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Cornwall and West Devon Mining Landscape
inscribed on the World Heritage List in 2006

Mining technology – overview

The history of mining within Cornwall and west Devon stretches back into prehistory when this area was uniquely-placed in Britain to supply the tin vital for the production of bronze. Likewise, the tin streams of Cornwall and Dartmoor were the basis for an industry which supplied almost all the needs of Western Europe during the medieval period. True underground mining is first documented in the Crown-operated silver mines of the Bere Alston peninsula during the late thirteenth century, but it was not until the early sixteenth century when the tin gravels of west Cornwall were approaching exhaustion that tinners were forced to turn to the parent lodes, most probably in what were to become the coastal mines of west Penwith.

The mining technologies in use during this period are documented by a number of contemporary European writers, notably Biringuccio (1540), Agricola (1555) and Ercker (1574) and show an industry that had already begun to develop sophisticated water-powered machinery, in particular for pumping, and were using extensive adits to provide natural drainage wherever possible. By 1602, however, Carew was making plain the limitations of the available technology as mines became deeper:

> 'For conveying away the water they pray in aid of sundry devices, as adits, pumps, and wheels driven by a stream and interchangeably filling and emptying two buckets, with many such like, all which notwithstanding, the springs begin to encroach upon these inventions as in sundry places they are driven to keep men, and somewhere horses also, at work both day and night without ceasing, and in some all this will not serve the turn.'

In Europe in the early seventeenth century, Giattambista da Porta had speculated on the application of power from a vacuum induced by steam, whilst David Ramsay had taken out a patent 'To raise Water from Lowe Pitts by Fire' in 1624; von Guericke, Papin, Boyle and Morland advanced the new science of steam power to some degree, but the first practical machine specifically for mining use was developed by the Devon engineer, Thomas Savery, in 1698. Some sources suggest that an early example of one of his mine pumps was installed at Wheal Vor, though this is a matter of some debate.

Savery's machine was a vacuum pump, however, and it was not until Thomas Newcomen of Dartmouth combined Guericke's cylinder and piston with Savery's separate boiler that a workable machine was created. Moreover, some sources indicate that the first Newcomen engine on a metal mine may have been that installed in Cornwall, possibly at '…the Great Work…' mine (or Huel Vor = Wheal Vor) in Breage Parish, in or around 1710 (Rolt & Allen, 1997), though some experts contend this. However, regardless of its true beginnings, the Newcomen engine was to be rapidly adopted across the coal mines of Britain and, to a more limited extent, in Cornwall over the coming decades. By the time of Newcomen's death in 1729, his engines were helping to drain mines in Hungary, Sweden, France, Germany, Belgium and Spain, whilst the following decades saw Josiah Hornblower erecting the first beam engine in North America.

Despite work by the Yorkshire engineer John Smeaton which resulted in the doubling of the efficiency of the Newcomen engine, it was proving too fuel-hungry for most Cornish mines, but the development of the separate condenser by James Watt transformed the efficiency of the engine and made possible efficient mine drainage from greater depths. Rotative engines which could be applied to mine haulage were developed in 1781, the use of expansive steam in the following year and double-acting engines soon thereafter. The end of Watt's patent in 1801 allowed local engineers free rein to experiment with further improvements to the beam engine, the development of the Cornish boiler and high-pressure working by Richard Trevithick being particularly significant. The beam engines which emerged in the early decades of the nineteenth century were to power Cornish and Devon mines for the whole of the following century.

In 1580, Ulrich Frosse had been charged with exploring the possibility of mining for copper in Cornwall, working initially at Perranporth and Illogan, though ore was also purchased from mines near St. Just and St. Ives. The venture was not a success. Within a few decades copper mining seems to have come to a halt and it was not until the last decades of the seventeenth century that production was restarted, largely as a result of the efforts of John Coster, a copper smelter who established works on the River Wye in 1680. Coster, a metallurgist and engineer, helped to develop adit drainage, made significant advances in assaying and dressing copper ore, erected one of the first horse-whims (for haulage) in Cornwall, and developed the first true Cornish copper mine, at Chacewater in the early 1700s.

