

## Chapter 2. The Alchemy of Lead Production

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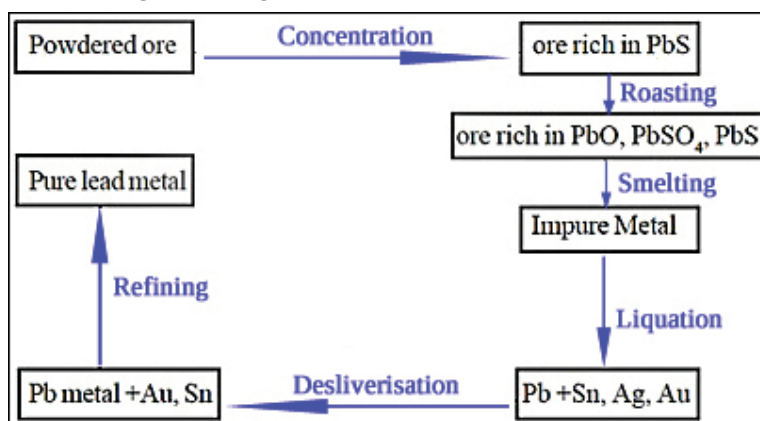


## 2.1. Introduction to the process.

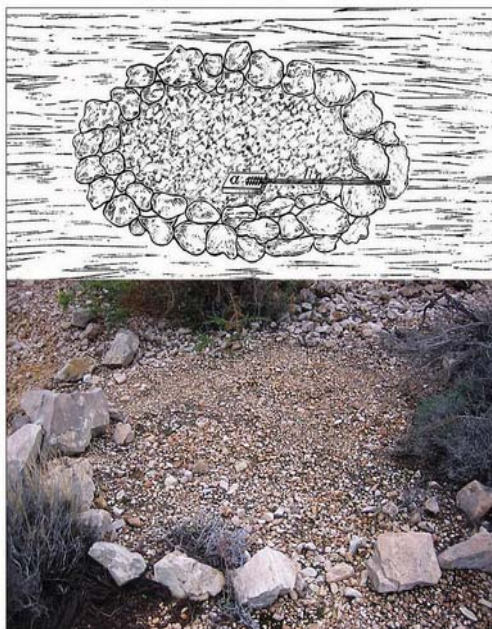
Mining, by its very nature, produces a tremendous amount of waste. Between 65 and 80% of the material extracted in the Almagrera was discarded. Mullock, or overburden, the non-ore bedrock in the mine, can be seen everywhere in the mountains associated with the shafts and workings.

Galena forms by direct precipitation from the hot waters that migrate through the earth's crust. It is associated with quartz, pyrites, barite and various other minerals. These unwanted minerals, that are an intrinsic part of the ore rock, are separated during concentration and are known as gangue or tailings. Where the ore was dressed at the mine this gangue was tipped over the edge of the “patio de minerales”, or dressing yards, into the ravines with little regard for lower workings. These spoil heaps or “escombreras” are very unstable and are best avoided. However, by looking at the size and colour of the pieces they do give clues as to what processes were carried out in a specific place.

Lead is processed in the following main stages.

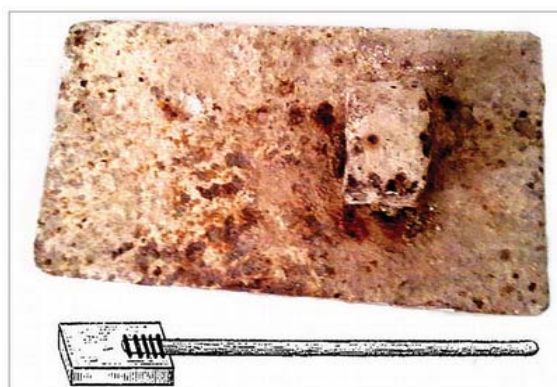


## 2.2. Concentration: crushing, picking and washing.



*Simple stone-lined circle.  
J A Soler Jódar*

The first stage in concentration was crushing the ore to separate it from any unusable or unprofitable associated minerals. This was often done at the pit head to reduce the cost of transporting the material to the foundries. Crushing was frequently a manual process, particularly at the smaller concessions. The rock was placed into a stone lined circle and hit with heavy wrought iron sledge hammers which had relatively flexible handles.



*Sledgehammer & handle fixing.  
J A Soler Jódar*





*Crushing circle in the Barranco Jaroso.*



*Hammering the rock has reduced it to pea-size lumps.*

Another method sometimes used at the larger mines was the animal powered crusher like the one shown below. This worked by repeatedly rolling a cylindrical stone over the ore in order to crush it.

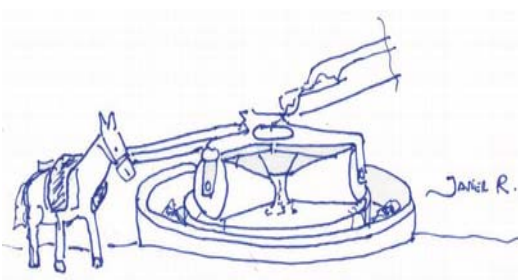


*Simple mule-powered crusher.*



*Cylindrical stones of the type used in these mills. A G Jódar*

An advance on this device was the use of two cones as shown below being operated by a three-legged mule! These mills were the same type as those used in olive oil production. The efficiency of the action of the two cones on the particles can be seen in the diagram of a modern cone mill.

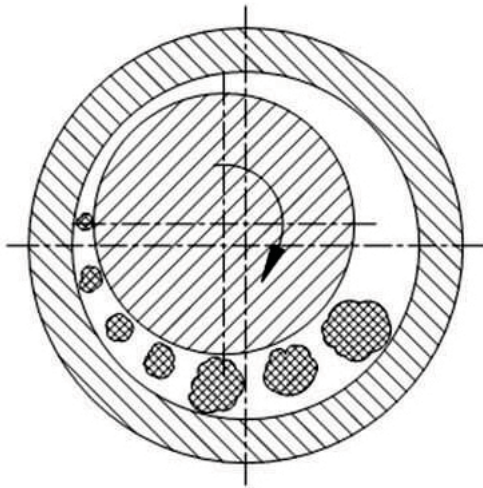


*The three-legged mule. Javier Rodriguez.*



*Cones from an olive mill. Antigüedades Diego Reinaldos.*





*Action of the cones in a modern cone mill.*  
Intech GmbH Downloads



*The fine grain gangue around the mine La Iberia is possibly due to the use of a cone mill.*

Unless any of the mines harnessed steam power, or later electricity, I don't think that any truly mechanised methods of grinding or crushing were used at the pit head. Water powered stamp mills were not an option but steam power could have been used. The electrical power supply to the Sierra – when it finally came – would not have been sufficient to drive devices such as ball mills.

After the initial crushing the material was sorted.

The profitable ore or “mena” was sorted into various well defined grades. This classification seems to have been the same throughout the various mines. I suspect that there was a generally accepted assay standard for each type. “Recio” described larger pieces of galena with the smallest quantity of gangue. “Garbillo de primera” was fine ore in which only a low proportion of barite and other non metallic substances were present. “Garbillo de segundo” were minerals in which argentiferous elements were found in a low proportion relative to the gangue. Low quality ore was called “guardillón” or, ore leftovers. Each grade commanded a different price.

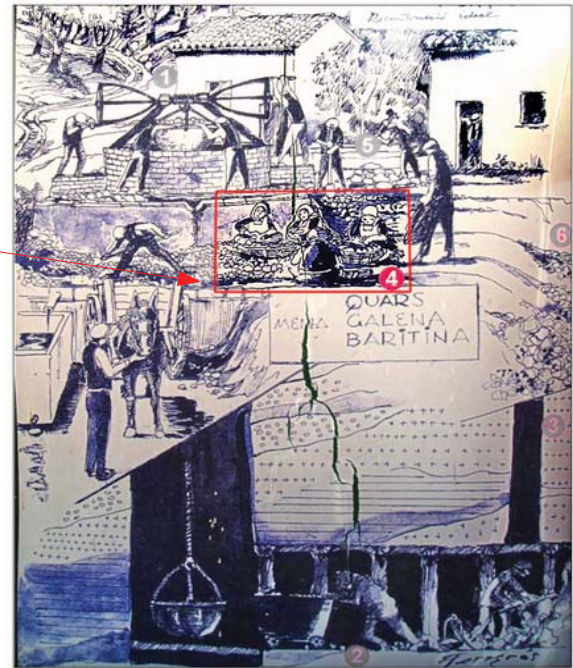


*The patio de minerales of a mine in the Sierra circa 1874*  
Rodrigo.

