A 'PROFESSOR' IN PERU: TREVITHICK AND THE TRANSATLANTIC MIGRATION OF THE INDUSTRIAL REVOLUTION

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INTRODUCTION

Much has been written about the life and inventions of Richard Trevithick: he is without doubt, Cornwall's most famous son. Yet, biographers and historians have presented his career in Latin America, where he spent over a decade after 1816, as a failure summed up by his penniless arrival at Hayle.[1] However, this is to do the man an injustice. This paper adopts a different approach and concentrates instead on the significant ramifications that followed his arrival in Peru for the transatlantic relationship between Britain and Latin America in the decades that followed. It finally examines what impact Trevithick's time in South America was to have on the place of his birth – the industrial region of Cornwall.

CORNWALL: ENGINE HOUSE OF THE INDUSTRIAL REVOLUTION

Before discussing Trevithick's Peruvian enterprise, it will be necessary to provide a brief sketch of the milieu from whence he came. From the 1970s there has been an increased awareness of the benefits of studying regions when looking at the process of industrialisation. This shift in spatial focus has uncovered combined and uneven regional patterns of industrialisation in Britain and drawn attention to Cornwall's leading role in the British industrial revolution.

Sidney Pollard was among the first to identify Cornwall, an early centre of metal mining and steam engineering, as one of Britain's ten earliest industrial regions.[2] Building on Pollard's work, Eric Richards, calling for "a better taxonomy of the regional paths adopted during industrialization", identified Cornwall as one of the regions on the margins of industrialisation.[3] More recently, Pat Hudson's work on the "really important spatial units of the industrial revolution" – distinct and specialised regions with extra-regional commodity exports - has placed Cornwall at the forefront of early British industrialisation.[4]

In the early nineteenth century the dynamic export commodity was copper ore that was sent to south Wales for smelting.[5] This, together with tin and some lead, provided the main output of Cornwall's mining industry. A successful hallmark of early and dynamic industrial regions, according to Pat Hudson, was the existence of sophisticated capital and credit markets with interregional markets. Roger Burt, writing about the role of the non-ferrous mining industry in the early stages of British industrialisation, makes a strong case for Cornwall as a dynamic, thrusting industrial region:

> In marshalling large quantities of fixed capital, promoting semi-joint stock forms of organization with a brisk informal share market, organizing large labour forces of men, women and children, often counted in many hundreds, and introducing specialist paid senior management, they [the Cornish mines] were in the vanguard of a movement that was not taken up by most other industries until the nineteenth century. [6]

Bernard Deacon adds to Burt's observations by noting that in the late eighteenth century Cornish capitalists had developed banking and risk-sharing as well as a strong attempt to cartelize the copper industry, thus displacing the outside investors, or adventurers as they were known, that had formerly played a significant role in the Cornish tin mining industry.[7] By the early nineteenth century, both Burt and John Rule concur that Cornish copper mines were comparable in size, scale and capitalisation to any industrial or commercial enterprise in Britain and probably Europe.[8] In his important case study of Cornwall as a proto-region, Deacon has argued that with its powerful capitalised industry and organised labour force, Cornish mining had established a clear comparative advantage in metal mining in a similar way that Lancashire had in cotton textile manufacture. Cornish copper grew faster than all other major national industrial sectors before 1770 and between 1780 and 1830 Cornish copper witnessed a steady growth outstripped only by cotton textiles and iron.[9]

Yet without significant advances in technology, the maintenance of a comparative edge in metal mining would have been impossible and it is here that Trevithick's work is of consequence. For Hudson also argues that successful industrial regions were those capable of generating a series of significant innovations in technology.[10] For centuries Cornwall had been exploiting its mineral wealth perfecting European mining methods of the kind described by Agricola and by the late Medieval period was renowned for the sophistication of its tin mining industry.[11] This was achieved in part through a willingness to accept, adapt and accelerate technology imported from elsewhere in Europe, as was the case with new designs for pumps and the use of gunpowder brought to Cornwall in the sixteenth and seventeenth centuries respectively.[12] But it was the introduction to Cornwall of steam technology, developed in neighbouring Devon by Newcomen and improved in Glasgow and the Midlands by Boulton and Watt, that was to have such an impact upon the future development of the metalliferous mining industry. In order to

capitalise on an increased national demand for copper, Cornwall had to overcome the considerable difficulties in the unwatering and raising of copper ore from ever-deepening mines.

This problem drew many of the finest engineers and innovators in Britain to Cornwall, including Dartmouth born Thomas Newcomen, Midlands engineering geniuses Boulton and Watt, the Hornblower brothers from Shropshire and Scottish born William Murdoch, an employee of Boulton and Watt's Soho firm. Cornish mines embraced firstly the engines of Newcomen and then those of Boulton and Watt; only the north east coalfield saw more Newcomen steam engines, 140 in all, erected than Cornwall between 1734 and 1780. This contrasts sharply with the few working intermittently in Continental Europe.[13] However, these monstrous stationary engines were expensive to erect requiring immense masonry engine houses and chimneys and separate boilers complete with reservoirs. Boulton and Watt's engine with its separate condenser was a considerable improvement on the fuel-hungry design of Newcomen. But Cornwall's need for increased fuel efficiency in an area devoid of coal reserves resulted in a series of litigious clashes with James Watt. These arose as numerous engineers and 'practical tinkerers' with hands on experience attempted to improve upon Watt's design by cumulative processes and minor adjustments that threatened to circumvent his patent on the low pressure steam engine.[14] Indeed, Kanefsky and Robey have described Cornwall as 'the powerhouse of the English industrial revolution', a region at the leading edge of science and engineering.[15] For the expiry of the Watt patent in 1800 ushered in a remarkable period of experimentation and innovation that lasted into the 1840s. During this time it was found that the type of steam engine being used to drain mines in Cornwall was performing much more efficiently than contemporary physics said was theoretically possible.[16] "The history of mining in England" stated Norwich born John Taylor,

> …is indeed intimately connected with that of the steam engine; and, if we had time to examine both, we should find that, as the mines were the scenes of all the early inventors or improvers of this machine, so they also have not only benefitted (sic) by it, and in a great measure become dependent upon it, but have gone on contributing to the latest period, towards its perfection and economy.[17]

Many of these 'practical tinkerers' and engineers were Cornishmen intimately connected with mining, including Arthur Woolf, Samuel Grose, William Sims, John West, John Budge and Matthew Loam. But the most famous of this group was undoubtedly Richard Trevithick (1771-1833). The Illogan born son of a Cornish mining captain, Trevithick was a precocious genius and his desire to circumvent the Boulton and Watt patent was likely to have been one of the driving forces that propelled his inventive mind. By experimenting with high pressure or 'strong steam' he, like many other engineers in Britain at the time, hoped to be able to avoid Watt's patent.

