

# Socioeconomic Impact of Metallic Mining in Mediterranean Europe: The Case of Andalusia

*This work analyzes the economic structure and the socioeconomic and environmental effects of metallic mining in Mediterranean Europe, with particular attention to Spain and Andalusia. Using a multidisciplinary approach, it examines the organizational characteristics of the sector, highlighting the predominance of multinational companies, the limited regional productive integration, and the strong dependence on international markets. The empirical analysis focuses on the case of the Alquife Mines (Granada), illustrating how mining activity can generate economic dependency, limited local benefits, and persistent effects after the closure of operations. It is also noted that this model is being reproduced in the development of critical minerals and rare earth elements. Finally, the study concludes that the current model is unsustainable from economic, social, and environmental perspectives. It therefore proposes the need to redirect the strategy toward regional development based on endogenous capacities, greater control over added value, and sustainability criteria, with the aim of reducing dependency and promoting balanced growth in Andalusia.*

**Keywords:** *metallic mining, extractivism, environmental impact, economic dependency, sustainable development, Andalusia.*

## Introduction and Overview

Metallic mining in Mediterranean Europe has played a crucial historical and contemporary role in the region's economic development.

Georgius Agricola is widely regarded as the “father of mineralogy” and one of the founders of modern geology. In his major work, *De Re Metallica*, he systematised knowledge of sixteenth-century mining and metallurgy based on empirical observation and the scientific methods of his time.

In *The Wealth of Nations* (1776), Adam Smith, although not addressing the topic in a monographic or specific manner, examined from an economic perspective issues such as natural resource rents, property rights, and extraction costs within the institutional framework of European legislation of his time.

John Stuart Mill, in *Principles of Political Economy* (1848), examines the rent of natural resources, as well as the causes and consequences of the depletion of numerous mines in the nineteenth century in the United Kingdom and continental Europe.

Karl Marx (Volume I) and Friedrich Engels (Volumes II and III), in *Das Kapital* (1867–1894), analyse resource extraction and capital accumulation.

The European Commission, in the *Raw Materials Initiative* (2008), produced a key document outlining the current mining strategy in Europe.

Finally, Marian Radetzki (2018) addresses energy minerals, particularly metals, reflecting upon and analysing the economic activity of mineral resources

1 in emerging economies, especially copper, iron ore, rare earth elements, and  
2 energy minerals ranging from coal and oil to uranium.

3 In general terms, these economic activities have undoubtedly generated  
4 economic development and growth in mining regions. However, it should not be  
5 overlooked that they have largely depended on foreign organisations and capital,  
6 while also causing significant environmental damage to the territory, ultimately  
7 giving rise to a form of “dirty” development.

8 Moreover, Europe and many other countries have embarked upon an energy  
9 transition, since development based on fossil fuels is, by definition, exhausted.  
10 Nevertheless, this new model presents inconsistencies, and in reality its limits  
11 are already approaching, as the production of renewable energy—assumed to be  
12 almost unlimited—relies on certain metals that are, in fact, finite.

13 A further dimension that must necessarily be incorporated here is that a  
14 considerable proportion of international and armed conflicts—such as those in  
15 Ukraine, Greenland, Venezuela, and Iran—are rooted in the search for and  
16 control over fossil fuels and rare earth elements by more developed countries.

17 This paper presents a study of the basic structure and the socio-economic  
18 effects of metallic mining, together with an outline of critical minerals and rare  
19 earth elements in Mediterranean Europe, both current and prospective,  
20 particularly in Spain and Andalusia. It analyses the organisational and economic  
21 structures of mining companies, evaluates their local and regional economic  
22 impact, and examines environmental issues, with particular attention to the  
23 pollution of inland waters and the Mediterranean Sea.

24 In sum, through a multidisciplinary approach, this paper examines industrial  
25 dynamics, socio-economic impacts, and environmental challenges associated  
26 with metal extraction in a fragile geographical and ecological context. Finally, it  
27 contrasts these analyses with the case of a currently depressed region—the  
28 Marquesado del Cenete, located in eastern Andalusia (province of Granada)—  
29 and the role played by the so-called Alquife Iron Mines.

## 31 32 **Metallic Mining in Mediterranean Europe**

33  
34 The Mediterranean region encompasses southern Europe, western Asia, and  
35 northern Africa, and surrounds the sea from which it takes its name, the  
36 Mediterranean. The countries that make up Mediterranean Europe include  
37 Albania, Andorra, Bosnia and Herzegovina, Croatia, Cyprus, Vatican City,  
38 Spain, and Greece

1 **Figure 1. Map of Mediterranean European Countries**

2  
3 Source: <https://proyectomamundi.com/mapas-del-mediterraneo/>

4  
5 **A) Historical Introduction.**

6 The earliest evidence of metallurgy in Europe originates from the Balkan  
7 Peninsula, around 4500 BC, and is considered to be of indigenous origin. In the  
8 rest of the continent, evidence appears during the second half of the fourth  
9 millennium BC; however, its widespread adoption—and the consequent  
10 abandonment of stone as the primary material for tool-making—only  
11 materialised with the advent of iron.

12  
13 **B) Territorial Distribution of Mining in Mediterranean Europe.**

14 Mediterranean Europe, comprising countries such as Spain, France, Italy,  
15 Greece, and Turkey, has a long-standing mining tradition dating back to classical  
16 antiquity. From silver extraction in Roman Hispania to modern copper and tin  
17 mining, metal extraction has been a key factor in shaping the socio-economic  
18 structure of the region.

1 **Table 1. *Metallic Mining in Mediterranean Europe***

COUNTRIES	METALS	2
SPAIN	COPPER, ZINC, LEAD, GOLD, SILVER, TUNGSTEN, TIN AND IRON.	
FRANCE	BAUXITE AND GOLD	
ITALY AND ADRIATIC	ZINC, LEAD, SILVER AND BAUXITE	
SLOVENIA	LEAD, ZINC AND MERCURY	
CROATIA	BAUXITE, LEAD AND ZINC	
BOSNIA ANDHERZEGOVINA	IRON, BAUXITE, LEAD, ZINC AND SILVER	
MONETENEGRO	BAUXITE, LEAD AND ZINC	
ALBANIA	CHROMIUM, COPPER, IRON, NICKEL, LEAD AND ZINC	
GREECE	BAUXITE, NICKEL, LEAD, ZINC, SILVER, GOLD	
CYPRUS	COOPER	
MALTA		

3 Source: Trading Economics (2026).

4  
5 The most active countries in mineral extraction are Spain, Greece, and  
6 Albania.

