CORNISH MINING HERITAGE

R.K. JOHNS

Front cover *Killifreth Mine: Ruined engine-house on Hawkes Shaft between Chacewater and Scorrier. Workings to 690 feet produced 4000 tons of black tin during 1859-1904.*

Back cover *Cornish coat of arms.*

Department of Mines and Energy
South Australia

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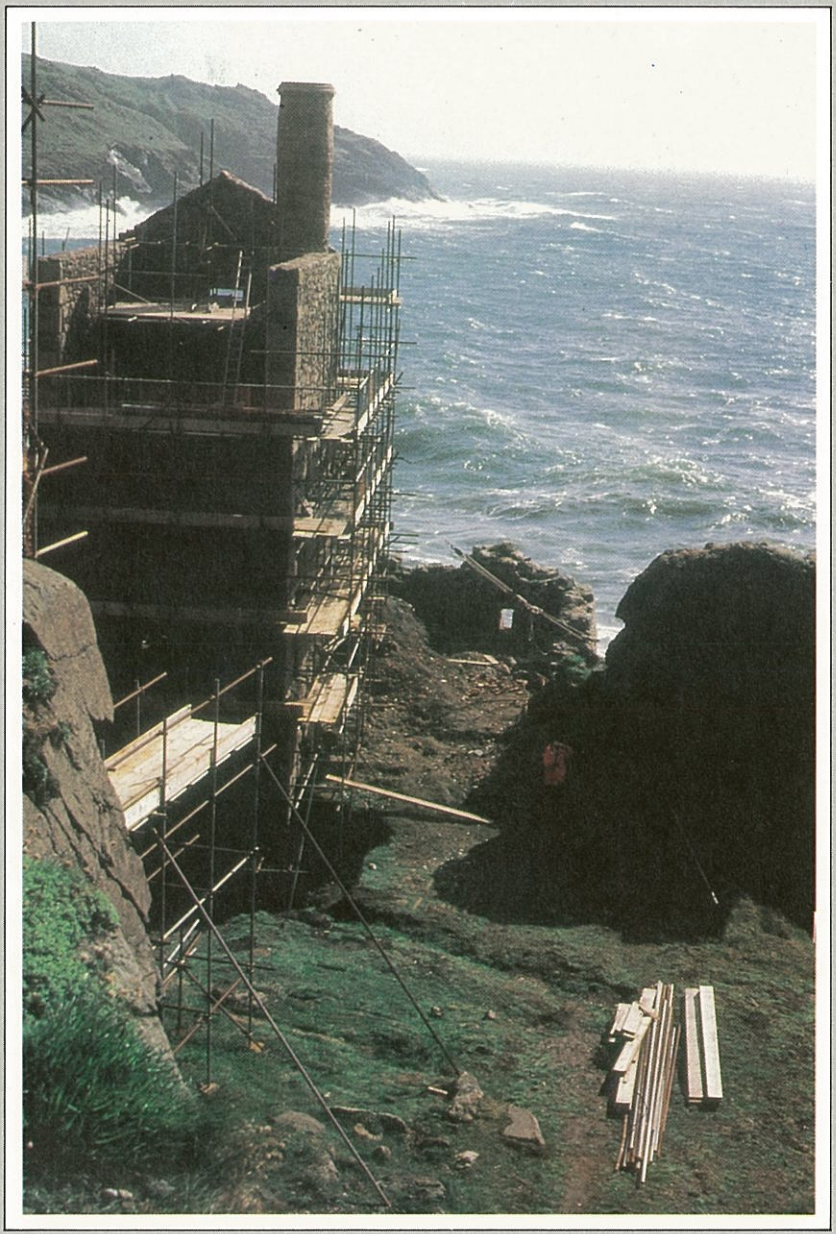


Frontispiece *Botallack engine house under repair - June 1985*

CONTENTS

NOTE: Owing to the historical nature of much of the material used in compiling this volume, the Imperial System of measurement has been used throughout.

INTRODUCTION

The Cornish influence during the formative years of the Colony of South Australia was profound. The discovery of copper deposits which served to underpin the colonial economy early in its history impacted adversely on the Cornish mining industry and attracted large numbers of immigrants from Cornwall. Thus, miners in their thousands travelled overseas to work the newly discovered deposits of silver/lead at Glen Osmond (1841), of copper at Montacute (1842), Kapunda (1842), Burra (1845), Moonta and Wallaroo (1861) and numerous other less important ones. These provided competition for markets for copper at home at about the same time as the tin mines were also facing similar financial difficulties through new overseas discoveries of that metal. Declining profitability of Cornish mines was accompanied by depression in the agricultural and fishing industries also.

In South Australia, mining methods, haulage and processing of ore and pumping of water from the mines were based on Cornish technology which remained in vogue until World War I, by which time underground mining of copper ores had virtually ceased through exhaustion of reserves. Thus, at Moonta, Kadina or Burra one cannot fail to observe derelict engine-houses and chimney stacks similar to those which dominate the Cornish landscape over much of its extent. But, what was their purpose? How did they function? What is their significance? How do these and associated masonry ruins relate to those on which they were based in Cornwall?

In South Australia's 150th year it is appropriate to reflect on our Cornish mining heritage and to consider how relevant archaeological relics might be recognised, interpreted and preserved for educational, historical and tourist purposes. The observations hereunder are based on a private visit to Cornwall in June 1985 to study the contemporary mining scene and inspect sites of formerly famous mining operations.

EARLY MINING ACTIVITY IN CORNWALL

The recovery of tin in Cornwall dates from the Bronze Age and 'tinners' were at work before 2000 BC. The tin trade was maintained by the Celts during the Iron Age and there has been more or less continuous production from the region since that time.

From the outset cassiterite was washed from alluvium derived from tin-bearing granites adjacent to the coast in the St Just area, in the St Austell, Luxulyan and other districts by a process referred to as 'streaming'. The gravity dependent washing recovery of tin accelerated erosion through removal of vegetation and the working over of valley bottoms

and of granite detritus on Bodmin Moor, Hensbarrow Moor and Dartmoor and contributed to siltation of previously navigable estuaries.

Streaming proved to be profitable not only to the tinners but also to the fortunate landowners. Tenure, payment of dues and royalties, and marketing were regulated by Stannary Charters, Courts and Parliaments from the 12th Century. Sampling and recovery have obviously improved with time and recovery of remnant tin from the shambles left from sites of such former mining operations still contributes small production.

In due course, streaming led to identification of the source of the tin and, by the middle of the 15th Century, well defined tin-bearing vein systems had been disclosed at the coast between St Just and St Agnes. Thus, mining of tin lodes was extended below the surface of the ground. Drainage of water was achieved by adits in favoured localities at cliff edges on the coast or in valleys but underground mining operations were slowed, inevitably, when workings intersected the water table. Primitive pumps as were available, including rag-and-chain pumps operated by horse gins or water-wheels (except, notably, at Devon Great Consols in the mid-19th century), and bucket pumps, were quite ineffective in view of requirements. The problem was solved with the development of steam engines.

CORNISH PUMPING ENGINES

The Cornish pumping engine was the final development by Richard Trevithick and other Cornish engineers of the single-acting beam engine, which was originally introduced by Thomas Newcomen for pumping water from the Cornish mines, and which James Watt so greatly improved. The first Newcomen 'atmospheric' engine was erected on a mine in 1715, the second in 1720; by 1778 over 60 were operating, at which time Watt's engine was first installed.

Richard Trevithick in 1811 developed the Cornish boiler by which steam could be used at a higher pressure: 50 up to 100 pounds per square inch (psi) as compared with the 2 to 4 psi of Watt engines. Thus, with little refinement, the Cornish beam engine was to serve for a period of 150 years as a reliable, effective and low cost means of powering pumps to raise great volumes of water from great depths in mines, and in mine haulage and for driving machinery all over the World. It is estimated by Ken Brown that more than 2000 beam engines operated in Cornwall alone, built in Cornish foundries. They were also adapted to other water pumping requirements in London. In Holland enormous 144-inch cylinder compound Cornish beam engines operated for more than 80 years to drain polders.

The engine was of basically simple design. Steam from boilers (Plate 1) was admitted above a piston within a vertically mounted cylinder

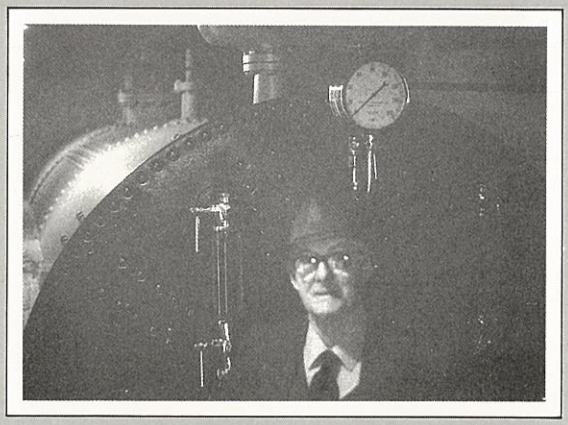


Plate 1 *High pressure Cornish steam boiler, rebuilt by National Trust, East Pool; Mr Gordon Richards in foreground.*

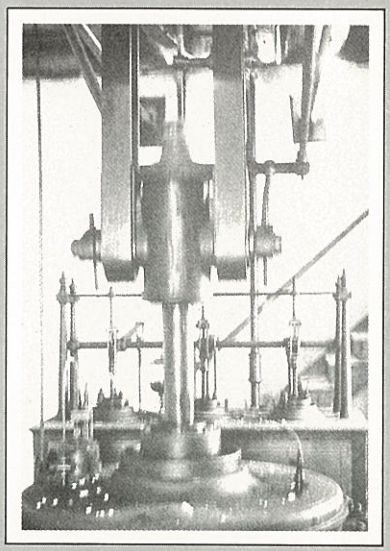


Plate 2 *Fifty-inch cylinder with piston rod towards end of 'indoor' stroke, Parkandillick beam engine, St Dennis (1852-1956).*

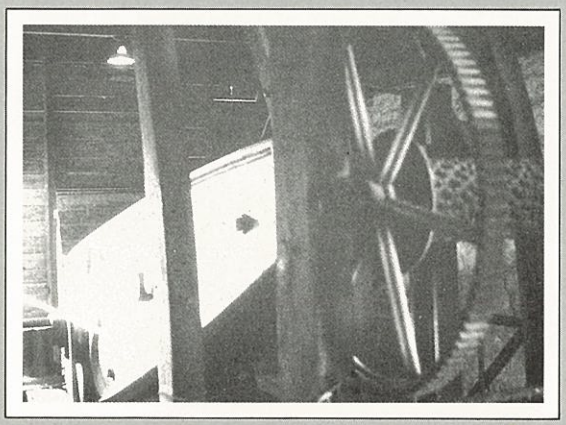


Plate 3 *Bob of Parkandillick beam pumping engine, St Dennis (1852-1956): The beam is unequal, the stroke in the cylinder being ten feet and in the shaft nine feet. Hand operated winch gear is in foreground.*

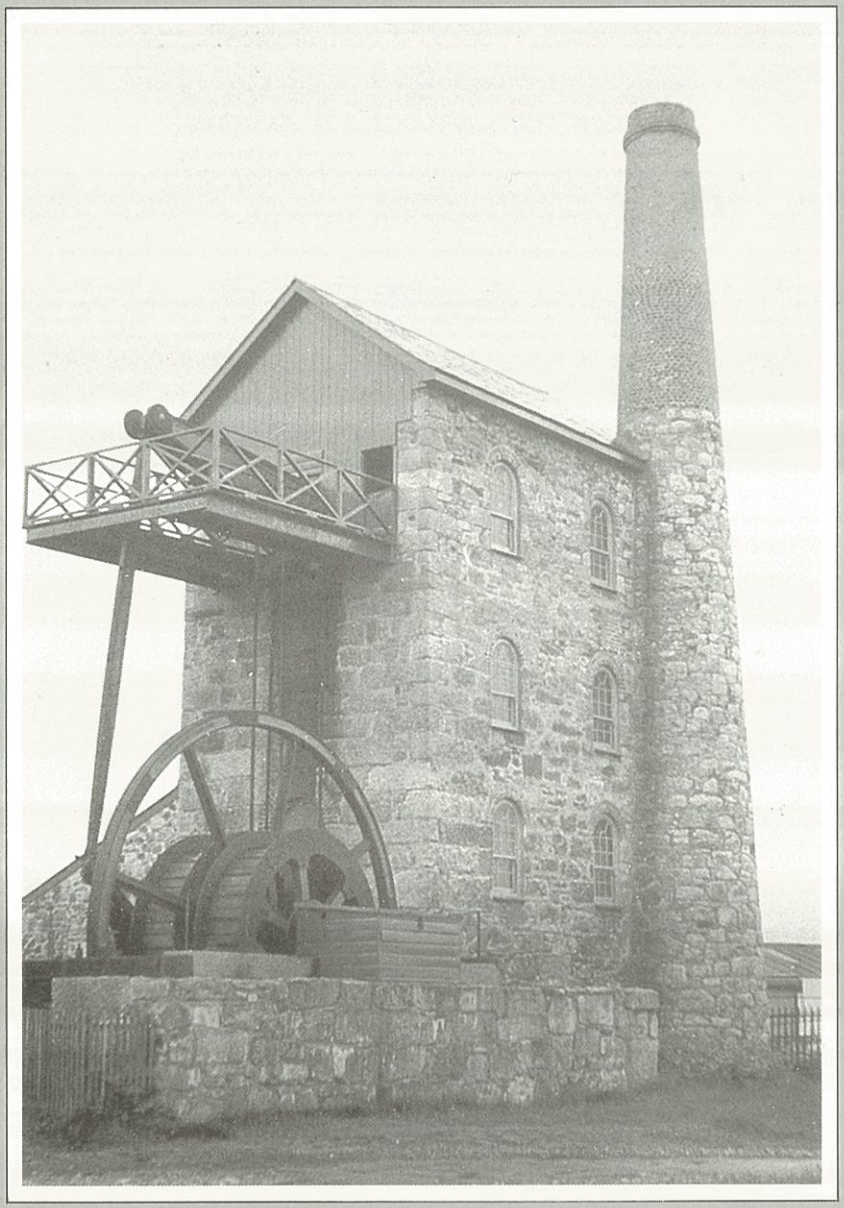


Plate 4 *Michells 30-inch Fire Whim, East Pool (1887-1921): Outdoor nose of bob, above bob plat, is connected by sweep-rod to crankshaft carrying flywheel and double winding drum. Boiler house with sloping roof is attached to left side of engine-house.*

(Plate 2) and exhausted by a regulated system of valves. Power was translated to the 'indoor' end of a cast-iron rocking beam or 'bob' (Plate 3) mounted overhead on a horizontal axis, from the 'outdoor' nose of which rods were suspended that extended down the shaft to operate a series of plunger pumps. Sufficient power was required only to raise the rods - the rods under their own weight (upwards of 500 tons being recorded and up to over 2000 feet in length on occasion) returned the beam to its down-stroke position. A large volume of water was raised stage by stage at each stroke of the piston in the cylinder.