But it was Trevithick's engine design that marked a significant leap forward in technology with his development of a new type of powerful compact steam engine. There was no separate condenser, the steam escaped directly to the atmosphere and the component parts of the engine were placed inside the boiler. Trevithick's 'puffers' worked at the unheard of pressure of 50psi and over: by contrast Watt's engines operated at a mere 15psi and the only way of increasing their power was to make the engine cylinders larger. As Hudson notes, the productivity of the steam engine in Cornwall was increased almost four times in the first half of the nineteenth century by higher pressure operations, the lagging of pipes and other adjustments. By contrast James Watt had increased the productivity of the engine by only two and a half times at most.[18] This was aptly summed up by Thomas Lean, a contemporary leading engine reporter:

> Great as are the advantages which this nation in general enjoys from the invention of the steam engine, and the successive improvements which it has received; there is, perhaps, no place in particular, where all those advantages have been greater, or more evident, than in Cornwall. The very existence of its deepest, and most productive mines, is owing, not merely to the invention of the steam engine, but to the state of great perfection to which that machine has been brought in that county.[19]

Trevithick and a coterie of Cornishmen, none of them formerly scientifically trained, therefore revolutionised the concept of the steam engine in an act of miniaturisation probably not equalled until the advent of the silicon chip[20] although Trevithick's contribution to the world of steam is only now beginning to receive the recognition it truly deserves.[21] For he was not just the pioneer of the high pressure steam engine, but built and successfully tested the world's first practical steam

carriage “up Camborne Hill” in 1801, the event immortalised in a popular folk song.[22] The versatility and relative cheapness of Trevithick’s engine ensured its success and it can be argued, formed the power source that was to transform the industrialised world in the nineteenth century, on farms, in factories and on mines, as well as being the forerunner of every car, train and self-propelled ship.[23] Trevithick and his contemporaries gave an emerging industrial society the Cornish beam engine, a veritable leviathan of the engineering and mining world. Accommodated in its characteristic masonry house, it would come to mark strange and exotic landscapes throughout the world in the decades that followed.

Shifts in spatial focus have therefore aided our understanding of the complexity of the process of industrialisation that has highlighted Cornwall’s significant contribution to the British industrial revolution in metal mining and steam engineering. Important advances too, have been made in the field of area studies.[24] Instead of viewing the world as being divided into a set number of large, quasi-continental regions, new, less rigid models of global scholarship re-frame area studies around ocean and sea basins.[25] We are increasingly being encouraged to look at the world not as divided into knowable, self-contained ‘areas’, but as part of an inter-linked whole where people, ideas, capital and technology are connected across great physical divides[26].

The importance in this spatial shift in area studies is that it highlights the importance of littoral societies, such as Cornwall, and enables us to view them not as peripheries of nation states or territorial civilisations, but as communities in their own right. With this advance in area studies and the new epistemological approach to industrialisation outlined above, it is perhaps timely to investigate the role of *regional* contributions to the overseas expansion of British industrial prowess in the early nineteenth century. For, Hudson also argues that the organisation of work and work practice prevalent in successfully expanding industrial regions often comes to influence the methods of an entire sector.[27] Arguably one of the most important chapters in modern Cornish history was opened by a transatlantic enterprise spearheaded by none other than Richard Trevithick which was to lead to Cornwall’s world dominance of the metalliferous mining industry and a century of labour migration.[28]

ENGINES FOR THE ANDES

Zacatecas, San Luis de Potosí, Guanajuato, Real del Monte, Cerro de Pasco, Potosí - these rich Latin American silver mines, long believed to be the source of Habsburg wealth and power, were fabled throughout the world. Yet, mining in the New World was carried out in regions that brought numerous engineering and logistical difficulties. Many mines, such as those in Mexico, were deep; flooding and draining were ever-present problems, while the *Cerro* of Potosí, although not prone to flooding was worked at over 16,000 feet above sea level. Supplying remote Andean mines posed logistical problems as thousands of llamas and mules were required to convey food and provisions, timber, ore and mercury through difficult terrain over trails that were often narrow and precipitous. By the late eighteenth century mining output in many parts of the New World was suffering from the exhaustion of accessible deposits and from financial and technical difficulties incurred in attempting to reach deeper lodes. Political instability in the aftermath of the fall of Napoleon and an increased desire for freedom from Iberian rule in Latin America merely compounded these problems.

This unstable background was the setting for the opening chapter that heralded a new epoch in Britain's relations with Latin America - the export of Cornish engines to Peru.[29] This enterprise has been depicted as a failure by Fenn and Gregory, the former noting that "the application of English machinery to the mines of South America [at Cerro de Pasco] had …been tried and shown not to be the panacea that many supposed…it to be…the Company was a total failure and all except one of the miners died."[30] In addition, adverse reports in the Cornish press that appeared in the following years served to perpetuate this belief, one Cornish miner commenting in the *West Briton* a half century later that the steam engines erected by Trevithick had not operated as well as expected. The problem originated in the construction of the machinery which "was not calculated to work at an altitude of 12,000 feet, and where the pressure on the column is only about 10 lbs to the square inch".[31] Yet, considerable doubt must be thrown on this negative hypothesis for neither Gregory or Fenn adequately explore the huge ramifications of the transfer of technology, nor of the foundations it laid for the future migration of British capital and labour to Latin America. Indeed, the role of Trevithick himself can be redeemed in the light of quantitative data for mineral production and also contemporary reports that clearly contradict the hypotheses of Fenn and Gregory.

