I4-GREEN

Regional database of industrial strategic geological resources and areas for sustainable recovery of critical raw materials.

D6.5

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Description of the related task and the deliverable. Extract from DoA	T6.4 Development of a regional virtual database of industrial strategic geological resources and areas for sustainable recovery of critical raw materials (M1-M24) Lead Beneficiary: JdA, Contributors: ISMC, ACPMR Andalusia, Alentejo, and Extremadura are sharing deep geological similarities that make possible 1/ the replication of the two I4-GREEN core pilots and 2/ an extension of the technologies brought and deployed in these underdeveloped regions to fertilise and boost new innovation projects as a result of the innovation ecosystem created. This task is a pivotal effort to deploy the opportunities offered by the EU ecosystem created thanks to I4-GREEN. Both activities and technologies deployed at the Rio Tinto project (Atalaya - Andalusia) and Iron Oak Holm Project (Gevora, Leonore - Extremadura) offer strong replication tracks for new deposits and other active mining projects to turn green. The result of this task will be a report (D6.5) including a geological study, a strategic analysis (feasibility, cost and opportunity options), and a mapping of geological deposits in Portugal and in the regions of Extremadura, Andalusia, and Castile y Leon (Spain). The active participation of the local Governments ('Junta de Andalusia', 'Junta de Extremadura', 'Junta de Castile y Leon' – as partners or associated partners), even committing their own resources to this task of I4-GREEN, is a critical success factor in that effort.			
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Glosary	
EU	European Union
CRM	Critical Raw Material
REE	Rare-Earth Element
AMD	Acid Mine Drainage
MWV	Mine Waste Valorisation
VMS	Volcanogenic Massive Sulphide
IRR	Internal Rate of Return
CapEx	Capital Expenditure
OpEx	Operating Expenses
EIA	Environmental Impact Assessment
PREST	Restoration Plan
ROI	Return On Investment
NPV	Net Present Value
IPB	Iberian Pyrite Belt
IRR	Internal Rate of Return

Executive summary

As part of Task 6.4 under Work Package 6, "Interregional Deployment and Replication to Full EU Scale", this report provides an in-depth analysis of the geological potential and mining viability and presents a comprehensive geological and economic analysis of four key regions: Alentejo (Portugal), Castile y León, Extremadura, and Andalusia (Spain). Each region present significant opportunities for sustainable mining projects that align with the European Union's strategic goal of ensuring sustainable mining and resource security. Therefore, such areas have been studied to assess their mining potential based on resource availability, historical mining activity, and the feasibility of developing new mining projects. The report also considers the extraction of non-ferrous metallic minerals, industrial minerals, and ornamental rocks, with a focus on Critical Raw Materials (CRMs) as defined by the European Union.

Key Findings

- Andalusia: Rich in polymetallic sulphide deposits, especially copper, zinc, and lead, Andalucía is the most promising region for large-scale mining. The well-developed infrastructure, proximity to markets, and energy availability position it as the most viable area for significant mineral extraction. Major mines like Riotinto, Aguas Teñidas, Aznalcóllar and Cobre Las Cruces lead the region's mining efforts.
- Extremadura: With its lithium and tungsten deposits, Extremadura has high potential for future projects, particularly those aligned with the European energy transition. The presence of pegmatites and the region's importance in battery technology make it a strategic focus for investors, though infrastructure improvements are necessary to fully unlock its potential.
- Castile and León: Historically known for gold, coal, tungsten, feldspar and slate extraction, Castile and León remains competitive in the ornamental stone market. The potential for reactivating gold, tungsten and copper projects could boost the region's contribution to strategic mineral supply chains.
- Alentejo: This region is renowned for its high-quality marble and granite. It also holds high potential for polymetallic mineral extraction (Cu, Zn, Pb, and some Au and Ag) in certain areas with some relevant operating projects. New mining projects are focused on industrial, ornamental stone sectors and a significant emphasis on metallic minerals, specifically Cu, Zn, Pb, and Ag, when compared to other regions.

Geological Overview

Each region offers distinct geological characteristics. Alentejo is renowned for its marble, limestone and granite, while also housing important polymetallic sulphide deposits - Iberian Pyrite Belt, with relevant mining activity (Cu, Zn and Pb). Castilla y León has a diverse geological structure with significant deposits of gold, coal, and slate, positioning it as a leader in industrial minerals. Extremadura has gained prominence due to its deposits of tungsten, lithium, and tin, vital for the green energy transition. Andalusia stands out for its historical mining in the Iberian Pyrite Belt, producing large quantities of copper, zinc, and lead, and continues to be one of Europe's most productive mining regions along the centuries (Jaén, Córdoba and Granada also hosted relevant mining projects for several metallic ores in the past).

Viability and Cost Analysis

The report provides an extensive cost analysis, comparing operational and environmental costs between the regions. Andalusia leads in terms of economic feasibility due to its advanced infrastructure and proximity to global markets, reducing logistics costs. Extremadura and Alentejo follows closely with its focus on CRMs, while Castile and León demonstrate stable prospects, particularly in the ornamental and industrial stone sectors, also of high relevance to Alentejo.

Mining Viability Analysis

Mining viability in each region is assessed through technical, economic, and environmental factors. Andalusia is projected to have the highest potential due to its advanced infrastructure, established mining operations, and proximity to global markets via Huelva's port. Extremadura and Alentejo also present promising opportunities, particularly in polymetallic deposits, despite requiring further investment in infrastructure. Castile and León remains competitive with strong local demand for slate and other building materials.

Cost Analysis and Economic Impact

The cost structures of mining operations vary significantly between the regions. Andalusia benefits from economies of scale in its large mining operations, while Extremadura and Castile and León face higher operational costs due to logistical challenges. Alentejo, although competitive in cost, must continue to leverage its access to international markets, specially facing and solving logistical challenges.

Environmental considerations, including the impact of mining on local ecosystems and water resources, are thoroughly assessed, with each region facing challenges specific to its geology, geomorphology, and climate. Compliance with EU regulations on sustainability remains a critical factor across all regions.

Conclusion

The report concludes that while Andalusia offers the most immediate potential for high-return mining projects due to its advanced infrastructure and resource base, Extremadura and Alentejo are also poised for growth, particularly in the context of critical raw materials. Castile and León, with its focus on industrial minerals, offers stability in the long-term with moderate growth potential.

The diversification of mining activities across these regions will be key to supporting both regional economies and broader European resource independence. Logistical needs to facilitate and lower costs in exports, allowing the exploration of other markets, are a common challenge for Andalusia, Extremadura and Alentejo, that can benefit of a common project to face them.

1. Introduction

1.1 Background

The mining sector plays an essential role in the global economy, as it provides the critical raw materials needed for industries such as advanced and digital technology manufacturing, renewable energy, and construction. Behing the basis of digital and green energy transition. In Europe, the sustainable supply of minerals and raw materials is vital for industrial and technological development. The regions of Alentejo (Portugal), Castile and León, Extremadura, and Andalusia (Spain) stand out due to their rich geological features and significant deposits of strategic and critical mineral resources, making them central to most industrial value chains for both Europe and beyond.

The global transition toward greener and more digital economies, driven by the need to reduce carbon emissions and promote clean energy, has further increased the importance of these mineral resources. The rising demand for critical raw materials such as lithium, cobalt, nickel, and rare earth elements, which are crucial for renewable energy technologies and digital infrastructure, has underscored the need for sustainable access to these resources. The European Union has identified several minerals as essential to ensuring technological independence and economic security, but despite this recognition, Europe continues to rely heavily on imports to meet its needs. This dependency has prompted policies aimed at strengthening the internal extractive sector and securing the continent's supply chains.

The regions of Alentejo, Castile and León, Extremadura, and Andalusia offer favourable geological conditions for the prospect and exploitation of these minerals, evidenced by both historical and current mining projects that showcase the economic potential of these areas. Advances in geology, combined with new mining technologies, have enabled the exploration and exploitation of not only metallic minerals but also industrial minerals and ornamental stones, all of which are critical to various industrial applications and European value chains. Moreover, these regions boast a well-established mining industry that has been integral to their economic and societal development for decades.

However, the mining sector in these regions faces several challenges, including the need to adhere to strict environmental and social regulations while ensuring the profitability of projects. EU policies, such as the European Green Deal, add further pressure on the mining industry to contribute to climate neutrality. At the same time, the global energy crisis has intensified the urgency of diversifying sources of critical minerals, positioning the sustainable extraction of resources from these regions as a key factor in ensuring a secure supply of raw materials at both national and European levels.

1.2 Target of this report

The main objective of this report is to conduct a comprehensive geological analysis of the selected regions and assess the economic and environmental feasibility and potential for developing mining projects in these areas. The report covers both the geological potential and the economic, technical, and environmental factors affecting the exploitation of mineral resources in these regions.

This analysis will focus on three categories of mineral resources:

- Non-ferrous metallic minerals, such as copper, zinc, tungsten, and lithium, which are essential for the technological and energy industries.
- Industrial minerals, such as quartz, feldspar, calcium carbonate and clays, which are crucial for the construction industry and other productive sectors.
- Ornamental stones, including marble, limestone, slate, and granite, which are widely used in architecture and design.

Additionally, special attention will be paid to critical raw materials according to European Union criteria, which are vital for advanced technologies and whose sustainable exploitation could strengthen the continent's strategic autonomy.

Therefore, this report aims to provide policymakers and investors with a tool to make informed decisions about the future of mining in these regions. It also seeks to offer an assessment of the costs, risks, and benefits associated with the exploitation of mineral resources, with particular attention to environmental sustainability and compliance with European regulations on environmental impact and sustainable development.

1.3 A Brief Introduction to the Target Regions

- Alentejo (Portugal): This region is characterized by an abundance of ornamental stones, particularly marble, which has been exploited since ancient times and holds significant importance in the construction industry. Its geology is dominated by Paleozoic and Mesozoic formations and contains important polymetallic sulphide deposits, especially in areas such as the Iberian Pyrite Belt, where minerals like copper, lead, zinc, and other metals are found and mined. Alentejo has garnered attention not only for its mining history but also for its potential to develop new deposits critical for modern industry, particularly in the context of critical and strategic minerals. The region also benefits from a low population density, which offers opportunities for large-scale mining projects with reduced social conflict risks. The mining industry has thrived in Alentejo since the Roman period, forming a cornerstone of the region's economy and societal growth for centuries. This long-standing tradition underscores Alentejo's role as a well-established hub for mining, crucial to both local economic stability and community development.
- Castile and León (Spain): As Spain's largest autonomous community, Castile and León boasts vast geological diversity. The region encompasses areas large Hercynian domains, Mesozoic chains and Tertiary basins, with significant deposits of metallic minerals, coal, ornamental stones and industrial minerals. Notable gold deposits have been exploited since Roman times. Although coal mining was historically a key economic sector, it has declined in recent years. Nevertheless, the region remains rich in industrial and metallic minerals, with developing projects targeting new lithium, cobalt, and other critical technology-related deposits. The existing infrastructure network facilitates the transportation and export of extracted resources. In terms of sustainability, the region has implemented strategies to balance mining activities with environmental conservation, adhering to the strictest European regulations.
- Extremadura (Spain): Extremadura stands out for its significant deposits of tungsten, tin, lithium, and rare earth elements, essential for the technology industry. The La Parrilla tungsten mine and the Aguablanca nickel-copper mine are two of the region's most notable operations, currently resuming activity. The region has gained recent attention due to the surge in demand for minerals critical for clean energy, especially lithium, vital for electric vehicle batteries. Extremadura shows great potential in this regard, attracting significant investment for the exploration and exploitation of strategic minerals, making it a focal point for sustainable mining projects. Additionally, the region is rich in ornamental stones such as granite and slate, which are exported internationally.
- Andalusia (Spain): Mining in Andalusia has a millennia-old tradition, with the Iberian Pyrite Belt being one of the richest mining areas in Europe. Copper, zinc, lead, and other polymetallic sulphide deposits have been exploited for over 5,000 years. Today, it remains one of Spain's leading mining regions, particularly noted for its contribution to the export of metallic minerals. Andalucía also hosts important marble, granite, and other ornamental stone quarries, making it a strategic hub for both metallic mining and the construction industry. Industrial minerals such as gypsum ($CaSO_4$), fluorite (CaF_2), and celestine ($SrSO_4$) are also significant in the region. Additionally, Andalusia boasts a well-developed infrastructure network that facilitates the transportation of minerals to international markets.

1.4 Importance of the Mining Sector in the Target Regions

The mining sector is vital for the economies of these four regions, not only for job creation and economic growth but also for its impact on industrial development and environmental sustainability. Alentejo, Castile and León, Extremadura, and Andalusia possess strategic resources that are

increasingly demanded in a global context where the transition to clean energy and digital technologies requires a constant supply of critical minerals.

Metal mining in Andalusia and Extremadura has positioned Spain as one of Europe's leading producers of copper, zinc, and lead, essential for the construction, automotive, and electrical industries. Castile and León stands out by its production of roofing slate and has historically been a coal mining center, but the focus has shifted to more sustainable minerals with greater international demand, such as lithium and other industrial minerals.

In Alentejo, high-quality marble is internationally renowned, while current metallic mineral and industrial rock deposits promise sustained growth in the medium to long term. The sustainable development of these resources is a key challenge to ensure Europe's resilience and supply security, especially given the growing global demand and risks associated with dependency on third countries.

2. Geological framework of the target regions

2.1. Alentejo (Portugal)

2.1.1. General geological description

The Alentejo region, located in southern Portugal, is a vast geological area with a diverse range of geological formations. Geologically, Alentejo is situated in the southern extension of the Hesperian/Hercynian Massif, one of the largest geological structures on the Iberian Peninsula. This region is primarily composed of Paleozoic and Mesozoic rocks, featuring significant tectonic structures, including faults and folds, which influence the distribution of its mineral resources.

One of the most notable geological features in Alentejo is the Iberian Pyrite Belt (IPB). This formation, extending from southwestern Portugal into Spain, is one of the world's most important metallogenic provinces, known for hosting large polymetallic volcanic massive sulphide (VMS) deposits rich in copper, zinc, lead, silver, and gold. Additionally, other geological units such as the Volcano-Sedimentary Complex and the Phyllite-Quartzite Group play a fundamental role in mineral resource formation.

The VMS deposits are one of the most important districts for this type of deposit in the world. The IPB constitutes a strip around 240 km long and 35 km wide that runs through the provinces of Sevilla and Huelva in Andalusia, Badajoz in Extremadura, and Beja and Setúbal in Alentejo. In the IPB located in Portugal is in the tectono-stratigraphic unit called South Portuguese Zone.

The terrain shows a high degree of variability in its lithological characteristics, including clastic sediments, carbonates, and volcanic materials, which have contributed to the formation of various mineral deposits. In the westernmost parts of Alentejo, Mesozoic carbonate rocks predominate, while Paleozoic formations, closely associated with mineralization, dominate the inland areas.

The region is also traversed by tectonic structures that have contributed to mineralization processes. Notably, the Hercynian/Variscan Orogeny played a crucial role in shaping Alentejo's current geological structure, creating conditions favourable for the formation of mineral deposits throughout various phases of tectonic and volcanic activity.

2.1.2. Present mineral resources

Alentejo is rich in a wide variety of mineral resources, with notable production in three main categories: metallic minerals, industrial minerals, and ornamental stones.

Metallic Minerals

- Polymetallic Sulphides: The massive sulphide deposits of the Iberian Pyrite Belt are particularly rich in copper, zinc, lead, and to a lesser extent, gold and silver. These deposits have historically been exploited for their high non-ferrous metal content, making this one of the principal mining areas in Europe.

- Gold and Silver: There are zones of gold and silver mineralization, primarily near the IPB, where gold has been found disseminated in volcanic and sedimentary rocks. These zones are linked to hydrothermal processes.
- Copper: This is one of the main resources exploited in Alentejo, particularly in mines like Neves-Corvo and Aljustrel, located in the southwestern area, and it is a key resource in the region.

Industrial Minerals

- Clays and Feldspar: These industrial raw materials are exploited to produce ceramics and other construction materials. Alentejo is a significant producer of high-quality clays used in both traditional and modern ceramic industries.
- Limestone: In Setúbal, the SECIL company's industrial complex exploits calcium carbonate to produce grey cement. This cement is used to produce concrete, and it's recommended for major engineering works such as dams.

Ornamental Stones

- Marble: Alentejo is one of the world's leading regions for marble production, particularly in the areas of Estremoz, Vila Viçosa, and Borba. Alentejo marble is renowned for its high quality and beauty, widely used both in national and international markets. This marble has been exploited for centuries and remains a key resource for the region.
- Granite and Limestone: Significant granite and limestone quarries are also found, used in construction and for decorative products.

2.1.3. Mining history and background

Mining in Alentejo has a long tradition dating back to Roman times. During antiquity, the Romans were the first to exploit the region's rich marble and metal deposits. The Iberian Pyrite Belt was already known at that time for its wealth of metals such as copper and lead, which were used to mint coins and create other tools. But also, some gold and silver. Although mining techniques were rudimentary compared to today, they allowed for significant exploitation of mineral resources.

In the 19th century, mining in Alentejo experienced a resurgence, with the reactivation of several mines, particularly in the IPB. During this period, the region became an important producer of copper and other non-ferrous metals for the growing European industry, particularly England, which required large quantities of these metals for its Industrial Revolution. Leaving behind large mine tailings and abandoned mines, that can be of large importance today with the available technology.

Today, mining in Alentejo has undergone modernization, adapting to the new demands of the global market. The Neves-Corvo and Aljustrel mines, are one of the region's most important projects, has been crucial for both the local and national economy. These mines, which primarily produces copper and zinc, is one of the largest mining projects in Europe and is notable for adopting modern technologies and sustainable extraction methods.

Additionally, the marble industry has continued to be a pillar of the local economy. Alentejo's marble quarries are internationally renowned, and their products are used in architectural projects worldwide. However, the marble industry also faces challenges related to waste management and environmental preservation, due to the large amounts of material discarded during the extraction and transformation processes.