National demand for copper was rising rapidly and Cornwall proved rich in ore, particularly to the north of Carn Brea. By the 1720s Cornwall was producing 6,000 tons of copper ore a year and in the next two decades this was to double. But deeper mines were inevitably wetter mines. Newcomen's engines were put to work on some, others developed adit systems; that begun by Sir William Lemon in 1748 to drain Poldice eventually becoming the Great County Adit and linking together dozens of mines, notably those being newly-developed in the parish of Gwennap. By 1770 Cornwall was producing nearly 30,000 tons of ore each year, but the copper ore raised from two vast opencasts on Anglesey from 1768 was to seriously challenge this growth. The only way to improve the economy of Cornish mines, and make them competitive, was to improve the efficiencies of their pumping engines. By the end of the century, the Anglesey mines had ceased to be a threat; copper prices were rising and the beam engine had been transformed. Cornish engineers such as Harvey, Trevithick, Woolf and West emerged during this period, new foundries and engineering works were established at sites like Perran-ar-worthal and Hayle. Soon, new ports were being constructed to ship ore, coal and timber, and tramways being laid down to serve the mining fields inland. John Taylor's Redruth & Chasewater Railway carried 50,000 tons of ore in its first year. Amongst the developments in mining machinery during the late eighteenth and nineteenth centuries were John Taylor's crushing rolls at Wheal Friendship in 1796, Trevithick's steam winder, erected at Stray Park in 1801, Woolf's steam stamps at the Carn Brea mines in 1813, the Brunton Calciner at Wheal Vor in 1829, the introduction of wire rope haulage at South Frances in 1840, Michael Loam's man-engine at Tresavean in 1842 and the Brunton Belt (a forerunner of the belt vanner), at Devon Great Consols in 1844.

Cornish engineers and inventors did not solely limit their efforts to mining technology, however, and the nineteenth century also saw the emergence of a substantial gunpowder making industry, the invention of safety fuse by William Bickford, whose company was to dominate world production for decades, the expansion of Perran Foundry and Harveys of Hayle into international suppliers of mining equipment, and the eventual emergence of Holmans of Camborne as world leaders in the field of rock drills and compressed air equipment. Murdoch lit his Redruth house with gas in 1792, Davy established himself as a pioneering British chemist, Goldsworthy Gurney ran a steam-driven coach from London to Bath in 1829 before turning his attention to lighthouses, Trevithick had trialled a practical steam carriage in 1801 and produced the first successful steam locomotive in the world. Cornwall during the late eighteenth and the first part of the nineteenth century was an important centre of innovation and technological development.

In 1836, the Caradon mines were discovered and in 1844, the phenomenally-rich Wheal Maria (with its sister mines, soon to become Devon Great Consols). The mines to the west of Truro had been worked extensively for half a century, however, and were showing signs of incipient exhaustion. In the 1830s Cornwall had dominated world copper production. Two decades later Chile's production far exceeded Cornwall's output, whilst the Lake Superior mines and those in South Australia were developing fast. Cornwall and Devon's peak year for production was 1855-6, when 209,305 tons of ore were mined. By the end of the decade, tin was replacing copper as the most important mineral, particularly in the western mines, and in 1866 the collapse of banking giants Overend & Gurney precipitated a disastrous crash in the copper market which Cornish copper mining could not survive. Chile, Australia, Lake Superior, Montana, and Arizona spelt the end for Cornish copper mines and, eventually, for the Welsh smelters.

Some Cornish mining districts were fortunate in that they also possessed tin reserves, and through increasing mechanisation and the adoption of efficient ore dressing technologies their mines were able to work on for a couple of decades more, despite falling tin prices; some former copper mines found a new lease of life in working the arsenical pyrites which they had formerly discarded as waste - indeed Devon Great Consols produced a substantial proportion of the world's arsenic during the closing years of the nineteenth century. Nevertheless, the great days of Cornish mining were over and one by one, mines whose reputation had spread far beyond Cornwall were abandoned forever.