Before examining Trevithick's arrival in Peru, it is necessary to trace the history of mining at Cerro de Pasco in order to more fully understand the impact the arrival of steam engines had on the Peruvian mining industry. Known in Spanish colonial times as *El Opulento*, Cerro de Pasco shared with Potosí (now situate in neighbouring Bolivia) the credit of being one of the greatest silver producing districts in the world. The area around Pasco had begun producing silver in the late sixteenth century, but it was not until 1630 that Cerro de Pasco, an extensive area some four square miles in extent, became important after silver was discovered in the *mineral* of Yauricocha.[32] Soon after, mining commenced in the nearby *mineral* of Santa Rosa, and by the 1690s the area's third important mineral zone, Yanacancha, was in production. The mineral deposits were of low grade, but they were shallow and easily exploitable and large fortunes were made as a result.

But in order to reach the richer deposits of ore it was necessary to mine below the water level. Many of the pits at Cerro de Pasco had been abandoned because the technology of the time was ineffective. This included employing hundreds of *apires* (ore carriers) to convey water in buckets, or by employing *malacates* (primitive man-powered whims), solutions which created further logistical problems. For Cerro de Pasco did not develop as was the usual pattern in Spanish America, as a self-sufficient unit with its surrounding haciendas, but as an isolated town in the midst of a barren, hostile plain, where most of the requirements of life and for the mining industry had to be supplied from lower altitudes, at great expense. As was done in Cornwall in the mid eighteenth century with the commencement of the Great County Adit, there had been some attempt to remedy the flooding of the mine-workings by cutting a *socavón* (adit), beneath the level of the pits that would therefore drain them and allow higher grades of ore to be mined. However, this entailed a huge outlay of capital, and with the limited knowledge of mining engineering at the time, was a speculative enterprise to say the least. Moreover, as the workings again reached adit level the need to cut a new socavón created further demands for capital on which the mining tribunal that put up the necessary finance, could not expect to see a return for several years, if at all.

Between 1780-86 the socavón of Santa Rosa was completed, followed by that of Yanacancha, constructed between 1794-1811, allowing silver production figures to soar. However, success was short-lived, for the Yanacancha Socavón, being fairly close to the surface (at 200 feet), meant that numerous pits had already been worked to its level before its completion in 1811. A new scheme to dig a deeper adit was

therefore mooted and in 1811 the new Quiulacocha Socavón was begun, but was ill-fated from the start.[33] A decline in the amount of silver being mined, smelted and sold, restricted the flow of capital necessary in its construction, and to further compound matters, a fatal error was made during its construction which resulted in its deviating from its intended course. The drastic decline in the figures for silver production in the *caja* of Pasco (see fig. 1) clearly reflect the seemingly insurmountable drainage problems encountered after 1811.

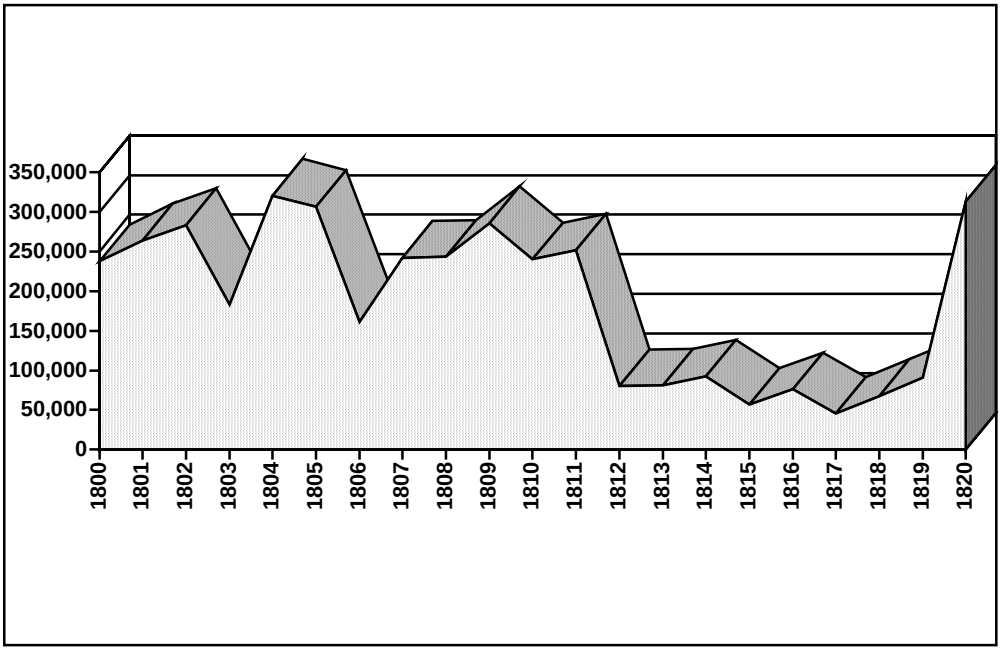

Fig. 1. Taken from Fisher (1977)

Yet, the figures reveal a striking increase after 1818, when for a couple of years production figures soared to levels close to their zenith of the eighteenth century. The reason for this sudden turn around was the introduction of European mining technology, in the form of British made steam engines that had been dispatched to Peru by none other than Richard Trevithick. On 26th September 1812 a mining enterprise - the Pasco Mining Company - was formed in Lima by Spanish merchant, Don Pedro de Abadía, an agent of the Philippine Company, his partner Joseph de Arismendi, and a Swiss watchmaker, Francisco Uvillé.[34]

Aware of the increasing problems of drainage at Cerro de Pasco, this company put a proposal to dewater the mines with British-made steam engines to Viceroy Abascal in 1812. With Britain rapidly acquiring the reputation of being the workshop of the world and forging ahead in steam technology, Uvillé had been sent there in

1811 to explore the possibility of bringing steam engines to Peru to dewater the mines at Cerro de Pasco. Naturally, he had visited the workshops of Boulton and Watt, pre-eminent in steam engine design, who returned a pessimistic verdict as to the applicability of steam technology in the rarefied atmosphere of the Peruvian Cordilleras coupled with the technical problems of transporting numerous engine and boiler sections high into the mountains. It was at this point that serendipity played an important role, for Uvillé happened to chance upon a model high-pressure steam engine in a London shop window, that had been manufactured by Trevithick. This he purchased for 20 guineas and returned to Peru where he set this innovative model engine to work at Pasco. It defied critics who claimed it would not function at over 14,000 feet in the rarefied atmosphere of the Andes, and greatly impressed members of the local *gremio* (mining guild) who signed a contact agreeing that two full-sized steam engines should be procured without delay.[35]

