EQQ

South Crofty Mine

The flow of Cornish tin ore has dwindled over the past 100 years and now the future of the only indigenous strategic tin supply in Europe hangs by the slender cable at South Crofty mine. The metal is very precious to anyone who has studied the world's mining history or wants a little part of Cornwall which is pure and beautiful forever.

There is evidence that the tin industry began in Cornwall over 2,500 years ago. References to merchants trading with Cornish tinners are found amongst the oldest writings of Greek and Roman geographers. The Cornish mining industry grew to reach its peak between 1750 and 1850. It established Cornwall as the centre of hard rock mining and created a world-wide demand for its experienced miners. From the thousands of mine shafts which riddled the Cornish fields, moorland and cliffs there is now only one left working. Today the ore from South Crofty mine is taken to Malaysia to be smelted and mixed with other tins. The very small amount smelted in Cornwall for quality control purposes has become rare and valuable as pure Cornish tin.

Very few people know what tin looks like or what are its properties. Of course, we all know of canned goods and the protection from corrosion afforded to the steel by a thin layer of tin. By itself tin has a life and beauty of its own.

Tin is very much like polished silver without the need to polish. It can be combined with a very small proportion of other metals to form pewter which is used for many purposes and can be converted into fine jewellery. Working tin is not easy. South Crofty have been making jewellery from this quality metal by casting it in a centrifuge to ensure perfect replicas. The castings take the appearance of ingots, Cornish Celtic crosses, commemorative emblems, the endearing Cornish pasties and an impression of the spirit who lurks within the mine, heard but never seen, the Tommy knocker. Many items are made as brooches or pendants on silver chain. Some feature as earrings for pierced ears.

Cornish World magazine

Cornwall Online

The Stannaries to The Civil War

From regulation, through development activity to and enforced decline brought about by national internal strife. This period was one of developments for use of the products in warfare. It was also the age of British Expansionism

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The Stannaries

Definitions. Stannum, tin from the Latin. Stannary, pertaining to tin mines. Stannaries, in Cornwall and Devon, the area in which tin is mined.

Miners are a law unto themselves. The Bar Moot of Derbyshire (moot, from Old Saxon môt, an assembly) was the body which governed Derbyshire Lead. Stannary Law was the collection of regulations which governed the extraction of tin.

The earliest documentary evidence that there were such laws comes with the appointment of William de Wrotham on 20th November 1197 as Lord Warden of the Stannaries. Prior to his appointment the tax on tin produced in Devon (@ 10s per ton) and Cornwall (@ 5s per ton) produced only £17 for the exchequer. The Stannaries then began as a taxation exercise to finance Richard I's expensive hobby of battles and wars. During 1198 juries on Miners were convened at Launceston to declare "the Law and Practice of the Tin Mines" and the phraseology of the resulting documents prove that there were traditions of long standing, and that tinners had rights and privileges by custom and practice.

The Lord Warden was quick to raise taxes. The tinner was a villein, subject to the Lord of the Manor, but able to work on any piece of land (similarities with the Derbyshire Bar Moot here) within the tin bounds they set by piles of turf, for "toll-tin", originally one fifteenth of the weight of tin processed. In the first year de Wrotham had standardised weights, taxed another mark (13s 4d, 66.67p) on each half ton and organised collection procedures. (You find that, when researching, mark is sometimes spelt merke). By this means he was able to raise monies far greater than the total Cornish revenue from all other sources, some £600 in the first year.

Within three years, in 1201, King John was to make more provisions for the tin trade, having seen its value. The 1201 charter allows tinners to continue "of digging tin, and turfs for smelting it, at all times, freely and peaceably and without hindrance from any man, everywhere in moors and in the fees of bishops, abbots and counts, and of buying faggots to smelt the tin without waste of forest, and of diverting streams for their works, as by ancient usage they have been wont to do". Furthermore, the only Magistrate over the tinners was the Lord Warden, and only he had the power to summon them from their work for civil or criminal matters. This somewhat went against Magna Carta, which had assured the manorial lords that no man could be summoned always from the lord's service. They could see all the villeins turning tinners, and by 1214 production was 600 tons annually. Henry III confirmed his father's charter, and there was the situation of a state within a state. They ran their own parliament, had their own laws and taxes and were subject of no manorial dues or duties, and obeyed the King only when his orders came through the Lord Warden.

The charter of King Edward I in 1305 is interesting in that, whilst not conferring many more powers, records the fact that the Stannaries of Devon and Cornwall had separated into two entities. In Devon, Tavistock, Chagford and Ashburton were Stannary towns. In Cornwall that honour fell to Truro, Lostwithiel, Launceston and Helston (or so they were in 1508). Stannary towns were appointed as the places where tin could be weighed and stamped. There must have been some sort of assaying process in place, because at a later time, any tinner found to have adulterated his metal was to have "three spoonfuls of it poured down his throat in a molten state". Stannary Parliaments, on the other hand was where the convocations of tinners were held. In Devon it was a Crockern Tor, just north of Two Bridges which is near Princetown, and in Cornwall on Hingston Down, near Callington. Later practice in Devon said that the parliament convened there then adjourned to Tavistock!

Times changed, and as in every extractive industry areas became worked out. In 1328 Plympton became a Stannary town and Tavistock lost its status, but had regained it by the following century. However, another tier of government was to by introduced in 1337 with the creation of the Duchy of Cornwall. Edward III created the title, and appointed his son, Edward the Black Prince as the first Duke. The government of the Duchy rests in officials appointed by the Duke, one of these being the Lord Warden of the Stannaries. This official is responsible for convening Stannary Parliaments, but the last one so convened sat in 1753!

Edward IV granted another charter in 1466, and the first Crockern Tor Parliament of which accounts remain was held in 1494. In 1508, the Charter of Pardon of Henry VII caused Cornish Tinners to pay £1000.00, and this sum was raised by a general levy on all tinners. In return the tinners won the right for more provisions of selfÐgovernment and the right to veto statutes and ordinances which would have affected them and the Stannaries, such was the importance of tin to the national economy at that time.

The Stannary parliaments have been of varying composition. The Cornish parliament had 24 Stannators (members), elected by the Stannary towns. The Devon had 24 Stannators, or jurats to the court from each Stannary Town. There was a Stannary prison at Lydford, to which the member of the Commons for Plympton, Richard Strode, was confined at one time in the reign of Henry VIII for bringing a Bill at Westminster compelling tinners not to discharge sand down the streams as the harbours were getting choked up! He refused to appear before the Stannary Court and had to give a bond of £100 to the deputy Warden of the Stannaries to be released. However, a Westminster Act was passed reversing his condemnation, and from that time the power of the Stannaries declined.