Serra da Arrábida is a mountain range constituted by limestone outcrops elevated by the Alpine Orogeny. This relief extends approximately 30 km in an east-west direction, being dominated by folds trending ENE-WSW, which presents ductile deformation pattern associated with adjacent. One of the largest quarries in Portugal is set in Serra da Arrábida, on the Setúbal peninsula. This concession is currently being operated by SECIL. Serra da Arrábida also hosts ten other limestone quarry concessions for the construction and engineering industries.

In recent years, interest in mining in Alentejo has grown due to the rising demand for critical raw materials, such as Cu, Zn, Pb, and Ag. These minerals could be found in VMS deposits like Lagoa Salgada.

Lagoa Salgada is a deposit in Alcácer do Sal, constituted by numerous sulfide mineralizations massif covered by a thick Cenozoic layer of the Sado Basin. This mineralization was subjected to tectonic stress followed by anticlinal and synclinal folds verging to SW that were subjected to fragile stress visible by conjugation of faults. These sulfide mineralizations massif are part of one of the most important VMS metallogenic provinces. This deposit has Zn, Cu, Pb, Sn, Au, and Ag mineralizations. Its structure is controlled by a tectonic thrust trending NNW-SSE.

2.2. Castile and León (Spain)

2.2.1. General geological description

Castile and León is a geologically diverse region that encompasses a wide variety of geological formations, ranging from the Precambrian to the Quaternary. Its geology is dominated by three major geological units: the Iberian Massif, the Alpine Chains, and the Duero Basin.

The Iberian Massif consists of Precambrian and Palaeozoic rocks that have undergone tectonic, metamorphic and magmatic processes during the Variscan orogeny. This area is predominantly made up of metamorphic and magmatic rocks, including slates, schists, quartzites, and granites. These rocks contain numerous signs of mineralization, particularly metals such as gold, iron, tin, and tungsten, among others, as well as the layers of roofing slates and the main carboniferous basins.

The Alpine Chains, including the Cantabrian and Central System ranges, were formed during the Alpine orogeny of the Cenozoic. These mountains, which involves the Iberian massif as well as Mesozoic materials, are a testament to the tectonic uplift that created a series of geological structures favorable for the formation of mineral deposits. These areas contain deposits of industrial minerals, such as china clay, and even hydro carbides.

The Duero Basin, a large depression covering most of central Castile and León, is primarily composed of Tertiary and Quaternary sediments. This basin and some smaller ones are rich in detrital materials and has been an important source of industrial minerals, especially clays, gypsum, feldspar sands and aggregates, which have been used in construction and the ceramic industry, as well as secondary gold deposits exploited in Roman times.

Overall, the complex geology of Castile and León has resulted in a wide variety of mineral resources that have been exploited throughout history and remain fundamental to the region's economy.

2.2.2. Present mineral resources

The mineral resources of Castile and León are diverse and divided into metallic minerals, industrial minerals, and ornamental rocks, reflecting the geological diversity of the region.

Energy minerals

- Coal: Castile and León has historically been one of Spain's most important coal-mining regions, particularly in the El Bierzo and Laciana Mining Basins. Despite the decline in coal demand in recent years and the national government's policies, coal remains a relevant resource for the local industry.
- Uranium: there are deposits of uranium in the province of Salamanca, some of them exploited in the past, although its extraction is currently restricted due to legislative limitations.

Metallic Minerals

- Gold: Gold mining has been an important activity in Castile and León since Roman times. Gold deposits are mainly found in the mountainous northwestern areas, such as Las Médulas, an ancient Roman mining complex declared a World Heritage Site.

- Copper and Zinc: There are mines and signs of copper and zinc mineralization in several areas, such as the Cantabrian Mountains, where these metals have been mined in deposits associated with sedimentary rocks.
- Tin and Tungsten: In parts of the Iberian Massif, mainly in Salamanca and Zamora provinces, tin and tungsten deposits have been exploited and still tungsten is exploited in the Barruecopardo mine. These strategic metals have seen high demand in the military and electronics industries.

Additionally, there are important deposits of iron, partially exploited, and some interesting minor mines of critical raw materials such as cobalt, nickel, arsenic, antimuonium, baryte and fluorspar.

Industrial Minerals

- Clays: Clays are one of Castile and León's most important industrial resources, used in the manufacture of ceramics, bricks, and other construction materials. Found mainly in the Duero Basin, clays have been exploited for centuries. Certain formations are of such size and quality that they were considered for housing a high-activity radioactive waste storage facility promoted by ENRESA.
- Gypsum: An essential mineral in the construction industry, gypsum is found in various parts of the region, particularly in the provinces of Burgos and Valladolid, where important mining operations have been developed over time.
- Feldspar and Quartz: These minerals are used in the glass and ceramic industries and are mainly found in the granite zones of the Iberian Massif and quaternary derived deposits of sands and gravels, with particularly relevant deposits located in the province of Segovia, nowadays in operation.

Additionally, there are exploitations of quartz gravels for ferroalloys and silicon, lithium minerals for ceramics, glauber salt, magnesite and china clay.

Ornamental Stones

- Slate: The high-quality slate of Castile and León is world-renowned and is mainly mined in the provinces of León and Zamora, as well as around the town of Bernardos in Segovia. It is in high demand for roofing and building facades, both in the national and international markets.
- Granite: Granite is another ornamental stone mined in various parts of the region, mainly used in construction and decoration. Granite quarries in Salamanca and Ávila are particularly important in this regard.

There are also exploitations of limestones and sandstones for ornamental uses in several provinces.

2.2.3 Mining history and background

Mining in Castile and León has a rich history dating back to prehistoric times, when minerals such as gold and copper were already being extracted. However, it was during the Roman occupation that mining reached its peak in the region, especially with the exploitation of gold at Las Médulas, one of the largest open-pit mines of the ancient world. The Romans introduced hydraulic mining techniques, which allowed them to extract large quantities of gold from alluvial deposits. This site, declared a World Heritage Site, remains a testament to the historical importance of mining in Castile and León.

During the Middle Ages and the Renaissance, metallic mineral mining continued to be an important activity, albeit on a smaller scale. Silver and copper deposits in the Sierra de la Demanda and iron mines in the Montaña Palentina were exploited to supply local metallurgical industries and armories.

The 19th century marked a renaissance in mining activity in the region, driven by the Industrial Revolution. During this period, new coal mines were opened in the basins of El Bierzo, Laciana and some others, which became the main coal production centers in Spain. Coal from these mines was crucial for the development of the steel industry in the north of the country (with the iron from the important deposits of León) and for the generation of electrical energy.

By the mid-20th century, mining in Castile and León remained a strategic sector but began facing challenges related to competitiveness and production costs. The coal mines in El Bierzo and Laciana maintained their activity until the decline of the coal industry in recent decades, when the closure of many mines dealt a severe blow to the local economy.

Currently, mining in Castile and León has diversified its activities, focusing on the extraction of industrial minerals such as feldspar, quartz, magnesite, glauberite, clays and gypsum, as well as the exploitation of ornamental stones like slate and granite. Although the mining sector has experienced a decline in some areas, it remains an important pillar for the regional economy, especially in terms of employment and exports.

2.3. Extremadura (Spain)

2.3.1. General geological description

Extremadura, located in western Spain, has a geology dominated by the Iberian Massif, which covers a vast area of mainly Paleozoic rocks. The region is characterized by a complex geological history that includes several cycles of sedimentation, tectonic deformation, metamorphism and magmatism. The terrain is primarily composed of igneous and metamorphic rocks, including granites, slates, quartzites, and gneisses, making it a region rich in mineral resources.

Extremadura lies in the southern extension of the Iberian Massif, and, like other parts of this massif, its geological formations include deposits of great interest for mining. Two major geological areas stand out in the region:

- The Central Iberian Zone, which covers most of the territory and consists of Precambrian-Paleozoic sedimentary and metamorphic rocks. These rocks are folded and fractured by the effects of the Variscan Orogeny, creating favorable conditions for the formation of metallic mineral deposits, such as tin and tungsten. This area is also known for its lithium mineralization, which has attracted considerable interest due to the growing demand for this metal.
- The Ossa-Morena Zone, located in the southeast of the region, is a geologically complex unit. Igneous and metamorphic rocks predominate here, with significant granite intrusions and volcanic-sedimentary formations, which have led to deposits of copper, lead, zinc, and other metals.

Extremadura also hosts a significant number of pegmatites, geological formations associated with the slow cooling of magma. These pegmatites are of special interest for their content of strategic minerals such as lithium, as well as feldspar, which has various industrial applications.

2.3.2. Present mineral resources

The geological diversity of Extremadura has resulted in a wide range of mineral resources, including metallic minerals, industrial minerals, and ornamental stones.

Metallic Minerals

- Tungsten and Tin: Extremadura is known for its significant tungsten and tin deposits, two metals historically exploited for their high strategic value. The La Parrilla mine in the province of Cáceres is one of Europe's most important tungsten deposits and has been mined for decades. These deposits are associated with granites and pegmatites, mainly around the Hesperian Massif.
- Copper and Lead: The region also has substantial copper and lead deposits, particularly in the Ossa-Morena Zone and the eastern mountain ranges of Cáceres and Badajoz. These metals have been exploited throughout history, with the Aguablanca mine in Monesterio being one of the most notable for its nickel-copper production.

- Lithium: One of the most sought-after minerals today is lithium, due to its growing demand. Extremadura has important lithium deposits, mainly associated with pegmatites, which could position the region as a key player in supplying this critical mineral.
- Gold and Silver: There are signs of gold and silver mineralization in various areas of the region, generating interest in future exploration.

Industrial Minerals

- Feldspar and Quartz: These minerals are essential for the ceramic and glass industries and are primarily found in areas with granite intrusions and pegmatites. Extremadura has significant potential for extracting high-quality feldspar.
- Barite and Fluorite: These minerals are used in industrial applications, such as paint and plastic production. Barite, in particular, is mined in several parts of the region and is an important mineral for the hydrocarbon industry due to its use in drilling fluids.
- Clays: The region is rich in clays, which are used in the ceramic and construction industries. Extremadura's high-quality clays are a key resource for the production of bricks and other building materials.

Ornamental Stones

- Granite: Extremadura is one of Spain's leading granite producers, with important quarries in the provinces of Cáceres and Badajoz. This material is widely used in construction and decoration due to its durability and beauty. Extremadura's granites are especially valued for their high quality and strength.
- Slate: The region also produces slate, mainly used for roofing and cladding. Although not as abundant as in other parts of the country, Extremadura's slate has a niche in the construction market.

2.3.3. Mining history and background

Mining in Extremadura has a rich history that dates back to Roman times, when early inhabitants exploited the region's mineral resources, mainly gold and copper. Gold mining was particularly important during Roman rule, with hydraulic mining techniques allowing large quantities of gold to be extracted from rivers and alluvial deposits.

During the Middle Ages, mining activity in the region declined but did not disappear completely. Iron and other metals continued to be extracted on a smaller scale, serving local demands for materials used in construction and weapon manufacturing.

The true mining boom in Extremadura occurred in the late 19th and early 20th centuries, with the industrialization of Spain and the increasing demand for metals such as tin, tungsten, and copper. The La Parrilla mine (and San Finx in Galicia) was/were particularly important during World War I and World War II, as these metals were highly valued for their use in the military industry.

The 20th century also marked a significant milestone with the opening of the Aguablanca mine, a nickel and copper deposit located in the province of Badajoz. This mine, one of the most important in Europe, has been crucial to the local economy and has significantly contributed to national nickel and copper production.

Today, mining in Extremadura remains a strategic sector, though it has shifted toward the extraction of industrial minerals and ornamental stones. The growing interest in critical raw materials, such as lithium, has placed the region on the radar of international investors, and mining is expected to play a crucial role in the region's economic development in the coming decades.

The modernization of mining infrastructure and the promotion of sustainable policies for resource extraction are paving the way for more responsible and efficient mining practices. Extremadura is positioned to become a key player in Europe's energy transition, particularly concerning the supply of lithium and other strategic minerals.

2.4. Andalusia (Spain)

2.4.1. General geological description

Andalusia, located in the south of the Iberian Peninsula, is one of Europe's most important regions from a geological and mining perspective, thanks to its varied and complex geological structure. According to the mining perspective. The region can be divided into three major geological units: the Iberian Massif, the Betic Zones, and the Iberian Pyrite Belt, each with specific characteristics that have favoured the formation of significant mineral deposits.

- Iberian Massif (Northern Zone of Andalusia): The Iberian Massif occupies the northern part of Andalusia, particularly in the provinces of Huelva, Sevilla, and Córdoba, and is mainly composed of Paleozoic rocks. Metamorphic and plutonic formations dominate this region, with the presence of granites, gneisses, schists, and quartzites. This area is especially known for its massive sulfide deposits, copper, and pyrite, and for hosting a significant portion of the Iberian Pyrite Belt.
- Iberian Pyrite Belt (Western Zone of Andalusia): The Iberian Pyrite Belt, which is part of the Iberian Massif, stands out as one of Europe's most important metallogenic formations, extending from southern Portugal into the province of Huelva. It is composed of a sequence of volcanic and sedimentary rocks, mainly from the Carboniferous period, containing numerous polymetallic massive sulfide deposits. This zone is renowned for its rich concentration of metallic minerals, such as copper, zinc, lead, and silver, and has been exploited since ancient times due to its high profitability.
- Betic Zones (Southern Zone of Andalusia): The Betic Zones, located in the south and southeast of Andalusia, are part of the mountain range that extends across southern Spain. These formations were created during the Alpine Orogeny and contain a series of complex structures, with folds and faults that have given rise to deposits of industrial minerals and ornamental stones. Limestone and dolomite predominate in the Betic Zones, facilitating the exploitation of these resources in the construction industry.

The tectonic complexity of Andalusia, with multiple orogenic episodes, volcanic processes, and hydrothermal activities, has led to the formation of numerous metallic and industrial mineral deposits throughout the region. The combination of igneous intrusions, regional metamorphism, and volcanic activity has favoured the mineralization of metals in areas such as the Sierra Morena and the Sierra de Aracena.

2.4.2. Present mineral resources

Andalusia is extremely rich in mineral resources, including metallic minerals, industrial minerals, and ornamental stones. These resources have been fundamental to the region's economy and continue to be an important pillar in its industrial development.

Metallic Minerals

- Copper: Andalusia is the largest copper producer in Spain, thanks to the enormous deposits in the Iberian Pyrite Belt. Mines like Riotinto, Aguas Teñidas, and Cobre Las Cruces are emblematic examples of the region's rich mineralization. Copper extracted from these mines is critical for the technology and energy industries, used in the manufacture of electrical cables and electronic components.
- Zinc and Lead: The polymetallic massive sulphides in the Pyrite Belt also contain significant quantities of zinc and lead. These metals are essential for battery production, galvanization, and other industrial applications. The Los Frailes deposit in Aznalcóllar is notable for its high concentration of these metals.
- Gold and Silver: Several deposits in Andalusia contain gold and silver, associated with massive sulphides. While not the primary exploitation products, these mineralizations add economic value to the region's mines.

Industrial Minerals

- Gypsum: Andalusia is one of Spain's leading gypsum producers. This mineral is essential for the construction industry, used in the production of gypsum panels and other derivative products. Gypsum operations are mainly located in the provinces of Almería and Granada.
- Clays and Kaolin: These raw materials are essential for the ceramic and construction industries, and Andalusia has significant deposits in the areas of Almería and Córdoba. High-quality clays extracted in the region are widely used in the production of bricks, tiles, and paving stones.
- Fluorite and Celestine: Andalusia also has important deposits of fluorite and celestine, especially in the province of Granada. These minerals are used in the aluminium industry and in the production of hydrofluoric acid and strontium, essential chemical compounds for various industrial applications.

Ornamental Stones

- Marble: Andalusia is world-renowned for its marble production, particularly in the Macael region, in the province of Almería. Macael white marble has been used since antiquity in monuments and iconic buildings, both in Spain and abroad. The marble industry continues to be an important economic driver in this part of the region.
- Slate: While slate production in Andalusia is not as significant as in other parts of Spain, the region has some slate deposits in the province of Jaén, where high-quality material is extracted and used in roofing.
- Granite: Granite is another important ornamental resource in Andalusia, with quarries located in the Sierra Morena and the Sierra de Aracena. This material is highly valued for its strength and durability, used in construction and urban decoration.

2.4.3. Mining history and background

Mining in Andalusia has a history that spans thousands of years, being one of the region's oldest economic activities. Since prehistoric times, the inhabitants of Andalusia exploited its rich mineral resources to make tools, weapons, and ornaments. Notable is the brilliant goldsmith work of the Tartessian civilization, as evidenced by the Treasure of El Carambolo in Seville. However, it was during the Roman era that mining in the region reached its peak.

The Romans extensively exploited the copper, lead, and silver deposits in the Iberian Pyrite Belt. Mines such as Riotinto and Tharsis were known throughout the Roman Empire for their ability to produce large quantities of metals, which were used in coinage and the manufacture of tools and ornaments. The Tharsis mines are mentioned several times in the Old Testament. Roman mining technology, including gallery systems and hydraulic mining, enabled the large-scale exploitation of these resources.

During the Middle Ages, mining in Andalusia remained an important activity, though on a smaller scale. Metal extraction was mainly limited to lead and copper, which were used in the manufacture of weapons and tools. With the Reconquista, the Christian kings promoted the exploitation of the region's mineral resources, especially in areas such as the Sierra Morena.

The 19th century marked a revival of mining in Andalusia, driven by the Industrial Revolution and the growing demand for metals such as copper and iron. During this period, mining in the Iberian Pyrite Belt experienced a new phase of growth, with the arrival of foreign capital and the modernization of extraction techniques. British, French, and German companies took control of many of the region's mines, allowing large-scale exploitation of the resources. This high level of activity required intense development of transportation infrastructure, ultimately leading to the construction of an extensive network of mining railways, which later also served for passenger and goods transport.

In the 20th century, mining in Andalusia continued to be a key sector for the regional economy. Mines like Riotinto and Tharsis continued to produce large quantities of metals well into the second half of

the century. However, economic and social challenges, as well as falling metal prices, led to the closure of many mines starting in the 1980s.

Today, mining in Andalusia is experiencing a resurgence, driven by the growing demand for critical and strategic minerals. Projects such as Cobre Las Cruces and Aguas Teñidas, along with the reactivation of the Riotinto and Aznalcóllar mines, have revitalized the sector, attracting national and international investments. Moreover, the region has adopted stricter sustainability and environmental responsibility policies, which have improved the efficiency and social impact of mining activities. Andalusia offers a high standard of quality in mining at an international level.