The Pasco Mining Company had ambitious and unprecedented plans. They agreed to bring sections of engines and equipment half way around the world, and transport them to the mines where they would commence unwatering Yuaricocha and afterwards Yanacancha, Caya Chica, Santa Rosa and the mining ridge of Colquijilca. They also planned to construct a pit for the collection of waters to a stated depth below the adit at Santa Rosa and undertook to commence to pump within eighteen months after the signing of the contract.[36] In order to achieve this the company planned to raise by private capital the sum of 40,000 *pesos* necessary to purchase, transport, and install the steam engines at Pasco, in the hope that they would be well rewarded by an agreed percentage of ores raised in the mines of Cerro de Pasco, and were grated a monopoly for nine years.[37] By early 1813 Uvillé, armed with 30,000 pesos (around £600), was on his way to Cornwall to engage Trevithick. The "strange gentleman with whom money is very plentiful", as Trevithick described him, persuaded the impulsive young engineer to begin making drawings for the design of six engines with the necessary auxiliary equipment, sweetened perhaps with the promise of future orders, and to undertake to organise their construction.

A historic transatlantic contract, the first of its kind, was signed on 8th January 1814 to provide the apparatus for 9 engines at a cost of around £10,000. Although he had no knowledge of the precise situation or condition of the Cerro de Pasco mines, and no reason to trust Uvillé, the level of Trevithick's interest is evidenced through his investment of about £3,000 in the Pasco Mining Company when Uvillé admitted

him as a fourth director of the company against the express wishes of his partners.[38] Uvillé had been forced to commence selling shares in London, aided by Trevithick who had previous dealings with Page and Day, a London law firm, to help finance the enterprise which he had rendered more expensive by increasing the order of engines from 2 to 6, again in contravention of his instructions. Trevithick later sold part of these shares in order to liquidate the mounting debt incurred in buying equipment and machinery for Pasco. In the meantime, Uvillé, a house guest of Trevithick, was fortunate to be able to visit Cornish mines such as Dolcoath that were working at the cutting edge of science and technology, becoming familiar with operations both above and below ground.[39] Times were obviously changing, for just over twenty years before a German visiting the Chacewater Mine in 1787 found machinery and working methods were hidden from him, so afraid were the British of industrial espionage.[40]

THE TRANSATLANTIC MIGRATION OF THE INDUSTRIAL REVOLUTION

On 1 September 1814, fifteen months after his arrival in Britain, Uvillé sailed from Portsmouth per the *Wildman* bound for Peru with a consignment of machinery dispatched by Trevithick that included four 33" single-acting Cornish pumping engines complete with pitwork, four 8 horse-power winding-engines with whims, barrels and shafts, and a portable 8 horse-power steam engine complete with its chimney, axles and carriage wheels (originally intended for a sugar refinery in St Kitts but modified for the Royal Mint at Lima). In addition there were two mills - one for grinding ore and one for rolling, engine spares, miners' blacksmiths' and carpenters' tools and four extra Cornish boilers. The cost amounted to somewhere in the region of £16,000.[41] Three Cornish engineers and erectors, who were to install and maintain the machinery joined the voyage, permission having been granted by the British government - an unprecedented event. They were Thomas Trevarthen of Crowan with William Bull of Chasewater as his assistant, and Henry Vivian of Camborne (the brother of Trevithick's brother-in-law) who although a skilled and experienced engineer, was prone to heavy drinking.[42]

The equipment had been manufactured by Hazeldine and Co., Bridgnorth Foundry, Shropshire, and what would become one of Cornwall's foremost foundries - Holman's of Camborne. To Holmans fell the task of building the boilers for the high pressure steam engines, Trevithick noting to Uvillé in June 1813 that he had "engaged

all the boiler plate in the county, which will be sent today to the different workmen…the master smiths I have engaged are the best in the kingdom. I have obligated them to put the best quality of iron, and to be delivered at Falmouth within four months". The boilers were completed by September 1813 and dispatched from Penryn, presumably for Portsmouth.[43] In common with the steam engines, all the parts had to be cast in sections to allow for easy transportation, via mules, to the mines of Cerro de Pasco where the engines were to be assembled.

Casting the various sections of the equipment, which had to be free of any imperfections, must have pushed contemporary engineering to its limit and was to prove particularly challenging to the engine erectors at the Pasco mines. Hazeldine and Holmans were then, manufacturers of the first machinery to leave British shores for Latin America. This event can be said to have marked the transatlantic migration of the industrial revolution, and the scale of the operation in an era that preceded modern communication and transportation systems was truly remarkable.

The men and machinery arrived at Callao, the port of Lima, in January of 1815 to a government gun salute. There then followed a tortuous twelve to eighteen month trek inland through difficult terrain over which no wheeled vehicle could travel to reach the Andean town of Cerro de Pasco. Situated on a plain surrounded by low hills, Cerro de Pasco lies on the snow-line some 14,206 feet above sea level. The discovery of silver is the only rationale for settling in such a hostile environment. Temperatures at Cerro rarely rise above 13 degrees centigrade in the warmest months (December-March), falling to sub-zero temperatures at night. Rain, hail, thunder and lightening can be expected daily and in the cold months the thermometer regularly plummets to -10 degrees centigrade. From the mid seventeenth century miners had poured into the area resulting in the haphazard growth of the town, the adobe miners' dwellings with their thatched roofs in many cases built precariously close to the mine workings that literally honeycombed the ground beneath. By the late eighteenth century Cerro de Pasco was reported to have around 116 mines, with some 85 in production, and a population of about 5,000, although with people arriving during boom periods, this figure was prone to fluctuation.[44]