The power of the Stannaries probably later conflicted with the Mines Royal, of which more anon, and the last parliament sat on Crockern Tor in 1748. In 1838 the tin coinage was abolished, and Queen Victoria and subsequent Dukes have been compensated in perpetuity. The loss of revenues was made good by customs duties being levied on imported tin and ore.

Little remains of the structure of the open-air Parliament. The slabs and Stannators seats had disappeared before the end of the eighteenth century from Crockern Tor. But every O.S. Outdoor Leisure map of Dartmoor has the site indicated. There are still some Stannary provisions in place, In Cornwall the Truro County Court is supposed to enforce that part of the law, and tinners may still pitch bounds on land belonging to other people providing strict conditions are observed. However, attempts to register tin bounds have met with a degree of frustration culminating in failure.

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Mediaeval Times

The mining and processing of tin developed, and among other things pewter (alloy of tin and lead) was becoming a common household material. Demand was increasing, as was the population. The earliest known smelthouse on Dartmoor was behind the Warren House Inn on the road from Princetown to Moretonhampstead. Indicative of its importance it is called Furnum Regis (the King's Oven). However, the balance of prosperity between Devon and Cornwall was swinging in Cornwall's direction, as the majority of the Dartmoor stream tin was worked out by the beginning of the thirteenth century. At this time about 200-450 tinners were on Dartmoor at any one time. In the reign of Edward III the population of the Stannaries was put at around 1000.

Production of tin in Cornwall reached a record in 1337 with 650 tons coined, the year that the Duchy was created. The practice of hushing, the ponding of streams behind dams and the sudden release of water to scour out the fine and less dense rocks and leave the heavy tin bearing rocks behind had effects beyond the moors. The ports of St Erth and St Blazey were ruined as ports by this practice, as the effluent silted up the harbours. This happened in many places in Devon and Cornwall, and there are Acts of Parliament over a long period which record the attempts to curtail this.

The Black Death affected Cornwall greatly. The outbreak of 1348 reduced the population of the county from 60,000 to 40,000, but because the economy was largely rural and had few towns, it escaped lightly. The manorial lords were deprived of labour, and it began a period of social reform. Tinners had suffered greatly, and the industry suffered with them. From the record of 1337 (650 tons), by 1355 production had fallen to 250 tons. The Duke (the Black Prince) issued an edict that owners and tinners should expend as much effort and capital as before, but to very little effect. it was not until the end of the century that the population recovered, and recruitments also, so that in 1400 the production was 800 tons. Communications were improving, and merchants traded directly with the continent through improved technology in shipping.

Remember that we're still mainly on stream tin, and any extractive industry's resources are finite. At this time more energy is being expended in finding resources as a proportion or total effort than in actually performing the extraction. In other words costs are rising. There was a limit to how long his could go on. Technology had not advanced. It took war to revive it.

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Tudors

Lode mining just had to be developed. Adit working developed on Dartmoor by the end of the sixteenth century. The knowledge was not in the hands of the natives, but in the German Miners, who had developed techniques for underground mining. In the latter part of the sixteenth century, BritainÕs mining was in a pretty poor state, at least compared with its continental counterparts (havenÕt we said something before about history repeating itself?) Sir William Cecil, Elizabeth IÕs Secretary of State masterminded their involvement. Brought here to develop the copper and lead industries, Daniel Hochstetter, who had extensive mining interests in the Tyrol, was granted exclusive mining rights in several counties. Initially starting in Cumberland, this was incorporated as the Society of Mines Royal. In parallel another venture, the Society of the Mineral and Battery Works (battery=gun) was also started and they were meant to be complimentary of each other. Within the aegis of these two new capitalised companies investment could be made in new techniques. Agricola in De Re Metallica (Basle, 1556) illustrated the new techniques in mining and processing, but it was only in 1580 that Mines Royal leased their rights in Devon and Cornwall to one Thomas Smith, Collector of Customs for the Port of London, for £300 a year. A smelting works was set up at Neath and copper was mined at Perran Sands. Development continued, for over a century, but by 1689 the Mines Royal Act was passed which abolished this monopoly, and enterprise mining developed in Devon and Cornwall. The story of copper and parallel tin mining is beyond this section. It must have some space devoted to is, and does not fall readily into a chronological treatment as this has been.

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The Civil War

Cornwall came out in the side of the Royalists. Plymouth, however, came out for Parliament. The internal warfare did little for the metal trade. The major families who were now playing a part in the development of tin and copper. Sir Francis Godolphin, whose interests centred around the area between Helston and Penzance, Sir Richard Vyvyan of Trelowarren, the Basset Family who had interests round Camborne, in fact much of the Cornish Gentry suffered, either by exile or fines, and with them the industry. The Bassets even had to sell St MichaelÕs Mount to John St Aubyn , the leader of the Parliamentarian forces.

The Anglican clergy also suffered. The Prayer Book Service was forbidden, many churches were ransacked for their finery, and many priests thrown out. Stained glass was smashed, and another phase of religious intolerance had arrived. Let it be said that religious intolerance in Ulster and Croatia must be similar: the present is the key to the past not only in geology!

The Restoration of Charles II reversed yet again the fortunes of many families. His supporters were rewarded and his opponents dispossessed. But this constant change had a weakening effect. Cornwall never enjoyed the same degree of independence after the Restoration.

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Social Conditions and the Miner

John & Sandy Colby

The people who mined the ores were more often than not poor, on a subsistence income and in poor health. These were all a result of the social conditions pertaining and of the sheer effort in mining for ores. Food was also a problem, both growing and paying for it.

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The Miner, the Huer and Starvation

Once the individual entrepreneur had all but gone, men worked in the mines for pay. Just how that worked out is another story. Women and children were also employed, but on the surface in ore processing. Each family might have their smallholding on which they grew vegetables but protein was in short supply. What was not in short supply was the sea. Cornwall is surrounded by it, and fish featured largely on the menu.

The principal fish for storage and trade was the pilchard, and later a healthy export trade had built up with it. Pilchard are not distributed evenly in the seas. They form large shoals and this aids the catching of them. When the sign of a shoal was seen as a darkening of the sea surface, the huer, the person responsible for sighting the fish, would make their presence known, probably by shouting. Seine boats would then put out and herd the fish inshore to a bay where they could be caught. Seiners would drop a net and confine the fish, gradually reducing the area of the net so that the fish could be scooped out with baskets. Other boats would put along the seiners to take the fish on a ferry basis to shore, where they would be cleaned and salted for preservation. Occasionally the huer would have little to do, as the pilchards would fail to come. This was the stuff of famine. Fishing for pilchard was a community effort, as the fish had to be preserved in as short a time a possible. Damaged fish were, in times of excess, put on the fields as manure. They may also have been given way to the poor (a relative term, no doubt). In the fourteenth century the population estimated at 40,000 ate 12,000,000 pilchards. (300 per person, less than one large sardine a day per person). Lots of fish, but not very big!

