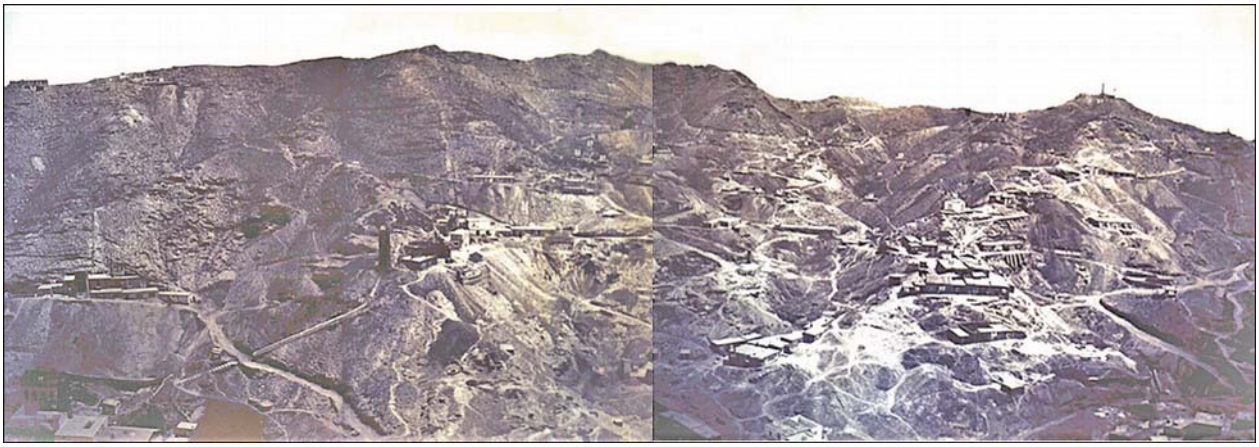
Chapter 3. Mine Development

3.1. In the beginning...

When the mining boom hit the Almagrera, the industry was governed by the 1825 Mining Act. The subsoil belonged to the crown, later to the state, and exploitation was allowed by means of concessions. The size of these concessions was strictly controlled, with the surface area of a demarcation limited to 200 x100 varas castellanas. (A vara is fractionally shorter than a yard at 32.909ins. or 0.9144m.) The majority of the early mines in the Sierra had a surface area of 13,974 sq. m.

The reason for the small size was an attempt to prevent wealth accumulating in too few peoples' hands. In practice, of course, it did nothing of the sort. Concessions cost money, 1,000 reales per annum, so who was likely to be able to afford one? Well, those already comfortably well-off, members of the clergy, landowners, merchants etc. Family connections played a big part. They were used to circumnavigate the restriction that any single person was only allowed to hold one concession. To get round this particular legislation, individuals would buy "acciones" or shares in multiple concessions which had been granted to consortia, consisting of various relatives or friends. They could also buy the services of a mining engineer to advise them on the likely position of the principle ore bearing seams. As a result the wealth of Cuevas del Almanzora was held in fewer than half a dozen families' hands. They were the ones who really struck gold, buying into the concessions that came to be known as "las minas ricas del Jaroso" (the rich mines of the Jaroso). Those of Ánimas, Constancia, Esperanza, Carmen, Observación, Rescatada and Estrella, all of which sat on the richest seam of galena in the whole Sierra.

The mines Constancía, Cármen, Observación, Rescatada and Estrella



The five richest mines Constancía, Cármen, Observación, Rescatada and Estrella. *Panorama, Rodrigo*

Share certificate for the Virgen Del Carmen mine.

Between 1839 and 1850, 70% of the production of the Almagrera was from these few mines giving their owners sufficient capital to invest in the canalization of the Rambla del Jaroso and some of its tributaries. Although the water no longer flows through this channel, its construction is to be marvelled at. Even right down at the entrance to the valley, its remains can still be seen. This is despite the torrents of water that cascade down after heavy rain. What it was constructed of I don't know, but I wonder if it is a conglomerate containing slag. What ever it is, it has endured.

Section of the water channel in the upper Jaroso valley.

The section from Esperanza to Ánimas was mostly underground, in a stone-lined tunnel, which also took the water from a tributary.

The entrance (above) and exit (right) of the tunnel under Esperanza which channelled the rambla.

Now that the water follows its own course, so much of Constancia and Esperanza has been washed away. Every year the erosion gets worse.

The channel exit seen from above where it crosses the present course of the rambla. The tunnel exit is to the right of the photo.

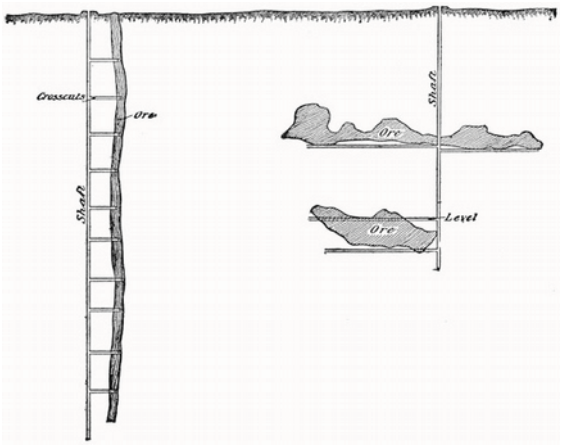
What of the rest of the concessions? Over 200 were granted. 1,700 shafts were sunk, 1,500 of these in the decade following the discovery of the argentiferous galena. However, official statistics show that in 1840 just three mines were productive, Observación, Carmen and Esperanza, and that by 1845, the number had only risen to nine.

What was happening was a great speculative movement, involving the buying and selling of shares in mines. This involved, not just people in the locality, but, as the tales of riches grew, people from Granada, Madrid and Barcelona were parted from their money. A second tier of moneyed gentry appeared in Cuevas and Vera, comprising of those who had profited from this activity. Many of these concessions were never even prospected never mind exploited. Even worse, many didn't even exist, so great was the extent of the fraud!

By the late 1840's, things had settled down. Everyone got down to the business of extracting the maximum amount of ore at the minimum possible cost. Mining is firstly about the search for ore and, secondly, the opening of avenues for its extraction. These two processes, the prospecting and the production, are difficult in hard-rock mining due to the nature of the ore deposits.

