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La minería hidráulica romana desarrollada en el Cerro del Sol (Granada) para explotar sus recursos auríferos

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RESUMEN
La Alhambra se encuentra asentada en el extremo más occidental de un depósito aluvial conocido con el nombre de Cerro del Sol. En este promontorio, que actúa como elemento separador entre las cuencas de los ríos Darro y Genil, está atestiguada la existencia de oro, encontrándose presente en el Conglomerado Alhambra. Con la romanización se inició la explotación a gran escala de los recursos auríferos del sudeste de la península Ibérica, haciendo uso de diversas técnicas propias de la minería hidráulica. En el caso del Cerro del Sol las zonas de extracción se ubicaron tanto en las laderas del valle del Genil como en las del Darro, siendo la más espectacular la del Hoyo de la Campana, donde se aplicó masivamente el sistema de cortas de minado. Para ello fue necesario abrir una canalización que conduciese el agua desde un punto situado a más de una decena de kilómetros de los frentes de explotación.

PALABRAS CLAVE
Minas de oro romanas. Canales. Hoyo de la Campana.

SUMMARY
The Alhambra is located at the westernmost end of an alluvial deposit known as the Cerro del Sol. On this ridge, which acts as a dividing line between the basins of the rivers Darro and Genil, there is evidence of the existence of gold in the Alhambra Conglomerate. The advent of the Romans saw the beginning of the large scale exploitation of the gold deposits in the southeast of the Iberian Peninsula, using various hydraulic mining techniques. In the case of Cerro del Sol, gold was extracted from the slopes of both the Genil and Darro valleys, but the most spectacular workings were at the Hoyo de la Campana where there was large scale application of the “ruina montium” or lashing system of mining. This involved the construction of a network of channels to carry the water from over ten kilometres away to the working faces.

KEY WORDS
Roman goldmines. Channels. Hoyo de la Campana.
Roman hydraulic mining at Cerro del Sol (Granada) to exploit its gold resources

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1. Introduction

The existence of gold deposits in "(...) a mountain range belonging to Bastetania (...)"1 –which would include Sierra Nevada—was mentioned towards the end of the first century BC by Strabo (Str. III, 4, 2). This well known quotation would suggest that gold deposits in the southeast of Spain may already have been exploited late in the 2nd century BC or early in the 1st century BC2, since the text by this classical author is based on the findings of Posidonius (135-51 BC) and perhaps also on those of Polybius (2nd century BC)3. As Claude Domergue and Francisco Javier Sánchez-Palencia Ramos have both stated, the exploitation of gold deposits in the vicinity of Granada may have started in republican times, which would make it one of the first gold workings carried out by the Romans in the Iberian Peninsula, a fact which remains to be proven by archaeology.

Posidonius’s testimony corroborated by Strabo must refer to the gold placers in the alluvial deposits of the Sierra Nevada and the Sierra de Baza-Los Filabres, which extend from the Tertiary to the Quaternary system. The ridge called the Cerro del Sol is composed of what is known as “Alhambra Conglomerate” which has an observable thickness of approximately 200 m and dates back to the Lower or Basel Pliocene period (~5 million years). It is made up of coarse detrital sediments bound to coalescent fans from the Sierra Nevada. These stones originate from metamorphic rocks (quartzites, mica schists, gneisses, serpentines, amphibolites, marbles...) in a matrix which is also detrital (sand/microconglomerate), among which quartzite clasts predominate. The “Alhambra Conglomerate” originates in turn from a “reworked” material of a previous substrate, originating in the Upper Tortonian stage (~8 million years), belonging to the Miocene series, which in turn originates from metamorphic rocks of the “Mulhacén Complex”. The possibility that the gold may actually originate from the Palaeozoic quartzites of this mantle4 has been mooted. The average gold concentration grade found in the alluvial gold deposits of the Cerro del Sol was thought to be 500 mg/m³, although these estimates date back to the 19th century5. Other more recent assays place the average grade at Hoyo de la Campana—located on the southern side of the Cerro del Sol (Illust. 1)—at around 300 mg/m³ (information provided personally by Luis Carlos Pérez García).

Various scientific studies have reached the same conclusion, that both at Hoyo de la Campana and in other nearby areas6 the telltale signs of Roman hydraulic mining can be seen. The Cañada Valderas trail at Pinos Genil has also been pinpointed as the possible site of a goldmine in this period7.

As early as 1889, the mining engineer Edmond Guillemin-Tarayre stated that, in addition to the goldmine at Hoyo de la Campana, we should add "(...) les résultats d’attaces attaques dont les vides se voient sur les bords du Darro au dessus de Jesus del Valle, autour de Casa Gallina (sic) et au nord du plateau d’Huetor"8. "(...) the results of other mining faces where voids can be seen above the banks of the Darro river, above Jesús del Valle, around the Casa Gallina (sic), and to the north of the Huetor plateau.”

2. Methodology

This work forms part of a broader piece of research in which we are identifying and studying all the gold workings operating in ancient times in the area currently occupied by the province of Granada.

In the particular case in question, our research methods have been based on four basic pillars: the study of historic documentation relating to the area of the Alhambra and the mining operations carried out in the vicinity, the interpretation of aerial photographs, the exploration of the area, and a systematic inspection of the underground shafts and galleries of the Cerro del Sol.

With regard to the first two research methods, we have made an exhaustive study of the graphic and written documentation on all aspects relating to Cerro del Sol. As for the second two methods, we have fully reconnoitred the area, with the invaluable help of the technical staff of the Conservation Service of the Council of the Alhambra and Generalife, and of agents of the Special Subsoil and Environmental Protection Unit of the National Police Force for East Andalusia (B.P.S.C. Granada). Manuel López Asensio’s knowledge of the subject has also been very valuable. To all the above we would like to express our sincerest thanks for their professionalism and kind support.

3. Historical references

Interest in the issue of gold mining in Granada in Roman times first arose in the second half of the 19th century. Mining activities that have doubtless left more spectacular and identifiable traces in various parts of the province are well known. However, more reliable proof of such activity was still required, and a comprehensive study of the phenomenon was called for, so that gold extraction works in the southeast of the peninsula could be properly inventoried.

Works containing references to this subject can be divided into two groups: those that mention gold mining in the Granada area as an isolated activity in comprehensive studies of gold workings in the Iberian Peninsula as a whole, and those that mention mining as part of the study of the old Roman settlement of Iliberis (Albayzin Hill, Granada) and its surroundings.

The works forming part of the former group have undoubtedly contributed more to this subject, while local historical writings have supported the conclusions drawn from early works.

Among those early works we need to go back to the mid 19th century to find the first writings which, in some way or another, touched on the ancient gold workings in Granada. To a large extent these works appeared in mining publications of the time. Their main purpose was to argue that the extraction of the gold found in Granada’s ferro-aluminous soil had to be profitable, given the historical precedents concerning these deposits.

