More about El Arteal

El Arteal its Bricks and Mortar.

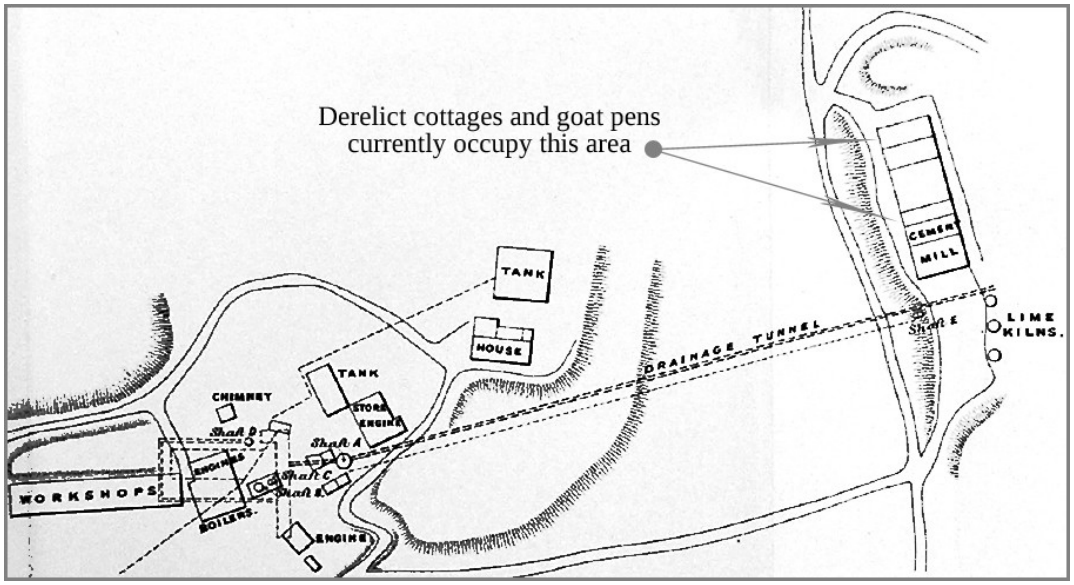
In 1894, when work began on the el Arteal pumping station, brick and lime kilns were constructed in order tomake the necessary bricks and mortar. Making bricks on site had great advantages, as the exact size and shape could be specially made for what ever they were required for. This was particularly useful when lining tunnels and shafts, and when building chimneys. Clay, similar to London clay, is found in abundance along the foot of the Sierra Almagrera, where it is layered with conglomerate and sandstone. The bricks used in the Jaroso buildings and underground workings were made at el Tomillar, using the plentiful clay found there. The clay used for the el Arteal project was probably dug from the area beyond where the bath houses now stand, the base of the incline plane, or near to the quarry on the top road to the bath houses.

Possible sources of the clay and brick kilns.

The position of the brick kilns is marked on the 1908 plan of the area. They were somewhere near to the pictured, circular structure above the Rambla del Arteal. There is no trace left of them.

Circular structure on the possible site of the brick kilns.

The engineer, Gustave Charles Reinhold, worked on the early part of the construction of el Arteal. In 1898, he presented a paper about the project to the Institution of Civil Engineers in London. In it was a diagram showing the position of the lime kilns and that of the adjacent cement mill.



Reinhold's diagram showing the position of the lime kilns and cement mill.

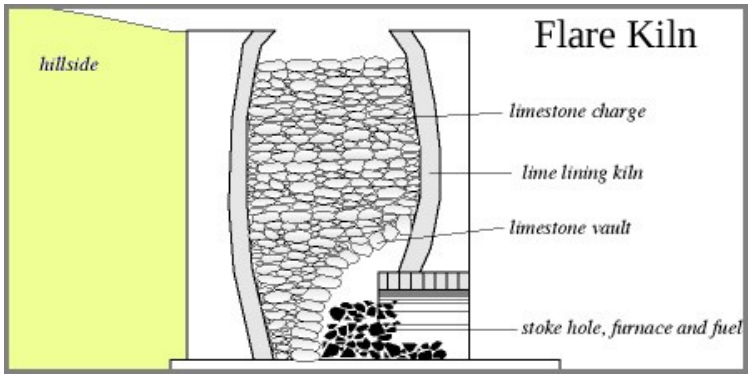
Of the three lime kilns, all that is visible today is the remains of either a buttress or the wind shield of one of them, incorporated into the wall of the house next to the entrance to the Casualidad tunnel.

