumped in a series of slug-like mounds forming a classic parallel pattern. To the north, eluvial workings snake up the hillside fed by a series of leats. An unusual amount of detail can be seen here, including individual mounds of waste and the clearly-defined squared-off end of one of the workings. Photo RAF 543/2332/F22/0170 ©Crown copyright. MOD

Eluvial Streamworks
Eluvial tin streams are those where tin-rich rocks eroded from the parent lode are deposited in dry valleys or on hill slopes rather than washed into river valleys.

From a tin streamer’s point of view the advantages of eluvial tin streams were that there was normally much less overburden to be dug away, there was no need to dig channels to divert the river (in some cases a major undertaking), and there was no problem with drainage in contrast to some low-lying alluvial workings. The great
disadvantage was that water for washing away the waste material had to be brought to the site from available streams, often over long distances. This was done through a system of hand dug channels known as leats. Water brought via the leats was stored in purpose-made reservoirs until needed.

For these reasons it is likely that eluvial streams were worked in winter when high rainfall meant water was plentiful. Conversely alluvial streamworks were probably worked in summer when river levels were lowest, making it easier to control the flow of diverted water and facilitating drainage.

![Photo of East Moor Eluvial Streamworks](https://example.com/photograph.jpg)

_eluvial streamworks at East Moor, Altarnum. To the left of the workings three leats can be seen. These would have brought water to a purpose-built reservoir for use as required. The well preserved dam visible at the head of the workings would have controlled the supply of water from the reservoir. Photo © Cornwall County Council Historic Environment Service_

In the upper part of the streamworks at East Moor, the workings comprise a cutting but few or no spoil banks. It seems overburden was particularly shallow or fine so it could simply all be washed away with no recourse to digging. Workings of this type are not uncommon but eluvial streamworks were most often operated using the parallel workings technique.

The working of eluvial tin streams called for skill in maintaining optimum water velocity given the steep or varying gradients of the hill slopes where they occur. In the lower part of the East Moor workings the waste has been dumped in banks running parallel to the cutting. This method of working was adopted on gentle slopes
where the flow of water was at optimum velocity for washing away the overburden; work would proceed out from the centre into the hillslope.

If this type of working were attempted on a steep slope, the force of water would wash away the cassiterite with the overburden. In those situations the water supply was brought in parallel to the contours to reduce its velocity and the force of water was further controlled by arranging the waste dumps parallel to the contour.

*Eluvial streamworks at Numphra, West Penwith. The curving form of the banks in this streamworks was designed to create optimum velocity of water for washing away overburden and waste. If the banks were parallel with the cutting the force of water would have been too great, if they were at right angles the force too weak to wash away the overburden. The curve provided a lower water velocity in the initial part of the operation, allowing the cassiterite to be recovered, and allowed the waste to be flushed away into the drainage channel following the gradient. Photo ©Blom Aerofilms*

**Lode & Shode**

Before 1700 the tin industry in Cornwall was of international importance whilst copper was of little commercial interest. A substantial amount of the tin produced in this period came from tin streaming. In some places however, streamworking was not feasible and the tin ore had to be dug from dry ground.

In some cliff-side locations veins of tin (known as tin lodes) were exposed and these were quarried out, leaving tell-tale linear cuttings in the cliff face. It is likely that these cuttings, or ‘open-works’ are amongst the earliest attempts at tin mining in the county.
Open-works were also used to quarry tin from inland lodes. But a much more widespread feature of the early mining industry are lode-back pits. These are lines of shallow shafts strung out along lodes. They are interconnected by underground tunnels and alongside some are the remains of platforms for the machinery used for lifting spoil and ore out of the pits.

Lode-back pits and open-works represent the beginning of the move underground which led to the more familiar deep tin and copper mines based on shafts and engine houses.

Mount Hermon, St Just. Slot-like cuttings in the cliff face where tin ore has been extracted. Although the date of these workings is unknown they are potentially the earliest excavations of tin in the county. Photo © Cornwall County Council Historic Environment Service

Shode Workings
A substantial amount of the tin produced before 1700 came from tin streaming. Some works exploited material known as ‘shode’; tin-rich stones lying on the ground surface after being eroded from an exposed outcrop. Streamworking techniques involved washing the shode to remove unwanted material and retain the tin ore (cassiterite). The process required large quantities of water to be brought to site and could only be carried out on sloping ground.

At some locations deposits of shode were located on hill tops or on level plateaux, where streamworking was not practical. Here the areas of shode were dug over by pick and shovel, leaving a pock-marked landscape made up of hundreds of small pits and spoil dumps. The hillocks left by the tinners were known as shambles. Material excavated from the shode pits was taken downhill to a water source for cleaning and processing.

At some sites the shode pits are clearly following the lines of lodes, but at others there is no obvious pattern to the workings. This suggests either that a spread of
material in the ground adjacent to the lode has been worked or that the shode ground has been dug over again and again.

Shode works at Belowda Beacon, Roche. Shode pits in the foreground and in the distance appear to be randomly dug; those in the main area of the photo are following the line of lodes. The larger pits and the linear trench in the foreground are later lode-back workings and shafts. Photo © Cornwall County Council Historic Environment Service

Open-Works
The tinners gradually turned their attention away from the increasingly exhausted alluvial tin streams and surface deposits of shode and towards the lodes themselves. Open-works are one type of early lode working site, sometimes called ‘beams’ or ‘coffens’. They represent opencast quarrying of the lode, which produced narrow elongated cuttings.