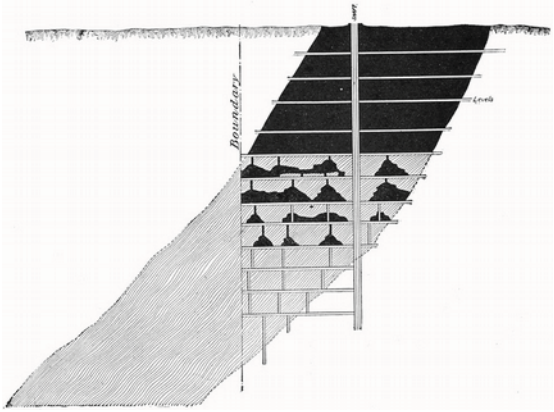
The principle method of prospecting in the lead mines of the Sierra Almagrera was to sink vertical shafts in the hope of locating a vein. If no vein was found, tunnels were bored out from the shafts into the county rock in an effort to find a lode. There are very few adits (tunnels from the slopes of the mountains into the mines for either prospecting or extraction) due to the restricted size of the concessions. As there was virtually no outcropping, or surface mining, of galena in the Sierra to indicate the presence and direction of a vein, the successful positioning of a prospecting shaft was very much a matter of luck. In the case of the principal Jaroso mines, where they were located pretty much at the centre of each concession, it seems that luck was on their side. Here, however, the lode was so wide and thick that it would have been difficult to miss. Many other mines waited for a neighbour to strike a vein and then prospected parallel to it in an effort to keep prospecting costs down.

Once a vein had been located a system of approach ways, or levels, had to be decided depending on its shape, size and inclination. Two simple methods are shown in the diagram below.



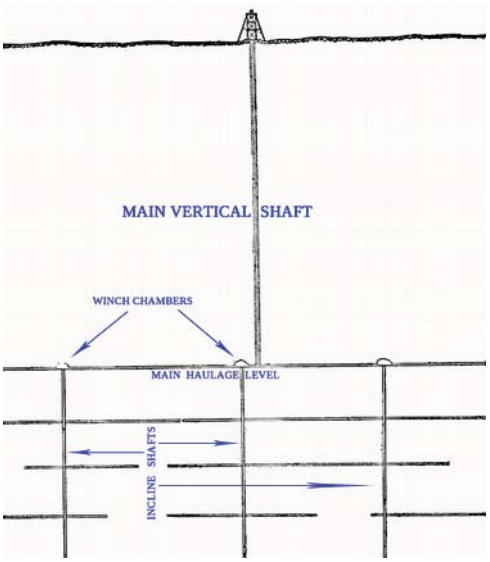
The approaches to vertical and horizontal ore veins.
Principles of Mining. Herbert C Hoover

There were further complications in the Sierra where, not only the dip of the lode and its position relative to the concession boundary had to be considered. The diagram below shows just how tempting following a wide seam could be.



The effect of concession boundaries on the exploitation of a vein.
Herbert C Hoover

The diagram on the next page shows the optimum layout of a hard rock mine with the vertical shaft entering the top of the deposit. While the aim was to have an equal length of lateral tunnel in every direction from the shaft relative to the angle of the vein it was easier said than done. Ore shoots and veins are so unpredictable that this was rarely achieved.

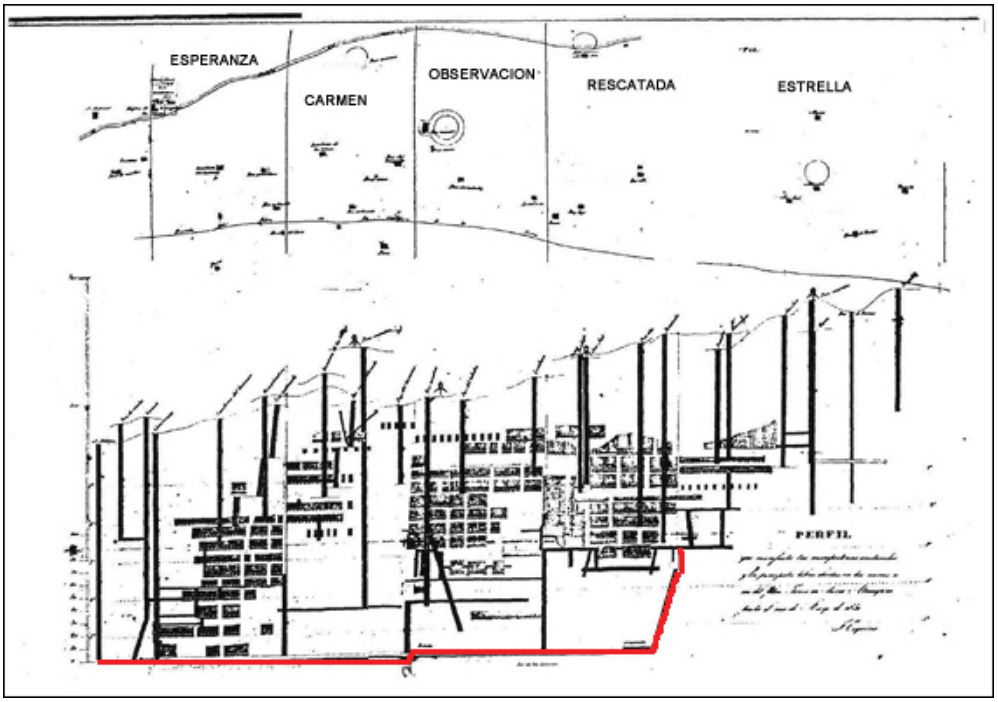


The optimum layout of a lead mine, with a main shaft and levels.

Herbert C Hoover

Once the ore deposits had been located and assessed decisions could be made about secondary access and ventilation shafts and consideration given to the future development of the mine. This, at least, was the theory and was known as the 'art' of mining to which graduates of the School of Mines ascribed.

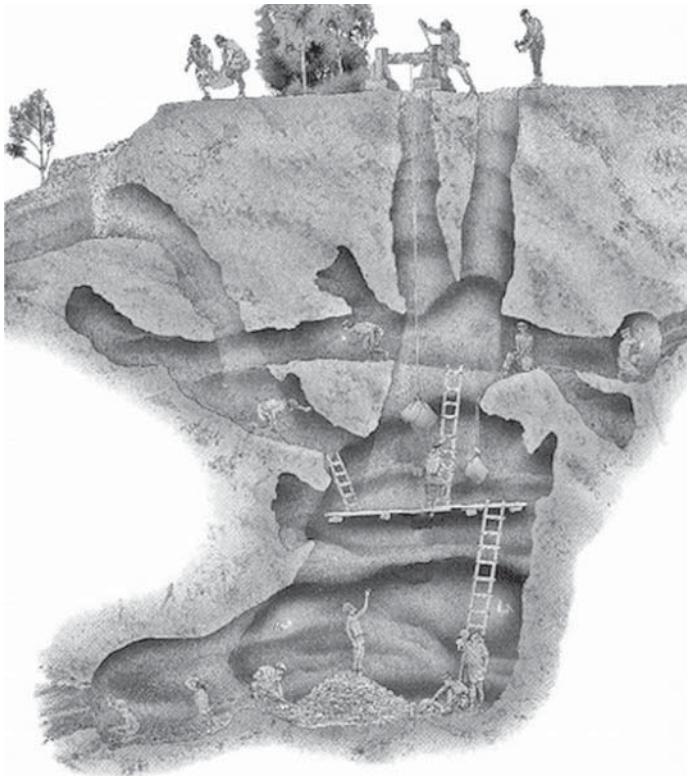
Ezquerra de Bayo's plan of the workings of the mines Esperanza, Carmen, Observación, Rescatada and Estrella, who employed qualified mining engineers, show well ordered workings. They also show a certain amount of co-operation, with inter-communication between the various levels of adjacent mines without encroachment on the areas of extraction. However, Bayo also pointed out that co-operation was not always the case between other mine owners.