The sloping wall on the right of the entrance to Casualidad's tunnel is now all that remains of the lime kilns.

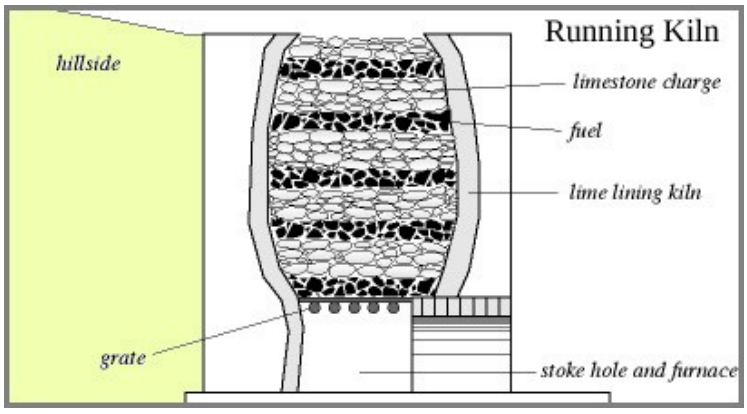
Classically, lime kilns were built into hillsides, close to a quarry, and near to where the lime was to be used. Those at el Arteal certainly used the lie of the land to great advantage. They could be charged from above and emptied onto the broad flat area at their base. They were also close to where the lime was to be used, which was at the adjacent cement mill. There was a quarry 150 metres along the track above the kilns, but I think that it was the stone used in the rough reconstruction of the buildings that was quarried there. The limestone possibly came from the area to the west of Los Lobos.

Google screen shot of the position of the cement mill, the lime kilns and the quarry.

The kilns at el Arteal could have been either flare or running kilns. Flare, or intermittent, kilns were loaded, fired, cooled and emptied. Then, the whole process started again. Running, or continuous kilns were, as the name suggests, continuously charged and fired.



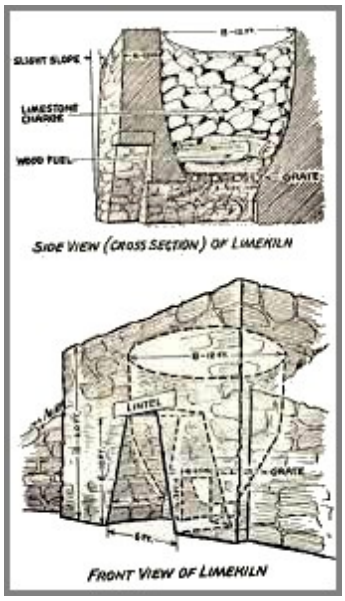
Flare or intermittent kiln.
ucl.ac.uk



Running or continuous kiln.
ucl.ac.uk

The fact that there were three kilns calcining two differing types of limestone, makes me suspect that they were flare kilns, possibly working in series when the demand for lime was high. Three running kilns would suggest production on an industrial scale, producing far more lime than was required for the el Arteal project. Both types of kiln look similar, the boxy shape being given by an outer, stone built casing that contains the tapering, cylindrical oven. The oven, or pot, is lined with refractory bricks, capable of withstanding the great heat. The gap between the oven and casing is filled with ash and rubble.

The casing provides support and insulation, and has an archway beneath the pot where the hearth and draw hole are situated. Both types of kilns are charged from the top and the quicklime removed from the bottom.