7  
8 **C) Structure and Economic Organisation of Mining Companies.**

9 Metallic mining in Mediterranean Europe exhibits a variety of corporate  
10 structures.

11 At the highest level are transnational corporations operating across several  
12 Mediterranean countries, organising and integrating production chains.

13 At the intermediate level are typically national companies that coordinate  
14 activities at regional and local levels, often maintaining close links with the  
15 corresponding public authorities.

16 At the lowest level are small local firms engaged in extractive and auxiliary  
17 activities, generally operating on a smaller scale and frequently under local  
18 concessions.

19 This organisational mosaic influences income distribution, access to clean  
20 technologies, and corporate social responsibility (CSR) practices. Mediterranean  
21 mining companies are integrated into international value chains, supplying raw  
22 materials to high-technology and automotive industries. While this  
23 internationalisation generates export revenues, it also exposes local economies  
24 to fluctuations in global metal prices and to environmental degradation.

25

1 **D) Economic Impact in Mining Areas.**

2 Metallic mining makes a significant contribution to employment in regions  
3 where mining operations are located and fosters the development of related  
4 sectors such as transport, services, and construction. However, local wages tend  
5 to be relatively low, while profits largely flow to other locations.

6 These economic activities are characterised by high levels of dependency  
7 and vulnerability from the perspective of mining regions. Indeed, they depend  
8 heavily on technological change, resource depletion, environmental regulation,  
9 social conflict, and, ultimately, international mineral prices.

10

11 **E) Environmental Impacts.**

12 Unlike earlier periods, when developmentalism and job creation  
13 mitigated—or at least muted—social opposition, metallic mining today faces a  
14 clear tension between meeting the growing demand for mineral resources in the  
15 global economy and the need to reduce environmental and social impacts.

16 Particularly contentious issues include the pollution of inland waters and,  
17 given that many river systems flow into the Mediterranean, marine  
18 contamination.

19

20 **F) Challenges and Future Perspectives.**

21 The transition towards sustainable mining in Mediterranean Europe  
22 inevitably requires the adoption of cleaner processes and technologies, as well  
23 as the circular management of waste.

24 From the perspective of legitimacy—and ultimately social viability—it is  
25 essential to incorporate governance criteria and community participation through  
26 the effective inclusion of local communities in decision-making processes.

27 In summary, metallic mining in Mediterranean Europe is an activity with  
28 deep historical roots and significant economic presence. Its organisational  
29 structure is diverse and generates important socio-economic benefits in rural  
30 regions. However, environmental challenges—particularly the pollution of  
31 inland waters and the Mediterranean Sea—require integrated management  
32 approaches and effective public policies. Achieving a balance between economic  
33 development and environmental protection is critical to ensuring the long-term  
34 sustainability of metallic mining in the Mediterranean region.

35

36

37 **Metallic Mining in Spain**

38

39 Spain is one of the European countries with the longest historical tradition  
40 and one of the most significant levels of current economic activity in the metallic  
41 minerals sector.

42

43 **A) General Characteristics of Metallic Mining in Spain.**

44 The main characteristics of metallic mining in Spain are as follows:

45 The production of metallic mining in Spain (in thousand tonnes) is detailed  
46 in Table 2.

1 **Table 2. Mining Production in Spain by Product**

MINERAL	YEARS (thousands of tons)						
	2017	2018	2019	2020	2021	2022	2023
INDUSTRIAL MINERALS	705	821	779	665	819	1179	906
ORNAMENTAL ROCKS	378	369	360	333	379	442	452
ENERGY PRODUCTS	119	89	40	27	6	0,9	0,6
QUARRY PRODUCTS	863	924	970	986	1055	1149	1226
METALLIC MINERALS	1167	1218	1181	1064	1204	1155	975
	3232	3421	3330	3075	3463	3925,9	3559,6

2  
3 Source: Ministry for the Ecological Transition and the Demographic Challenge (2025)

4  
5 Mining production in 2023 amounted to €3.56 billion. Although a moderate  
6 upward trend can be observed over the last seven years, a decline of 9.3% is  
7 recorded in the final year of the period under review.

8 Similarly, metallic minerals experienced moderate growth over previous  
9 years, increasing from 1,167 thousand tonnes in 2017 to 1,204 thousand tonnes  
10 in 2021, followed by a decline in subsequent years, particularly in the final year,  
11 when production fell by 19% compared to 2021 levels.

12 **Table 3. Mining Production in Spain by Autonomous Communities**

NUMBER OF FARMS	ENERGY PRODUCTS	METALLIC MINERALS	INDUSTRIAL MINERALS	ORNAMENTAL ROCKS	QUARRY PRODUCTS	TOTAL
ANDALUCIA	1	5	33	68	371	478
ARAGON			21	43	139	203
ASTURIAS		1	8		34	43
BALEARES			3	21	44	68
CANARIAS			3		55	58
CANTABRIA			3	2	23	28
CASTILLA-LEON		1	22	77	298	398
CASTILLA-LAMANCHA			27	7	238	272
CATALUÑA			4	40	314	358
CEUTA					1	1
EXTREMADURA			2	24	63	89
GALICIA		1	16	94	103	214
RIOJA	1				39	40
MADRID			3	8	34	45
MURCIA			5	29	48	82
NAVARRA			3	2	36	41
PAIS VASCO			2	6	34	42
VALENCIA			17	22	105	144
TOTAL	2	8	172	443	1979	2604

14 Source: Ministry for the Ecological Transition and the Demographic Challenge (2025).  
15

1 The distribution of mining activity across Spain's autonomous communities  
 2 is highly uneven. Andalusia accounts for 34% of total production value and,  
 3 together with Catalonia and Castile and León, represents nearly 60% of national  
 4 mining output.

### 6 **B) Ownership Structure of Metallic Mining Companies in Spain.**

7 As noted in the European context, metallic mining in Spain follows a  
 8 pyramidal structure in which production and capital are highly concentrated in a  
 9 small number of multinational corporations. National companies occupy an  
 10 intermediate position, while at the lowest level are local firms engaged in  
 11 extractive and auxiliary activities.