Many open-works were cut into hillsides so the ore could easily be removed as the work proceeded, through the area already mined. Open-works which were sunk vertically down into a lode formed large pits with sheer sides, presenting the problem of how to lift the ore out of the working. The solution was to cut the trench in stages, producing a stepped profile. Each step was roughly six feet below the next – as high as a man could throw up the tin ore with a shovel.

In some open-works the ore was heavily weathered and could be excavated with just pick and shovel. Where the rock was harder, hammers and wedges were used to break it up. Reservoirs found at some open-works suggest that the technique of fire setting may have been used to fracture the rock by heating it with a fire which was then doused with water from the reservoir.
Historic documents show that open-works were mainly in use between 1500 and 1700 but it is likely that the first open-works are earlier, when the documents are less clear about the specific type of operations carried out at tin works. It is also more than likely that cliff face sites such as Mount Hermon were being quarried at a very early date.

The largest open-work in Cornwall is at Mulberry Hill. Here there were several parallel, closely-set lodes of tin and so the ground was taken out in bulk. This pit was still being worked in the nineteenth century but initial excavations at the site may have been much earlier. The tin ore at Mulberry pit was sufficiently weathered to allow its removal by pick. Records show that five to six tons of ore was the average weight of ore mined per person in one day. Photo © Cornwall County Council Historic Environment Service

**Lode-Back Workings**

The earliest underground mines in Cornwall were worked by pits or shallow shafts, often interconnected by tunnels and galleries underground, and usually dug in lines following the mineral veins or lodes. Lode-back pits or shafts, as they are known, were in use by the thirteenth or fourteenth centuries.

Lode-back workings removed tin ore that lay above the water table and the pits are usually several metres deep. The principal involved – sinking shafts into the tin ground and mining the ore by the use of galleries along the lodes - was the same as later shaft mining. Mining to a greater depth presented problems with drainage. The move from lode-back working to shaft mining began when the easy pickings near the surface became exhausted and technological advances made deep working feasible.

Unlike later deep mining, where very few shafts were used to extract the lode, shallow working required numerous pits. This is because the underground excavations were very narrow and it was easier to sink more shafts than to haul waste long distances back to the original shaft to take it to the surface.
Although later deep mining often destroyed all trace of earlier lode-back working, at mines where the lodes were not sufficiently rich to warrant deep working lode-back pits have survived and are a familiar feature at many mining sites.

Craddock Moor, Minions. Three lines of lode-back workings follow the mineral veins across the moor. Each pit is surrounded by a mound of spoil. The pits are typically five metres deep and are connected underground by tunnels and galleries. Photo © Cornwall County Council Historic Environment Service

Removing & Processing the Ore

A variety of machines were used to raise the mined ore from the pits. The simplest was the windlass, capable of raising material from relatively short distances below. The windlass was widely used in the early tin mining industry but was inefficient in that it needed two people to operate it. Developments to the windlass involving the addition of wheels and cogs allowed material to be brought up from a greater depth with less effort.

Horse power was also used. Harnessed horses turned vertical axles by pushing against one or more protruding cross beams. These rotated overhead barrels which carried ropes which in turn raised and lowered buckets in which the ore was drawn out of the workings. These machines are known as horse whims. The circular whim platforms of these horse engines survive in large numbers at early mining sites.
A windlass shown in operation in Eastern Europe from a 1556 engraving by Agricola

Unlike the relatively pure tin ore obtained by tin streaming, lode ores required crushing and dressing. This was done in stamping mills, roughly 150 of which are known in Cornwall before 1700. The ore-bearing stones were crushed by heavy iron-headed timber beams (stamps) turned by waterwheels. The ore was reduced to a fine sand to which water was added. The resulting slime flowed through a channel to the nearby dressing floors. Here the lighter wastes were washed away in a series of wooden troughs known as buddles, allowing the heavier tin ore to settle out. This often needed to be repeated several times to concentrate the ore.

A 1556 engraving by Agricola showing water-powered tin stamping machinery of a type similar to that used in Cornwall at this time.
The processed ore was then sent to the smelter as ‘black tin’. Smelting was carried out in blowing houses, few of which now survive in Cornwall. The ore was smelted by mixing it with peat or wood charcoal and reducing it in a furnace fed with air by means of a waterwheel bellows. Finally the ingots were taken to the Stannary towns where the tin was tested for purity before being taxed.

**Age of Invention**

The period from 1700 to the early part of the twentieth century was the hey-day of Cornish mining. Technical advances in steam pumping marked the Industrial Revolution in Cornish mining. This development in technology made deep mining possible by the end of the eighteenth century.

The steady growth in copper and tin production resulted from exploitation of deep ore deposits based on underground mining and the replacement of small scale tin-blowing by coal-fired (reverberatory) smelting. Copper mining grew from the early 1700s and between 1750 and 1850 it was the most important mineral in the region. The production of arsenic was pioneered in Cornwall during the later nineteenth century. For a time Cornwall was the largest producer of tin, copper and arsenic in the world.

The impact of the industry on the landscape was large-scale and the speed of its decline has left a well-preserved relict mining landscape. Its legacy includes thousands of mine shafts, numerous engine houses and the widespread remains of tin and arsenic processing.

*A view of the area around the Camborne and Redruth area in the Central Mining District around 1893. These are among some of the most productive mines in the world at that time. As far as the eye can see the land is given over to metal mining.*

*Photo reproduced by kind permission, The Cornwall Centre Collection*
Water Power
The earliest underground mining took the form of lode back workings. The problem of drainage limited the depth of this type of mining because each working had to be individually drained.

