# A multiapproach for solving geoarchaeological problems: inferences from Roman gold mining in the Eria Valley (León)

*Un enfoque múltiple para resolver problemas geoarqueológicos: inferencias de la minería de oro romana en el valle del Eria (León)*

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**ABSTRACT**

*The Eria River valley exhibits one of the largest gold mining complexes in NW Iberia from Roman age. In this study, a geoarchaeological work is presented, combining a multiapproach based on airborne LiDAR remote sensing, descriptive geology and radiocarbon dating. The studied area is characterized by the presence of a mining infrastructure comprised of hydraulic canals driving the water at different levels to the mines. Mining works were associated with Plio-Quaternary raña deposits and Quaternary materials consisting of hillside and periglacial deposits, and fluvial terraces. The washing of the gold deposits used the hydraulic force to break up and drag out the sediment, giving rise to three different types of exploitation depending on the characteristics of the different materials. The results shed light on the geological materials exploited and other geographical aspects that conditioned the exploitation techniques. The work contributes to improving the knowledge about Roman gold mining and its geological context in northwest Iberia.*

**Key-words:** *geoarchaeology, roman gold mining, Eria river valley, radiocarbon dating, LiDAR.*

**RESUMEN**

*El valle del río Eria presenta uno de los mayores complejos de minería aurífera de época romana del noroeste de la península ibérica. En este trabajo se presenta un estudio geoarqueológico que combina un enfoque multidisciplinar basado en el análisis por teledetección con LiDAR aerotransportado, geología descriptiva y datación radiocarbónica. La zona estudiada presenta un entramado minero compuesto por una red de canales que dirigían el agua a distinta cota hasta las explotaciones. Los desmontes fueron realizados sobre materiales plio-cuaternarios de tipo raña y cuaternarios constituidos por depósitos de ladera, periglaciares y terrazas fluviales. El lavado de los depósitos auríferos empleó la fuerza hidráulica para deshacer y arrastrar el sedimento, dando lugar a tres tipos distintos de explotación en función de las características que presentan los diferentes depósitos. Los resultados arrojan luz sobre los materiales geológicos explotados y otros aspectos geográficos que condicionaron las técnicas de explotación de los yacimientos. El trabajo contribuye a mejorar el conocimiento sobre la minería aurífera del noroeste y su contexto geológico.*

**Palabras clave:** *geoarqueología, minería aurífera romana, valle del río Eria, datación radiocarbónica, LiDAR.*

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## Introduction

The most prolific auriferous mining sector in the Iberian Peninsula configures a bent gold belt that extends from the regions of Asturias and Galicia towards the Duero Basin (Fig.1A). This area is interspersed with a large number of mines that dates back to the Roman times (Pérez-García *et al*., 2000; Sánchez-Palencia and Currás-Refojos, 2014). Despite most of these sectors are well known since the early 70-80s decades (Lewis and Jones, 1970; Domergue, 1970; Sánchez-Palencia, 1980; Bird, 1984), there are fundamental questions concerning the geology of exploited deposits that remain unclear yet. Differentiate between natural landforms or anthropic deposits is not always obvious due to the important landscape transformation that occurred during the past 2,000 years (Fernández-Lozano *et al*., 2020). Therefore, a more detailed analysis based on the combination of different methods (geomorphological analysis, geochronology, etc.) and techniques (remote sensing from LiDAR and drone data) can shed light into the mining landscape, providing new insights over the nature of the mining deposits (*i.e.* natural or anthropic) and the location of gold occurrences to historians, archaeologist, and geologist.

This research work explores in detail a small sector of the Eria river valley (León) to describe the Roman gold mining infrastructure and the geomorphological features associated with the exploitation of secondary deposits (Fig. 1B). The implemented multidisciplinary approach relies on geomorphological mapping, stratigraphic analysis, high-resolution LiDAR-derived data (1 m Digital Terrain Models) and geochronology based on radiocarbon dating from a charcoal sample.

## Roman hydrologic infrastructure

The mining infrastructure implemented for hushing the auriferous deposits comprised a dense irrigation system of canals and tanks for water collection (Fig. 1B). In the study area, two different types of canals can be recognized according to Sánchez-Palencia (2014): i) supply canals or *corrugi* (numbered c-1, etc.), which bring water from the catchment areas (rivers or springs) or tanks that regulate the volume of water and transport it to the principal mining sectors; and ii) exploitation canals or *emissaria* (numbered e-1, etc.), which usually present variable-length showing ramifications from supply channels and tanks and directed to the exploitation fronts. Note that the canal number shown in figure 1B is solely referred to the studied sectors.