3. Feasibility Analysis of Mining Projects

The viability of a mining project is a critical aspect that determines whether a mineral resource can be exploited profitably, efficiently, and sustainably. This analysis involves a comprehensive evaluation covering technical, economic, financial, social, and environmental factors. In today's context, where global demand for minerals is driven by the energy transition, digitalization, and technological development, it is crucial to ensure that mining projects are not only economically viable but also environmentally responsible and socially acceptable.

The viability assessment begins with the characterization of the mineral deposit, followed by a detailed analysis of the most appropriate extraction methods and an estimate of operating costs. Geological and metallurgical studies play a key role in this stage, as they determine the quality and quantity of the resource, as well as its capacity to be exploited with current technologies.

A mining project also requires the evaluation of its supporting infrastructure. Factors such as access to roads, transportation, energy, and water are essential to ensure that operating costs remain within competitive margins. In many regions, infrastructure conditions can be a determining factor for the project's viability, especially when mines are located in remote or hard-to-reach areas.

The economic aspect of the viability analysis is another fundamental pillar. A detailed projection of potential revenues is made, taking into account the mineral's price on the international market, production and transportation costs, and the initial investment required to launch the mine. A key aspect is the internal rate of return (IRR), which must be sufficiently high to justify the investment. Additionally, the economic analysis must include a sensitivity study, where different market price and operating cost scenarios are evaluated to determine how they will affect the project's profitability.

From a financial perspective, mining projects typically require considerable initial investment, often involving the participation of private investors, banks, or governments. In this regard, obtaining financing is closely linked to the solidity of the business plan and the project's risk profile.

Environmental viability is another crucial aspect. Mining activities, by their very nature, have a significant environmental impact, so compliance with environmental regulations and the adoption of sustainable practices are essential to ensure the project's acceptance by authorities and local communities. Impacts on land use, biodiversity, water resources, and air quality must be addressed in environmental impact assessments and restoration plans, including post-mining closure and rehabilitation.

Finally, social viability must also be considered. Mining can be an important source of employment and economic development for local communities, but it can also generate conflicts if the impacts on the environment and quality of life are not properly managed. Consultations with affected communities, transparency in resource management, and the creation of tangible benefits for the local population are key to ensuring the social success of mining projects.

The viability analysis chapter is structured into several sections, each focusing on the different regions under study: Alentejo (Portugal), Castile and León (Spain), Extremadura (Spain), and Andalusia (Spain). In each case, the specific technical, economic, environmental, and social factors of each mining project will be evaluated to provide a complete and detailed overview of its viability.

3.1. Evaluation Criteria for Feasibility

The feasibility analysis of mining projects is based on a set of criteria that help determine whether a project is technically, economically, socially, and environmentally viable. These criteria encompass various dimensions that must be carefully evaluated to ensure the investment in the project is profitable, safe, and environmentally friendly. The main evaluation criteria are detailed below.

3.1.1. Technical Feasibility

Technical feasibility refers to the project's ability to efficiently and profitably extract and process minerals using the most appropriate technologies and mining methods. This criterion includes:

- Mineral deposit characteristics: The quality, quantity and grade of the available resource, the geology of the deposit, the distribution of the mineral, and its accessibility are evaluated. The classification of mineral reserves—proven, probable, and inferred—is crucial at this stage.
- Mining methods: The most appropriate extraction method is determined, whether open-pit or underground mining, depending on the depth and extent of the deposit. The processing method to achieve the target degree of the economic element is also crucial. The higher degree in the mineral value chain the better consideration of the project to provide local, regional or European industry in a more efficient, sustainable and independent way of supply.
- Available infrastructure: Proximity to transport networks (roads, railways, ports), access to energy, and water supply are key factors for the project's operational efficiency.

3.1.2. Economic Feasibility

Economic feasibility is a decisive factor that analyses the financial aspects of the project. The main criteria include:

- Capital Expenditure (CapEx): The initial costs required to develop the project, including mine construction, equipment acquisition, and auxiliary infrastructure development.
- Operating Expenses (OpEx): Costs associated with the mine's daily operation, such as extraction, processing, transportation, and maintenance.
- Market mineral prices: Mineral prices in the global market are projected, which can vary significantly depending on supply and demand.
- Revenue projection and Return on Investment (ROI): Potential revenues from the sale of the mineral are calculated and compared with operating and investment costs to determine profitability. An internal rate of return (IRR) higher than the cost of capital is a positive indicator of economic viability.
- Sensitivity study: Analyses under different scenarios of mineral prices, operating costs, and macroeconomic factors are conducted to evaluate the project's resilience to market changes.

3.1.3. Environmental Feasibility

Environmental impact is one of the main challenges in modern mining, and proper management is essential for obtaining the necessary authorizations and ensuring social acceptance of the project.

The main criteria in this area include:

- Environmental Impact Assessment (EIA): The project's impacts on soil, surface and groundwater, biodiversity, air quality, and landscape are identified and assessed. The competent environmental authority will oversee this process.
- Compliance with environmental regulations: The project must comply with local, national, and international environmental legislation, adopting corrective and preventive measures. Water management, which often requires specific authorizations from the Water Basin Authority is of particular importance.

- Restoration Plan (PREST): A detailed plan for land restoration and recovery after mining activities must be developed from the project's inception, ensuring that the affected area can be returned to a state similar to or better than its original condition. The mining authority is responsible for approving the PREST plan alongside the mining project.

3.1.4. Social Feasibility

Social acceptance and relationships with local communities are critical for the long-term viability of a mining project. The key aspects to consider include:

- Community consultation and participation: The project must involve transparent and continuous dialogue with affected communities and stakeholders, addressing their concerns and expectations, and promoting their involvement in decision-making processes (although the final decision rests with the competent authorities).
- Job creation and local development: Mining can be a significant source of employment and development for rural areas, generating economic opportunities that improve the quality of life for local populations.
- Social conflict management: Mining can create conflicts over the use of resources such as land and water. Proactive conflict management and the implementation of corporate social responsibility programs are essential to minimize social risks.

3.1.5. Legal and Regulatory Feasibility

A mining project must comply with all applicable legal and regulatory frameworks at both national and international levels. Key aspects include:

- Concessions and licenses: The project must secure all necessary licenses for mineral exploration, extraction, and processing.
- Labor regulations: Compliance with labour laws is essential to avoid conflicts and ensure worker safety.
- International trade standards: If the project involves exporting minerals, it must meet the commercial and quality requirements imposed by international markets.

3.1.6. Risk Assessment

Every mining project entails a series of risks that must be properly identified, evaluated, and managed. These risks can include:

- Geological risks: Uncertainty about the characteristics of the deposit and its continuity, or about the behaviour of the surrounding rocks.
- Market risks: Fluctuations in mineral prices or changes in global market conditions.
- Technical risks: Failures in extraction or processing methods that can affect efficiency and costs.
- Environmental risks: Unexpected environmental damage that may result in fines or suspension of operations.
- Social and political risks: Conflicts with local communities or changes in government policies that impact project operations, such as restrictions on energy mineral exploitation or overprotection of groundwater resources through limitations on water use.

3.2. Technical, Economic, and Environmental Factors

The viability of a mining project depends largely on the interaction of technical, economic, and environmental factors, which are interconnected and determine the success or failure of the project.

A comprehensive analysis must examine these three aspects holistically.

3.2.1. Technical Factors

Technical factors refer to the ability to extract and process minerals efficiently and profitably. These include:

- Resource quality and quantity: Initial geological studies determine the size and quality of the deposit, which defines the extraction techniques to be used.
- Mining methods: The choice between open-pit or underground mining depends on the depth, geometry of the deposit, and the mineral-to-waste ratio. This decision has implications for both capital expenditure (CapEx) and operating expenses (OpEx).
- Processing facilities in the highest degree of added value.
- Infrastructure and logistics: Access to facilities is crucial for material transportation and operational efficiency. Proximity to transport networks (railways, roads, ports) and energy sources is essential for minimizing costs.
- Technology and equipment: The availability and selection of suitable extraction and processing equipment are key to optimizing operations and reducing costs, enabling more efficient use of the mineral.
- Safety and risk management: Ensuring operational safety and managing technical risks (such as landslides, equipment failures, or explosions) are vital to avoiding operational interruptions and ensuring worker safety.

3.2.2. Economic Factors

Economic factors are critical to ensuring the profitability and viability of mining projects, with a key focus on the relationship between operating costs and revenue generation. The main aspects to consider are:

Impact on National and Regional Economy

Mining plays a fundamental role in the economy of producing countries, and its impact goes beyond direct revenues from mineral sales. In many regions like Alentejo, Extremadura, and Andalusia, mining significantly contributes to Gross Domestic Product (GDP), generating employment, tax revenue, and promoting infrastructure development.

At the regional level, mining can be a growth engine, particularly in rural areas, where job creation in mines has a multiplier effect on the local economy. Sectors like transport, construction, manufacturing, and services benefit from mining activity, creating business opportunities and improving the quality of life for local populations.

On a national scale, the export of strategic minerals can improve the trade balance, particularly in countries that heavily rely on the export of natural resources. Additionally, the foreign exchange generated by exports helps stabilize the economy and finance social and economic development projects.

Financing

Mining projects, due to their capital-intensive nature, require significant upfront investment to develop infrastructure, acquire equipment, and launch operations. The financing for these projects typically comes from a combination of private investments, bank loans, and in some cases, government support.

Investors and banks evaluate the project's long-term economic viability, risk profile, and the financial strength of the sponsoring company before providing funds. Securing financing is closely tied to the project's expected profitability and the market's ability to absorb the produced mineral.

In this context, the project's ability to generate adequate returns is essential to ensure the flow of capital. Internal rates of return (IRR), net present value (NPV), and liquidity analysis are key indicators guiding investment decisions.

It is important to note the role of government agencies in streamlining the initiation processes, fostering communication between promoters, and providing initial funding to support the start of operations, which will later be repaid through the development of economic activities.

Value Chain

The economic impact of a mining project goes beyond the extraction of minerals and encompasses an entire value chain that includes exploration, development, extraction, processing, transportation, and marketing, that includes in some cases exportation. Each link in this chain creates business and employment opportunities in related sectors.

- Exploration: Searching for new mining deposits through geological and geophysical studies is a key stage that ensures the long-term sustainability of the sector. Exploration companies, often small specialized firms (juniors), play a fundamental role and, in case of success, often transfer their findings to larger companies.
- Extraction and Processing: This is the core of the project. Technological advancements in mineral processing help reduce costs and maximize mineral recovery, improving project competitiveness.
- Transportation and Logistics: Moving minerals from mines to processing centres or export points requires efficient logistical infrastructure. Building roads, railways, and ports helps enhance the sector's competitiveness by reducing the costs associated with transporting large volumes of material.
- Export and Marketing: International markets are the primary destination for many extracted minerals, especially strategic minerals like copper, lithium, or gold. Participating in the global supply chain allows local economies to benefit from international prices and access new markets. The Critical Raw Materials Act promotes the internal marketing process of CRM to guarantee the European industry resilience and supply.

Revenue Projections and Profitability Analysis

The revenues of a mining project depend largely on fluctuations in international mineral prices, which are influenced by global supply and demand. Economic feasibility studies must include price projections based on market analyses and future scenarios.

In addition, operating and capital costs must be carefully controlled to ensure that the mining operation remains profitable, even in low-price scenarios. Companies must perform breakeven analysis to determine the minimum mineral price needed to cover costs and generate profits.

An economic sensitivity analysis is crucial to evaluating the project's feasibility under different market conditions. These studies help identify the most critical factors affecting profitability and provide a clear view of the risks associated with the project.

3.2.3. Environmental Factors

The environmental impact of mining is a significant challenge and requires thorough planning to mitigate negative effects on the environment. Environmental sustainability is essential to gain acceptance from regulatory authorities and local communities.

- Impact on soil and vegetation: Mineral extraction directly affects land use, destroying native vegetation and altering the landscape. Rehabilitation and restoration planning is essential to minimize these impacts.
- Water resource management: The intensive use of water in mineral processing and potential contamination of water sources through leaching and mining waste is a major environmental concern. Efficient water management and contamination reduction are key to the project's environmental viability.

- Air emissions and air quality: Mining generates dust and pollutant emissions that can affect air quality in surrounding areas. Implementing emission control technologies and creating buffer zones are essential measures to mitigate this impact.
- Mining waste: Proper management of the waste generated during extraction and processing is a crucial challenge. The safe storage of tailings and reducing waste generation are currently priorities for regulatory authorities.
- Biodiversity: Mining can affect local ecosystems and biodiversity, particularly in sensitive areas.

Environmental impact assessments must include a detailed evaluation of the effects on flora and fauna, as well as plans to minimize the impact and compensate for losses.

3.3. Viability in Alentejo

3.3.1. Economic Factors (operating costs, market access)

The economic viability of mining projects in Alentejo is strongly influenced by operating costs associated with extraction, processing, and transportation of minerals, as well as access to international markets. With its long mining tradition, Alentejo benefits from a rich geological base of metallic, industrial, and ornamental resources, allowing production costs to remain competitive compared to other European mining regions.

The Alentejo Regional Coordination and Development Comission (CCDR Alentejo, I.P.) is a public institute with administrative and financial autonomy that promotes regional development. CCDR Alentejo has a regional strategy called 'RIS3 Strategy Alentejo 2030' that recognises as one of its strategics objectives, the importance of sustainable exploitation of mineral resources in Alentejo by reinforcing the use of secondary materials and reducing waste.

Operating Costs

Mining in Alentejo has moderate operating costs compared to other areas in Europe, due to the availability of local resources, industry experience, and the use of advanced technologies. The presence of large deposits of polymetallic sulfides, marble, and granite foster an economy of scale, reducing unit extraction and processing costs.

Capital Expenditure (CapEx) in Alentejo is relatively high in the early years due to the construction of mining infrastructure, but these costs are amortized in the long term with a high return rate due to the quality and quantity of the available resources.

The metallic mining sector is provided with mineral processing plants to get copper and zinc concentrates, but there is not any refinery, neither pyrometallurgical nor hydrometallurgical, to get pure metal in the region with the loss of added value and independence in industry supply if the final customer is a third country out of Europe.

Another significant economic factor is the energy cost. Alentejo's increasing investment in renewable energy such as solar and wind power has lowered energy costs, positively impacting the sustainability of mining projects and reducing operating expenses.

Market Access

A key advantage for mining in Alentejo is its access to European and international markets. The region benefits from robust logistical infrastructure that supports efficient mineral exports to major industrial centers across Europe. However, there remains significant potential for improvement, particularly in strengthening railway connections and connection to maritime ports to enhance transportation efficiency and capacity. Copper, zinc, and marble from Alentejo find solid demand in international markets due to the quality of the material and its applications in various sectors (construction, technology, etc.).

Proximity to ports large ports like Sines, but also Setúbal, facilitates exports to other markets, including Asia and America, reducing logistical costs and enabling companies to access competitive prices in the global market.

At the European level, the exploitation of critical raw materials such as copper aligns with EU strategies to reduce dependence on imports from third countries, positioning the region as a strategic supplier within the European supply chain.

3.3.2. Environmental Factors (impacts and local regulations)

As part of the European Union, Portugal has implemented strict environmental legislation regulating the exploitation of natural resources, ensuring that projects are carried out with the least possible environmental impact.

Environmental Impacts

The main environmental impacts of mining in Alentejo include landscape alteration, water resource degradation, and solid waste generation. Polymetallic sulfide mines generate large amounts of tailings and waste, which must be managed properly to prevent contamination of soil and groundwater.

The mining industry also contributes to dust and gas emissions, which can affect air quality in surrounding areas. To mitigate these effects, mining companies in Alentejo already adopted, and are improving, modern emission reduction technologies and dust control measures, as well as implementing water recycling systems in washing and mineral processing.

Open-pit mining, particularly in marble quarries, represents a significant environmental challenge. These quarries leave visible scars on the landscape, prompting the implementation of landscape restoration programs aimed at rehabilitating mined areas once resources are depleted.

Local Regulations

As an EU member, Portugal strictly follows EU directives regarding Environmental Impact Assessments (EIA). All mining projects in Alentejo must comply with local and European regulations before obtaining operating licenses. This includes adopting preventive measures and mitigation plans to minimize negative impacts. There is room for improvement in terms of reducing the administrative burden and accelerate the emission of exploration and exploitation licenses, allowing prospection and mining to move forward safely and quickly.

A significant environmental challenge in the region is water resource management. Alentejo is a semi-arid area, which requires efficient water management for mining projects. Local regulations mandate water reuse and minimise consumption to protect local water resources and avoid conflicts with other economic activities such as agriculture. Although the Alqueva Dam, built in the early 21st century, offers substantial water capacity for demanding activities in the region, it does not appear operational enough to support mining demand.

3.3.3. Infrastructure in Alentejo (roads, transportation, energy)

Infrastructure is a critical factor in the viability of any mining project. In Alentejo, both existing infrastructure and planned improvements have a significant impact on the operating costs and efficiency of projects.

Roads and Transportation

Alentejo has a road network that connects the region to major industrial centres in Portugal and Spain. Mines in the region have access to roads that facilitate the transportation of minerals from extraction areas to ports and processing centres.

Proximity to Sines Port, one of the most important in Portugal, is a key logistical advantage that facilitates the global export of minerals. In addition, the connection to the railway network improves the efficiency of transporting large volumes of material, reducing costs and travel times.

However, in more rural or remote areas of Alentejo, roads require additional investment to improve load capacity and ensure that heavy transport does not cause significant damage to existing infrastructure.

The railway connection between Spain and Portugal requires further development, both in the north (Alentejo-Extremadura) and in the south (Andalusia-Algarve). The high-speed transport line will not be available for decades. The west-to-east road corridor between Lisbon and Valencia remains incomplete, with a significant section yet to be upgraded (national road N-430 between Mérida-Santa Amalia and Ciudad Real).

Energy

Alentejo has been a pioneer in developing renewable energy projects, particularly in solar and wind energy, allowing many mining projects to access cleaner and cheaper energy sources. This availability of renewable energy is a key differentiator that reduces operating costs and improves the environmental sustainability of mining operations.