It should be noted that the first preserved mentions of the mining of these alluvial gold deposits date back to the 16th century, and suggest that the workings date back to Visigothic times. After the expulsion of the Moors, opinion was divided as writers began to consider the Muslim period as a more likely starting date, and even as recently as the second half of the 19th century, many still favoured this latter option. This was the case of Tomás Sabau y Dumas (1850 and 1851)9, El Vocal Rute (1877)10, Williams Vazie Simmons (1880)11, Joaquín Gonzalo y Tarín (1881)12 and Antonio Rubio Gómez (1881)13.

It was not until the arrival of French engineers in the last quarter of the 19th century that the origins of the large scale exploitation of the Hoyo de la Campana gold deposits were definitively placed in Roman times. The testimonies of A.-F. Nogués (1885)14, Edmond Guillemin-Tarayre (1885)15 and
1889\textsuperscript{16} and Alex.-J. Bourdariat (1894)\textsuperscript{17} are among the most significant in this respect.

By the first half of the 20th century this thesis was generally accepted by most authors on this subject\textsuperscript{18}. From this period perhaps the most important work is by Oliver Davies *Roman mines in Europe* (1935), which described the Granada gold workings in the following manner:

"The auriferous clay of the Darro and Genil valleys in Granada has been cut away to more than 1,000 feet above the present river-bed, especially at the Hoyo de la Campana, by a hydraulic installation similar to the Roman work in the valley of the Sil. This exploitation is almost certainly previous to the capture of Granada in 1492, and the silence of Arabic authors makes a medieval date improbable, even though it has been thought possible to distinguish two periods in the style of construction of the channels; it must thus be Roman, and is probably the gold-mine referred to by Strabo as behind Malaca"\textsuperscript{19}.

That same year, three more authors agreed to a greater or lesser extent with these comments: Manuel Maldonado\textsuperscript{20}, Pablo Fábrega\textsuperscript{21} and Juan Rubio de la Torre\textsuperscript{22}.

Five years later, the work of Raymond Thouvenot *Essai sur la province romaine de Bétique* (1940) once again underlined this aspect:

"Au Cérou del Sol, surtout à Hoy de la Campana, non loin de Grenade, les coteaux sont percés de puits et de tunnel et sillonnés de larges canaux, aux parois solidalement construites en gros blocs soigneusement équarris, qui alimentent de très loin l'eau nécessaire. Ce courant débouchait le plus haut possible au-dessus de l'exploitation, de là il était dirigé sur les points choisis, où la violence du jet désagrégeait la roche. Les matériaux dissociés étaient ensuite recueillis dans les canaux de lavage, où les parties légères et stériles étaient aussitôt emportées par le courant, tandis que l'or et les matériaux lourds tombaient dans le fond des rigoles. Les grosses pierres que l'eau n'avait pas entraînées s'enlevaient à la main, et on n'avait plus qu'à recueillir le métal jaune"\textsuperscript{23}.

["At Cerro del Sol, especially at Hoy de la Campana, not far from Granada, the hillsides are pierced with bores and tunnels, and forrowed with long channels, with solidly built walls made of large, carefully quarried blocks of stone, which used to carry the required wa-
ter from a very distant source. The water would discharge as high up the workings as is possible, from where it was directed at selected spots where the force of the water would break up the rock. The loose material would then be collected in the sluices where the light parts and the gangue would be carried down-stream by the current, while the gold and heavy material would fall to the bottom of the sluices. The heavy stones that the water had not carried away were removed by hand and all that remained was to collect the gold."]

But it would be in the last quarter of the 20th century when publications by various scientists specialized in the study of ancient mining and metallurgy workings in the Iberian Peninsula placed the gold workings in Granada within the framework of workings throughout Spain, establishing shared characteristics and relative chronologies. Two names stand out in this respect: Claude Domergue and Francisco Javier Sánchez-Palencia Ramos.

Among the former's numerous works, two are particularly interesting as they make specific mention of gold mining in the vicinity of Granada. In his *Catalogue des mines et des fonderies antiques de la Péninsule Ibérique* (1987)\textsuperscript{24}, Domergue described the workings carried out at Hoy de la Campana and at another two nearby sites. In his other great work *Les mines de la Péninsule Ibérique dans l'antiquité romaine* (1990)\textsuperscript{25} he again mentioned gold mining in Granada. He was also the first author to point out that: "S'il était prouvé que les travaux de Hoy de la Campana (GR 2), situés en Turdetanie et où l'épaisseur du dépôt paraît impliquer l'usage de la ruina montium, datent bien de la fin du IIe ou du début du Ier siècle avant J.-C., ils en seraient le premier témoignage" [If it was proven that the workings at Hoy de la Campana (GR 2), located at Turdetania, where the thickness of the deposits would seem to indicate the use of "ruina montium" mining methods, dating either from the end of the 2nd or the beginning of the 1st centuries BC, this would be the first evidence of such workings].

With regard to the second of the two authors, Francisco Javier Sánchez-Palencia Ramos, a number of his works refer to exploitations around Granada, and he also acknowledges the Roman mine at Hoy de la Campana, together with the Cañada de Valderas (Pinos Genil) working. These gold workings would have been located in *"Turdetania et zona limitrofe* Provincia Ulterior republicana, posteriormente dividida en Bética y Lusitania, es decir la *"Turdetania et zona limitrofe* de Posidónius recogida en el texto de Strabo (Str. III, 2, 8)\textsuperscript{26}*. And, in addition *"los placeres fluviates actuales de los ríos Darro, Genil, Dilar y Monachil (explotados en época reciente); zona de Canales, con placeres en el río Golopón y arroyos de Bodurria, y depresión de Ugijar-Alcolea, también con placeres actuales"*\textsuperscript{27}. ["Turdetania and surrounding area of the Ulterior Province of the republic, later divided into Bética and Lusitania, i.e. the Turdetania and surrounding area of Posidónius as mentioned in Strabo’s writings (Str. III, 2, 8).\textsuperscript{28} And, in addition "the present day fluvial placers of the rivers Darro, Genil, Dilar and Monachil (worked in recent times); the area of Canales, with placers in the river Golopón and the streams of Bodurria; and the Ugijar-Alcolea depression, also with present day placers"].

Julio Mangas Manjares and Almudena Orejas Saco del Valle (1999)\textsuperscript{29} supported Claude Domergue when they said that a great "societas publicanorum", documented in the Cástulo mining hinterland, could have been in charge of the Hoyo de la Campana goldmine. Previously Ramón López Domech (1996)\textsuperscript{30} had also agreed with this hypothesis.