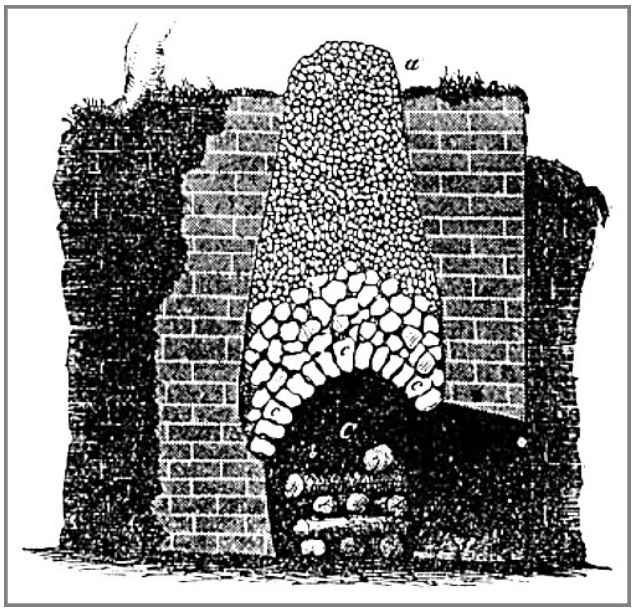


Drawing of a flare kiln
monroehistorical.org

Remains of a running kiln.
newcumnockhistory.com

In a flare kiln, a vault made of large stone blocks is created above the hearth, and a single charge of limestone is placed above it. A fire is then lit, and kept stoked for several days, until the limestone has been calcined. At this point, the top of the kiln is sealed and the everything is allowed to slowly cool down over several days. The contents, which now are 45% lighter, are then removed.

Diagram of a flare kiln showing the stone vault.
vtarchaeology.org



A running kiln has a permanent grate on which the fuel and limestone are piled in layers. The heat from one layer of fuel, dries and pre heats the next layer of stone before it reaches the hottest part of the kiln. As the limestone is calcined the resulting powdery quicklime drops through the grate and is removed, thus giving room for more fuel and limestone to be added to the top.

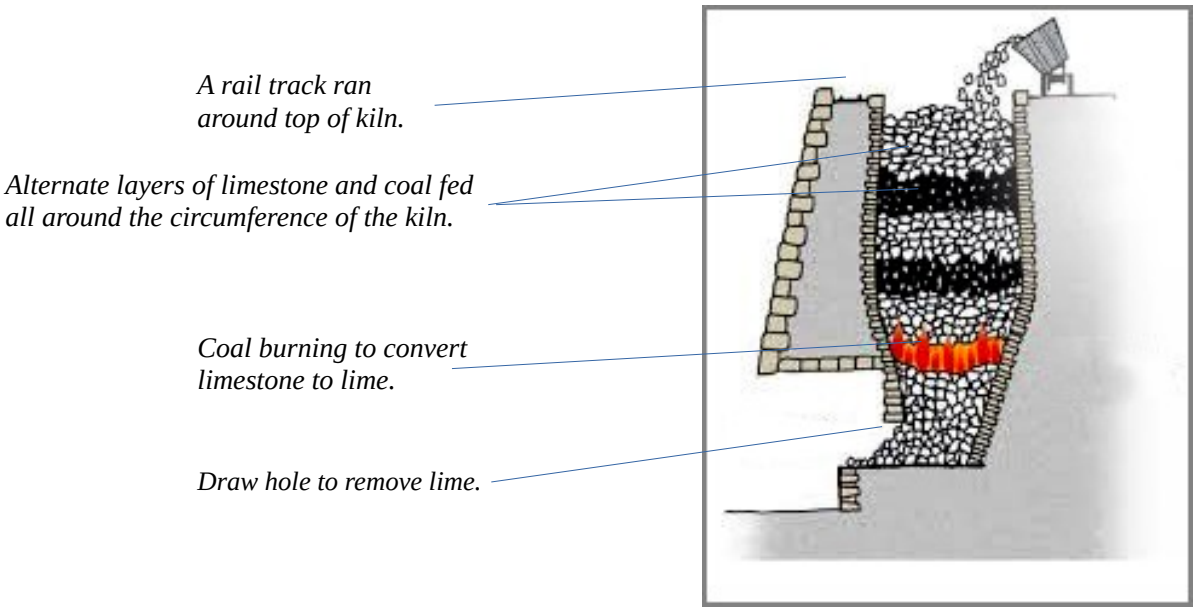
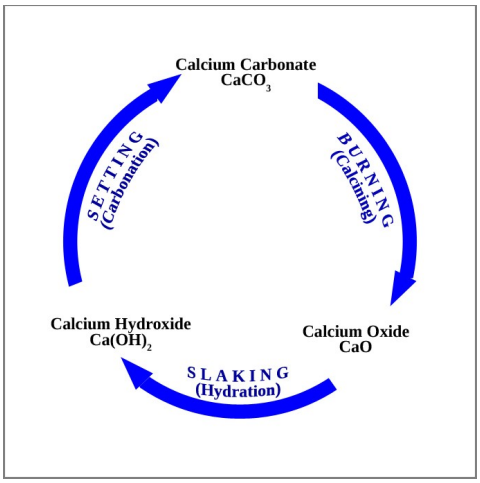