Reference

Rolt, L.T.C. & Allen, J.S. (1997) *The Steam Engine of Thomas Newcomen*, Ashbourne: Landmark Publishing Ltd., p.44, 45

NB. In reaching their conclusion regarding the first Newcomen engine, Rolt and Allen cite the work of the nineteenth century geologist and industrialist Joseph Carne (1782-1858), that of the historian A.K. Hamilton Jenkin (*The Cornish Miner*), and the testimony of Davies Gilbert (1767-1839), as quoted in Gilbert, D. (1838) *The Parochial History of Cornwall, founded on the manuscript histories of Mr. Hals and Mr. Tonkin; with additions and various appendices, by Davies Gilbert,* London: J.B. Nichols and Son.

Adits and water wheels

Water drainage

The growth in mineral output that created Britain's most important non-ferrous metal mining region was due to vertical exploitation of irregular and erratic lodes within hard rock. This necessitated shaft mining and presented a continuous challenge in terms of depth and water drainage.

- **Adit levels and the Great County Adit (Gwennap)**

The driving of long drainage tunnels (adits) from the lowest suitable points in the topography was vigorously pursued from 1700 onwards. By the second half of the eighteenth century most established mines possessed adit systems.

The Great or County Adit was a venture headed by the Lemon and Williams families and drained the largest concentration of copper mines in the world. It was commenced in 1748. Its branching network eventually drained over 100 mines to an average depth of 80-100m and attained a length of over 65km. In 1839 it discharged around 66 million litres (14.5 million gallons) per day and had more steam engines pumping into its course than were used by the whole of continental Europe and America combined.

A high level of dissolved metal salts in this discharge gave rise to copper precipitation (cementation) works and iron ochre works in the Bissoe Valley. Even when steam engines were introduced, adits remained cost-effective, especially in coastal locations such as at St Agnes where up to 100m of vertical ore-ground could be drained by using sea-level adits. In the deeply incised Tamar Valley Mining District this was even greater, and an adit driven in the mid nineteenth century at Gunnislake Clitters Mine met the ore-ground at a depth of 160m.

At Wheal Rose near St Agnes in 1725 the Newcomen engine was so costly that the adventurers decided to drive a 2.4km adit to alleviate the cost of carrying on firing it. By the time steam engines were adopted, the ore-ground above an adit was often exhausted.

- **Water-wheel engines**

'We are all assured, that a large water-wheel engine, if water is plenty and cheap, is most effectual and steady for the purpose of draining our mines.' (W Pryce, 1778)

Water had long been removed from mine workings by devices that employed manual, horse or water power. William Pryce, writing around 1760, records horse whims that drew 120 gallon (545 litres) barrels by the power of four horses. He writes

‘*The water-wheel with bobs is yet a more effectual engine, whose power is answerable to the diameter of the wheel and the sweep of the cranks fixed in the extremities of the axis.’*

Water wheels also provided power for winding machinery, stamping mills and a host of other appliances. There were hundreds in the region, often working on a seasonal basis, some through leats taken off streams further up the valley, but also through leats taken from reservoirs that would only allow effective working during the rainy months of winter and spring.

Water was a valuable commodity and landlords often rented out their streams for considerable sums of money. Mines themselves sometimes drove adits in search of water, constructed single leats many kilometres long to secure water, and sited additional large waterwheels and water pressure engines underground to maximise the use of this precious energy resource.

Steam technology and the beam engine

Of the thousands of beam engines erected only a small number have survived and those still on their original sites are fewer still. It must be noted that the relocation of beam engines from one mine to another was very common practice. An engine may have been moved three or four times during its lifetime and therefore may have had several different but entirely authentic locations.

Within the World Heritage Site there are four beam engines still in situ on their original metal mines: There is an indoor winding engine at Levant Mine (St Just Mining District); there are two at East Pool & Agar Mine - Taylor's pump and Michell's Whim (or North Whim) - and the Robinson's pumping engine at South Wheal Crofty (Camborne and Redruth Mining District).

Many beam engines were moved from mines to the St Austell china clay district. These include engines at Rostowrack and Parkandillick, the Goonvean engine and the Greensplat engine which has been re-erected at Poldark Mine (Wendron Mining District). The china-clay industry's adoption of beam engines has contributed to their present-day survival.