Plan of the shafts and workings of the five mines showing how they were separate. The gallery that links them (shown in red) was for drainage and not for exploitation. In 1843, there were 1,650 underground workers in this 500 metre long section of the Barranco del Jaroso.

Plan by Joaquin del Bayo Ezquerra from La Mineria Almeriense en el Periodo Contemporaneo. (Perez)

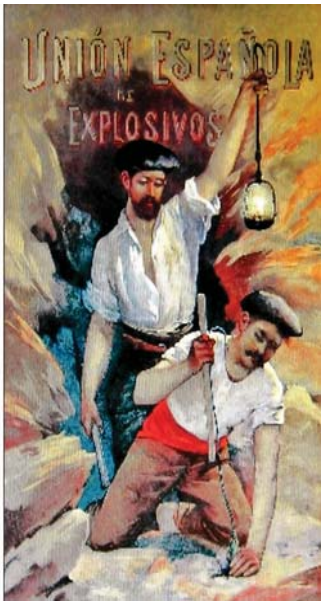
J. Pie y Allué, a mining engineer and director of the Vera School of Mining, was very scathing about many of the mines in the Sierra. Here, satisfying shareholders, getting rich quickly and maximising returns for minimal effort was the modus operandi. Such mines were worked with no planning or development. Veins were chased along their lengths without cross-cuts or haulage levels so they were a maze of narrow passages that rose and fell with the run of the mineral. This practice was very short-sighted as it meant that little or no prospecting was done. The illustration below of a medieval mine gives some idea of a mine worked without due thought to its development.



Poor planning in a medieval mine. Some of the mines in the Sierra were little better.

Openedition.org

A further major safety problem in many of the Sierra;s mines was the accumulation of waste rock. Mines in other parts of Europe generally had a fixed time – usually at the end of each shift – for the firing of explosive charges. Where there were firings during the shift the whole area would be evacuated. However, in many parts of Spain there was no fixed firing time and neither was there any evacuation as this interrupted production which lost money. Here, the barrenos, or shot-borers, set their charges at will and shouted "¡Barreno!" as loudly as they could. Their fellow workers would take up the call and all would hot-foot it to safety. Then, in order to save on cost, the resulting waste rock was left to accumulate in these narrow passageways instead of being either packed back into the stopes to prevent collapse or being winched to the surface. The dangers associated with this practice cannot be underestimated. Ezquerra de Bayo, whilst railing against the state of the passageways in even the most ordered of mines, attributed the fact that there weren't more deaths from this practice to the simple fact that the men were used to picking their way over the rubble. In his opinion it was recklessness and bravado that caused the most accidents. The English writer, Hugh James Rose, in his book "Untrodden Spain and Her Black Country", expressed the same opinion about the accidents during shot firing in the mines at Linares, attributing them to the same aspects of the Spanish temperament.



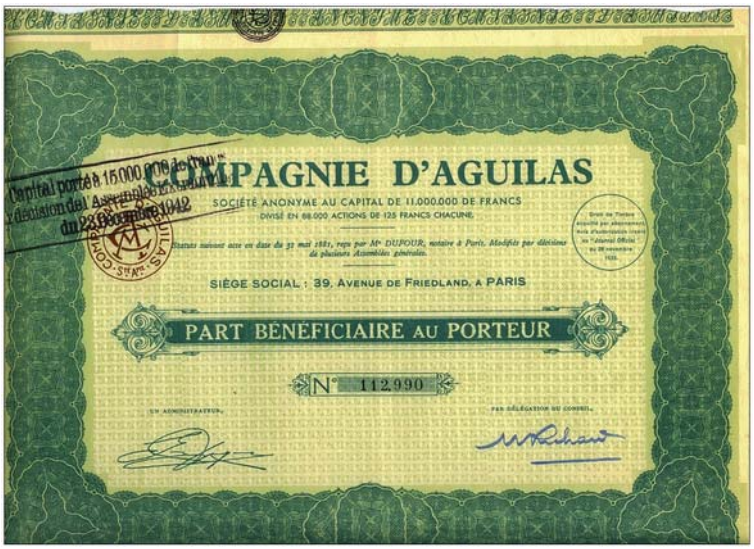
A somewhat stylized print of dos barrenos setting a charge

The 1849 Mining Act removed the royalist principle of land sovereignty, and eased the restrictions on ownership. The maximum size of a concession was raised to 300 x 200 varas. These later concessions in the area ranged from 40,000 to 50,000 square metres but existing concessions had to remain at their original size. Shafts had to be sunk in each concession and extending existing underground galleries into new concessions was not allowed. The conditions regarding the holding of a concession were complicated and many fell foul of them, leading to repossessions and redistributions. One curious condition was that a concession had to be in continuous operation, “pueble” or peopled by at least 5 operatives. Abandoned workings were the source of much litigation in the Sierra. Another problem associated with such a restricted surface area was the fact that a concession often ran against the grain of the mineral vein. This led to frequent intentional or unintentional incursions into a neighbour’s dependency particularly if it had been abandoned.

Legislation, in 1868, lifted the limits on surface area and removed the requirement to continuously operate a mine. More importantly, the restrictions on the number of concessions that an individual, or company, could exploit were abolished. This legislation was important because it opened the door to foreign investors who were not previously interested in operating on the small scale imposed by old, small concessions. While the so called “rich mines” of the Jaroso continued to be exploited by their owners, many others seized the opportunity to lease their mines. They ceded the working of their mines to prospecting companies in exchange for a percentage on the mineral produced. (This could be 40, 50 or even 60%.) By 1879, 60% of the mines in the Sierra were leased. The most important of the foreign companies at this time was the French company, La Compañia de Águilas.