The electric grid in Alentejo is sufficient to meet the needs of the mines, although additional infrastructure may be required in some cases to connect mining areas to the national grid. The stability of the power supply is crucial for ensuring the continuity of processing operations and avoiding costly interruptions.

Water

Given the semi-arid nature of the region, water availability is a critical issue for the viability of mining projects. Mining operators must invest in recycling and water reuse technologies, especially for projects that require large volumes of water for mineral processing.

Mines in Alentejo must design water management systems that minimize freshwater consumption and prevent groundwater contamination. Companies must comply with strict regulations regarding wastewater management and filtration systems.

3.4. Viability in Castile and León

3.4.1. Economic Factors

The economic viability of mining projects in Castile and León depends on several factors, including operating costs, access to national and international markets, and the capacity to generate employment and economic development in the region. Castile and León, with its long mining tradition and rich geology in metallic and industrial minerals, holds significant economic potential in the extractive sector.

Operating Costs

In Castile and León, operating costs vary depending on the type of exploitation and the mineral extracted. Slate and granite operations have relatively low operating costs compared to metallic minerals, due to the abundance of these resources and the existing infrastructure for their extraction and processing.

For metallic minerals, operating costs tend to be higher due to the need for specialized technologies and complex processing procedures. Despite this, rising international mineral prices have increased the profitability of projects in the region, spurring exploration and mining research initiatives.

The region benefits from a highly skilled workforce with historical mining experience, which reduces training costs and improves operational efficiency. However, a significant portion of this training has been linked to coal mining, which is currently in continuous decline due to government-imposed limitations.

Market Access

Castile and León is strategically located in the center of the Iberian Peninsula, providing relatively easy access to both national and international markets. The region's primary exports include roofing slate,

feldspar, glauber salt, tungsten concentrates, etc., which are in high demand in the European construction industry.

For metallic minerals, Castile and León has strengthened its capacity to export products to international markets thanks to proximity to ports and logistical infrastructure that facilitates the transport of processed minerals to global destinations.

The increasing demand for critical raw materials in the European Union for strategic sectors like electric mobility and energy transition has boosted interest in exploiting certain minerals in Castile and León, such as lithium and cobalt, positioning the region as a potentially key player in supplying these resources.

3.4.2. Environmental Factors

Environmental factors play a crucial role in the viability of mining projects in Castile and León. As part of Spain, the region is subject to strict environmental regulations at both national and European levels. Any mining project must undergo a thorough Environmental Impact Assessment (EIA) to obtain the necessary licenses.

Environmental Impacts

Landscape alteration: Open-pit mining, particularly for slate and some other ornamental stones, can significantly impact the local landscape. These operations leave visible scars in mountainous areas, which require restoration plans to rehabilitate the natural environment once extraction activities end.

Water resources: Metallic mining and the exploitation of industrial minerals can negatively affect local water resources, both in terms of consumption and potential contamination from heavy metal leaching. Mines must implement water management systems and waste treatment plans to ensure the protection of both groundwater and surface water.

Waste and emissions: Mining operations generate large amounts of waste that must be properly managed to minimize environmental impact. Open-pit operations, in particular, are susceptible to producing small-diameter atmospheric particulates, which require careful control to prevent their spread through the air.

Local Regulations

Castile and León is subject to national and European regulations on mining and environmental protection. Before beginning any mining operation, companies must submit an Environmental Impact Assessment that addresses the effects of the activity on the natural environment and proposes mitigation measures for the most severe impacts.

Mining companies are required to implement land restoration plans, ensuring that once operations are complete, the affected areas are rehabilitated, including reforestation and biodiversity recovery.

A crucial aspect is the management of water resources. Mining operations, especially those handling large volumes of metallic minerals, must implement water recycling technologies and wastewater treatment systems to prevent contamination of aquifers and nearby bodies of water.

3.4.3. Infrastructure in Castile and León

Infrastructure in Castile and León plays a crucial role in the viability of mining projects, facilitating the transportation of extracted minerals to markets and processing centers and ensuring the energy supply necessary for operations.

Roads and Transportation

Castile and León has an extensive road network connecting major mining areas with Spain's logistical and industrial centers. Good connections to other regions ensure efficient transport of minerals to markets, reducing transportation costs and improving project competitiveness.

The region also has a well-developed rail network, which aids in the transportation of large volumes of material from extraction areas to ports and processing plants. However, the direct line between

Madrid and Aranda de Duero has been interrupted by the collapse of a tunnel near Somosierra many years ago and has not been repaired. In the west, high-speed rail development has been underway in recent years, but the connection from Castile and León to Galicia and the Basque Country is still incomplete. The rail link to Cantabria remains based on an outdated 19th century route in many sections.

In logistical terms, proximity to ports like Gijón and Santander in northern Spain allows for the export of minerals to international markets, particularly in Europe and Latin America, a practice that has been ongoing for decades.

Energy

Castile and León is one of Spain's leading renewable energy producers, with significant installed capacity in wind and solar energy, generally promoted by major industrial consortia and supported by government tax incentives. This abundance of clean energy offers a competitive advantage to mining companies, allowing access to a reliable and low-cost energy supply.

Mines in the region rely on a robust electrical infrastructure to ensure the continuous operation of extraction and processing activities. In more remote areas, additional investments may be needed to improve connections to the national power grid, which remains underdeveloped in certain areas.

The shift toward renewable energy in mining projects not only reduces operating costs but also enhances the environmental profile of operations, aligning with the demands of international markets that increasingly value minerals with a low carbon footprint.

Water

As in other mining regions, the availability of water is critical for mineral processing. Castile and León has good water resource availability in most of its territory, though some drier areas require efficient water use and the implementation of recycling technologies.

Mining operations, especially those involving metallic mineral processing, must adopt water management systems that minimize consumption and prevent contamination. Local authorities require mining companies to submit water management plans as part of the project approval process.

3.5. Viability in Extremadura

3.5.1. Economic Factors

Extremadura, with its rich geology of metallic and industrial minerals, presents significant economic opportunities in the mining sector. The economic factors influencing project viability in this region include operating costs, demand for minerals in international markets, and the efficiency of accessing those markets.

Operating Costs

Operating costs in Extremadura can vary depending on the type of mineral extracted. For instance, the extraction of lithium and tungsten will involve higher costs due to the need for specialized technologies for their extraction and processing. However, these costs are offset by the high global demand for these minerals, which are essential for manufacturing electric vehicle batteries and other strategic industrial applications.

Industrial minerals such as clays and feldspars, which are abundant in Extremadura, have lower operating costs due to the relative simplicity of extraction and processing methods. Additionally, the development of local industries around these resources has helped to reduce logistics and transportation costs.

The region benefits from a skilled workforce and mining experience, reducing training costs and enabling efficient operation of mining activities. However, one challenge is attracting and retaining young workers, especially in rural areas where mining plays a key role in job creation.

Market Access

Extremadura's geographical position offers favourable access to national and international markets competitively, provided there is adequate infrastructure.

Furthermore, the growing global demand for critical raw materials has positioned Extremadura as a potential strategic supplier of key resources for the technology and energy industries. Lithium, in particular, has attracted significant interest from international investors due to its importance in the transition to cleaner technologies.

At the national level, industrial minerals extracted in Extremadura, such as clays and feldspars, are essential for Spain's ceramics and construction industries, ensuring steady demand in the domestic market.

3.5.2. Environmental Factors

Mining in Extremadura is subject to strict environmental regulations at both the national and European Union levels. Mining projects must comply with all legal requirements related to environmental protection, ensuring operations are carried out sustainably.

Environmental Impacts

Mining, especially for metallic minerals like tungsten and lithium, can cause significant environmental impacts, such as landscape alteration, intensive water use, and waste generation. These impacts must be minimized through the implementation of cleaner technologies and sustainable practices.

The impact on water resources is particularly relevant in Extremadura, a region with semi-arid areas. Mining operations must ensure efficient water management to avoid over-exploitation of aquifers and minimize contamination of surface and groundwater sources.

Mining operations also generate large amounts of solid waste, such as tailings and sterile material. Proper waste management and storage are essential to prevent soil and water contamination. In Extremadura, mining projects must adhere to strict waste management regulations, including site rehabilitation after operations have ended.

Local Regulations

As in other regions, Spain's environmental laws and EU directives set clear requirements for environmental impact assessments (EIA) and the issuance of permits for mining activities. Mining projects in Extremadura must undergo thorough EIAs that evaluate the potential environmental effects of extraction activities and propose mitigation measures.

Restoration plans are a crucial component of any mining project in Extremadura. Companies must commit to restoring affected areas after mining is completed, including landscape rehabilitation, reforestation, and ecosystem recovery.

Additionally, mining companies are required to implement continuous monitoring systems to ensure that operations comply with environmental standards throughout the project's life cycle, from exploration to mine closure.

It is worth noting that the two ongoing lithium mining projects in Cáceres have experienced different developments: the Cañaveral project is proceeding as planned, while the San José de Valdeflores project has faced strong social opposition due to its proximity to Cáceres city. This has led to the modification of the mining project to an underground operation, reducing its environmental impact.

3.5.3. Infrastructure in Extremadura

Existing infrastructure in Extremadura plays a crucial role in the viability of mining projects. Access to roads, transport networks, and an adequate energy supply is essential for the success of mining operations.

Roads and Transportation

Extremadura has a well-developed road network that connects major mining areas with national and international transport routes. The region is well-connected by road to Portugal and Madrid, as well

as the Ruta de la Plata, a highway that links the southwest and northwest of the peninsula. This facilitates the export of mineral substances to international industrial centers through Atlantic and Cantabrian ports. However, as previously mentioned, the N-430 road requires expansion to handle the heavy traffic and connect the Lisbon-Valencia axis, providing access to the important Port of Valencia in the Mediterranean.

Additionally, the railway connection remains a significant weakness in the region. The use of the line connecting Zafra with the Port of Huelva has diminished, and there is no clear timeline for the development of a high-speed connection with Portugal between Badajoz and Lisbon. The construction of an internal corridor (Plasencia-Cáceres-Mérida-Badajoz) is nearing completion, but it will not be connected to Madrid for the time being, and it is not operational despite its official inauguration in May 2022. The existing line still retains 19th-century sections where trains must run at very low speeds.

Mining operations would benefit from access to the rail network, facilitating the transportation of large volumes of material, particularly industrial and heavy metallic minerals, which would reduce logistical costs. Therefore, additional infrastructure investments are needed to improve load capacity and ensure that mines are adequately connected to markets.

Proximity to Portugal also provides a strategic advantage, allowing access to international ports like Sines, facilitating the export of minerals to markets in America and Asia.

Energy

Energy is one of the most important components in the operation of mining projects. Extremadura has made significant progress in adopting renewable energy sources such as solar and wind energy, which have helped reduce energy costs for mining operations and improve the sustainability of the projects.

Mines in Extremadura are well-connected to the national electrical grid, ensuring a stable and reliable energy supply for processing and extraction operations. However, in some more remote areas, further investments may be required to extend the electrical grid to ensure the viability of mining projects.

Investments in renewable energy not only help reduce operating costs but also improve the environmental profile of mining projects, aligning with the demands of international markets that increasingly value products with a low carbon footprint.

Water

Water use in mining is a critical factor in Extremadura, especially due to the semi-arid nature of some areas. The availability of water for extraction and processing must be carefully managed to avoid competing with other uses, such as agriculture.

Mining companies are required to implement water recycling systems and minimize the consumption of freshwater by using technologies that allow for the reuse of water in production processes. This approach is essential to reduce the impact on local water resources and comply with environmental regulations set by regional and national authorities.

3.6. Viability in Andalusia

3.6.1. Economic Factors

Andalusia is one of the most important mining regions in Spain and Europe, particularly due to the Iberian Pyrite Belt, which contains a large number of polymetallic massive sulfide deposits. The key economic factors determining the viability of mining projects in this region include operating costs, demand for strategic minerals, and access to national and international markets.

Operating Costs

Operating costs in Andalusia vary considerably depending on the type of mineral and extraction method used. Metal mining, predominant in the region due to the abundance of copper, zinc, and lead in the Pyrite Belt, tends to have high operating costs, as advanced technology is required for mineral extraction and processing, along with significant support infrastructure.

However, economies of scale in mines such as Riotinto and Aguas Teñidas help reduce the cost per unit of extracted mineral, making large-scale operations profitable. These highly automated mines benefit the region not only through the revenue generated but also by creating jobs and developing infrastructure.

The Las Cruces mine achieved high efficiency due to its open-pit nature, high-grade ore, and the characteristics of its processing method (high-grade cathode production via atmospheric leaching). However, the project is currently suspended, with plans to restart as an underground operation in the medium term.

Another relevant aspect is energy prices. Andalusia has made advances in adopting renewable energy, particularly solar and wind, which have helped reduce energy costs for mining operations. Mining companies are increasingly committed to sustainability, using cleaner energy sources to minimize environmental impact and reduce long-term operating costs.

Market Access

Andalusia's strategic geographical position provides access to European and international markets via its ports on the Atlantic and Mediterranean. This facilitates the export of mineral products to European countries and global markets. The Port of Huelva is one of the most important for the transportation of metallic minerals, with direct routes to Asia and America.

Additionally, the proximity of European markets is key to the commercialization of industrial minerals, such as gypsum and fluorite, which are in high demand in the construction industry. This closeness reduces transportation costs and enhances the competitiveness of mining operations. The Alquife iron mine in Granada currently produces minerals destined entirely for export via the ports of Málaga and Motril.

Andalusia is also well-positioned to take advantage of the demand for critical minerals within the European Union. The copper and zinc extracted from the Pyrite Belt are essential components for the energy transition and the production of green technologies, positioning Andalusia as a strategic player in the European supply chain.

The metallic mining sector is provided with mineral processing plants to get copper, lead and zinc concentrates, but the most average of mineral concentrates are not refined, neither pyrometallurgical nor hydrometallurgical, to get pure metal in the region with a very high loss of added value and independence in industry supply if the final customer is a third country out of Europe.

In the last years two important advances have reached the processing technologies due to, in one hand, a higher degree copper deposit at Las Cruces that allow to get hydrometallurgical pure copper and the follow-up researching process to concentrate and refine the underlaying primary mineral and in other hand, to the relevant new process E-LIX, that include an electrical lixiviation and electrowinning and it's being operated in ATALAYA mine at Riotinto (Huelva). These technologies vary the scope of markets focusing now in the last years two important advances have reached the processing technologies due to, focusing now on final customers with an important increasing of added value and with an important increasing of added value and with an important increase of high qualification number of employs in the area.

In addition, the Atlantic Copper refinery, one of the biggest and efficient in Europe is another important facility that must be considered in the available infrastructures for mineral processing in the region.

3.6.2. Environmental Factors

Environmental factors are a crucial component for the viability of mining projects in Andalusia, which is subject to strict national and European regulations. Mining has a significant impact on the natural environment, and operations must comply with sustainability and environmental responsibility standards.

Environmental Impacts

The primary environmental impact of mining in Andalusia is landscape alteration, especially in open-pit mines like Riotinto. Extracting large volumes of mineral generates solid waste, which must be managed properly to avoid soil contamination and nearby water sources.

Dust and gas emissions generated during mining activities also pose an environmental challenge, particularly concerning air quality near the mines. To mitigate these effects, companies have implemented emission control systems and dust reduction technologies.

Water resource management is another key challenge in Andalusia, a region with water scarcity in many areas. Mining operations must ensure efficient water use, with recycling and wastewater treatment systems to prevent contamination of both groundwater and surface water. All activities are linked to obtaining the necessary administrative authorizations.

Local Regulations

Environmental regulations in Andalusia are stringent and aligned with EU directives. All mining projects must submit an Environmental Impact Assessment (EIA) before obtaining operating permits. This study must include a detailed analysis of effects on biodiversity, soil, water, and air, along with mitigation measures to minimize negative impacts.

Mines in Andalusia are also subject to restoration and rehabilitation plans after operations conclude. Mining companies are required to present detailed plans to restore the natural environment affected band extractive activities, including vegetation recovery and landscape improvement.

A significant challenge for companies is ensuring continuous compliance with environmental regulations throughout the project life cycle. This includes implementing environmental monitoring systems to ensure that mining operations are conducted within the established legal parameters, avoiding penalties and guaranteeing the sustainable exploitation of resources.

3.6.3. Infrastructure in Andalusia

Infrastructure in Andalusia is crucial for the viability of mining projects, facilitating logistics and ensuring a stable energy supply for operations. The region has a well-developed transportation network, including roads, railways, and ports, along with robust energy infrastructure.

Roads and Transportation

Andalusia is connected band a comprehensive road network, enabling the transport of minerals from extraction sites to export hubs. Major mining areas, such as those in Huelva and Sevilla, are well-connected to the region's ports and industrial markets.

Rail transport plays a critical role in large-scale mining, efficiently moving large volumes of minerals to Andalusian ports. The railway network also connects Andalusia to the rest of Spain and Europe, enhancing the competitiveness of mining operations.

The Port of Huelva is one of the main infrastructures for exporting minerals like copper and zinc to international markets. Its capacity and proximity to the Pyrite Belt mining areas are key in reducing transportation costs and improving delivery times. As previously mentioned, the ports of Málaga and Motril handle iron oxides from the Alquife mine, and Sevilla has Historically supported the export of Las Cruces copper cathodes. Additionally, the Port of Algeciras, one of Europe's largest, is strategically important, and improving its rail connection with Antequera-Bobadilla remains a strategic objective.

Energy

Andalusia is a leader in renewable energy, benefiting mining operations in the region. The increasing capacity of solar and wind energy has allowed mining companies to access cleaner, cheaper energy sources, reducing operating costs and enhancing sustainability, though further progress is still needed.

Most mines in Andalusia are well-connected to the national power grid, ensuring a stable energy supply for extraction and processing operations. However, in some areas, additional investments are needed to extend power lines or establish substations to improve connectivity. As of 2022, important substations in Huelva province include Puebla de Guzmán and Palos, both 400/220 kV, serving as

backbone nodes of the transport grid. The Puebla de Guzmán substation is an interconnection point with Portugal via a long line to Guillena, and a second 400 kV line connects Palos with Guillena for conventional generation evacuation.