In many parts of Spain this picking was done by women just as it was in Cornwall by the “bal maidens” who worked at the tin mines. However, in the Sierra Almagrera this was not the case. Contemporary accounts in the 1840s speak of a wave of cat-calling and a cacophony of tool banging if a women were even to set foot in the Barranco Jaroso. This may have been due in some part to the fact that the workforce travelled a long way to the mines and did not return home for extended periods. The women stayed at home and worked the land. However, by the 1850s women were occasionally found in the canteens of the larger mines. This absence of women may explain the higher than usual numbers of children employed in the area.



This wonderful drawing by Joan Ferrerós shows a pit head in Montrás, Girona. The women (4) can be seen picking the ore. Behind them are the men crushing it with hammers in a stone circle. It is graded in the settlement tanks on the left and then loaded into the mule cart.



Following crushing and picking the ore was then washed to remove any loose organic material. Occasionally, this was done at the pit head in the “porches de limpia”, and there is also evidence of ore washing in the bed of the Jaroso, below the artificial water channel. The site used water that was channelled down the Jaroso Valley as well as the water pumped up from the nearby de-watering plant.



*The probable remains of ore chutes in the Jaroso Valley.*

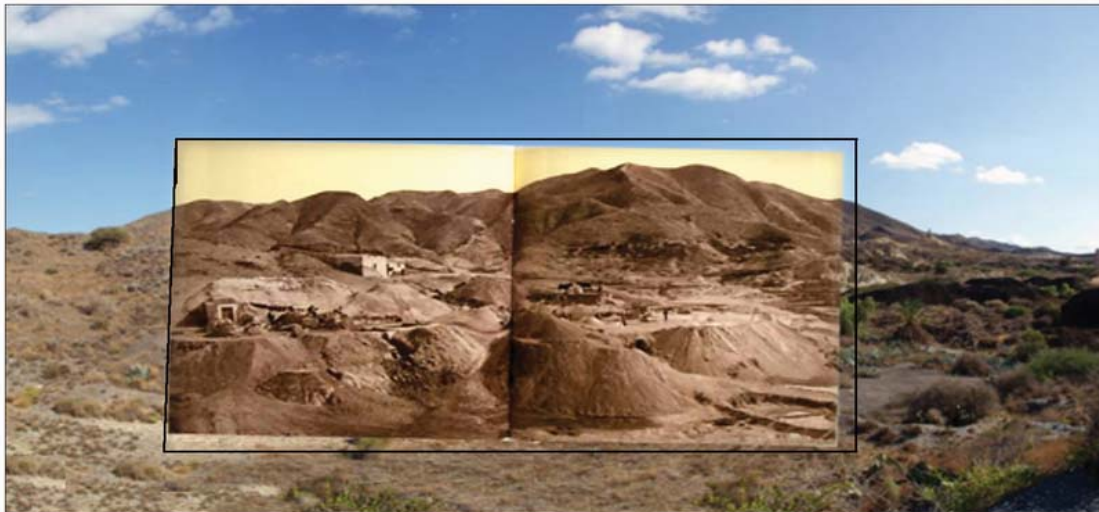
The planking is probably the remains of ore chutes, directing the ore into mills or rumbos. There is a marked similarity between images above and those found in A G Jódar’s ‘Bajo Los Esparales’ post about the Sierra Almagro. On the next page the picture on the left shows an almost intact chute while that on the right, taken 30 years later, shows what time and erosion can do.





*Ore chute in the Sierra Almagro – then & now.  
Helios & Jódar*

More often though, washing was carried out at dedicated lavaderos, or washing plants, like the one shown below



*The washing plant, or lavadero, at El Tomillar.  
Photo montage A G Jódar using the original shown below by José Rodrigo.*

With the adjacent Rambla de Muleria in full spate and water cascading down onto it from the Barranco de Chaparral, this lavadero was badly affected by heavy rain in November 1879. A young child who was playing in the area a few days later died when an underground fume tunnel, affected by the softening of the ground, collapsed.





*The scene today. Only mounds of fine waste cover the entire area.*

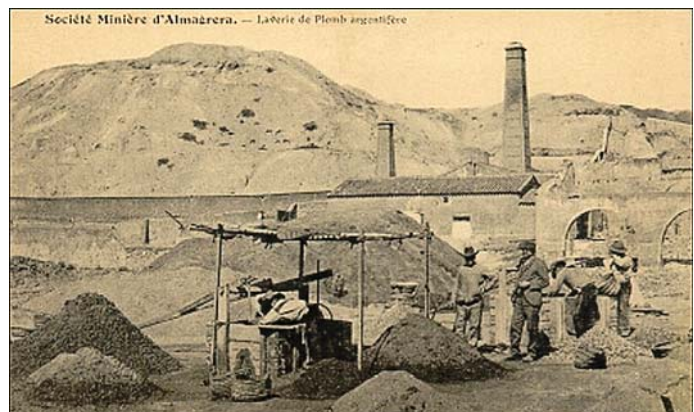
Another lavadero was situated below what is now the football pitch in Los Lobos. The remains of a rumbo were revealed after the catastrophic flooding in 2012. It is highly likely that it had been destroyed by previous flooding of the Rambla de Muleria. Lavaderos, because of their need for a water supply, were vulnerable to inundation and destruction whenever the heavens opened unleashing the powerful “gota fria”.

The most basic washing method was jiggging in a “criba cartegenera” where soil and other debris was literally “sloshed” over the sides of a bath. The crushed ore was spread over a screen that formed the base of a box. This was then lowered into a larger box full of water. The screen was jerked up and down by means of attached hand- operated levers. This sharp jerking motion forced water up through the screen or sieve. The ore was held in suspension while the debris was carried over the sides of the screen's box into the gap between the two boxes by the water.

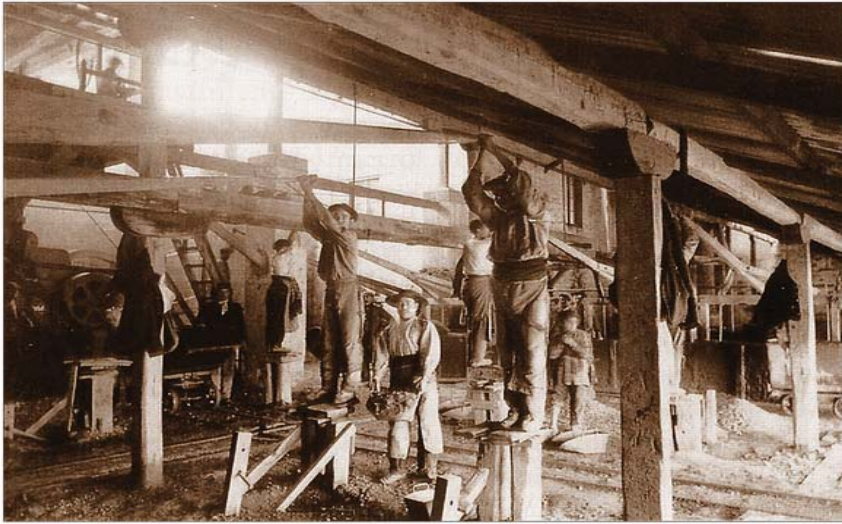


*The inner screen of the criba cartegenera.*  
*regmurcia.com*

*A criba cartegenera in use at  
a mine in Las Herrerías.*  
*E.L.Morin.*



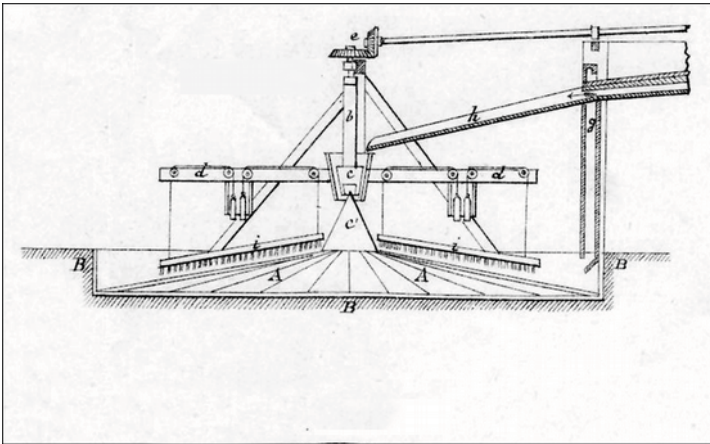




*A criba cartegenera in use at a lavadero in Jaén. The pedestals and the long levers counteracted the sheer weight of the lead.*