At first the engines were of small size and power with cylinders of 19-inch to 30-inch diameter and operating 9-inch diameter pumps. By the time that they were supplanted by electric motors early in the 20th Century, cylinders of 80-inch diameter were not uncommon; 90-inch cylinders (and a few giants, up to 100-inch) worked pumps up to 20-inch diameter. Bobs became bigger and heavier as a consequence, and culminated in that cast in 1892 for Taylor's Engine at East Pool mine which weighed 56 tons. Sometimes their inordinate weight contributed to their failure and occasions when major repairs were required to cracked bobs are well documented, as for several of those which are now on display.

These were powerful machines which pumped at a rate of between five and eight strokes per minute. Counterweight balance boxes were generally incorporated at the surface and down the shaft to assist on the upstroke to raise the weight of the rods.

From 1810 onwards smaller high pressure winding engines with cylinders from 15 to 32 inches in diameter were built with a flywheel and crank ('sweep rod') to provide the required rotative motion to the winding drum ('cage') for haulage - these were known as 'fire whims' (Plate 4). Other engines of about the same size were used for operating crushers, stamps and man-engines.

From the foregoing it is not surprising, therefore, that very substantial structures were required to house Cornish pumping engines. While modifications were made to design and the beam was brought into the house on some adaptions, or dispensed with as in the Bull engine, there was need to assure that the cylinder was adequately bolted down to withstand the enormous stresses imposed. To support the weight of the beam and to ensure stability of this and other components, engine-houses were of necessity massive tall structures generally of granite construction whose doors and windows were located and dimensioned with purpose. The bob which emerged at the back of the building was supported by the 'bob wall' several feet in thickness. Rather squat engine-houses were built for inverted (Bull) or horizontal types of engines which did not require such strong high walls in the absence of a beam. Internally, there were three floors connected by staircases. On the bottom chamber (the driving floor) stood the cylinder and valve gear (Plate 5); the middle chamber gave access to the top of the cylinder and the nozzles (Plate 6); the bob loft gave access to the beam for regular application of grease to bearings

and housed a winch for repair and maintenance. The outer end of the beam was reached through a small door leading onto the bob plat - a wooden gallery cantilevered out from the wall of the house. An ingenious device devised by Watt to assure vertical movement of the piston rod connecting to the indoor 'nose' of the bob is the 'parallel motion' linkage (Plate 7).

Boilers were housed in a structure attached to the engine-house. Architectural variety was provided in chimney stacks through variable height, shape and brick finish at the top. A distinctive feature, not seen in South Australia, is incorporation of the chimney as an intergral part of the structure of the engine-house.

Thus, after about 1750, the Industrial Revolution which was based on the harnessing of steam included among its developments in Great Britian the introduction of an engine which was to enable mining to extend to depths of up to 2550 feet and to transform the mining industry not only in Cornwall but all over the World. The Cornish beam pumping engine enabled underground mining, previously impossible through influx of water, to proceed at greatly expanded rates - a timely development since it coincided with the discovery of rich copper lodes. Until well into the 19th Century copper outstripped tin in importance and was responsible for the success of deep mining, for the widespread introduction of steam power for drainage, and for creation of the Cornish mining ports and associated mineral railways.

TIN AND COPPER, 1700-1900

Though copper had been recognised occasionally in association with tin towards the end of the 15th Century, no mine was worked purposely for the recovery of copper until about 1710 when massive copper lodes were discovered west of Truro on the uplands from Chacewater to Redruth, to Camborne, and in a belt extending from Gwennap to St Agnes. By 1750 copper mining was of great importance and demand for the metal expanded rapidly. The mines of Cornwall became the World's major producers of copper and this dominance was to continue for the next 100 years.

Mining operations expanded as discoveries were made in the St Austell area in 1812, at Caradon Hill near Liskeard in the 1830s, and of what proved to be one of the greatest producers across the River Tamar at Devon Great Consols in the 1840s.

The tin and copper deposits are associated with granites of Late Carboniferous to Permian age intrusive into a folded succession of marine and deltaic Middle Devonian to Upper Carboniferous slates, shales, sandstones, limestones and volcanic rocks which are generally slatey in

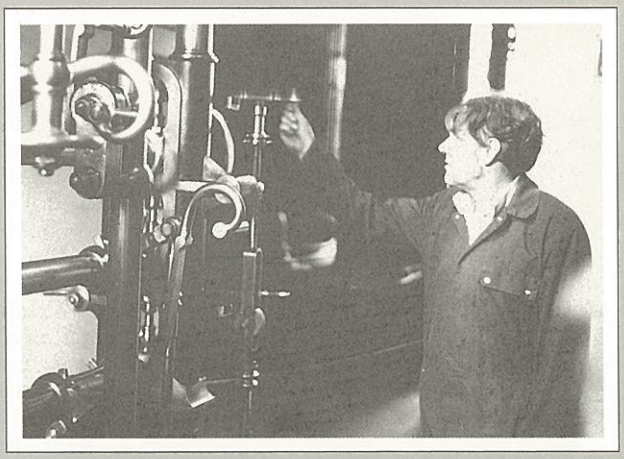


Plate 5 *Valve gear: Starting the Grand Junction 90-inch Cornish beam engine, Kew Bridge Engines Museum; driver, Kenneth Brown.*

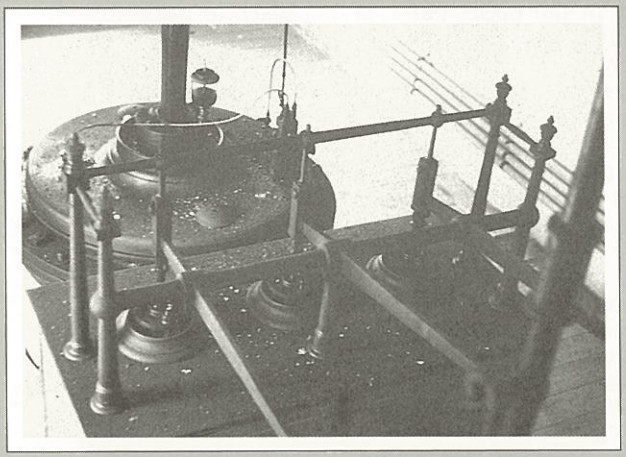


Plate 6 *Top of 50-inch cylinder and nozzles in foreground, Parkandillick beam engine, St Dennis.*

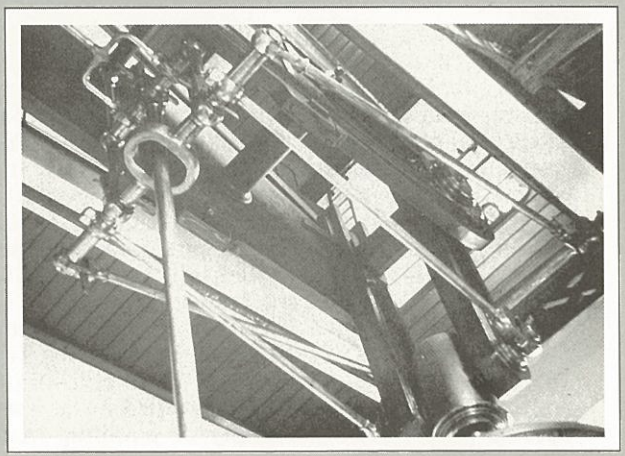


Plate 7 *Piston rod connecting to bob (above) and parallel motion; Grand Junction 90-inch Cornish beam engine, Kew Bridge Engines Museum.*

character and are referred to as 'killas'. The mineralised veins with dominant east-northeast strike and of remarkable straightness are generally located near the contacts with five large masses of granite and a number of smaller ones (Figure 1). The larger granite plutons are exposed as elevated moorlands 600 to 1000 feet above sea level; circular or elliptical in plan they rise on a more or less continuous subterranean ridge from Dartmoor to beyond the Scilly Isles.

The greatest concentration of mineralised veins occurs west and north of the Carnmenellis granite; rich deposits occurred near Camborne, Redruth, Gwennap, St Day, St Just and St Agnes. The mineral districts are characterised by preponderance of a particular metal - the lodes in granite are generally rich in tin and those in killas rich in copper. At the contacts both tin and copper are found and many lodes of this type furnish instances of the variation in proportions of tin to copper with change in depth - copper in the upper parts, giving place to tin below. The ore of tin is invariably cassiterite; it may be associated with arsenic, copper, tungsten, or, rarely, uranium - gangue comprises quartz, chlorite, tourmaline, haematite and mica. Copper mineralisation comprises sulphides, principally chalcopyrite.

The mining methods employed in the Cornish mines, because of similarities in the nature of the lodes, were readily translated by the Cousin Jacks to Wallaroo and Moonta and other South Australian mines (Figure 2).

As the old districts were being worked the mines grew steadily deeper and became more costly to operate. But new rich lodes were discovered. The cliff mines in the St Just area continued to thrive and some extended out under the floor of the Atlantic Ocean, notably at Cape Cornwall, Botallack (Crowns and Wheal Cock), Levant, Wheal Margery (between St Ives and Carbis Bay), Trewavas Mine (near Porthleven) and Wherry Mine (Penzance).

The thriving and expanding mining industry brought other major industrial developments in its wake. Copper was smelted locally for a time, notably at Copperhouse near Hayle, but because of large coal requirements it was more profitable to ship ore to the smelters at Swansea where coal was at hand. The shipment of ore and import of coal led to growth of ports and quays at Hayle, Portreath, and Trevaunance (on the north coast), Devoran and Newham (on the Fal), Charlestown, Par and Looe (to serve the Caradon Mines) and Morwellham (for the mines in Devon). Mineral railways were built, including the Portreath Tram Road in 1815, the Devoran and Redruth Railway of 1824, the Hayle-Redruth Railway, the Caradon-Looe Line and the Devon Great Consols Railway. The great civil engineer Isambard Kingdom Brunel designed and built the Royal Albert rail bridge (Plate 8) across the Tamar at Saltash (opened 1859) and viaducts, remnants of which still survive (Plate 9). Foundries and engineering works were established in the major mining centres and became famous for the supply of pumping machinery and casting of

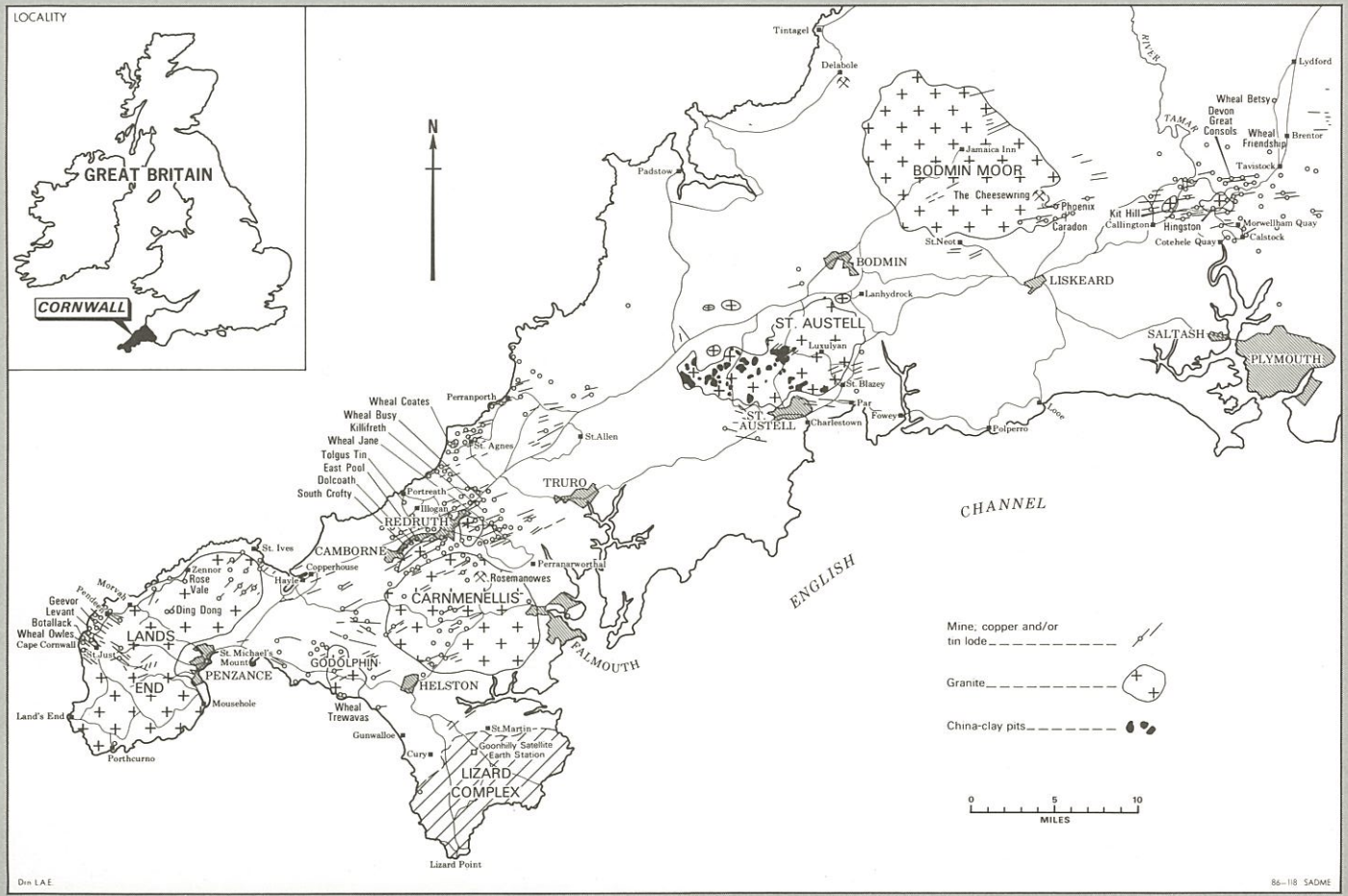


Figure 1 *Mines and mineralisation in Cornwall, showing their relationship to the intrusive granites.*