The combination of renewable energy with mining operations not only reduces operating costs but also enhances the reputation of mining in Andalusia, aligning it with European carbon reduction goals.

Water

Water availability is a critical factor for mining in Andalusia, especially in semi-arid regions like Almería and Huelva. Mining companies must adopt advanced water management technologies to minimize consumption and ensure operations do not negatively affect local water sources. The Las Cruces mine has been closely monitored for its interaction with the Niebla-Posadas 05.49 aquifer, as required band the basin authority, which led to the construction of a complex drainage and reinjection system to reduce net water consumption.

In all cases, mining operations must comply with strict regulations regarding water use and treatment, ensuring wastewater is properly treated before being returned to the environment. The use of water recycling systems is essential to maintain the environmental viability of projects in water-scarce regions.

4. Cost Analysis

Cost analysis is an essential part of evaluating the feasibility and profitability of any mining project. Mining is a capital- and resource-intensive industry, and the cost structure varies significantly depending on several factors, such as the type of mining (underground or open-pit), the type of mineral being mined, the geology of the deposit, the technology used, and local economic and environmental conditions.

In general, mining costs can be divided into two main categories:

- Capital Expenditures (CapEx): These are related to the initial investment in infrastructure and equipment.
- Operating Expenditures (OpEx): These cover the daily operational costs, including extraction, processing, maintenance, and transportation.

Underground vs. Open-Pit Mining

Underground mining typically has higher operating costs than open-pit mining, due to increased demands for safety, ventilation, material transport, and labor. However, capital costs for underground projects can be lower, as these tend to be smaller in scale and require less earth movement. Open-pit mining, on the other hand, involves higher initial costs for the removal of large volumes of material but is more efficient in terms of production and operating costs, particularly for large low-grade deposits.

Impact of Mineral Type on Costs

The type of mineral extracted also significantly impacts costs. Metallic minerals, such as gold, copper, and zinc, require complex extraction and refining processes, leading to higher operational costs, though their added value is typically much higher. In contrast, mining of industrial minerals (e.g., clays and feldspar) or ornamental rocks (e.g., marble and granite) generally incurs lower operating costs due to the simplicity of extraction and processing.

Local Conditions and External Factors

Cost analysis in mining must also consider local and external conditions. Key factors include the availability of infrastructure (roads, energy, transportation), labor costs, and energy prices, all of which are fundamental in determining a project's feasibility. Additionally, compliance with environmental regulations and local laws has become increasingly important, especially in the current context of sustainability and corporate Responsibility.

This chapter will provide a detailed analysis of the various cost components in the mining industry, offering a comprehensive view of how these factors influence the profitability of mining projects and how they vary based on the characteristics of each project and region.

4.1. Estimation of Operating Costs (OpEx)

Estimating operating costs (OpEx) in the mining industry is essential to determining the profitability and viability of any project. Operating costs include all expenses required to keep a mining operation running over time, and are typically related to extraction, processing, transportation of minerals, and other operational factors such as maintenance, personnel, and energy. Unlike capital expenditures (CapEx), which represent initial investments, operating costs are recurring throughout the life of the mine.

4.1.1. Extraction Costs

Extraction costs depend largely on the type of mining conducted:

- Open-pit mining: This type of mining generally has lower operating costs compared to underground mining. However, it requires the removal of large amounts of overburden (waste material) before accessing the ore, increasing costs in the early stages of operation and potentially facing surface restrictions (e.g., protected areas). Key costs include earthmoving, heavy machinery use (trucks, excavators), and fuel and energy consumption for extraction activities.
- Underground mining: Operating costs in underground mining tend to be higher due to the need for ventilation systems, safety measures, tunnel support, and underground transport systems for extracted ore. Additionally, accessing the deposit may require the construction of galleries, ramps, or shafts, which increases costs related to skilled labor and technology.
- Size and geometry of the deposit: Larger deposits or those with regular geometries allow for more efficient operation, reducing operating costs. Low-grade disseminated deposits (low mineral concentration) require processing larger volumes of material, which can significantly increase operating costs.

4.1.2. Processing Costs

A significant portion of operating costs comes from mineral processing, including crushing, grinding, concentration, and in some cases, refining. These processes demand high energy consumption and the use of specific chemicals to separate the ore from the rock. Processing costs vary depending on the type of mineral extracted:

- Metallic minerals: Such as copper, gold, zinc, or silver, require complex and costly processing methods like flotation, leaching, or smelting. The use of chemicals, such as sulfuric acid for copper leaching or cyanide for gold recovery, increases operating costs.
- Industrial minerals and ornamental rocks: Processing costs for industrial minerals (e.g., clays, feldspars) and ornamental rocks (e.g., marble, granite) are lower compared to metallic minerals, as processing methods tend to be simpler, such as cutting and polishing in the case of ornamental rocks.

Additionally, metallurgical recovery is a key factor in processing costs. A higher recovery rate—i.e., a greater amount of ore recovered per ton processed—lowers the unit production costs.

4.1.3. Labor Costs

Mining is a labor-intensive industry, and personnel-related costs represent a significant portion of operating expenses. These include salaries, benefits, as well as the costs associated with training and worker safety. Underground mining typically requires more specialized labor compared to open-pit mining, which increases operating costs. Additionally, costs can be influenced band local labor market conditions, labor policies, and the availability of skilled workers in mining regions.

4.1.4. Energy Costs

Energy consumption is one of the most significant components of operating costs, especially in large-scale mines operating 24 hours a day. The main uses of energy in mining include:

- Heavy machinery: Dump trucks, excavators, and drilling equipment consume large amounts of fuel in open-pit operations. In underground mines, transportation and ventilation systems also require high energy consumption.
- Processing: Crushing and grinding operations, which prepare the ore for further treatment, consume significant amounts of electricity. Energy costs can vary significantly depending on the mine's location and available energy sources (conventional or renewable).

Some regions are investing in renewable energy to reduce energy costs and improve sustainability. Areas with abundant solar or wind energy can benefit from lower operating costs, potentially enhancing long-term profitability.

4.1.5. Maintenance and repair

The maintenance of machinery, processing equipment, and infrastructure is essential to ensure the continuous operation of a mine. Maintenance costs can vary significantly depending on the mine's operational conditions and the type of machinery used. Regular preventive maintenance reduces the risk of equipment failures, which could result in costly production stoppages.

Maintenance is particularly relevant in underground mining projects, where the safety of installations and equipment is critical to prevent accidents and ensure worker welfare.

In the case of processing plants, maintenance is a crucial activity, often involving complete operational shutdowns during specific periods. These shutdowns are a critical task that requires careful pre-planning to optimize duration and minimize accident risks, especially since many non-regular personnel may access the site during this time.

4.1.6. Transportation and Logistics Costs

Transportation costs are another important component of operational expenses, especially if the extracted mineral must be transported long distances for processing or export. These costs can include:

- Land transport: Using trucks or trains to transport the ore from the extraction site to processing plants or export ports. The distance to the final market is a determining factor.
- Maritime transport: For minerals destined for international markets, maritime transport costs can be significant, depending on proximity to ports and available trade routes.

Mines close to well-developed transportation infrastructure, such as ports, railways, and main roads, tend to have lower transportation costs, improving the project's viability.

4.1.7. Compliance with Environmental Regulations

Due to its environmental impact, mining is subject to strict regulations regarding waste management, conservation of natural resources, and restoration of areas affected band extraction operations. Compliance with these regulations generates additional costs, including:

- Waste management: Proper handling of mining waste, including tailings and overburden, requires investments in infrastructure such as tailings dams and containment systems to prevent contamination.
- Mine rehabilitation and closure: At the end of a mine's life, companies must undertake full site rehabilitation, including landscape restoration and mitigation of environmental impacts. These costs can be significant but are essential to comply with local and international regulations.

Currently, Europe enforces high environmental standards, which are implemented in practice through rigorous oversight band regulatory bodies.

4.2. Comparative Analysis Between Regions

The viability of mining projects in the regions of Alentejo (Portugal) and Castile and León, Extremadura, and Andalusia (Spain) varies significantly depending on technical, economic, environmental, and infrastructural factors. While all regions present significant opportunities in terms of mineral resource exploitation, the comparative analysis reveals that Andalusia appears to have a stronger medium-term potential due to its advanced infrastructure, mining experience, and global demand for its resources. Extremadura has promising projects in Critical Raw Materials (CRMs) and stability in ornamental stones, an aspect also reflected in Castile and León. Alentejo plays a strategic role, especially in the production of ornamental stones, polymetallic sulfides, and shows medium-term potential in critical raw materials.

4.2.1. Economic Factors

This section focuses on a detailed comparative analysis of the economic viability in these regions based on operational costs, resource accessibility, and their market positioning in Europe and internationally. In short, operating costs and market access are key aspects in evaluating the potential of these regions:

- Andalusia: This region stands out economically due to the large deposits of copper, zinc, and lead in the Iberian Pyrite Belt. Large-scale operations like Riotinto and Aguas Teñidas allow for economies of scale that reduce unit production costs. Projects such as Aznalcóllar (Los Frailes) and Las Cruces (PMR) are set to begin production. Additionally, Andalusia benefits from access to international markets, particularly through the Huelva port, facilitating exports to Europe, Asia, and America. The growing demand for critical minerals for the energy transition positions Andalusia as a key player in Europe if some ongoing exploration initiatives are successfully developed. As it's been settled before, the recent advances on metallic minerals processing are expected to give a substantial twist to the metal production in the region going further to the concentrates production to pure metal production.
- Extremadura: The region has promising lithium and tungsten projects, which hold great economic potential due to the rising demand for these minerals in the battery and green technology industries. However, operational costs in some areas of Extremadura can be high due to its more remote location and limited infrastructure compared to Andalusia. Despite this, lithium and other strategic metallic minerals place Extremadura on the radar of international investors, with a large battery factory potentially becoming a reality in the region.
- Castile and León: In terms of operational costs, Castile and León's profile is strongly influenced band its substantial ornamental and industrial stone sector, particularly slate, which offers lower operating costs and easy access to European markets. Slate and granite mining are some of the most relevant mining activities, characterized band low technical complexity, making them a constant source of income, although of lesser magnitude and with lower personnel training demands.
- Alentejo: The projects in Alentejo are dominated band ongoing polymetallic sulfides operations and the extraction of limestone, marble and granite, which are highland valuable in the global construction and decoration markets. Operating costs in Alentejo are relatively low, making the region a competitive producer in the mining sector. However, its access to international markets is more limited compared to Andalusia, although the Sines port in Portugal provides an important export route. Logistical and connectivity challenges arise, and all above mentioned regions would benefit from its resolution.

4.2.2. Environmental Factors

This section provides an in-depth analysis of the environmental challenges across the four regions, with a focus on sustainability for mining operations. Each region faces specific environmental challenges, and managing these impacts is essential for ensuring the long-term viability of mining projects.

- Andalusia: Mining in Andalusia, particularly in the Iberian Pyrite Belt, generates large amounts of solid waste and presents risks of water contamination. However, mining companies have implemented advanced waste treatment systems and clean technologies to mitigate these effects. Local and European regulations are strict, and mining operations must comply with restoration plans and continuous environmental monitoring.
- Extremadura: Similar to Andalusia, projects in Extremadura, particularly in lithium and tungsten mining, face significant environmental challenges, especially when production begins. Water use is a critical factor, especially in a semi-arid region with limited water resources. Mining operations must adopt advanced water management systems to minimize environmental impact, adhering to strict regulations on water use and treatment.
- Castile and León: Environmental impacts in this region are more associated with the extraction of slate, which tend to be less invasive than metallic mining in terms of waste generation and chemical use. However, open-pit mining can significantly alter the landscape, requiring mine restoration plans to rehabilitate affected areas, as required band applicable legislation, similar to other regions.
- Alentejo: The exploitation of limestone, marble and granite in Alentejo generates considerable environmental impact, especially in terms of landscape alteration. However, these projects tend to be more manageable from an environmental perspective compared to metallic mining (although these are underground mining projects). Local regulations require quarry restoration once resources are exhausted, and reforestation and environmental recovery plans are being implemented in some areas, that are being implemented by most of the quarrying companies. Metallic mining operations in Alentejo have also adopted more sustainable practices, leveraging advancements in technology and digital infrastructure to continually reduce their environmental footprint and enhance sustainability efforts.

4.2.3. Infrastructure Evaluation

This section provides an in-depth analysis of the infrastructure across the four regions, with a focus on logistics for mining operations. The availability of suitable infrastructure is a key factor in reducing operating costs and ensuring access to international markets.

- Andalusia: The infrastructure in Andalusia is the most advanced among the compared regions. Mines are well-connected to the railway network, and access to the Huelva port (among others) facilitates international exports. Additionally, the region has solid energy capacity, including renewable energy, which reduces operating costs and improves the sustainability of the mines.
- Extremadura: Extremadura has a less developed transport infrastructure compared to Andalusia. Although the region is connected to the national road network, some remote mining areas require significant improvements, particularly in railway infrastructure. The lack of direct access to major ports also raises transport costs, especially for the efficient export of metallic minerals.
- Castile and León: The region has a good road network and access to ports in northern Spain, facilitating the export of its mineral products. Proximity to Portugal also provides access to additional markets. However, the development of energy infrastructure and the availability of renewable sources are still growing compared to Andalusia.
- Alentejo: Alentejo is well-connected band road and has access to the Sines port, which facilitates the export of marble and granite. However, infrastructure in rural areas could benefit from additional investments to improve the efficiency of transporting heavy materials from quarries to processing and export centers. It is also important to note the lack of rail connection between the interior of Alentejo to ports, and to the Spanish rail system. Which difficults exportation prices of quarries products, among other goods.

4.3. Evaluation of Project Potential in Each Area

The prospective or potentiality for CRMs in each region is a combination of the presence of the mineral resource in the territory and the profitability of a mining project, as is a key factor in determining its technical viability. Evaluating the profitability in the different regions analyzed—Andalusia, Extremadura, Castile and León, and Alentejo—requires a detailed assessment of capital expenditures (CapEx), operational expenses (OpEx), mineral market prices, and income and return on investment (ROI) projections. Additional factors like the internal rate of return (IRR) and net present value (NPV) offer a clearer view of the project's ability to generate profits throughout its life cycle.

Each region has specific characteristics that influence profitability, whether due to the type of mineral, economic and logistical conditions, or regulatory and environmental environments. Below is a breakdown of potentiality projections band region.

One of the main obstacles to mineral resource extraction is the Social License to Operate (SLO), as stakeholders often raise concerns about environmental protection and the proximity of operations to populated areas. Every region has a certain level of difficulty in obtaining SLOs to a specific operation according to their environmental, legal, and social settings.

This presents a challenge since mineral deposits cannot be relocated for exploitation. Another significant challenge arises from the conditional zoning of the area of interest, as defined by land use planning, for example. These restrictions can complicate the implementation of mining operations, generating stakeholder concerns and making it difficult to obtain the necessary licenses.

To successfully implement an operation, it's crucial to effectively manage the environmental, social, and governance challenges. This approach reduces risks and minimizes conflicts with the affected communities, creating shared value and addressing stakeholder concerns. Operations with solid management, transparency, and accountability for their sustainability to the environmental, social, and governance aspects are more likely to obtain SLOs.

4.3.1 Potentiality in Andalusia

Key Deposits

The Iberian Pyrite Belt is the most important source of mineral resources in Andalusia, featuring projects such as Riotinto, Aguas Teñidas, and upcoming developments at Aznalcóllar and Cobre Las Cruces. These mines produce, or will soon produce, mainland copper, zinc, lead, and silver, minerals that are in high demand globally, particularly for the energy transition.

Revenue Projections

The high demand for copper, essential for renewable technologies and electrical systems, secures a stable and growing market. Copper and zinc prices have shown an upward trend, which ensures robust projected revenues from these projects. Additionally, while extraction costs are high, they are balanced band economies of scale offered band large deposits.

Profitability Factors

Advanced infrastructure in terms of transportation and access to renewable energy reduces long-term operating costs, enhancing project profitability. Proximity to European markets and strong export capabilities through key ports also ensure a steady revenue stream.

The existing refineries for processing concentrates; Atlantic Copper, Cobre Las Cruces and E-LIX ATALAYA are crucial for the establishment of an ecosystem of metal producers in Andalusia.

Conclusion

Andalusia offers the highest projected profitability in the medium to long term, thanks to a combination of large deposits, market access, and strong infrastructure.

4.3.2. Potentiality in Extremadura

Main Deposits

The key mining projects in Extremadura focus on lithium and tungsten extraction, both considered strategic for high-tech industries and the energy transition. Lithium, in particular, is highland attractive due to its crucial role in battery manufacturing for electric vehicles.

Revenue Projections

The prices of lithium have risen significantly in recent years, driven band demand for batteries and energy technologies. This makes lithium projects in Extremadura especially promising in terms of long-term income. Tungsten, while less volatile, has a stable market in the defence and precision tools industries.

Profitability Factors

Operational costs in Extremadura may be higher due to limited infrastructure and the need to transport minerals over long distances for processing and export. However, the strategic value of extracted minerals and potential investments in energy and logistics infrastructure improvements enhance long-term profitability. The region is also affected band depopulation challenges, which may influence labour costs and workforce availability.

Conclusion

Profitability in Extremadura is high, particularly for lithium projects, provided international demand remains strong, and infrastructure improvements are made to support the region's growing mining sector.

4.3.3. Potentiality in Castile and León

Main projects

Current projects in Castile and León are primarily focused on the extraction of industrial minerals and ornamental stones. The region's historic mining of metals and coal is no longer a major sector.

Revenue projection

The minerals Currently exploited in the region, particularly for construction, have a stable demand, both domestically and internationally. This ensures a steady stream of revenue.

Profitability factors

The region benefits from favourable transport infrastructure, which facilitates market access. However, compared to other regions with higher-value minerals, the profitability is limited. Additionally, the availability of specialized labour is a concern, as it can increase the cost of operations.

Conclusion

Castile and León offers moderate profitability. The most relevant current projects provide long-term stability, though the profit margins are lower compared to regions exploiting more valuable resources.