Eighteen months after the arrival of the men and machinery at Callao and after £10,000 had been expended transporting the equipment to the mines and erecting the engines, the 27th July 1816 saw the dawn of the industrial revolution in Latin America, when one of the engines was started at the Santa Rosa Mine under the

direction of William Bull. It demonstrated its potential by rapidly draining a pit below adit level (beneath the level at which water will flow from a mine naturally), astonishing a local official who described the innovation as "the most significant for the mining industry since the conquest of Peru."[45] In addition the first winding engine had also been commissioned at Santa Rosa. The significance to the *gremio* of the dawn of the industrial revolution in Peru is evident from the subsequent report by the *Lima Gazette*:

> Immense and incessant labour…and boundless expense, have conquered difficulties hitherto esteemed altogether insuperable; and we have, with unlimited admiration, witnessed the erection, and astonishing operation of the first steam engine…we are ambitious of transmitting to posterity the details of an undertaking of such prodigious magnitude, from which we anticipate a torrent of silver, that shall fill surrounding nations with astonishment.[46]

A 'PROFESSOR' IN PERU

Indeed, silver production figures showed an immediate, although not staggering increase in 1816, but the elation was to be short-lived as further progress was impeded by problems with the Mint engine. This was not totally unexpected when we consider the pioneering nature of the enterprise, involving the exportation of complicated, heavy machinery half way around the world to a region without the infrastructure of improvising engineers, foundries and workshops, taken for granted in Cornwall, as well as language difficulties with the native workmen. The problems arose with the boiler in particular and caused great concern, as this was so vital to the successful operation of the high-pressure steam engine. It transpired that the boiler tube had to be adapted for the burning of wood instead of coal, the fuel commonly used in Britain, a task that seemed beyond the capabilities of the Cornish engineers sent out to Peru.

Trevithick, writing of the end of the Napoleonic Wars and of the general depression in mineral prices, stated that the Cornish mines were very poor and that consequently there were a great many miners in want of employ: "I wish a thousand or two was at Pasco." Perhaps thoughts of difficult economic times in Cornwall, the logistical difficulties involved in sending instructions his men on another continent, or merely the challenge of the unknown, galvanised his decision to travel to Peru. In company with an experienced Cornish boilermaker, James Sanders of Camborne, as

well as London lawyer Richard Page, who was to act as agent for the Pasco Mining Company, Trevithick left Penzance on 20th October 1816 via the *Asp*, a South Seas Whaler. [47] The cargo contained more mining equipment and coining apparatus for the Royal Mint at Lima, as well as furnaces for the refining and alloying of silver.

The importance of Trevithick's migration to Latin America was not lost on Henry Boase, the treasurer of the Royal Geological Society of Cornwall, who presented a paper at the Anniversary Meeting of the Society in September, 1817. Describing Trevithick as "one of that superior class of miners" he opened his lecture with the following statement:

> As the introduction of Cornish machinery and Cornish intellect to the Spanish American mines, hitherto interdicted to foreigners, will probably form a remarkable epoch in the history of mineralogy, some notices of that singular event, may perhaps be deemed worthy of record in the annals of the Cornwall Geological Society.[48]

Nor was it lost on the officialdom of Peru, the local press attaching great importance to the arrival of Trevithick and of the spirit of cordiality between Britain and Peru engendered by the unprecedented transfer of technology. In contrast to the more muted and accurate description of Boase, the *Lima Gazette* described Trevithick as "…an eminent professor of mechanics, machinery and mineralogy":

> This professor, with the assistance of workmen who accompany him, can construct as many engines as shall be wanted in Peru, without the necessity of sending to Europe for any part of these vast machines…let us hope that his [Trevithick's] arrival in this kingdom will form the epoch of its prosperity, through the enjoyment of its internal riches, which could not be realised without such assistance, or if the British government had not permitted the exportation from England; an object hitherto deemed unattainable by all who know how jealous that nation is of all her superior inventions in the arts of industry.[49]

Trevithick's arrival was timely. Two engines were at work drawing water, and two were drawing ore, but in an imperfect state, Uvillé knowing nothing about erecting steam engines and Bull very little. "If I had not arrived, it must all have fallen to the ground, both in their mining and in their engines" wrote Trevithick, noting also that the only skilled engineer, Henry Vivian, had died of insobriety. Trevithick immediately improved the efficiency of the Royal Mint, and another engine, reported

to have been "far superior in size and beauty to the first" was thereafter set to work in early 1818.[50] But relations with Uvillé, who seems to have initially held Trevithick in high regard writing to his associates "that heaven had sent him for the prosperity of the mines" became increasingly strained. This was compounded by a lack of finance and problems over the supply of fuel for the engines, problems that no doubt exacerbated Trevithick's tendency towards irascibility.[51] Much doubtless rested upon the Cornishman whom, judging from the description above, the *gremio* had built up into something of a saviour, claiming that he would be able to construct as many engines and parts *in Peru* as were necessary and therefore save the enterprise from ruin. The fact was that without local foundries capable of manufacturing complicated engine parts, or of suitable fuel to steam the Cornish engines, long-term, Trevithick was extremely limited in the short-term as to what he could do.

The problems at Cerro were soon known in Cornwall, making news in the pages of the *Royal Cornwall Gazette* in 1818:

> It appears from letters just received by a person in this country, from South America, that the Cornishmen who went out to that country in the 'Asp' Capt. Kendy; about 2 years ago, for the purpose of erecting steam engines on the silver mines of Pascoe [sic] in Peru, have not met with that encouragement which they were fully given to expect.[52]

According to John Miers, writing in the 1820s, Trevithick was badly used at Pasco by Uvillé, Page, and a clique of London shareholders who conspired to oust him with accusations of mismanagement.[53] Disgruntled but not daunted, this led to his being granted permission by the Viceroy to travel through Peru to inspect the general mining system and importantly, to continue the diffusion of British mining technology by making the native miners acquainted with English modes of working. He was also reported to have worked copper mines in the rich mineralised valleys around Copiapó of neighbouring Chile, mines that would yield incredible riches to another Cornishman - Sampson Waters, later in the nineteenth century. According to Captain Waters, the name of Trevithick was better known to Chileans than to Cornishmen.[54]

But it was a copper and silver mine with real potential in the Andean province of Caxatambo that greatly interested him, and with the blessing of the government of Peru this he began to work, raising quantities of ore and making plans to ship this to Britain for smelting. However, the political problems created by the Latin American

