The Significance of the Australian Cornish Mining Heritage Site

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The Cornish mining landscape at Moonta Mines: Richmans Enginehouse and dressing plant ruins in the foreground with Hughes Enginehouse in the distance. PIRSA Photo 044041

Introduction

Mining in Cornwall dates back to *c.*1800 BC but underground mining did not begin until the 16th Century. By 1750, copper mining began on a large scale and by 1800, Cornwall was the principal mining area of the world. This dominance continued until 1850, when Cornish mining was at its peak and from then declined until the great crash in 1866 and by 1880, copper mining had virtually ceased. For more than a century from the late 1700s, Cornish miners were regarded as the best hard rock miners in the world. After the 1840s, Cornish miners emigrated to the New World taking with them their mining expertise and culture; in particular to South Australia, Mexico and Spain.

A miner usually began his working life as a picky boy often as young as eight years of age and whose job it was to sit at a table or conveyor belt sorting good ore from waste. After a few years he could join a team working underground at the rock face sinking shafts and opening drives. Miners showing promise would then be invited to enjoy a tribute team working the exposed ore body and paid on the amount of value of ore removed.

Cornish miners and engineers played a central role in the early development of the State's mining industry and it was therefore natural that Cornish machinery and mining methods should be adopted. The successful mining of copper would not have been possible without Cornish beam engines, which drained mines, raised ore, and powered crushing and concentrating machinery.

In 2006, the *Cornwall and West Devon Mining Landscape* was inscribed on the World Heritage List. The Cornish Mining World Heritage Site is a serial listing of ten sites scattered across Cornwall which contain mining areas and associated settlements from the period 1700 to 1914. The *Cornwall and West Devon Mining Landscape* was inscribed on the World Heritage List under the following criteria.
Criterion (a) (ii): Exhibit an important interchange of human values, over a span of time, or within a cultural area of the world, on developments in…*technology*…
Criterion (a) (iii): Bear a unique, or at least exceptional, testimony to a *cultural tradition*…which is living or which has disappeared.
Criterion (a) (iv): Be an outstanding example of a type of … *technological ensemble or (and) landscape* which illustrates (a) significant stage(s) in human history.

World Heritage status recognises Cornish mining's fundamental influence on World hard rock mining, ore dressing and in particular steam engine technology during the 19th century. During this time Cornwall developed a distinctive regional identity which took on global significance with mass migration of Cornish culture after 1840. Cornish technology embodied in its engines, enginehouses and mining equipment was exported around the world along with its mining culture.

The Australian Cornish Mining Heritage Site
Following an approach from Cornwall, the South Australian Heritage Council prepared a nomination of the Australian Cornish Mining Heritage Site (ACMHS) for consideration by the Australian Government for National Heritage Listing and for the World Heritage Tentative List. The site has been shortlisted for assessment by mid-2013. The aim is have the Australian Cornish Mining Heritage Site joined as a Transnational World Heritage Listing, involving Cornwall, South Australia, Mexico, Spain and South Africa to the existing Cornish World Heritage Site. This would recognise that the distinctive mining landscapes in those locations were derived directly from the Cornish mining landscape.

The proposed ACMHS consists of two areas – the Burra and Moonta Mines State Heritage Areas – which contain the most authentic and historically significant components of the Cornish Mining Landscape in Australia for the period 1845 to 1923. The site contains mine and mineral processing sites which contain infrastructure including Cornish beam enginehouses, mine transport systems and mining settlements, and social infrastructure such as churches and miner's cottages.

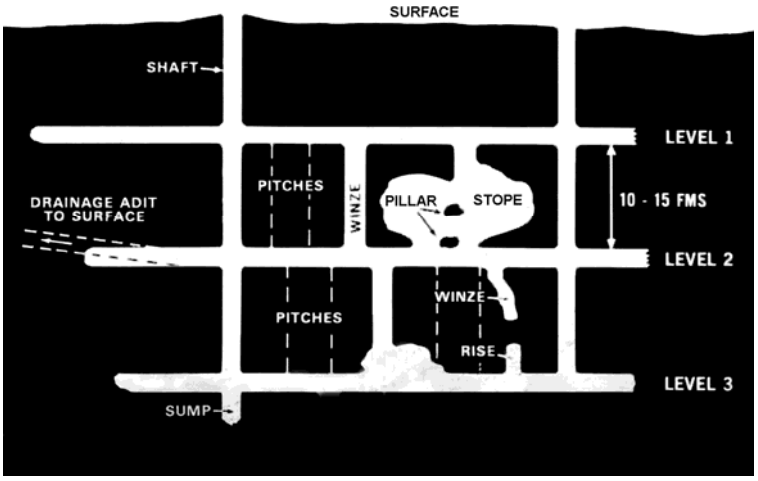
To enable the ACMHS to be linked to the Cornish Mining World Heritage Site it will need to reflect the impact of the revolution caused by Cornish mining and ore processing technology which took place in Cornwall in the late 18th and early 19th centuries and was transferred to South Australia after the early 1840s. This will truly reflect *the ingenuity of the Cornish.* The evidence can be clearly seen in the transfer of Cornish mining and mineral processing methods, steam technology and associated cultural traditions such as mine management and employment systems to South Australia from the 1840s until the early 20th century.

Cornish Mining Technology
The Cornish system of working mines was established in the mid 18th century when new techniques had allowed mining to progress underground. The form and arrangement of a mine depends on the nature of the mineral deposit to be excavated; Cornish mines worked tabular or rectangular mineral deposits known as veins or *lodes.* Depending on the dip of the lode, a shaft was sunk vertically to intersect the lode at a given depth or inclined following the lode. These shafts were rectangular and of two types; small winding or *whim* shafts which were often inclined and larger vertical engine shafts used for pumping.

At a depth of about 10 fathoms (60ft or 18m), a horizontal level or *drive* was excavated in both directions by two sets of miners and further shafts were sunk at intervals of 50 fathoms for ventilation. Further levels were driven at 10 fathom intervals thus dividing the mine into zones measuring 50x10 fathoms (300x60 ft). These

were further subdivided by internal shafts or *winzes* and these zones were then surveyed into blocks called *pitches* measuring about 60ft high and 20-30ft wide.