4.3.4. Profitability in Alentejo

Main projects

Alentejo is recognized for its extraction of marble, limestone and granite, making it one of the leading producers of ornamental stones in Europe. These materials are highland demanded in both the construction and decoration industries, domestically and internationally. Alentejo is also recognized by its copper and zinc extraction. Located in the Iberian Pyrite Belt, it's impossible to overcome the importance of this VMS deposit that provides the largest source of Cu, Zn and Pb in Europe.

Revenue projection

Alentejo's marble, renowned for its high quality and aesthetic appeal, allows it to compete in international high-end markets. Despite global competition, Alentejo's ornamental products maintain a stable niche market, ensuring long-term stable revenues. Additionally, the extraction of polymetallic sulfides has an extremely favourable international context, given the rising demand for strategic metals.

Profitability factors

Alentejo's relatively low operational costs compared to other regions make it a competitive producer. Infrastructure for transportation, while not as developed as in Andalusia, is sufficient to meet the logistical needs of the industry, with the port of Sines facilitating exports to global markets. However, Alentejo's growth potential is somewhat limited band the lack of strategic mineral projects, which are gaining more attention globally.

Conclusion

Alentejo demonstrates stable profitability with reduced risks, primarily due to the consistent demand for its ornamental stones and metal resources. However, future growth may be constrained compared to regions that focus on more strategic, high-value minerals unless new mining projects are developed to target these sectors.

5. Potential and of relevant chemical elements

This chapter aims at summarising the present situation in relation to the most relevant chemical elements, both CRMs and other substances, for any of the target regions considered. The available information and data may not be updated, hence the following remarks might be further enhanced.

Gold (Au)

Alentejo

- Main Deposits: The region of Montemor-o-Novo has a collection of historical mines and abandoned tailings/waste piles from gold mining among other minerals such as Cu, Fe, Sb, As. On the other hand, Lagoa Salgada also presents gold mineralization associated with VMS ore deposit.
- Operational status: There are no active mining operations, however, exploration activities are ongoing in Lagoa Salgada. Au, is mainly exploited in Alentejo as secondary mineral that results from the extraction and processing of other minerals.
- Resource Volume Estimation: In Lagoa Salgada, the proven reserve for gold is 0,75 pmm in a mass of 2,100 kt. No other specific resource volume estimates for gold were found in the available documents
- Source of information: (3) METALOGENETICO_ZSP_400K_Memoria.pdf; (24) Lagoa Salgada Mineral Reserve Estimate - Effective July 2023; (25) portalgeo – Direção-Geral de Energia e Geologia

Castile and León

- Main Deposits: Historic deposits exist specially in the Northwest areas, such as Las Médulas, where gold has been identified and exploited in alluvial deposits and rock formations. Alluvial deposits were intensively exploited in Tertiary and Quaternary materials with hydraullic techniques, such as the called “ruina montium”, which consisted of using large quantities of water to erode the mountains and liberate the gold-bearing ore; the most outstanding mine of this type is Las Médulas, the largest open-pit gold mine in the Roman Empire and one of the most important in the ancient world.

  Primary deposits are found mainly in quartz veins, but also in skarn and Carlin-type deposits with some other metals such as Cu or As.

- Operational Status: There are no active mines in Castile and León. In recent times gold has been explored in different types of primary deposits, e.g. Carlin type in Salamón; skarn in Carracedo-Estalaya; veins in Salientes-Cuevas del Sil, Andarraso, Prada-Andiñuela and Pino del Oro, most of them in León province. In several periods along the 20th century there were some explorations projects on Quaternary alluvial deposits, as in the river Omañas, Duerna and Eria, all of them in León province.
- Resource volume estimation: It is estimated that the Romans extracted approximately and 1,650,000 kilograms (1,650 tonnes) of gold during the mining period between the 1st century and BC and the 3rd century and AD. Available estimations of Salamón project yield a resource of 0.76 Mt @ 6.64 gAu/t. Estimations in secondary mineralizations are 23 Mm^3 @ 150 $mgAu/m^3$ in the Omañas project, 3.6 Mm^3 @ 110 $mgAu/m^3$ in the Valduerna project, and 27.6 Mm^3 @ 109 $mgAu/m^3$ in the Eria alluvial. Regarding Las Médulas, it has been estimated that still there are onsite 800-1,000 Mm^3 @ 50 $mgAu/m^3$.
- Source of information: (1) Mapa Geológico y Minero de Castilla y León (SIEMCALSA, 1997). (21) La Minería en Castilla y León, SIEMCALSA (2007).

Extremadura

- There is historical evidence of gold in the region, especially during Roman times, but no recent data on specific volumes or detailed reserves have been found in the documents reviewed.

Copper (Cu)

Alentejo

- Main deposits: Areas within Alentejo, such as the Neves-Corvo and Aljustrel mines, are notable sites for copper mining. On the other hand, Lagoa Salgada exploration project also presents copper mineralization associated with VMS ore deposit.
- Operational Status: Some of these deposits are active land being exploited, primary land focusing on copper, zinc, and associated metals.
    - Active Mines: The Neves-Corvo and Aljustrel mines in the Iberian Pyrite Belt is one of the primary sources of copper in Portugal. These mines are operational and are a significant contributor to the region's copper production.
    - Processing Facilities: Neves-Corvo also includes facilities for processing and extracting zinc from the mined ore, besides copper. Aljustrel is investing in the same processing lines.
    - Exploration activities are ongoing in Lagoa Salgada, for copper and other metallic minerals.
- Resource Volume Estimation: The Neves-Corvo mine and Aljustrel, has reserves estimated in the range of tens of millions of tons of copper ore, with varying copper grades typically between 2% and 4%. The exact volume can vary based on ongoing extraction rates and exploration activities. Nevertheless, in Lagoa Salgada, the proven reserve for copper is 0,26% in a mass of 2,100 kt.
- Future Prospects: The region holds potential for further discoveries and expansions of existing deposits due to its geological characteristics, which are conducive to sulfide mineralization.
- Source of Information: (3) This information was derived from the analysis of mineralization patterns in the document titled "METALOGENETICO_ZSP_400K_Memoria" and "RMI_ZSP_400K_Memoria."; (24) Lagoa Salgada Mineral Reserve Estimate - Effective July 2023

Andalusia

Andalusia is the largest copper producer in Spain, a role it has played since ancient times, with most of its copper coming from the Iberian Pyrite Belt. Well-known mines such as Rio Tinto, Tharsis, La

Zarza, Aguas Teñidas, Sotiel, Masa Valverde, Aznalcóllar, and Cobre Las Cruces are notable for their copper production, which has accounted for around 339 Mt of pyritic and polymetallic sulfide resources in recent decades.

Other areas with copper mining potential are located in the Central Iberian Zone, particularly in the Los Pedroches batholith, and in the Ossa-Morena Zone, specifically associated with the Malcocinado Formation and the Santa Olalla granodiorite.

- Main Deposits: Copper deposits in Andalusia are primarily located in the Iberian Pyrite Belt, one of the most significant metallogenic provinces in Europe. Key mining areas include the mines of Riotinto, Aguas Teñidas, and the Cobre Las Cruces project. Some additional projects are underway at present, such as the historical exploitations of Tharsis, La Zarza, Lomero and others, as well as several new projects like Escacena and Masa Valverde.
- Operational Status: The mines of Riotinto and Aguas Teñidas are currently operational. The Cobre Las Cruces project is temporarily suspended but is expected to restart with underground operations.
- Resource Volume Estimation: The deposits in the Iberian Pyrite Belt are extensive, with significant quantities of copper, as well as zinc, lead, and silver. Detailed volume estimates are available in the project's feasibility studies and company reports.
- Sources of Information: (8) The information regarding copper deposits in Andalusia was obtained primarily from geological reports and data specific to the Iberian Pyrite Belt, as well as historical data on the mineral industry in the region. Specific volume estimates can be found in technical studies and feasibility reports produced band the companies operating in the area. This information aligns with what is typically reported in studies related to the mineral wealth of Andalusia and specifically the Iberian Pyrite Belt, known for its rich base-metal sulfide deposits.

Castile and León

- Main Deposits: Historical production of copper in Castile and León was 22,245t between 1861 and 1963, and was mostly concentrated in the provinces of León and Palencia. In León stands out the Profunda and Divina Providencia mines of the Cármenes district, with epithermal mineralizations of Cu-Co-Ni that were exploited since the Chalcolithic, but mainly from the end of the 19th century to the beginning of the 20th century. In Palencia the main production comes from the skarn-type deposits of the Carracedo and Estalaya districts, exploited in the mid 19 and 20th centuries.
- Operational Status: Currently there are no active exploitations, but there are some promising exploration projects of Cu-Co-Ni epithermal deposits in Cármenes (León) and Cu-Zn-Sn-W skarn deposit in Otero de Herreros (Segovia).
- Resource Volume Estimation: Otero de Herreros project: 4.6 Mt @ 1.11 %Zn, 0.49 % Cu, 1,400 gSn/t, 1,300 gWO3/t and 38 gAg/t. There are no available estimations from Cármenes district.
- Source of information: (21) La Minería en Castilla y León, SIEMCALSA (2007)

Extremadura

- Main Deposits: Copper (Cu) is present in several mineral deposits in Extremadura, with notable occurrences in both the Central Iberian Zone and the Ossa Morena Zone.
- Notable areas include:
    - Zona Centro Ibérica: Mineralizations are linked to tectonic and magmatic activities with occurrences of Pb-Zn-Cu and Pb-Zn-Ag sulfide veins located in granitic areas, often controlled band shear zones and extensional faults.

    - Zona de Ossa Morena: Includes skarns with Fe and Cu-Au replacements, as well as veins containing Cu-Au-Bi. There are also stratiform Cu-Fe-Au deposits in volcanic sedimentary complexes from the Lower to Middle Cambrian period in locations like Las Herrerías de Alconchel, La Vicaría, and La Bilbaína.
- Operational Status: The specific status of copper mines in Extremadura isn't clearly detailed in the documents, indicating that many deposits may be in the exploration or inactive stages rather than active commercial extraction.
- Resource Volume Estimation: No precise volume estimates for copper resources were found for Extremadura, suggesting that detailed quantifications might not be readily available or are subject to further geological studies and exploration phases.
- Source of information: (15) Information extracted from the document titled "MINERIA EXTREMADURA.pdf"

Lead (Pb)

Alentejo

- Main Deposits: Lead occurrences in Alentejo are primarily associated with poly-metallic sulphide veins, often found in combination with zinc and copper within shear zones or faults. The region also contains stratiform disseminations in volcanic-sedimentary sequences of the Upper Precambrian era.
- Operational Status: For Pb there are current active mines in Neves-Corvo and Aljustrel. In Lagoa Salgada there are no mining operations, however, exploration for Pb activities are ongoing.
- Resource Volume Estimation: In Aljustrel concession the 'Volume of Pb: 20,000 tPb/year (Mining.com, 2023)' and in Neves-Corvo 22kt of lead concentrate/year. In Lagoa Salgada, the proven reserve for Pb is 2,80% in a mass of 2,100 kt.
- Source of Information: (19) This information was derived from the analysis of mineralization patterns in the document titled "METALOGENETICO_ZSP_400K_Memoria" and "RMI_ZSP_400K_Memoria."; (24) Lagoa Salgada Mineral Reserve Estimate - Effective July 2023

Andalusia

- Main Deposits: Lead (Pb) deposits in Andalusia are typically associated with polymetallic sulfides and are found in vein-type formations, often in combination with other elements such as Zinc (Zn) and Silver (Ag). The ongoing PMR project at Las Cruces site will produce lead from the primary sulfide mineralisation.
- Location: Known deposits are concentrated in areas like Linares, La Carolina, and other locations in the province of Jaén.
- Operational Status: Most of the lead mining activities in Andalusia are not currently in active production but have historical significance. They have been the subject of past extraction efforts primarily during the peak of mining operations in the 19th and 20th centuries.
- Resource Volume Estimation: Specific estimations of the remaining volumes of lead resources in Andalusia are not well-documented or available in the current data. The deposits in these regions are largely considered to have been significantly depleted during historical extraction.
- Source of Information: (8) Information extracted from the documents reviewed and general historical data about mining in Andalusia.

Castile and León

- Main Deposits: Historical production in Castile and León was 6,539 t, exploited between 1874 and 1985, mainly in the province of León (mainly Antonina mine) and Soria (mainly Grupo Minero Juan de Austria).
- Operational Status: There is no active lead mining in Castile and León, although there are exploration projects in the province of León around Antonina mine and Sta. Bárbara project.
- Resource Volume Estimation: Antonina mine: 0.7-1.4 Mt @ 5.3 %Zn, 5.2 %Pb and 47 gAg/t. In Sta. Bárbara project: 2.9 Mt @ 10.5 %Zn, 7.1 %Pb and 50 gAg/t.
- Source of information: (21) SIEMCALSA (2007).

Extremadura

- Main Deposits: There are notable occurrences of Pb-Zn, Pb-Zn-Cu, and Pb-Zn-Ag in Extremadura. These deposits are typically found as vein-type sulfide deposits within or near granitic bodies, often controlled by shear zones or faults. Some of the main areas with these mineralizations include:
    - Abadía, Ibor, San Roque, Plasenzuela, Alcollarín in Cáceres province.
    - Siruela, Castuera, Garlitos, El Borracho, Santa Marta, Afortunada, and the area of Azuaga in Badajoz province.

  Additionally, stratiform deposits of Pb-Zn-Cu are found in volcano sedimentary levels from the Upper Precambrian in areas such as:
    - Puebla de la Reina (Mina de Las Herrerías)
    - Azuaga (Indicio Fuente de la Gamarra)
- Operational Status: There is no specific information indicating whether these deposits are currently operational.
- Resource Volume Estimation: No precise estimation of resource volume was found.
- Source of Information: (15) Information is derived from the document titled "MINERIA EXTREMADURA.pdf"

Silver (Ag)

Alentejo

- Main Deposits: There are known occurrences of silver associated with polymetallic sulfide veins in Alentejo, specifically linked to Pb-Zn-Ag mineralization. Alustrel and Neves-Corvo are active mines that exploit this element as a secondary result from extraction and processing.
- Operational Status: There are no active mining operations, however, exploration activities are ongoing in Lagoa Salgada. Ag, is mainly exploited in Alentejo as secondary mineral that results from the extraction and processing of other minerals.
- Resource Volume Estimation: In Neves-Corvo the mineral reserve (proven + probable) for Ag is 33 g/t in a mass of 21,207 kt. In Lagoa Salgada the proven reserve for Ag is 62 pmm in a mass of 2,100 kt.
- Source of Information: (19) The information is derived from references to polymetallic sulfide veins in the geological contexts discussed in various regions of Alentejo, particularly linked with lead-zinc-silver associations; (24) Lagoa Salgada Mineral Reserve Estimate - Effective July 2023

Andalusia

- Main Deposits: The ongoing PMR project at Las Cruces site will produce silver cement from the primary sulfide mineralisation.
- Operational Status: These deposits are currently active or in various stages of exploration and development.
- Resource Volume Estimation: Specific volume estimates for silver are not consistently reported in the sources, although the associated deposits are recognized for significant resources in other metals like copper, zinc, and lead, which typically contain silver as a by-product.
- Source of Information: (8) This information has been compiled from various regional geological and mining reports, including sources like "RMI_ZSP_400K_Memoria" and related Andalusian mining datasets.

Castile and León

- Main Deposits: Minor production associated to the exploitation of Pb, Zn and Cu. 570 kg Ag in 1975-1983, mostly associated to Pb-Zn Antonina mine (León). Also, there was a small production of argenteous lead in the 19th century in Soria and León provinces, and argenteous copper in Burgos.
- Operational Status: Currently, there are no active mines in Castile and León. The most advanced exploration projects are Zn-Cu-Sn-W-Ag Otero de Herreros project, in Segovia province, and Antonina mine and Sta. Bárbara project in León province.
- Resource Volume Estimation: Otero de Herreros project: 4.6 Mt @ 1.11 %Zn, 0.49 % Cu, 1,400 gSn/t, 1,300 gWO3/t and 38 gAg/t. Antonina mine: 0.7-1.4 Mt @ 5.3 %Zn, 5.2 %Pb and 47 gAg/t. Sta. Bárbara project: 2.9 Mt @ 10.5 %Zn, 7.1 %Pb and 50 gAg/t.
- Source of information: (21) SIEMCALSA (2007).

Extremadura

- There are no specific references to significant occurrences or active mining projects related to silver in the available documents.

Zinc (Zn)

Alentejo

- Main deposits: The region contains polymetallic deposits that are rich in zinc (Zn), copper (Cu) and lead (Pb), mainly within the geological formations related to the Ossa-Morena Zone and South-Portuguese Zone. Neves-Corvo is an active mine that exploit this element as a primary result from extraction and processing. Aljustrel is investing in the same processing lines.
- Operational status: Neves-Corvo and Aljustrel are active mines with already exploited and proven resources of Zn. In Lagoa Salgada there are no mining operations, however, exploration for Zn activities are ongoing.
- Resource volume estimation: In Neves-Corvo the mineral reserve (proven + probable) for Ag is 135 kt in a mass of 21,207 kt. In Lagoa Salgada the proven reserve for Zn is 3,10% in a mass of 2,100 kt.
- Source of information: (3,19) The information was derived from geological discussions on the polymetallic nature of the Ossa-Morena Zone found in the documents titled "METALOGENETICO_ZSP_400k_Memoria" and "RMI_ZSP_400k_Memoria."; (24) Lagoa Salgada Mineral Reserve Estimate - Effective July 2023

Andalusia

- Main deposits: Andalusia, specifically the Iberian Pyrite Belt, hosts numerous zinc deposits along with other polymetallic ores. Key mining areas include the Riotinto, Aguas Teñidas, and Aznalcóllar regions, where zinc is often found in association with copper, lead, and other metals. Zinc will be the main product in the new PMR project at Las Cruces site.
- Operational status: The deposits in the Iberian Pyrite Belt are currently being exploited or are in the process of reactivation. Projects like those in Aguas Teñidas and Riotinto are actively producing, while the Aznalcóllar site is under plans for reopening.
- Resource volume estimation: Although there are known significant reserves, specific volume estimates for zinc resources in Andalusia were not detailed in the reviewed documents.
- Source of information: (8) The information is based on details from the documents "RMI_ZSP_400K_Memoria," "METALOGENETICO_ZSP_400k_Memoria," and other relevant reports on the mining activities in Andalusia.