*T Cérón.*

Another common method of ore washing, particularly the smaller lumps, was a “rumbo” or round buddle as they were called in England. This was a circular pit made of masonry in which the floor sloped down towards the outer edge. The crushed ore, mixed with water to form a slurry, was fed into the middle. Tarpaulins or vanes suspended from beams fixed to a central, powered shaft, brushed against the slurry mix.



*Diagram of a rumbo or round buddle.*

*G Moncada*

As the shaft rotated, the heavier mineral remained near the centre. Less dense ore moved further out, and the lighter, unwanted material, or gangue, moved towards the edges from where it was removed and the liquid drained. The remaining bands of different grade ore were extracted in a concentric pattern using special flat shovels.

*The remains of a rumbo shovel*  
*farodededar.com*



The beauty of the buddle was that it was cheap to construct and required little motive power. It could be operated by hand, often by children known as “cigüeña” or “storks”, by animal traction or, if available, water power.





*Two views of the buddle below the mine San Edmundo in the Barranco Jaroso*



*The ore was mixed with water in this area (above) and fed into the buddle via the simple pipe line made from roofing tiles (right).*



*Detail of a rumbo showing the feed line.*

*regmurcia.com*

### **2.3. Roasting.**

The concentrated ore was prepared for smelting by roasting or calcination, heating in the absence of air to a temperature below that of fusion. This destroyed any remaining organic matter, drove out moisture and made the ore porous. The lavadero below San Edmundo in the Jaroso valley had a very primitive calcining oven, the remains of which can be seen in the photographs. Originally it would have had a chimney similar to that shown below, right. Judging by the amount of calcined waste to be found in the Sierra, particularly in the Jaroso Valley, I'm sure that many other mines roasted their ore. The problem is that the ovens were so simple that little trace of them remains.





*Above and right, primitive calcining ovens.*



*Above photo. J A Soler Jódar*

Originally, ore was roasted in brick-built stalls, about one metre high, arranged to form prismatic spaces within a quadrangle. The ore was arranged on a bed of pine wood which was then lit. When the temperature became high enough to burn some of the sulphur, this combustion was sufficient to maintain the heat required for the process. After about 12 days the fire went out of its own accord. The ore was sufficiently dried and purged to be smelted. No provision was made for capturing the toxic fumes that were given off.

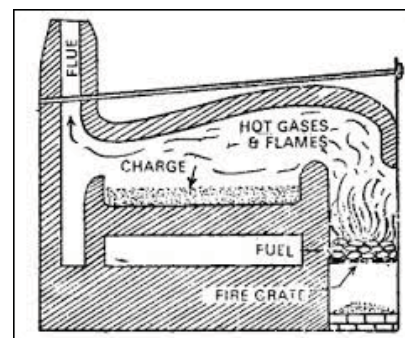


*Roasting ore in the open air.*

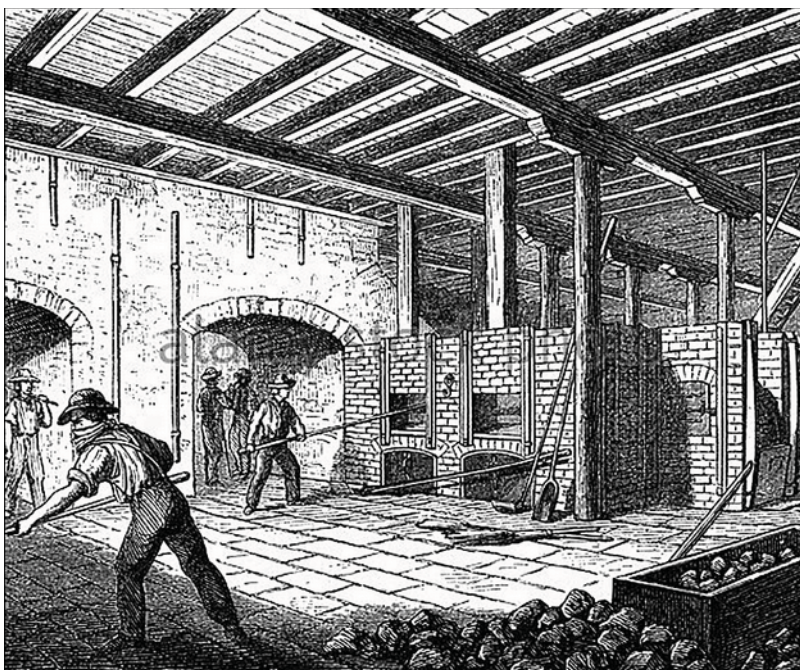
Later, as concentrating methods improved and the supply of pine wood was dwindling, the ore was calcined in reverberatory furnaces at a foundry. This was done by moving the material progressively closer to the fire and controlling the air supply.

*By controlling the air supply to keep the temperature moderate the ore could be roasted.*

*[chem-brains.blogspot.co.uk](http://chem-brains.blogspot.co.uk)*



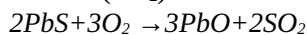




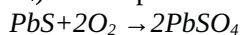
*Roasting ore in a reverberatory furnace.*

*Alamy stock photo.*

At the moderate temperatures of the reverberatory furnace, the galena ( $2\text{PbS}$ ) was partly oxidized to lead monoxide ( $2\text{PbO}$ ) and Sulphur Dioxide ( $\text{SO}_2$ ).



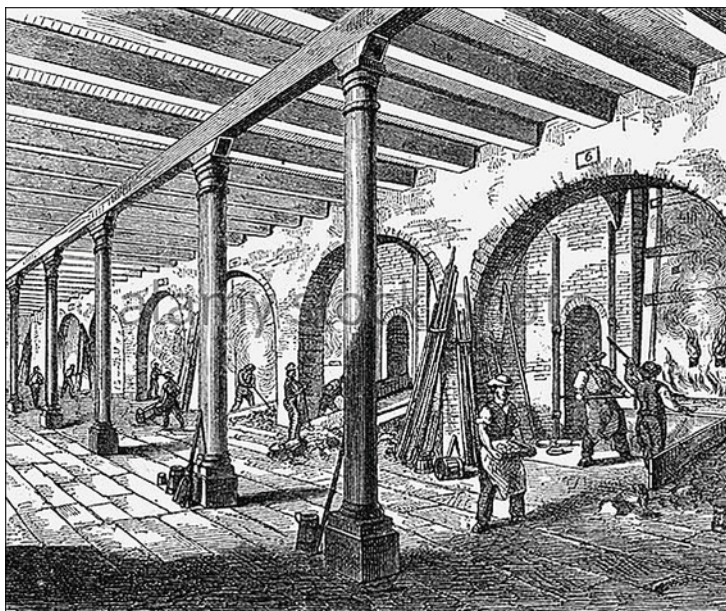
and partly to lead sulphate ( $\text{PbSO}_4$ ) and sulphur dioxide ( $\text{SO}_2$ ).