In recent times a number of authors who have written on various subjects of a provincial scope have again insisted on the Roman origin of this mine. Perhaps the most important of these are César Girón López (2000)\textsuperscript{31}, José Manuel Martín Martín (2000)\textsuperscript{32} —whose work is an essential reference for anyone wishing to understand the geological formation of the gold deposits in Granada— and Arón Cohen Amsalem (2002)\textsuperscript{33}, an acknowledged specialist in 19th and 20th century mining in the province of Granada.

Then there are the reflections of researchers who have focused their studies on Iberia and surrounding areas, in which they make some reference to gold workings in Granada. Within this group we can find the works of:

Mauricio Pastor Muñoz (1983, 2002, 2005)\textsuperscript{34}, who maintains that the exploitation of gold-bearing sands of the rivers Genil and Darro must have been one of the three most important industrial activities of the *Municipium Florentinum Ibereri-
tanum*. The other two would have been the production of ceramics and the extraction of marble from the Sierra Elvira. He also suggests that, before
Iliberi became a municipality, it must already have enjoyed a privileged economic position thanks to the exploitation of its agricultural, gold, and pottery resources.

José Manuel Roldán Hervás (1988) ascribed gold workings in the vicinity of Granada to the Roman empire, while also stating that, although agriculture would have been Iliberi’s main economic activity, other production resources would have existed, such as mining.

Miguel Jiménez Jiménez (1999) expressed a similar opinion when he wrote that Iliberi’s economic prosperity was founded on the agricultural wealth of the Granada Depression and its strategic position on the route linking the Cástulo mining area with the Punic factories and ports on the coast, especially Sexi. Not to forget a very important potter industry and the exploitation of its own mining resources; iron in the foothills of the Sierra Nevada, alluvial gold in the rivers Darro and Genil, and marble from the quarries of the Sierra Elvira.

Meanwhile Cristóbal González Román (2000) stressed the relationship between the development of several Iberian settlements in the Granada area, such as Iliberi, Basti (Cerro Cepeo, Baza) and Asci (Guadix), after Roman colonization, and their mining potential.

Margarita Orfía Pons (2002) also mentioned these mine workings, maintaining that they would have been established as soon as the Romans had conquered the region of Granada, due to the appeal of the region’s gold deposits, since gold was one of the Romans’ prime interests in this first phase of Romanization.

In short, the vast majority of this documentation insists on the same historical fact; that the alluvial gold deposits of the Cerro del Sol were already being mined in Roman times, and that there are visible remains of hydraulic mining at Hoyo de la Campana.

4. Traces of gold workings at Cerro del Sol and Colina Roja

Durante the 19th century and the first third of the 20th, a succession of placer mining claims were made at Cerro del Sol until practically the entire territory was staked out, although none of the claims were profitable. Logically not all those mines were on the site of ancient workings. The places where possible traces of Roman mining may be found are as follows:

4.1. River Darro side

Traces of ancient mine faces could be seen even at the Colina de la Alhambra, especially in the Tajo de San Pedro gorge (Illustr. 2[1]) and adjacent areas. There is an immense cut into the hillside, which was first mentioned in 1520 and is constantly evolving, since it is affected by several fault planes, the most important of which coincides with the dihedral edge. The existence of a gallery with a visible entrance on the western shelf of the cut, at a higher level than the Acequia la Romayla stream, may suggest the initial use of the hushing method to dislodge a large part of the overlying material. Other places where there may be traces of workings can be found at the Cuesta de los Chinos slope (Illustr. 2[2]), at the Barranco de las Cañas gully (Illustr. 2[3]), or at the Barranco del Aljibe de la Llueva or del Conjeo gully (Illustr. 2[4]). The galleries to be found below the Silla del Moro, which have no exit to the outside save for the inlet shaft, could also be related to mining practices (Illustr. 2[5]). In the mid-19th century there was mention of the existence of evidence relating to the extraction of gold at the Barranco de las Tinajas gully (Illustr. 2[6]), “En lo alto del barranco se observa un tajo ó corte artificial y una boca de galeria que se dice forma parte de la gran mina que atraviesa todo el Cerro del Sol (...)” (“At the top of the gully you can see a man-made cut and a gallery mouth which is said to form part of a great mine that tunnels under the entire Cerro del Sol”) At Umbría de El Valle (Illustr. 2[7]) and on both banks of the river Darro, the mining engineer Edmond Guillemin-Tarayre wrote of the existence of Roman workings.

Nearly half a century before, in an application made to the Governor of the Alhambra, mention was made of the existence of “old mine entrances” in the vicinity of the Acequia Real at the point where this canal passes through Umbría de El Valle opposite Jesús del Valle. Opposite these two last named areas there are several archaeological sites dating back to Roman times, although we are currently unaware of whether any of them may be related to this mining activity.

4.2. River Genil side

Ancient mine faces could have reached the Colina del Mauro hill, since under the Carmen Rodríguez Acosta gardens there is an entire network of restored tunnels that may have formed part of mining operations (Illustr. 3[1]), although such a theory is now very hard to prove. Several erosions in the Cuesta del Pinos (Illustr. 3[2]), del Pedregal (Illustr. 3[3]) and de los Hoyos –also known as de las Minas– (Illustr. 3[4]) gullies may be the result of ancient mining operations. Such erosions are much more prominent in the Barranco Bermejo gully (Illustr. 3[5]) and surrounding area, where remains can be found of galleries and shafts which may have been used for several hushing mining operations. From this point on there is more evidence of large scale mining operations. Structures typical of this type of mining can be found close to the Olivar (Illustr. 3[6]), the Casa de las Gallinas (Illustr. 3[7]), the Casilla (Illustr. 3[8]), and the Araña (Illustr. 3[9]) gullies. In the next gully, the Pantano or Higuera gully (Illustr. 3[10]), there are working faces and galleries in its downstream section, and in the middle and upstream sections there are boreholes perpendicular to the hillside. The large cirque of the Barranco de la Campana gully (Illustr. 3[11]) deserves a separate mention, and so it will be looked at in depth in later paragraphs. For this point on, in the 19th century a number of gold mining claims were registered in the Almez or Terreras gully (Illustr. 3[12]), in the Término gully (Illustr. 3[13]), in the Oro gully (Illustr. 3[14]), in the Venta gully (Illustr. 3[15]), in the Arcos gully (Illustr. 3[16]) and in the Angustias or Cenes gully (Illustr. 3[17]). However, the erosions apparent in the latter five gullies do not appear to have been caused by ancient workings.

Although there is as yet no archaeological evidence to prove the existence of a Roman road in the Cerro del Sol well serving the these mining operations, there is in fact a road which runs high above the bottom of the gullies where the workings are and above the highest line of erosion which could be caused by the advance of mine faces over time. Some of the areas where the workings were located may have been served by branch tracks off this road, which would have established an unbroken line of communication between the Granada Depression and the Hoya de Guadix, where it would have linked up with the Via Augusta.