During the sixteenth and seventeenth centuries tin deposits near the surface were becoming exhausted and the increasing demand for tin led to the development of deeper underground mining. This was made possible by the digging or ‘driving’ of adits into the workings. Adits are slightly sloping tunnels driven from low-lying ground, usually a valley bottom or the base of a cliff. These tunnels often provided drainage to a considerable depth; sea level adits at St Agnes, for instance, allowed 100 metres depth of tin lodes to be drained.

The first deep mines were organised around adits and shafts served by horse engines and waterwheels, and are known as ‘shaft and adit’ mines; a few survive at sites where more developed mining proved unprofitable.

Adits not only lowered the natural water table thereby enabling deeper mining but also created a new level to which water could be pumped up from below. The depth at which this could be done was limited by the power and design of pumps in use at the time. Until the middle of the eighteenth century pump engines were operated manually or were horse- or waterwheel-powered.

Water wheels were used extensively for a variety of functions in Cornish mines before the invention of steam-powered engines. The wheels shown here in Agricola’s engraving of 1556 are working in tandem to lift water from a lower level of the workings to the surface.
It took more men to operate manual pumps than to carry out the actual mining; horse power was more efficient but waterwheels provided the most effectual and powerful engines. Waterwheels also provided power for winding machinery, stamping mills and other appliances. There were hundreds throughout Cornwall’s industrial landscape, fed by man-made channels known as leats. Leats, which took water off streams or from purpose-dug reservoirs, were sometimes many kilometres long.

![Image](photo.jpg)

Kenidjack valley near St Just in West Penwith contains a remarkable concentration of mining remains. The course of the Kenidjack stream has been repeatedly diverted and numerous leats skirt the hillsides to the south. The Kenidjack River once powered fifty waterwheels, including the ‘Great Wheel’ at Boswedden Mine – the second largest waterwheel in Britain. Photo © Cornwall County Council Historic Environment Service

**Steam Power**

The period from 1700 to the early part of the twentieth century is the most significant era of Cornish mining. The introduction of gunpowder greatly facilitated underground rock-breaking and enabled adits to be driven far more quickly than before. But the most important innovation was the adoption of steam power.

Steam power transformed Cornish mining into an industry capable of reliable large-scale production. Cornwall developed from being an area with a growing mining industry into a region with one of the earliest fully industrialised economies in Britain.
This development was set in motion by the invention in 1712 of the Newcomen Atmospheric Beam Engine. The increase in pumping power and improved drainage provided by this early coal-fired steam engine enabled mines to be sunk to twice the depth previously possible. However Newcomen engines worked extremely inefficiently and were expensive to install and to fuel.

A major breakthrough in engine design came in 1769 with the invention of the Boulton & Watt Separate Condenser Engine. These engines were far more powerful than the Newcomen engine, their fuel consumption was much lower and by 1800 mines were able to attain depths of around 300 metres below adit.

Levant Mine, St Just. Levant was one of the most productive mines in Cornwall and remained in operation until the 1930s. The workings extend one and half kilometres from the shore at a depth of 600 metres beneath the seabed. Extensive remains of mine buildings and ore processing plants survive. Photo © Cornwall County Council Historic Environment Service.

The era of the Boulton & Watt engines ended in 1800 with the invention by Richard Trevithick of the Cornish Beam Engine and boiler, the most efficient equipment of its kind anywhere in the world. Trevithick’s new engine used high pressure steam and was much more powerful and economic than Boulton & Watt’s. The Cornish engines were quickly adopted by the industry and by the 1870s mine depths of almost 600 metres below adit were being achieved.

These large steam engines needed purpose-made buildings to contain them and the basic design of the Cornish engine house was established by the early 1800s.
Associated structures include boiler houses, chimney stacks, and ponds which stored water for the engine condensers and boilers. Nearly 3,000 engine houses were built in the county and those that survive have become a distinctive and evocative feature of the Cornish landscape.

Wheal Coates, St Agnes. A complex of tin and copper mining and arsenic production remains, with extensive tin dressing floors. The engine houses in this photo served different functions; pumping, winding, and stamping. The remains of this famous tin and copper mine are owned by the National Trust which has consolidated all the buildings. Photo © Cornwall County Council Historic Environment Service

Deep Mining
Tin and copper mines were arranged around shafts. These served a variety of functions. Some provided access to the workface; some were simple draught openings cut upwards from underground levels to provide ventilation; some were for pumping water out of the mine; others were for winding ore, spoil and materials up from below.

Extensive mining remains at Greenburrow in West Penwith. The complex of features at Greenburrow mine illustrate the development from shallow extraction manifested
by lode-back pits to deep mining with collared shafts and engine house. Photo © Cornwall County Council Historic Environment Service

Pumping and winding shafts normally had built collars and an adjacent engine house to provide power. Winding shafts had tall headgear carrying large wheels over which the winding ropes ran. Winding was powered by rotative engines – beam engines in which the motion of the beam was converted to rotary motion via a sweep rod, crank and flywheel.

The development of deep mining threw up practical problems for which solutions had to be found. The industry was constantly experimenting, innovating and evolving. More efficient ways were found to use gunpowder, in particular high explosives, in mines; their use was made far safer by the invention by William Bickford in 1830 of the safety fuse.

