

# SPECIAL EXHIBITION

18 May 2019 - 12 April 2020  
**extended**



## The secrets of Puig de s'Argentera:

## The galena ore and its mining throughout time

Museu Monogràfic del Puig des Molins  
Via Romana, 31. 07800 Eivissa



**PUIG DES MOLINS**  
museu monogràfic i necròpolis púnica

## 1. INTRODUCTION: THE HISTORY OF PUIG DE S'ARGENTERA MINING

Mining around the Puig de s'Argentera (lat: argentum, silver) is mentioned in written documents for the first time in the 13th century, that is, after the Catalan conquest of 1235.

However, for the oldest phase documented archaeologically until now dating back in Phoenician era, no trace of mining activity was directly detected in the area of the mines. We have knowledge of this activity through the study and comparison of the lead isotopes of the galena nodules found during the excavation of the Phoenician settlement of Sa Caleta -located at 22 km in direct line from the mining area- and the ore samples taken in the proper mines. In any case, it remains to be seen if there could have been an even more ancient exploitation phase, which would have taken place in prehistoric times. This presumption, still to be confirmed, is based on the remains of lead that appeared in prehistoric sites that could be linked to the s'Argentera ore.

The first archaeological phase, proven by small fragments of pottery found during the excavations at the Puig de s'Argentera, dates back to the late Punic period.



*Location of the Puig de s'Argentera to the north of Santa Eulària des Riu, island of Ibiza (detail of the topographic map by the IGMN)*

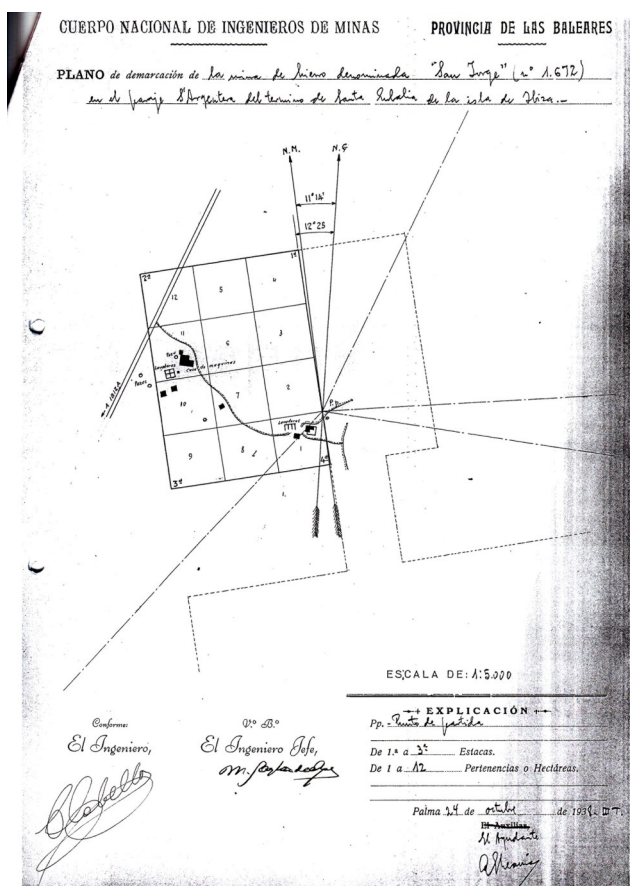


Very well documented is the mining activity in medieval Islamic times (XII century), both through numerous ceramic fragments, and through the radiocarbon analysis (C14) documenting the use of the mineral at that time. In addition, an overlapping of traces of exploitation is observed: while the previous phase presents remains of narrow, irregular galleries with smoothed edges, typical for the application of fire as a method of advancement (firesetting) which just follow the seam, the subsequent overlaid phase present broader galleries with clear signs of use of iron tools, lowering the level of rock with edges at right angles.

The most visible phase is, without a doubt, modern mining (19th and 20th centuries), known both through references in documents and for the remains of mining in the topography of the place. In total, more than 140 mining licensees of this era are known.