Fish was also caught by other means, and there were the gamebirds, rabbits and hares on my lord's land for the adventurous. However, penalties were high and gamekeepers tough. But there was not a lot of arable land for corn, and merchants could charge what they liked for the imports. Food riots were not unknown, and subsequent hangings and transportation for these offences all too common. But this was the tenor of the age. A working miner of fifty was a rarity. Life expectancy was around 45, and there were many more widows than widowers. Mining was dangerous, deaths and maimings being frequent. And not only underground. The propensity for steam boilers to explode was quite high, suffering as they did from more than occasional poor design, lack of maintenance and heavy workings. To the toll must be added death and injuries from rock falls, floods and the miner's diseases, which came from long hours working in a atmosphere which would barely support the candle flame which was their only source of light. Follow a seven hour shift in these conditions on a poor diet with a climb of several hundred feet to grass (the surface) at the end of a shift.

Fuel is also a problem. Coal for smelting and engines, (eventually) has to be imported from South Wales, and the packhorse has to carry the loads the last part of the way from the port. Fuel also has to be found for these packhorses, increasing the pressure on agriculture. The seas over which the coal comes is subject to storms and vagaries of the weather. Real documentation of mining started around the beginning of the 1700s. Perhaps at this point we should take a look at an outsider's observations on the mining industry.

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Celia Feinnes

Celia Feinnes was a remarkable woman for her age - not physical age but the time in which she lived. Born on 7th June 1662, in the reign of Charles II, she concerns us because she did what very few women were able to do in her time - she travelled. Not only did she travel, she kept a complete journal of her travels. Her journeys spanned the years 1685 to 1712, so this was no flash in the pan. In 1698 she travelled into Cornwall, and saw and described tin workings. Here are some of the descriptions of the sites around St Austell.

"I went a mile further and soe came where they were digging in the Tinn mines. there was at least 20 mines all in sight which employs a great many people at work, almost night and day, but constantly all and every day includeing the Lords day which they are forced to, to prevent the mines being overflowed with water; more than 1000 men are taken up about them, few mines but had then almost 20 men and boys attending to it either down the mines digging and carrying the oare to the little bucket which conveys it up, or else others are draineing the water and looking to the engines that are draineing it, and those above are attending the drawing up the oare in a sort of windlass as it is to a well; two men keeps turning bringing up one and letting down another, they are much like the leather buckets they use in London to put out fire which hang up in churches and great mens halls; they have great labour and great expense to draine the mines of the water with mills that horses turn and now they have the mills or water engines that are turned by the water, which is convey'd on frames as timber and truncks to hold the water, which falls down on the wheeles, as an over shott mill - and these are the sort that turns the water into severall towns I have seen about London Darby and Exeter, and many places more; they do five tymes more good than the mills they use to turn with horses, but then they are much more chargeable; those mines do require a great deale of timber to support them and to make all these engines and mills, which makes fewell very scarce here; they burn mostly turffs which is an unpleasant smell, it makes one smell as if smoaked like bacon; this oar is made fine powder in a stamping mill which is like the paper mills, only these are pounded drye and noe water let into them as is to the raggs to work them into a paste; the mills are all turned with a little streame or channell of water you may step over; indeed they have noe other mills but such in all the country, I saw not a windmill all over Cornwall or Devonshire tho' they have wind and hills enough, and it may be its too bleake for them."

That's a single sentence. This the English style in which leases are drafted even today. Celia Feinnes goes on to mention Cornish Diamonds - quartz crystals and notes the number of mines she passed. Whether we are to take her numbers as accurate is open to question, but it is a description which is unequalled elsewhere describing the condition of the mines and the people employed therein. Several things can be gained from this description:

1. Drainage of mines was obviously a problem
2. In this period, the main energy was supplied by water, horse and man, the water power being the most efficient.
3. Mines used large amounts of timber for supports and structural materials
4. Because of this fuel for cooking was turf - pretty inefficient as fuel.
5. Windmills need structural timber, but this was used up in the mines, not that there was a vast quantity in the first place. The only available structural materials are stone and timber.
6. The question of why not windmills must also be answered by the reliability of the wind. It is not a constant power source, and draining mines needs constant power.

Later in her journals she documents her journey around Redruth where she found copper mines, and mentions that they were drier. She also describes the travels of copper to Bristol by the "North Sea", the Bristol Channel, whence also was shipped coal for fuel.

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The Trade and Wrecking

With such a long coastline, the plethora of bays and coves, the high taxes and the willingness of those in authority to receive gifts of brandy led to the expansion of smuggling, the Trade. Of course the Excise were about, supported at times by dragoons, but it was profitable. Governments tax the most unlikely things - like the salt which was required for the preservation of pilchards - and this was the poor man's main source of protein. So it was not uncommon for obstructive methods to be put into place when the excise were about. Hiding places under many Cornish houses were carefully constructed. Anything that was taxed was ripe for smuggling, and some operators had agents in French ports, so regular was the trade. George Borlaze reported in 1753:

- The coasts here swarm with smugglers from the Land's End to the Lizard so that I wonder the soldiers (who were late quartered here) should have been ordered off without being replaced by others.

Wrecking was another matter. The coasts of Cornwall were treacherous - and many ships foundered. Borlaze again.:

- Sometimes the ship is not wrecked, but whether 'tis or not the mines suffer greatly, not only by the loss of their labour, which may be about £100 per diem if they are two thousand in quest of the ship, but where the water is quick the mine is entirely drowned and they seldom go in a less number than two thousand.

The £100 divided by 2000 make the wage a shilling a day, and the wreckers had a chance of salvaging more than that in goods or wood. The deliberate wrecking policy employed in fiction by the vicar of Altarnun (Jamaica Inn - Daphne du Maurier) may be an embellishment, but the practice of salvage for personal use was understandable in the light of the grinding poverty in which most lived.