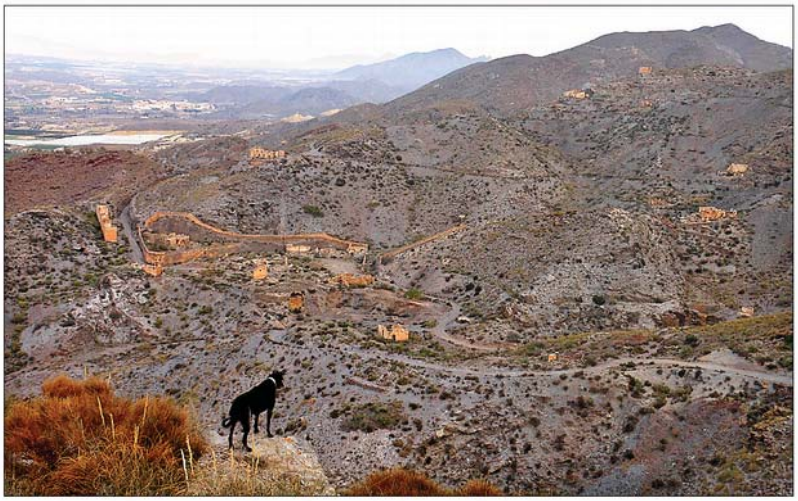
3.2. La Compañía de Águilas.

La Compañía de Águilas marked a “before and after” in the history and development of mining in the Sierra Almagrera. Founded in 1881 in Paris, and with the might and money of the ubiquitous Rothschild empire behind it, the company soon became a dominant player. They expanded rapidly, not just in the Almagrera and Las Herrerías, but also Águilas, Mazarrón, Lomo de Bas, Bédar, and Cabo de Gato. As they bought or leased mines, they introduced planning and systems for orderly exploitation. From the beginning, they made large capital investments and tackled major developments. Their corporate approach was in marked contrast to the Spanish way of doing things.



Their representative in Spain was Luis Figuera y Silvela. He knew the Sierra Almagrera well as he had been associated with the company which had operated the pumping station in the Jaroso Valley. La Compañía de Águilas re-opened the pumping station when they took over the running of the mine Constancia.

La Compañía de Águilas did things on a grand scale, in the case of in the Barranco del Francés, literally changing the face of the mountains. Here, they blasted out a broad swathe of rock to create a wide plaza in order to build a new pumping station and carved a deep cutting through to the next valley wide enough for an accommodation block and access road.



The remains of the pumping station at Barranco del Francés as it is today.

As well as acquiring mines in the Jaroso, they also built an administrative centre there, controlling their interests of Justicia, Gloria and San Luis Gonzalez on the southern side of the valley, together with their interests in Republica and Carmen de Gómaz Larios in the Barranco del Chaparral.

Not to be outdone, the Dos Mundos company, which operated in the Barranco del Francés, built an even more imposing headquarters, Casa Dos Mundos, in order to control their interests there.

La Casa de la Compañia de Águilas in the Jaroso. mtiblog *Casa Dos Mundos above the Barranco del Francés.*

As mines introduced steam power, the owners had been obliged to construct a track up to the pit head, in order to haul up the necessary boilers. These were very much individual tracks rather than lines of communication. La Compañia de Águilas realized immediately that this lack of communication in the rugged mining areas was seriously hampering operations. They constructed good solid caminos (tracks) to enable the transportation of coal and other materials up, and minerals down, the mountain. They also linked their various centres of mining activities. For the first time it became possible to traverse the Sierra quickly. Maintaining a steady 15-20% gradient and with sweeping curves, these tracks were used by mules and teams of oxen. This was the means of transport right up until the closure of the mines in 1958. The tracks are still there, partially eroded in some places but nearly all are passable on foot. The main ones are negotiable by trail bikes and buggies. They can be clearly seen on Google Earth but it is easy to lose sight of them on the ground.

The 'easy way' up to the Atayala Árabe . . .

. . . and the 'interesting' way down again.
(Villaricos is just out of view in the top-right.)

In Águilas, they constructed a port, large enough for steam ships, in order to move minerals from their interests in Mazzarón and Lomo de Bas. Within 3 years of their arrival, they were providing 8,000 jobs in the area. However, this did not last long. As a company, they had a wide range of interests in several countries, so kept a close eye on the vagaries of the international markets. They foresaw the fall in the price of silver and lead so decided to pull out. From 1886 onwards they rapidly liquidated their mining and metallurgical assets. This hasty retreat paralysed the pumping stations which in turn condemned to closure all of the mines remaining in the hands of small companies. A writer at the time lamented that “The barrancos were silent. The roads that had been crammed with pack mules taking water and supplies up and bringing minerals down were empty. You could walk without exchanging a word or seeing a living soul”.

In addition to being held to blame for the collapse of the mining industry in the Sierra Almagrera, they were also blamed for the inundation of Las Rozas in 1884.

The open cast mine of Santa Matilde just behind what is now called Las Rozas was, for several years, operated by Guillermo Huelin an entrepreneur from Málaga. At a depth of 20 metres there was occasionally water ingress from the Rio Almanzora. Aware of the danger of serious flooding, Huelin maintained a buffer zone between the excavations and the river. In 1882, six years after Huelin's death his son transferred the interests of the business to La Compañía de Águilas.

Disregarding the prudence of the previous owners, and seeking to improve production and profit margins this perfidious French company compromised the barrier that Huelin had maintained. 1884 saw unusually heavy and prolonged rainfall in the area and the Almanzora was full to overflowing. The combined forces of greed and nature resulted in 1,800 litres of water per minute pouring into the workings.

All of the mines of Las Herrerías were flooded. Landslips engulfed buildings, pit heads plummeted down their shafts and huge cracks opened up. Total disaster and ruin! The aftermath was devastating. Not only had the population lost its livelihood, but the standing water harboured mosquitoes so malaria was endemic. After a failed attempt to dry out Las Rozas, La Compañía de Águilas hived off their interests in Las Herrerías and Palomares on a 99 year lease to a Spanish company on condition that they drained the rozas.

Las Rozas flooded. *Rodrigo*

Interestingly, the pumping machinery installed by La Compañía de Águilas in the Barranco del Francés was brought down and recycled for use in drying out Las Herrerías.

3.3. Of pozos. (In this context the translation of pozo means a shaft and not a well.)
There was a marked differences in ways that the mines were operated depending upon the money available for infrastructure. The smaller, less profitable, concessions were accessed in a very primitive manner. Sometimes there was just a single shaft which served for access, ventilation and extraction. The mine Arrojo, bordering on to the Rambla del Arteal, seems to have been one of these. In the photograph, in what would normally have been the housing for just the access shaft, there seems to be a winch mechanism. If that is the case, then the miners would have been winched down on a rope hoist, putting their life in the hands of the tornero or winch man. The chimney-like structure at the right of the canopy is a ventilation flue, where air was channelled up the side of the shaft. Using a system that dates back to at least Roman times, a section of the shaft was partitioned off to form a flue. This in turn created an air uptake and an air intake and, for this mine, seems to have been its main ventilation. There is no clear track to this mine, indicating that it was never converted to steam power. By 1890 it seems to have been had been abandoned.