#### 13 **Figure 2. Pyramidal Ownership Structure of Metallic Mining Companies in Spain**

##### 14 MULTINATIONAL CORPORATIONS

- 15 - Foreign capital / Listed on stock exchange



##### 17 NATIONAL COMPANIES

- 18 - Predominantly Spanish capital
- 19 - Occasional exploration and exploitation



##### 21 LOCAL SMEs AND AUXILIARY COMPANIES

- 22 - Mineral extraction
- 23 - Technical services
- 24 - Transport and drilling

25 Source: Author's elaboration.

### 27 **C) Main Sources of Pollution from Metallic Mining in Spain.**

28 Pollution generated by metallic mining companies in Spain represents a  
 29 major environmental problem, both historically and in the present. Despite the  
 30 modernisation of the sector and the incorporation of certain environmental  
 31 considerations into extractive activities, the reopening of previously "exhausted"  
 32 mines, together with increased social awareness, highlights the unsustainability  
 33 of the current model and brings previously latent environmental conflicts to the  
 34 forefront.

### 36 **D) Rare Earth Elements and Critical Minerals and Metals in Spain.**

37 The potential for rare earth deposits in the subsoil of the Iberian Peninsula  
 38 appears to be considerable. However, only a limited number of deposits have  
 39 been exploited to date, mainly due to unresolved environmental concerns  
 40 associated with their extraction.

41 Initial developments include lithium deposits in Extremadura (Cáceres and  
 42 Badajoz), rare earth elements in Castile-La Mancha (Ciudad Real), and tungsten  
 43 and tin in Galicia and Salamanca. However, the full expansion of these  
 44 activities—and the opening of new mines—faces strong social opposition and  
 45 strict environmental regulation.

1 In the case of rare earth elements and critical minerals, environmental  
 2 impacts are particularly significant because these resources are not typically  
 3 concentrated in veins but are dispersed and mixed within the Earth's crust. As a  
 4 result, their extraction requires the removal of large volumes of material and the  
 5 use of chemical processes. This is one of the main reasons why social opposition  
 6 is well founded and often particularly strong.

7 Spain has not historically had active rare earth mines; however, ongoing  
 8 research, pilot projects, and initial operations are substantially reshaping the  
 9 outlook for the coming years.

10 In the province of Granada, critical minerals such as fluorite and strontium  
 11 are already being extracted, and Spain is currently the world's leading producer  
 12 of strontium.

13 More recently, on 10 March, the Spanish government approved the First  
 14 Action Plan for the Sustainable Management of Mineral Raw Materials (2026–  
 15 2030), with an investment of €414 million. The plan includes 34  
 16 interdepartmental measures aimed at increasing Spain's strategic autonomy by  
 17 strengthening the supply of critical raw materials for the ecological transition, as  
 18 well as promoting the recovery of materials from electronic waste.

19 Nevertheless, the scientific challenge that emerges at this stage opens a  
 20 further intellectual dimension that warrants exploration. Among other issues, it  
 21 raises fundamental questions: is this process driven by demand or supply? What  
 22 is the purpose and rationale behind the intensive and urgent exploitation of rare  
 23 earth elements and critical minerals? Who makes these decisions, and who  
 24 benefits from them? Are there widespread social demands urging governments  
 25 to significantly increase investment in the exploration of rare earths, considered  
 26 essential for the technological industry?

## 27 28 29 **Metallic Mining in Andalusia**

30  
31 The main characteristics of metallic mining in Andalusia are summarised  
 32 below.

### 33 34 **A) History of Mining in Andalusia**

35 The evolution of metallic mining in Andalusia has been long and decisive  
 36 for its economic and social history, as the region contains some of the oldest and  
 37 richest mineral deposits in Europe.

38 The origins of civilisation in Andalusia are closely linked to its mineral  
 39 wealth and its exploitation and trade by eastern Mediterranean cultures. In this  
 40 context, the civilisations of Los Millares (3200–1200 BC) and Tartessos (1200–  
 41 500 BC) became major centres of attraction for Mediterranean peoples.

### 42 43 **B) Metallic Mining in Andalusia: General Characteristics.**

44 Andalusia is the leading producer of mineral resources in Spain, accounting  
 45 for approximately 40% of national output. Metallic extraction is particularly

1 significant, representing around 90% of Spain’s total production of metallic  
2 minerals. These include pyrite, copper, zinc, lead, iron ore, gold, and silver.

3  
4 Andalusia has consolidated its position in 2026 as the undisputed engine of  
5 metallic mining in Spain, concentrating 90% of national metal production and  
6 becoming a strategic region for the industrial autonomy of the European Union.

7  
8 **-Current production.**

9 The region is currently experiencing an unprecedented expansion phase  
10 since the late twentieth century, driven by high raw material prices and the  
11 energy transition.

12 Andalusia is the second-largest copper producer in the European Union and  
13 the world’s leading producer of strontium.

14 In 2024, companies in the sector generated a gross value added (GVA) of  
15 nearly €1.1 billion. Total sector turnover has recently reached €4.5 billion, with  
16 annual growth exceeding 12%.

17 The European Commission has included Andalusian projects in its list of  
18 “Strategic Projects” to secure the supply of critical minerals (such as copper,  
19 zinc, and cobalt) required for green technologies.

20 At the same time, there is growing social pressure and increasing evidence  
21 calling for moratoria in the Iberian Pyrite Belt in order to prevent a potential  
22 “hydrological collapse” and to protect water quality in agricultural areas and  
23 natural parks.

24 In 2026, metallic mining in Andalusia is at historic highs, consolidating the  
25 region as a key supplier of critical raw materials for the European Union.

26  
27 **-Main metallic mining companies in Andalusia.**

28 There are six main metallic mining operations in Andalusia at different  
29 stages of activity. Five are located in western Andalusia (Agua Teñidas,  
30 Magdalena, and Sotiel in Almonaster la Real, as well as the Rio Tinto Mines in  
31 the municipality of the same name in Huelva, and Las Cruces Copper Mine in  
32 Gerena, Guillena, Salteras and La Algaba in Seville). One is located in eastern  
33 Andalusia: the Alquife mine in Granada.