Diagram of a running kiln.
geolancashire.org.uk

The main difference between the two types of kiln is that in the former the limestone charge does not come into direct contact with the fuel. This is the same difference as that between a reverberatory and an ore hearth furnace used for smelting lead.

When limestone, calcium carbonate ($CaCO_3$), is burned at temperatures in excess of 900°C, it gives off carbon dioxide, (CO2) and is converted into calcium oxide, or quicklime (CaO). When slaked with water, the highly corrosive quicklime becomes calcium hydroxide, or hydrated lime $Ca(OH)_2$.

Hydrated lime, more commonly called lime, is thoroughly mixed with either enough water to form lime putty, or with less water to produce a lime powder. As slaking is an exothermic reaction, a dry powder can be produced because excess moisture is driven off as steam. Hydrated lime, naturally turns back into calcium carbonate as it reacts with carbon dioxide in the air. For this reason it needs to be stored either under a film of water, in the case of the putty, or in air tight containers, in the case of the powdered product.



The Lime Cycle. *Mind42*

Whichever type of kiln was used at el Arteal, the fuel was probably imported coal or coke as this would have already been on site to fuel the boilers. The kindling was most probably dried jara, what we call yellow rock rose, it was the traditional kindling in this area. The Barranco Jaroso owes its name to the jara that grew abundantly there and which, with the healing passage of time, is again flourishing.

Halimium atriplicifolium. Jara or yellow rock rose. ©José Quiles

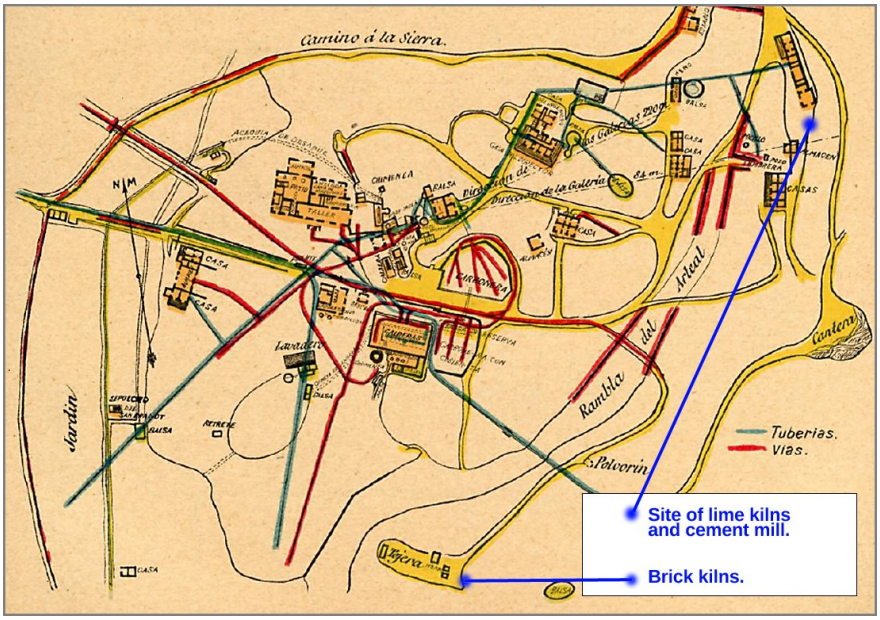
Reinhold had this to say, *"Excellent limestone of two kinds was found in the neighbourhood and was burnt in kilns erected for the purpose. One kind of limestone when ground yielded a hydraulic cement of excellent quality, very quick setting, and attaining in time to great hardness. This was invariably used whenever masonry or brickwork had to be carried out and where the work was interfered with by water, or likely to become submerged soon after completion"*

The availability of this limestone was a boon to Brandt, Brandau and Siret. It was argillaceous, or clayey, limestone which, when burnt, reacts differently from more usual limestone. Clayey limestones contain 15-40% silica, alumina and iron oxide. When burnt in a kiln, lime combines with them to form silicates aluminates and ferrites of lime. This modified stone doesn't crumble and isn't slaked when water is poured on it. Known as Natural Hydraulic Lime, it sets partly by reaction with water, (hydraulic set), and partly by reaction with air, (carbonation). Cement made by grinding this lime would set, even in areas that were wet, and unlike Portland cement needed no further additives.