Wars of Independence eventually ruined the whole enterprise and he was conscripted for a time into the army of Simon Bolívar, *El Libertador*. He was later to record the events, noting that, "revolution followed revolution and the war appeared to me to be interminable…numerous as my misfortunes had been in Peru, and heavy as my disappointments, I felt none so sensibly as this because it was an enterprise entirely of my own creation."[55]

Trevithick also had plans for metallurgical innovations. But these too were jeopardised by the unstable political situation. According to Miers, he entered into speculations with some of the miners at the Andean mine of Conchucos for whom he constructed grinding mills and furnaces. Innovative as ever, he hoped to be able to substitute the process of smelting for that of amalgamation in silver ores, a costly process due to the high price of mercury. But this ended in another financial setback as war encroached on the district; a further blow occurred when two Cornishmen recruited by him were murdered by their guides en route to the mines of Conchucos.[56]

With the death of his arch rival Uvillé, and Bull in 1818, Trevithick felt able to return to Cerro de Pasco to direct affairs, where he made the first detailed plan of the Cerro de Pasco mines. Fortune smiled when in 1819 a seam of coal in the vicinity of the mines was discovered by Cornish mine Captain Hodge, resolving the pressing problem of fuel.[57] By the end of 1819 three engines were at work at the mines of Santa Rosa, Caya and Yanacancha. Figures for silver production at Cerro de Pasco (fig. 1) show that the application of Trevithick's steam engines had a dramatic, immediate effect on silver mining, enabling rich ores lying below adit level to be exploited for the first time. Silver registration at Pasco rose by 350 per cent in 1820, an increase to the highest level since 1811, and the second highest figure ever recorded for Pasco, representing over 65 per cent of Peru's total registered silver production for 1820.[58]

Although Trevithick was unfortunate with his silver smelting enterprise at Conchucos, a party of Cornish miners recruited by Don Pedro de Abadía, who had arrived in Peru under Richard Vivian on 5th November 1819, met with more success. They appeared to have made a significant breakthrough in the recovery of lead which was formerly lost in the native silver smelting process, successfully setting up one of Trevithick's furnaces at Pachachaca near Pasco. This looked destined for success until the wars of emancipation intervened and all but one of the smelters, William Bevan of Camborne, fled the area.[59]

Indeed, the bright prospects offered to the Peruvian mining industry through the introduction of British skill and technology, pioneered by the Cornish, were severely retarded by battles that raged in the Pasco area for at least four years and silver production dwindled to a virtual halt as the mines changed hands several times. During this time valuable machinery was either hidden or smashed and the Cornish engineers, miners and smelters fled to Lima. Trevithick escaped to Chile and thence to Ecuador and Colombia, and ended up attempting to work the gold and silver mines of Coralillo, Quebrada-Honda and Padre Arias in the Costa Rican Cordilleras, planning to bring steam engines by sea from Peru.[60] Here his ideas were frustrated by his inability to speak fluent Spanish, government bureaucracy, a poor labour force, political in-fighting, a lack of finance and the absence of a navigable route from the mines to the ocean across the Isthmus of Panama.[61]

During the civil war in Peru Arismendo fled the mines and the life of Don Pedro de Abadía, one of the two remaining directors of the Pasco company, was placed in jeopardy following his arrest and possible death sentence. He was acquitted, but the continuing turbulent political situation in Peru forced him to flee from Lima with what fortune he could muster to an estate he had purchased in Puerto Rico.[62] He and Arismendi had lost $600,000. Such abrupt withdrawal of finance was endemic in Latin America as Spaniards, fearing reprisals, fled to Spain and elsewhere. This caused a severe financial shortage that militated against an immediate resumption of mining activity at Pasco, and other metalliferous sites across South and Central America.

CONCLUSION

Trevithick is one of Cornwall's most famous engineers and migrants and he is also one of the first return migrants. Yet, in common with much that has been written about return migrants in Cornish Studies, he is cast as a failure. History records that he remitted no money to his family in his eleven year absence in Latin America and his return to Cornwall in 1827 was only made possible through the generosity of Robert Stephenson. Many years his junior, Stephenson had, like Trevithick, been acting as an engineer and advisor at the copper mines of Aroa, then a part of Gran Colombia. Somewhat ironically, Stephenson was to return to Britain and see to fruition what Trevithick had begun over two decades before - steam locomotion. By contrast, Trevithick arrived in Cornwall penniless and his failure is further underlined

in conventional histories which record that his attempts to interest Cornish entrepreneurs in the financing of a mining enterprise in Costa Rica came to nought. [63] He was to die in Dartford in 1833 a virtual pauper.

Indeed, his own son Francis - who was later to write his father's biography - condemned the Peruvian venture as worthless. But quantitative evidence in the form of silver production figures for the Caja of Pasco do not support the hypothesis that Trevithick's transatlantic enterprise at Pasco was a failure, although he did not find his personal *El Dorado* in Latin America. Trevithick was ahead of his time, for although the mining regions of the New World were prepared to embrace the technologies he introduced they were not able to fully capitalise on them. This would be made abundantly clear in the years following Trevithick's departure and the investment boom of the 1820s, which will be discussed in the following chapter.

Due to exogenous circumstances the Pasco Mining Company did not succeed in a renewed expansion of the Peruvian silver mining industry as hoped either, although initial signs of a revival in silver production were promising due chiefly to the introduction of Trevithick's high pressure steam engines. And this is supported by an account written by John Miers, who saw piles of imported machinery abandoned at Lima and elsewhere only a few years after the events at Pasco:

> …at the end of seven years, the engines had succeeded, in 1821, in draining the mines to the desired depth; but they had hardly time to commence the mining operations, when the patriot forces advanced, took possession of the mining district, and seized whatever property could be found on the spot. All those parts of the steam engines which were likely to be destroyed, robbed, or carried off, were carefully concealed in some hiding place where they have since remained…The concern was thus circumstanced when I was in Lima at the end of 1823, and the subsequent convulsed state of the country has prevented all father proceedings.[64]

Trevithick's success cannot be measured in personal terms, for materially he had little to show for his efforts in Latin America. Rather, his success needs to be viewed from a national and regional perspective, for here the impact of his sojourn in Latin America had far-reaching and profound consequences not just for Latin America, but also for Britain and Cornwall. Following the end of the wars of emancipation, Latin American mine owners believing the resumption of mining to be the touchstone of their new democracies' economies, looked, as the Pasco Mining Company had done, to Britain for technical and financial aid.