The mine Arrojo as photographed by Rodrigo

Arrojo it is today

A more usual arrangement was to have two main shafts, one for extraction and one for access, and one or more ventilation shafts. The miners reached the workings via a series of ladders and platforms down the “pozo del escalado”. In the deeper mines there could be as many as eighty sets of ladders to be scaled at the beginning and end of each shift.

Many of the smaller mines operated with a manual winch for the extraction of ore. The main disadvantage of this type of winch was that the depth of the shaft was limited by the strength of the “torneros” or winch men. It was possible to have winches sited at intervals down the shaft and to bring the ore up in stages, but this made the process very laborious. The very early winch drums were simple cylinders. The drawback of these was that, as the esparto rope was reeled in, the coils travelled from side to side of the drum. As a result, the esparto basket containing the ore acted as a pendulum, frequently knocking into the sides of the shaft. To overcome this unfortunate occurrence, an ingenious type of drum was developed which was waisted in the form of a diabolo. This kept the rope and the baskets centred in the shaft reducing the risk of tipping and saving on the wear of the esparto baskets.

A manual winch in operation.

The diabolo or "saddle" drum.
Dialnet-Los Castillos Mineros

Greater depths could be reached by using a mule powered hoist, known as a malacate. Some of these were quite elaborate affairs, often covered with an esparto grass canopy. They consisted of a vertical shaft or axle with one or more bars radiating from it. A mule, or mules could be hooked up to these bars and made to walk round in circles, thus providing the motive force. A malacate had twice the lifting power of a manual winch. Apart from Carmen, the "rich mines of the Jaroso" had such hoists.

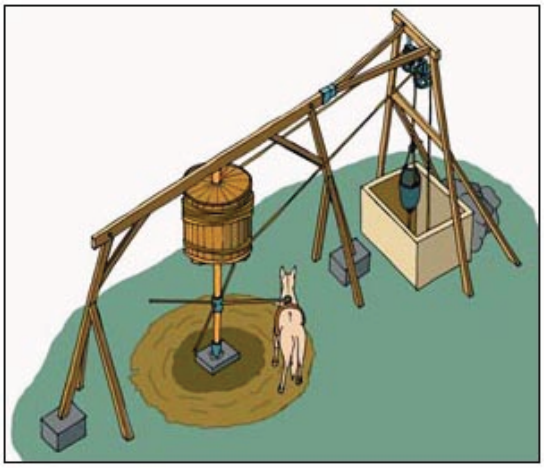


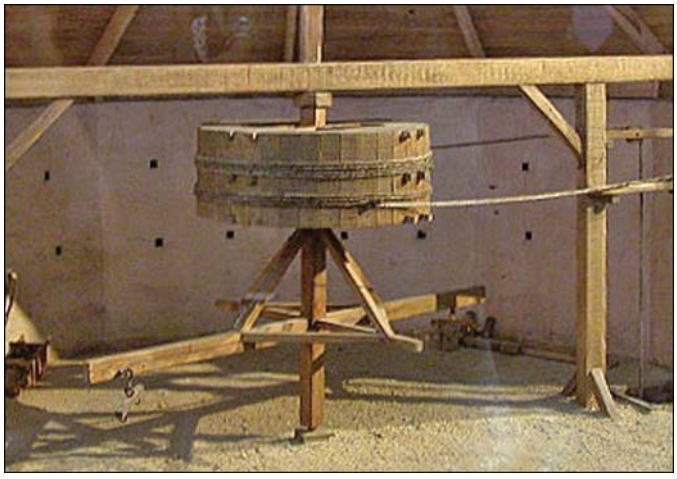
Diagram of a malacate.

Malacate in use in the Sierra Almagrera.

Carmen had what was called a baritel, which was a variation of a malacate. Again it was animal powered. The mechanism and animal were housed in a circular, roofed enclosure. The drum of a baritel was often 6m. in diameter and the housing 10m. Carmen's baritel was able to operate to a depth of 200 metres. All that remains of it today is a section of the housing.

Remains of the baritel of the mine Carmen.

Model of a baritel showing how it operated.



The baritel of the mine San Andres in Almadén.

The great advantage of both the malacate and the baritel was their dual action drum, which was capable of raising and lowering a load simultaneously.

These animal hoists were remarkably efficient, so much so that, even 20 years after steam power was introduced to the area, the “rich mines”, Carmen, Observación, Rescatada and Estrella were still operating them.

Steam power came to the Sierra in 1864 when the first powered winch, complete with steel cables rather than esparto grass ropes, was installed in the Purísima Concepción mine in the Barranco del Jaroso. Far greater depths could now be exploited. Chimneys, boiler houses and, most importantly in this arid region, large water collection cisterns were constructed.

The water collection cistern of the mine San Andres.

The sign of an affluent mine was a chimney and the classic pit head winding gear. Amazingly, one of these very early, wooden, head frames has survived. All of the others, like everything else in the Sierra have been scavenged. It is very rare to find a scrap of metal or a plank of wood anywhere in the mountains. The winding gear of the Encantada mine, in the Barranco del Chaparral, has been partially restored. The boilers and engine are exposed as the engine room was not re-built. The head gear has been reinstated. It is easy to get to and is well worth a visit.

A general view of Mina Encantada.

Mina Encantada's pulley sheaves and above, winding drums.

Although simple, these early timber head frames were very efficient. They could be operated with either flat metal cables or flat esparto ropes. In many cases they lasted for the working life of the mine.

The engine and boilers of Encantada are interesting. 80% of the steam engines in the Sierra were of this type, designed and installed by a Belgian engineer named Paul Colson. This particular 10 Hp. engine was manufactured for him by the Reading Iron Works Ltd. They were assembled on site and their small sized boilers could be transported up the mountain with comparative ease. (Unlike the Humbolt boiler which required a team of a dozen oxen to haul it up to La Guzmana.)

La Guzmana. Rodrigo captured the arrival of a boiler at La Guzmana hauled by a team of oxen.

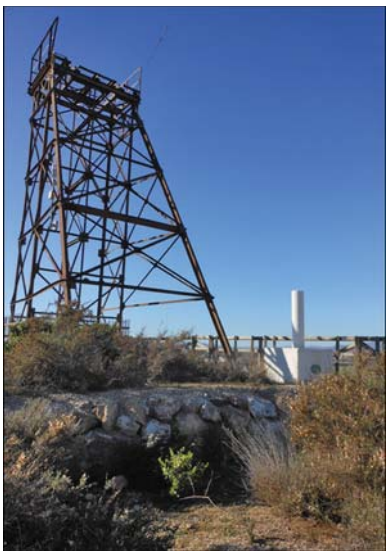
The small boilers favoured by Colson.