Castile and León

- Main deposits: In Castile and León, indications of zinc deposits are primarily found in the Cantabrian Mountains and other northern zones of the region. These areas have hosted zinc mineralization associated with sedimentary rock formations. In 1865-1985 16,242 tZn were produced, mostly in Palencia and León provinces. The most recent and important mines and projects were Antonina mine and Sta. Bárbara project, both in León, and the Otero de Herreros project in Segovia.
- Operational status: Currently, there is no significant active zinc mining operation in Castile and León. Historically, these areas have been explored and exploited, but there is no major production occurring at this time. The most advanced exploration projects are Zn-Cu-Sn-W-Ag Otero de Herreros project, in Segovia province, and Antonina mine and Sta. Bárbara project in León province.
- Resource Volume Estimation: Otero de Herreros project: 4.6 Mt @ 1.11 %Zn, 0.49 % Cu, 1,400 gSn/t, 1,300 gWO3/t and 38 gAg/t. Antonina mine: 0.7-1.4 Mt @ 5.3 %Zn, 5.2 %Pb and 47 gAg/t. Sta. Bárbara project: 2.9 Mt @ 10.5 %Zn, 7.1 %Pb and 50 gAg/t.
- Source of information: (21) SIEMCALSA (2007).

Extremadura

- Main deposits: Zinc mineralization in Extremadura is primarily associated with the polymetallic deposits found in the Ossa-Morena Zone, where zinc often appears alongside other metals like lead and copper.
- Operational status: Currently, there are no major zinc mining operations active in Extremadura, though exploration activities have been carried out in the past, especially in polymetallic districts.
- Resource volume estimation: There are no specific estimates for zinc volumes in Extremadura mentioned in the reviewed documents.
- Source of information: (15,16,17,18) The information is based on details from the documents "METALOGENETICO_ZSP_400K_Memoria" and "RMI_ZSP_400K_Memoria."

Iron (Fe)

Alentejo

- Main deposits: Iron mineralization in Alentejo is known to occur mainly in sedimentary and volcanic formations, particularly within the Iberian Pyrite Belt, where iron is present in association with other sulfide minerals.

- Operational status: There are no large-scale iron mining operations currently active in Alentejo, although historical mining activities did exploit some of these resources in the past.
- Resource volume estimation: The reviewed documents do not provide a specific estimation of iron resource volumes in the Alentejo region.
- Source of information: (19) The information is based on details from the "METALOGENETICO_ZSP_400K_Memoria" document.

Andalusia

- Main deposits: Andalusia has several significant iron ore deposits, particularly in the Sierra Morena region and the Alquife mine in the province of Granada. Alquife has historically been one of the largest iron ore deposits in Western Europe.
- Operational status: The Alquife mine is currently operational, with ongoing production and a focus on exporting iron ore to international markets, particularly through the ports of Málaga and Motril.
- Resource volume estimation: The Alquife deposit has been estimated to contain significant iron ore resources, but specific volume details are not clearly outlined in the reviewed documents.
- Source of information: (8) The information is derived from knowledge of current industrial operations in Andalusia.

Castile and León

- Main deposits: The main iron deposits in Castile and León are in the Astorga-Ponferrada mining district, outstanding the mines called Coto Wagner, Coto Vivaldi and Coto San Bernardo, all of them Ordovician oolithic type. The main production was in the periods 1861-1920 (108,804 t) and 1952-1990 (12,239,697 t), and was the basis for the Ponferrada steel industry.
- Operational status: Currently, there are no active iron mining operations in Castile and León, as the extraction of iron has largely ceased due to economic and logistical challenges.
- Resource volume estimation: The whole resource for the Astorga-Ponferrada district is around 270 Mt @ 52-53% Fe.
- Source of information: (1) Information has been gathered from the document Geological Map of CyL and external knowledge on historical mining activities in Castile and León.

Extremadura

- Main deposits: The main indications of iron in Extremadura are found in the Sierra de Gata and Los Pedroches areas. Historical records indicate that these regions were explored for iron ore, with some small-scale operations in the past.
- Operational status: Currently, there are no active iron mining operations in Extremadura. The deposits are not being commercially exploited due to the low grade of the ore and the lack of competitive advantage compared to other regions.
- Resource volume estimation: There are no recent or reliable estimates of iron ore volumes in these deposits. The lack of recent exploration and development activities has resulted in limited data availability.
- Source of information: (15,16,17,18) The information is based on the documents "MINERIA EXTREMADURA.pdf" and "METALOGENETICO_ZSP_400K_Memoria," along with additional historical context about mining activities in Extremadura.

Tin (Sn)

Alentejo

- Main deposits: Alentejo has known occurrences of tin associated with the regions of the Iberian Pyrite Belt (IPB), where tin is often found in conjunction with other mineral deposits such as copper and zinc. However, tin is not the primary focus of mining activities in these areas, and the mineralization is typically of low grade.
- Operational status: Currently, there are no active tin mining operations in Alentejo. Tin is not being directly exploited, as the economic viability of these deposits is limited in comparison to more abundant metals in the region. On the other hand, in Lagoa Salgada the exploration for Sn activities are ongoing.
- Resource volume estimation: In Lagoa Salgada, the proven reserve for Zn is 0,15% in a mass of 2,100 kt.
- Source of information: (19) The information has been extracted from the document "METALOGENETICO_ZSP_400K_Memoria" and "RMI_ZSP_400K_Memoria," which provide details on the mineralization patterns in the Iberian Pyrite Belt, along with relevant geological insights; (24) Lagoa Salgada Mineral Reserve Estimate - Effective July 2023

Andalusia

- Main deposits: In Andalusia, tin occurrences are primarily linked to the Iberian Pyrite Belt (IPB) and the surrounding areas. These deposits often occur in association with polymetallic mineralizations, including copper, zinc, and other metals. Specific tin deposits have been historically identified in areas such as the Sierra Morena, since they are currently finishing their permitting procedure.
- Operational status: Currently, there are no active mining operations focused solely on tin in Andalusia. Tin is often considered a by-product of other mining activities in the region, especially those targeting base metals like copper and zinc.
- Resource volume estimation: There are no precise estimates of tin reserves in Andalusia, as tin is not the primary focus of exploration and mining in the region. Most deposits are of low grade, which limits the feasibility of dedicated tin mining operations.
- Source of information: (8) This information has been gathered from the documents "METALOGENETICO_ZSP_400K_Memoria" and "RMI_ZSP_400K_Memoria," which discuss the mineral potential of the Iberian Pyrite Belt and the broader geological framework of Andalusia.

Castile and León

- Main deposits: In Castile and León, tin occurrences are primarily found in association with granite-related mineralization, particularly in the western regions of the region, such as in the provinces of Salamanca and Zamora. Historical mining activities were more prominent in these areas due to their tin and tungsten potential. Production in 1861-2004 was 8,928 tSn, mostly in Salamanca, outstanding the following mines: Feli, Mari Tere, El Cubito and Casualidad, Sta. Elisa, etc. (quartz veins with Sn+/-W); Golpejas (albititised granite with Ta) and Insuperable (placer).
- Operational status: Currently, there are no active mining operations exclusively dedicated to tin in Castile and León. Any tin extracted in the area is typically a by-product of other mining activities targeting minerals like tungsten (W). The most important exploration projects are Valtreixal (Zamora, Sn-W in quartz veins), Otero de Herreros (Zn-Cu-Sn-W-Ag in skarn) and the re-opening of Mina Mari Tere in Lumbrales (Salamanca)
- Resource volume estimation: Lumbrales: 2.54 Mt @ 2,500 gSn/t and 100 gMo/t. Valtreixal: 2.83 Mt @ 1,300 gSn/t and 2,500 gW/t. Otero de Herreros: 4.6 Mt @ 1.11 %Zn, 0.49 % Cu, 1,400 gSn/t, 1,300 gWO3/t and 38 gAg/t.

- Source of information: (1) This information is derived primarily from the document titled "Documento 1," which discusses the mineral resources and geological features of Castile and León. (23) Almonty website: Valtreixal Reserves/Resources NI 43-101

Extremadura

- Main deposits: Tin deposits in Extremadura are primarily found in the areas with granite and pegmatite formations. Notable occurrences include regions such as the Sierra de Gata and Las Villuercas in the province of Cáceres, which have historically been recognized for their tin and associated tungsten (W) mineralization.
- Operational status: Currently, tin is not actively mined as a primary resource in Extremadura. However, there are ongoing exploration activities in some areas, and tin is sometimes recovered as a by-product of tungsten extraction.
- Resource volume estimation: The specific volumes of tin resources in Extremadura are not well-documented in the available sources. The deposits are generally considered to be of moderate size, with historical exploitation indicating potential for further exploration.
- Source of information: (15,16,17,18) This information is based on the documents "METALOGENETICO_ZSP_400K_Memoria," "RMI_ZSP_400K_Memoria," and the recent "MINERIA EXTREMADURA.pdf," which provide detailed geological and mineralogical insights into the region.

Tungsten (W)

Alentejo

- Main deposits: Tungsten occurrences in Alentejo are primarily associated with the northern part of the region, close to the Portuguese extension of the Iberian Variscan Belt. The mineralization is typically linked to granitic intrusions and metamorphic terrains, with indications in areas such as the Ossa-Morena Zone, which has geological conditions favourable for tungsten deposits.
- Operational status: Currently, there are no known large-scale tungsten mining operations actively extracting this mineral in Alentejo. Historical mining activities did take place, particularly during periods of high demand, such as during the world wars.
- Resource volume estimation: There is limited information available on the precise volumes of tungsten resources in the Alentejo region. The existing data points to minor occurrences that may have economic potential if explored further.
- Source of information: (19) The information has been derived from the "METALOGENETICO_ZSP_400K_Memoria" and "RMI_ZSP_400K_Memoria" documents, which outline the geological structures and historical mining records of the region.

Andalusia

- Main deposits: The mining potential for tungsten (W) in the Andalusian region is highly localized and presents very limited interest. One of them is the Los Pedroches Batholith (Córdoba) and its immediate surroundings, whose characteristic feature is the presence of mineralization not only of tungsten (W) but also of other critical metals such as bismuth (Bi) and tin (Sn). The area of greatest interest is located in the northern part of the province of Córdoba, in the eastern sector of the Los Pedroches Batholith. It is divided into two subzones: one to the south of the batholith, from Montoro to the southeast of Villanueva de Córdoba. The other, around 80 km long, extends from the Sierra de Andújar to the vicinity of Belalcázar. In both cases, the mineralization is found in monzogranites or within the thermal metamorphism aureole, always very close to both lithologies. It consists of wolframite in massive white quartz veins, associated with tensional structures with a single filling episode. Another tungsten occurrences in Andalusia are also associated with the Sierra Nevada region and other granitic

belts found in the province of Granada. Notable deposits are linked to skarn-type mineralization and contact zones between granitic intrusions and metamorphic rocks. Historical evidence suggests that these areas have had minor occurrences of tungsten.

- Operational status: Currently, there are no large-scale active mining operations specifically focused on tungsten in Andalusia. However, small-scale or exploration activities might still be ongoing due to the high value of this metal.
- Resource volume estimation: There is limited publicly available data on the exact volume of tungsten resources in the region. The known occurrences are generally considered minor and not sufficient for large-scale production at present.
- Source of information: (8) Information has been compiled from the "RMI_ZSP_400K_Memoria" and "METALOGENETICO_ZSP_400K_Memoria" documents, which provide geological overviews and historical mining data for Andalusia.

Castile and León

- Main deposits: Tungsten occurrences in Castile and León are mainland found in the province of Salamanca. The mineralization is primarily associated with quartz veins in granitic intrusions. The 1904-1986 production was 8,995 tWO3, mostly in Salamanca. The most outstanding mines are Barruecopardo, nowadays in operation (quartz veins with W); Los Santos, active in 21th century (skarn); Peña do Seo in León (quartz veins) and the aforementioned Valtreixal project (Zamora).
- Operational status: The Barruecopardo mine was recently reopened and is one of the few active tungsten mining operations in Europe. It has seen renewed interest due to the increasing demand for tungsten in various industrial applications. The Los Santos mine has also been operational until recent years, though its activity can fluctuate depending on market conditions. The most advanced exploration projects are Valtreixal (Zamora, Sn-W in quartz veins) and Otero de Herreros (Segovia, Zn-Cu-Sn-W-Ag in skarn).
- Resource volume estimation: The Barruecopardo deposit has been reported to contain a substantial amount of tungsten, with estimates indicating resources in the range of several million tonnes of ore with significant tungsten content. Specific data on the Los Santos deposit is more limited but suggests it is also a notable source of tungsten in the region. Additionally, Valtreixal deposit has a resource of 2.83 Mt @ 1,300 gSn/t and 2,500 gW/t, and Otero de Herreros 4.6 Mt @ 1.11 %Zn, 0.49 % Cu, 1,400 gSn/t, 1,300 gWO_3/t and 38 gAg/t.
- Source of information: (1) Information has been gathered from Document 1 (specific to Castile and León) and other regional mining reports that provide data on the geology and production history of these deposits. (23) Almonty website: Valtreixal Reserves/Resources NI 43-101.

Extremadura

- Main deposits: Extremadura has several significant tungsten occurrences, with the most notable deposits being the "La Parrilla" mine near Almoharín in the province of Cáceres. This deposit is one of the largest tungsten resources in Spain. The mineralization is typically associated with quartz veins and skarn formations within granitic rocks.
- Operational status: The La Parrilla mine is currently active, with modern production operations focused on meeting the demand for tungsten. It has seen significant investment in recent years, aiming to become a major supplier of tungsten concentrate to the European market.
- Resource volume estimation: The La Parrilla deposit is estimated to have several million tonnes of ore with a high-grade tungsten content. Production levels have been designed to deliver a substantial annual output, positioning it as one of the leading tungsten producers in the region.
- Source of information: (15,16,17,18) The information has been extracted from the documents "METALOGENETICO_ZSP_400K_Memoria," "RMI_ZSP_400K_Memoria," and "MINERIA

EXTREMADURA," which provide detailed insights into the geological characteristics and current status of tungsten mining activities in Extremadura.

Lithium (Li)

Alentejo

- Main deposits: Currently, there are no known deposits of lithium in Alentejo.

Andalusia

- Main deposits: In Andalusia, lithium occurrences were primarily associated with pegmatitic rocks and granitic formations. These geological settings have shown potential for lithium mineralization, specifically in areas close to the Sierra Morena. Although lithium exploration is not as advanced in Andalusia as in other regions, the area's geological characteristics suggest a possibility of discovering significant lithium deposits. In recent times, the most promising lithium (Li) in Andalusia is found in post-tectonic Neogene basins, in the form of brine, with the Almería Depression standing out, including the Almanzora and Bajo Andarax basins, as well as those of Pulpí, Campo de Dalías, Sorbas-Tabernas, Níjar-Carboneras, and in the Arteal area in Sierra Almagrera, all located in the province of Almería.
- Operational status: Currently, there are no operational lithium mines in Andalusia. However, the region is under consideration for potential exploration projects, driven by the increasing demand for lithium in energy storage and electric vehicle battery manufacturing.
- Resource volume estimation: No specific resource volume estimates for lithium deposits in Andalusia have been documented as of now. The region's lithium potential is still under evaluation, and detailed exploration data are required to determine the size and quality of any possible reserves.
- Source of information: (19) The information has been gathered from the documents "METALOGENETICO_ZSP_400K_Memoria" and "RMI_ZSP_400K_Memoria," which provide geological context and indicate areas of interest for lithium exploration in Andalusia.

Castile and León

- Main deposits: There are some indications of lithium-bearing minerals in pegmatites within the geological formations of Castile and León. The presence of lithium is mainly associated with granitic and pegmatitic rocks found in areas of the provinces of Salamanca mainly. These areas have been identified as having potential for lithium mineralization due to their geological characteristics, which are similar to other lithium-rich areas in Spain.
- Operational status: Currently, there are no active lithium mining operations in Castile and León. From the mid 1990's to mid 2010's there were two quarries of Li-bearing pegmatites in La Fregeneda (Salamanca), whose production was addressed to the ceramic sector in the East coast of Spain. In the 1960's there was a small production of Li concentrate in the Sn-Li Barquilla mine (Salamanca). Nowadays, there are several exploration projects (e.g. Villasrubias) at an early stage, with a focus on assessing the viability and economic potential of the identified occurrences.
- Resource volume estimation: No specific estimates of resource volume for lithium have been reported in Castile and León. Further exploration and detailed geological studies are needed to determine the quantity and quality of lithium reserves.
- Source of information: (1,21) The information has been extracted from document 1 related to Castile and León, which discusses the region's mineral resources and potential for future exploration of lithium deposits.

Extremadura

- Main deposits: Extremadura is one of the most promising regions in Spain for lithium exploration, with several significant lithium-bearing deposits identified. The most notable deposits include the "Valdeflórez" project near Cáceres and the "Las Navas" project in Cañaveral, being the latter in a much more advanced stage with the permitting procedure. The lithium in these areas is primarily found in pegmatitic rocks, which are known for their potential to host economically viable concentrations of lithium.
- Operational status: The lithium projects in Extremadura are currently in the exploration phase, with plans to advance to development stages in the coming years. The Valdeflórez project has faced some social and environmental challenges, particularly due to its proximity to urban areas, leading to modifications in the mining approach. Despite these hurdles, the region remains a focus of interest for future lithium production.
- Resource volume estimation: The Valdeflórez project has been reported to contain significant lithium reserves, with initial estimates suggesting around 1.2 million tonnes of lithium carbonate equivalent (LCE). The exact resource volume for the Las Navas project has not been fully disclosed but is also considered substantial based on initial exploration data.
- Source of information: (15,16,17,18) The information was primarily sourced from the documents "MINERIA EXTREMADURA.pdf" and "RMI_ZSP_400K_Memoria.pdf," which provide a detailed overview of the region's mineral potential and ongoing lithium exploration activities.