## Material and Methods

Firstly, a 1:25:000 geological and geomorphological mapping was carried out using 3D images from Junta de Castilla y León Spatial Data Infrastructure-Idecyl service (https://idecyl.jcyl.es/). Then, a detailed stratigraphic column of the most controversial deposit (Figs. 2 and 3) and the radiocarbon $^{14}C$ (tested at the BETA Analytics laboratory) analysis of a piece of charcoal collected from a tree branch fragment found in the interior of the material complemented the interpretation of natural and anthropic landforms related to the mining activity. Moreover, detailed surveying of the mining infrastructure was performed using high-resolution (1 m) LiDAR-derived images from the Spanish Geographical Institute (www.ign.es). Finally, the identification and description of different mining elements were assessed with fieldwork.

## Results and discussion

The studied area consists of secondary gold occurrences. Detailed geological mapping pointed out to three main deposits that were exploited by the Romans: i) Plio-Quaternary raña deposits consisting of orange to reddish conglomerates typical of alluvial fans; ii) Quaternary fluvial terraces of the Eria River that comprise up to 4 levels (see Fig. 1, levels T4-T1), and iii) scree deposits. The raña conglomerates were intensively exploited in the valley, but in many areas, their presence has been inferred from the exposed mining tails, locally named *murias* (see mining sectors S-2, 5, 6 and 7 in Fig. 1B). The exploitation of these deposits consisted of deep trenches and mining cuts using the hydraulic force. While the fluvial terraces are widespread identified over the valley, the landscape transformation due to agriculture and livestock conceals the mining works. However, the development of hummocky morphologies suggests the presence of gold works. Another outstanding feature is represented by abundant scree with charcoal fragments (Figs. 2A,B) that may resemble deposits originated during the mining works (deposit S-3 in