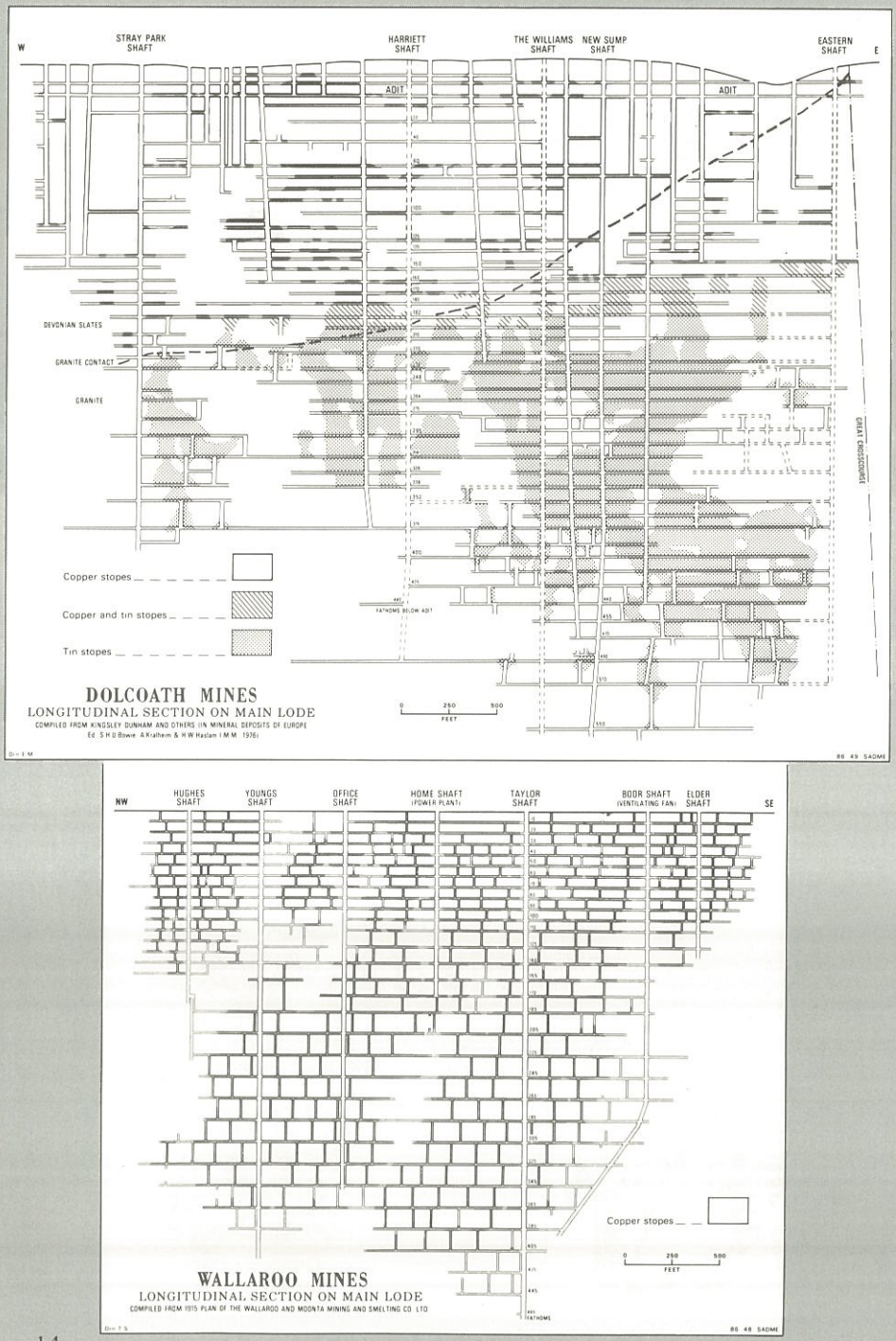


Figure 2 *Comparison of mining methods, Cornwall and South Australia.*

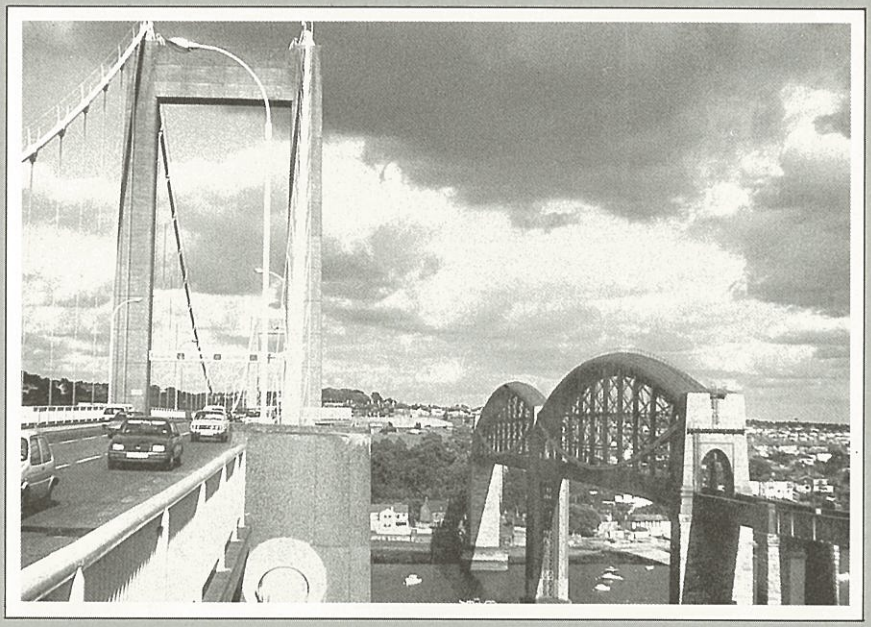


Plate 8 *Saltash: On the right is I.K. Brunel's Royal Albert Railway Bridge (1859). The two main spans across the River Tamar are each 455 feet wide and the total length of the bridge with its 17 approach spans is 2200 feet. In foreground is the road suspension bridge built in 1971.*

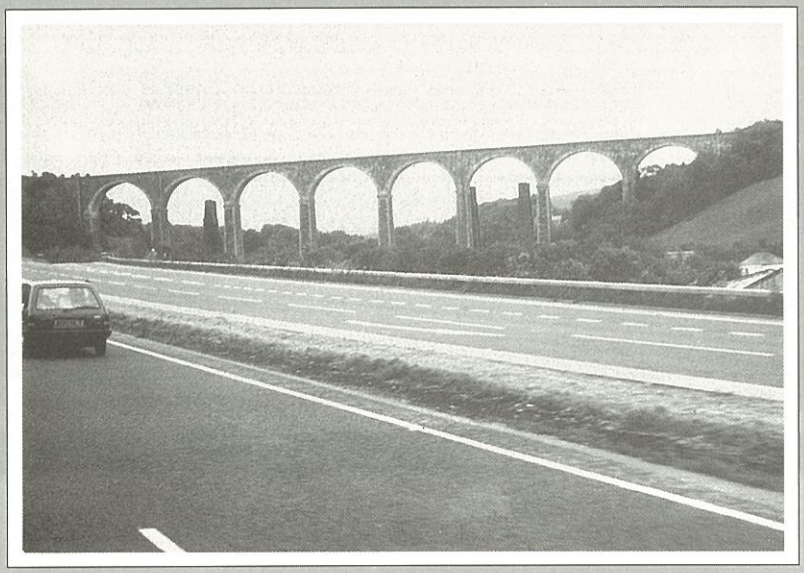


Plate 9 *Railway viaducts which are notable features of the West Cornwall landscape were designed by Brunel. They were built of Baltic pine on tall granite piers and were rebuilt towards the end of the 19th Century - old pillars are visible beyond the modern Mosswater Viaduct near Liskeard.*

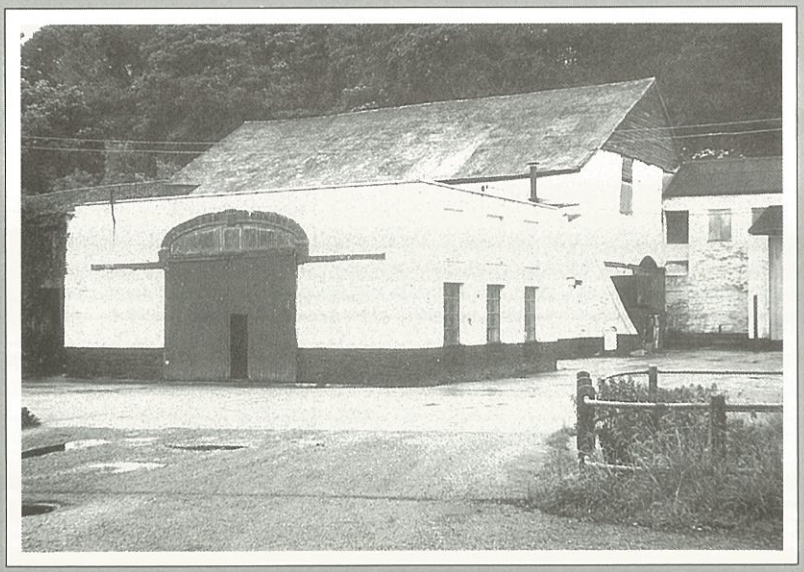


Plate 10 *Perran Foundry (1791), Perran-ar-Worthal, situated on an inlet of the River Fal.*

mining equipment used in every Cornish mine and exported all over the World; they include the Perran Foundry Co. of George Fox at Perran-ar-Worthal (1791) (Plate 10), Hayle Foundry of John Harvey and Co. (1800), Copperhouse Foundry of Sandys, Carne and Vivian (1810), Holman Bros Works at Camborne (1801), St Blazey Foundry (1848), Plymouth, Tavistock and smaller ones at St Just, Charlestown, Tuckingmill, Redruth and Wadebridge.

By 1860 copper mining in southwest England was at its peak, there being 50 000 employed on 400 active mines. The annual output of copper ore totalled 200 000 tons which yielded 15 750 tons of copper metal - almost 75 percent of the World's production. About 10 000 tons of black tin were produced also, 50 percent of World output. Man-engines were developed after 1841 for raising and lowering of miners in the deepest shafts and, by 1862, eight had been installed. On a typical mine there were three engine-houses, the largest at the main shaft for pumping, one nearby for winding and another to operate stamps. On a big mine there might have been a dozen or more engines, as was the case at Botallack, Dolcoath, South Caradon, Wheal Owles, Wheal Vor and United Mines at St Day. Cornwall is reported to have yielded metals to the value of upwards of £200 million 'from hundreds of miles of shafts and thousands of miles of galleries driven, forests of timber were used to support the ground, mountains of ore and rivers of water were brought to the surface by the aid of fleets laden with coal' [Collins (1897)]. The mines were concentrated in West Cornwall, in Penwith to Camborne and Redruth towards Truro, in the St Austell area and from Caradon Hill easterly into west Devon.

The boom reached its peak in the 1860s when there were signs that many of the older districts had bottomed and were more or less exhausted. Faced with competition from abroad, including the new discoveries of copper at Moonta and Wallaroo, mines were closed and workings flooded. The Cornish mining industry was in sharp decline from 1865 onwards. By 1870 copper mining was virtually extinct in Gwennap and in most of west Cornwall. A few of the newer mines with rich lodes such as South Caradon survived for another decade, but by 1880 it was plain that copper mining in Cornwall was at an end. There was no alternative to starvation for the miners but mass migration. A third of the mining population left Cornwall before the end of the Century, taking their skills and mining methods with them, to South Australia and elsewhere.

During Cornwall's long mining history several thousand mines operated and produced about 2 500 000 tons of tin and 2 000 000 tons of copper metal; other metals of minor importance included arsenic (250 000 tons As_2O_3), iron, lead, zinc, tungsten and silver.

METAL MINING, 1985

Since the turn of the Century there have been occasional short lived revivals of tin mining; today, there are three principal active mines but, by World standards, Cornwall is negligible as a tin producer. The Rio Tinto Zinc (RTZ) mining company has acquired control of 80 percent of tin mining output in the United Kingdom and is engaged in exploratory drilling at a number of sites in the region.

Geevor Tin Mines PLC is working a swarm of narrow fissure veins (average 18 inches thick and ranging in width from 1 foot to 10 feet) in the northern sector of the St Just Mining District near Pendeen (Plate 11). Since registration in 1911 the company, in which RTZ metals now have an interest, has raised more than five million tons of ore to produce 50 000 tons of black tin. This amounts to one third of the total produce of the district, the balance coming from a number of mines operating over several centuries of which the last, Levant Mine, closed in 1930.