34

1 **Table 4. Metallic Mining Companies in Andalusia**

DENOMINATION	COMPANY	VINCULACION	LOCATION	MINERAL	TRANSFORMATIO	EMPLOYEES
Minas Las Cruces	Cobre Las Cruces S. A (100%)	First Quantum Minerales Ltd.	Gerena, Salteras y Guillena (Sevilla)	Cooper	láminas de cobre	176
Minas de Rio Tinto	Atalaya Riotinto Mine	Atalaya Mining	Minas del Rio Tinto	Cooper	Floatation	472
Aguas Teñidas	MATSA. Aguas teñidas	Sandfire MATSA	Valdelamusa y Almonaster La Real (Huelva),	sulfides		726
Mina Sotiel	MATSA. Sotiel	Sandfire MATSA	Calañas	Zinc, lead and silver		
Mina Magdalena	MATSA- Magdalena	Sandfire MATSA	Almonaster la Real	Copper, zinc plating, and others		
Minas de Alquife	Minas de Alquife , S.L	Alquife Holding	Alquife	Iron		
TOTAL						1198

2 Source: AMINER (2026) and author's elaboration.  
3  
4

#### 5 -Employment.

6 One of the most controversial and methodologically weak aspects in  
7 industry reporting is the estimation of employment linked to mining projects.

8 Alongside direct employment figures, companies often include estimates of  
9 indirect or induced employment, which are typically multiplied by factors of five  
10 or even ten, referring to jobs supposedly created in related sectors.

11 However, these estimates lack empirical rigour and are essentially advocacy  
12 claims designed to magnify the perceived benefits of mining projects and offset  
13 associated negative externalities, particularly environmental impacts.

14 According to official Social Security records, direct employment in the three  
15 main operating companies in 2022 amounted to 7,198 registered workers.

16 In contrast, the Spanish Association of Metallic Mining (AMINER) reports  
17 12,000 direct jobs and 32,000 indirect and induced jobs in 2023. This  
18 discrepancy—exceeding 80% relative to direct employment—highlights the  
19 absence of a transparent and consistent methodology, making reconciliation of  
20 these figures difficult.

21 Most mining jobs (up to 96%) are full-time and relatively well paid, with  
22 average wages above the regional industrial average, indicating comparatively  
23 high job quality within the sector.

24 Growing demand for copper, zinc, lead, and other critical metals—driven  
25 by electrification, renewable energy, and electric vehicles—reinforces the long-  
26 term economic viability of Andalusian mining and its labour requirements.

27  
28

1 **-Sales and exports.**

2 According to AMINER, total sales in 2022 reached €4 billion, of which  
3 approximately €2 billion corresponded to exports. This positions Andalusia as a  
4 major mining hub in Europe.

5 However, independent commercial reports suggest that both sales and  
6 export figures are significantly lower, approximately half of those reported by  
7 industry sources.

8

9 **-Multinational ownership.**

10 All metallic mines in western Andalusia are owned by foreign entities or  
11 multinational corporations, often controlled by larger investment funds with  
12 global holdings.

13 This has several important implications:

14 It is difficult to determine the effective decision-making centres governing  
15 Andalusian mining operations.

16 All currently active mines are owned or controlled by foreign companies,  
17 either directly or through Spanish-registered subsidiaries.

18 Corporate decision-making and strategic interests are largely disconnected  
19 from regional development objectives in Andalusia.

20 A substantial share of profits and value added generated by these operations  
21 is transferred abroad.

22 Environmental damage is not fully internalised by companies, particularly  
23 after mine closure, when impacts on ecosystems, local economies, and public  
24 health can be severe and long-lasting.

25 Several major multinational companies operate in Andalusia, including:

26 Atalaya Mining

27 Sandfire MATSA

28 First Quantum Minerals (Las Cruces, Canada)

29 Freeport-McMoRan (Atlantic Copper, USA)

30 Tharsis Mining (international joint ventures)

31

32 **-Subcontracting.**

33 These companies rely heavily on subcontracting for a substantial share of  
34 operational activities. Subcontractors are often not guaranteed employment  
35 continuity once contracts end.

36 Labour conditions and payment guarantees are typically less secure than  
37 those of core company employees, and cases of wage arrears have been reported.

38 Subcontracted activities typically include:

39 Operations and maintenance

40 Construction works

41 Auxiliary installations

42 Logistics and material transport

43

44 From a critical perspective, these practices have been described by  
45 environmental groups and local communities as part of broader strategies aimed  
46 at securing a “social licence to operate”, although no evidence of unlawful

1 financing has been established. Nonetheless, ethical concerns regarding  
2 transparency and accountability remain debated in mining-affected areas.

#### 3 4 **-Foundations.**

5 Foundations are non-profit organisations that, by design, allocate assets to  
6 activities of general interest. Their funding sources are diverse, including initial  
7 endowments, public subsidies, and private donations.

8 Due to limited oversight in some cases, concerns have been raised regarding  
9 transparency and the potential use of foundations for indirect political financing  
10 or preferential allocation of public contracts, although such claims vary in  
11 evidential support.

12 In the mining context, these foundations act as intermediaries between  
13 companies, public institutions, and society. They do not engage in extraction  
14 activities but promote cultural, educational, and sustainability-related initiatives  
15 linked to mining.

16 Examples include:

17 Río Tinto Foundation for the History of Mining and Metallurgy

18 Mining and Life Foundation

19 From a critical standpoint, some observers argue that large corporations and  
20 financial institutions may use foundations to improve their public image and  
21 mitigate social concerns related to their core activities.

#### 22 23 **-Mineral processing and value added.**

24 The majority of minerals extracted in Andalusia are exported without further  
25 processing. Only Las Cruces Copper Mine has significant local transformation  
26 capacity, where ore is processed into copper sheets in a hydrometallurgical plant.

27 As a result, most of the value added generated by metallic mining does not  
28 remain in Andalusia but is transferred abroad.

#### 29 30 **-Business model**

31 The prevailing business model consists of operating companies registered  
32 in Spain that hold little or no substantial capital, as they are fully controlled by  
33 foreign parent companies within multinational groups, including global  
34 investment funds.

35 Strategic decisions are made outside Spain, while profits and value added  
36 are largely repatriated abroad. In this context, accountability for environmental  
37 and social impacts is difficult to enforce.

38 This structure is reinforced by extensive subcontracting, which further  
39 complicates labour protection and corporate responsibility mechanisms.