Towards the end of the nineteenth century compressed air rock drills were introduced and replaced the steam rock-boring engine invented by Richard Trevithick. There were numerous other improvements to the working infrastructure of the mines during this period, such as the adoption of wire rope for haulage.

Hedged shafts and the foundations of mine buildings at Wheal Busy, Chacewater. Photo © Cornwall County Council Historic Environment Service

Processing the Ore
Tin ore was crushed and concentrated at the mine site. From the early nineteenth century this became an increasingly mechanical process requiring large areas of land with a sloping gradient and a water supply. Ore dressing sites are typically arranged in a ‘stepped’ layout.
Women and boys broke up ore-bearing rocks using large hammers. The broken rock was taken downhill to sheds in which it was crushed to a fine sand by stamps. These were heavy beams with forged iron heads which were lifted and dropped onto the ore. Stamps were powered by rotative steam engines up to the end of the nineteenth century.

West Basset mine. The complex of buildings at the rear of this view includes the engine house which powered the New Stamps and, in front of it, dressing floors in which the remains of circular buddles are clearly visible. Photo © Cornwall County Council Historic Environment Service

Water was added to the crushed rock as it was stamped to form a solution from which the tin quickly fell out. Agitating the solution facilitated this separation and from the middle of the nineteenth century this process was carried out using mechanical buddles. These were circular pits with rotating brushes. Material would normally be re-processed to maximise ore concentration. The concentrated ore was then roasted to burn off unwanted impurities such as arsenic and sulphur. Roasting was carried out in furnaces or ‘calciners’.

Processing copper differed from tin as the ore is easily lost in water separation. Ore-rich rocks were broken by hand, although mechanised copper crushers (known as the ‘Cornish Roll’) were introduced at the beginning of the nineteenth century. The crushed ore was then ‘jigged’ – agitated in water - and lighter wastes were skimmed off.
Smelting

Tin smelting was carried out in the county. At the beginning of the eighteenth century radical increases in the efficiency and output of the smelters were effected by the introduction of the reverberatory furnace. This was a type of kiln in which indirect contact between the heat source and the ore was achieved by means of a network of flues. The reverberatory furnace differed from the old blowing houses in which the ore was mixed with charcoal before firing. The new system reduced the ore by the application of heat alone, so avoiding contaminating the tin, and the heat was provided by coal instead of charcoal.

Tin smelters were at first concentrated close to the Stannary towns and navigable rivers and ports. Once rail transport had developed Penzance, Redruth and Hayle became important centres for smelting.

The smelting of copper is technically complex and requires large amounts of coal to fuel the reduction process. Some smelting was carried out in Cornwall until 1829, after which it was more economical to ship the ore to the coal fields of South Wales. Swansea became the world centre for the trade in copper, and much of it was controlled by Cornish industrialists. The transport of millions of tons of copper ore required an extensive transport infrastructure. Tramways, railways, quays and industrial harbours were all built to provide the means of transporting ore to Wales and for bringing back Welsh coal to fire Cornwall’s steam engines.

Portreath Harbour. This mining port dates from 1760 and was used for the export of copper ore to the Swansea area. The port was linked to the inland mines by a tramway and, from 1838, by the Hayle railway. The famous Portreath Incline, forming part of this railway, can be seen towards the centre top of this photo. Photo © Cornwall County Council Historic Environment Service
The Minerals
Cornish mining was based on three main minerals; copper, tin and arsenic.

The first significant copper mines in Cornwall were developed in the early 1700s. Major developments in steam pumping technology towards the end of the eighteenth century and improvements to the Cornish beam engine from the 1820s allowed deeper mining and increased output. By the early nineteenth century Cornwall was the pre-eminent copper producer in the world.

The exploitation of Welsh copper reserves at the end of the nineteenth century almost caused a collapse of the Cornish copper industry. The response – the development of efficient steam pumping engines – allowed Cornwall to become predominant again. By 1860 tin was replacing copper as the county’s most important mineral and the 1866 crash in the copper market spelt the end of the great days of Cornish copper mining. After this disaster Cornwall could not compete with the mines of Chile, Australia and North America.

Part of South Caradon mine, one of the largest Cornish copper producers. Photo © Cornwall County Council Historic Environment Service

The world market was dominated by Cornish tin until the 1870s. The ability to increase production when the market demanded was dependant on technology. The peak production period was the 1870s, after which large outputs from Australia and Malaya drove down tin prices.

The demand for arsenic arose in the nineteenth century for use in dyes in the cotton industry, in wallpaper manufacture, in the manufacture of sheep dip, and, from the 1870s, as an insecticide to control the Colorado beetle. Arsenic production was a by-product of tin and copper mining pioneered in Cornwall and during the late nineteenth century Cornwall was the world leader in arsenic production providing a quarter of the world’s supply.
Tin produced in Cornish mines frequently contained arsenic and sulphur. These elements were detrimental to smelted tin and therefore had to be removed by roasting; this was done in burning houses or calciners. The fumes released in the calciner entered a series of chambers on whose walls they condensed. The chambers were interconnected and the arsenic fumes were forced to follow a zigzag path through them. Once the arsenic had condensed as a crust on the chamber walls it was then removed by hand. These structures are known as labyrinths.

![Botallack arsenic works, showing the remains of early twentieth century arsenic production. Photo © Cornwall County Council Historic Environment Service](image)

The international importance of the Cornish mining industry, in terms of both its historical and cultural significance, has recently been recognised by the designation of the mining landscape as a World Heritage Site.