Beam engines in the United Kingdom

The Newcomen engine at the Elsecar Colliery in Yorkshire is on its original site. Others are to be found in the Science Museum, London, and in Dartmouth, the Devon birthplace of Thomas Newcomen. Later mine engines are to be found in situ at Hodbarrow Iron Mine, Cumbria (built by the Perran Foundry), Dorothea Slate Quarry, Caernarvon (built by Holman Brothers of Camborne) and Prestongrange Colliery. Kew Steam Museum, near London, was a pumping station that pumped water for public utilities. It contains important Cornish engines. Similar sites such as Crofton (where water was pumped to upper levels of the Kennet and Avon Canal) have other examples of beam engines, some of which were made in Cornish foundries. Beamish and Blist's Hill at Ironbridge (Shropshire) and the Science Museum in London have important examples of ex situ beam engines.

Mining applications for the new steam technology

The first steam stamps were installed at Wheal Fanny (Carn Brea) in 1813; the first steam capstan, by William West, at South Hooe in 1835; and the first British man-engine by Michael Loam at Tresavean in 1842. But it was the Cornish pumping engine and the rotative winding engine which were to be the mainstay of Cornish and west Devon foundries. They were produced in their thousands for mines and manufacturing works the world over. On overseas mines however, the rotative winding engine was quickly superseded by more efficient methods.

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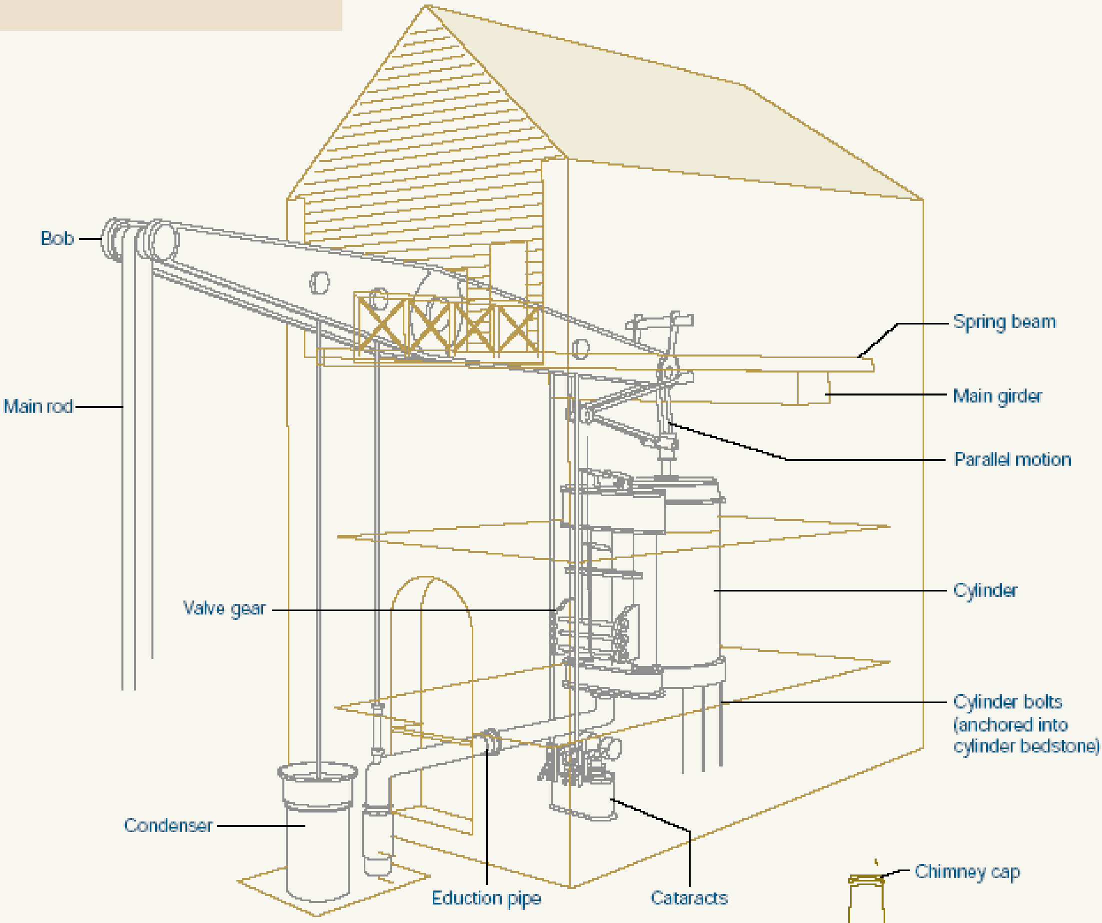
The Cornish type engine house