It was primarily to Cornwall that numerous mining companies came to recruit skilled technicians and to place orders for steam engines and mining equipment. This began a process of labour migration that was to last for over a century, heralding the genesis of Cornwall's world-class export market in mining machinery. Initially connected by dense transatlantic trade and migration networks with South and Central America, Cornwall was to form the hub of a developing international mining market. Anticipating an 'age of connexity,'[65] global developments in information and communications prompted by the regional migration of mining and engineering technology from Cornwall began to challenge the spatial frames within which people on both sides of the Atlantic lived and worked.

Trevithick's enterprise in Peru therefore laid the foundations that ushered in a period causing a renaissance in mining in South and Central America backed by large sums of British capital. This opened a new and exciting epoch in British-Latin American relations as "imperialism through trade" culminated in a massive and dramatic incursion of British capital in the Latin American mining industry for the first time. From this a further phase in the transatlantic exportation of British industrial technology commenced, broadening the frontiers of Britain's "informal empire". And it also had important regional implications, for from the 1820s Cornwall acquired an international reputation as a highly skilled labour-sending region. The valuable experience gained in Latin America equipped Cornish miners well to practically dominate the global mining labour market for over a century.

NOTES AND REFERENCES

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[2] Pollard, S., 'Industrialisation and the European Economy', *Economic History Review* XXVI, 1973, p. 14. Although in the very early nineteenth century, mining was restricted almost entirely to the far-west of Truro, as the century progressed the dynamic mining sector expanded and new mining areas were developed in the east of Cornwall. By the 1840s these extended as far as the Tamar.

[3] Richards, E., 'The Margins of the Industrial Revolution' in O'Brien P., and Quinault, R., *The Industrial Revolution and British Society*, Cambridge, 1993, p. 225.

[4] Hudson, P., (ed.), *Regions and Industries: a perspective on the industrial revolution in Britain*, Cambridge, 1989.

[5] See Newell, E., 'The British Copper Ore Market in the Nineteenth Century, with particular reference to Cornwall and Swansea', unpublished PhD thesis, University of Oxford, 1988; Hughes, S., *Copperopolis: Landscapes of the Early Industrial Period in Swansea*, Royal Commission on the Ancient and Historical Monuments of Wales, 2000; Rees, R., *King Copper: South Wales and the Copper Trade 1584 – 1895*, University of Wales Press, 2000.

[6] Burt, R., 'The transformation of the non-ferrous metals industries in the seventeenth and eighteenth centuries', *Economic History Review,* XLVII 1995, p. 42.
[7] Deacon, B., 'Proto-regionalisation: the case of Cornwall', *Journal of Local and Regional Studies,* 18:1, 1998, pp. 27-41.
[8] Burt, R., *John Taylor: Mining Entrepreneur and Engineer 1779-1863*, Buxton, 1977, p. 29; Rule, J., *The Vital Century: England's Developing Economy 1714-1815*, Harlow, 1992.
[9] Deacon, *Op Cit*, 1998.
[10] Hudson, P., *The Industrial Revolution*, London, 1992, p. 23-24.
[11] Hatcher, J., *English Tin Production and Trade Before 1550*, Oxford, 1973, p. 3-4.
[12] Radical new ideas in pumps known in Germany, Hungary and Slovakia, were introduced to Cornwall in the sixteenth century and thereafter modified. Gunpowder, used in Germany, was brought to Cornwall via Somerset in the late seventeenth century.
[13] Mathias, P., *The First Industrial Nation: An Economic History of Britain 1700-1914*, first published 1969, Second Edition, 1983, p. 122.
[14] It must be stressed that experimentation of this kind was not unique to Cornwall; by the 1790s engineers in Lancashire, Northumberland, Birmingham, Scotland and London were also thinking about the advantages of high pressure steam engines. Trevithick was the most famous of these in Cornwall.
[15] Kanefsky J., and Robey, J., 'Steam engines in 18th Century Britain', *Technology and Culture*, 2, 1980, pp. 176-177.
[16] Griffiths, J., *The Third Man: the Life and Times of William Murdoch 1754-1839*, London, 1992, pp. 239-242; Kanefsky J., and Robey, J., *Op Cit*., 1980, pp. 176-177.
[17] Lean, T., *On the Steam Engines in Cornwall*, London 1839, Reprinted by Barton D.B. (ed.), Truro, 1969, p. 1.
[18] Hudson, P., *Op Cit*., 1992, p. 24. See also Tunzelmann, G. N. von., 'Technical Progress During the Industrial Revolution', in Floud R.C. and McCloskey, D., (eds.), *The Economic History of Britain since 1700*, Cambridge, 1981, pp. 143-63.
[19] Lean, *Op Cit*, 1839, p. 1.
[20] French C., and Hosken, P., *Trevithick, First in Steam 1801-2002,* Trevithick Society, Camborne, 2001, p. 6.
[21] See for example the bibliography of Trevithick by Burton, A., *Richard Trevithick: Giant of Steam,* London, 2000.
[22]The white stockings mentioned in the folk song refer to the puffs of water vapour from the exhausting steam, and 'going up Camborne Hill, coming down' was an observation that the engine went up hill in reverse with its chimney at the rear. French, C., and Hosken, P., *Op Cit*, p. 13.
[23] French, C., and Hosken, P., *Op Cit*, p. 6.
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[27] Hudson, P., (ed.), *Op. Cit.*, 1989, p. 23.
[28] See Schwartz, Sharron, 'Exporting the Industrial Revolution: The Migration of Cornish Mining Technology to Latin America in the Early 19th Century', in *New Perspectives in Transatlantic Studies*, H.S. Macpherson and W. Kaufman (eds.), New York, 2001, pp. 143-158 and 'The Making of a Myth: Cornish Miners in the New World in the Early Nineteenth Century', *Cornish Studies 9*, Exeter, 2001, pp. 105-126.
[29] The first steam engine to have crossed the Atlantic was that constructed by Josiah Hornblower, who on leaving Cornwall in the late eighteenth century installed a Newcomen type engine at the copper mines of New Jersey, USA.
[30] Fenn, M.J., 1969, *Op Cit.*, p. 100; Gregory, D., *Op Cit.*, 1992.
[31] Fenn, M.J., 1969, *Op Cit.*, p. 100; Capt. Davies Trebilcock to the *West Briton*, quoted in the *Cornubian*, 31 December, 1869. The barometer stands without much variation at 17.30 to 18 in., which gives an atmospheric pressure of 8.5 lbs. per square inch, as against 14.7 lbs. at the coast. *Mining Journal*, 27 May, 1871.