All that remains of a compact 10 hp. engine.

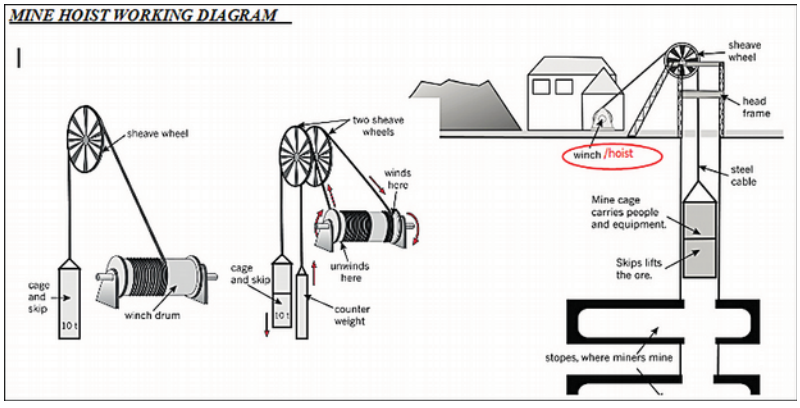
Colson's engine was very economic in terms of water consumption and, in addition, was relatively inexpensive. He would take a down payment and the balance in stages, as a percentage of the value of the mineral extracted over a given period. (An early form of the never-never!)

Mines which had a relatively long life span substituted the timber head frame for a larger, more elaborate, metal one. The only surviving example is the Pozo Susana frame, minus its winding gear, in Las Herrerías which was operated by a 50h.p. motor.

Pozo Susana above Las Herrerías.



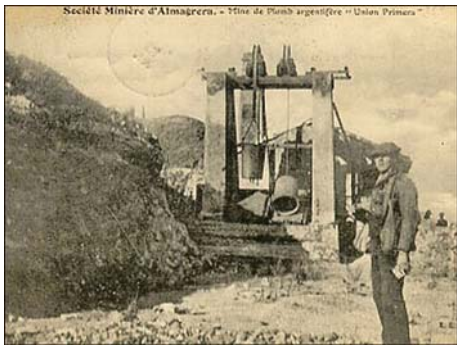
Wherever you come across a large, rectangular shaft and the remains of a building next to it, you can be sure that you're looking at the remains of an engine room and pit head. Because the buildings which housed the engines and winding gear were solidly build to withstand the vibrations and stresses and strains, they are often the only remains left standing.



The buildings housing the winding gear needed to be solidly built.

Above, winding gear of the mine Paraíso.
Rodrigo.

A later development was that shown in the picture of the mine Union Primera in 1905. Here, the head frame is mounted on a low wall and the wooden buckets are emptied without the need to remove them from the hoist.



Union Primera.
Moran.

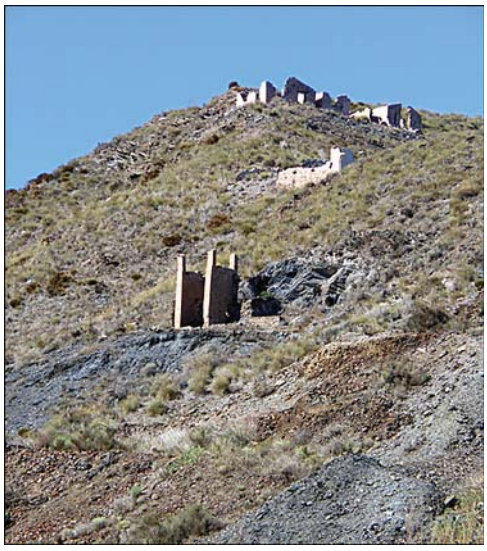
There are several examples of this type structure for example, San Andres near Pico Tenerife, and Mesías in the Barranco del Francés. They are the intermediate development between the very early winches and the tall castilletes, of which, more in the next section.

Above, the head-frame supports of San Andrés (J A Sanchis) and, right, Justicia.

3.4. and castilletes.

There is no mistaking the “castilletes de mampostería”, or masonry pulley supports. These were built of roughly mortared, waste rock, which was then smooth rendered. Their height varied, but their function remained the same. These graceful towers are the landmarks and signposts as you explore the Sierra.

The supports for Mina Ánimas (left) and
for Mina Santa Isabel (above).
These two mines guide you up the Jaroso Valley.

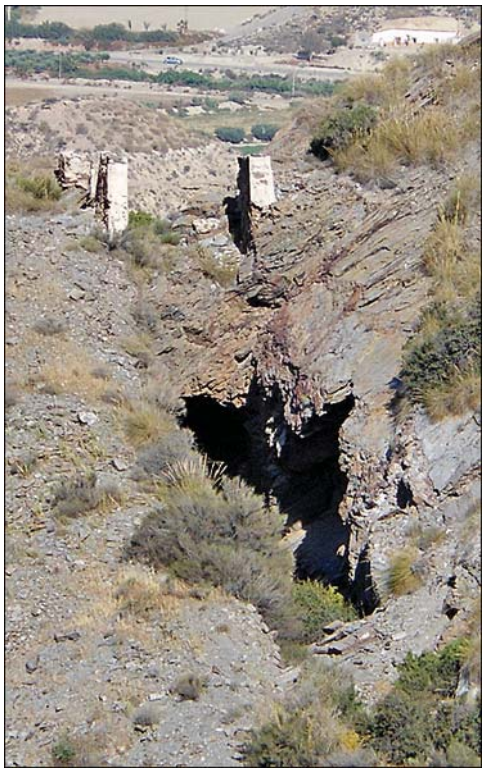


Rafaela (above left) stands guard over the right fork from the Jaroso into the Barranco de Fernádez, on the way up to the summit. Numancia (above right) towers above the Barranco de Las Palomas. *mtiblog*

These castilletes are not to be confused with the supports for aero cables like these on “Television Hill” and in the Barranco de Las Palomas.

(“Television Hill”, so-called because – incredibly – someone went to the trouble of transporting and then dumping a large television half way up the track. It’s skeleton remains.)