Reinhold tells us that no special machinery was used to grind the burnt stone. It was simply spread onto a stone floor (probably circular), where it was ground by the action of roller, made of either stone or cast iron, pulled by a mule. After sieving, the ground cement was spread on to a floor and left to dry for about a week, and then stored in bags. Neat cement was used to render the surfaces of anywhere that was intended to be watertight, for example the balsas. Ordinary lime, presumably produced from the other type of limestone mentioned by Reinhold, was added when the setting time of the mortar needed to be extended.

The cement mill was situated where this ruin and house stand today.

While the brick kilns are shown on the 1908 plan of el Arteal, the lime kilns are not. It is even possible that they no longer existed by the time that Reinhold actually presented his paper. He left the project, probably in 1897, before the tunnel to Casualidad was driven, the entrance to which is on the possible site of the kilns.



1908 plan. *Hastial 2012*

Because of the experience and skill required to calcine limestone, traditionally it was a family business where boys learnt the art as they grew up, working alongside their uncles, cousins, fathers and grandfathers. This poses a question about the operatives of the kilns at el Arteal. Were they perhaps a peripatetic group, who both built and operated kilns for relatively short term projects, such as the construction of the pumping station, rather than the more traditional, long-standing, family affair?

For details about some of the skill that was required to load and operate a lime kiln I recommend buriton.org.uk. Buriton Lime Works and Mr Chitty's Story. If however, you understand Spanish, or have the patience to Google Translate it, the PDF, Estudio y análisi de la utilización de la cal para el patrimonio arquitectónico. R.M.Usedo Vallés, takes you through every stage. From the quarrying and dressing of the stone, through the careful selection of pieces for the arch, and the meticulous placing of the charge inside the kiln. To the laying, lighting and maintaining of the fire, which had to be nursed night and day, until it was time to cap the kiln and allow it to cool. Vallés's paper would serve as a handbook for anyone wanting to revive this lost art.

Dressing Limestone.

R.M. Usedo Vallés.

The precision placing of limestone in a kiln.

R.M. Usedo Vallés.

More technical details of lime kilns can be found at:
Rosendale Cement.
Kiln Architecture and Technology. ucl.ac.uk
Original Issue of 200 years of Soot and Sweat. vtarchaeology.org.

Falling

Down

on

the

Stairs.

The Guzmana steps. *Author's Photo.*

By chance, I came across an account by 'El Corresponsal',writing, on the 4th October 1890, to La Crónica Medidional from Vera, about the ore processing facilities at the Guzmana mine. While researching the early jaw crushers and other early mechanized plant he was describing, I found the illustration (below) of an ore washing system that was buried in a Google search. There was no denying the similarities between the flight of stairs at the Guzmana and those in the picture.