Opening up of the mine by sinking shafts and driving levels was called *tutwork* which prepared the lode for extraction of ore or *tribute.* Hence two kinds of mining activity were undertaken – development of the mine and ore extraction which were generally carried out simultaneously. The Cornish system of mining was the first to develop the concept of ore reserves which they called the *eyes* of the mine and their removal was referred to as *picking out the eyes of the mine*.



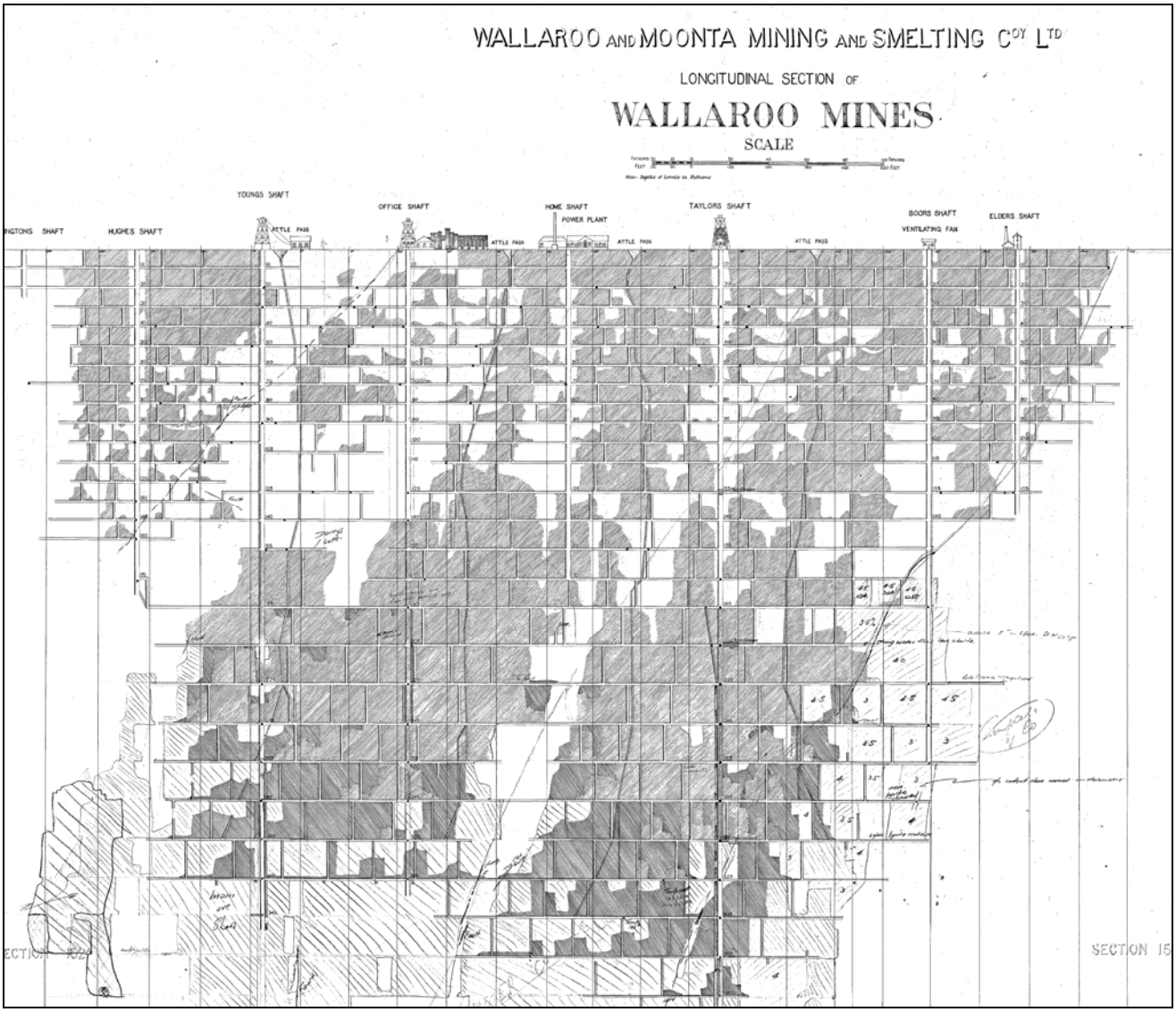
The Cornish Mining System

In removing ore, miners worked from the upper part or *back* of one level towards the *bottom* of another. This was known as *overhand stoping* and the resultant excavation or *stope* was arranged for ore to fall to the level below and then wheeled in trucks (*tramming*) to a hauling shaft. Timbers were hitched into the sides of the stope to create a protective cover to the level below and a platform or *stull* for the excavated ore, with timber chutes for loading ore into trucks on the level below.


Tributers working in a wide stope, Wallaroo Mine c.1918. PIRSA Photo N10767.

Gunpowder was used in Cornwall for underground blasting from the late 1600s and its safety was greatly improved with the introduction of the safety fuse in 1831. A series of up to 12 holes each about 1-2 ft deep were drilled into the face of a drive so that explosive could break the rock out section by section. The powder was tamped in so that when it exploded the sides of the hole were burst away. This had to be done very carefully and accidents were common. Modern high explosives like nitroglycerine were introduced into mines in the 1870s and gradually replaced gunpowder. The holes were drilled by hand where one or two miners would swing a heavy hammer against a hardened drill steel held and turned by another miner, a method was known *hammer and tap*. A good team could drill over an inch per minute but it demanded a large amount of labour and skill. Hand drilling was eventually replaced by pneumatic drills which were introduced in the 1880s.

The mineral deposits discovered in South Australia from the early 1840s were veins similar to those that had been worked in Cornwall. As a result Cornish mine captains and miners who were engaged to work these deposits were able to apply their traditional mining systems and skills virtually unchanged. The evidence for this can be seen in the surviving workings and plans of the Glen Osmond Mines, the site of Australia's first metal mining activity. By the time of the discovery of rich vein deposits in the Moonta-Wallaroo district, Cornish mining culture was well established in South Australia. This is clearly demonstrated in mine plans and underground photos from the ACMHS.