5. Hoyo de la Campana mining structures

Nowadays there can be no doubt that the origin of these spectacular mine workings, both at an extensive and intensive level, goes back to ancient times. The Barranco de la Campana gully and several parts of the Higuera or Pantano gully and the Almez or Terreras gully have been so altered by
mining operations that the sources of the latter two have ended up being tributaries of the former. Also the sides of the gullies have been totally disfigured and the intervening hills have been “gutted”. Apart from the eloquence of descriptions of this phenomenon provided by many sources, we have also the evidence of aerial, terrestrial, and subterranean exploration which has detected the presence of every single structure evidencing the practice of Roman gold mining by the hushing or “ruina montium” method. In this method water was carried through channels from far away to an ingenious series of galleries and shafts excavated in the mine faces. When suddenly released into the system, the pressure of the water would dislodge entire sections of the hillside, creating a series of hydraulic explosions capable of “ruining the mountain”.

5.1. Major vertically cut mine faces

These are accompanied by huge excavation voids where the overhanging rock is often scalloped in form (Illust. 4). The most spectacular are without a doubt those cutting into one of the slopes of the Cerro del Sol, in the area known as Los Aguadres. Old working faces surround the entire ore field, which seen from the air has the shape of the silhouette of a sea skate.

These morphological features are the result of the systematic and successive use of hushing, the most spectacular of all hydraulic mining techniques, which is used to:

- Dislodge and break up the gold-bearing conglomerate. This can be done in stages or simultaneously, depending on the mass of conglomerate in question and the amount of water used.

- Channel the flow of the resulting mud to the conglomerate augeae or sluices, in order to obtain gold concentrate by decantation of the heavier gold particles. This operation should take place right after the first one so as to prevent the water from losing pressure and depositing the gold particles before the water reaches the sluices.

- Manual removal of the larger pebbles before the mud reaches the augeae.

5.2. Presence of inselberg peaks and slopes

The successive attacks are separated by arêtes and inselbergs, the result of safety margins left between the various mine faces (Illust. 5). The man-made formations are simply the remains of safety zones left between one attack and the following one. In this way they ensured that the rock mass to be dislodged did not collapse ahead of schedule.

5.3. Remains of shafts and galleries (Illust. 6)

One peculiarity of this ore field is the great concentration of preserved remains of tunnels and galleries, which are in need of a detailed archaeological study to determine to which time period they belong. Of these remains, at least those that were left hanging in inaccessible cuts in later centuries must have once formed part of ancient mining systems, excavated prior to collapsing the hillsides in order to access the ore.

Documented galleries and shafts can be broken down into four well-differentiated types:

5.3.a. Hydraulic galleries through which water from the supply channels (corrug) (Illust. 6a) and feeder channels (gold particles) (Illust. 6b) flowed. Some of them were reused in later centuries, as may have been the case of certain former hydraulic mining channels that were reused during the Narsid dynasty to supply the various royal properties in and around the Alhambra, or of feeder channels which were once again pressed into service in the last quarter of the 19th century. These channels were used to carry water to the various sectors Adolphe Goupil placed gold claims, thereby serving different purposes from the ones for which they were originally intended in Roman times.

5.3.b. Remains of galleries that may have been related to the network of mining galleries used to dislodge the rock mass. The final section of many of the remains to be found in the cuts of certain excavation voids have been preserved, and are usually less than two metres deep. As has already been mentioned, at least those located in the more inaccessible places must date back to Roman times (Illust. 6c), which would suggest that the fracture plane existed before the end of the galleries.

5.3.c. Remains of the shafts through which water was injected to flood the mine. Some of them have collapsed into the cuts, others are cut lengthwise (Illust. 6d), and a few have managed to survive almost intact, at least at their entrance (Illust. 6e). The shaft that survives in “La Caverna”, a man-made cave below the Cerro del Zapatero (Illust. 6f), is of particular interest. This cavity was formed by a surge of water entering an underground mine system, which did not achieve its objective since it failed to dislodge the mass of conglomerate above it.

5.3.d. Remains of inclined galleries the purpose of which appeared to be to search for rich ore-bearing levels, perhaps in areas where conglomerate faces met (Illust. 6g). This type of excavation has also been found forming part of networks of underground galleries, and also in isolation in certain areas where hushing operations were carried out. In this case they must have been excavated in the cuts after the deliberate collapse of mine faces in order to probe the deeper strata of the deposit. Although many of them may have been excavated in the 19th century (Illust. 7), others date back to ancient times, as evidenced by an 18th century graphic document which was captioned “descenderie ancienne”.

5.4. Head and feed tanks located above the working faces

At first sight it might appear that the Hoyo de la Campana mine did not have any water storage tanks, but a systematic search of the area has revealed footprints of such tanks. At least one piscina or stagnum has survived intact (Illust. 8a), as well as another two which were cut in half when performing their task of discharging water in the last moments of the mining operation (Illust. 8b), having reached the end of their useful life. Their shape and aspect gives us a clue as to how the scalloped overhangs of the eastern and western faces were formed (Illust. 8c): it may have been the result of successive collapses provoked by hushing operations in which the piscinae from where the water was discharged were immediately above the mines, causing them to disappear when the last hushing was effected. No footprints have been found of regulating tanks, which, had they existed, may have fallen victim to the large scale cuts made in the area of Los Aguadres. This type of water storage system may well have been used in the area of Umbria de El Valle, on the far slope facing the river Darro. If the “Central Tunnel”, which passes under the Cerro del Sol to emerge at the mine faces of Los Aguadres, had existed in Roman times, it may have carried water from one of these hypothetical regulation tanks. However, in the description of the hydraulic works performed by Edmond Guillemin-Tarayre between 1882 and 1886 there is reference to the execution of the “Tunnel du Darro maçonné … 600 m” (Illust. 9). The present-day impossibility of reconnoitring this long tunnel, which is closed off at both ends due to the
fact that the water feed to the Lancha del Genil Potable Water Treatment Plant passes through it, prevents us from being able to make a more accurate estimate of its age.

5.5. Existence of large accumulations of tailings
This is evidenced in the tailings cone at the Barranco de la Campana mine (deposits of an accumulation of fine tailings) and inside the mine itself (piles of coarse gangue).

5.5.a. In the former case it should be mentioned that the waste material generated by this vast gold-mine, in particular the limestones and finer sedimentary materials, helped create a large area of very rich and productive cropland (Illust. 10a). Several Andalusian agricultural communities settled on this land, with such well-known names of Cenes de la Vega, Genil, Casa de las Gallinas, Pedregal. Also all the material washed down from the Hoyo de la Campana mine and other smaller exploitations must have raised the level of the bottom of the valley.