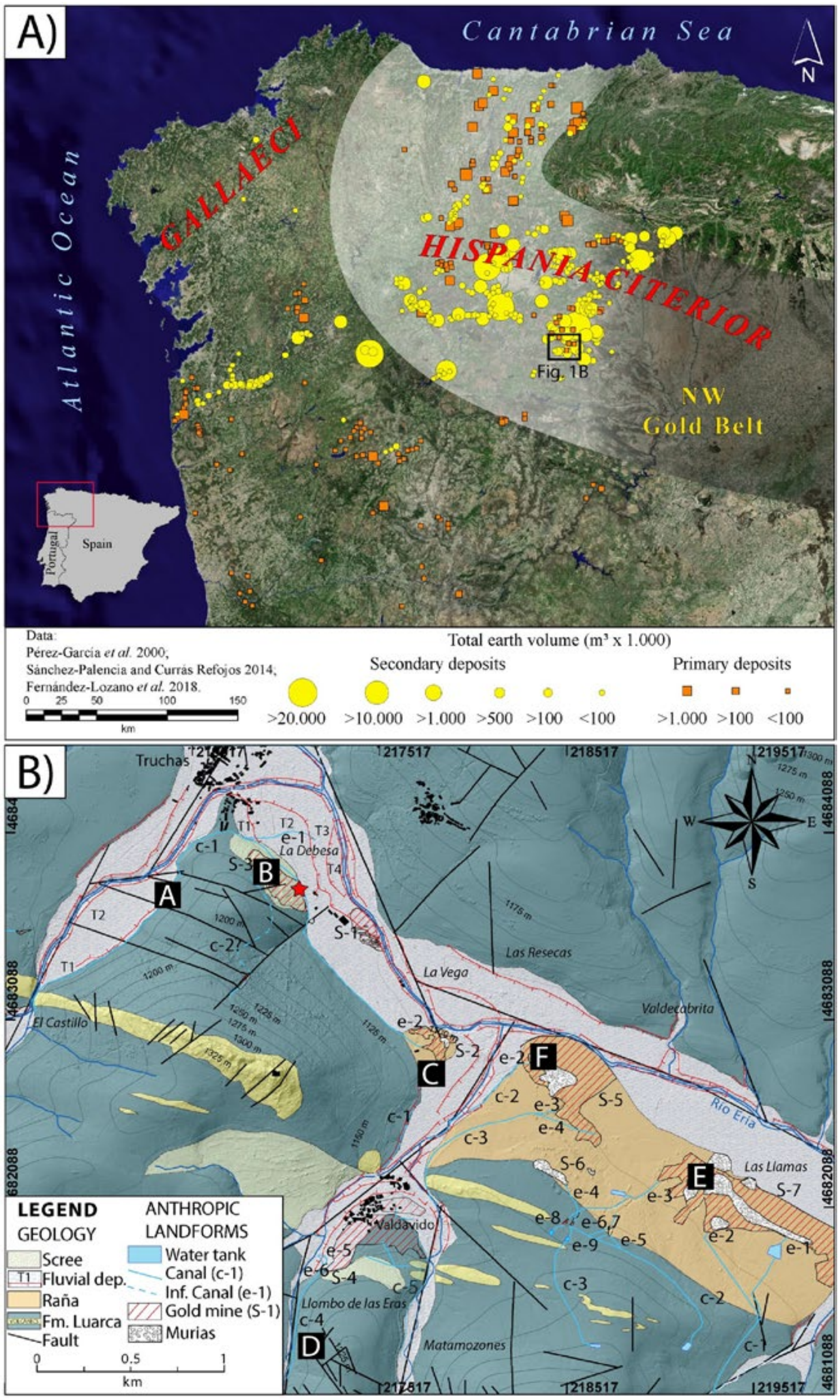


**Fig. 1.- A) Location of the principal Roman gold mining complexes across the NW Iberian Gold Belt (data compiled from Pérez-García et al., 2000, Sánchez-Palencia and Currás-Refojos, 2014; Fernández-Lozano et al., 2018). B) Geological map showing natural and anthropic landforms related to Roman gold mining activity and hydrologic system comprising canals and water tanks. Red star indicates the location of the stratigraphic section showed in figure 3. Letters indicate the location of pictures in figure 4. Ver figura en color en la web.**

*Fig. 1.- A) Mapa de localización de los principales complejos auríferos romanos a lo largo del cinturón aurífero del noroeste (datos procedentes de Pérez-García et al., 2000, Sánchez-Palencia and Currás-Refojos, 2014; Fernández-Lozano et al., 2018). B) Mapa geológico mostrando las principales formas naturales y antrópicas asociadas a la minería aurífera romana y el sistema hidráulico constituido por canales y estanques. La estrella roja indica la localización de la columna estratigráfica mostrada en la figura 3. Las letras indican la ubicación de las imágenes de la figura 4. See color figure in the web.*

Fig. 1B). To gain insights into the nature of these deposits a detailed stratigraphic section was performed as shown in figure 3. It comprises a symmetric alternance of argillaceous microconglomerates (slate fragments < 1.5 cm) and conglomerates

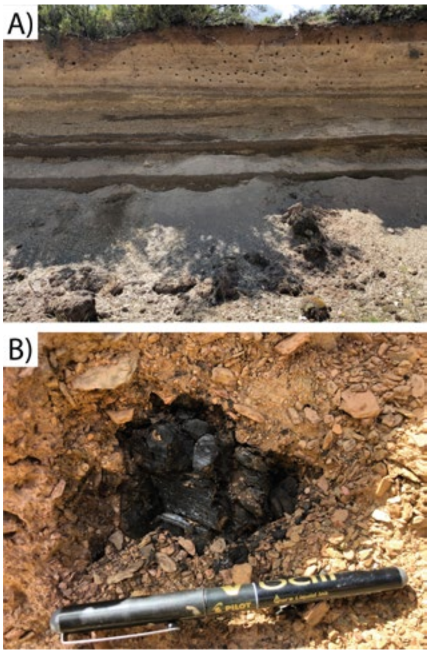


**Fig. 2.- A) Studied section. B) Coal fragment used for $^{14}C$ dating. Ver figura en color en la web.**

*Fig. 2.- A) Sección estudiada. B) Fragmento de carbón sobre el que se ha realizado la datación por $^{14}C$. See color figure in the web.*

consisting of slate and quartz fragments (1.5-4 cm). Fragments are oriented parallel to the hillslope and, in some cases, quartz cobbles appear included in the deposit, accommodating the bed lamination. The section ends up towards a brown soil layer. About 1.6 m from the top of the section, several fragments of charcoal (diameter: 6-10 cm) were found associated with fine grain levels strongly rubefacted. The $^{14}C$ dating from a charcoal fragment yielded a conventional radiocarbon age of 4660 ± 30 BP. Therefore, it implies that this type of deposits was originally natural, which obey to a *grèzes litées* periglacial deposit. However, they present trenches and grooves overprinted by the mining activity, and a lower canal cross-cuts the deposit (Fig. 4A).

Similar deposits are found in the area of Valdavido (S-4). They show a series of trenches and convergent grooves that are similar to the systems used by the Romans to benefit the gold in shallow deposits (*i.e.* typical funnel-like structures with a narrow end for washing the fine auriferous materials). Therefore, these morphologies correspond with the well-known horseshoe-shaped opencast and mining trenches (Fig. 4B).