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Famine, Migration and Emigration

The centre of major mining activity moved east, and miners migrated to find work. Mines closed as they were worked out or closed for other reasons and new ones opened as new ground was discovered. Census returns show that as new ground was broken, young men migrated into lodgings in the area, and then married and settled down. This is a simplistic view, there were of course other factors. The failure of the potato crop of 1840, the copper price crash in 1866 and the simultaneous opening up of Australia and America, the discovery of gold in California in 1849 all meant that the grass looked greener elsewhere. Agents were appointed by both the colonies and the mining companies to recruit experienced Cornish miners to open up the new territories. In September 1875 the West Briton reported that during the first six months of 1875 10,576 emigrants left Cornwall for Australia.

Wages were also variable. In 1865 a hard working miner in St Just could earn £3-3s-0d (£3.15) a month, but by 1867 this had fallen to £2-10s-0d (£2.50), with a sack of flour rising from £1-10-0d (£1.50) to £2-10s-0d (£2.50) in the same period. The workhouses also felt the effects.

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The Twentieth Century

The decline of Cornish mining is well documented, the coming of the railways too late to do anything substantial. There is, however, the Camborne School of Mines which stands as a reminder of that past and a centre of mining teaching excellence. From dying away almost completely in the 1930, the Second World War did not revive it. However in the 1960s new extraction and processing technologies meant that previously uneconomic deposits (and waste dumps) could be profitably reopened. Demand for tin grew, and the great hope was that there would be a revival. However, mines closed in the 1970s and 1980s, and the tin price crash caused by the collapse of the International Tin Agreement in 1985, from £10,000 per tonne to £3,000 per tonne. Currently only one mine remains in production, Next section - Mining Methods | Go to top of page | Return to history index | Return to home page

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Mining Methods

The Cornubian Mineral Province

John & Sandy Colby

If you dig a hole it will fill with water - the deeper the hole the more problem you have in getting the water out. Until the advent of mechanical pumping there was a limit to how deep you could go.

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Tin Streaming

When tin was discovered it was not mined, but gained from pebbles picked up from stream beds. One can speculate that some one or several of our distant ancestors would have collected pebbles from a stream and have used them for a hearth. The heat from the fire, in combination with the reducing effect of the carbon produced by the burning of the fuel (whether wood, turfs or peat), may have reacted with the cassiterite contained in the pebbles, giving a first accidental smelting. Once the value of the metal had been ascertained, they they would go round looking for other similar pebbles, and better ways of smelting. These supposed pioneers, provided they could use tin as a tool or ornament, would have something of value to trade with contemporaries. They might have noticed that when you blow on a fire it get hotter, so a set of skin bellows might somehow be made from that which originally contained lunch when alive, and an industry started.

This, of course, is pure conjecture. The precise method of the discovery we shall never know for certain. What we do know is that as the industry developed and continued for millennia, that tin streaming was the major source of the raw material. Here we will examine the mechanism for the deposition of the tin pebbles at the base of stream beds.

If you look on the North Norfolk coast today around Weybourne, you can see that there is chalk covered by glacial till. At the base of the till is a collection of flints, which have been left after the erosion of the chalk by ice. The cliffs at Weybourne show a good cross section of an eroded surface of chalk topped by flint debris topped by till.

It is supposed that erosional forces deposited tin in the valleys on the granite. It is also suggested, with good evidence, that the surface of the granite exposed today is near the top of the emplaced batholith. And the mineral which condensed first from the hydrothermal systems in the granite and killas is cassiterite Ð tin dioxide. So if the land is eroded down to the top of the granite what is likely to be left is the heaviest particles which were originally closest to the top of the granite.

In the periglacial conditions experienced at the close of the last major glaciation 18,000 BP, ice had reached the coasts of North Devon and Cornwall. There would have been extensive erosion, frost shatter, precipitation, all causing extensive washout of any soil around. The heaviest particles would have settled in the river valleys. As precipitation lessened and plants came back to colonise the area, soils developed and lighter residue would have remained, covering the heavy pebbles deposited earlier.

This is exactly what would have been found in the tin streaming areas, heavy tin bearing stones at the base of the flood plains of the river valleys overlain by lighter sediments.

It is a particularly fortunate combination of circumstances that this did occur, that erosional processes were 'just right' for this to have happened. Early miners in the Christian era attributed the tin stones to

Noah's Flood (but that event is now attributed to the tsunami associated with the Minoan Santorini explosion and collapse).

What happened was that tinners would search up streams for likely signs of ore bearing pebbles, and follow them upstream until they saw them peter out. They would then have a good indication of where the lode was from which the pebbles originated. They did not have the technology to go deep into the lode, but used their experience of the way that the tin bearing pebbles lay along the valley. The old men described three types of tin ore, stream, shode and mine. Stream and mine are self evident, shode are the concentration of large tinstones near the parent lode.

This, however, required a bit of effort. The tinstones were covered with several feet (20 to 36 being common) of other sediments. So they used a trench and backfill process to take out the lowest layer.

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Drainage

If you dig a hole in the ground it will fill with water - fact. Whether from rain, groundwater seepage or the tide coming in. The technology of mining is limited primarily by how fast and effectively you can remove this water. The second limitation is how you get the ore to surface, the third by how you get men down to mine the ore and back up again, and the fourth how fast you can process the ore from the gangue.

There is no mention herein of safety, employment, air supply or hazards associated with mining. These are aspects of the task which have varied in importance with the years. And we are limiting ourselves to the production of ore, not metal, in this stage of the argument.

Yet each of the activities mentioned above requires the expenditure of some form of energy, whether it be humans with picks and shovels (and these may have been the antlers and scapulae of deer) or some more modern form, iron picks and shovels for example. Once man had got into the idea of using levers then there was the application of mechanical advantage, where a greater force or speed could be utilised to advantage. Remembering O level physics and first, second and third order levers, we could be dealing with very simple technology. If we include the windlass as a vast improvement in hoisting technology, this is all that we need to think about when we consider what is employed in mining. Before any objections are raised, this is of course a simplistic view. We also need to consider chemical energy in the form of explosives and fire, but that is a later development.

Advance in technology is only a method of making work easier or getting something else to do the work for you.

Lode mining could not advance initially above the depth that could be kept dry by a man with a bucket until some sort of fast method of water clearance could be invented. This means a few metres in an impermeable rock like granite and killas. Grimes Graves, the flint mine, in Norfolk is a different kettle of fish, as there are two factors to consider. Firstly the rock (chalk) is permeable, so water can drain away, and secondly the rainfall in Norfolk is much less than in Cornwall. There is less incoming (rainfall in Norfolk is (currently) a third that of West Penwith) and what does come in has a chance of going away because of the permeability of the rock. Both factors have a bearing on the drainage potential of mine workings.