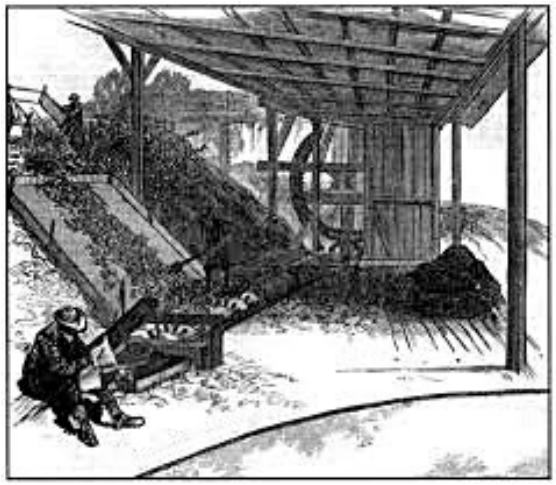
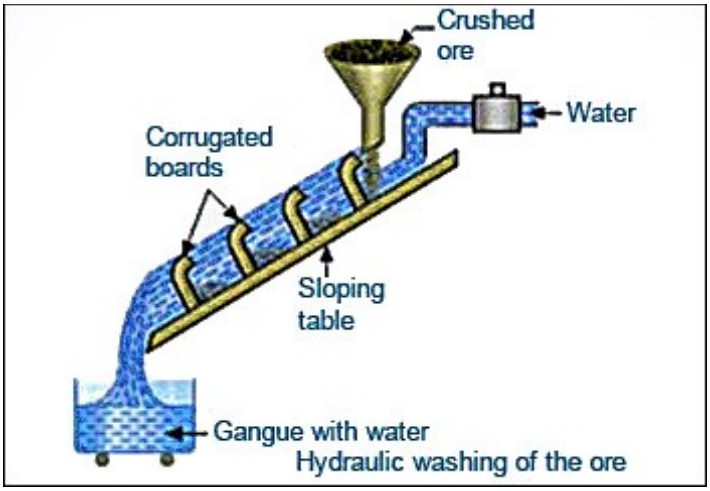


Illustration of a stepped ore washing system. Jstor



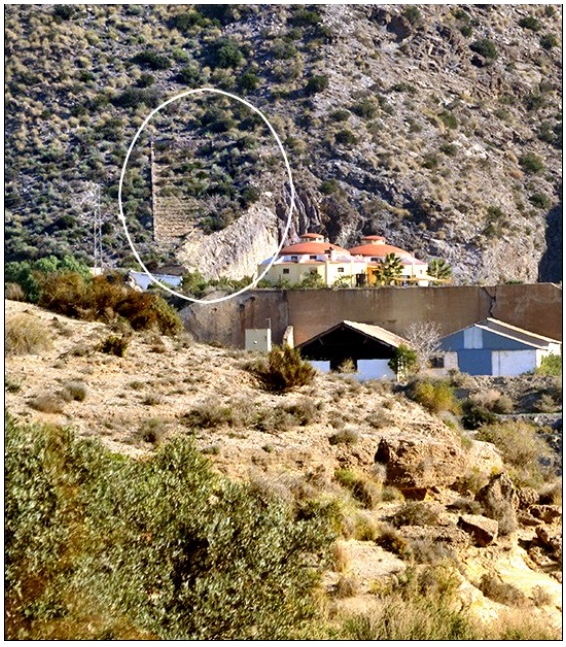
How the system works. simplyscience

The stairs are a gravity separation system, where the heavier, denser ore particles remain on the treads, while the lighter gangue particles are washed away by a stream of water flowing down the steps. Because of the aljibe situated at the bottom of the flight, I had assumed that it was a system, working on the same principle, but for collecting detritus out of the rainwater before it entered the aljibe. According to Antonio Gonzalez Jódar and Francisco Mulero, this aljibe was used to collect water from the ore washing process so that it could be recycled and passed over the steps again.

The aljibe at the bottom of the steps. *Author's Photo.*

I may be wrong again, but I imagine that the aljibe wasn't built for this purpose, but rather was repurposed for it. El Corresponsal makes no mention of this type of gravity washer in his account, so I'm of the opinion it was brought on line at a later date, possibly the 1920's. By this time the Guzmana was using electricity to power the machinery, so would have had ample supplies of water in the massive balsa at the mine. The captation and filtration system associated with this cistern was as good as that used for an aljibe, meaning that the water would have been suitable for human consumption, so may have rendered the aljibe redundant.

The above illustration, and the actual Guzmana steps, were the only examples of this type of system that I had ever seen or even heard of, but, I was in for a shock. For 15 years I have holidayed at el Arteal and had never realized that what I'd always thought of as the traces of an inclined plane were, in fact, the remains of a similar flight of steps. These possibly date to the same era as the Guzmana steps, somewhere between 1908, when the pumping station was remodeled, and 1936, the Spanish Civil War.



Two views of the el Arteal steps, situated next to the cutting for the aero-cable.

Left, sif-mes-1. Above, Google screen print.

The Almagrera doesn't reveal its secrets lightly, and it continues to confound me.

El Arteal Under Siege.