Longitudinal section of the Wallaroo Mine, 1907. Shows stoped areas and updated to 1912. PIRSA Plan N2095

Mine Management

The practical direction of all Cornish mines was undertaken by a mine *captain* who was the working manager. He was experienced in all aspects of development and operation of mines and the success of a mine depended on its captain. There were often separate underground captains and surface or *grass* captains. Other salaried staff included the Purser (or accountant), Assayer, Pitman, Engineer and Doctor. All staff were provided with housing on the mine property. At its peak, the Moonta Mine employed almost 1600 men and boys, including 18 captains and other officers.

Employment Systems

For more than 150 years, hard rock mines throughout the world were worked using the traditional Cornish employment systems known as *tribute* and *tutwork*, which were forms of contract employment. Tutwork involved the development of the mine (*dead* work) by sinking of shafts and driving of levels. Tutworkers were contracted by the fathom and the rate depended on the nature of the rock to be excavated. Tribute on the other hand involved the excavation of ore and removal to the surface and was paid as a proportion of the value of ore mined. Individual Cornish miners organised themselves into self-selected teams called *pares* which were usually four to eight men and/or boys. The work shifts were usually eight hours and the period was called a *core.* Pares could elect to bid for tutwork or tribute contracts but tribute required considerable judgement and knowledge by the pare as the orebody could pay very well or disappear.

The underground workings were surveyed into blocks or *pitches*. Each pitch and tutwork contract or *take* was numbered and let by public auction on *Survey* or *Setting Day* for a period of two months. Prior to auction the various pitches were carefully inspected by the pares and the mine captain. Each *pare* was responsible for breaking and sorting ore, tramming to a shaft, and paying for hauling and ore dressing of ore, candles, tools and gunpowder. Each pare was thus in competition with other pares at the letting of the contracts for the areas to be worked. Cornish miners were in a sense in partnership with the mine owners. They behaved like entrepreneurs in the mines which demanded knowledge, skill and intuition to survive. As the 19th century progressed, the tribute system was increasingly abandoned in favour of more strictly regulated tutwork with fixed contracts. In South Australia, tribute mining operated at the Moonta and Wallaroo mines until abolished in the early 1900s due to falling ore grades.

Survey or Setting Day

Each tribute or tutwork contact or *take* lasted for two months after which another contract was let. The day when miners were paid for the previous take and took new contacts was known as *Survey* or *Setting* Day which was a traditional holiday for Cornish miners. Prior to setting day, the mine captain would tour the underground workings to determine what work needed to be done. At the same time, the captain would also assess the mineral value of each stope. With this information, acceptable contract rates would be set and pares could decide what work they wanted and how much they would bid for it.

On Survey Day, pares bid against each other for the various tribute pitches and tutwork contracts, the lowest bid being successful. The bids were given as a value per £; for example a tribute of 1/6 would mean a pare would be paid 1/6 for each £ of the total value of their ore mined during the take. The tribute was controlled by the richness of the ore contained therein so if it were rich perhaps 4/- or 5/- tribute would pay the men fair wages, whereas if it were poor 10/- or more might be required. Should the pitch fail the pare had the right to abandon it on payment of a fine. At the next renewal of the pitch, the tribute rate was readjusted by the captain until the lode failed. As the pares were only paid every two months a *subsist* of about £1 per miner was advanced to pares until the next Survey Day.

The Cornish tribute system was an ingenious work practice with a number of advantages over modern organisation work groups. The pares were self-regulating work groups and hence more skilled miners generally became tributers; the selection of a miner to a pare required trust of other members. The tribute system provided pares with autonomy and significant inducement to work as they were responsible for working the orebody

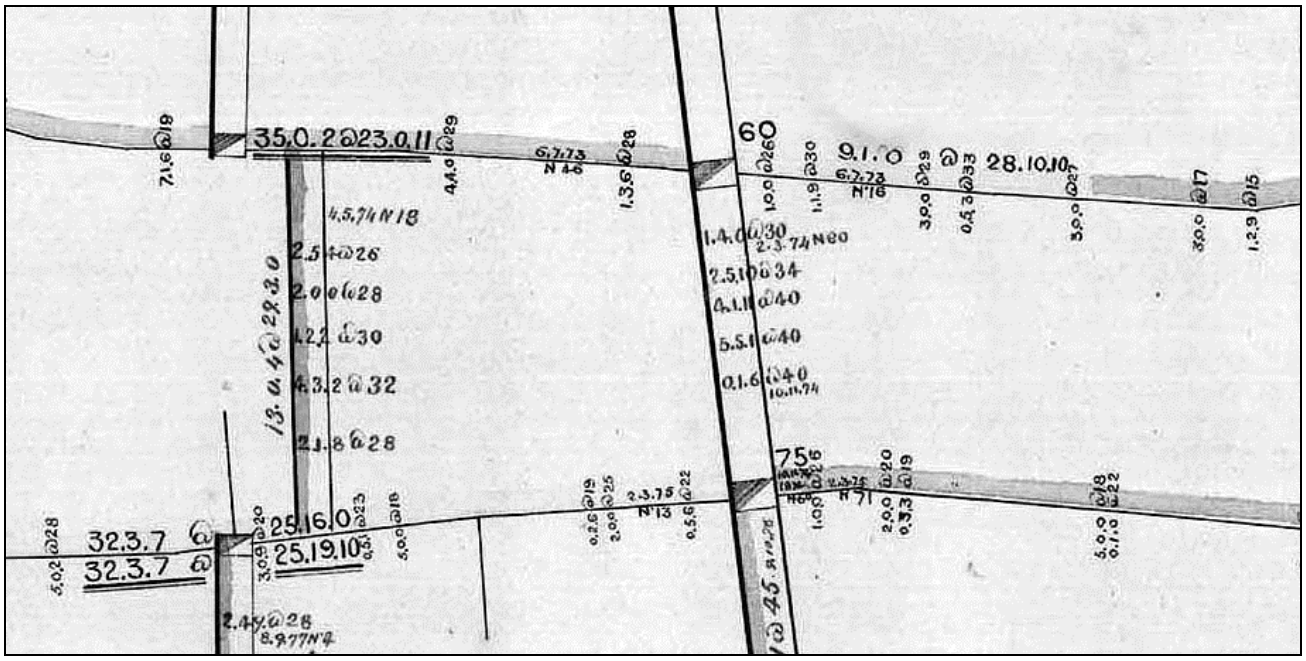
within their pitch and the approach to its excavation was left to them. Tributers required skill and judgement in assessing the nature of the orebody and hence they were rewarded with safety and profit. They were better of financially than other miners and workers at the time. The pare relied on the collective knowledge of the group which came from their underground experience and tribute mining provided ample opportunity for experimentation for example with the use of gunpowder.