Share title of the company "Nueva Minera Ibicenca" of the year 1906 (Arxiu Històric d'Eivissa)



Map of the territory of the San Jorge pit of 1939 (Arxiu del Regne de Mallorca)



Widened natural cracks partly exploited at the southeast slope of Puig de s'Argentera





*Panorama of the remains of the infrastructures of the San Jorge pit*



*Diverse infrastructures of the San Jorge pit. Explosives magazine of the mines of Ibiza*



## 2. ARCHAEOMINING AND ITS TECHNIQUES APPLIED TO THE MATERIALS FROM IBIZA

### Archaeomining

Study of the mining remains using archaeological methodology. The sources of information can be archival documents, superficial and underground prospecting of the site, as well as the archaeological excavation.

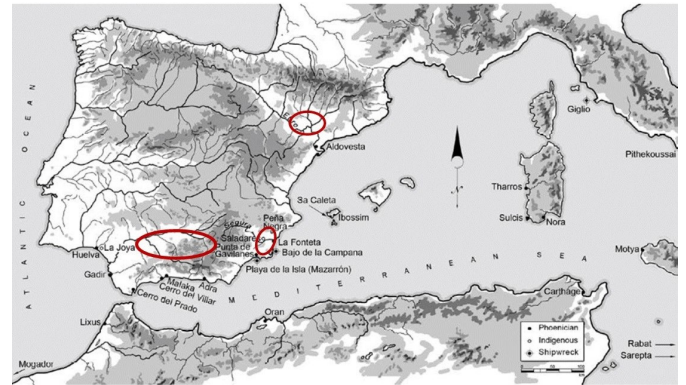
Very difficult is the dating of mining remains, such as widened crevices, cavities, shafts or galleries. They are usually framed chronologically by comparison and analogy to other studied places, by the stratigraphy of their filling or of the nearby located waste heaps as well as by the typology of the found archeological objects. Very important in this context are the analytical studies, e.g. the radiocarbon method<sup>14</sup> (C14). Usually a combination of these methods is applied.



Map of the island of Ibiza with points of mining / metallurgical interest (© DAI, Madrid)

### Archaeometry

Archaeometry is a scientific discipline that uses physical or chemical methods for archaeological studies. The aim is the dating of objects and vestiges of archaeological sites, the characterization of materials, the determination of their physical and chemical properties, the type of technology used, the origin of these materials, etc.



Map of the ore deposits of the Iberian Peninsula, which provided the metal of objects analyzed in the Archaeological Museum of Eivissa and Formentera (based on Polzer-Pinedo 2009)

### Archaeometric studies on the island of Ibiza

The most representative techniques of archaeometry for the analytical study of ore and metal on the island of Ibiza are:

Typological studies: They allow comparing different objects based on various features and shape elements.

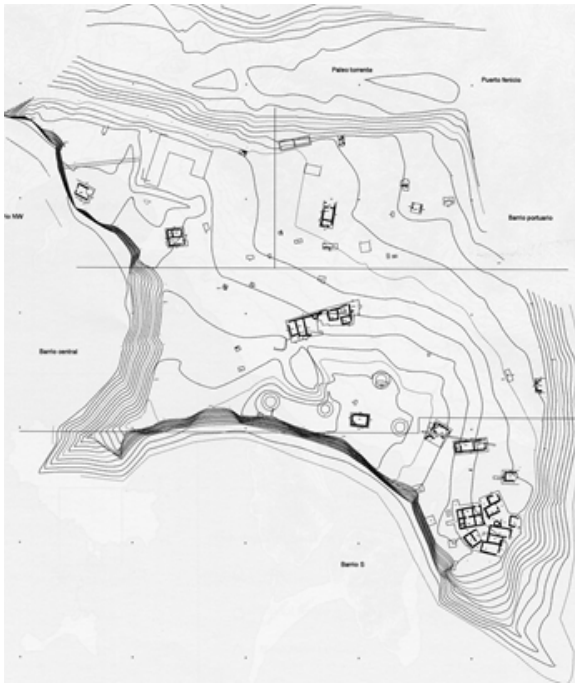
Analysis of physical and chemical composition: Quantifies the chemical elements present in each object.