**White Gold**

**Introduction**

China clay (kaolin) is a form of decomposed granite used in the making of porcelain and, more recently, as an ingredient in paper, plastic, cosmetics and pharmaceuticals. The production of china clay remains a major extractive industry in mid-Cornwall.

In the early part of the nineteenth century, clay production was a localised small scale industry. Extracting the clay was very labour-intensive, output was restricted by the slow drying process in use at the time, and there was no developed transport infrastructure in the St Austell area (the main centre of china clay production).

After 1820, during the copper mining boom around St Austell, new harbours were built, some connected by rail to the industrial hinterland, and the industry was transformed around 1850 with the adoption of pan kilns to dry the clay. Between 1840 and 1860, production increased five-fold. By the turn of the twentieth century more than half a million tons of china clay were being produced annually in Cornwall.
The importance of china clay extraction is recent in historic terms, being little more than 200 years old, but it has created its own unique and fascinating industrial landscape.

**Stream & Strake**
China clay or kaolin is a fine white clay found in deposits of granite in which feldspar crystals have been altered by geological processes. In Cornwall it is found mainly on the Hensbarrow Moors north of St Austell but also on Bodmin Moor, in West Penwith and on Tregonning Hill near Helston. The potential for the use of china clay in the manufacture of porcelain was first recognised by William Cookworthy at Tregonning Hill near Breage around 1746 and soon afterwards the first pits were opened.

These first pits were shallow in order to avoid the costs of pumping, and production methods were primitive. After removal of the surface soil or overburden a supply of water was brought to the site; this was done by digging channels known as leats across the moors to divert water from streams. The water was then directed over the exposed clay ground to take off the clay in suspension, leaving behind the unwanted rocks in a gully or ‘strake’. This was carried out by men stood in the stream, breaking up the ground with ‘dubbers’ (specialised pick axes). The clay then flowed downhill to the processing area.

The waste material left behind in the strake had to be removed. In the early days of the industry this was done by hand but the disposal of waste was later mechanised, with power provided by waterwheel, horse whim (capstans powered by horses walking around a circular platform) or steam engine, the wastes being hauled up a railed incline and then trammed out along flat-topped finger dumps. These dumps are a characteristic feature of early china clay workings but few survive today.
In these early, shallow pits the liquid clay flowed out of the lower end of the pit. Processing took place downhill from the pit where the clay slurry flowed through three stepped tanks to separate the kaolin from the other components of granite. In the first tank sand was deposited, in the second a mixture of fine sand and mica, in the third tank mica alone was deposited.

The clay was then allowed to flow into rectangular or circular stone-lined settling pits. In these the clay settled to the bottom and the top water was drained off through wooden pipes. The clay slurry was then run off through a sluice in the base of the tank into shallow pans where it slowly dried in the open air. When it was dry enough to be cut into blocks it was stacked in open-sided sheds known as air drys.

**Pan kilns**

Up until about 1850 all china clay extracted in Cornwall was dried in air drys. Given the damp Cornish weather this was an inevitably slow process and required much heavy labour. In winter, preparation of the finished clay could take as long as eight months and only two ‘ savings’ were produced annually.

During these early years there was only one adequate harbour from which to ship the finished clay to the Staffordshire potteries. This was at Charlestown, built by Charles Rashleigh as a mineral port during the 1790s. New ports were built at Pentewan and Par to serve the rapidly expanding copper industry, and in 1842 a horse tramway was built from Par harbour to Bugle in the heart of the clay country. The improvement of the transport systems had the effect of lowering the price of china clay which in turn increased demand for the product. Cornish producers struggled to meet this demand.
At a stroke the major obstacle to increased production was removed in 1845 with the building of the first pan-kilns for the drying of clay. These were based on the slip kilns of Staffordshire. A furnace at one end of the building was connected to a chimney at the other by a series of brick flues running beneath a floor of porous tiles. The creamy clay was run from settling tanks onto the floor of the kiln. Moisture in the clay was drawn out through the floor tiles and through the chimney in a white plume. During the 1860s and 70s pan kilns developed into a standard form to become a familiar part of the landscape of the clay country.

A ruined pan kiln at Leswidden near St Just. Photo © Cornwall County Council Historic Environment Service.

**Sky Tips & Mica Drags**
The years of increasing china clay production in the second half of the nineteenth century saw a number of changes and improvements in the industry. The old methods were uneconomical with the land; the extensive finger dumps of waste material, for example, were lying on top of good clay ground. Sky tips were a new form of waste dumping. Waste was hauled out of the pits up steep railed inclines and dumped off the top of the incline which gradually extended upwards as the tip grew. The resulting pyramidal dumps, the ‘Cornish Alps’, were a distinctive feature of the clay country. After the Aberfan disaster of 1969 most of the sky tips were levelled.

The china clay landscape at this time was characterised by numerous shallow pits controlled by individual companies, each with tightly defined land boundaries within which they could legally extract and process the clay. These constraints meant that many existing pits could not be extended outwards and had to be sunk deeper. This necessitated pumping the liquid clay to the surface rather than letting it flow out of the pit. This was done by sinking a shaft by the edge of the pit, digging a tunnel or ‘adit’ to a point below the centre of the pit, and then digging another tunnel or ‘rise’ upwards to the base of the pit. The liquid clay was fed into the rise, flowed along the adit and was then pumped up the shaft from where it ran to the processing area.
The landscape at Hensbarrow Downs in 1949. In the centre left of the photo is a disused and water-filled china clay pit fringed by a series of finger dumps and a processing area with circular settling tanks. In the top left of the photo a sky tip, taking waste from a pit out of the photo, is spilling into the disused pit. Photo RAF 543/2332/F21/0207 ©Crown copyright. MOD

Waterwheels were used initially to pump the clay up the shaft but later Cornish beam engines, widely used in the tin and copper mines, were adopted by the china clay industry and engine houses became a common sight in the clay district.