Evidence of the application of the Cornish employment systems in South Australian mines is abundant in newspaper reports throughout the second half of the 19th century. There are advertisements for the letting of tutwork bargains and tribute pitches at the Burra Mine in the late 1840s. Detailed descriptions are provided of Survey Day at the Burra and Moonta mines which are strikingly similar to accounts from Cornwall. Survey Day at the Burra Mine in the 1850s was described as follows:

There was a day appointed for letting contracts or takes, it was called Servaday. The men worked in companies of two, three, or more in each pitch. So when Servaday came one or more attended to accept a new take. The procedure on Servaday was somewhat peculiar, the manager, Captain Roach, acted as an auctioneer standing where all could see him, he would put up the pitches by number with the tribute in this way. "No. 50, seven and sixpence", and then picking up a pebble from a dishful on his table he would toss it away and when the pebble came to ground and no objection had been raised the contracts or take was let at the tribute named. If tribute was reduced to an amount which would not pay the men the take could be refused.

Solomon Williams, Burra Record 1934

Company working plans of the Moonta Mines record information relating to tutwork contracts such as distance driven and price per fathom. Cross sections of the underground workings clearly show ore zones divided into pitches with tribute details recorded. Plans of mine levels and shafts projected to the surface show the details of tutwork contracts.



Part of a plan of Beddomes Lode, Moonta Mine 1879. The hand written details record tutwork contracts for sinking Beddomes Shaft and winzes, and driving the 60 and 75 fathoms. PIRSA Plan N01895

Longitudinal section of MacDonnells and Fergussons lodes, 1887. PIRSA Plan N1908
The hand-written details record the details of the tribute contracts in the various pitches.

Cornish Ore Dressing

Since metallic minerals have a higher specific gravity than associated waste, use was made of this differential for mineral concentration or *ore dressing* until the early 1900s. With copper ores the specific gravity differences did not allow good gravity separation in fine sizes so in the 18th century Cornish mines began developing an ore dressing process which initially involved breaking by hand (*spalling*) followed by hand-picking. This was undertaken at the surface on extensive *dressing floors* which were a characteristic feature of Cornish mines throughout the 19th century.

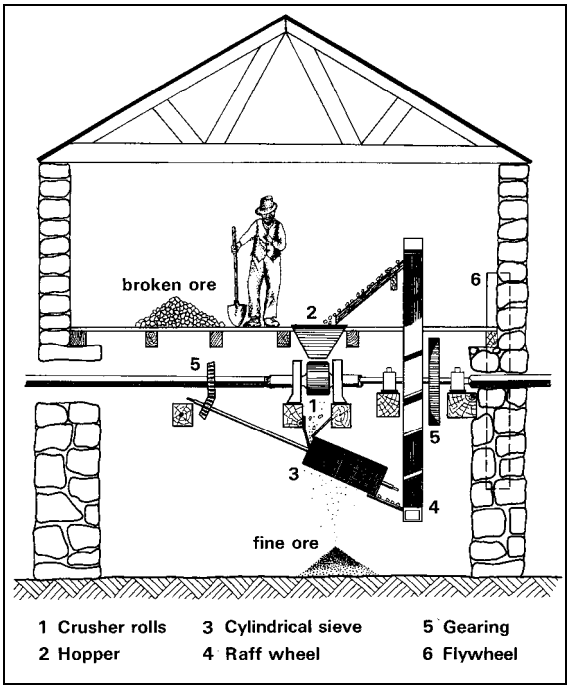
Prior to the widespread use of mechanised dressing machinery after about 1860, ore dressing was very labour intensive employing large numbers of men and young boys. Women or *bal maidens* were also employed in dressing ore but this tradition was not implemented at Burra or Moonta.

After some initial sorting underground, lumps of ore from shafts was hand-picked at the surface into high grade (*prills*), low grade (*drage* or *halvans*) or waste (*attle*). The prills were reduced by hand with *bucking* hammers to walnut size and sent for smelting. The attle was sent to waste dumps or back into the mine as fill in worked out areas. Drage was reduced to sand size and sent for concentration or by *jigging* which involved gravity separation in water. The Cornish jigger originally consisted of a sieve hung from the end of a lever and immersed in a trough of water. The sieve was filled with crushed ore and continually shaken by hand in the trough using the lever. This action caused the lighter waste particles to rise to the top which were periodically scraped of by hand. Up to the 1860s, about 150 men were employed operating individual jiggers on the Burra Mine ore floors.

In the early 1800s, mechanical improvements to rock breaking and concentration were introduced in Cornwall and soon became the standard technology at mines throughout the world during the next 100 years. Cornish beam engine technology was quickly adapted to power this new technology. Cornish crushing rolls replaced hand bucking and consisted of two cast iron rolls about 60 cm in diameter running against each other. Ore was fed between the rolls, crushed and passed through a sieve below but any undersized was lifted by a raff wheel and tipped back for re-crushing. Two storey Cornish crusherhouses were a distinctive feature of 19th century copper mining landscapes along with beam enginehouses. More than 20 were erected at mines throughout South Australia including five at Moonta and Burra.

Cornish stamps had sets of four iron heads on square wooden stems which crushed to sand size to separate finely mixed ore. These evolved into the famous Californian stamps which revolutionised the concentration of gold won from hard rock during the 19th century gold rushes.

The first mechanical jiggers appeared about 1830 and consisted of a fixed sieve with a plunger to produce the rising and falling current of water. They were used from the commencement of dressing operations at Moonta Mines and replaced the old hand jiggers at Burra when that mine mechanised in the late 1860s. A number of improvements were made to the jigger at Moonta including development of the famous Hancock Jig which became well known throughout the world.