#### 40 41 **C) Copper prices and economic viability.**

42 The international price of copper, currently around 12,000 US dollars per  
43 tonne after a strong increase over the past 15 years, is highly volatile. It is  
44 influenced by global supply and demand conditions, speculative movements,  
45 geopolitical events (such as the war in Ukraine), and cyclical shocks such as the  
46 COVID-19 pandemic.

1 More recently, expectations linked to the “green transition”—including  
2 electric mobility, decarbonisation policies, and industrial electrification—have  
3 also exerted upward pressure on demand.

4 However, market prices do not incorporate environmental externalities  
5 associated with extraction and processing, such as water consumption,  
6 contamination of aquifers, damage to fisheries, agriculture, and ecosystems.

7 Consequently, part of the social costs of copper production is effectively  
8 borne by society at large, constituting an implicit subsidy to multinational  
9 mining companies.

10 Additional factors affecting viability include global commodity markets,  
11 geopolitics and tariffs, exchange rates, energy costs, and environmental  
12 regulation.

#### 13 14 **D) Environmental impact of metallic mining in Andalusia.**

15 By definition, metallic mining is an unsustainable economic activity insofar  
16 as it involves the extraction of non-renewable resources. Moreover, during  
17 operations—and particularly after closure—environmental and social  
18 degradation may reach severe levels and persist for decades or even centuries.

19 Enforcement of environmental liability is often limited, especially when  
20 corporate structures are financially insulated through subsidiary companies with  
21 limited assets.

#### 22 23 **E) Public intervention and corruption risks.**

24 High unemployment levels and relatively weak political awareness in some  
25 mining areas may lead local authorities to focus primarily on perceived benefits,  
26 particularly employment creation and municipal tax revenues.

27 This may reduce scrutiny of long-term environmental costs and structural  
28 economic dependencies.

#### 29 30 **F) Summary.**

31 The main characteristics of its economic organization have been described,  
32 from the companies that directly exploit the mineral deposits and their registered  
33 office, corporate links, employees, turnover, influence on the local economy, use  
34 of foundations for the development of part of their activities, added value,  
35 environmental impact, dependence on foreign prices...and in short and at a more  
36 general level, the Andalusian mining economic model is outlined, concluding in  
37 its most defining aspects, namely, extractivism, dependence and marginalization  
38 and unsustainability.

39 The organization of metallic mining in Western Andalusia is such that it  
40 lacks any subsequent processing or transformation of the extracted minerals.  
41 These are exported abroad almost immediately, leaving little added value in  
42 Andalusia and, on the contrary, causing serious environmental problems.  
43 Furthermore, the ownership and management of the companies carrying out the  
44 extraction activities belong to multinational corporations based abroad, where  
45 the profits are channeled. This structured mining activity generates significant

1 negative local externalities, and the authorities have failed to establish the  
2 necessary mechanisms for companies to internalize the resulting social costs.

3 In short, we are witnessing mining extractivism in Andalusia in its most  
4 damaging form for this community.

5 In the current economic and institutional context, where we are witnessing  
6 a growing reduction in our decision-making capacity, the basic strategy for the  
7 sustainable regional development of Andalusia within a globalized environment  
8 must be based on its endogenous potential. A competitive economy and a high  
9 quality of life for its citizens will allow it to address the globalization of this  
10 now-revalued basic strategy and, where necessary, minimize any potential  
11 negative effects of globalization.

12 it is an intermediate but not sufficient objective to increase the added value  
13 generated by Andalusian metal mining, but also to ensure that this value remains  
14 in Andalusia, self-sustaining the internal economic circuit, increasing control  
15 over it and, among other goals, distributing it territorially in a balanced and  
16 sustainable manner.

### 17 18 19 **Metallic Mining in South-Eastern Spain: The Alquife Mines**

20  
21 The south-eastern Iberian Peninsula (Almería, Granada, and surrounding  
22 areas) has traditionally been a region of extraction of lead, iron, and other  
23 minerals since the nineteenth century.

24 A historic iron deposit located in the Marquesado del Zenete, the Alquife  
25 iron mines, has constituted a significant part of Granada's industrial landscape,  
26 and their relevance lies both in their long extractive history and in their potential  
27 for recent local industrial development.

28  
29 **Figure 3.** *Open pit of the Alquife Mines*



30  
31 Source: Author's own elaboration (2025)

1 **A) Historical Introduction and Development of the Alquife Mines.**

2 At their peak, particularly between the 1950s and 1960s, the mines  
3 employed between 3,500 and 4,000 direct workers.

4 The operating company built the mining settlement of Los Pozos between  
5 the 1950s and 1970s, marking the first time that a stable and hierarchically  
6 structured mining workforce was established in close proximity to the site.

7 The area became a dynamic economic zone, and the closure of a mine that  
8 once provided more than 4,000 jobs led to a population decline of over 70% in  
9 affected villages, with significant emigration towards Central Europe, Catalonia,  
10 and the Basque Country.

11 This depopulation was accompanied not only by severe demographic  
12 decline but also by soil contamination and cases of occupational disease and  
13 premature mortality among miners.

14  
15 **Figure 4.** *Scrap material abandoned after mine closure*



16  
17 Source: ACER Granatense (2014)

18  
19 In summary, the definitive closure of the Alquife mines in 1996 was not  
20 caused by physical depletion of the ore body but mainly by economic and  
21 international market conditions external to the operation, including:

- 22 A fall in international iron prices
- 23 International competition
- 24 High production costs
- 25 Financial difficulties of the operating company

1 Dependence on external markets  
2 Indeed, decades later the project was considered economically viable again,  
3 and mining operations were reactivated in 2020 under new ownership.  
4

5 **B) The Alquife Mines and the Public Interest**

6 The project obtained environmental authorisation in 2020 from the Regional  
7 Government of Andalusia (Junta de Andalucía), including favourable  
8 environmental impact and restoration reports.  
9

10 **C) Environmental Impacts of the Alquife Mines**

11 Following the definitive closure of operations in the 1990s, the open pit  
12 gradually filled naturally with water through groundwater inflows and  
13 precipitation.

14 The reopening project requires, among other measures:

15 Draining the flooded open pit (initially 130 hm<sup>3</sup>, followed by approximately  
16 15 hm<sup>3</sup> annually), using floating pumps and drainage wells.

17 Implementation of a perimeter dewatering well system to ensure slope  
18 stability during operation, as well as pit-bottom wells for mineral extraction.