The hydraulic infrastructure conceived by the Romans to benefit these auriferous deposits consisted of a system of canals excavated in slate or volcanoclastic rocks and leats to bring the water to the main mining sectors (Figs. 4A,C,D). Approximately they comprised a network over 3.5 km that collected water from rivers, streams and springs. The water level across these canals there must have been variable, as it has been observed to vary from a few centimetres to 0.35-0.40 m. Also, the canal width shows important variations from 0.4 m to over 1.2 m both differences must account either for the availability of water from the catchment areas and/or the strength of the excavated material (rock or soil) (Fernández-Lozano and Sanz-Ablanedo, 2021). In some cases, these canals were reinforced using nearby resources such as slate to build retaining walls (Fig. 4D).

The striking mine tailings, also known as *murias,* are widespread in the area (Fig. 4E). They consist of quartzite boulders that were set aside and accumulated during the mining works. Their size and characteristics are compatible with the observed alluvial fan reddish conglomerates of the raña. It is also important to notice the presence of prospection levels, a type of horizontal galleries carried out in the red sediments and often used to control the gold grades before the mine was abandon (Fig. 4F).

## Conclusions

Understanding the geomorphic landforms in a mining context is vital to identify the Roman activity preserved over the landscape successfully. The northwest Iberian Peninsula represents a natural laboratory for unveiling ancient mining landscapes. The identification of large volumes of material and geological formations altered for gold extraction can provide new insights into the large-scale infrastructure developed during the Roman times. The discovery of new elements of the hydraulic system and the geological characterization of auriferous materials improves the knowledge of the Roman gold mining in the Eria River valley (León) and contributes to better understand the technical and methodological mining developments implemented by the Romans in Hispania.

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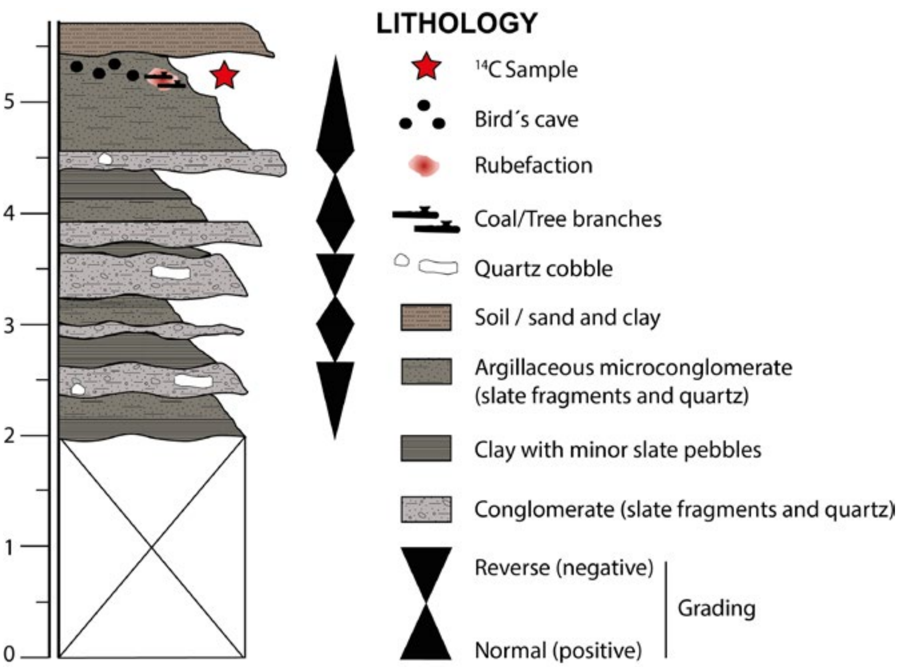


**Fig. 3.- Tentative cross-section depicting the stratigraphy of the grèzes litées-type deposit. Ver figura en color en la web.**

*Fig. 3.- Columna estratigráfica del depósito de tipo grèzes litées. See color figure in the web.*


**Fig. 4.- A) Supply canal (c-1) collecting water from the Truchillas River. B) Converging grooves used for the extraction of gold in the grèzes litées-like deposit. C) Leat (c-1) from the Valdavido sector. D) Slate tiles used for wall protection of the (c-4) canal in the Valdavido sector. E) Mine tailings (murias) in Las Llamas sector. F) Prospection levels excavated in the raña deposits covered by mine tailings (locally called San Martín Cave). Ver figura en color en la web.**

*Fig.4.- A) Canal de abastecimiento (c-1) que toma el agua del río Truchillas. B) Explotación en "surcos convergentes" para la extracción aurífera en el depósito grèzes litées. C) Canal (c-1) excavado del sector de Valdavido. D) Muro realizado con lajas de pizarra colocadas a "escote" para la protección del canal (c-4) situado en el sector de Valdavido. E) Depósito de estériles (murias) en el sector de las Llamas. F) Entrada de una galería prospectiva realizada en los depósitos de raña (localmente llamada Cueva de San Martín). See color figure in the web.*

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