The principal function of an engine house was to provide the integral framework for the engine it contained and its basic design was essentially established by Newcomen for his Atmospheric Engine. The distinctive architecture of Cornish beam engine houses links their landscape context - both in the United Kingdom and overseas - with Cornwall and west Devon mining engineering. More beam engines were installed in Cornwall and west Devon than any other mining region of the world: a total of around 3,000 engine houses were built to house them.

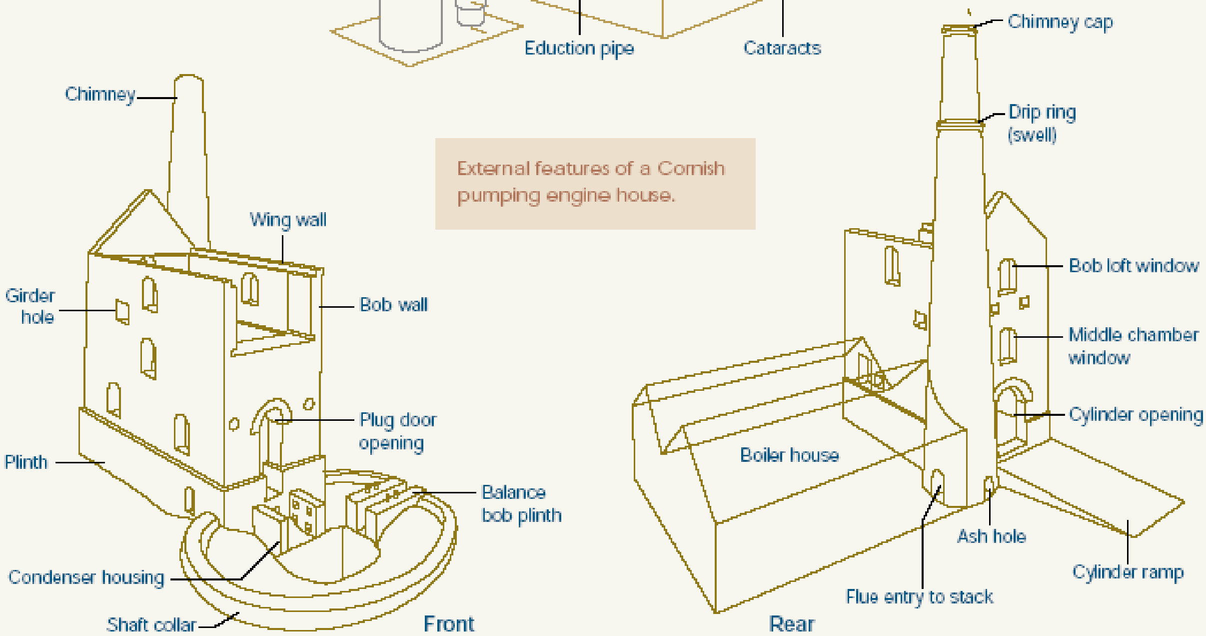
Most surviving engine houses are rectangular in plan with a much thicker wall in the front (the bob wall), this was constructed using more massive stone (often cut granite) and was perhaps two-thirds of the height of the other walls. This wall supported the reciprocating beam (known in Cornish mining as a ‘bob’) which transmitted the reciprocating motion of the piston to the pump rods in the adjacent shaft (in the case of a pumping engine) or to the hoisting or crushing machinery. This wall had to withstand both the weight (that might be over 50 tons for a large pumping engine) and the rocking forces of the bob.

The other walls braced the bob wall and helped to take some of the working stresses of the engine. The rear wall (usually with a gable that supported a pitched roof) contained the cylinder opening through which the cylinder, bob, and other large components were brought into the house. There were usually three chambers (floors) internally.