The tailings cone at Hoyo de la Campana is now perfectly delimited by the route of the Camino Real (Royal Way) of Cenes, Dúdar, and Güéjar-Sierra, a track which runs along the valley bottom and dates back to Mediaeval times at least. As it passes by the mouth of the mine, the man-made changes to the topography forced the Camino Real to skirt around the tailings dump, where it is still possible to see the sharp difference in level with respect to the present day road. As for the thickness of these tailings, Edmond Guillemin-Tarayre said in 1889 that: "Le courant des stéries guidé par des canaux formés de gros blocs était écoulé vers le Genil, sur les bords duquel, il ont accumulé un mase de rejets de plus de 40 mètres de hauteur"³⁵. ["The flow of gangue guided by the channels formed by large blocks of stone ran towards the river Genil, on the banks of which a pile of tailings nearly 40 metres high has accumulated"]

Even more remarkable is the diversion which the Barranco de la Campana stream is forced to make as it passes by the mine entrance. When the stream’s natural course was blocked it was forced to flow around the southernmost foothills of the Loma de las Terreras hill, until it reached the shallow depression between the Barranco de la Campana and the Barranco del Almez gullies, which were also affected by ancient workings.

It is difficult to know whether the silting of the valley might have caused a temporary barrier to form in the river Genil (as happened with the Carrucado lake (León)) due to the deposit of tailings from the Las Médulas mines. The La Lancha estate, which is now a district of Granada called Lancha del Genil, was founded on the huge tailings cone produced by the Hoyo de la Campana workings. In the Middle Ages this area was already known as Lamyar, from the word Lancha, meaning “a place with abundant pools of water”. This word may originate from the possibly Iberian word Lancha which would have meant “small pool of living perennial water”, akin to the Latin words Lacus (lake) and Lacuna (lagoon)³⁶. This would square perfectly with the fact that it refers to tailings cone that would systematically receive slurry and mud from the mine. This place name may also allude to the creation of a small man-made lake as a result of the flow of the river Genil having been blocked at a certain moment in history.

5.5.b. Also, inside the mine there are a number of piles of pebbles as a result of the manual and selective removal of the coarser pieces of gangue from the conglomerate dislodged by the water, before the mud entered the sluices, which otherwise would be damaged by the stones. The most visible example of this is the great pile of stones at the end of the gully, just below where a major hushing operation was carried out, the “tongue” of which reaches as far as the tailings dump of the mine worked by Adolphe Goupil (Illust. 10b). This pile was as high as 15 m to 20 m in places. While in the 19th century this was the main place where medium size pebbles were piled, its position, right above the La Lancha tailings cone, may indicate a location that had already been chosen in ancient times. With regard to ancient tailings dumps, despite their having been exploited for quarrying purposes in recent times, it is still possible to find large concentrations of pebbles in over fifteen sectors of the mine (Illust. 10c-10f).

6. Parts of the Hoyo de la Campana workings
As in the case of other alluvial gold deposits that were worked by the Romans using hydraulic power³⁷, the Hoyo de la Campana mine has the following, well-differentiated parts (Illust. 11):

6.1. Water system
The components of the water system used in Roman mine workings to extract gold from secondary gold deposits are as follows: a water supply channel (ornagus), storage tanks (stagnae or piscinae), feeder channels (emissaria), and evacuation trenches or troughs for the dislodged conglomerate.

6.1.a. We have evidence of the existence of a clearly identifiable water supply channel which reaches the Cerro del Sol via the Collado de los Arquillos hill (909 msl), which was the highest point via which the water could reach this ridge (Illustr. 12). In other workings in the northwest of the Iberian Peninsula, where water is far more abundant than in the southeast, the number of mining channels constructed grew as the working faces advanced, as those at a lower level become unusable. Thus, the water system at Las Médulas had at least 2 channels on the north side of the Aquilianos hills (northern network) and 6 main channels on the southern side of these hills (southern network), in which the longest channel (channel C–3) was 143 km long³⁸. This type of infrastructure was referred to by Pliny as “ornagus” (pl. “ornagi”) –just as the indigenous people of the northwest of the peninsula used to call them– or by the Latin term “canal” (pl. “canalis”)³⁹.

These were long channels built to carry water from source points, normally simple diversion dams, to the working faces of the mines. Their average slope was in the region of 0.50% and their width in several places in the northwest where they have not been altered ranges between 90 cm and 150 cm (between 3 and 5 Roman feet). In the case of the ornagus which supplied the Hoyo de la Campana workings, which may have also supplied other gold workings on either side of the Cerro del Sol, the slope was more gradual, ranging from between 0.22% and the 0.32% along most of its length. With regard to width, in a half-sunken gallery a small section of the channel has survived, complete with marks left by the passage of water. It measures a mere 0.55 m, although the normal width in places where the channels were put to a later use is around twice that figure.

This type of mining channel tended to be built by digging directly into the ground, without any major ancillary work. They were limited to what Pliny would call “substanti canales” (Historia Natural XXXIII, 74) or foundation structures for these channels as they passed through water courses and gullies. It is clear that Pliny was making a difference between ornagi and the water supply canals serving cities. Logically the excavation of mining channels did not require so much care, but care
was however taken in maintaining the slope. When steep or unstable hillsides were encountered, tunnels or galleries were often dug into the conglomerate or rock, and traces of these works still survive in some places.

The water supply channel for the Hoyo de la Campana mine, whose diversion dam was on the river Beas, is evidenced by the existence of another at the same level and in the same direction—the Acequia de los Arquillos canal—which had been commissioned by Müh’ammad V in the second half of the 14th century to supply water to various palatial buildings in the Alhambra area. In order to span the Arroyo de Almecín (or de Belén) stream and the Collado de los Arquillos, two elevated aqueducts were built.

This canal was significantly modified in the last quarter of the 19th century in order to carry water to the mining claims of the "Sociedad Anónima de los terrenos auríferos de España", represented first by Carlos Álvarez de Sotomayor and a few years later by Adolphe Goupil. Despite the fact that at that moment the visible remains of the Acequia of los Arquillos must to a large extent have dated back to Nasrid times, the mining engineer who directed the goldmine for the second rights holder, Edmond Guillemin-Tabary, believed this branch canal to date from Roman times. Although most of the material remains that he must have encountered may not have been so old, it would have been logical to think that the path taken by this canal would be the same as that taken by the corruquis of Roman times, since the two branch canals from the Acequia de los Arquillos both went past the entrance to the gold workings of Umbría de El Valle and Hoyo de la Campana. This engineer was a firsthand witness of this ancient canal system, which was dismantled where it coincided with his Canal de Beas y Almecín.

6.1.1. Network of feed tanks, called by Pliny either "piscinae" (pl. "piscinae") or "stagnum" (pl. "stagna"). These tanks served a number of different purposes, such as the storage of water carried by the corruquis, the distribution or regulation of water flows, and the storage of water at the mine heads.