Since 1960, faced with dwindling ore reserves and surrounded by flooded workings, the company have dewatered Boscaswell Downs Mine to give access to the northeast and the newly discovered Simms Lode, and have sealed a breach between the seabed and the submarine workings of Levant Mine, followed by a staged dewatering to successively deeper levels.

During the last decade work has focussed on the granite contact area and the extensions of the Geevor vein swarm which converge on the Levant workings offshore. This necessitated sinking of a sub-incline extension to the main hoisting Victory Shaft to follow the lower limit of the economic tin zone. Geevor has also extended its operations to include the Botallack Mine and intends reopening Allens Shaft as a base for exploration of the undersea extensions of the old Wheal Owles and Wheal Edward Workings. Development costing £2.2 million is in hand. In 1984, 282 000 tons of ore were treated at Geevor for the recovery of 1015 tons of tin in concentrate; 364 people were employed.

RTZ acquired control of the South Crofty Mine (Plate 12), in November 1984. The present property has brought together twelve former mines at Pool, between Camborne and Redruth, some of which were worked as long as 260 years ago with workings extending to a depth of 2300 feet. A modernization programme costing £10 million is in hand to provide access to the bottom of the mine through a new decline from the surface (Plate 13). In 1984, 600 people were employed; 295 000 tons of ore were treated for the recovery of 1817 tons of tin in concentrate. The ore is much simpler than that of Wheal Jane and recovery is also enhanced because of coarser grain.

In 1979, RTZ purchased Wheal Jane (Plate 14) and Mount Wellington Mine to work as a single operation, two modern but recently abandoned

Plate 11 *Geevor Mine: From left to right - stockpiled crushed aggregate, mill and headframe of Victory Shaft. In foreground, remains of round buddles formerly used for dressing of fine tin concentrate.*

Plate 12 *South Crofty Mine: Head-frame at Robinsons Shaft, 2021 feet deep, near Camborne. Robinsons 80-inch Cornish pumping engine with its 38 ton bob, built in 1854, was the last to operate on a mine (1903-1955).*

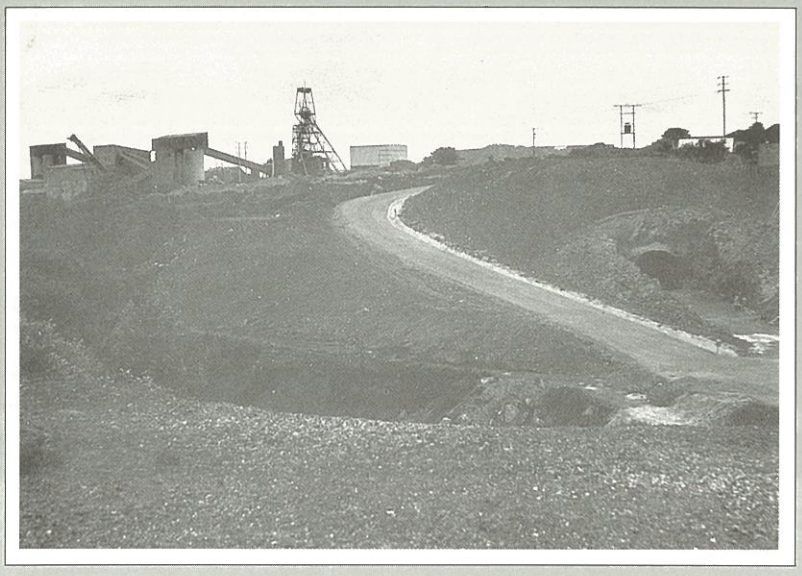


Plate 13 *South Crofty Mine: From left to right - ore bins, head-frame of New Cooks Kitchen Shaft, and portal of major new decline being driven from the surface in Tuckingmill Valley to connect with existing underground workings.*

Plate 14 *Wheal Jane: Surface facilities.*

properties at Baldhu, three miles southwest of Truro. Wheal Jane had been previously opened in 1971 by Consolidated Gold Fields after an investment of £6 million. It had been last worked in 1913 but the complexity of the ore had defeated the treatment methods then available. Thus, a large block of ground had been left almost untouched.

Production from the 1100 feet level of Wheal Jane is by sub-level longwall stoping of two lodes ranging from 2 to 75 feet in width; north lode dips at 44° and south split at 86°. Development has been extended to 1500 feet and reserves amounting to 3 million tons have been defined - run of mine ore grades 0.8% Sn, 0.25% Cu, 2.0% Zn and 7 ppm Ag. In 1984, 295 000 tons of ore were treated for the recovery of 1863 tons of tin in concentrate, 7159 tons of zinc and 657 tons of copper; 415 people were employed.

The Mount Wellington Mine which has been worked on an extension of the same lode system failed to develop as planned because of the unexpectedly high flow of water into the workings. And water remains the main problem - Wheal Jane probably pumps more water per ton of ore raised than any other mine in the World!

CHINA CLAY, ST AUSTELL

Quarrying of china clay (kaolin) is undertaken on a large scale in the St Austell area and contributes one of Cornwall's most important industries.

Kaolin was discovered by William Cookworthy at Tregonning Hill, near Helston, in 1746 within the Godolphin granite pluton. Since that time china clay pits have been worked at St Austell, Lands End (near St Just), on Bodmin Moor and on the southwestern extremity of Dartmoor. Large scale extraction began in the 18th Century and expansion during the latter part of the 19th Century afforded employment to the increasing numbers of tin miners thrown out of work. The most important deposits are located on St Austell Moor where huge conical piles of waste have transformed the landscape (Plates 15,16). Approximately 120 million tons of china clay have been produced and large reserves remain beneath 25 square miles identified as being underlain by kaolin within the St Austell pluton.

The St Austell granite displays a wide range of granite types and facies of hydrothermal alteration. Sodic felspars (albite) have been preferentially converted to kaolinite while potassic felspars have been kaolinized only in areas of more intense alteration. The china clay deposits are roughly funnel shaped, extending to depths of at least 800 feet, with a strong structural control. Kaolinization is not uniform and unaltered granite

Plate 15 *St Austell: Conical piles of waste dumps.*

Plate 16 *St Austell: China clay pits and waste dumps beyond.*

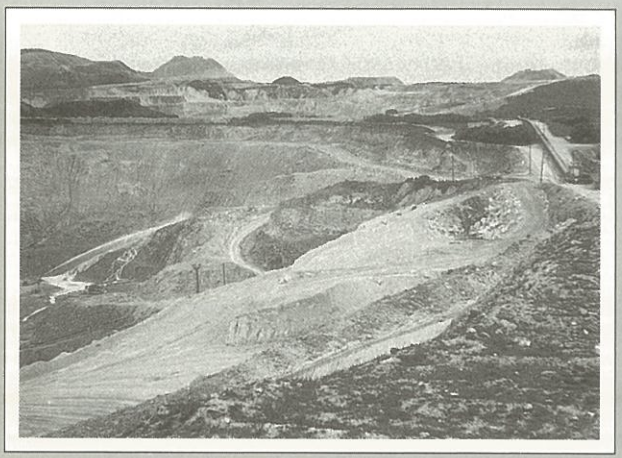


Plate 17 *St Austell: Hydraulic monitor operating in china clay pit (lower left).*

Plate 18 *Old Pound Pit, St Austell: Remote-controlled hydraulic monitor.*

Plate 19 *Carthew area: Rehabilitated waste dumps and water-filled pit.*

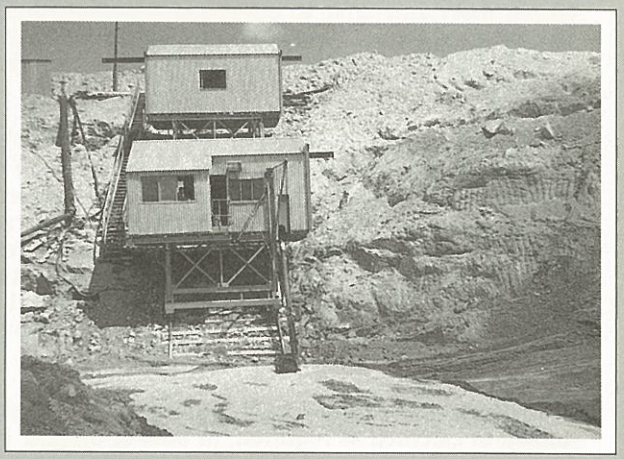


Plate 20 *St Austell: Pump mounted on rim of Old Pound china clay pit.*

separates the ore bodies. The china clay rock comprises up to 15% china clay and up to 10% white mica, the remainder being quartz.

There are twenty-one pits operational, fifteen at St Austell - the principal operator is English China Clays PLC, the World's largest producer of china clay which operates an intensively mechanised industry.

At St Austell five rigs are engaged in a continuous programme of core drilling (down to 150 feet centres) to detail overburden and for computerised evaluation of china clay reserves, open pit mine planning, geology, mining engineering, slope stability, design and economics. Old Pound Pit, the only pit to be opened in the past fifty years, extends over an area of 40 acres and has reserves sufficient for five years production. The largest pit (Little Johns) covers 325 acres; on average, the pits cover 128 acres and extend to almost 400 feet with average depth being 130 feet. Overburden ranges from 5 to 50 feet in thickness and is removed by trucks.

Mining is achieved by using pressurised remote-controlled water cannon which project up to 1200 gallons per minute of water at 300 psi at the pit face to disintegrate the matrix and wash out the clay (Plates 17,18). Bulldozers are used to rip the clay matrix and to create optimum claystream density.

'Stent', the non-clay bearing ground comprising waste rock and quartz, is removed from the bottom of the pit by trucks so that fresh faces are continuously exposed. Up to a dozen hydraulic monitors may be operated in rotation to maintain a consistent blend. Approximately 7 tons of waste are separated for each ton of clay recovered. The waste was formerly elevated to form extensive white conical piles adjacent to the pits and which formerly typified these operations. However, waste dumps are now less obvious in compliance with new requirements to improve stability, to conform more closely with natural landscape profiles, and to provide slopes more amenable to establishment of rhododendrons, gorse, willow, shrubs and grasses. Worked out pits are variously backfilled with mica waste or used to provide storage for water for clay extraction and processing (Plate 19).

The claystream, comprising suspended china clay, fine sand and mica residues, is pumped from a sump in the floor of the pit (Plate 20); after separation of quartz sand, it is transferred to settling tanks 1.4 feet in diameter and 10 feet deep. Water overflow is recycled to pit monitors while the slurry is dewatered and processed in central refining plants to produce blends of required specification. Separation is achieved through spiral classifiers, hydrocyclones, use of chemical dispersant, centrifuges and ultraflotation (Plate 21), bleached to improve brightness and dried in filter presses (frame or tube types).

Products are shipped as a slurry, with variable content of moisture, milled or calcined as required, in bulk or bagged. High intensity magnetic

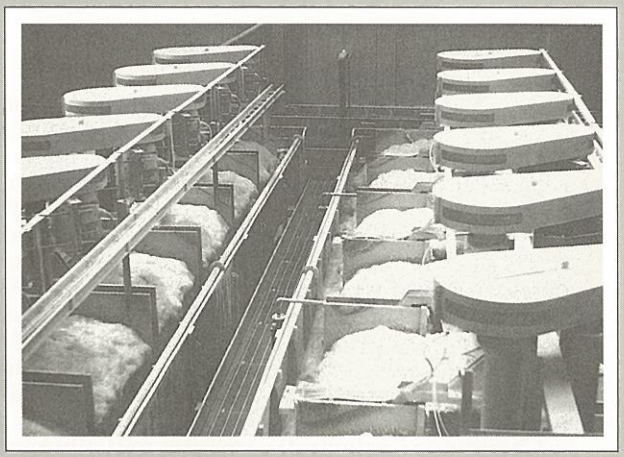


Plate 21 *English China Clays PLC, St Austell: Lines of flotation cells for recovery of kaolin.*

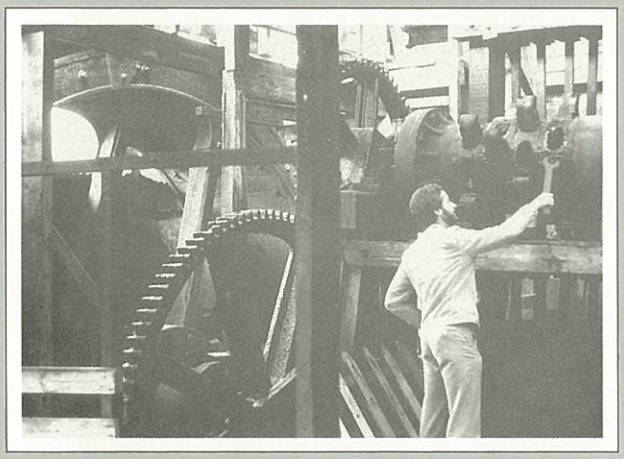


Plate 22 *Tolgus Tin Mill: Twelve-head Cornish stamps powered by 150 year old 14 feet diameter waterwheel; Greg Drew adjusts lifters.*

Plate 23 *Geevor Tin Mines museum, Pendeen: Cornish stamps driven by water-wheel.*

separators are used to remove iron bearing minerals from clays for the ceramics industry. Close quality control is maintained throughout.

Production, amounting to 2.75 million tons in 1984, is loaded out by rail or road for the United Kingdom market (15%) or shipped out from Par and Fowey for the Continent (60%) and from Plymouth for other overseas destinations. About 82% of the product is used by the paper industry as a filler or as a coating pigment (40% in high quality paper and 5% for newspapers); the ceramics industry uses about 13% for china porcelain, sanitary ware, pipes and insulators; 5% is used as a filler or extender in paint, rubber, plastics, medicines and toothpaste. The china clay industry employed 6400 people (in Cornwall and Devon) in 1984.