Cross section of a Cornish crusherhouse, c.1860. PIRSA Plan 1999-0526

The Cornish round buddle was introduced about 1850 to concentrate the fine waste (*slimes*) from jiggers which might contain 1-3% copper. The main type of buddle was concave in form and made of a wooden floor about 5 m in diameter set into the ground. The slimes pulp was spread from a cone at the centre with the aid of rotating brushes. The heaviest particles settled first and the lightest escaped at the circumference. Periodically the buddle was dug out in several concentric rings, that nearest the centre being the richest. Later rotating buddles were developed and at Moonta Mines these were housed in three-level timber structures adjacent to the plant at Richmans Enginehouse.

The impact of Cornish dressing technology could still be seen at world class mines at the end of the 19th century; at Broken Hill in 1894 ore was crushed in Cornish rolls and concentrated in jigs and buddles. However the introduction of the flotation process in 1904 very quickly saw the demise of the 100 year old Cornish technology.

Cornish buddles adjacent Richmans Dressing Plant, Moonta Mine, c.1898. PIRSA Photo 039691

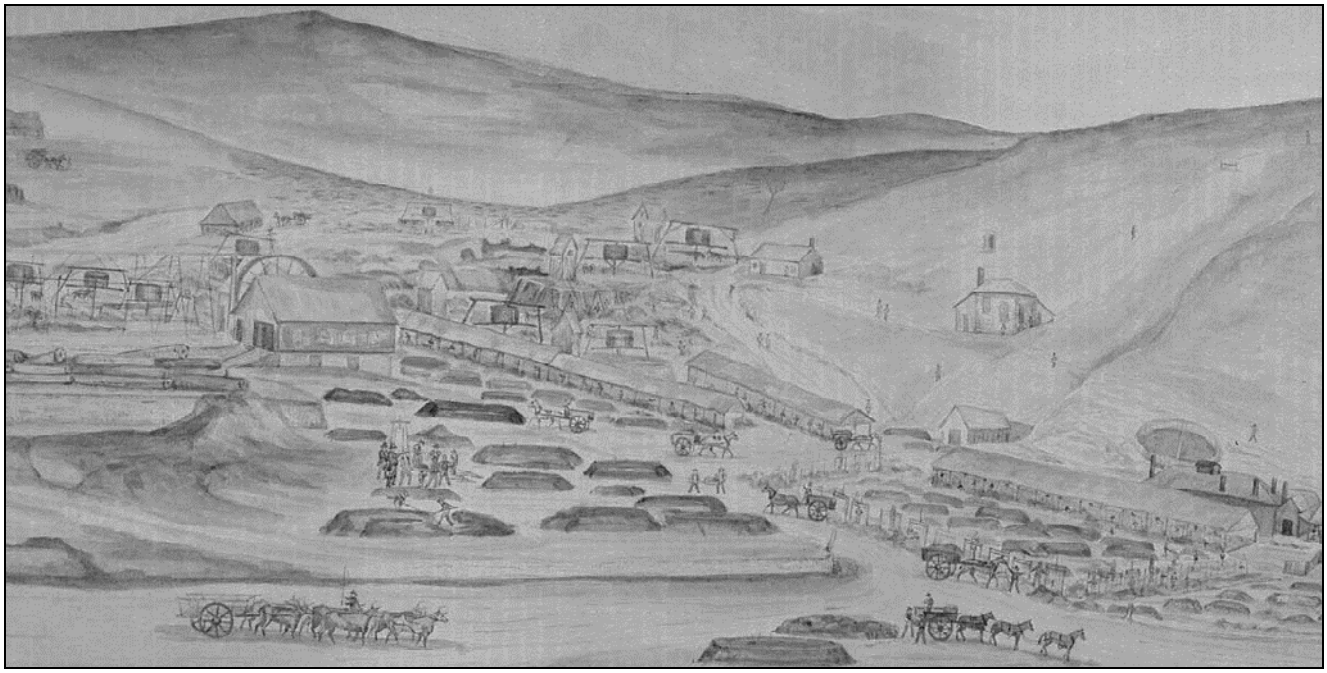
Sampling Day

During the bi-monthly period of a take, each pare's ore was brought to the surface, concentrated and placed in a separate pile on the mine ore floors. These piles were flat topped and up to 0.75 m high and 10 m square by the end of the take. It was then necessary to sample each pile to determine the amount of copper as the miners were paid on that basis. To ensure a representative sample, the tributers thoroughly mixed their pile by re-turning and cutting. The company sampler then bagged several shovelfuls to be used for assay. A set of portable scales was then used to weigh the pile a hundredweight at a time.