19 Management of water generated during dewatering and operational phases  
20 (non-consumptive use).

21 To undertake in advanced stages of the operation a new diversion of the  
22 Lanteira Ravine, to allow the exploitation of existing resources in the western  
23 sector and to carry out a necessary control of drainage and infiltration waters,  
24 guaranteeing the stability of slopes and mining safety.

25 Although extensive literature documents the environmental impacts of iron  
26 mining, these effects are widely known both scientifically and empirically across  
27 multiple sites.

28 Without attempting an exhaustive list, typical impacts include:

29 Noise and vibration from blasting and machinery

30 Desertification: deforestation, erosion, and loss of fertile soil

31 Landscape alteration and visual impact

32 Slope instability due to excavation and overburden loads

33 Changes in groundwater levels and recharge regimes

34 Dust and solid waste deposition

35 Heavy metal contamination

36 Hydrocarbon pollution from liquid and solid effluents

37 Acidification due to sulphide oxidation and acid mine drainage

38 Alteration of river morphology

39 Increased sediment load and downstream deposition

40 Toxicity of water due to heavy metals such as iron  
41

42 Undoubtedly, these impacts are distorted or hidden among the most directly  
43 affected inhabitants, as the propaganda of the promoters and public authorities finds  
44 fertile ground among many local people who suffer from a high and chronic level  
45 of unemployment and, of course, have legitimate aspirations to overcome it.

1 But, in reality, the environmental impact of the economic activity of the  
 2 Alquife mines is of such magnitude that even the City Council of the Almerian  
 3 municipality of Carboneras, through whose port the company planned to ship  
 4 the iron ore, taking into account the concerns and aspirations of its inhabitants,  
 5 has decidedly refused to do so.

6 At its plenary session on 12 June 2020, the municipality submitted  
 7 objections and appeals against the environmental authorisation and associated  
 8 transport operations, which had previously been considered through the ports of  
 9 Motril and Almería.

10 Furthermore, in the Andalusian Parliament, MP Noemí Cruz (PSOE)  
 11 questioned the project, highlighting its environmental and social risks and its  
 12 potential impact on local employment expectations.

13 More recently, reports indicate that some shipments have taken place via the  
 14 Port of Málaga to destinations such as Croatia, which would increase transport  
 15 distances and associated environmental impacts.

#### 17 **D) Economic Organisation of the Alquife Mines.**

18 The composition of the current board of directors is shown in Figure 5.

19  
 20 **Figure 5. Company Board of Directors**

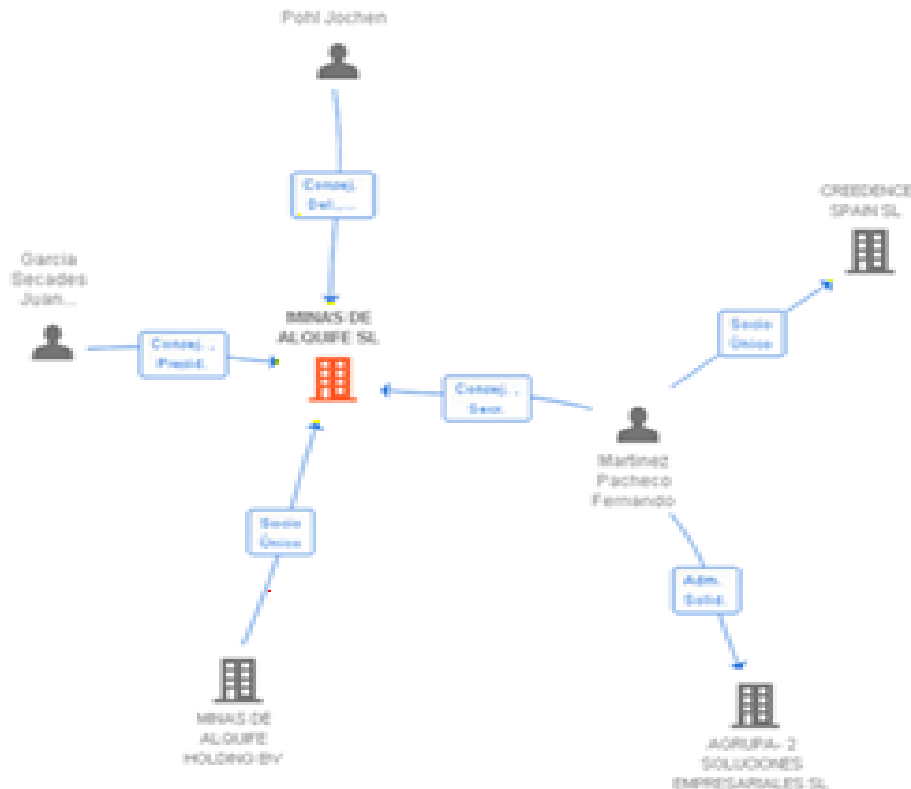


21  
 22 Source: Own elaboration.

23  
 24 The operating company, Minas de Alquife S.L.U., was established in 1998  
 25 and is wholly owned by Minas de Alquife S.L., whose stated objective is the  
 26 resumption of open-pit iron mining in Alquife (Granada, Spain).

27 The registered office was initially located in Alquife (Barrio Minas del  
 28 Marquesado) but was relocated in 2020 to Madrid (C/ Marqués de Riscal 11, 5th  
 29 floor).

30 The sole shareholder is Minas de Alquife Holding.

1 **Figure 6.** *Ownership structure of Minas de Alquife S.L.*

2  
3 Source: Author's own elaboration

4  
5 Behind a complex network of companies, EPPENDORF HOLDING  
6 SOCIEDAD LIMITADA, with registered office at Calle Ángel Muñoz, 14 1º -  
7 office 2, 28043 Madrid, is, in reality, the head of the group that acts as a variant  
8 of an Investment Fund or a company that merely holds shares in other  
9 companies.

10 The Board of Directors is made up of two holding companies, but the one  
11 who actually holds the management position is the sole shareholder of the  
12 Alquife Mine Holding Company, and the Fauteck Jurn Hinnerk family is  
13 involved in other holding companies.

#### 14 **E) Expected Duration of Activity.**

15  
16 This aspect is rarely emphasised, yet it is arguably one of the most relevant  
17 dimensions of the project.

18 It should be noted that we are not dealing with an economic activity with  
19 significant fluctuations in both its production volume and international product  
20 prices, over which the company, logically, has no influence.