Chinastone ('petuntze') comprises partially kaolinized granite in which plagioclase is intact but the orthoclase has been replaced. It occurs over an area of 25 square miles in the western part of the St Austell granite mass. Being well jointed, the rock is readily quarried and ground into a fine powder for use in ceramics and in manufacture of high quality porcelain.

CORNISH MINING HERITAGE

There is intense interest in Cornwall's mining history, as evidenced by the number of mining museums available for which charges are made for admission, and their popularity with tourists. It is reported that over 50 000 formerly visited Tolgus Tin Mill annually and 100 000 visit Morwellham Quay, annually. It is noteworthy that many of the operating mines maintain a museum. At each, informative introductory audio-visual presentations recount history and provide a background to the mining activity concerned and its relevance to the region; displays include maps and photographs, relics, tools of trade, machinery, mineral specimens, etc; book stalls, souvenirs, food and refreshments are available.

Tourist mines have been established to provide a picture of underground metal mining activities of the past at Morwellham Quay (George and Charlotte Mine) and at Wendron Forge, three miles northeast of Helston where the 'Poldark' Mine (formerly Wheal Roots) is open to the public as a mining museum. A private mine which is available for inspection by arrangement is the Rosevale Mine, near Zennor, owned by Mike Shipp.

Tolgus Tin Mill, one mile west of Redruth, has been operating for over 200 years (Plate 22). Production amounting to 20 tons of tin concentrate annually is based on scavenging of remnant gravels discarded during the course of previous mining activities. The former visitor centre is now closed and the mill is used to treat ores from Wheal Concord and from re-working of old burrows.

Geevor Mine operates a tourist amenity open to the public, comprising a video film showing surface and underground activities and featuring the history of tin mining in the County, a display of mining and milling tools, a Cornish mining museum (including the Trevithick Collection), an 8-head stamp battery operated by water-wheel which formerly operated at Locke near Nancledra and was re-erected at Geevor in 1984 (Plates 23 and 24), and guided tours of the working surface treatment plant producing tin concentrates.

The biggest slate quarry in the United Kingdom at Delabole (Plates 25 and 26) has operated since Elizabethan times and is renowed for an arrray of roofing, paving and walling materials and of Delabole blue slate, in particular. A working museum is open to the public. The Carnglaze slate caverns and slate quarries, a half mile south of the village of St Neot are also open to visitors.

The Wheal Martyn Museum (Plate 27) in the heart of the clay mining district 2 miles north of St Austell explains the history of this unique industry. There is an audio visual presentation together with indoor displays and models relating to the china clay industry. Its special attraction is an open air museum which includes a viewing area on the rim of an operating clay pit, relics of an earlier phase of mining and processing including wagons, locos, settling tanks, mica rakes, dries and water-wheel operated pumps (Plates 28 to 32). The 18-foot diameter water-wheel was constructed in 1902. Charlestown Harbour and Dock, 2 miles southeast of St Austell, is a port built in 1800, formerly for shipment of china clay and copper ores (Plate 33).

Museums featuring mineral displays include the Penzance Geology Museum, comprising the collections of the Royal Geological Society of Cornwall, founded in 1814 and being the second oldest geological museum in the World; the County Museum in Truro, together with a range of miners' tools and machinery; Camborne School of Mines, founded in 1859; Holman Bros, Engineers, formerly maintained a mining museum in Camborne but the collection is now dispersed, mainly to Wendron Forge and Geevor (Trevithick collection).

The most obvious relics of Cornwall's mining past are the engine-houses and their associated chimney stacks which are prominent features of the landscape throughout the old mining districts (Plates 34 to 39). These 'Cornish castles' were mostly of thick walled granite construction that might have been expected to last forever. However large numbers have been demolished and, of the remainder, deterioration through exposure to the weather is evident.

Concern for preservation of a fast declining stock of steam engines led to the establishment of the Cornish Engines Preservation Society which dates from 1935 and grew out of activity of a group of enthusiasts to acquire and preserve the whim at Levant Mine. Records of other engines and buildings were compiled and five engines in working order acquired

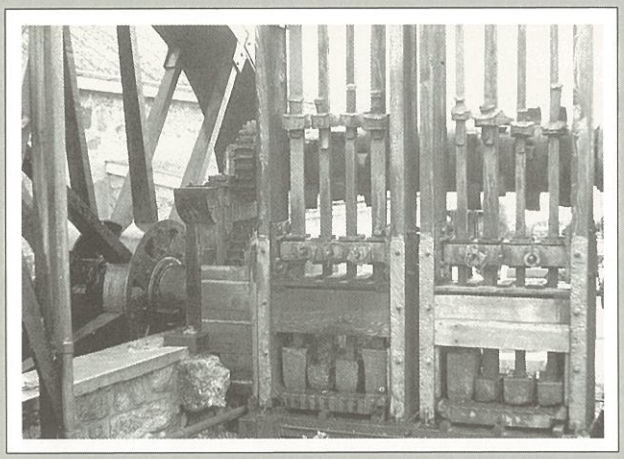


Plate 24 *Geevor Tin Mines museum: Cornish stamps.*

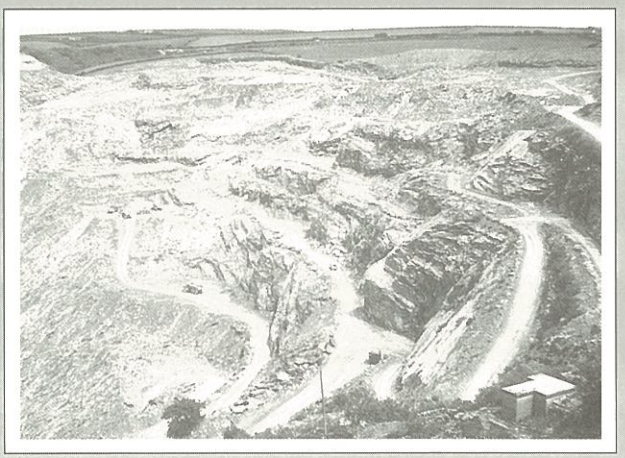


Plate 25 *Delabole slate quarry, 500 feet deep.*

Plate 26 *Stocks of slates, flags and walling materials at Delabole.*

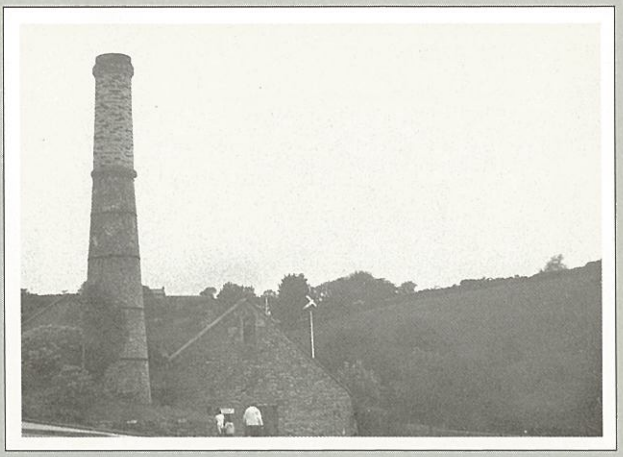


Plate 27 *Wheal Martyn museum: Cornish clay industry*

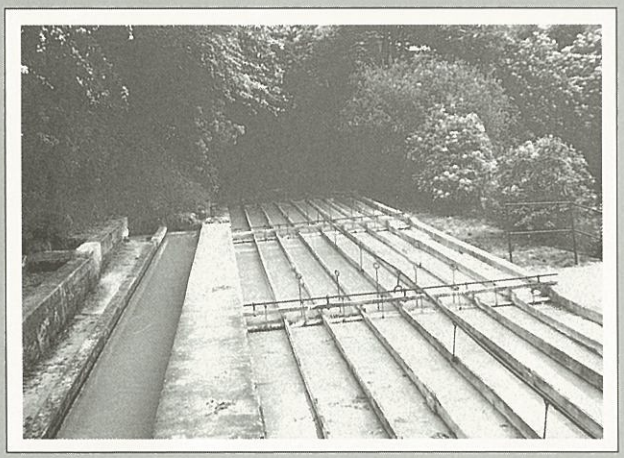


Plate 28 *Wheal Martyn: Mica drags.*

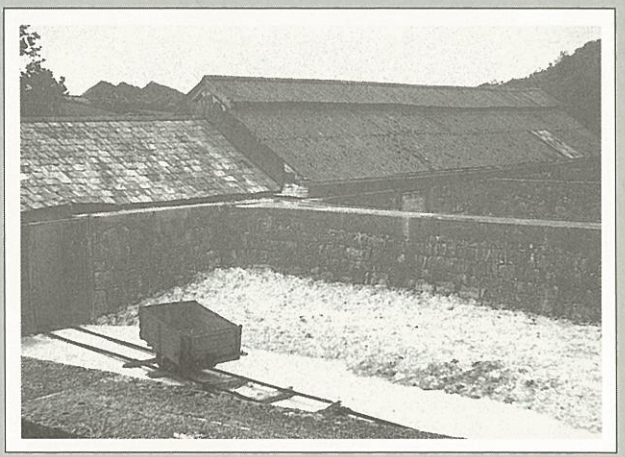


Plate 29 *Wheal Martyn: Clay drying bays and sheds.*

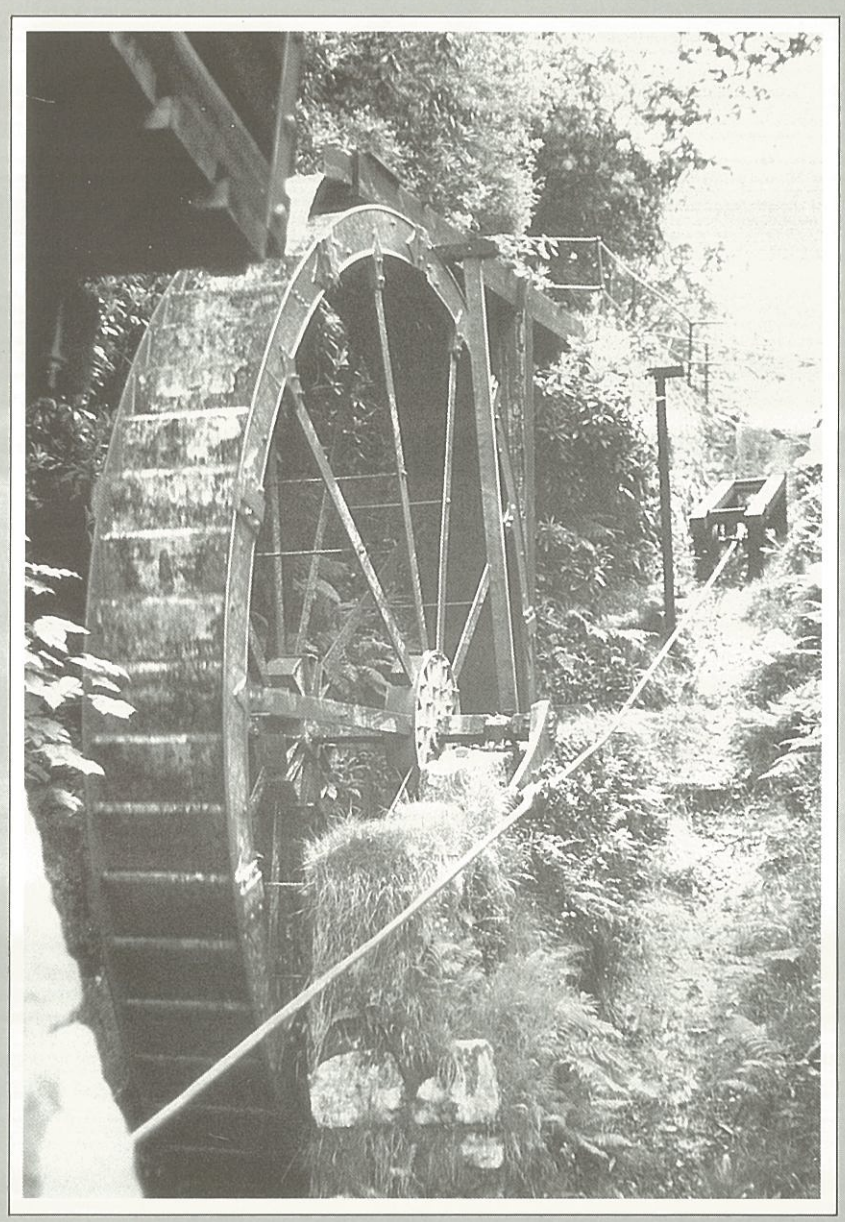


Plate 30 *Wheal Martyn outdoor museum: Waterwheel 18 feet in diameter with counterweight actuating flat rods to waterpump (see Plate 31).*

Plate 31 *Wheal Martyn: Pump powered by waterwheel with clay settling tanks in foreground.*

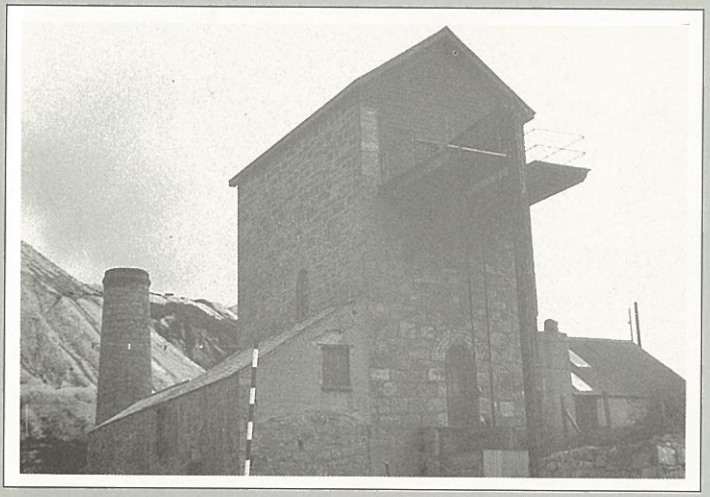


Plate 32 *Parkandillick 50-inch cylinder pumping engine at St Dennis (1919-1956), preserved in working order (built in 1852 and formerly installed at St Agnes).*