The addition of lime to the ore in the calcination oven reduced the amount of toxic sulphur dioxide.

#### 2.4. Smelting.

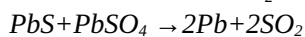
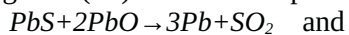
Although smelting could be achieved in the same reverberatory furnace as roasting, for some reason, in this part of Spain, it was done in a blast furnace known as an ore-hearth.



*Blast furnace or ore hearth.*

*Alamy stock photo.*

By adding more galena, reducing the air supply, and raising the temperature the lead sulphide reacted with the two oxidized products giving lead ( $\text{Pb}$ ) and more sulphur dioxide.

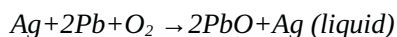




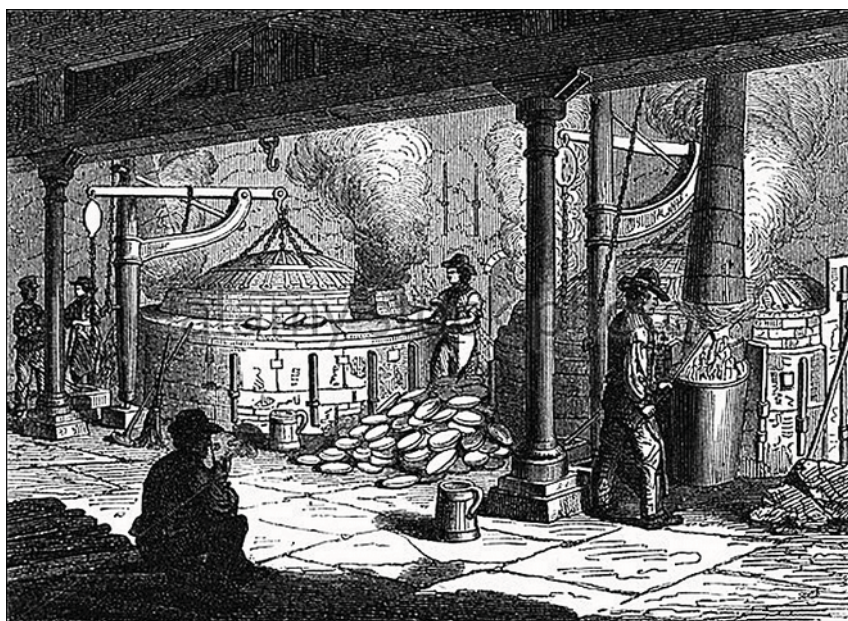
Smelting produces impure lead, known as lead bullion. It also produces regulus or matte, consisting of sulphide of iron, sulphides of copper and other metals. This floats to the top of the lead when it is tapped. It is brittle when cold and can easily be separated. In addition, grey slag is produced. This is mainly silicate of iron, but generally contains sufficient lead to warrant re-treatment to recover it.

## 2.5. Liquation and desilverisation

One of the impurities contained in the lead bullion was the all important silver. Further heating was necessary to refine the lead and separate out the silver using the process known as cupellation. Cupellation works on the principle that precious metals, unlike base metals, do not oxidise, when they are heated at high temperatures. The impure lead was heated to 960 degrees C. in a furnace lined with porous, lime-rich material, and air blown across the surface. This oxidised the lead to lithage, (lead oxide, PbO) which was separated from the liquid silver. This process was carried out in a reverberatory furnace.



The lithage then needed reducing back to lead.

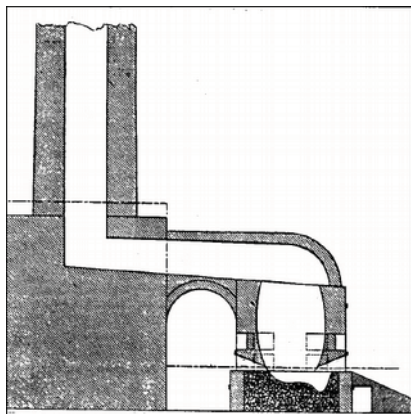


*Cupellation of silver into 'cakes'*

*Alamy stock photo.*

## 2.6. Scavenging.

The regulus and grey slag resulting from smelting, together with the lithage, was scavenged to extract any lead present. This was done in a blast furnace known as a slag hearth. The lead obtained was known as slag lead, which was hard, due to the presence of sulphur, copper and iron. A commonly used slag hearth was a horno Cartagena, which was developed for the reprocessing of slag. This was an unusual, hybrid furnace where there was no artificial blast of air. The required draught through the tuyères, or blast pipes, was actioned by an arched chimney. It was classed as a blast furnace because the ore and fuel were mixed.



*The Spanish slag hearth with its arched chimney providing the "blast".*

*Percy*



### 2.7. Purification.

The hard, slag-lead was then purified, or softened, in a reverberatory furnace. The impurities were oxidized and collected on the top as dross. The dross was a dull brown colour and was hard and heavy. Mountains of it can be seen by the ovens of the Nueva Foundry on the coast road to San Juan.



*Dross from the Nueva Foundry. The San Juan road is behind the ‘crenellated’ walls.*

### 2.8. Foundries

Hot on the heels of the discovery of argentiferous galena, the Spanish Government passed a law, in 1840, prohibiting the export of the unrefined ore. Ostensibly, the reason behind this was to promote the growth of indigenous expertise. However, the increased revenue raised by taxing silver bullion was widely believed to be the reason behind the move.

As a result of this law there was an explosion of both small and large foundries, known as “boliches” and “fundiciones” respectively, along the coast and at the foot of the Sierra. The initial problem with complying with the new law was, naturally enough, lack of expertise. While smelting galena is a relatively simple process, producing good quality lead, through the correct control of the sulphides present, is not.

This foundry at Las Rozas was known as El Boliche even though its name was La Araucana. The term boliche also referred to the fact that it used Spanish reverberatory furnaces. These had no fire grille since they used wood for fuel.



*El Boliche.*



*El Boliche or La Araucana as it is today in Las Rozas*

*The wood for the Spanish furnaces can be seen in this photo.*

*Rodrigo*



The owner of La Araucana also built the Fundición San Francisco Javier in Palomares. This was much larger, and occupied the whole of the lower part of Palomares below the remains of the chimney.



*The entrance to the San Francisco Javier.*

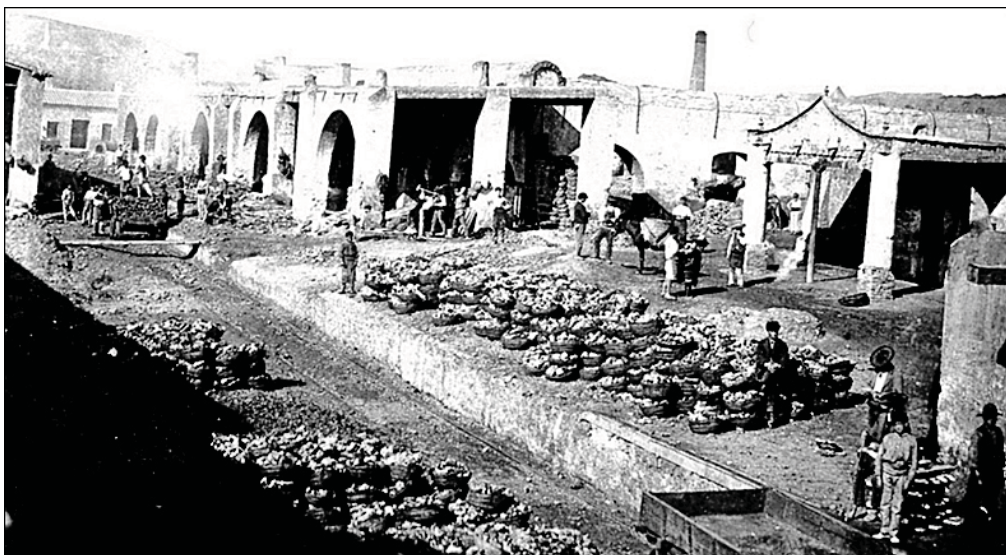
*Rodrigo*

*The approximate area covered by the San Francisco Javier foundry.*





Another problem was the lack of infrastructure, in particular transport. The ore was taken in esparto baskets on the backs of mules and donkeys to even the largest foundries.