Associated structures include: boiler houses which were often attached to the engine house as a lean-to building; chimney stacks which were either built-in to a rear corner of the engine house or sometimes detached and connected by a flue; and engine ponds (usually upslope) which stored water for the engine condensers and boilers.



Simplified layout of a Cornish pumping engine house showing the position of principal components.



External features of a Cornish pumping engine house.

Local stone was used to build engine houses. This was sourced from quarries (commonly opened up near the site to provide the rubble walling), sometimes from mine waste and often from existing derelict engine houses on the same or adjoining mines that were pulled down to re-use the stone, particularly cut granite that was always favoured for the cylinder bedstone, the bob wall and coigns. Gable roofs were covered with Cornish slate and bricks were brought in to construct the topmost section of the chimney stacks and to form arch/window details. The necessary massive construction of these engine houses is the principal reason for their survival.

The Man-Engine

Cornishman Michael Loam, engineer of Consolidated Mines, was one of the first to design a man-engine that could use the reciprocating motion of pump rods in engine shafts. In 1829 he tried to sell his invention but it was rejected without trial.

In 1834 a prize was offered by the Royal Cornwall Polytechnic Society in Falmouth - for the best improvement in the method of ascending and descending mines; miners had long suffered the arduous and time consuming task of climbing ladders to get to and from their workplace. The prize was won by Michael Loam and his Man-Engine in 1835, two years after a similar machine (known as a Fahrkunst) was independently developed and installed in the Harz mining district in Germany.

It was not until 1842 that the first engine was installed in Cornwall at Tresavean Mine in Lanner near Redruth. By 1864 eight man engines were in use in Cornwall. It was a successful design but initial cost combined with the crookedness of Cornish shafts, which frequently changed angle to follow the lode, meant that many mines did not adopt the device. These crooked shafts, due to lack of investment, were used well into the twentieth century until vertical shafts began to replace them.

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Mineral products and their transport implications

Tin ore was crushed at the mine to a fine mass and the waste separated out to produce sacks of cassiterite concentrate (around 70 per cent tin metal). These were taken to local tin smelters. Copper ore was sorted and broken by hand into small lumps and taken in bulk (6-12 per cent copper metal) mostly to ports to be shipped to south Wales for smelting. Arsenic ore was refined (either to the oxide or a pure form) at the larger mines or special refineries, and packed in casks.

By far the greatest volume of carriage from the mines was therefore due to the transportation of copper ore to the nearest port for shipment to south Wales. The beginnings of the nineteenth century marked a great era of expansion and growth in Cornish copper mining but progress was being impeded by the inadequacies of a slow, congested and sometimes even seasonal transport infrastructure. Mines in the region were concentrated in a spatial and structural relationship with the outcrops of granite and their metamorphic aureoles. However, the geographical distribution of output shifted temporally as new lodes (and even districts) were discovered and old ones exhausted.

Mining hinterlands required a substantial transport network that formed a reliable, economic and high capacity link from mine to port. The transport sector that served the mining industry required some of the largest investments in the region and promoters were nearly always those mineral lords, mine owners and/or bankers who were already engaged in mining. The development of an effective industrial transport network had a considerable impact upon the landscape, involving as it did the construction of extensive railway trackbeds, bridges, tunnels and viaducts, as well as harbours and their associated infrastructure.

Supplies (coal and timber)

Devon and Cornwall had no suitable coal to fire mine steam engines, the inferior coals found in north and south Devon being mainly used domestically and for lime-burning. All the region's needs were supplied from the coalfields of the Bristol area and subsequently from south Wales, an unlimited supply made accessible by sea and navigable river systems. Timber was required in immense quantities for pump rods and underground for shaft timbering and stull pieces within levels and stopes. Pitch Pine was found to be most suitable and durable, due to the wood's high resin content preserving it from decay, and was brought from Scandinavia and Canada, again by sea.

Mineral ports and harbours

Cornwall has an extensive coastline and a long maritime tradition but until the late-eighteenth century it had few large specialised ports. The mining trade was handled by newly-developed specialist industrial harbours throughout the region. Pre-eminent amongst these were: Hayle, Copperhouse, Portreath and Devoran.