According to Pliny (Historia Natural XXXIII, 75) these tanks were excavated directly into the ground and measured 200 x 200 x 10 feet (about 60 x 60 x 3 m = 10,800 m³), although the size and shape would obviously be tailored to the particular conditions of the place where they were to be installed. Tanks that have been documented at other gold workings in the Iberian Peninsula come in all shapes and sizes, although they are usually long and narrow and tailored to the topography of the land so building them requires as little earthmoving work as possible.

Of the identifiable feed tanks at Hoyo de la Campana, one, located over the working faces of sectors I₃ and I₄ (Illust. 8a), stands out in particular as having survived intact, albeit very silted up (D₃₄). It was of a smaller size than those described by Pliny, in the region of 45 m x 22 m, and its depth is hard to estimate. Most of the other tanks were systematically destroyed as the hushing operations progressed. However the western half of one, crowning the Cerro del Zapatero hill (D₃₉), still survives. It measures 10 m x 15 m and is over 3 m deep (Illust. 8b).

6.1.1. Network of feed channels or "emissariun" (pl. "emissariums"), comprising the various channels branching of the corruquis and leading into the mine, so that the water could be aimed at the different working faces that were to be attacked. As work progressed, these feeder channels needed to be constantly rerouted and redesigned, and, when it was possible, the water supply channels needed to be raised in order to reach increasingly higher areas. In the case of the Hoyo de la Campana workings this latter option was impossible since the maximum height to which the water could be raised was predicated by the height of the Collado de los Arquillos (909 masl) and the height of the channel system the water had to pass through. According to Edmond Guillemin-Tabary, the remains of the elevated Los Arquillos aqueduct, which must have dated back to Nasrid times, were 12 m high at their highest point.

Inside the Hoyo de la Campana goldmine it is possible to see the routes taken by feeder channels; indeed, the remains of one of them, cut off by later striping operations, have been perfectly preserved. It is a very wide trough, perhaps to prevent the water coming down from Cerro del Sol hillside (Illust. 13) from overflowing.

During work carried out in the mine during the 19th century, Alex-J. Bourdariat mentioned the discovery of a number of pre-industrial channels:

"Les grands travaux de déblaiement du cirque de l’Hoyo de la Campana, qui avait été peu à peu comblé par des éboulements, firent successivement dé-
6.2. Mine-related levelling and voids

As has already been explained, the Hoyo de la Campana site is delimited by the hushing operations carried out on the final working faces (Illust. 14). Without a doubt it is the clearest evidence that this type of man-made erosion is the result of a Roman goldmine using hydraulic extraction methods.

6.3. Sluices and evacuation of tailings

Pliny the Elder referred to the former as "aggoa" (pl. "aggoae"). They were ephemeral structures made of wood, just like the sluices that have been used for washing alluvial gold deposits since the 19th century. They comprised two side pieces and a bottom and were made from wooden planks. According to Pliny's description, they used line them with branches of heather or grass ("ulces", pl. "ulcae"), being a plant that was especially good at trapping gold particles and one that was readily available in the mining areas of the northwest. On southern hillsides grass is not so common, so in the sluices that concern us they may have used a number of xerophyils plants which are abundant in the Cerro del Sol region.

The siting of the aggoae can be deduced by the existence of concentrations of coarse gangue associated with pools, gullies or river beds. The sluices will always be downstream of these piles of coarse material, in a narrowing channel which funnels the material to be sluiced, while the end of these sluices will be identified by the existence of tailings or an evacuation gully.

Meanwhile, the channels used to evacuate tailings are often denoted by more or less deep depressions in the ground, with a profile akin to an open "U" and with smooth surfaces and a slope towards the outfall area (Illustr. 14). Inside the mine, these tailings would be directed towards the Barranco de la Campana gully, which in turn was used to extract all the waste conglomerate towards the great tailings cone of La Lancha.

6.4. Accumulation of gangue and tailings

As mentioned earlier, these accumulations would take place both inside the mine, in the case of the coarser gangue, and after the sluices in the form of tailings cones, in the case of the finer materials.

6.5. Mining settlements

We have not detected the existence of abandoned Roman settlements at levels higher than the Hoyo de la Campana. Therefore we would have to assume that some of the population nuclei settled in the valley bottoms, next to the tailings cones of possible gold workings, date back to pre-medieval times.

One of those mining settlements may have been at La Lancha. After writing about the large accumulation of tailings deposited in the area now occupied by this district of Granada, Edmond Guillemin-Tarayre said in 1889:

"La découverte de deux fours à calciner le quartz et celle de l'air de l'un atelier d'amalgamation, ainsi que la constatation de traces d'amalgane d'or dans le résidu des anciennes laveries permettent d'établir que les anciens bûchaient le quartz après l'avoir calciné et qu'ils en extrayaient l'or par l'action du mercure."

["The discovery of a calcining kiln for quartz and the site of an amalgamation mill, and the finding of traces of gold amalgam in ancient tailings, allowed us to establish that in olden times the quartz used to be crushed after being calcined before the gold was extracted using mercury amalgamation."]

Even though today it is impossible to verify just when those kilns date from, they do provide proof of the pre-industrial existence of activities related to the exploitation of gold-bearing quartz in this area.

Once mining activities started to go into decline, these settlements may have switched to agricultural production, taking advantage of their position in the bottom of a valley, with a plentiful supply of water and the benefit of the same sedimentary deposits from the mine workings that created the broad water meadows.

7. Sectorization of the Hoyo de la Campana mine

It is clear that the present day aspect of Hoyo de la Campana is the result of a great many erosive processes caused by decades of mining operations. In medieval times, activity in the area would have been basically limited to the reuse of some channels for supplying water to a number of royal properties in the Alhambra area, which would imply the abandonment of hydraulic mining on a large scale. Up until now, everything seems to point to the fact that the gold mentioned by Muslim authors would have been obtained by the more or less intensive working of alluvial placers of the Darro and Genil rivers, and perhaps also by sluicing the sands extracted from some galleries. There is also the possibility that gold-bearing quartz from ancient tailings was processed by means of smelting ovens. Meanwhile, the reworking of the mine carried out in the 1870s by the "Sociedad Anónima de los Terrenos Auríferos de España" was insignificant. After Adolphe Goupil's acquisition of this company early the following decade, efforts in the first year were directed at the refurbishment and restructuring of the Canal de Beas y Almencín, the use of which would be immediately halted for a period of five years. Four years of hard work was put into the Canal de Aguas Blancas, so during that time only gold concentration assays could be carried out. In terms of conglomerate workings in the little under five years up to 1893 when Adolphe Goupil died, this was limited to the surface sluicing by pressurized water jets of some of the old working faces and of several deposits dislodged centuries ago. Thus the amount mined was insignificant compared to the total amount mined in Roman times. In the 19th century, some galleries would have been excavated to extract assay samples and several trial shafts dug in the form of stepped trenches following the steepest path of those hillsides where mining claims had been made. The scars on the landscape of these 19th century excavations are still very visible today. Activity in the 20th century was mainly aimed at refurbishing the Canal de Aguas Blancas to help carry potable water to Granada from the Quentar reservoir.