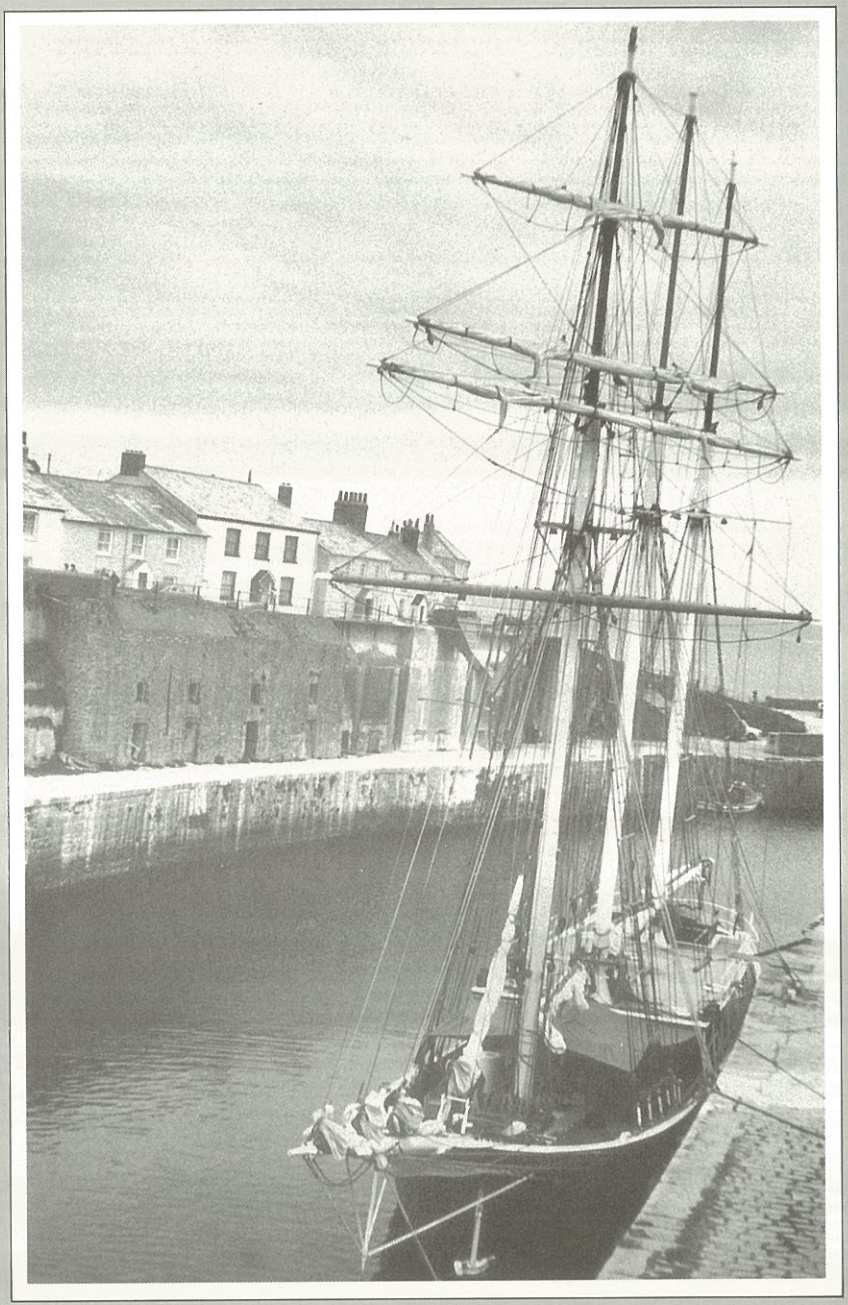


Plate 33 *Charlestown: Old shipping quay.*

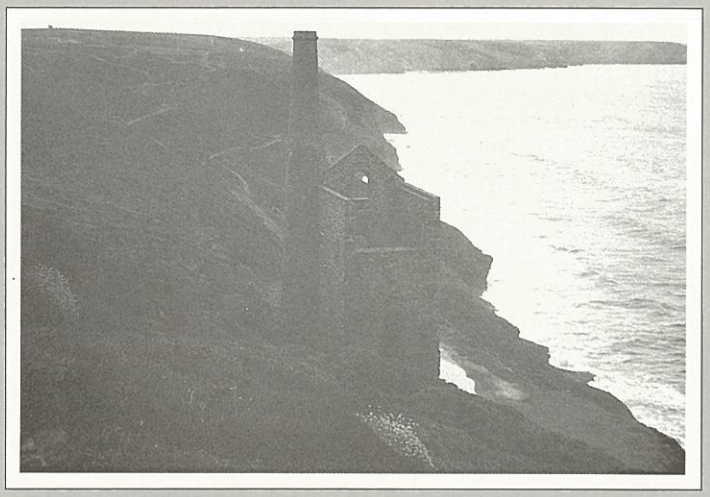
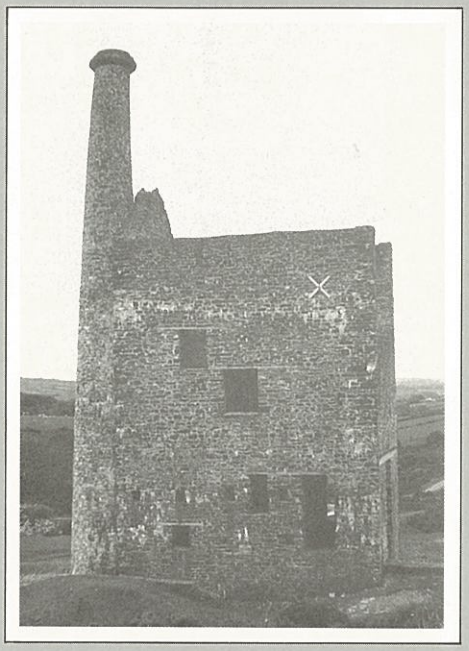


Plate 34 *Wheal Coates, Chapelporth, St Agnes: Sixty-inch pumping engine house on Towanroath Shaft (636 feet deep - closed in 1885).*



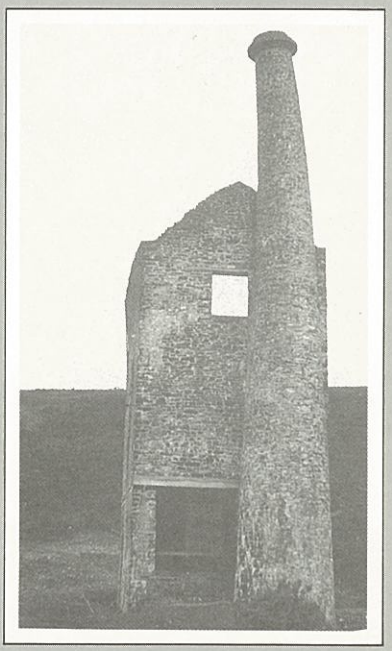


Plate 35 and 36 *Wheal Betsy engine-house with peculiar curved chimney stack at Mary Tavy near Tavistock. The restored structure is on Jobs Shaft (852 feet deep), a silver/lead producer during the period 1806-1877.*

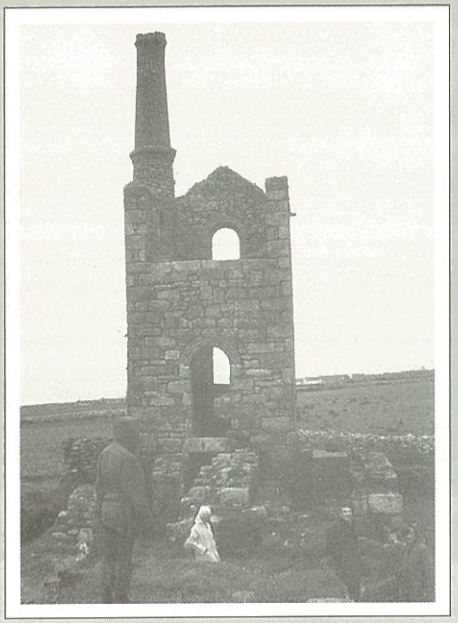


Plate 37 *Levant engine-house, Higher Bal: This contained a combined engine; the flywheel, pumping crank and drum were located within the masonry foundations at the front of the house.*

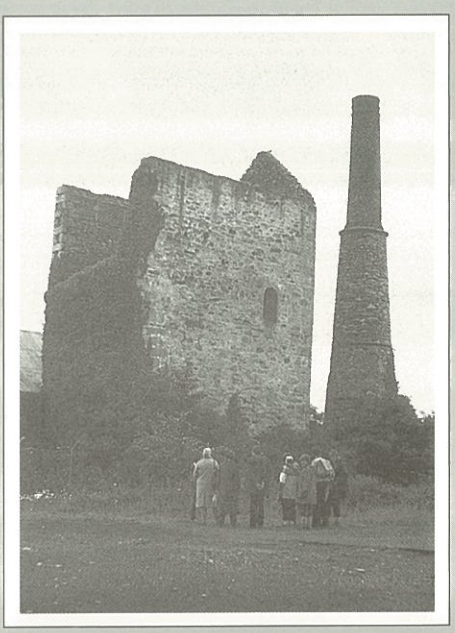


Plate 38 *Wheal Busy engine-house, built in 1856: This contained three different 85-inch engines at different times, the last being scrapped in 1952.*

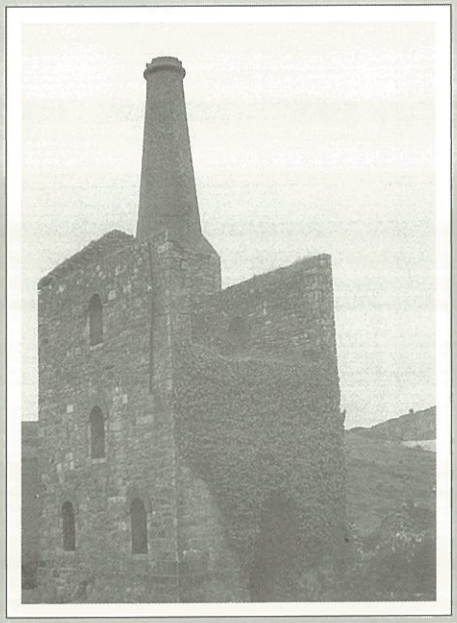


Plate 39 *Engine-house for 80-inch pumping engine, Prince of Wales Shaft (1200 feet), erected on reopening of Phoenix Mine (1907-1914). Cheesewring tors and the granite quarry on Bodmin Moor are in right background. Granite was carried by the Liskeard-Caradon railway which ran from the floor of the workings to the shipping port at Looe for export (1858-1916).*

and placed under the care of the National Trust. In 1969 the CEPS amalgamated with the Cornish Water-Wheel Preservation Society to form the Trevithick Society. The interests of this body now cover all aspects of industrial archaeology in Cornwall.

Pumping engines had been disappearing at a rapidly accelerated pace by the closure of mines, by salvage and through replacement by electric power. Through the efforts of the above groups and with public support and of that of sympathetic mine operators, nine are now preserved in working condition in Cornwall - five others are preserved at Kew Bridge Museum. Despite their bulk and weight, the engines were commonly transported, erected and dismantled for removal to different houses as fortunes of mining rose and fell. Those that now survive and whose future is assured include the following:

- 24-inch rotative beam winding engine, Levant Mine (operated 1840-1930) (Plate 40). This is the oldest engine in Cornwall; in care of National Trust
- 22-inch single acting rotative engine (operated 1851-1952). Formerly operated at Rostowrack Clayworks and exhibited in the now defunct Holmans Museum in Camborne, this is now awaiting re-erection at Wheal Martyn Museum
- 80-inch Robinsons Pumping Engine on Robinsons Shaft, South Crofty Mine (operated on four different mines 1854-1955 and the last to work on a mine); in care of National Trust
- 90-inch pumping engine on Taylors Shaft, East Pool and Agar Mine (operated 1892-1954) (Plates 41 and 42); in care of National Trust
- 30-inch double acting rotative beam winding engine (Michells Fire Whim), East Pool Whim (operated 1887-1921) (Plate 4); in care of National Trust and now driven by electric motor for demonstration purposes
- 40-inch pumping engine, Carpalla Clayworks. Formerly worked at West Polbreen Mine and afterwards moved to West Kitty Mine, St Agnes before removal to St Austell, this was operated from 1863-1944 and is now stored at the Science Museum, London
- 50-inch pumping engine, Goonvean Clayworks. Originally worked at Penhalls Mine, Trevaunance and Gooninnis in St Agnes Parish, before removal to St Austell, this operated from 1863-1956
- 50-inch pumping engine, Parkandillick Clayworks, St Dennis. Worked at Wheal Kitty, St Agnes, before removal to its present site in 1912, this operated between 1852-1956 (Plate 32). It is preserved by English China Clays PLC and is operated by low pressure air

- 30-inch pumping engine, formerly at Greensplat Clayworks, St Austell where it worked until about 1960; now at Wendron Forge (Poldark Mine).

The National Trust has acquired ownership of lands adjacent to the coast to assure preservation of engine houses at Wheal Coates, Towanroath Shaft, St Agnes (Plate 45); Wheal Prosper, Rinsey Cliff, Breage; Carn Galver; Zennor; and Wheal Betsy at Mary Tavy, Devon (Plates 35 and 36).