These jointly handled almost all the requirements and output of the mines and industries of west Cornwall. Harbours were also built at St. Agnes, Par and Charlestown, and those at Newquay, St Michael's Mount, Porthleven, Looe, Calstock, Morwellham and New Quay were enlarged to cope with several phases of the expansion of mineral output.

Mule trains

Until the nineteenth century horse and cart transport was rarely used for the carriage of ore and coal as the track ways and roads of the mining districts were totally unsuitable for wheeled transport of any kind, particularly in wet winter months. Pack-horses and most commonly mules were universally adopted and became a highly visible feature of the landscape. Stables were purpose-built for large numbers of the animals; in 1800 Matthew Boulton estimated that there were 1,500 mules engaged in the copper ore–coal trade with west Cornwall mines. To this may be added a similar number of horses and mules that worked on the mines themselves and in ancillary industries.

A mule carried a load of around 150kg in leather or sail-cloth sacks slung across a wooden saddle. (They could however haul up to seven times as much if the load was in a wagon riding on iron rails). Mule packing frequently involved journeys of 30km a day or more with the laden mules working from daybreak to midnight in summer. In winter however, tracks often became impassable due to heavy rain and mud, adding to the logistical bottleneck of transporting coal to and copper ore from, the mines. During the Napoleonic Wars (1803-1815) the steep increase in fodder prices side-lined the mules and led to the emergence of tramroads and railways, the latter some of the first railways in the world.

Mineral tramroads and railways

Cast iron rails were first adopted in Coalbrookdale (Shropshire) in 1767 and short industrial tramroads were soon in use at mines and quarries across the country. Far heavier loads could now be moved, by the same power, than on the finest road surface. During the 1820s, many of the more important mines in the region adopted horse-drawn tramroads to link production shafts and dressing floors. Traction continued to be provided by horse and mule power until steam locomotives were introduced.

The early Cornish tramroads and railways were built to link copper mines with mineral ports. Up until the early nineteenth century practically the entire copper mining region was within a 13km radius of Carn Brea Hill.

- **Portreath Plateway (1809) (Camborne and Redruth Mining District)**

The Portreath Plateway, the first of the mineral lines, was started in 1809 to link the copper mines of North Downs and the Gwennap district with the harbour of Portreath on the north coast. It was leased from the Bassets of Tehidy and promoted by the Williams family and their friends the Foxes of Falmouth. Gwennap parish alone produced one third of the total output of Cornish copper and mines such as Poldice benefited greatly from the new plateway. Poldice was both the richest mine in Gwennap and the last to close down (in 1873). It had gradually switched from tin to prolific copper production during the last quarter of the eighteenth century.

- **Redruth & Chasewater Railway (1824) (Gwennap Mining District)**

John Taylor (1779-1863), industrial rival to the Lemons, the Williams and the Foxes, built the Redruth & Chasewater Railway in 1824 to link the principal mines which he leased in Gwennap - including Consolidated - to his new port at Devoran. This was built on one of the estuaries above Falmouth Harbour on the south coast.

- **Hayle Railway (1834) (Port of Hayle)**

The Hayle Railway linked the Redruth-Camborne district to the port of Hayle from 1834 to 1839. The Portreath Branch was constructed in 1837. This was intended to capture the trade of the rich mines in the district north of Carn Brea.

- **Luxulyan Valley**

In 1829 Joseph Thomas Austen (later changing his name to Treffry) opened a canal from Par to the foot of Penpillick Hill, later to be extended to Ponts Mill. This connected with a tramroad and inclined plane to Lanescot Mine, later to form part of the rapidly expanding Fowey Consols, and was used to convey copper ore for shipment to the Welsh smelters. Ten years later work began on another, much larger, incline (to be worked by water wheel) through Carmears woods to terminate near the viaduct/aqueduct which was then being constructed to span the Luxulyan Valley. After leaving the viaduct the line terminated at Molinnis near Bugle. In 1844 Treffry turned his attention to the north coast and constructed a railway from Newquay harbour to St Dennis with a branch to East Wheal Rose. The line was completed in 1849 and was the beginning of what was to become the Cornwall Minerals Railway.