Therefore, in respect of the various processes carried out at the Hoyo de la Campana mine (Zone I), and in order to gain a better understanding of the evolution of the mine faces worked by the Romans, we have decided to subdivide the
mine into thirty sectors (Illust. 15). To do this we have used a chronological criterion, since it was in the uppermost part of the workings where the last massive hushing operations were carried out. Only in this way is it possible to understand the logic behind the evolution of this complex archaeological mining site.

To delimit each sector we have applied affection criteria to the process of stripping the gold conglomerates. Naturally, several of these sectors may have been worked at the same time, or at least worked during the same chronological period. Similarly, only the most visible actions have been zoned, those bounded by cirques, vertical cuts, and inselberg peaks and slopes. Unquestionably many more workings were completely obliterated by the advance of the successive working faces, so we can only have a vague idea of what was actually going on.

In spite of the spectacular nature of the workings carried out at Hoyos de la Campana, the alluvial gold mine is actually only a medium size one. Its surface area is in the region of ten times smaller than the best known sector of Las Méndulas (Valdivias Cirque and adjacent areas). Consequently we can work back to its original topography with a reasonable degree of accuracy if we take a number of key data as our reference.

The tank located at the top of the Cerro del Zapatero hill (884 mad), the summit of which is now almost isolated and cut off by the western working face of the mine, must have been fed by an abrissarium which received water from a corribus which would have passed by the Collado de los Arquillos hill (909 mad). The same would have happened with the tanks and channels seen on the opposite hill, which we have called the Loma de las Terreras. From this we can deduce that the slopes dropping down from the Cerro del Sol would have linked up with the two ridges which are now isolated, and with others relating to the original courses of the Campana, Pantano or Higueru, and Almez or Terreras gullies, giving us an idea of the original topography of those natural geographical accidents.

It was decided to include the latter two gullies in the general study of Barranco de la Campana mine, calling them Zone II (Barranco del Almez or Terreras) and Zone III (Barranco de la Higueru or del Pantano). We decided to adopt this criterion because they present elements and structures that are related to the Hoyos de la Campana mine, whose workings altered and appropriated the sources of those two water courses.

8. Evolution of the working faces of the Hoyos de la Campana mine

The detailed analysis of the above mentioned sectors allows us to obtain a broad view of the sequence of the evolution of the mine workings. We have considered it appropriate to divide the mine workings into four main chronological phases (Illust. 16), although we could have broken them down further. No doubt each of these major phases could in turn be subdivided into as many sub-phases as there were working faces in the mine, some of them detectable and most obliterated by subsequent workings. To attempt to attain that degree of detail would mean dealing with many unfathomable gaps in our knowledge which would oblige us to move continually in the realm of surmise. The four phases we have identified are as follows:

8.1. 1st phase

This would have been of a similar nature to what we have encountered in other gullies with early workings, such as the nearby Barranco del Pantano or de la Higueru (Zone III).

After the construction of the water supply channel, basically following the route of the later Acequia de los Arquillos, the actions carried out in the Barranco de la Campana would have consisted basically of building two feeder channels down the sides of the Cerro del Zapatero and the Loma de las Terreras hills. These may perhaps have fed a head tank, so that water could have been discharged into the mine from these tanks through the channels, so as to carry out an initial surface sluicing of the hillsides.

Although in the Hoyos de la Campana mine there are few surviving traces of the use of the trench-channel system, it would be logical to suppose that in the early phases such systems may have been employed, but were subsequently obliterated by the major hushing operations performed later. An example of this exploitation technique seems to exist on the hillside in sector I3b, and on the right bank of the Barranco del Almez or Terreras gully (Zone II).

At the same time we assume that they would have started to excavate the first galleries for the mining systems. These galleries would have been sited at the foot of the hillsides, in the area close to the bottom of the gullies.

8.2. 2nd phase

In this phase sectors I3, I4, I5 and I6 would have been subjected to major hushing operations. Other less ambitious operations would also have been carried out in sectors I9, I10, I22, I24, I25 and I26, in the areas closest to the Barranco de la Campana. The first surface sluicing of sector I9 would also have taken place at this time. In all these workings there could have been stripping operations either by the trench-channel method or, in particular, by hushing.

For this purpose an entire system of head tanks would have been built on top of the Loma de las Terreras hill and along the Cerro del Zapatero hill. On the first hill the stagnum D3.4 has survived, while on the second one all the tanks disappeared as a result of the advance of the working faces, with the exception of D10 which is split in half.

At the same time we can suppose that some attacks were already being made on the southern slope of the Cerro del Sol, to the east of the Barranco de la Campana. The conglomerate dislodged in this latter area would have been evacuated through sector I4 and others of a similar nature in Zone II. All have large deposits of pebbles, which would indicate that they served as evacuation channels for the gold-bearing mud, while the agogae would be downstream of these accumulations of coarser gangue.

The Barranco del Almez or de las Terreras gully (Zone II) would start to take on an aspect similar to the present day, acting as a great sluice, the sides of which would have been stripped by the action of the water.

Meanwhile, the lower half of the Barranco de la Higueru or del Pantano gully (Zone III) would start to be affected. Water would have arrived from the main corribus, either via the tank located on top of the Cerro del Zapatero (D10) or via the galleries criss-crossing sectors I5 and I6.

8.3. 3rd phase

Massive hushing operations would now be used predominantly, stripping the upper and medial part of the sides of the Barranco de la Campana. The aim would have been to reach the internal levels of the two hills bounding the gully. It is possible that a number of selective trial galleries may have detected empirically a higher concentration of gold in the heart of the Cerro del Zapatero and in the Loma de las Terreras hills. In that case the aim
would have been to reach those lower, presumably richer, levels by major stripping operations.

However, in all the sectors worked in this phase there exist, or there are traces of, accumulations of coarse gangue, which leads us to suppose that the conglomerates dislodged were also sluiced to the exit of the excavation voids.

Thus sectors I₁₈, I₁₉, I₁₀, I₁₃, I₁₄, I₁₂₄, I₁₂₅ and I₁₁₆ were attacked completely or partially. Operations in other sectors, such I₁₃ to I₁₂₁, were also started up, as well as the sectors opposite them in zone I₁₂₂, an area much more disfigured by the successive operations carried out. The spectacular arch of earth which still survives where sectors I₁₁₃, I₁₄ and I₁₂₂ meet would have been made in order to allow the excavation of conglomerates dislodged in this area (Illust. 14).