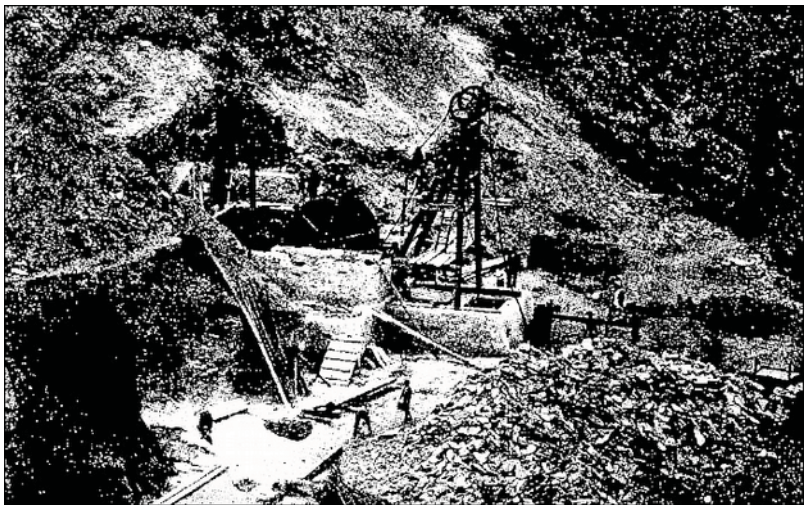
Aero cable supports on "Television Hill".



Aero cable supports over the Barranco de Las Palomas.

The following photographs illustrate the development of the method of ore extraction through the 19th century. The mine República started life with a manual winch as seen in the first photograph. However, if you look carefully, to the left of the picture, you can see the sheave wheels of new, powered, winding gear waiting to be installed. In the second picture the head frame has been erected and the extraction shaft reinforced.

The manual winch of Republica.
Rodrigo. Taken from 'Tiempos de Plata y Plomo', Enríque Fernández Bolea.



Erecting the powered winch at Republica.
Los Negocios de los Fernández Manchón. Enríque Fernández Bolea.

It was probably upgraded by the Compañía de Águilas and then upgraded again in the 1950's. It would have certainly have needed something bigger than the original Colson engine to power it!

Republica as it is today.

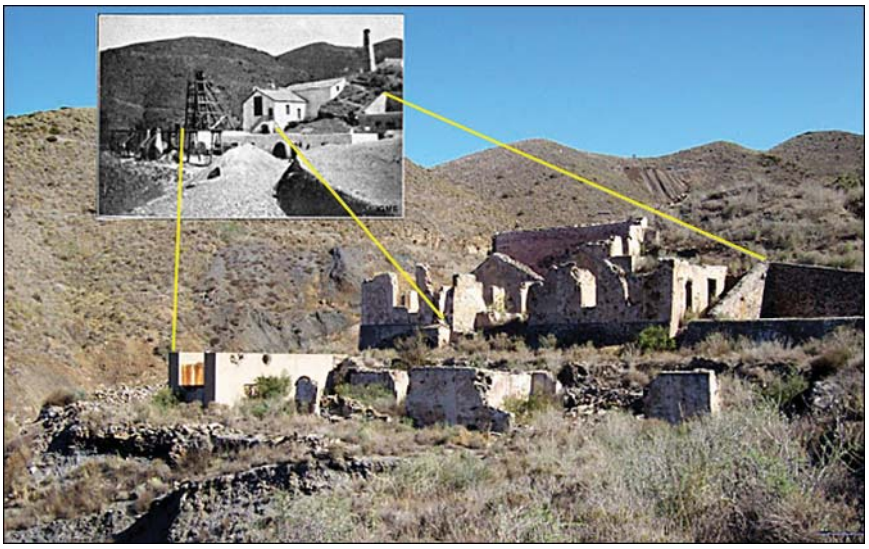
Below, the arches where the ore was taken out. *mtiblog.*

The ore was taken from the hoist via the arches.

The best example of these arched extraction points are to be seen at the mine Fuensanta.

The gated arches to the shaft of Fuensanta.

There are some interesting castilletes in the Barranco Hospital de Tierra, on the way up to La Guzmana. The mine Independiente had the type of head frame shown. The massive walls simply supported a frame and sheaves. Underneath, is a dual purpose shaft, used for extraction and access.



Independiente, then and now. *Photo. A.G. Jódar.*

The shaft of the Independiente was used for access and extraction. The ladders and platforms can be seen behind the guide rails of the lift cage.

Photo. A. G Jódar.

Also in the Barranco Hospital de Tierra, is the mine Patrocinio, with its leaning towers of Piza. There are insulators attached to the side of one of the castilletes, indicating that it was powered by electricity in its later years.

The leaning castilletes at Patrocinio. *Photo. mtiblog.*

The winding gear at these mines would have looked like this.

3.5. Ventilation.

Adequate ventilation is a permanent problem in mines and, with very few exceptions, natural ventilation systems were used. I have done some research into how it was achieved in the Sierra. I think that for the most part, systems of natural ventilation were used. This was probably due to a variety of factors such as avoiding the need for capital investment, no running cost and limited access to technology.

Many of the shafts in the Sierra are ventilated by means of a grooved integral channel running down the side of the main shaft as can be seen in the picture of Constancia's shaft. This channel would have been bratticed (partitioned) using a wood and gypsum mix, similar to wattle and daub, or canvas cloth. Wood was in short supply throughout the Sierra so the use of wooden planks to effect the partition was uncommon.

The shaft in Mina Constancia would have been bratticed with wattle and daub.
A G Jódar

Other shafts have a ventilation channel which looks to be separate from the main shaft as can be seen in the pictures taken by A G Jodár using a remote camera.

The ventilation shaft (on the left) in Elisa is separate. This is looking down from the top of the shaft. *A G Jódar*

The ventilation shaft at the bottom of the main shaft. A fire could have been set in its base.
A G Jódar

I am inclined to think that, as the shaft was being sunk, a groove was cut and then mortared to create two distinct shafts. It is also possible that fires may have been set at the base of these channels to create an updraught as was the practice in other countries.

There are several of these white topped ventilation shafts in the Barranco del Francés and in the Barranco del Jaroso.

Ventilation shafts in the Barranco del Francés and (below) in the Barranco del Jaroso.

There are also several ventilation shafts that are just deep holes in the ground. These are the most dangerous of all the shafts in the Sierra as there is no warning of them.

Beware!