It was the advent of the input of the German mining technologists which was to advance the accessibility of the ores in lodes. They brought advances in the pump and windlass, covering three of the four points mentioned initially. The windlass could be adapted to get men and equipment up or down or minerals up. It was either that or men carrying it on their backs. The pump is a method of getting water up. The alternative is the bucket or scuba diving, but that hadn't been invented in the sixteenth century. The essential element in either of these is to get some sort of continuous motion. And this usually means rotary motion somewhere in the power train. For the windlass the rotary motion can be provided by man, and for the rag and chain pump men winding a handle can provide the energy. Some simple descriptions will highlight the essential elements and limitations of this technology.

The windlass is a drum with rope wound around it which can hoist or lower men or materials. It is essentially a oneÐway device, either pulling in rope or paying it out. What dangles on the other end of the rope is either, therefore, going up or down. The rag and chain pump is a vertical pipe with a continuous chain passing up through the middle and down the outside. Through some of the links of the chain are roughly circular plates which almost fill the bore of the pipe. The bottom end of the pipe in in the water sump of the mine and the top end passes over a drum with a handle. Turning the handle (in the correct direction) causes the plates to pass up the pipe. As the bottom end is immersed in water, and as the plates nearly fit the pipe, water is persuaded to travel up as well, and if you arrange the discharge to be away from the mine entrance, you have a method of getting water out of the mine.

This is all very well until you have to consider who actually provides the energy input, and in his case it is man. We do have an advance in technology by making things easier. What we have is an application of rotary motion for two things, winding and draining. What we need now is for something else to do the work for us.

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Animate and Inanimate Power

The Cornubian Mineral Province

John & Sandy Colby

Once you employ other means than your own muscle to win tin, then you have to have an infrastructure to support it. You also, whether you employ animate or inanimate sources of power, have to maintain and fuel them, whether it be hay for horses or water for wheels.

Horses, Water and Wind

This is the animate and inanimate. The horse is stronger then a man, eats grass, not meat, and can be persuaded by virtue of domestication and a whip, to do the work of several men. If you constrain a horse or mule to walk in a circle, persuaded on by small boys, then you have rotary motion without human effort. It is not for nothing that the imperial measure of work is called horsepower! The horse-whim was then born (whim is the Cornish name for something that winds). With horses you could then free up men for more productive work, like digging, and leave a boy at the surface with a goad for the horse (or mule).

Additionally, falling water gives up energy. And water in a stream tends to a lower level. There are very few recorded instances of water flowing naturally uphill! So if you can divert water so that it falls in a controlled fashion, and make it turn something on the way down, you can get some power input. The water wheel is such a device. If you can hold a quantity of water at a distance from a fulcrum (the lever again) the more force it will exert at the fulcrum. In other words, if you make a big water wheel, you'll get quite a lot of power, because the force magnification is great, (second order lever). As you have made a wheel you get rotary motion anyway.

What a water wheel needs is a supply of water, and quite extraordinary lengths were taken to ensure this. A stream many have been used many times on its descent to the sea, both for power and for minerals dressing.

But there are no large scale windmills powering mines in the Cornubian province. In this exposed and often stormy area would it not be a good idea to harness the power of the wind? There are a number of things mitigating against this. The power of wind can be used for grinding corn, and if the wind drops its not disastrous, as the corn will start to be ground again when the wind picks up. When you're draining a mine of water then it would be quite daunting. If a man is halfway up a shaft when the wind drops, then he's in trouble. And the power generated by wind is not sufficient to generate much energy. Even on a good day it would not be sufficient even to pump from a few fathoms. There is also the problem of building the windmill in the first place. If the only structural materials you have are stone and wood, and you need the wood to prop up the mines and to make charcoal for smelting your product, you are left with precious little for windmills. So wind power is not an option.

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Ore Dressing and Refining

Ore does not come out of the ground in big lumps ready for the smelter. It comes out in little lumps mixed up with a load of other stuff. Dressing processes separate ore from other stuff, called gangue

The gangue is either valuable, containing other ore which you know about, or waste, containing material which is either of no commercial use or contains material which is of commercial use which you don't know about - yet.

So in order to start the extraction process of the useful ore from the other stuff, and we are here talking almost exclusively about tin, you bash it about and sort it. Sorting can be by hand if the ground is sufficiently rich to allow ore to be identified visually. Otherwise you have to use some sort of technology to separate the required from the dross. Cassiterite is generally denser than the gangue. Use of this property will give a method of separation. It's like separating wheat from chaff in agriculture, where you use a flow of air to blow away the unwanted material. Rock, however, is not susceptible to be blown away, so you have to use a denser medium as your fluid. The most common and readily available denser fluid is water, so you have the development of ore dressing using water. Archimedes' principle then applies, where here is a reduction in apparent density when you place objects in water. This is the principle of panning.

Minerals processing is (or was) panning on a large scale, preferably with the assistance of stream, because if you can get water to flow over a subhorizontal surface upon which you spread the granular ore and shake the table, this will displace preferentially the less dense particles from the denser particles. Of course some of the more dense particles will be carried away as well, but this is all part of the recovery process to limit the amount of useful stuff which is discarded.

Today there is a complex process of grinding, separation, regrinding and flotation to recover as much as possible.

But in the early days, the first drawing of cassiterite was on a peat fire, which produced a gritty tin. In Dartmoor in the twelfth century this impure product was then carried down to a recognised smelting centre for final smelting and purification. The recognised smelting centre was to become the Stannary Town. And of course, the hand of government had to come in with a tax, which is where, if you're trying to get some sort of accurate picture, is where variable weights also come in. A tax of 2s 6d had to be paid at the first smelting, so to compensate the Devon standard tin pound was eighteen ounces. The ingots were cast at 195lb, by whichever standard, and transported far and wide, even to the Near East. Dartmoor was the prime source of tin for the majority of the then civilised world at that time.

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Blowing Houses

The importance of the smelting centre declined when tinners, or groups of tinners, set up their own blowing houses. This was a small mill and foundry which used the power of water (of which there is usually plenty on Dartmoor) to work a water wheel which worked both stamps to crush the ore and the bellows to give forced draught to the furnace.

Blowing houses, or their remains, are common on south west Dartmoor. They were also called Jews House, but whether this is whether Jews were particularly concerned with tin smelting or whether it is a language corruption is uncertain. The term Jews Harp for the musical instrument could be a corruption of jaws harp!