21 Unlike other conventional industrial companies that exhibit large and  
22 frequent fluctuations in their level of economic activity, in many cases these  
23 fluctuations are mitigated by variations in warehouse stock levels and changes  
24 in sales policies. However, in this project, the start and growth of the activity, or

1 its eventual cessation, will have severe effects on the territory, the local economy,  
2 and, in particular, on the jobs and resulting livelihoods of the local people.

3 Despite this strong impact, decisions about this company are made in places  
4 far removed from the Marquesado del Cenete and its people have no influence  
5 whatsoever on them.

6 Under these conditions of the company's activity, international iron prices  
7 make it a merely speculative activity, in the search for short-term profits;  
8 however, its actions, especially the closure or abandonment of the mine, will  
9 have a perverse and long-term effect on the people of the Marquisate and the  
10 territory, as historical evidence has taught us.

11 Under these circumstances, the foreseeable period of activity for the  
12 development of the economic activity is uncertain, but most likely, if it definitely  
13 starts with some regularity, the duration will not exceed eight or nine years.

14 Employment effects remain uncertain and insufficiently substantiated.  
15 While initial projections suggested up to 900 jobs (direct and indirect), more  
16 recent estimates provided by the promoter reduce this figure to approximately  
17 50 jobs, without clear methodological justification.

18 Furthermore, it should be noted that a large proportion of the workers will  
19 be high-level managers and technicians, so these positions will most likely not  
20 be filled by people from the Marquesado area.

21 The positive effect on the local economy will likely be negligible, as it lacks  
22 any connection to other activities; that is, it will not foster the creation of  
23 auxiliary services and industries, nor companies dedicated to mineral processing,  
24 much less to their commercialization.

25 In short, the absence of any objective net social benefit or corporate social  
26 commitment to the Marquesado region makes its installation inadvisable and, in  
27 particular, fails to meet the requirements to be declared a project of Superior  
28 Public Interest, in the fullest sense of the term.

29  
30 **F) Application of the Water Framework Directive Cost Recovery Principle**  
31 **(WFD).**

32 Article 9 of the Water Framework Directive states that Member States shall  
33 take into account the principle of recovery of the costs of water-related services,  
34 including environmental and resource-related costs, in light of the economic  
35 analysis carried out, and in particular in accordance with the polluter-pays  
36 principle.

37 Achieving this Community objective requires that the water policy actions  
38 of the Member States be preceded by the corresponding cost-benefit studies or,  
39 better yet, multi-criteria studies that guarantee the efficiency in the use of water  
40 resources and for this purpose that the costs to water users include all these  
41 concepts including the environmental costs measured in terms of the recovery of  
42 good ecological status, in this case, of the affected water bodies.

43 The hydrological plan will include a summary of the analysis of costs,  
44 revenues and the level of cost recovery for water services, including at least the  
45 following information:

46 Water service costs

1 Environmental and resource costs  
2 Water service revenues  
3 Current cost recovery rate  
4 Forecasts of planned investments for each water service.  
5

6 This analysis is absent in the actions and effects caused by the exploitation  
7 of the Alquife Mines by the PHG 2022-2027.

8 But beyond that, the Treaty on European Union (2002) in Article 174  
9 includes the Precautionary Principle as an instrument for managing potential  
10 risk, stating in its second paragraph that: "Community policy in the field of the  
11 environment shall aim at a high level of protection" and shall be based on the  
12 precautionary and preventive action principles, bearing in mind the diversity of  
13 situations existing in the different regions.

14 Directive 2004/35/EC of the European Parliament and of the Council of 21  
15 April 2004<sup>1</sup> on environmental liability with regard to the prevention and  
16 remedying of environmental damage must be enforced by promoting the  
17 'polluter pays' principle, as set out in the Treaty.

18 According to this principle, an operator that causes environmental damage,  
19 or that imminently threatens to cause such damage, must bear the cost of the  
20 necessary preventive or remedial measures to restore the site to its condition  
21 prior to the damage. Furthermore, companies whose activities may harm the  
22 environment must demonstrate that they have the necessary financial resources  
23 to address any ecological damage they may cause.

24 The exploitation of the Alquife Mines requires the draining of the aquifer,  
25 which, as happened in previous periods of its operation, will cause adverse  
26 effects. The most recent available evidence concerns the effects caused between  
27 1980 and its closure in 1996: The loss of aquifer recharge caused springs of the  
28 Verde River to dry up, and the river itself was practically transformed into a dry  
29 riverbed. While it is true that the mine owners only partially and without legal  
30 justification attempted to mitigate these damages by providing water pumped  
31 from the mine shafts to the affected concessions, including the municipalities of  
32 Lanteria, Alquife, and Valle del Zalabí.

33 Today it would not be technically very complex to calculate the damages to  
34 the affected agents, including the environment, affected by the activity of the  
35 Mine, in order to carry out the due compensations.

36 However, the precautionary and preventive action principles of the WFD,  
37 together with the general principle of legal certainty for affected parties, advise  
38 the establishment of a sufficient bond to guarantee payment, where applicable,  
39 for damages caused to the water environment and the affected people, which will  
40 be particularly effective in the case of groups of companies, where financial  
41 responsibilities are frequently evaded.

#### 42 43 **G) Conclusions: Sustainable Development?**

44 The owners of Minas de Alquife state that:

45  
46 *The reopening of the Marquesado Mines means reinstalling, in a currently*  
47 *depressed rural inland area, an important engine of development that will allow*

1 *the planning and development of the continuity of the region's economic activity*  
2 *beyond the horizon of the mine's closure.*  
3

4 The reality is quite different. The current project to open the Alquife Mines  
5 is presented as a merely circumstantial activity, and for many of the people in  
6 the region consulted, it is, in reality, purely speculative.

7 It will contribute virtually no wealth to the region: the foreseeable  
8 employment for local people is negligible and without any guarantee of  
9 continuity. This company's activity is not integrated or connected with other  
10 existing businesses, and the product will not undergo any processing in the  
11 region, but will be immediately transported to more or less distant locations. In  
12 reality, as in many other cases, this is the exploitation of an area's natural  
13 resources by foreign capital, transferring the added value elsewhere, but  
14 mortgaging the region's economic future, as has already happened, with a heavy  
15 ecological footprint and the disruption of the local economy after its eventual  
16 closure.