The introduction of mica drags made the process of separating the clay from the unwanted sand and mica far more efficient. Drags consisted of rectangular stone tanks with a very shallow gradient and divided into a series of long narrow channels separated by boards (in later years by concrete dividers). Instead of letting the clay slurry flow into three stepped tanks, it was now directed into the drag. Because of the gradient the flow of liquid clay was slowed allowing the heavy sand and mica to be progressively deposited in the bottom of the channels.
Modernisation
At the turn of the twentieth century the landscape of the St Austell area had become transformed by numerous pits, conical dumps, settling tanks, engine houses and pan kilns. Further changes allowed the industry to keep pace with the international demand for china clay.

High powered hoses replaced ‘stream and strake’ to wash the clay from the ground. Electrical pumps were introduced and in time they replaced the beam engines for pumping the clay slurry out of the pits. The high price of coal spelt the end of the pan kiln; these were replaced oil-fired driers. Pits expanded and merged to become deep and extensive excavations, and waste material is now dumped by lorry onto flat-topped ‘benches’ which are seeded with grass.

These huge twentieth century workings have damaged or completely destroyed most of the earlier pits, dumps and processing areas. Here and there are remains of the earlier industry, but the most extensive remains of the china clay workings are to be found in the areas where the industry was less successful, on Bodmin Moor and in West Penwith.
Treviscoe works, near Summercourt. Nanpean and St Dennis villages in the background. Photo © Cornwall County Council Historic Environment Service.

Dark Satanic Hills

Stone is fundamental to our way of life. Think of how many millions of tons of stone make up our everyday environment: the pavements we walk on, the buildings we live and work in, the roads we drive along, in hedges and in walls. All this stone has been quarried, shaped and moved over the last few hundred years.

Cornwall has a rich variety of high quality stone which has been widely exploited, both for local use and for export all over the world. There are three main types of quarry in Cornwall; building stone (unshaped material used in hedges and walls), aggregate (crushed stone used for road building and in concrete), and dimension stone (shaped and dressed stone used for civil engineering and fine masonry work).

The main rocks quarried are granite and slate, although stone such as greenstone, elvan and serpentine and soapstone are also exploited. Local variations in geology are a principal contributory factor in the diversity of local architecture and the industry has left a legacy of abandoned pits and quarries all over the county.

The quarrying industry once employed thousands of people and contributed to the development of a transport infrastructure; tramways, railways, river quays and industrial harbours for exporting Cornish stone. In places such as Delabole, Mabe and St Breward, new communities developed to serve the industry.
Delabole quarry and village. Delabole slates were shipped from Port Gaverne and Tintagel until 1899 when the railway (visible cutting across the middle of this photo) was built linking the site to Padstow in the west, and to Devon and beyond in the east. Photo: Peter Trudgeon.

Slate quarries
The main area of slate quarrying is centred on the north coast between Tintagel and Trebarwith. Slate quarrying in this area is recorded at least as far back as the fourteenth century. The slate was used as building stone and for splitting into roofing slates and paving.

Coastal slate quarries at Bagalow, south of Tintagel. Each of the excavations in the cliff is a slate quarry where the cliff faces have been formed by workings. Horse whims, used for hauling the quarried stone up the cliff face, and dressing floors are
Coastal slate quarries are a spectacular feature of this industry. These are confined to a small area of about five miles either side of Tintagel and little is known about their history. In order to work the vertical cliff face strong points were built from stone at the heads of the working areas. From these ropes were dropped down the working faces. The slate was hauled up the cliff face on these cables which were wound using horse whims – capstans powered by horses walking around a circular platform.

Waste was dumped into the sea or at the foot of the cliffs, and the stone was shaped and split on dressing floors on the cliff top. These were originally housed in sheds but now survive as level terraces and are marked by screes of waste rock on the cliff slope.

There are a number of conventional quarries in the area of which Delabole is the largest and most famous.

**Granite Quarries**
Cornwall has an important granite quarrying industry and its stone has been exported all round the world. The streets of London are paved with Cornish granite and the docks at Tilbury, Gibraltar and Singapore are made from it.
seventeenth century. This is partly because access to ports in Cornwall was poor; most quarrying was for local use until these were developed. And it is partly because of the abundance of moorstones in Cornwall. Moorstones are the loose boulders scattered around the granite tors and were for many centuries the principal source of raw granite. Stone-splitting pits (and the characteristic ‘wedge and groove’ marks of the stone masons) are very common in the granite districts. There was extensive moorstone cutting in the Carnmenellis area, where some tors were removed completely, and abandoned dressed moorstone for bridges, lighthouses and other structures can be found around Stowe’s Hill on Bodmin Moor and elsewhere.

Industrial quarrying was made possible by developments in stone-splitting methods and controlled blasting techniques. Before 1800 a row of chiselled grooves would take iron wedges which were then hit with sledgehammers until the rock split. After this date plug-and-feather splitting was adopted; iron plugs were hammered into lines of hand-drilled holes, each flanked with a pair of hardened iron ‘feathers’, until the rock broke along the line.