On the right bank of the Barranco de la Campana the working faces advanced until they arrived at the line of the present day overhang. The water was discharged from a series of head tanks of which only one, D₁₀, has partially survived. Since the system used in the other sectors would seem to have been along the same lines, the tanks used in sectors I₁₂₃ and I₁₇ must have been deemed to have reached the end of their useful life the last time they were used. At least 3 of them appear to be recognizable along the edge of the overhang.

8.4. 4th phase

In this final phase it was decided to bring down the sides of the Cerro del Sol in the Los Aguaderos area, thereby advancing the working face to the maximum point at which the highest water channel could be used, which would have been at a maximum height of close to the 920 masl. To do this they excavated extensive systems of galleries, in such a way that the galleries formed an arc, as has been preserved in the exposed cut of sector I₂₈. Surprisingly the highest galleries are above this channel. This channel is perfectly recognizable in the cut of this sector due to its larger cross-section (Illust. 6c), which may be to do with the dry stripping described by Jean-Louis Bordes and Claude Domergue65.

If the “Central Tunnel” had existed in Roman times, it may have been excavated at this stage, to contribute to the supply of water to the gallery system built to strip the remaining conglomerates.

Thus, there were at least four major stripping operations, perhaps with the idea of dislodging the increasingly thick outer layers and reach lower, more gold-rich layers. Most of the conglomerates were deposited on the sides of these cuts, filling part of other sectors that had been worked previously.

However, the existence of some concentrations of pebbles and a number of pools among these dislodged conglomerates, as can be seen in sectors I₂₉ and I₃₁, lead us to believe that part of these conglomerates were sluiced and not considered en masse as unproductive gangue. To do this, water was discharged from the channel built into this man-made slope, which in broad terms matches the one which was reused in the 19th century to supply several gold mining claims acquired by Adolph Goupil. With the reestablishment of this channel built into the dislodged rock, water could be carried to other working faces located in the gullies to the west of Hoyo de la Campana.

In turn, this replacement of the corroquus could have enabled the working of other small areas of the mine which had become cut off from their water supply system. We do not know whether it was at this point in time or at an earlier date when sectors I₁₁ and I₁₂ were collapsed by hushing operations. The water could not have reached them by any route other than by the underground gallery (Illust. 6b), the entrance to which survives to the north of the Cerro del Zapatero. This gallery could have been reached by means of an ephemeral aqueduct to span the water course created between it and Los Aguaderos. After penetrating into the core of the hill, the water would have descended down a shaft (Illust. 6d) into a great mammaned void below, before being swept out of the larger of the outlets.

The vast system of galleries belonging to the “Zapatero Mine”–located at the base of the hill of the same name– may have been built in this last phase, although it might also have been excavated in previous or even subsequent phases. In 1894 Alex-J. Bourdariat referred to this mine, describing it as having a legendary richness due to its being in the lower part of the alluvial deposit66. On the surface we can see the existence of at least two depressions which must be related to the obstructed shafts which can be seen inside the mine. There are historical descriptions of other gallery systems in this ore deposit site, although this one is the clearest example of selective underground mining of alluvial gold deposits67 at Hoyo de la Campana.

9. Conclusions

The study of historic documentation, the interpretation of aerial photography, the reconnoitring of the area and of the surviving underground galleries, together with the understanding of some of the dynamics related to the evolution of these mining landscapes, enables us to detect and research the remains of Roman gold mining in the province of Granada.

Classical sources are very limited in terms of the development of these southern gold workings, although they do seem to suggest that they would have been in operation in republican times. Around 197 BC, Rome had already absorbed southeast Spain into its empire, from the Guadalquivir valley to the Levante coast, including the great mining area around Cartagena (Cartaghes Nova). In 154 BC Rome would extend its control to most of the mining area of the Sierra Morena and the pyrite belt of the southwest corner of the peninsula. From the first stage of the Roman conquest, the territory now occupied by the present day province of Granada would have been under Roman influence. As a result, in the occupied areas there was a period of intense mining activity during the 2nd and 1st centuries BC, which in many cases carried on into the 1st and 2nd centuries AD.

In the republican era the mining areas were considered as agri publici. The publicani or the sociates publicanorum responsible for organizing the exploitation of these mining areas did so using a system of locationes or concessions, which made regular payments to the state in the form of taxes (sestigalium) or metals (particularly gold)68. At the same time, mining afforded wealth and position to the individuals or groups who in one way or another were responsible for the exploitation of the mining resources, which in many cases gave rise to aristocracies with Roman roots, based on descendents of Italian colonials who settled in the Iberian Peninsula after the conquest.

The republican gold mines have an irregular structure compared with those of the high imperial period. The former are the result of an exploitation system divided up into locationes, whereby each concession would be the sole responsibility of the concessionaire. They would be responsible for the preparation of the ore deposit sites, the ore extraction operations, the addressing of safety or water related issues, the metallurgical processing of the mineral, and possibly its marketing69.
Even though this might square with various areas of the Cerro del Sol, where some of the workings may be more primitive and anarchical, the scale of the mine at Hoyoj de la Campana would seem to rule out such a theory. It must have been operating over a long period, and would have required considerable material and human resources, working within a well-run and well-planned organization.

Therefore it is still too early to suggest specific dates regarding the management and development of the ancient gold mines at Cerro del Sol in particular, and of the southeast of the peninsula in general, not even in respect of Posidonius’s testimony reported by Strabo. While the use of hydraulic mining techniques is a common denominator of all the mines, a detailed study of the geology of these mines and the archaeological research into them needs to be carried out at a future date. As occurred in the mining areas of the northeast, to which these southern workings bear a certain similarity, archaeology will be the key to answering most of the questions posed today. Only then will we be able to determine when the alluvial gold deposits of Granada were first mined, establish their timeframe, and know when they started to fall into decline. Some of the archaeological sites that we are finding close to areas where there are clear signs of ancient mining may provide us with more information in the future.

Endnotes

1 Estrabón. Geografía, Libro III. Translations, introductions and notes by María José Meana and Félix Piñero. Madrid: Ed. Gredos, 1992, p. 90. See also the passage referring to the gold workings of Turdetania and surrounding area (Str. III, 2, 8).


12 Gonzalo y Tamarí, J. “Reseña Física y Geológica de la Provincia de Granada”. Boletín de la Comisión del Mapa Geológico de España. 1881, vol. viii, p. 120.


15 See note 5.

16 See note 8.


18 In spite of this some would still maintain that, while the Romans must have already worked these mines, the largest scale workings must have been in the Muslim period: Mesenguell Pardo, J. “El oro y sus yacimientos en España”. Revista Minera, Metalúrgica y de Ingeniería. 1926, vol. lxxxvi, p. 322; Gavilán González, L. Historia de la mina de andaluza. Málaga, 2001, pp. 19, 22-23; Bueno Porcel, P. Granada (Geografía-Historia-Comarcas). Granada: Comunidades, Granada, 2005, p. 21.


24 See note 6.

25 See note 2.

26 See note 7.