*The esparto panniers can be seen in this photograph of the San Jacinto foundry at Las Marinas-Bolago near Pueblo Laguna.*

*Rodrigo.*

Then there was the reluctance, on behalf of the owners, to make any capital investment. A classic example of this was the heating of the smelting furnaces. To achieve the necessary temperatures for the process either bellows or fans were needed. Fans were operated by 3 teams of horses or mules working 8 hour shifts. Bellows were operated by men, known as palanqueros from “palan” meaning lever, who worked 4, six hour shifts. It was cheaper to operate bellows than to hire horses for fans.

Gradually, things improved and both men and horses were replaced by steam operated blasts. This was not without problems. The owners of the Contra Viento y Marea foundry at Los Lobos were taken to court because the wider spread of toxic fall-out from the chimney contaminated the pasture, killing the grazing animals. They were forced to move the chimney  $\frac{1}{2}$  a mile away. Soil contamination for this area remains a problem to this day.



*All that remains of the Contra Viento y Marea foundry.*

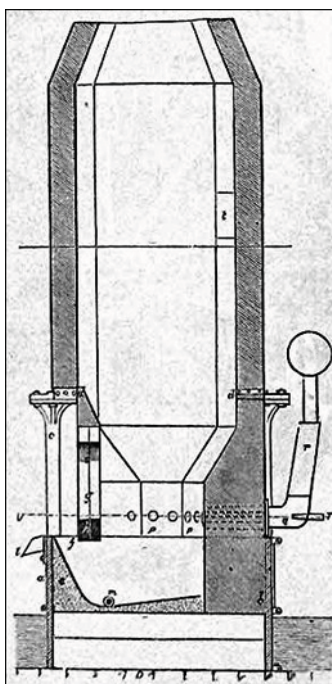
*mtiblog.*

The French Revolution of 1848 was a catastrophe for the Almagrera. 90% of the silver produced had, until then, been exported to France through the port of Marseilles. It was a classic case of all the eggs in one basket. Profits at the foundries plummeted, as in turn did those of the mines. The government stepped in and authorised the banks to buy silver on behalf of the treasury. However, there was a sting in the tail to this move. Producers of silver were taxed, paying 5% on total production as if it were all of high quality even though, by this time, the majority was of a lower grade.

Soon, the industry was in deep trouble. They were having to mine deeper for lower grades of ore. The higher amounts of impurities were making smelting more costly, since it required a greater amount of imported English coal. Some foundries shut down their furnaces, waiting for an upturn in fortunes.

In 1850, the law was relaxed and tariffs were imposed on imported galena. Some foundries resumed production of unrefined ore to be shipped to England for processing. Only the San Jacinto foundry at Las Marinas-Bolago near Pueblo Laguna made any real capital investment in terms of upgrading their furnaces. They introduced the Piltz blast furnace which had the water cooled jacket that is still a feature of modern blast furnaces. They also used the hot water generated by the process to drive the air blast.

*Diagram of a Piltz furnace.  
The Engineer, July 1874*



1870 saw a general fall in lead prices. Silver was fluctuating on the international market and many countries were moving away from using it in favour of gold for their currencies. The days of the lead foundries were numbered and one by one they closed.

## **2.9. Furnaces.**

A variety of furnace types were used in the foundries that sprung up in the area.

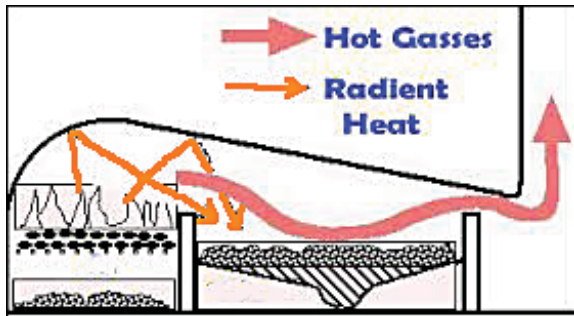
A contemporary account by Madoz (in his Geographical Dictionary of 1845) of the Madrileña or Duro foundry, which was situated behind the pine wood between the Repsol garage and the mouth of the Almanzora, lists the following.

- 5 hornos de manga.
- 3 hornos reverberos.
- 2 hornos de copela inglesa.
- 2 hornos de copela de alemana.
- 16 hornos de calcinacion por el systema inglés.
- 3 pilas grandes por el aleman.
- 1 horno para la calcinacion de huesos.



That is quite a battery! Researching the subject was difficult because many of the types also went under different names, but I think that I have sorted it out.

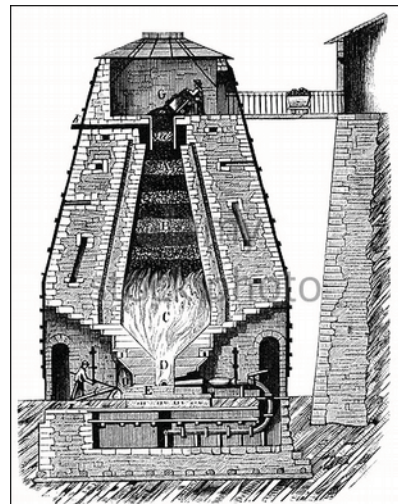
Furnaces fall into two main categories, reverberatory and ore hearth. The main difference between the two is that, in the former, the fuel and ore are kept separate, the heat reverberates in the hearth chamber, while in the latter, they are mixed, and an artificial blast of air is required for efficient operation. The term blast furnace refers to this artificial blast of air.



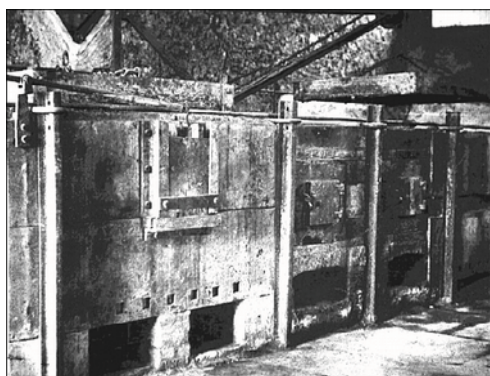
*Section of an English reverberatory furnace.*

*Section of an early blast furnace.*

[www.alamy.com](http://www.alamy.com)



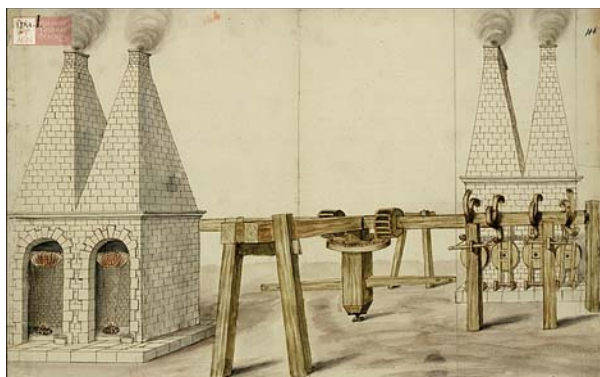
The 16 hornos de calcinacion por el systema inglés would have been reverberatory furnaces of the Flintshire type. These were generally arranged in a row, often in an arcade which served as support for the common flue. I don't know why the smelting wasn't done in the same furnaces, as was the case in England.