Lead isotope analysis: Used to propose metalliferous ore supply areas.

The last two were applied for the designation of the argentiferous galena site of the Puig de s'Argentera and to determine the origin of the remains of the galena ore found in archaeological context (e.g. the Phoenician settlement of Sa Caleta) and of archaeological objects made of lead (collection of the Archaeological Museum of Eivissa and Formentera), some of which are shown in this exhibition.



Metallographic analysis: Facilitates knowledge of the metallic microstructure and provides relevant data about the production process.

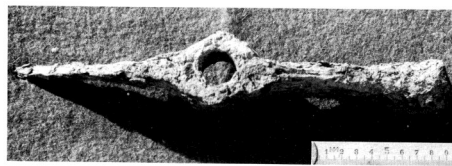
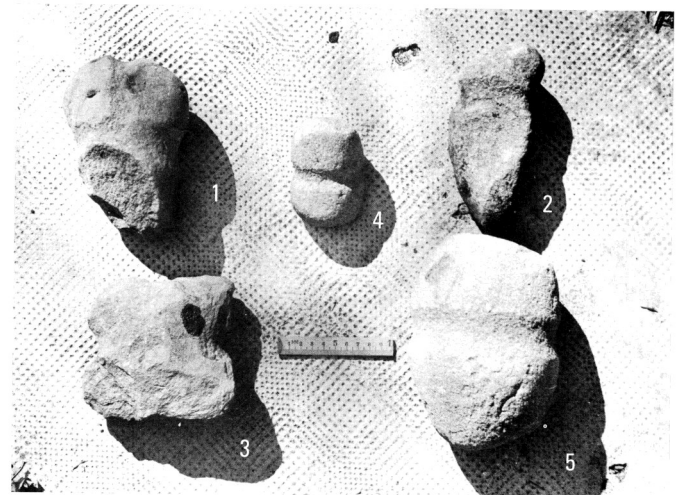
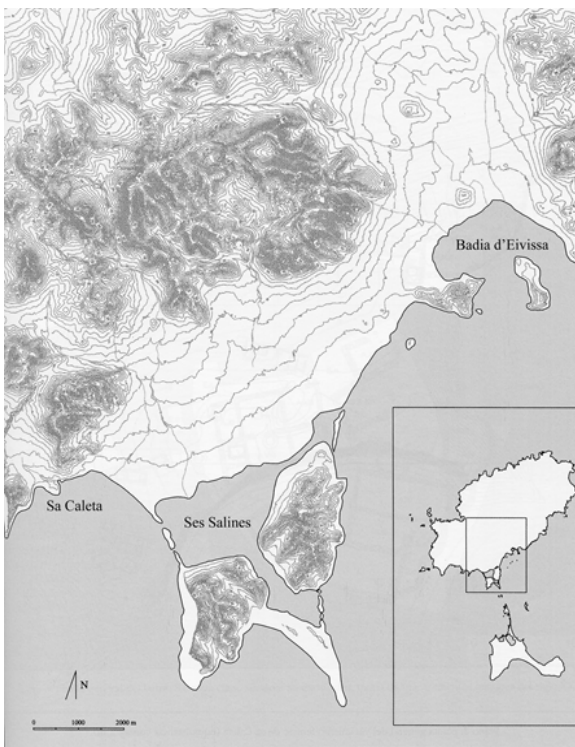


### 3. MINING AND METALLURGY: THE OPERATIONAL CHAIN

The operational chain consists in the extraction of the ore, that is to say, the exploitation of the mine itself, the preparation of the ore and the processing or extraction of the metal.

- First, the extraction of the ore: the galena (lead sulphide PbS) is obtained, either by surface mining (open air mining), or by underground mining. Advance can be made by direct mechanical removal of the rocks (maces, hammers), or by their previous weakening by the application of a direct heat source (firesetting). The hauling out of the galleries takes place by manpower - no tramway infrastructure existed in the Ibizan mining industry.