S Farminer

El Arteal under siege.
My stay at El Arteal in January 2020 was tinged with sadness. The imposing Central de Transformación building, built in the 1920's by Luis Siret's Société Minière d'Almagrera to house the 535Hp German diesel generator which powered two of the subterranean pumps, was open to the sky. Daylight was streaming in where, once, the roof had been. The roof girders hanging drunkenly, the walls blackened and not a single pane of glass remaining. There had obviously been a fire, but why and how? Who would want to torch this historic, iconic building? The friends with whom I stay with at El Arteal told me the sorry tale. Sometime during the night of December 3rd a fire had broken out in the building and the tons of discarded irrigation tubing, which was stored within it, had burned for the best part of 24 hours.

Neither the local police, who surveyed the scene from the other side of the Rambla de Muleria, nor the owner of the tubing, seemed in the least bit bothered by the event. The weather was wet and the Rambla was crossable only by 4x4, so no attempt was made to douse the fire nor to examine its cause.
There is the possibility that the building was hit by a lightning strike and the tubing, or something else which was stored in there, caught alight. Whatever the cause, the walls contained the fire, the roof girders buckled, the terracotta tiles fell, the remaining windowpanes shattered and tons of unwanted plastic was reduced to a sticky mess. How long will the walls, which had so valiantly resisted the inferno, remain standing now that the roof has gone, and will anyone care?

Then

Now

Open to the sky.

Not a window remaining.

Worse was to come. Between the 6th and 17th of January, truck loads of earth and rubble trundled along the track to el Arteal and returned empty. I thought that perhaps the old water deposit up by the bath houses, or the one by the transformer building, was being filled and prepared for agricultural use. I was horrified when I saw what in fact was being filled.

The 1908 coke storage bays, which themselves had been repurposed as ore sedimentation tanks, probably by MASA, were now almost completely full and the site levelled. The pump house where the slurry was pumped into the tanks is still, for now, just about standing. It is in the centre left of the before photograph.

The tanks before their destruction.

What tanks?

I can understand that the area could be put to agricultural use, as the tanks would retain water, thus minimizing irrigation, but what I saw next was totally incomprehensible. The only remaining wall of the massive, 30 metre long, double galleried boiler house, built in 1908 to house eight condensing boilers had been demolished. Now all that remains of the magnificent power plant, built to power the pumps situated 220 metres underground, is the water tower and the base of the 45 metre chimney.

The boiler-house wall before demolition.

What wall?

To what end had this wall been demolished? Now there is nothing to indicate the presence of a once magnificent piece of turn of the century industrial architecture. Will the water tower be next?

The extent of the boiler-house wall.

The rubble is buried.

I am also becoming increasingly concerned about the future of the married miners' quarters. They have been quietly decaying since they were 'comprehensively decommissioned' when MASA pulled out in the 1950's. Every year, more of the roofs cave in, and the courtyards become more and more overgrown. However, now they are under siege from another quarter, from below. This time it is water, and not just the rain that falls on them but unnecessary flooding of their shallow foundations which will soon take its toll. The occasional flooding when the Rambla de Muleria overflows its banks is one thing, but flooding every time there is a day of rain is quite a different, and more frequent, matter.

For whatever reason, in 2018, one, but only one, of the old acequias, or irrigation ditches, was re-excavated.

Because the rest of the network of ditches were left overgrown, silted up and incomplete, the result was, that every time it rained, water flooded into the field on the northern side of the main track into el Arteal. Now, a drain has been run under the track, and the water flows at an alarming rate into the field at the side of the miners' quarters, creating an almost perfect wetland habitat for the ducks and drakes.

In this diagram of the acequias the red line denotes the ditch that was re-excavated. The new drain was built under the causeway, presumably to relieve excessive flooding in the northern fields at the end of the new ditch.

Flooding in the northern field and in front of the miners' quarters.

Whether this has been done to enrich the soil as the water brings important nutrients, or not I don't know. What I do know is that clay soil, alternating very dry and very wet conditions, and shallow foundations, equals subsidence and further disintegration. There is a small measure of embankment in front of the miners' quarters, but this is inadequate and barely contains the surface water. The rapid increase in the amount of cane growing in the courtyards since the opening of the acequia tells its own story.