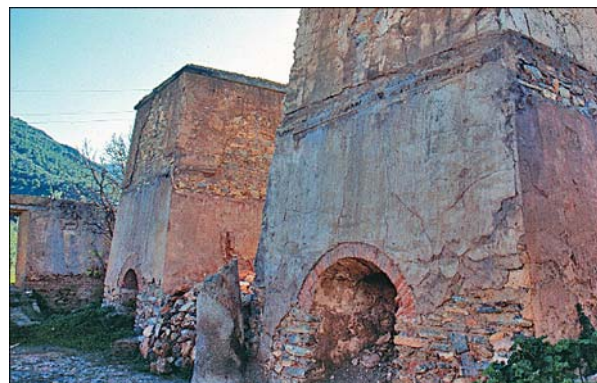
*Hornos de la fundición This bank of furnaces in the foundry that was at Las Marinas-Bolago, has an English cupellation furnace (left of photo) and Flintshire furnaces on the right.*

Rodrigo

The 5 hornos de manga would have been ore hearths. The term manga refers to the fact that the air blast was generated by sleeves (arms), in other words, hand operated bellows. These were most likely hornos castellanos. These were unusual in that they had 3 tuyères, or blast pipes, rather than 2, possibly because they were hand operated. These furnaces could be operated in tandem, as shown in the illustration, making good use of the motive force.



*Diagram showing hornos castellanos being worked in tandem.*



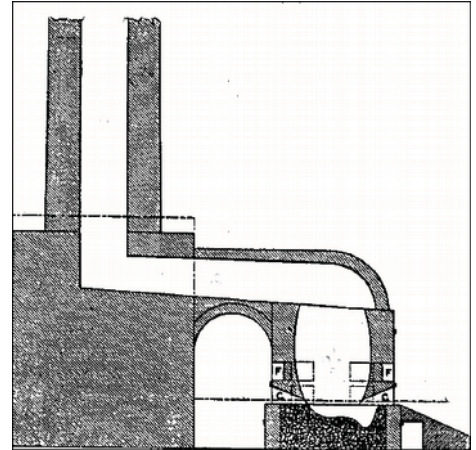
*Remains of two hornos castellanos in Alcora.*

I Jiménez Terrón.

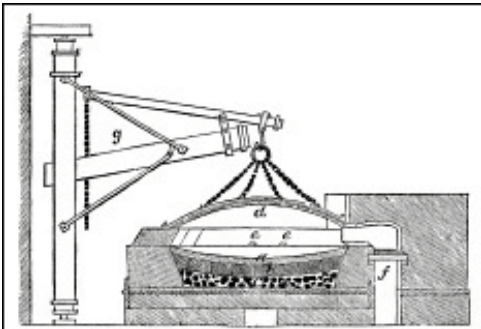


As the writer doesn't mention any horno Cartegena, it seems that the Castillian furnace was used at this foundry for both the ore-hearth and slag-hearth stages. This is strange, given that the motive force at this foundry was man-power. The Cartegena furnace needed no bellows for its operation.

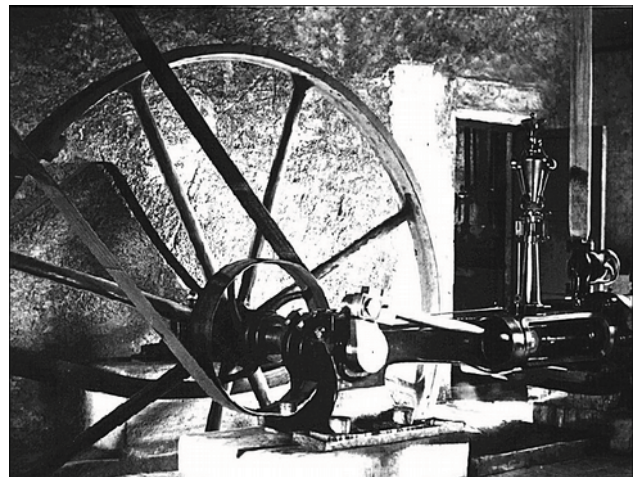
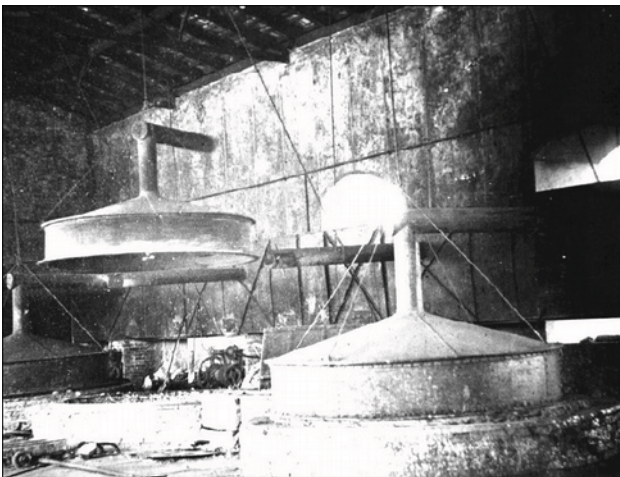
*Horno cartegena.  
Percy.*



The 2 hornos de copela inglesa and the 2 alemana were English and German cupellation furnaces. Why they would want to use both types is another mystery. Cupellation furnaces were reverberatory furnaces, unusual in that they had a forced air supply. The design of the two types differ considerably, but the results were pretty much the same.



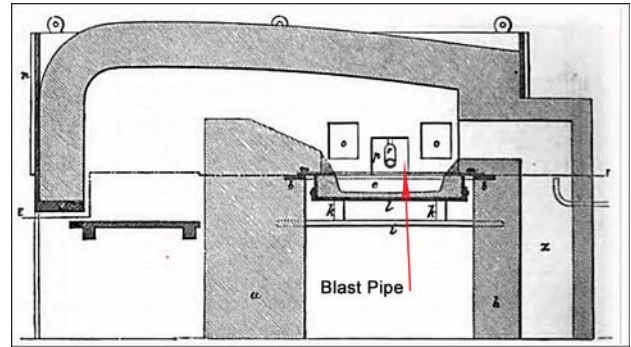
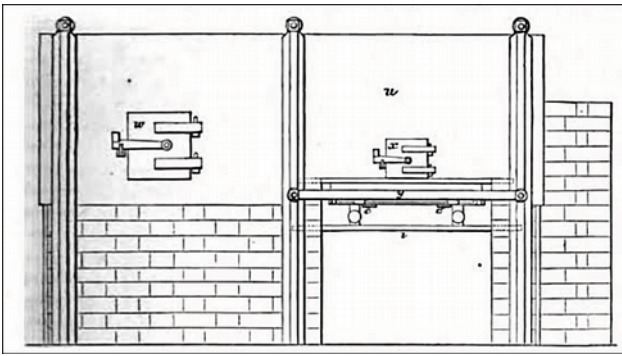
*Diagram of a German cupellation furnace.  
The domed lid was lifted by a crane.*



*These German cupellation furnaces and the steam engine (right) that provided the blast of air were in the  
La Española foundry in Garrucha.*

*Rodrigo*



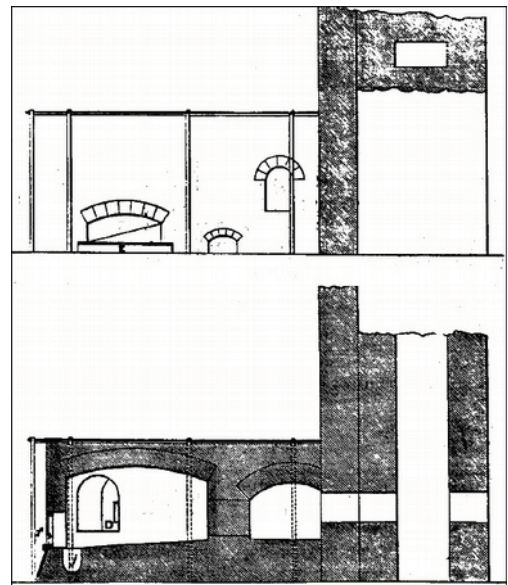


*English cupellation furnace: exterior and interior.*

The 3 hornos reverberos would have been the Spanish reverberatory furnaces. These differed from the English style in that they had a second chamber. These would probably be used for purifying the hard slag-lead. While originally constructed to burn wood, many of these Spanish reverberatory furnaces were modified to burn coal by the installation of a fire grate.

*Diagram of a Spanish reverberatory furnace.*

*Percy.*



The 3 pilas grandes por el aleman would have been coking ovens, converting the British coal to coke, providing the fuel for this enormous battery of furnaces.