The Levant engine and house (Plate 40), on land worked by Geevor Mine, is owned by the National Trust and is about to undergo complete restoration.

The Crowns engine houses at Botallack (Plates 43 and 44) have been restored by the Carn Brea Mining Society who now hold a lease from Lord Falmouth. Scaffolding was still in place in late June following repairs to the cliffside engine houses of The Crowns (Botallack Mine) at a cost of £40 000 and for which public donations were being sought. The stacks of Kit Hill Mine and Cape Cornwall Mine (Plate 46) have been preserved as monumental landmarks.

There is little to show at the surface for other 'champion' mines such as Dolcoath (Plate 47), the deepest and most celebrated old copper and tin mine in Cornwall, and Devon Great Consols, the former great copper mine of Devon. The Trevithick Society proposes to undertake a full-scale archaeological survey and excavation of the site around New Sump Shaft.

The Devon Great Consols Mine operated during the period 1844-1901, the principal lode extending 2 miles in length. Mineralisation, rich in copper with arsenopyrite, close to the surface and comprising the last great copper discovery in the west of England, extended through a belt 4 miles wide and 12 miles long between Callington and Tavistock, with less important north-south trending lead lodes. Workings extended to a depth of 1200 feet and exploration was undertaken to a depth of 1800 feet in a vain search for tin. There were 45 miles of underground levels serviced by twelve main shafts. Production amounted to 750 000 tons of copper ore and 72 000 tons of refined arsenic.

Because of the ready availability of water from the Rivers Tamar and Tavy, mines in this district made full use of water-wheels in their operation through a system of leats over 8 miles long. At Devon Great Consols thirty-three water-wheels, underground and on the surface, were used to drive machinery, power being transmitted through extensive lines of flat-rods.

During the last phase of operational life this mine, and some 100 others in the region, turned to recovery of arsenic which was in demand for use in dyes, paint, glass and to control boll weevil in American cotton

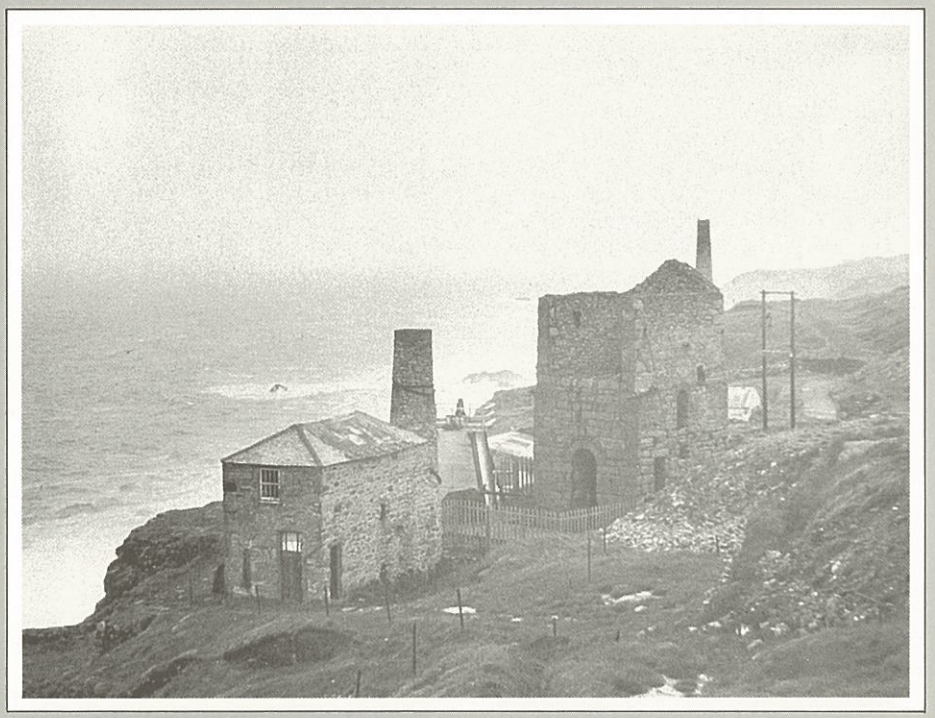


Plate 40 *Levant Mine, at the head of Levant Zawn on the edge of the cliff above the Atlantic Ocean, was one of the richest mines and among the most famous. Extending for 2 miles beneath the sea at 2100 feet below sea level, it operated continuously during the period 1820-1930 (a Cornish record) to produce 26 000 tons of black tin and 130 000 tons of copper ore and arsenic.*

Pump house on right is situated above an engine shaft 2150 feet deep.

Engine-house at left contains 150 year old winding engine which wound from Skip Shaft.

Plate 41 *Taylors Shaft engine-house, Redruth: View from Michells whim, East Pool.*

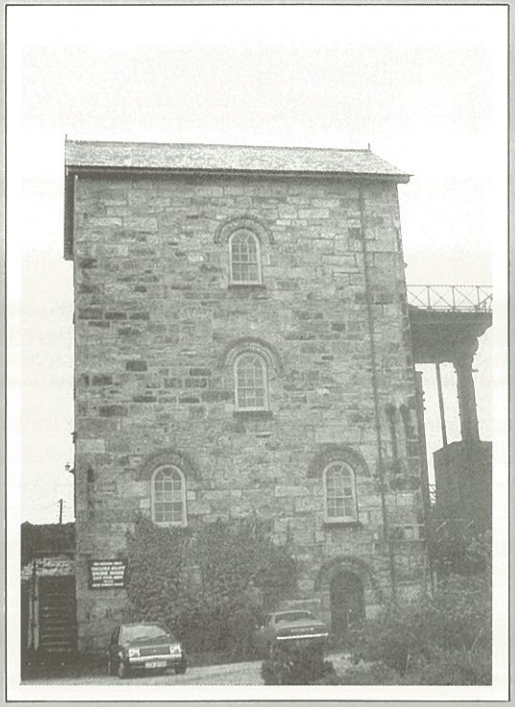


Plate 42 *Taylors Shaft (1680 feet deep) engine-house, East Pool Mine (1924-1954) contains a Harvey & Co. 90-inch Cornish pumping engine with a ten foot stroke in the cylinder, and a nine foot stroke in the shaft. The engine was brought from Carn Brea Mine in 1924. The bob, built in 1892, is 33 feet 3 inches in length and weighs 56 tons, the heaviest ever made.*

Plate 43 *Botallack Mine: The lower engine-house is that of the 36-inch pumping engine on the Crowns Engine Shaft (1841). The engine-house above contained the winding engine (1860) which drew ore from the Boscawen Diagonal Shaft; this was 2616 feet long and at an angle of 32½° to allow working to the 1500 feet level under the bed of the Atlantic Ocean, 2580 feet beyond the cliffs and 1360 feet below sea level.*

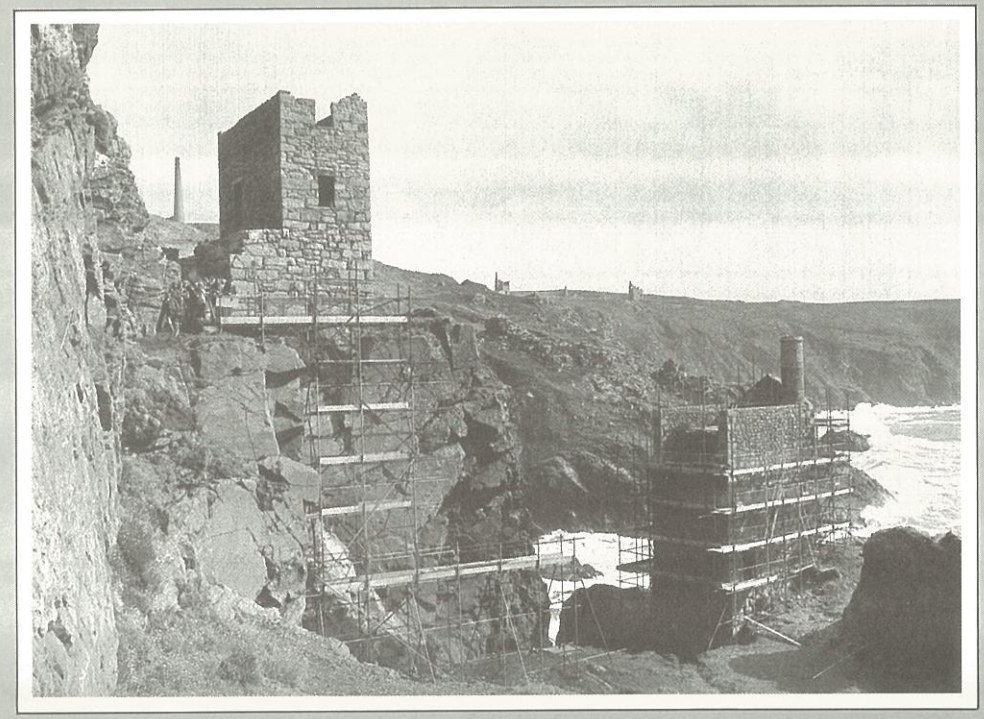


Plate 44 *Botallack mine: The Crowns section showing engine houses under repair - view towards Wheal Edward and Wheal Owles, St Just Mining District. The mine operated from 1721 but principally between 1836 and 1895, producing tin and arsenic in the inland lodes from granite, and copper from killas from submarine workings. Note chimney stack located within pump house.*

Plate 45 *Stamps engine house and winder house (background) on the cliffs at Wheal Coates, Chapelporth, above Townroath Shaft. The Engine-house was built of killas in 1872.*

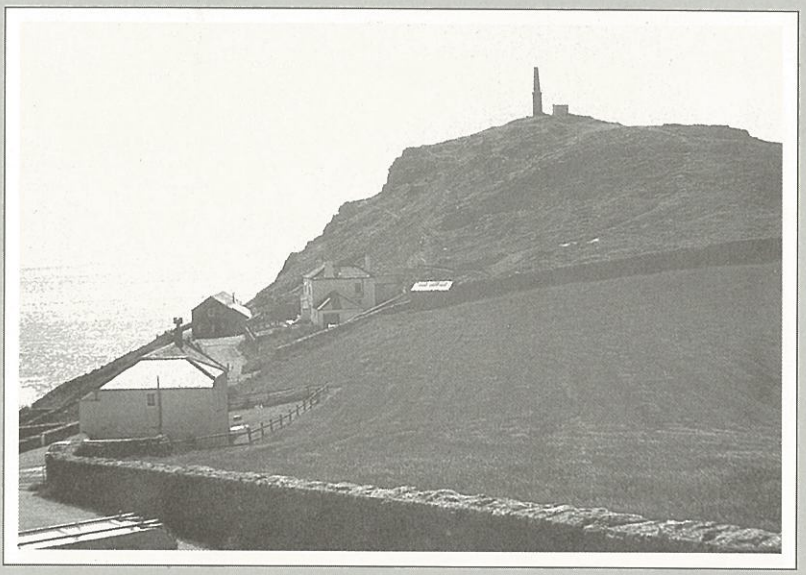


Plate 46 *Cape Cornwall Mine whose chimney stack, erected in the 1850s, can be seen on the headland, was 600 feet deep with levels extending beneath the sea.*

Plate 47 *Dolcoath pumphouse site, Camborne, being excavated by the Trevithick Society, near Dolcoath Counthouse. This was considered to be the 'first' mine in Cornwall, being the richest and deepest; it produced 355 500 tons of copper from the shallowest levels in killas and 93 500 tons of black tin from the deepest levels in granite to 3 300 feet. New East beam whim engine house is in background.*

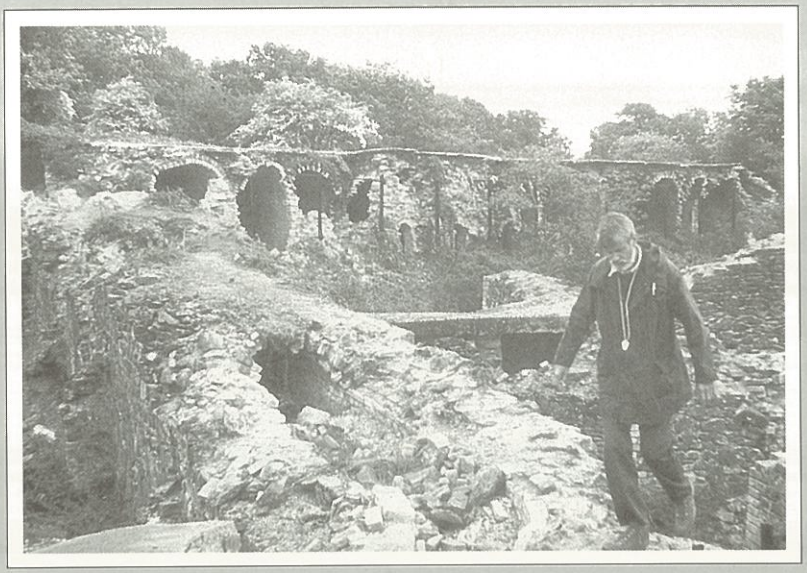


Plate 48 *Wheal Friendship: Labyrinth of arsenic flues.*

crops and the Colorado potato beetle. This had the effect of prolonging lives of some mines for almost 30 years which assumed a predominant position in output of arsenic during the period 1868-1914 (Plate 48).

Morwellham Quay, located on the east bank of the Tamar southeast of Gunnislake and 20 miles from Plymouth, serviced the requirements of the mines in the district until connection by rail was made between Plymouth and Tavistock in 1859 when it ceased to be used as a navigable waterway. In its heyday it served as a terminal for the Tavistock Canal (completed in 1817 after development of copper mines such as Wheal Friendship in the 1790s) and a private railway - terminating as inclined planes - and as a tidal shipping port and dock. Copper ores,arsenic and manganese ores were exported; coal, iron for foundries, timber, machinery and supplies for the mines were brought in through this port.