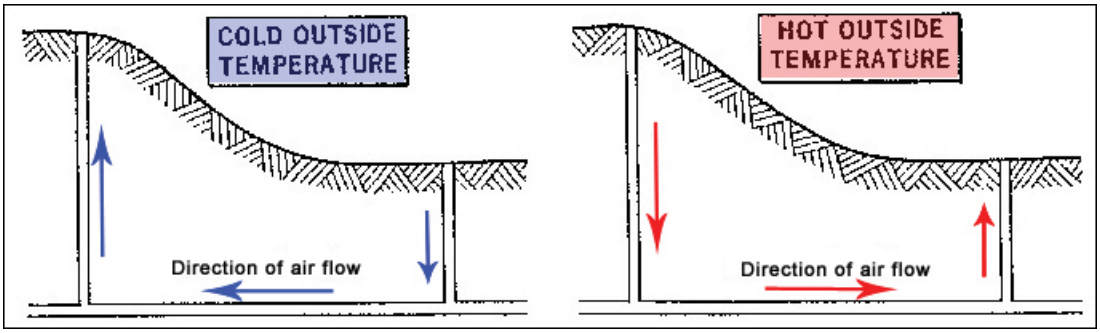
Originally these ventilation shafts had a cone-shaped cap with a hole in the centre as shown in the pictures on the next page. Over the years these caps have collapsed and fallen down the shafts leaving only an open – and unguarded – hole.


Ventilation shafts originally had domed caps. This is the only intact example I have found, hence the warning.

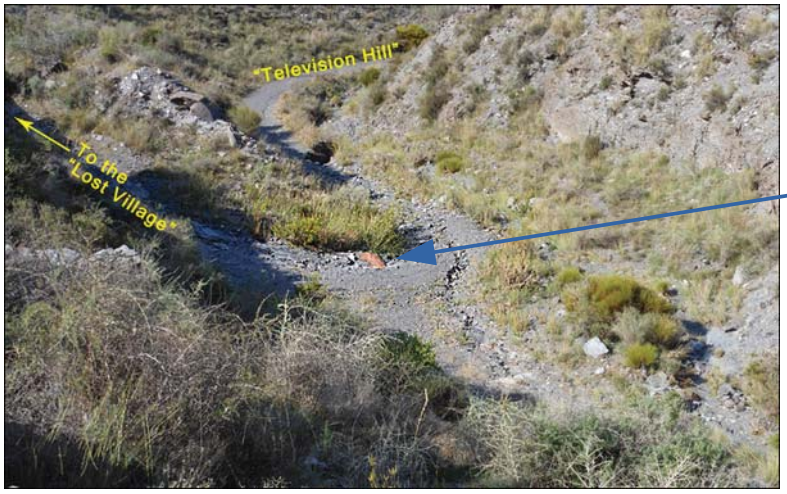
So, how does natural ventilation work? The proper term for it is buoyancy driven ventilation. It is due to the differences in density of interior and exterior air. These density differences are, to a large part, due to temperature differences. When there is a temperature difference between two adjoining volumes of air, the warm air will have a lower density and be more buoyant. This causes it to rise above the cold air, creating an upward air stream.

The problem with the system is when the outside temperature changes. Good ventilation occurs in the winter, as can be seen in this photograph, with warm air condensing out above a ventilation shaft on a January morning.

On a hot summer's day, the results of natural ventilation are not so apparent. There are also problems when hot days become cold nights. The air flow tends to reverse with the fluctuation in external temperatures.



I believed I had found evidence of forced ventilation at the top of “Television Hill” when, after years of puzzling over the feature shown below, I thought I had found the answer.

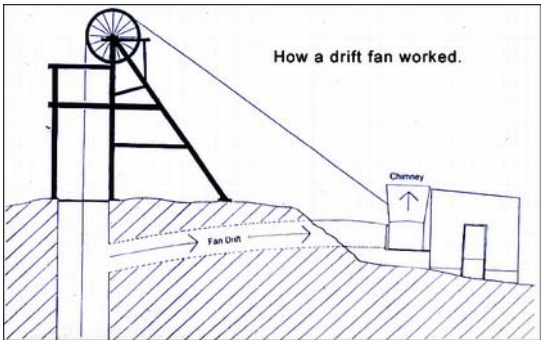


Location of the mystery feature.

Up close.

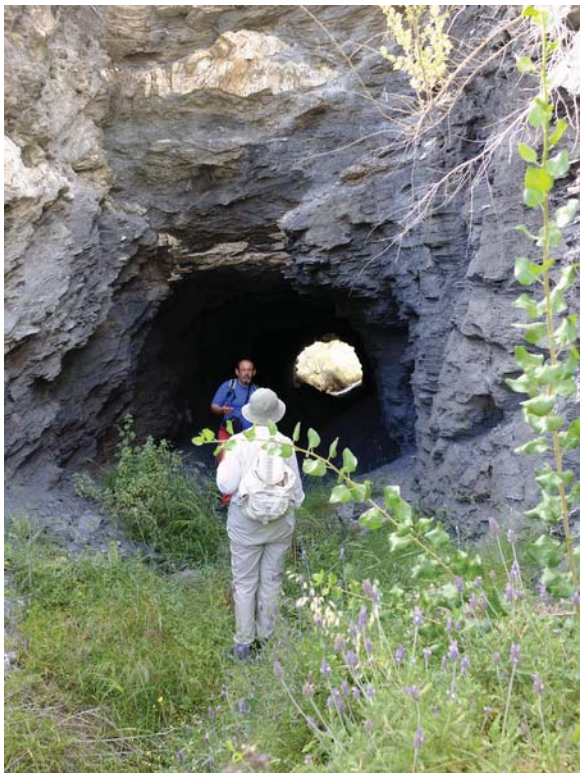
Left, reconsruction of A Capell drift fan.

Below, how a drift fan worked.



During a visit to the Black Country Museum in Dudley I saw a reconstruction of a Capell drift fan and was sure that my mystery feature was the remains of one. The nearby Centinela mine had been a drift mine in the 20th century, extracting iron ore rather than galena and there are numerous brick-arched drift entrances nearby which reinforced my theory. Once again Señor Jódar, while understanding the plausibility of my notion, told me that it was simply a means of diverting the flow of rainwater down the gulley. Years previously he had passed a remote camera through it showing that it was no more than a pipe made of bricks. All was not lost though. He told me about the only incidence of forced ventilation that he knew of and kindly

took me to its location, the mine Monserrat high up in the Jaroso valley. There, near to the tunnel through which the old road up to the top of the mountain passed, is an unusual shaft. Steps are cut into the side, so it was obviously used for access, but also up the side is a ventilation groove that would have been bratticed.



Left, the tunnel by Monserrat, through which the old camino passed.

The shaft, with steps cut into it and the ventilation channel running up the left-hand side.

Nothing unusual there then, except for the fact that the channel extends into a small building next to this shaft. It would be quite easy to mistake this for a latrine, apart from the fact that the hole in it gives directly into the adjacent shaft!

The end of the ventilation shaft in the ruins of the small adjacent building.

The only explanation for this set-up is that there was some form of forced ventilation mechanism housed in this small building. I have no idea how it was powered and could have been a simple hand-operated fan or a more complex mechanical one.