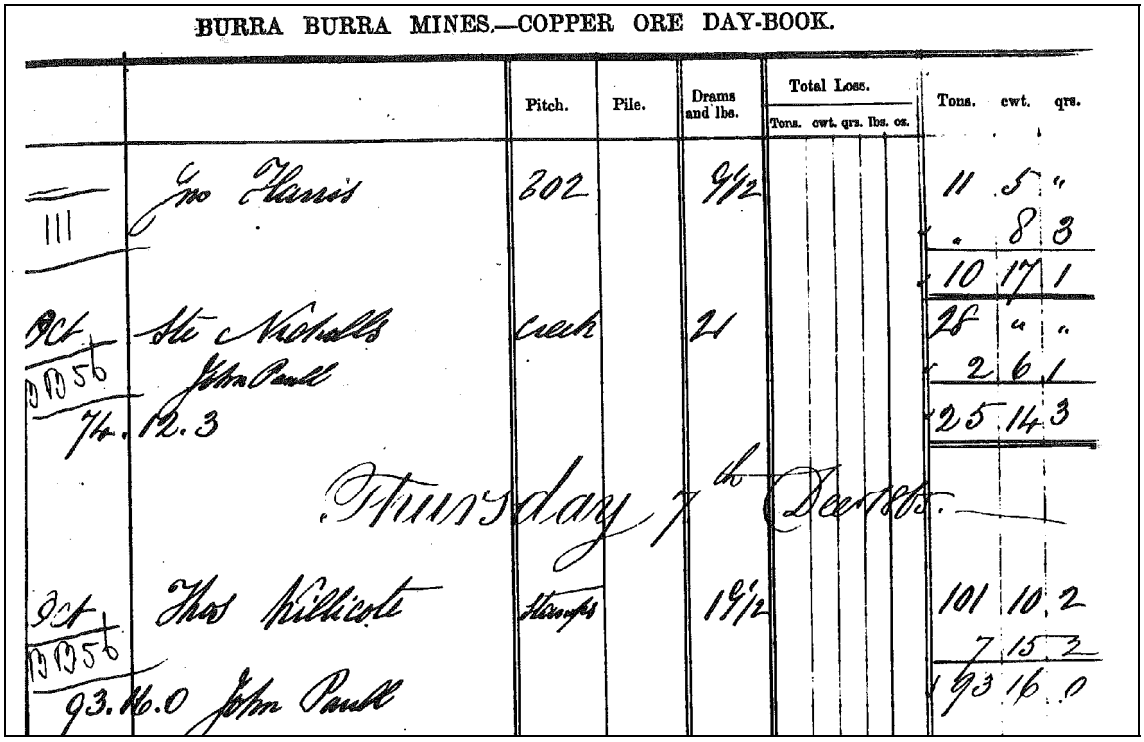
Settling Up

The representative ore sample taken to the mine assay office was first weighed, dried and then re-weighed to determine the water content. The copper content of the sample was then determined by fire assay. This assay value and the net weight of the tributers' ore pile allowed the total amount of copper and hence its value to be calculated. The assay value was of course critical as it determined the tribute payment for the two month contract period. Many disputes arose concerning the value so an independent value was obtained for comparison. Dissatisfaction with the company's assays led to a four month strike at Burra in 1848, the first industrial strike in Australia.

Early photographs of the Burra and Moonta Mines do not record Sampling Days as the long exposure times required did not capture activities. Fortunately a panoramic view of the Burra Mine painted by William Bentley, the 12 year old son of a miner, records in detail the surface activities in 1858. The painting clearly shows the Cornish crusherhouse, rows of long open sheds containing hand jiggers, the flat topped piles of tributers' ore and the process of sampling being conducted. Several surviving Burra Mine Copper Ore Day Books from the early 1860s record information about tribute teams and the ore produced during each take.



Burra Mine ore dressing floors, 1858 from a painting by William Bentley. PIRSA Photo 039299.
The large waterwheel (left centre) powered a Cornish crusher and the carpenters' shop. The long open sheds contained hand jiggers for concentrating crushed ore and the piles of tributers' ore can be seen across the foreground. The group of men in the foreground are sampling and weighing an ore pile.


BURRA BURRA MINES.—COPPER ORE DAY-BOOK.

		Pitch.	Pile.	Drams and lbs.	Total Loss. Tons. cwt. qrs. lbs. oz.	Tons. cwt. qrs.
111	Geo Harris	202		9½		11 5 0
						8 3
						10 17 1
Oct 1856	Hte Nicholls	Creek		21		28 0 0
	John Paull					2 6 1
	74. 12. 3					25 14 3
	Thursday 7th Decbr.					
Oct 1856	Thos Williams	Stamps		19½		101 10 2
						7 15 2
	93. 16. 0 John Paull					93 16 0

An example of entries in the Burra Mine Copper Ore Day Book in December 1865. They record leader of a tribute party, the pitch number, the weight of dressed ore and the amount of contained water and hence the net weight which was assayed to calculate the amount of copper the group had produced.

Cornish Steam Technology

From the early1700s, Cornwall played a leading role in the development of the stream engine used to pump water from its mines, haul ore to the surface and crush it. The first engine installed was a Newcomen engine in 1712 which was later modified by Boulton and Watt and first installed in Cornwall in 1777. Steam power was the greatest technical innovation of the Industrial Revolution and Cornwall was central to its introduction and development. After 1800, Cornish engineers began to develop the high pressure steam engine into what became known as the *Cornish Beam Engine.* This was further advanced by other Cornish engineers reaching its peak about 1850.

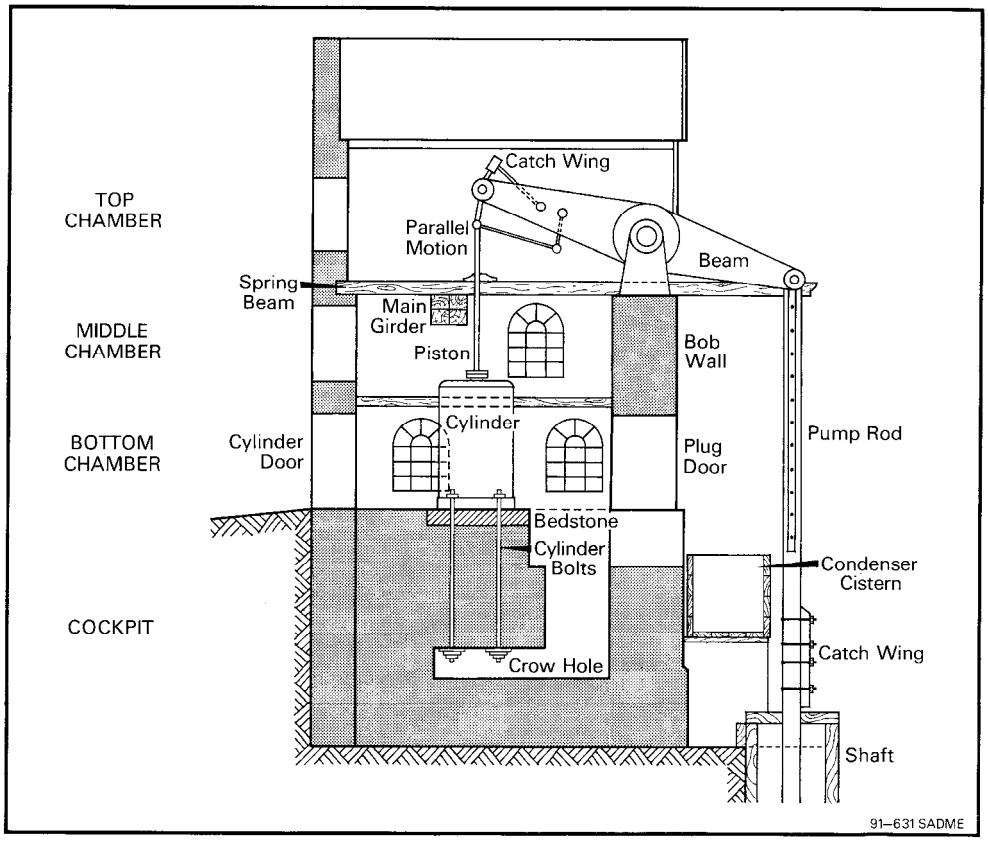
More than 2000 were erected in Cornwall of which about 200 survive. Cornish engineering technology was exported to other mining areas from the mid 1820s including Mexico, South Australia, Spain and South Africa. In South Australia, 23 Cornish engines were erected in the period 1848-1888 and the last to stop work was in 1923; all were made in Cornish foundries. In the 1860s and 1870s, about 16 were working at one time in South Australia, the majority being in the ACMHS.