*The archaeological remains:* lithic and metal tools (maces, chisels, picks), traces of exploitation, diverse mining remains, parts of a mine.



a - Maillets à rainure (n° 1, 2, 4, 5) ou à encoches (n° 3); petit et moyen format. Formes diverses. Date: Age du Bronze. - 1: Arroyo de los Almendrijos (CO 77). - 2 et 4: El Piconcillo (CO 60). - 3: Los Pobos (CO 1). - 5: Castripicón (CO 43); b - Mine romaine (plomb-argent, cuivre) de La Loba (CO 55): pic de mineur en fer (II<sup>e</sup>-I<sup>er</sup> siècle avant J.-C.) vu de dessus et de côté. L.: 280 mm.

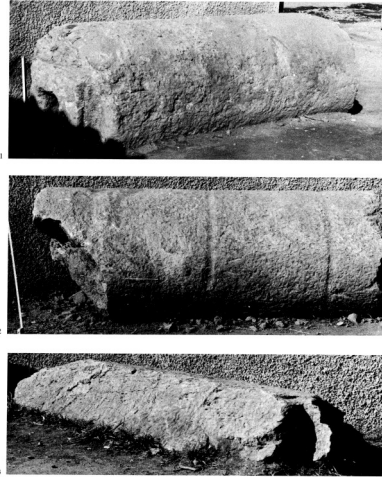
*Exploitation tools found in different mining areas on the Iberian Peninsula (Domergue 1990)*

*Location of the Phoenician settlement of Sa Caleta. Plan of the site (Ramon 2007)*



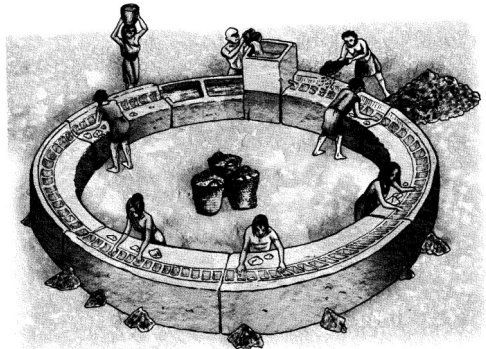
- The second step, the preparation or concentration of the ore, consists of its crushing or milling to separate the unfeasible rock material (gangue), and the reduction of mass to the ore itself. The mineral obtained this way is concentrated and enriched by means of washing in basins built for this purpose (sieves, round-buddles).

*The archaeological remains: tools (anvils, maces), querns and mills (cylinder, rotary, hammer) and mortars, in addition, also washing basins.*



Mine romaine (plomb-argent) de la Sierra de Cartagena (MU 3) - éléments d'un appareil de broyage en pierre (Carrère Emilia, La Unión) (voir fig. 46). 1 - Cylindre en calcaire, l. hors tout: 2,31 m; diam.: 0,90 m. Un remarquera, à gauche, le massif carré (50 x 51 cm), en saillie de 12,5 cm, percé d'une cavité de section carrée (17,5 cm x 17,5 cm), profonde de 0,31 m, dans laquelle était engagé un axe enroulé d'une garniture en plomb (voir planche XXXI.6). 2 - Cylindre en calcaire, du même type que le précédent, mais tronqué. L. accolée: 2,07 m; diam.: 0,805 m. À noter les trois gorges (l. 4 cm; prof.: 6,5 cm) disposées à intervalles réguliers. 3 - Bloc de calcaire paraissant avoir servi d'élément femelle à l'appareil.