17 Furthermore, all decisions regarding the Mine will be made by people and  
18 in places far removed from the Marquesado.

19 According to the UNITED NATIONS, SUSTAINABLE DEVELOPMENT  
20 is defined as development that meets present needs without compromising the  
21 ability of future generations to meet their own needs, balancing economic  
22 growth, environmental protection, and social well-being.

23 From this perspective, the compatibility of the Alquife project with  
24 sustainable development remains highly questionable unless robust  
25 environmental safeguards, economic integration measures, and social guarantees  
26 are effectively implemented.

27 In short, in light of the above, in my opinion as a university researcher in  
28 Water Economics and Management, there are sufficient technical and scientific  
29 reasons and arguments for the Zalabí Valley Council, if it so chooses, to submit  
30 objections or oppose the PHG Project currently under public consultation. This  
31 project would result in the drainage of the “Guadix” ES050MSBT000051201  
32 and “Corredor La Calahorra-Huéneja” ES050MSBT000051202 aquifers, which  
33 lie beneath the Marquesado del Zenete region, and would also affect the surface  
34 water body ES050MSPF011011005 “Guadix River and tributaries.”  
35 Specifically, the Council argues that the inclusion of these actions should be  
36 considered one of the exemptions contemplated in Article 39 of the Hydrological  
37 Planning Regulations.

38 Reopening may be socially beneficial, but only within a framework of  
39 responsible environmental and socioeconomic management. Ignoring the risks  
40 could lead to negative impacts that outweigh the social benefits, generating  
41 dependency, conflict, and environmental degradation that directly affect the  
42 quality of life of the local population.

43  
44

1 **Conclusion: The Andalusian Mining Economic Model: Extractivism,**  
 2 **Dependence, Marginalisation and Unsustainability**

3  
 4 **A) Extractivism.**

5 Mining activity is particularly significant in the region of Andalusia, where  
 6 copper production alone accounts for more than 90% of Spain’s national output.

7 However, mining operations are inherently unsustainable, as—alongside the  
 8 severe environmental impacts they generate—these activities are finite and are  
 9 exhausted over a more or less extended period of time.

10 Mining activities generate severe environmental impacts on biodiversity,  
 11 soil, air, water, and human health, as well as on fauna and flora. Less frequently  
 12 studied, but equally important, are the processes of economic and social  
 13 disarticulation affecting local communities after mine closure.

14  
 15 **B) Dependence, Marginalisation and Unsustainability of the Andalusian**  
 16 **Mining Model.**

17 More than forty years ago, Professor Manuel Delgado Cabeza, in  
 18 *Dependencia y Marginación de la Economía Andaluza* (1981), provided an  
 19 analysis of both the origins and the then-current condition of the Andalusian  
 20 economy. The title of his work remains highly illustrative, and unfortunately its  
 21 diagnosis continues to be relevant today, particularly in the metallic mining  
 22 sector.

23 In the current economic and institutional context—characterised by a  
 24 progressive reduction in regional decision-making capacity—the basic strategy  
 25 for sustainable regional development in Andalusia, within a globalised  
 26 environment, should be based on endogenous potential.

27 A competitive economy and a high quality of life for citizens would enable  
 28 a more robust engagement with globalisation and help mitigate its potential  
 29 adverse effects.

30 In this sense, it is not sufficient merely to increase the value added generated  
 31 by Andalusian metallic mining. It is also necessary to ensure that such value  
 32 remains within the region, reinforcing internal economic circuits, increasing  
 33 local control over production processes, and promoting a more balanced and  
 34 territorially equitable distribution of economic benefits.

35  
 36 **C) Final Conceptual and Methodological Considerations.**

37 *“The ways in which phenomena are named shape the ways in which they are*  
 38 *understood.”*

39 It is common in administrative and policy-oriented literature to use and  
 40 consolidate concepts that lack solid scientific grounding. These are not neutral  
 41 terms, and they have significant practical implications. Two examples are  
 42 particularly relevant:

43  
 44 – **The concept of “closure of offices vs. Mines”.**

45 The caution required when starting up and reopening metal mines is not the  
 46 same as that required, for example, with the potential closure of offices where  
 47 financial activities take place. This has little physical impact on the area; it is

1 limited to the abandonment of the premises and the subsequent rapid relocation  
2 of its few assets, such as computers and furniture, and even staff, to another  
3 similar activity in a nearby location.

4 No, in this case the installation of a mining activity causes, among other  
5 things, the transformation of the territory, the economic model of the area, the  
6 environmental quality, the health of the population, the purposes of educational  
7 institutions,...The closure causes the presence of a contaminated territory,  
8 economically disarticulated, many sick people, in short, an area emptied of  
9 population and depressed both economically and socially and even  
10 psychologically.

11  
12 – **The concept of resource depletion.**

13 . The concept of mineral depletion in a mine is not physical, or rather, solely  
14 physical. The private economic viability of opening or closing a mine is  
15 motivated to a very small extent by the level of physical depletion of the  
16 materials sought, but essentially by the international price of the material. Thus,  
17 a significant fluctuation in this price will decisively affect the private  
18 profitability of a mining operation, even if the availability of the mineral has not  
19 necessarily changed substantially.

20 In short, the depletion of a mineral is not only a physical concept but  
21 essentially an economic one. Of course, the consequences for the land and the  
22 population are not only physical and psychological but also strictly economic.

23 These discussions are particularly applicable to so-called rare earth  
24 elements, where their concentration in the environment is the determining factor  
25 for the profitability of their extraction.

26  
27 – **Conditions for socially acceptable new or reopened mines.**

28 Although sustainable mining is not impossible, the reality is that it is an  
29 extremely difficult goal, the achievement of which would require a long series  
30 of essential requirements, in addition to the mere pecuniary and social  
31 profitability required of regular economic activities.

32 Mining activity must be environmentally friendly (minimal impact and  
33 restoration), generate quality jobs, and involve social participation and control  
34 by local authorities so that it contributes to improvements and social  
35 development.

36 Given the real and traditionally dangerous nature of these activities, in  
37 addition to ordinary regulation, it is advisable to establish a fund fed by  
38 earmarked taxes whose revenue would be destined for the economic, social and  
39 environmental improvement of the environment, without neglecting, of course,  
40 that of human capital.

41  
42  
43

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