*Coking ovens.*

*A Cabrera.*



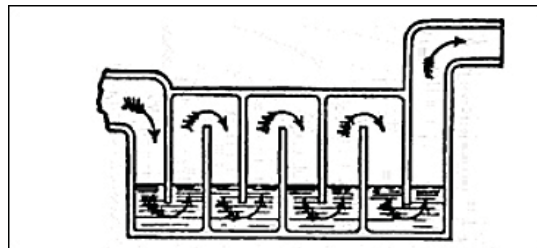
Last, but not least, 1 horno para la calcinacion de huesos. A bone calcining oven, the bone ash was used to line the English cupellation furnace where it absorbed a considerable amount of the lithage.

*Bone calcining oven.*



This foundry was unusual in that it didn't use the snaking condensation tunnels that are such a feature of the coast line. Instead, it used a Stokoe twin condensation chamber to which all of the furnaces would have been linked. The fume was forced through the off-set bank of stalls, while a mist of sea water descended from a reservoir at the top of the chamber. Brushwood, laid on an arrangement of horizontal beams, filtered the fume as it passed from one water trough to the next. When the water reached a certain level it was run off and the sediment in it collected.

*A Stokoe condensation chamber*



Not a single trace of any of this remains, apart from a small amount of black slag.

In the summer of 2016, this edifice appeared on the roundabout on the coast road below Palomares. I assumed that it was a representation of a furnace, but with too much artistic license to say which particular type it is meant to be.



I was pleased to see this acknowledgement of the area's history positioned as it was equidistant from three foundries, the Madrileña, the San Francisco Javier and the Don Guillermo.

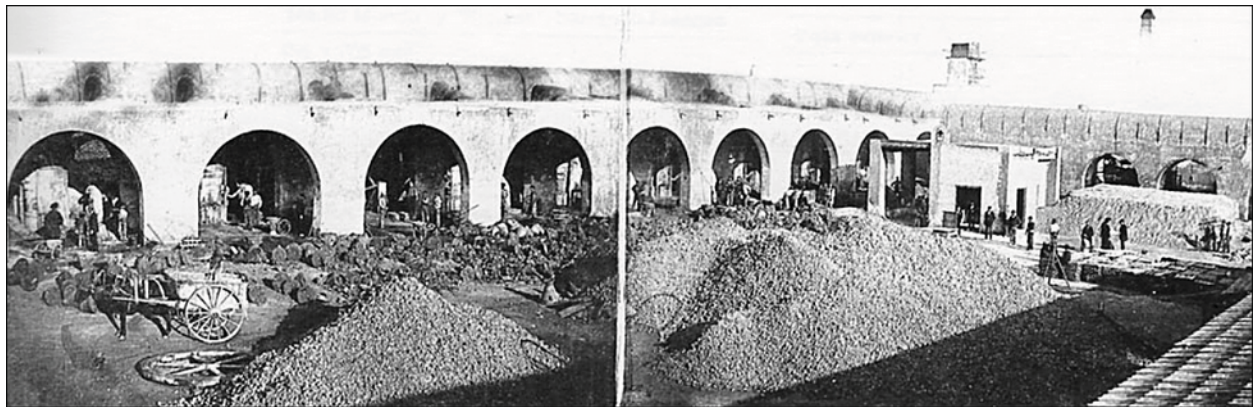
I have since discovered that it actually represents part of a castle, the Castillo de Marques de los Velez, in Cuevas del Almanzora! Señor Jódar could understand my assumption but gently corrected me.



*Cuevas castle. The arch is tucked away in an obscure corner of the inner courtyard.*  
*elalmanzora.com*

## 2.10. What's left?

So what is left to be seen today? A ride along the coast from Villaricos to Pozo del Esparto gives a glimpse of the past. The arcade of the Invencible foundry is unmissable. All that remains of the battery of furnaces are these arches which supported the fume flues. They would have been similar to these arches and fume flues at the San Jacinto foundry at Las Marinas-Bolago.



*Galeria de hornos at San Jacinto.*

*Rodrigo.*

When the coast road was constructed, drainage water was channelled onto the site and only the air intake tunnel and a few bits of masonry from the back of the ovens has escaped erosion.





*Remains of the arches of the Invincible foundry. All that is left of the furnaces can be seen at the base of the arches.*

*The draught of air for the furnaces entered by this opening, which can be seen from the road.*

*mtiblog.*



When I first saw these arches, I thought that they were for carrying the noxious gases out to sea. Only later did I realise that the lead fume was carried in the other direction and passed through the kilometres of snaking tunnels that wind round the hills.



*These condensation tunnels can be seen on the left shortly after passing the arches. Photo. mtiblog*

As well as sulphur dioxide, the fume from the various processes contained a certain amount of lead. As the fume passed through the tunnels it cooled and the lead content precipitated, caking on the sides. About once a year, men and boys entered the tunnels through the shuttered access points and recovered the lead by scraping it off the walls. This was then processed along with any grey-slag and lithage.





*Inside the tunnel (left)  
and an entrance door (above).*

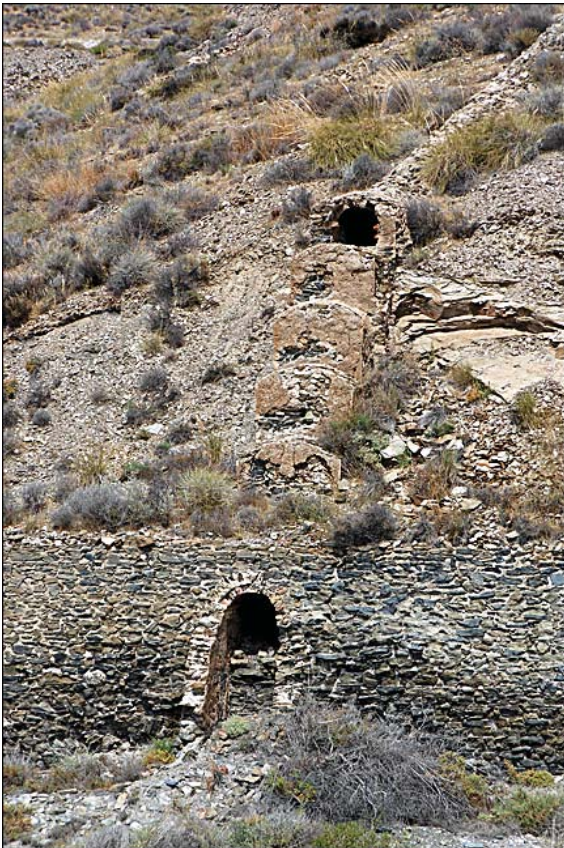
The men and boys who went in were equipped with a handkerchief to cover their mouths and noses and were allowed a day off to purge their systems. Small wonder that the life expectancy was so low!

Just a little further along the road are the remains of the Fábrica Nueva. This foundry was more substantial than the Invencible and it was powered by steam engines. The fume flue was carried along the top of the furnaces, then across to the labyrinth of tunnels.



*The furnaces seen from above and from flue level.*





*The fume flue at the start of the serpentine.*

The openings through which the ore was introduced, or charged, can be seen from the road and are uniform in size and position.



*The furnaces were charged from this side.*

However, on the lower, seaward level where the ore was worked, the openings are different, indicating two distinct types of furnace.