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Transport

Roads were tracks, wheeled wagons would get bogged down except in the driest weather, and so apart from someone carrying whatever it was the pack animal was used. A horse can carry about 3cwt

(150kg), and so you have a string or horses, or pack train. Naturally you need to think about fodder, water and looking after the animals as well. To carry half a ton, well within the capacity of the average sized car, you would need four packhorses and a driver. Packhorse trains in the Midlands were about fortyÐfifty horses long and would need a number of people to look after them (no brakes, you see). That may have been of different lengths in Cornwall. As mines got more technologically advanced, and needed coal, then the only feasible way was to have a packhorse train frequently visiting. Or several visiting in succession. The requirement for coal is discussed later. It is said that one firm of merchants in Hayle had over a thousand horses at one time.

As we have said, a horse can carry about 3cwt, but give it a railway wagon and it can pull 3 tons. Immediately a twenty fold saving in fodder, hence cost, and it could deliver the goods faster. The first railway built in Cornwall was the tramway from Portreath to Scorrier and was in use in September 1812, extended to Poldice in 1819 and closing in 1865. The second was also horse drawn and was the Redruth and Chasewater, opening in 1826 which was horse drawn until 1854. Let it be said that the coming of the railways was too late to save either the tin or copper industries in Cornwall.

In addition to coal, structural timber for the mines had to be imported and transported.

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Bang Flash Wallop

Instead of digging out all of the ore with picks, if you drilled holes and inserted a chemical reagent known as gunpowder, lit the fuse and stood back, you get a lot of broken rock for less effort. This technological change came about in the sixteenth century. However it also brought its risks, of premature explosion, rock falls, unexploded charges, people not getting out of the way fast enough so being hit or buried by flying rocks and flooding. If you had dug this out, you might have had warning because you may have seen the seepage before it became a flood. Drilling for explosives was originally carried out by hammer and borer, maybe two hammerers and one man holding the borer, lifting and turning it between strokes, hoping that the hammerers had a good aim. Every so often the men would change positions, borer becoming hammerer, etc. Often they would be boring uphill, overhand stoping. It was all very exhausting, and when air powered drills came into use they made the effort needed less, so with the same effort one man could drill more holes.

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Fuel and supply

Copper, once the mainstay of the Cornish industry, was smelted mainly in Wales, and the whole industry under the domination of the entrepreneurs in Wales. Wales had coal, so it was economic sense for the ore to be taken there. Neath and Bristol were the first smelters, Bristol giving way to Neath because of the transport costs for the fuel, and Swansea became the prime market. Smelting had been tried in Cornwall, in Hayle and near Perranporth, but the economics of transporting the fuel rather than the ore defeated them. There is still a district of Hayle called Copperhouse.

The coal came to Cornwall in small ships (c. 50 ton) and the unloading process was manual. Small derricks and baskets to offload the coal to the quay, from whence it would be transported by pack animal. The returning ships would transport the copper to the smelters. The copper manufacturers controlled the whole trade.

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Steam and its People

John & Sandy Colby

Controllable inanimate power came in the form of steam pumps. The efficiency of the first set was quite low, but at least it meant that you could work deeper. Greater efficiency came with its price - patent protection, and eventually a very efficient method of pumping took hold in Cornwall. However, the previous money extraction had exacted its toll.

Newcomen's Engine

Getting water out of the mines was the prime consideration, so something which would speed this process was welcomed. Thomas Newcomen (1663-1729), an engineer from Dartmouth, constructed the atmospheric engine in 1712. He did not invent the principle. Giambattista della Porta (1538-1615) sketched and described an apparatus whereby steam from a boiler forced water out of a tank. Thomas Savery (1650-1715) built a practical pumping engine at his workshops in Fleet Street, London. But this was not applied in Cornwall.

Newcomen's was a condensing engine, where steam was admitted to a cylinder and on condensing could perform work. The arrangements from making this a repeatable process were more complex than this, but the Newcomen engine was called an atmospheric engine because the work was performed by the atmosphere reacting against a partial vacuum created by condensing steam. At 100 Celcius (or 212 Fahrenheit as would have been current at the time) steam occupies a volume of approximately 1660 times greater than the same volume of water (both at atmospheric pressure).

There were limitations to the Newcomen engine. The areas of concern, which we see nowadays, were fires and their shape, the pressure which the boilers could stand, the inefficiency of the single stroke engine, the inefficiency of cooling and the excessive coal consumption.

The fires were several feet deep, which meant that combustion was inefficient. There was insufficient understanding of chemistry at that time to allow for the fact that oxygen had to get to the coal to allow it to burn. What happens in a deep fire is that you have oxygen starvation, the fire at best will glow a dullish red rather than a bright orange, and the heat transfer will be limited in efficiency. The speed of heat transfer relies on the difference in temperature, so a much slower rate of heat transfer will occur if you have a dull red fire rather than a bright orange one. It wasn't to be until the end of the eighteenth century that changes in technology and knowledge of heat transfer processes would bring a difference in fire shape, and hence efficiency, about.

Another limitation to this technology was the construction of the boilers. Copper was the favoured material, but this (and other things) meant that pressures had to limited to 3-4psi (pounds per square inch). Once wrought iron plates became available, and the technology for riveting them together, then boilers could be made to withstand higher pressures. However, in the absence of secure riveting technology, another method was needed. What happened was that when you'd joined to plates as best you could you packed any gaps with iron filings and rammed them home. Then you expanded the iron filings by oxidising them, i.e. you made them rust. In order to do this you sealed the outlets with clay to prevent leakage, and made a reservoir of the same material to contain your fluid. It speeds the reaction if you make your fluid acid, and apart from peaty water (a very dilute acid), gone off beer (which you'd use as vinegar) the most readily available material for free was urine. Collection and presentation of this to site need not concern us here! When your reaction had proceeded, and your joint allowed no escapes, then you could proceed to the next section. It might be expected that boiler explosions were not uncommon!

The third factor to any limits of efficiency was the sealing mechanism at the top of the cylinder. Cylinders had to be large - the active force was a maximum of only 14.7 psi - the atmosphere, and obviously less because of the impossibility of producing an absolute vacuum and 100% efficiency. Technology did not exist for producing a perfectly circular cylinder or piston, so the seal was water, available and topped up occasionally.

Coal consumption was a problem. A large engine could consume twelve tons a day. Pumping engines had to run seven days a week 24 hours a day. They couldn't have a day off on Sunday otherwise on Monday morning you couldn't actually start work because of the water. So just consider what is involved:

- 1 packhorse load is 3cwt and anengine consumes 12 tons of coal per day, therefore (12 x 20 /3) packhorse load per day = 80 packhorse loads per day
- 1 packhorse train - 40 horses, so 2 packhorse trains per day.
- 1 50 ton ship could carry perhaps 20 tons of coal. You need 12/20*7 = 4.2 shiploads a week just to keep one big engine going, and there were 40-50 engines across Cornwall.