- **Liskeard & Caradon Railway (Tamar Valley Mining District)**

This railway was started in 1844 and linked the Liskeard & Looe Union Canal at Moorswater to South Caradon Mine. In 1846 the line was extended to Minions and Cheesewring Quarry via a long incline at Gonamena. Further extensions took place over the years including the incorporation of the Kilmar Railway and a route around Caradon Hill, taking in other productive mines including East Caradon and Marke Valley, and avoiding the Gonamena incline. By the late 1850s the canal was proving to be inadequate due to increasing traffic and so the canal company constructed a railway, mostly built on the bed of the canal. This gave the railway a direct route to the port of Looe.

- **The East Cornwall Mineral Railway (Tamar Valley Mining District)**

The first turf of the Tamar, Kit Hill and Callington Railway was cut in 1863, and the line was completed as the East Cornwall Minerals Railway in 1872. The line connected the mines in the Kit Hill-Gunnislake area with the port of Calstock. The railway above Calstock (worked by two steam locomotives) was connected to the Calstock quays and the River Tamar by a rope-worked single track incline with a passing loop at its mid-way point. The line was taken over in 1901 by the Plymouth, Devonport & South Western Junction Railway. The Calstock viaduct was built in 1907 and subsequently the Calstock incline was abandoned and a fifteen ton wagon lift was constructed against one of the viaduct piers. This was dismantled and sold for scrap in 1934.

Other railways constructed in Cornwall and west Devon

Other railways constructed in Cornwall and west Devon to link developing industrial areas to the coast were: the Pentewan Railway (1829) connecting St Austell to Pentewan; the Bodmin and Wadebridge Railway (1834); the Newquay to St. Dennis line (1849) with its branch to the Newlyn East lead mines; the Fowey Consols to Par line (1851) replacing the Par Canal; and the line linking Devon Great Consols to Morwellham (1857).

The Pentewan Railway was built in 1829 by Sir Christopher Hawkins primarily for china clay traffic, although there was however a siding near London Apprentice that served Polgooth Mine. It was not until 1874 that a locomotive replaced horses. The silting of the harbour at Pentewan combined with the reluctance of the clay companies to transport their clay by horse and cart to the terminus at St Austell, brought about the closure of the line in 1918.

With the completion of Brunel's Royal Albert Bridge (1859) across the River Tamar, Cornwall had, for the first time, a main line connection to the rest of Britain. Some sections of mineral railways were converted to passenger use, but many remained predominantly or wholly industrial carriers for the remainder of their operation.

Canals

Canals were generally not a practical option for moving minerals and supplies, particularly in the western part of the World Heritage Site. In the main, the mines here were in relatively easy reach of navigable water and many were on or close to the granite uplands. Across Cornwall and west Devon, however, there were some notable exceptions.

The Tavistock Canal (built 1803-17) was 7.2km in length and was constructed by John Taylor to link the copper mines that he managed in the Tavistock area with the River Tamar, the principal transport highway to the sea at Plymouth. A 2.4km tunnel carried it beneath the high ground of Morwell Down and an inclined plane connected the Morwellham canal basin with the quays below.

The Liskeard & Looe Union Canal (opened in 1827) connected Moorswater with Looe. The canal owed its success to the discovery of copper ore at South Caradon Mine in 1836 and to the considerable traffic of the Caradon mines and granite quarries thereafter. From 1844 the Liskeard & Caradon Railway linked South Caradon with the inland canal terminus at Moorswater. By the late 1850s the canal was proving to be inadequate, however, due to the high level of mineral output from the Caradon mining district and so, in 1860, the canal company extended the railway down to Looe. This initially relieved congestion on the canal and then swiftly replaced it.

The Par Canal (opened in 1829) was constructed by Treffry from Par to the foot of Penpillick Hill and later extended to Ponts Mill. This connected initially with Lanescot and Fowey Consols mines by tramroad and inclined planes, and was later linked with the granite quarries of the Luxulyan Valley, and Hensbarrow beyond.

At Carclaze Mine, a tin open-work near St Austell, a subterranean canal was in operation from around 1720-31. This ran beneath the length of the pit and was connected to it by a 40m deep shaft down which ore was lowered into the barges. These were made of oak, 2.0 x 1.5 x 0.3m deep, with flat bottoms and were simply floated out and transferred by cart to the stamps and dressing floors, 1.5km to the west.