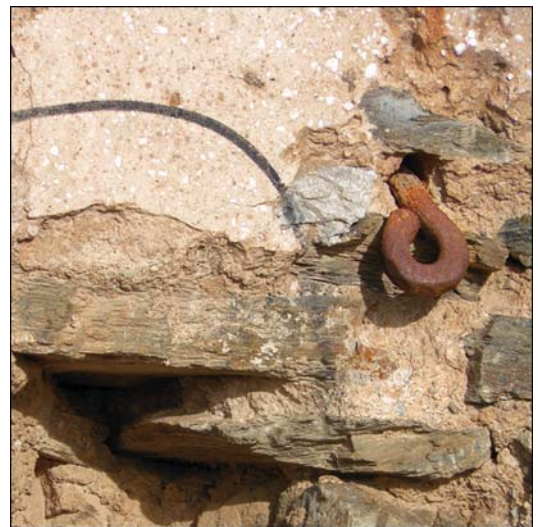
*The lower working level.*



*The other type furnace opening.*

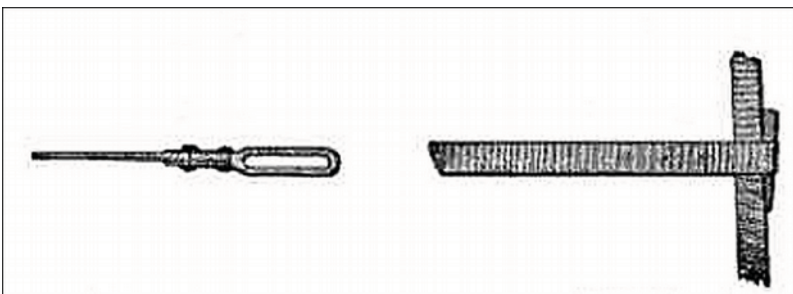
The first eight furnaces are reverberatory calcining ovens and the last few are possibly blast furnaces indicated by the different type of opening (above). The whole structure has been filled in and the openings stoppered.

When I saw this iron eye hook embedded in the wall by one of the working doors, I thought that it was a rabbling tool and got quite excited about it, imagining someone using it to rake the ore through the calcining oven a hundred years ago.



*Iron eye hook.*

On a second visit to the site I found a series of them, at regular intervals round the oven. They were actually the fixing pegs of the furnace binders, iron bands that reinforced the structure.



*Furnace binder and fixing peg*



There is a noticeable difference between the slag at these two adjacent foundries. That at the Invencible is made up of small pieces, while that at the Fábrica Nueva has a lot of larger, red-orange, flat sided pieces as well as the more usual bubbled chunks. Maybe they used more iron as a flux, or, the ore was not cuppelled so the slag was not affected by the lithage.



*Slag from the Invencible*



*Flat slag from the Nueva*



*Bubble slag also from the Nueva.*

## 2.11. What's not associated with lead?



*The oven at Quitapallejos Beach by the Repsol garage.*



*The ovens at Cala las Conchas.*

There are several ovens in the area, like the ones shown above which were not used for the smelting of lead. This type of oven was used for the roasting of iron ore so was not covered in the section on furnaces for lead production.

They were simple roasting ovens used to burn off any organic material present with the ore, remove moisture, burn off any sulphur impurities and to oxidise Ferrous Oxide to Ferric Oxide. These ovens served the same purpose as the calcining ovens used for lead processing, the only difference being in the large quantity of air that was introduced to the process.



Ovens of this type had a metal tops and loading platforms as can be seen in these photographs of working and restored ones below.

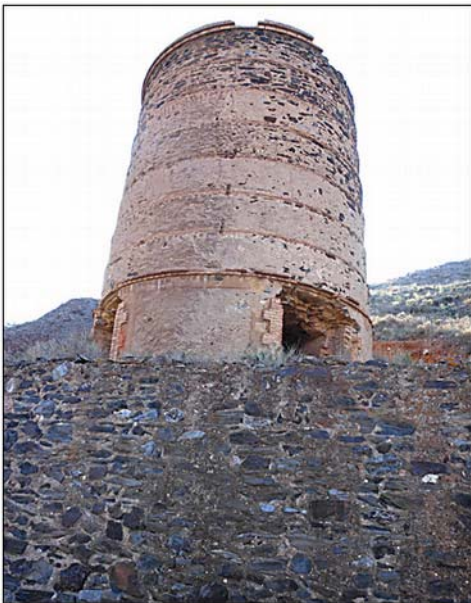


*Above, working ovens. (taken from La Minería del Hierro Contemporánea en Almería. Miguel Á Perceval Verde).*



*A restored oven.*

There is an interesting oven at the mine Republica Romana with a cone inside that intrigued me.



*Republica Romana and the cone inside.*

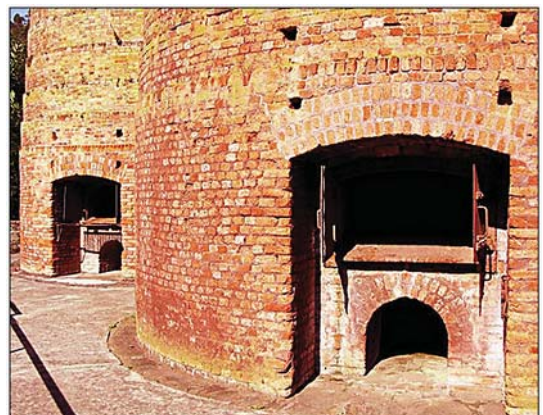


I have since found pictures of other examples of cones in ovens of this shape.



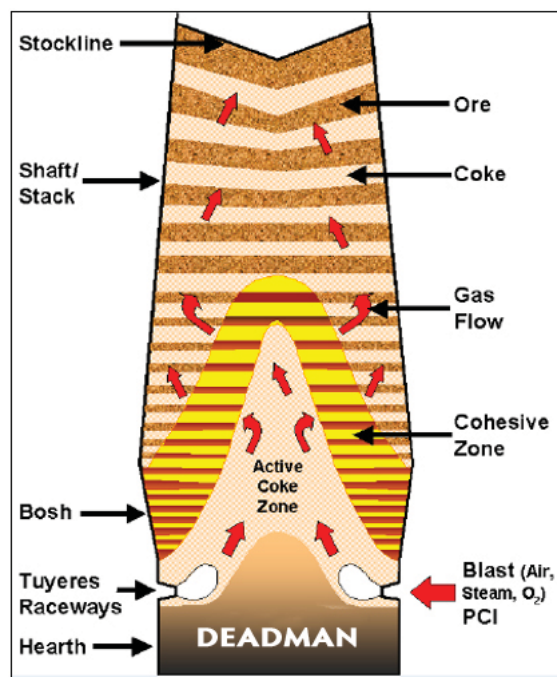
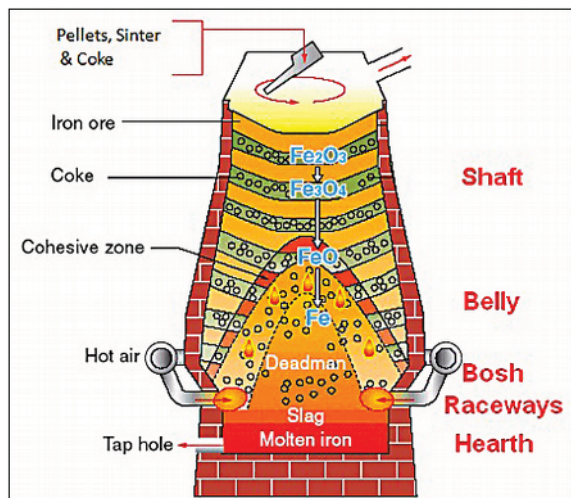
*Left:  
Restored  
cone.*

*Right:  
Restored blast  
furnace door.*





When I started to research the cones further, I found that they are known in Britain as the deadman. What I also found was that they are only found in blast furnaces, and play an important part in the smelting process. I can only conclude that the oven at Republica Romana is the remains of a blast furnace and that the ore was both roasted and smelted on site. This discovery solved one of my mysteries, I couldn't work out why there was so much unstable, bubbled slag around La Violeta and Republica Romana if the ore had only been roasted.



The above diagrams illustrate the importance of the deadman in assisting the conductivity of heat and the flow of the molten metal towards the tap hole.



Another mystery is this tower at the entrance to El Arteal. At first sight it looks like an iron roasting oven and is described as such on some websites. However, there are certain anomalies. Neither its size nor its shape conforms to the norm and, in addition, the number and position of its apertures would not have supported the calcining process. It looks more like a defunct water tower than an oven but, who knows? Perhaps, one day, I will have a definitive answer.