*Explotation tools found in different mining areas on the Iberian Peninsula (Domergue 1990)*



*Reconstruction of an ancient circular washing excavated at Laurion (Greece) (Domergue 2008)*

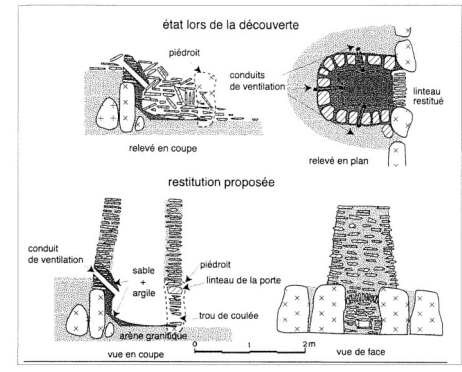


*Remains of a washing facility type "round-buddle" of modern times, located at the mining area of Puig de s'Argentera.*

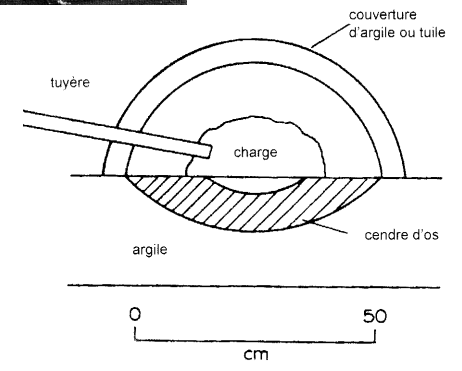
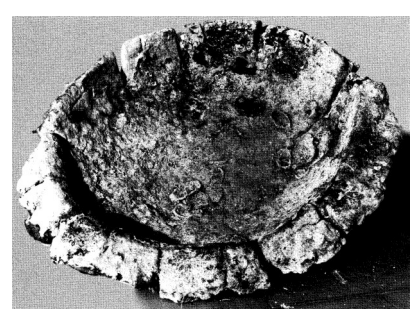
- The third step, the extraction of the metal, is carried out by means of a pyrotechnic treatment, that is, a chemical and thermal process. The ore is first introduced into a smelting or reduction furnace and then in a cupellation furnace to obtain lead and silver.

*The archaeological remains: smelting or reduction furnace, cupellation furnaces and cupels.*

Finally, the different forms of the obtained metal (Pb, PbO, Ag, that is to say: lead, litharge and silver) are molded in ingots and transferred to the foundry for their later use or commercialization.



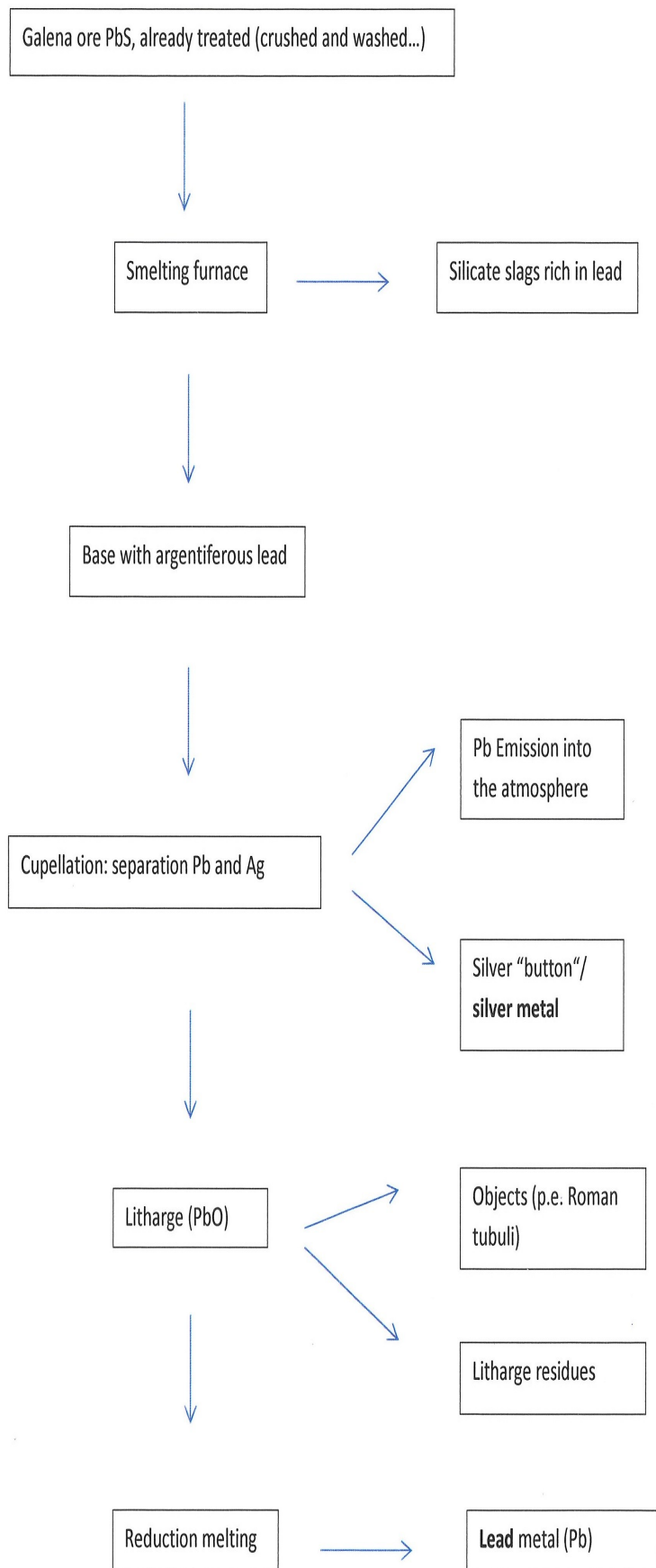
*Melting furnace. Archaeological context of Martys (France) and reconstruction. Representation of a furnace on a Roman coin (Domergue 2008)*