Lime for agricultural use on local acid soils was burned on site from limestone brought from Plymouth. The kilns were built during the period 1770-1830; the lime trade reached its peak during 1810-1850.

The Dartington Amenity Research Trust acquired land adjoining Morwellham Quay in 1970 adjacent to the Duke of Bedford's cottages and restored the site at a cost of over £150 000, following 60 years of neglect. Silt was cleared from the dock, buildings rehabilitated and facilities installed to replicate middle 19th Century usage when this was the most important copper ore export centre in Europe (1850-1860) and when over 200 people lived and worked here (Plates 49 and 50). Restoration was completed in 1981. The assayer, blacksmith, cooper, chandler, in period dress, demonstrate their crafts to visitors and there are informative museum displays. An introductory slide show is given on arrival. The open air museum is visited by 100 000 annually. The adit of the nearby George and Charlotte Mine has been rehabilitated and visitor access is provided into the underground 'workings' by electric tramway.

While there were many other quays on the Tamar on which lime kilns were based and from some of which copper ores were shipped, the only other one of tourist interest is Cotehele Quay, down river of Calstock. Attractions include a museum, the rehabilitated *Shamrock* (built in 1899) (Plates 51 and 52), lime kilns and docks, and Cotehele House which belonged to the Edgcumbe family from 1353 until it passed to the National Trust in 1947.

KEW BRIDGE ENGINES

The Kew Bridge waterworks engines are the only large working survivors of the Cornish beam pumping engine. On a site shared with the Thames Water Authority, the Kew Bridge Engines Trust and Water Supply Museum has, since 1975, featured and preserved steam engines,

including five Cornish beam pumping engines, that pumped water from the River Thames to service London requirements for over 100 years (Plates 53 and 54).

Cornish engines are 'steamed' each weekend by volunteers, including a Boulton & Watt 64-inch West Cornish Engine dating from 1820, the Grand Junction 90-inch engine built in 1846 and the 65-inch Maudslay (1838). Cornish engines on display but not working include a 70-inch Bull engine and a 100-inch beam engine built in 1869. Other stationary and traction engines are on display together with water supply relics, a forge and machine shop.

To see these great engines in steam is to appreciate in some measure the prose of Bryan Earl (1968) and the fascination of their operation:

> A working Cornish Pump was indeed a sight to see. The great stone building, with its arched doors and windows, stood right at the heart of the mine. Going inside, one was met by the neat, turned woodwork furnishings, and the clean sweet smell of the hot oil characteristic of a working steam engine. The enormous cylinder, usually clad with varnished wood bound with polished brass, stood in the middle. The brightwork of the valvegear, spotlessly polished, twinkled as the scoggan catches smoothly operated the valves. Led up the staircase by a proud engineman, one came to the floor, the 'middle chamber', with the great cylinder cover and nozzles, the shining piston rod disappearing up into the complex of the parallel motion and main beam. One more trip up the balustraded stairs to the bob - the huge beam, swinging quietly up, pausing, and then majestically sweeping down again. At the 'nose' of the beam was hung the first of the pump rods, probably of 18 in. square pitchpine, disappearing all the way down the shaft below - perhaps more than 2000 feet. The bob paused at the top and bottom of the stroke to control the rate of pumping (timed by the cataracts), and to allow the valves to seat all the way down the shaft.
>
> The whole engine was remarkably quiet, and all that could be heard was the soft, deep 'Boom' as the steam rushed into the condenser, quickly followed by the sound of fresh steam entering the cylinder through the steam valve, the clicking of the valvegear and the flow of water into the pan of the air pump, at each cycle. Coming down and out of the engine-house, one might see a sudden brilliant orange glare, as a firedoor on the boilers was opened to let a shovel full of coal be thrown on the fire, just 'so', in such a way that the coal landed in the right spot to give an even firebed. Of steam, smoke or noise there was practically none.
>
> The last of these wonderful engines on a Cornish mine, at Robinson's Shaft of South Crofty, stopped work in 1955, after 101 years of active life.

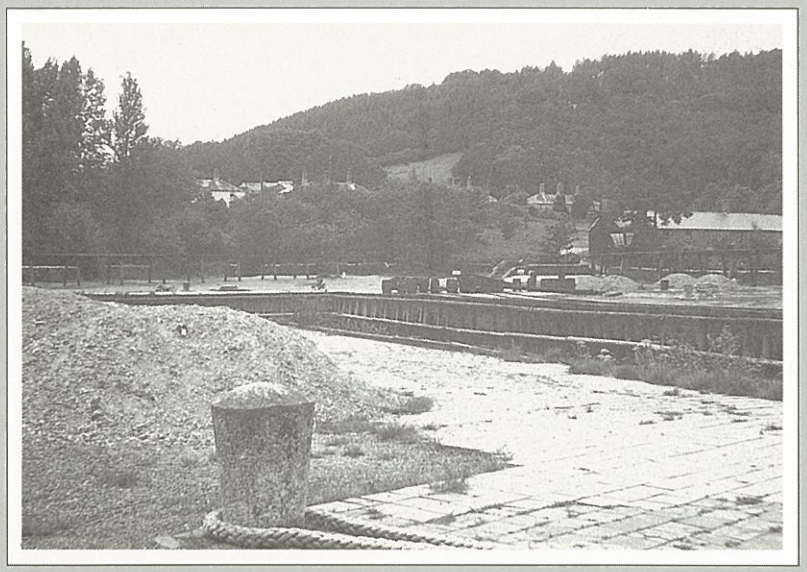


Plate 49 *Morwellham Quay, with ore floors extending beyond granite bollard to dock; elevated railway is in background.*

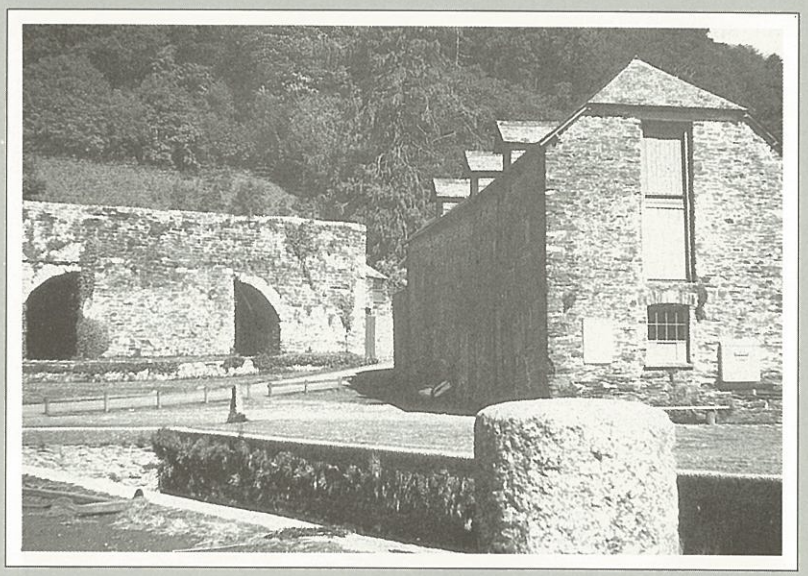


Plate 50 *Morwellham Quay: Lime kilns at left, museum with indoor displays at right.*

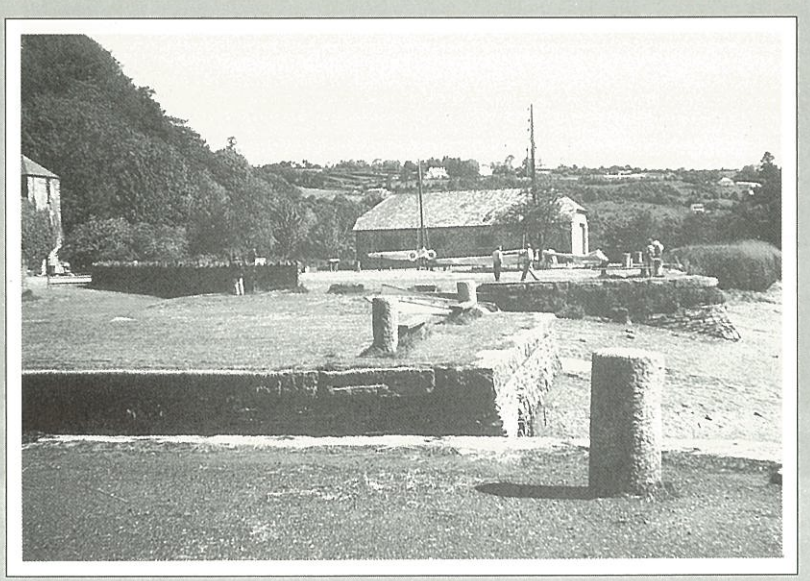


Plate 51 *Cotehele Quay.*

Plate 52 *Cotehele Quay with the 'Shamrock'.*

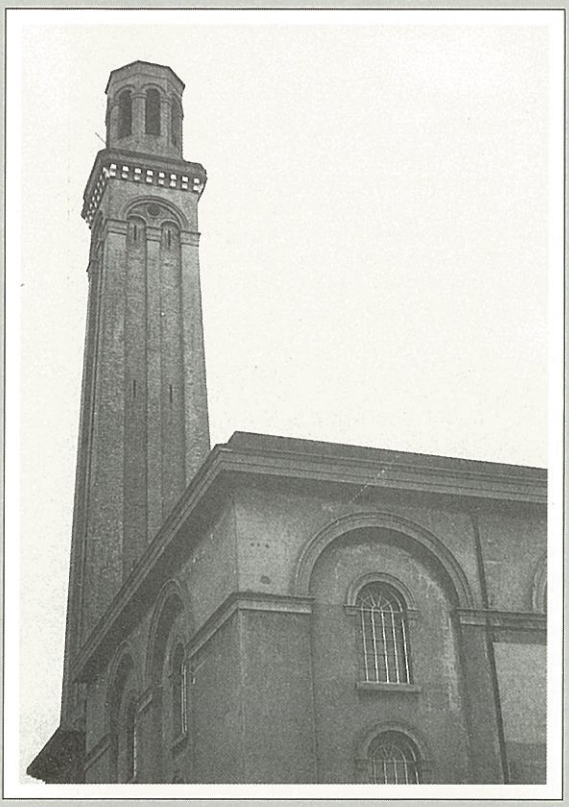


Plate 53 *Kew Bridge Engines Trust and Water Supply Museum: Standpipe tower (1867).*

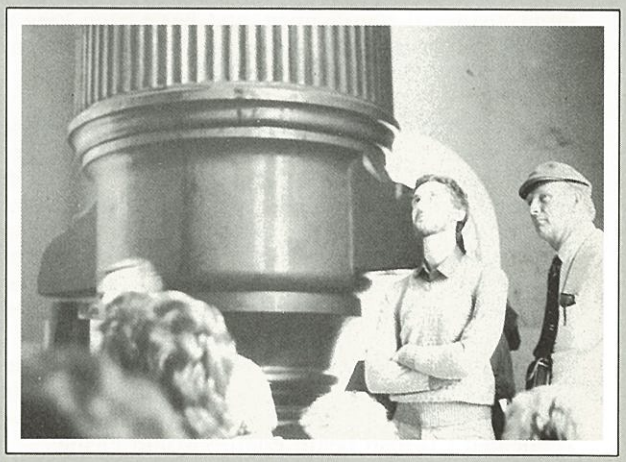


Plate 54 *Pump plunger and weight box at the end of outdoor stoke, Grand Junction 90-inch Cornish beam engine, Kew Bridge, with Greg Drew and Richard Hancock. Note catch wings which support the plunger when the engine is at rest.*

SOUTH AUSTRALIAN MINING HERITAGE

Concerned individuals, local authorities, and several Government Departments have done much to promote awareness of South Australian mining heritage, in recognition of items and sites of historical significance and in contribution to literature, by documenting history, and by industrial archaeology. Thus, a number of sites and items have been secured through placement on the State heritage register and progress made in planning for their management, as at Moonta and Wallaroo, at Burra and Glen Osmond. Walking trails with points of interest identified have been established in the Jupiter Creek gold mining area near Echunga and at Talisker silver lead mine.

However, much remains to be done as there are many other relics at these and other mining fields that are worthy of preservation and, unless action is taken to purchase the land on which they are situated or they are otherwise appropriately vested, they will continue to decay and be irretrievably lost.

The engine-houses that survive in South Australia are fine examples of structures that formerly supported steam-powered engines, of particular relevance in supplementing those in Cornwall on which they were based. Engine-houses and chimney stacks at Moonta, Burra, Worthing, Balhannah, Grunthal and Prince Alfred Mines are in remarkably good condition. However, there are other masonry structures which require immediate attention if they are to survive, at these and other centres.

My observations in Cornwall suggest that we are on the right track with regard to catering for tourist and other interest at Kapunda, Burra, Moonta and Wallaroo - sites which are strategically located and where rehabilitation and management programmes are in hand. But relics on other mining fields, many of them much closer to Adelaide, are also of great historical significance, and have been long neglected; these include the old mines of Glen Osmond, Worthing, Balhannah, Grunthal, Wheal Ellen, Aclare, Kanmantoo and Bremer.

For its part the Department of Mines and Energy has endeavoured to foster awareness of South Australian mining heritage through publications, lectures and field activities, interpretation and identification of mining relics, conducting excursions for school parties and other interest groups, etc. In the State's 150th year and in anticipation of the Australian Bi-Centenary, concerted effort is being given to restoration of Morphetts Engine-house and appurtenances at Burra in association with a local committee concerned with planning, development and funding. Retimbering of the collar of Morphett's Shaft is seen to be an urgent matter to obviate collapse and possible impairment of the engine-house of which it is an important complementary adjunct. Reinstatement of the sub-level entry to the shaft, shears, counterweight, whim and, ultimately, a replicated Cornish beam engine would ensue.

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ILLUSTRATIONS

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