The Cornish engine was based on Watt's pumping engine and most features of valves and controls were unchanged in basic function. The engine was refined by the use of cast iron for all heavy parts of the engine rather than wood. The pumping system was greatly improved and a single lifting stage was accepted as standard at the bottom of the shaft. Subsequent stages used plunger pumps to force water up no more than 300 ft per stage, requiring a pressure of 150 psi in the pump cylinder. This type of pump, driven from the crankshaft of horizontal rotative engines, continued in use for many years after the Cornish engine's popularity waned and was still known as the Cornish pump.

The period of greatest development of the Cornish pumping engine was between 1820 and 1850, which coincided with the installations in South Australia at Kapunda and Burra. Cylinder diameters of 60 to 90 in. were common, with strokes of 10 to 12 ft. Expansive operation of the steam was general with cut-off at about two fifths of stroke. A typical plant included three Cornish boilers, each 36 ft long by 6 ft diameter, to provide steam.

It was in this period of high development of the Cornish engine and the early days of the horizontal engine, that South Australia moved into the industrial era as its early mining ventures became mechanised. Two of the pumping engines at Burra were each rated at 250 hp. Assuming that 250 horses could have done as much work as one engine in an hour, they could not have done it 24 hours a day, every day of the year. The horses would have worked at that rate for no more than three to four hours, so that with changes and reserves, at least 1000 horses would be required to replace each engine, along with the men to drive them and the space to house them.

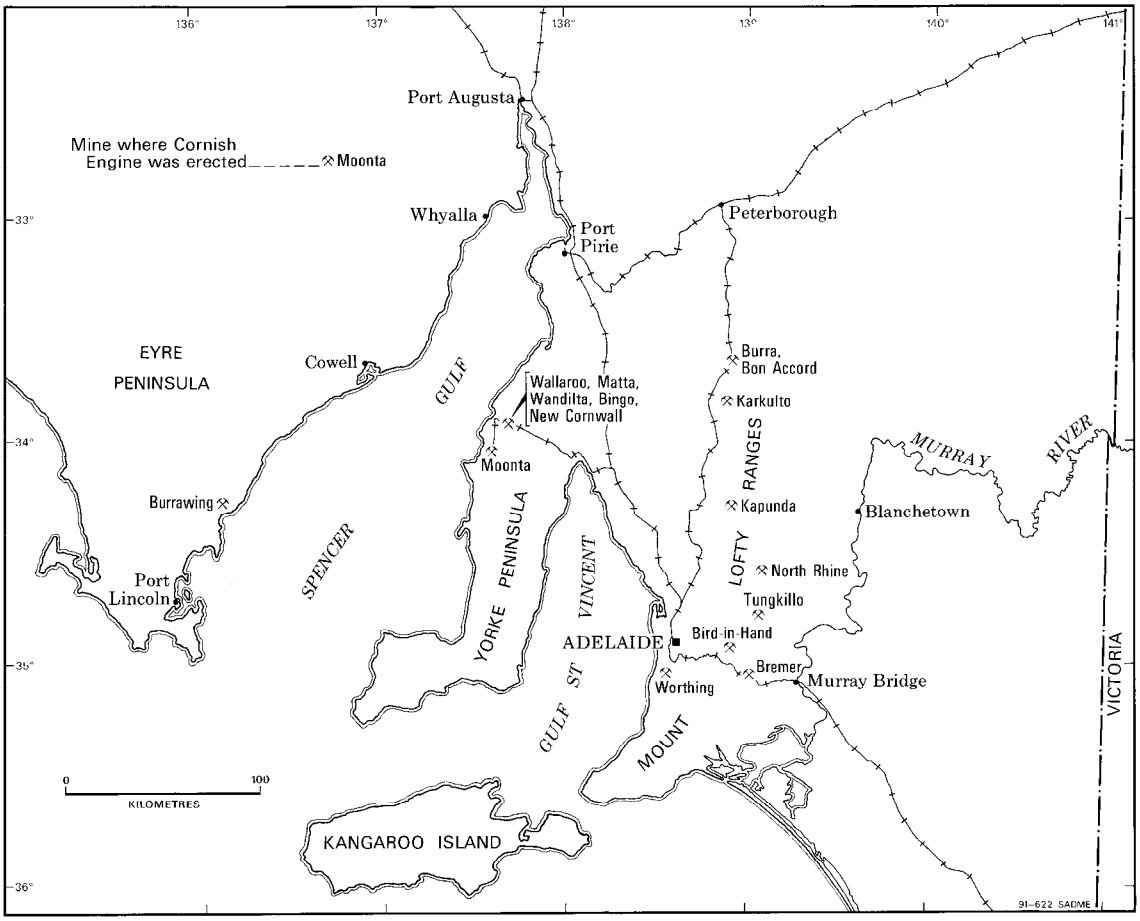
Mining engines installed in South Australian mines after 1848 and more or less coincident with the peak of development of the Cornish engine, were of two principal types; beam pumping engine and beam rotative engine, the latter generally referred to as a steam whim or *fire whim*, winding engine or crushing engine according to its application. The Cornish pumping engine was a single acting beam engine, live steam acting on the piston on the indoor stroke only. The beam, or *bob* as the Cornish engineers called it, was carried on the front or bob wall of the enginehouse, next to the pump shaft. One end of the beam was connected to a piston rod in a cylinder, which rested on a great mass of stonework and was securely bolted to it by cylinder bolts.