Add to this the manhandling, the unloading, the horse forage, the food for the men, and it was a very large undertaking to have just one pumping engine on your mine. And of course, the Newcomen engine was not efficient - it was the best that could have been done at the time. You could not heat up and cool the cylinder completely every stroke, the system would get warmer, and so less efficient as the vacuum would not be created at every stroke. The vast coal consumption was prohibitively expensive. It only acted on one stroke. And on and on. It was left to James Watt and his partner Matthew Boulton to improve the efficiency of his engine, but first something on mine design and pumping.

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Mine Geometry, Pumping and Drainage

Initially, before technology, mines followed lodes, and except in rare circumstances, lodes are not vertical. Or straight. So old mines have a lot of bends and twists in them. The advent of steam engines meant that something had to be straightened out somewhere. We will take these arguments as if there is a vertical shaft, but please accept that bends and nonÐverticality was commonplace.

In order to pump water out of a mine the pump cannot be situated at the surface and suck. Physics doesn't behave that way. If you have a column of water with a vacuum above it, the column of water will only be 34 feet high (that's less than six fathoms) and mines were deeper than that. What needs to happen is that you need to transfer the pumping mechanism to where the water was, i.e. in the sump at the bottom of the mine. You also needed to transfer the power down there as well. In the discussions which follow about engines, we will use reciprocative rather than rotary motion as supplied by the beam engine. We'll look at how the reciprocative motion can be turned into rotary when the appropriate technology had been invented.

This is skipping forward a bit and the technology described had in some cases to wait for the power source technology to catch up. But it is applicable to many of the power source improvements which came in the eighteenth and nineteenth centuries.

It was most convenient to have your power source on the surface, and the pump in the sump. Transference of power between them was by coupling them with a long rod which is attached to the end of the beam. However if you allow the long rod to hang from the beam it is going to be pretty heavy, and will break your beam, if not the rod itself. Bear in mind that we're taking about timber and cast or wrought iron for the materials which were able to be used. If, however, you arranged counterweights down the rod, then you would only be overcoming the momentum of the mechanical system rather than supporting a heavy load. You did have to have some weight acting on the beam, because it was this weight which cause the admission of steam into the cylinder on the Newcomen engine.

As the pumping requirement increased as the depth of mining increased, then you extended the pumprod, increased the counterweights and did not change the mechanics of the systems much. The power requirement for pumping could be lessened if you didn't have to bring water all the way up to grass. If you can drive an adit which will run downhill into a stream or out to sea, then you can discharge water at this level. Adits, some interconnected from many mines, occur wherever there are mines.

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Watt Improvements and Patents

Although the Newcomen engine was inefficient, it was the only one available. A few minor improvements had been made, but the most significant improvement came when James Watt and Matthew Boulton came on the scene. The Watt designs made considerable improvements to the original, and brought into play some newer technologies and concepts. Some were made available by the advances in engineering techniques.

Watt, an instrument technician at Glasgow University, examined a model of the Newcomen engine he was given to repair, and experimented, manufactured, patented and came up with the following improvements:

- Recognising that there was a considerable energy loss by constantly heating up and cooling the main cylinder, he insulated the main cylinder and provided a separate condenser.
- Made the cylinder double-acting by closing the top end and providing a gland which would seal the rod.
- As you have a double acting cylinder, and chains can't push, provided a rod to the beam. But the beam describes and arc, so also invented parallel motion to transfer the power from the cylinder to the beam.
- Designed sun and planet gear so that reciprocating motion could also be made rotary - for winding, etc. We now have the steam whim. (note here - in general a beam engine without a flywheel is used for pumping, one with a flywheel is a whim, a winding engine or one supplying power to stamps).
- Using a governor to regulate the speed of the engine automatically.
- Designing a pump to draw air and water from the condenser.
- Designing for the expansive working of steam, where the steam is admitted for only part of the stroke of the piston, and the expansion of the steam does the rest of the work.
- Using steam at higher pressure necessary for working expansively and with better boiler designs this became possible.

The application of the Boulton and Watt designs to Cornwall provided a coal saving of two thirds. The downside for the adventurers and mine owners was the patents that had been carefully taken out in 1775. The first Watt engine was erected at Wheal Busy at Chasewater in 1777. He also made improvements in 1784. The result of all this was that the efficiency improvements not only saved money for the industry, but also gave Boulton and Watt a considerable income, not only from the sale of their engines, but from the licence of a third of the fuel saving made over the Newcomen type. As an example of the saving, a 30 inch (cylinder diameter) engine was doing better work than a 72 inch Newcomen type, with a considerable saving in coal.

The licence system was to cause problems and friction between Boulton and Watt and the mine owners, and stifle improvements in the technology until 1800, when the patents ran out. The subject of this is a very interesting, contested and long account, ably described by other writers.

Suffice to say that the Watt technical innovations on steam technology saved many mines. Their costs for so doing were also high, and although improving the profitability initially, then depressed the profitability of the mines hampered by the continual charges made. The protectionist nature of the patent also meant that improvements could not easily be made.

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Richard Trevithick

Richard Trevithick was born at Illogan on 13th April 1771 to a mining family. He was the fifth child with four older sisters, his father was mine captain to four mines. School reports were not altogether favourable, but it is said that he had a prodigious capacity for mental arithmetic. When grown he stood six foot two, very tall for the age, strong, and was an accomplished Cornish Wrestler (wrastler). He is alleged to have thrown a sledge hammer over an engine house roof! He is recorded as working at East Stray Park mine (Camborne) in 1790 and as consultant engineer at Tincroft (now part of South Crofty) two years later. In 1797 he married Jane Harvey, daughter of Harvey's the Hayle boilermaker.

His first contribution to steam development came when he used higher pressure steam, and got around the Watt patent by dispensing with the separate condenser. After 1800 he concentrated on road locomotives, but in 1812, partially as a result of this work, came up with the Cornish boiler. This was a technological advance because the hot flue gasses could also be used to heat the water, so improving efficiency. Trevithick's combined improvements made the new design of Cornish engine do double or treble the duty of the Watt type, and so they supplanted them as the Watt type had supplanted the Newcomen styles.

Trevithick did not have business acumen, nor a partner like Boulton, and did not receive money or regard due. He tried to find fortune in the silver mines of Peru in 1816, but got involved with Simon Bolivar, revolution and money loss. Returning to Britain penniless in October 1827, he returned to his wife after a ten year absence, and despite having many more revolutionary ideas died, penniless, on 22nd April 1833 aged 66 and is buried in a pauper's grave in Dartford churchyard.