**Kit Hill**

*Kit Hill, Stoke Climsland. Stone was removed from the quarry on an inclined tramway running downslope to the East Cornwall Minerals Railway which opened in 1872. Within the quarry itself, the granite blocks were moved by cranes and tramways, traces of which are still visible (some of them now under water). The line of the incline can be seen on this photo; trucks were hauled up and down the tramway by means of cables attached to a drum. Photo © Cornwall County Council Historic Environment Service*

The full development of the granite quarrying industry can be traced at Kit Hill in Calstock, east Cornwall. Nearly 5,000 stone-splitting pits are recorded from its slopes; these pits were dug around large moorstones which were then split into useable pieces to be made into arches, lintels, rollers, troughs and other artefacts.
Small quarries, no more than 10 metres across, cut into exposures of bedrock were developed in the early 1810s. There are many of these scattered over the higher slopes, each with a downhill entrance wide enough to admit a wagon. The introduction of the plug and feather splitting technique enabled the working of bedrock in this way.

On the southern slopes is a group of three small industrial quarries active in the later part of the nineteenth century but abandoned by 1872. These used black powder for blasting as well as plug and feather splitting techniques. Stone was transported from these quarries by a metalled track and large numbers of men would have been employed in this industry.

The quarries on the north side of the hill represent a radically different kind of industry. By the end of the nineteenth century the Kit Hill quarries were producing finished blocks for massive civil engineering projects. Stone from Kit Hill was used in the construction of six of London’s bridges, the docks at Millwall and Devonport, and for the Bishop Rock lighthouse.

**Aggregate Quarries**

From the medieval period or earlier loose stone and rab (a form of subsoil granite commonly found in Cornwall) were quarried for infilling tracks and making roads. Alongside every old road shallow pits where material was dug to fill potholes can be found.

Large scale quarrying for roadstone and aggregate is essentially a twentieth century industry and there are a few quarries still at work. The crushed and graded stones are used not only for road making, but also for railway ballast and as aggregates in concrete. A range of stones are quarried for aggregates including greenstone, granite, gabbro and serpentine.

*Porthoustock Quarries, St Keverne. Large scale quarrying on the coast of the Lizard Peninsula began in the early 1890s, exploiting gabbro and greenstone for use as*
aggregates. The crushed rock was carried by tramway to quays on either side of Porthoustock Cove. Fine waste from the quarries and from loading operations at the quays accumulated on the beaches. Beaches in the area have extended seawards by more than 100 metres as a result. Photo © Cornwall County Council Historic Environment Service

The rock was (and is) usually crushed on site and often there are no dumps of waste rock; everything but the overburden (soil stripped off the bedrock) was taken away and used. Aggregate quarries generally have little to tell of their working history although the remains of their crushing mills sometimes survive.

A Land Transformed

Transport
The beginning of the nineteenth century was an era of rapid expansion in the Cornish extractive industries, particularly copper mining. This expansion was hampered by the region’s slow and congested transport infrastructure. Copper ore had to be shipped to South Wales for smelting and coal brought back to fuel the steam engines on which the mines depended. Vast quantities of timber were also needed for pump rods and underground shoring, and this was brought by sea from Scandinavia and Canada. Almost everything had to be moved by huge mule trains.

Hayle Harbour. Hundreds of thousands of tonnes of copper ore were exported from here for smelting and vast quantities of coal and timber for the mines passed through this historic port. In this view the site of Harvey’s foundry is in the top right, the railway crosses the top and the quays serving Harvey’s foundry are in the left and

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Despite its long coastline Cornwall had few large specialised ports. New industrial harbours were constructed to handle the mineral trade. The most important were Hayle, Copperhouse, Portreath and Devoran, as well as smaller ports such as St Agnes, Par and Charlestown. Elsewhere harbours and quays were expanded to cope with the growth in mineral output. Together these form an internationally significant group of eighteenth and early nineteenth century industrial ports.

Until the nineteenth century the trackways and roads of the mining districts were unsuitable for wheeled transport so carriage of materials between the mines and the ports was dependant on pack-horses or mules. Each mule carried a load of 150kg and mule trains were made up of anything between 20 and 60 animals. During the Napoleonic Wars (1803 – 1815) the rise in fodder prices hastened the introduction of tramways and some of the first railways in the world.

The earliest Cornish railways (still initially powered by horse and mule) linked the copper mines with the mineral ports. The Portreath Plateway of 1809 linked the mines of the Gwennap district with Portreath Harbour, the Redruth and Chasewater Railway (1824) linked Gwennap with the port of Devoran, and the Hayle railway of 1834 linked the Redruth/Camborne district with Hayle. The railways also served Cornwall’s other extractive industries: for instance an incline was added to the Liskeard and Caradon Railway in 1846 to serve Cheesewring granite quarry, and granite from Kit Hill quarry was transported on the East Cornwall Mineral Railway which was originally built in 1872 to connect the Kit Hill and Gunnislake mines with the port of Calstock.
A particularly well-preserved example of the industrial transport infrastructure survives in the Luxulyan valley. At the base of the valley the Par Canal was built to take copper ore from inland to the newly created copper port at Par. The harbour at Par became important for the china clay industry after 1842 when a tramway was built through the valley into the clay district. The tramway was rebuilt during the 1870s as a steam railway and extended to the port of Fowey. The Cornwall Minerals Railway, as it was known, was responsible for the rapid development of Fowey as Cornwall’s major china clay port.