Section through a Cornish beam pumping engine. PIRSA Plan 1991-0631

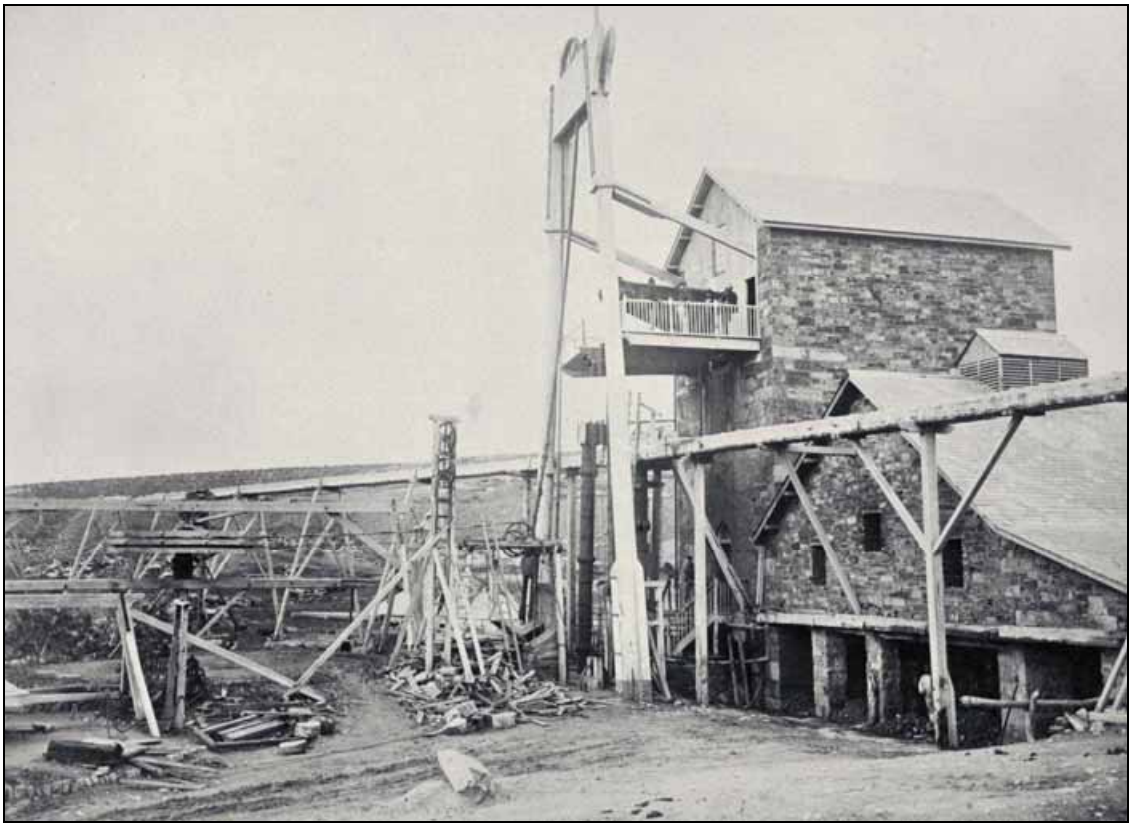
The outer or outdoor end of the beam projected out over the pump shaft and was connected to the pump rod which extended down the shaft. The engine lifted the pump rod on the indoor stroke, which then fell under its own weight to pump water on the outdoor stroke. The beam was usually made of cast iron in two pieces and weighed as much as 50 tons. The cylinder was an iron casting encased in an outer cylinder or steam jacket with a separate bed plate bolted to the bottom. An 80-inch cylinder and steam jacket weighed about 20 tons. The piston and rod worked up and down in the cylinder and were kept in alignment during the working of the engine by the parallel motion.

The operation of the engine was controlled by massive and complex valve gear. The engine driver operated the valves by hand at starting. Once started, the three valves (steam, equilibrium and exhaust) were worked automatically by valve gear through plug rods hung from the beam.



Location of Cornish beam engines in South Australia. PIRSA Plan 1991-0622

The first Cornish beam engine in South Australia was erected at Kapunda in 1848 and the last at the Wallaroo Mine in 1888. By 1900, the Cornish beam pumping engine was still efficient and effective but the beam rotative engine was considered obsolete and most had been displaced by the horizontal steam engine on new installations. At that stage, Wallaroo and Moonta were the only South Australian mines using beam engines. The last of these gentle monsters ceased pumping in 1923 when Elders Engine at the Wallaroo Mine and Hughes at the Moonta Mine were halted, allowing the workings to flood and signifying the closure of the mines. Within the next two years those two engines and Harveys Engine at Wallaroo, which had not been operated since 1906, were reduced to scrap, thus ending the Cornish engine era in South Australia.



Morphetts Enginehouse, Burra Mine, 1875. This was erected in 1860 and contained an 80-inch beam engine. PIRSA Photo 035888.

For more than 70 years, during the heyday of copper mining in South Australia from the 1840s until the 1920s, Cornish enginehouses, with their great beams bobbing up and down, graced the barren mining landscape. The beam engines they contained were the central machines of the industrial revolution. Today, eight massive enginehouses of the original 33 remain as monuments to our mining and engineering past. They were erected between 1850 and 1876 and are perhaps the most tangible links in South Australia with the industrial revolution. The mine sites at Burra and Moonta display distinctive Cornish mining landscapes with their Cornish enginehouses, a critical requirement for linking with the Cornwall Mining World Heritage Site.

Conclusion

Whilst the industry brought to South Australia by several generations of ingenious Cornish miners and engineers endures by way of distinctive mining landscapes at Burra and Moonta and aspects of Cornish culture, it is important that we are ingenious in finding ways to secure the long term future of the physical evidence. Linking of the Australian Cornish Mining Heritage Site to the Cornish Mining World Heritage Site will play a very significant role in enabling a wider audience to understand the relevance of the site and hence to increase economic benefits to enable their long term survival.

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