*Cupellation cupels. Diagram of use (Domergue 2008)*



Obtaining silver and lead: scheme of the operational chain of the treatment of galena.



#### 4. THE MINES AND THE LANDSCAPE

The mining remains are the product of the exploitation of metalliferous resources. In Ibiza we also find other mining resources besides metal: the exploitation of the salt pans (for salt) and the exploitation of quarries (for stone and gravel).

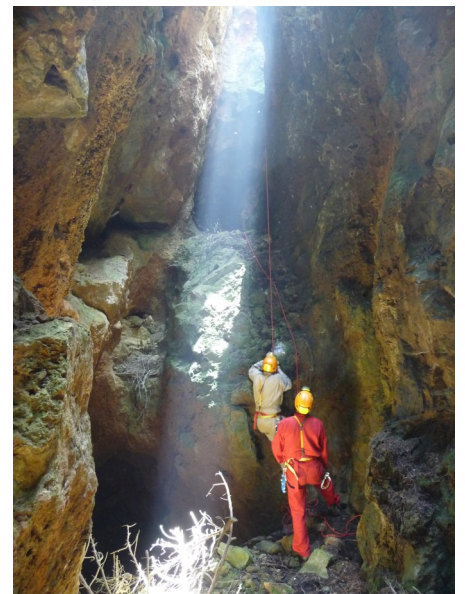
As a result of mining, different visible vestiges provide the surrounding landscape with a peculiar look. On the one hand, we have a "lunar landscape" typical of a superficial mining activity by shallow shafts. On the other hand, we find underground structures, such as shafts (vertical structures), galleries and exploitation chambers (horizontal structures). Worth mentioning are also different linear structures on the surface: crevices (natural cracks that were exploited), widenings (cracks widened artificially), and cuts (open-air mining). Finally, the many mounds of diverse nature and size found throughout all the mining area are very characteristic: the waste heaps and the slagheaps. The waste heaps can be of barren (work progress in the shaft, gallery or chamber), of crushed or washed substance, depending on the consistency of the discarded material and the processing stage of the extraction of the mineral.

Visible in the landscape are as well the remains of the buildings that were part of the infrastructure of the mining pits such as: offices, washing facilities, explosives magazine, machine rooms, water pipes and basins, etc.



Map of the area studied from 2014 to 2016 (© DAI, Madrid)





Map of the area studied from 2014 to 2016 (© DAI, Madrid)

Different views of the studied area. Remains of exploitation of different periods (© DAI, Madrid)







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G CONSELLERIA  
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I PARTICIPACIÓ  
B I ESPORTS



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