His legacy is today seen all around Cornwall. The engine houses, the Cornish engine, the Cornish boiler. Without Trevithick we would not have such an industry to study, as it would have died out long before it did.

Richard Trevithick, the engineer, Trevithick Day and Cornish Engine Operation (a German Site) are featued on the net.

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Accounts, People and Arsenic

John & Sandy Colby

The mode of accouning the miners and their skills and the by products of mining together were unique to the Cornish development. Selling ore was a lottery, and open to cartels and price fixing. The legacy of mine waste tips and their leached residues has efects on today's environment.

Adventurers and Cost Book Accounting

The finance of a mine was achieved by persuading a number of people to take shares in the venture Ð the adventurers. The mining venture would succeed or fail, and accounting reporting would be at the quarterly meetings of the adventurers or their agents Ð the count house dinner. At that time the profits would be divided or extra calls made, because the practice of cost book accounting was used. This is a principle that there are no assets or reserves held in the company, the total being paid out to the adventurers every accounting. This had advantages and disadvantages. The advantage was that the adventurers could see a return on their investment. the major disadvantage was that there was no reserve, no buffer to tide over difficult times. There was no writing down of assets gradually over time. If you bought a new steam engine it was paid for over one accounting period, not written down over a number of years.

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Ticketing

In order to sell ores or metals, you had to get it where there was a market, so the practice of ticketing came into being. This was at a recognised place at a recognised time. There was, for instance a quarterly ticketing at Truro. Miners would bring their parcels of ore or ingots of tin and merchants would make sealed bids for them. The highest of these bids would get the parcel of ore/ingots. If two or more bids were first equal, then the parcel would be split. This had all sorts of ramifications for cartels, secret pacts, skullduggery and price fixing. It also brought the miners into contact with their merchants.

As the ticketing was quarterly, and the miners were paid monthly, this was a risky business. The merchants may also have extended credit to the adventurers, and this was a time for repayment of debts. There was also the system by which miners could only buy supplies, like candles and powder, often at inflated prices perhaps against future earnings, from the adventurers or companies run by them (still South Crofty miners have to buy their own explosives) hence there was a dependency cycle built up which was very hard to break.

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Tributers, Tutworkers and Bal Maidens

In order to dig a mine, you have to have people to do it. If you are starting from grass you have an idea whatÕs under your feet from prospecting. But let's say that you have a lode which is paying. You need to mine this lode, to prospect for new ground and to process your minerals at grass (i.e. at the surface). Leaving aside all technology, considerations of water, pumping etc., you paid one set of men to bring up ore for a proportion of the value of the ore Ð these were the tributers. You paid another set of men to drive tunnels or shafts per fathom, or by the hour or whatever, these are the tutÐworkers, and you paid womenfolk to dress the ore on the surface, the balÐmaidens. Child labour was also used, but not to the extent as in the coal mines. At the surface you had stamps, mills and dressing floors Ð all powered by hand, horse, water or steam. You might also smelt your tin at surface.

An innovation was the dry, a place where the miners would change clothes. The boiler house was sometimes used in the early days of boilers, but with their lack of safety and propensity for exploding it was not altogether a safe place. So when the management could be persuaded to invest money, the dry came into being. You also have the technological bods, the carpenter, the blacksmith, the whole infrastructure which is necessary to keep an industrial complex going. In charge was the mine captain, in control of the finances the purser, and various other captains down or at grass supervising the work. There is not space here to enter into more details, just imagine the infrastructure which would have been necessary.

But here we have another Cornish speciality, the pasty. The specialty is not what goes in it, but its shape. The thick ropey crust, made by joining and sealing the edge of the pastry, was not designed to be eaten, but was the handle by which the miners held their lunch (called croust) with hands made filthy by the mining activity. There were (and still are not) underground washing facilities.

A Scotsman once made some comments about a pasty!

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Arsenic Refining

A secondary mineral in the lodes is arsenic, in various compounds. This was a nuisance and mainly dumped, the effects of which are still being felt today. In the 1840s and 1850s there was a blight on American cotton crops in the shape of the bol weevil. Solutions were rapidly required, and one was an arsenic based insecticide. The way of removing arsenic from the ore is to roast it out. If you then pass the flue gasses along a condensing labrynth, you can scrape out the arsenic from the sides of the labrynth. There are two tricks here, the first is to slow down the flue gasses so that they have more time to cool, and so release their load of arsenic, and you have to take the exhaust where it would disperse, off your own area, at least. When you have roasted you ores for a certain time, you get into the labrynth and get others to scrape off the arsenic for use. You do provide them with protective clothing Ð wet rags around their faces, so its quite all right.

Another use for arsenic in Victorian times was as a restorative, bought as tincture of arsenic, and it was also used in a number of patent medicines.

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Arsenic Today

Any material taken to excess can have detrimental effects. Arsenic is one of those materials in which the effects are extreme. Taken in small quantities it was used by the Victorians as a restorative, in larger quantities it kills you, as Agatha Christie knew! In mining, arsenic was thrown away on tips as waste, and now after leaching with rain and groundwater, this is becoming a problem. Arsenic contaminated land is common over a large part of the tin and copper mining areas, but it is not taken up by plants, Instead it remains in the soil, with obvious effects on the food chain. This even extends to farm livestock. The problem is with cows, not sheep. Sheep nibble grass off, and as arsenic is not taken in by plants etc etc they donÕt get the problem. Cows wrap their tongue around longer grass and pull it out. Soil cones up with this (some studies have said as much as 25%) and the arsenic comes up with the soil. So monitoring the arsenic input to cattle is important, as the human food chain is involved. Curiously, if cows have been grazed on arsenic land, and are moved off, then they lose condition. If cattle grazed on non-arsenic land are moved to arsenic land, they lose condition. Arsenic was used to treat syphilis as recently as the 1940s, until penicillin was discovered. And in the 1930s ParishÕs Food was given to pale children, and this contained arsenic. An effect on a friend of this has been to create a lesion on his hand which has not really healed in sixty years, and a dermatologist has put this down to the arsenic in this health food.

Recent studies on this effect have been carried out in the west Cornwall area, and maps of contamination have been produced. Farmers and Water Companies have to consider what is in their land as well as on it, and treat it accordingly.

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Conclusion

We hope, from past and future research, to document and illustrate the pushes and brakes on an industry which, although in decline, may have to revived in the next half century because of lack of tin and copper stocks worldwide. Here is the conflict between environment and exploitation, between landscape and materials, and between unthinking opposition and informed development. We canÕt escape from it, and although weÕre looking on this as an historical exercise, history has a habit of repeating itself.

Thanks to all who came, John & Sandy

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