Ancillary Industries
The boom in the Cornish mining and china clay industries led to an increased demand for quarried stone for engine houses and other industrial buildings. The Cornish brick industry, whilst never of great economic importance, developed mainly to serve the needs of the mining and china clay industries. In particular, bricks made of impure china clay were highly heat-resistant and were in great demand for the boiler houses, calciners and smelting furnaces of the mining industry as well as for the building of pan kilns for the china clay industry.

Other industries developed and flourished: ropes, chemicals, charcoal, clothing, candles, crucibles and scientific instruments were all needed to sustain the mining boom. The most important ancillary industries were foundries and smelters. From the early nineteenth century onwards steam engines were made in Cornwall. The largest foundry was Harvey’s at Hayle; it was established in 1779 and became the pre-eminent engine foundry in the world. Harvey’s and its local rival, the Copperhouse Foundry, directly influenced the development of Hayle into two distinct urban areas; Harvey’s Foundry Town beside the railway and Copperhouse on the eastern arm of the estuary.

Another product essential to the extractive industries was explosives. The adoption of gunpowder for rock-breaking was a huge technological advance, the scale of which is illustrated by the fact that in 1836 alone, 30 tonnes of gunpowder were used in Cornish mines. Gunpowder was imported until 1808 when the first factory opened at Perran-ar-Worthal near Falmouth. Dynamite was invented in the 1860s by which time high explosives were being used far more efficiently in underground mines and in quarries. In 1888 the principal Cornish manufacturer established the National Explosives Company and built its first factory in the protective environment of the sand dunes at Hayle Towans.
The high explosives factory at Hayle Towans. Photo © Cornwall County Council Historic Environment Service

Industrial settlements

Tuckingmill, Camborne. The town of Camborne and the Camborne/Redruth conurbation contains the best example in Cornwall of large-scale urbanisation associated with the Industrial Revolution. The townscape is dominated by industrial terraces, many of which remain largely unaltered. Photo © Cornwall County Council Historic Environment Service

The mining and associated industries employed huge numbers of people; in the boom years a quarter of Cornwall's population worked in the mines themselves.
There was a constant movement of miners across the county as the fortunes of the mining districts rose or declined. Up to the mid nineteenth century every parish west of Truro experienced rapid population growth; as mining boomed in east Cornwall there was a notable shift of population from Gwennap and St Austell to Liskeard and Calstock. Villages such as Pendeen, Lanner and Four Lanes grew up and towns such as Redruth and St Just expanded rapidly (the population of St Just more than trebled between 1801 and 1861). Camborne grew from a small village to one of west Cornwall’s major towns.

A similar influx of population to the St Austell area accompanied the growth of the china clay industry. In the second half of the nineteenth century as copper production, then tin, declined in the face of foreign competition, china clay offered steady work for miners facing the prospect of unemployment or emigration. This led to the creation of a new mining community in villages – Stenalees, Bugle, and Foxhole - on the moors above St Austell. St Austell itself was a new industrial centre and rapidly expanded with areas of new terraced housing and the large town houses of the clay company owners. On a lesser scale industrial settlements sprang up to house the workers of the quarrying industry. Villages such as Mabe, in the important dimension quarrying area in the hills above Penryn, were established for this reason.

Nanpean, showing a classic arrangement of industrial terraced housing. Photo © Cornwall County Council Historic Environment Service

Smallholdings
The majority of those employed in Cornwall’s extractive industries lived in towns in terraced houses with only very small gardens or courtyards. Some were housed in rows of cottages with gardens in which food could be grown to supplement incomes. In the late eighteenth century, however, many miners laid out smallholdings; two- or three-roomed cottages with a few acres of land on which to grow vegetables and keep livestock.
Miners’ smallholdings typically consist of small rectangular fields and were held under the three lives system. They are sited in areas which were formerly upland rough ground. Some of this land was farmed in prehistoric times and later formed the upper margins of the medieval farming zone. Whilst the best arable land had been enclosed by the seventeenth century these upland areas remained uncultivated and had been used as heathland grazing and as a source of gorse for fuel. During the eighteenth and nineteenth centuries over 50,000 hectares of upland rough ground were taken into cultivation. The establishment of smallholdings had a significant impact on the landscape which in many areas is still clearly visible.

**Grand Houses, Parks & Estates**

The extractive and ancillary industries made great wealth for a very small number of those engaged in them. As in industrial landscapes elsewhere in Britain, this wealth was openly expressed in the form of grand houses, parks and estates. Mineral rights to metal ores and the royalties due from them were vested in a small number of ‘mineral lords’. These were mostly prominent landed families such as the Bassets, Boscawens and St Aubyns, which amassed fortunes at a scale which agriculture alone could not have provided.
Tehidy, located on the edge of the Camborne and Redruth Mining Districts. The Basset family transformed Tehidy into one of the finest country house estates in Cornwall. Photo © Cornwall County Council Historic Environment Service

The riches that minerals brought enabled Cornwall’s industrial families to indulge in horticulture on a grand scale and many of them became nationally distinguished plantsmen and gardeners. The gardens at Glendurgan, Trebah, Trengwainton, Caerhays and Trewthen, among others, are all nationally famous. These gardens are distinctive because the maritime climate and their sheltered aspect provide conditions in which exotic plants such as camellias, rhododendrons, palms and tree ferns can flourish.