[32] Hodge, Edward. *Reminiscences of a Veteran Engineer*. Unpublished manuscript, Capetown, South Africa, n/d. Copy in possession of the author.
[33] See Fisher, J. R., *Silver Mines and Silver Miners in Colonial Peru, 1776-1824*, Monograph Series No. 7., Liverpool, 1977, pp. 112-3.
[34] The company was to consist of the three contracting parties without admitting anyone else with a capital of about £8,000, of which Don Pedro de Abadía and Arismendi each held two-fifths, with Uvillé holding the remaining fifth. He was authorised to spend about £6,000, the estimated purchase price of two engines in England, with the proviso that if he could obtain another engine on credit, he could purchase it on account of the company. He was also authorised to engage a couple of workmen to accompany the engines.
[35] Fisher, 1977, *Op Cit*., p. 114.
[36]Agreement between Uville and his partners, *Journal of the Trevithick Society*, No. 3, 1975, p. 15.
[37] The company were to take in payment 15 per cent in the case of Yanacancha and Yauricocha mines and 20 per cent of the value of the ores raised of neighbouring mines.
[38] Agreement between Trevithick and Uville made on 8 January 1814 in London, *Journal of the Trevithick Society*, No 3, 1975, pp. 10-12.
[39] Dickinson H.W., and Titley, A., 1934, *Op Cit.*, p. 164. Wheal Alfred, Phillack, was another such mine.
[40] Hubatch, W., *Der Freiherr von Stein und England*, Koln, 1997, pp. 28-9. I thank Ronald Perry for this reference.
[41] Trevithick, F., 1872, *Op Cit*., Vol. II p. 220.
[42] Thomas Trevarthen, son of Thomas and Martha was baptised at Camborne in 1767. In 1791 he is noted as mining in Breage and became a Mine Captain resident at Carn Tremayne in Crowan Parish in 1814. William Bull, his fellow traveller, was a witness to his will made on 24th July 1814. Trevarthen died in Peru around the 4th August 1815 and the will was proved on 12 May 1816. Information courtesy of Alan Trevarthen, Brittany.
[43] Carter, C., *Cornish Engineering 1801-2002: Holman, Two Centuries of Industrial Excellence in Camborne*, Camborne, 2001, p.8.
[44] For more on the town and district of Cerro de Pasco see De Rivero, M.E. y Ustáriz. *Colección de Memorias científicas, agrícolas e industriales*, Brussels, 1857, Vol. 1; Helms, A.Z., *Travels from Buenos Ayres by Potosí to Lima*, London 1807. See also the *West Briton*, 22/7/1825.
[45] Fisher, 1977, *Op Cit*., p. 115.
[46] *Lima Gazette* 10/8/1816.
[47] For Trevithick's arrival in Peru see Boase, H. 'On the Introduction of the Steam Engine to the Peruvian Mines', *Transactions of the Royal Geological Society of Cornwall*, Truro, Vol. 1, 1818.
[48] Boase, H., 'On the Introduction of the Steam Engine to the Peruvian Mines', *Transactions of the Royal Geological Society of Cornwall*, Vol. 1, 1818, pp. 212-223. Trevithick had promised the Society a case of mineral specimens from the Peruvian Cordilleras.
[49] *Lima Gazette* 12/2/1818.
[50] *Lima Gazette* 12/2/1818.
[51] Trevithick's temperament is brilliantly summed up by Burton, A., 2000, *Op Cit*.
[52] *Royal Cornwall Gazette* 10/10/1818.
[53] Miers, J., *Travels in Chile and La Plata*, London, 1826, Vol. II, p. 441.
[54] Trevithick, F., 1872, *Op Cit*., Vol. II p. 250.
[55] Trevithick, F., 1872, *Op Cit*., Vol. II p. 254
[56] Miers, J., *Op Cit.*, 1826, Vol. II, p. 441.
[57] E. Hodge, p. 18.
[58] Fisher, pp. 122 and 114.
[59] Miller, John. *Memoirs of General Miller in the Service of the Republic of Peru*, Vol. II. London, 1829, pp.143-44. Bevan, described by Miller as an intelligent and industrious character, took shelter from the Spanish army in the mountains and lived as he could. Miller saw to it that Bevan was able to rent the government mine of Yaule and furnished with the means of carrying on the work. He sadly died two years later just as the enterprise was showing signs of great success.
[60] For details of Trevithick's exploits in Costa Rica, see Davies D.W., 'Richard Trevithick in Costa Rica', *Journal of the Trevithick Society* 5, 1977, pp. 7-26. The engines and equipment he hoped to import to Costa Rica might have been that noted as lying in a ruinous state in Lima by John Miers in 1823.
[61] Davies D.W., *Op Cit.*, 1977, pp. 7-26.
[62] Miller, *Op Cit*., 1829, p. 145.

[63]Schwartz, S.P., 'Exporting the Industrial Revolution: Trevithick and the Migration of British Steam-Engineering Technology to Latin America', *Journal of the Trevithick Society*, 2001, pp. 3-12. See pp. 10-11 for more detail, also Davies D.W., *Op Cit*., 1977.
[64] Miers, J., *Op Cit.*, 1826, Vol. II, p. 441.
[65] For more on the Age of Connexity see Mulgan, G., *Connexity: Responsibility, Freedom, Business and Power in the New Century.* (London, Vintage, 1998).