Uranium (U)

Alentejo

- Main deposits: Alentejo has some occurrences of uranium mineralization, although they are not considered to be of significant commercial importance compared to other regions. The uranium in Alentejo is generally associated with the geological formations of the Iberian Massif, particularly in areas with granitic and metamorphic rocks.
- Operational status: Currently, there are no active uranium mining operations in Alentejo. The focus on uranium in this region has decreased due to both environmental concerns and the lack of economically viable deposits that can be exploited under current market conditions.
- Resource volume estimation: There are no specific estimates available for uranium resource volumes in Alentejo. The existing indications do not point to large-scale deposits that would justify commercial extraction.
- Source of information: (19) Information derived from the geological review and mineral resource documents provided, including the "METALOGENETICO_ZSP_400K_Memoria" and "RMI_ZSP_400K_Memoria" documents, which outline the mineral occurrences in the region.

Andalusia

- Main deposits: Uranium occurrences in Andalusia are primarily associated with the granitic rocks and other intrusive formations found in regions such as Sierra Morena. The geological context suggests the presence of uranium in low concentrations, often related to specific mineralized veins and fracture zones within the area's geological structures.
- Operational status: There are no active uranium mining operations in Andalusia at present. Historical exploration efforts have identified the potential for uranium mineralization, but none of the deposits have been deemed economically viable for commercial mining activities under current conditions.
- Resource volume estimation: No detailed volume estimates for uranium resources are available for Andalusia. The identified occurrences are not considered to be significant enough to warrant the development of large-scale mining projects.

- Source of information: (8) Information gathered from documents such as "RMI_ZSP_400K_Memoria" and other geological studies provided, particularly those focusing on Andalusia's mineral potential.

Castile and León

- Main deposits: Uranium occurrences in Castile and León are known to be associated with the granitic and sedimentary formations, particularly in areas such as the province of Salamanca. Mina Fé and Corta D, exploited from the 1970's to 2000, were the most important mines. The region has been historically significant for additional uranium exploration, with notable deposits located in areas like Retortillo-Santidad and other zones near Ciudad Rodrigo.
- Operational status: Some of the uranium projects in Castile and León, such as the Retortillo-Santidad deposit, were previously in the advanced exploration or development stage but have faced regulatory and environmental challenges. These projects are not currently in active production due to delays in obtaining necessary permits and public opposition.
- Resource volume estimation: Estimates suggest significant uranium reserves in Castile and León, particularly in the Retortillo-Santidad deposit, which has been evaluated to contain several million pounds of uranium oxide (U_3O_8). However, the exact volume can vary depending on exploration results and regulatory approvals.
- Source of information: (1) Information is drawn from Document 1 of the provided list and other detailed geological reports, indicating the strategic importance of uranium resources in the region.

Extremadura

- Main deposits: Uranium occurrences in Extremadura are found mainly in association with granitic and sedimentary formations, similar to other regions in the Iberian Peninsula. Known deposits are primarily located in areas like La Haba (Badajoz), which has been subject to historical exploration efforts.
- Operational status: Currently, there are no active uranium mines in Extremadura. The projects in the region remain in the exploration or early development phases, facing similar regulatory and environmental constraints as other uranium projects in Spain.
- Resource volume estimation: No precise volume estimates have been reported in the available sources for uranium deposits in Extremadura. The historical exploration data suggest a presence of uranium that could be of interest if market conditions and regulations become favourable.
- Source of information: (15,16,17,18) Information extracted from the "METALOGENETICO_ZSP_400K_Memoria" and "RMI_ZSP_400K_Memoria" documents, which detail the geological potential of the region for uranium exploration.

Barium (Ba, Barite)

Alentejo

- Main deposits: The occurrence of barium in Alentejo is mainland associated with barite (barium sulfate) mineralization. These deposits are typically found in sedimentary rocks and hydrothermal veins throughout the region. Known areas of interest include the Aljustrel mining area, where barite is present along with other sulfide minerals.
- Operational status: There is Currently no active extraction of barite in Alentejo. The deposits are considered non-operational, although they have been subject to historical mining activities in the past.

- Resource volume estimation: No specific volume estimates for barium (barite) deposits have been found in the available documentation. The potential remains largely untapped, with exploration efforts focusing more on other critical minerals.
- Source of information: (19) Information extracted from the "METALOGENETICO_ZSP_400K_Memoria" and "RMI_ZSP_400K_Memoria" documents, which provide geological insights into the mineral occurrences in Alentejo.

Andalusia

- Main deposits: The most important barite deposits in Andalusia are located in Paleozoic and Permo-Triassic terrains. The most profitable ones are found in the provinces of Córdoba, Jaén, Huelva, Sevilla, Málaga, and Almería. The areas with the greatest mining potential are in the northern parts of Córdoba and Jaén. In the province of Córdoba, within the Ossa-Morena Zone, they are associated with the Villaviciosa de Córdoba Magmatic Axis and another area near Villanueva del Reand, where vein mineralization takes advantage of Alpine faults that reactivate Variscan and post-Variscan structures. In the Central Iberian Zone of the province of Córdoba, another highland potential strip is located, an alignment approximately 25 km long in a WNW-ESE direction and about 6 km wide. In Jaén, the potential area is located north of La Carolina, where the mineralization is controlled band N-trending fractures. Andalusia has also shown several occurrences of barite (barium sulfate) primarily associated with hydrothermal veins and sedimentary deposits. Significant deposits are known to be present in the Sierra de Gador and the Sierra Almagrera regions, where barite often occurs alongside other sulfide minerals such as lead and zinc.
- Operational status: Currently, there is no large-scale extraction of barite in Andalusia. Although historically mined, the deposits are considered non-operational at present, with limited small-scale extraction or exploration efforts.
- Resource volume estimation: There are no detailed resource volume estimates available for barite deposits in Andalusia in the documents reviewed. The mineral's economic potential remains under-assessed in comparison to other resources in the region.
- Source of information: (8) Information has been sourced primarily from the "RMI_ZSP_400K_Memoria" and "METALOGENETICO_ZSP_400K_Memoria" documents, which provide geological and mineralogical data specific to Andalusia.

Castile and León

- Main deposits: Castile and León hosts several occurrences of barite (barium sulfate), primarily found in hydrothermal veins and associated with stratiform deposits in carbonate-rich rocks. Significant deposits have been identified in the provinces of León and Zamora.
- Operational status: The deposits in Castile and León are Currently considered non-operational, with no active large-scale mining projects focusing on barite. Historically, small-scale extraction took place, but it has since ceased.
- Resource volume estimation: There are no precise estimations of resource volumes for barium deposits in Castile and León within the documents c. The economic viability of these deposits has not been extensively evaluated or developed.
- Source of information: (21) Information is primarily derived from the document titled "Metalogénesis and recursos minerales en Castile and León," which provides geological and mineral resource assessments specific to the region.

Extremadura

- Main deposits: Barium, in the form of barite (barium sulfate), is present in several locations in Extremadura. The most notable deposits are found in the provinces of Cáceres and Badajoz, typically associated with hydrothermal veins and stratiform deposits.

- Operational status: The extraction of barite in Extremadura is not Currently active on a large scale. There have been small-scale mining operations Historically, but they are now mostly inactive.
- Resource volume estimation: No detailed estimations of the volume of barium resources have been identified in the available documents. The current data does not provide precise figures or assessments of the economic potential of these deposits.
- Source of information: (15,16,17,18) The information is sourced from the document "MINERIA EXTREMADURA" and relevant sections of the "METALOGENETICO_ZSP_400K_Memoria," which describe the occurrence of barite in the region.

Phosphorus (P, Phosphate)

Alentejo

- Main deposits: There are no significant main deposits of phosphate reported in Alentejo, Portugal, in the reviewed documents. The region is not known for phosphate production or exploration at present.
- Operational status: There are no active phosphate mining operations in Alentejo.
- Resource volume estimation: No estimations of phosphate resources have been found for this region.
- Source of information: (19) The information is based on the review of documents, including "METALOGENETICO_ZSP_400K_Memoria" and "RMI_ZSP_400K_Memoria," where no references to phosphate occurrences in Alentejo were found.

Andalusia

The presence of phosphates in Andalusia is not common, and their occurrences are associated with two well-differentiated domains: the Variscan Domain and the Betic Domain.

In the Variscan Domain, the richest area in phosphates is the Central Iberian Zone, where phosphates can be found in metamorphic rocks with depositional environment characteristics of platform and slope settings, as well as phosphates associated with igneous and vein rocks. Two former exploitations stand out, which extracted stratiform mineralizations hosted in Visean limestone olistostromes in the Guadiato Basin (Córdoba). Additionally, stratiform mineralizations are found in the Lower Cambrian in Puebla de los Infantes (Seville).

In the Subbetic, within Jurassic carbonate sediments, the presence of "Chard-grounds" covered band phosphorites is not uncommon. Similarly, "condensed series" are also frequently observed, particularly in the Lower Cretaceous, where concentrations of phosphorites occur.

- Main deposits: Following the previous comments, there are no significant Main deposits of phosphate reported in Andalusia in the reviewed documents. The region does not appear to have relevant phosphate occurrences or active exploration efforts at present.
- Source of information: (8) Information based on the analysis of the documents "METALOGENETICO_ZSP_400K_Memoria," "RMI_ZSP_400K_Memoria," and other Andalusia-specific reports where no mentions of phosphate deposits were encountered.

Castile and León

- Main deposits: There are no significant Main deposits of phosphate reported in Castile and León within the reviewed documents. The region does not seem to have notable occurrences of phosphate, and no active exploration initiatives have been recorded.
- Operational status: There are no known phosphate mining operations Currently active in Castile and León.

- Resource volume estimation: No estimates regarding the volume of phosphate resources were found for this region.
- Source of information: (21) The information is based on an analysis of the "Recursos Minerales de Castile and León" report and other relevant documents specific to this area, where no phosphate occurrences were identified.

Extremadura

- Main deposits: There are no significant Main deposits of phosphate reported in Extremadura based on the data available from the reviewed documents. The region does not Currently have any known occurrences or potential areas of interest for phosphate mining.
- Operational status: There are no active phosphate mining operations in Extremadura at this time.
- Resource volume estimation: No estimates regarding the volume of phosphate resources were identified for this region.
- Source of information: (15,16,17,18) The information is derived from a thorough review of the "MINERIA EXTREMADURA" document and other supporting sources relevant to the region, which did not indicate any phosphate-related activities.

Magnesium (Mg, Magnesite)

Alentejo

- Main deposits: There are no significant Main deposits of magnesite identified in the Alentejo region based on the available data. Magnesite is not highlighted as a mineral of interest in this area.
- Resource volume estimation: No estimates regarding the volume of magnesium resources were identified for this region.
- Source of information: (19) Information is gathered from the review of the "METALOGENETICO_ZSP_400K_Memoria" and "RMI_ZSP_400K_Memoria" documents, which do not list magnesite as a significant resource in the region.

Andalusia

Magnesium appears in Andalusia in the form of the mineral magnesite, magnesium carbonate ($MgCO_3$), with a content of 47.8% MgO and 52.2% CO_2, and it is the main natural source of magnesia. In Andalusia, a total of 13 magnesite occurrences have been inventoried, all located in the province of Almería. These are small deposits associated with the Middle-Upper Triassic dolomites of the Alpujárride Complex. The southern and southeastern slopes of the Sierra de Gádor, at altitudes between 100 and 600 meters, are dotted with thousands of small, chaotic mining workings, no larger than 8-10 meters in maximum dimension, which were opened for the extraction of magnesite. This activity experienced its peak during World War I and the post-war period in Spain.

- Main deposits: According to that, there are no significant Main deposits of magnesite identified in the region of Andalusia according to the data available. Magnesite is not prominently mentioned as a resource in this area.
- Operational status: There are no known active operations for magnesite mining in Andalusia.
- Resource volume estimation: No estimations of resource volume for magnesite have been found in this region.
- Source of information: (8) The analysis is based on data from the documents "METALOGENETICO_ZSP_400K_Memoria," "RMI_ZSP_400K_Memoria," and other related sources that do not highlight magnesite as a mineral of economic interest in Andalusia.

Castile and León

- Main deposits: The main deposit of magnesite is the Borobia deposit, in Soria province.
- Operational status: The Borobia mine is in operation since mid-2000's.
- Resource volume estimation: There are no precise recent estimations of the volume of magnesite resources available, but the deposits in Castile and León are recognized as substantial on a national scale.
- Source of information: (1) This information has been derived from Document 1, which focuses on mineral resources in Castile and León, highlighting the presence and historical significance of magnesite in this region.

Extremadura

- Main deposits: There are no significant indications or known deposits of magnesite reported in Extremadura. The region's geology does not appear to favour the formation of this mineral in commercially relevant quantities.
- Source of information: (15,16,17,18) This conclusion is based on the analysis of documents, including the METALOGENETICO_ZSP_400K_Memoria and RMI_ZSP_400K_Memoria reports, as well as the document titled "MINERIA EXTREMADURA.pdf."

Fluor (F, Fluorite, Fluorspar)

Alentejo

- Main deposits: There are no significant indications or known deposits of fluorite reported in Alentejo. The geological conditions in this region do not prominently feature fluorite formations that would be commercially viable.
- Resource volume estimation: No estimates regarding the volume of fluorite resources were identified for this region.
- Source of information: (19) This information is based on the analysis of the METALOGENETICO_ZSP_400K_Memoria and RMI_ZSP_400K_Memoria reports, which cover the mineralogical potential of the area comprehensively.

Andalusia

The fluorite occurrences are concentrated in the provinces of Almería, Córdoba, Málaga, and Granada, the latter being home to the only active fluorite mine located in the municipality of Órgiva.

In the Ossa-Morena Zone, fluorite is found in different metallogenic units or domains, with varied types, hosted in rocks dating from the Upper Precambrian to Lower Cambrian, which were heaviland deformed band the Variscan Orogenand. Notable occurrences in the province of Córdoba include: Cerro Muriano, Chaparral, Perseverancia, Grupo Minas Gloria, La Florina-Mirabueno, La Cardenchosa, the Villanueva de Córdoba and Cardeña mining district.

In the Betic Internal Zone, the main occurrences are found in the Alpujárride Complex, although there are less significant ones in the Maláguide Complex. In the Alpujárride Complex, fluorine (F) mineralizations are associated with Pb-Zn occurrences. They are hosted in dolomites and limestones of the Middle-Upper Triassic carbonate formations in the central-eastern Alpujárride units, especially in the lower tectonic units. Most of the mineralizations are stratiform, sometimes vein-like. The most important deposits are located in the Sierra de Gádor, Sierra de Lújar, and Sierra de Baza. Other less relevant districts include the northwestern edge of the Sierra Nevada, Sierra de las Estancias, Sierra Alhamilla, Sierra de la Contraviesa, Sierra Almijara, Sierra Tejada, Cerro del Toro, Turón, and Benínar. In Sierra de Lújar is where the only active mine in Andalusia is located.

In the Betic External Zone, Pb-F mineralizations are small in scale, mostly hosted in Jurassic series of the Middle Subbetic, which occasionally contain subvolcanic basic rock masses. There is an occurrence of interest at Las Pedrizas de Mures, southeast of Alcalá la Real (Jaén).

- Main deposits: Fluorite (CaF_2) deposits are known in several areas within Andalusia, primarily in the provinces of Granada and Córdoba, as previously said. These deposits are associated with hydrothermal processes, often linked to carbonate rocks. The most notable occurrences of fluorite have been identified in the Sierra de Baza and in the areas near Priego de Córdoba.
- Operational status: While some fluorite deposits were Historically mined in Andalusia, there is no significant large-scale extraction Currently underway. Past operations mainland targeted fluorite for industrial uses, such as in the production of hydrofluoric acid and in the steel industry.
- Resource volume estimation: There is no precise estimation of the fluorite resource volume available in the public domain for the current state of these deposits. Historical records suggest moderate levels of production, but no detailed quantified data has been identified.
- Source of information: (8) The information has been derived from the documents METALOGENETICO_ZSP_400k_Memoria and RMI_ZSP_400k_Memoria, which discuss the mineralization processes and the known occurrences of fluorite in Andalusia, as well as additional resources from documents 6 and 10 that apply to the region.

Castile and León

- Main deposits: Some deposits of fluorite are found in Castile and León, particularly in the province of León. The mineral is hosted by Carboniferous carbonate rocks and occurs in hydrothermal veins, small masses and disseminated
- Operational status: Some of the fluorite deposits in Castile and León have been historically mined, with a focus on producing fluorite for industrial applications, such as in the production of ceramics, chemicals, and metallurgy. However, large-scale active mining operations are limited, with extraction activities being sporadic or small-scale. None of them is currently active.
- Resource volume estimation: There is limited publicly available data regarding the precise volume of fluorite resources in the region. Historical data indicates a moderate to significant production potential, especially in the areas where fluorite is found in relatively high purity and concentration.
- Source of information: (1) The information is primarily based on the regional mining reports and data from Document 1, which provides detailed geological and mineralogical information specific to Castile and León.

Extremadura

- Main deposits: Fluorite occurrences in Extremadura are relatively limited compared to other regions. The mineral is mainland found in association with hydrothermal veins, often alongside other minerals such as quartz and barite, in localized areas, particularly in the northern parts of the region.
- Operational status: There are no large-scale mining operations dedicated specifically to fluorite in Extremadura. The mineral has been identified in minor occurrences, but these deposits are not Currently being exploited on a commercial scale.
- Resource volume estimation: There is no significant data available indicating the exact volume of fluorite resources in Extremadura. The deposits identified so far appear to be relatively small and not sufficient for large-scale extraction.
- Source of information: (15,16,17,18) The information is derived from the geological surveys and mineral resource reports included in the documents titled

"METALOGENETICO_ZSP_400K_Memoria" and "RMI_ZSP_400K_Memoria," which cover mineral occurrences in Extremadura.

Strontium (Sr, Celestite)

Alentejo

- Main deposits: Strontium, in the form of celestite ($SrSO_4$), has been reported in the Alentejo region, mainland in sedimentary basins. The occurrences are often found associated with evaporitic deposits, which is a common geological setting for celestite formation.
- Operational status: There are Currently no significant strontium extraction activities or dedicated mining operations in Alentejo. The identified occurrences are not being exploited on a commercial scale.
- Resource volume estimation: There is no detailed estimation of the volume of strontium resources available in Alentejo. The deposits are considered minor and are not sufficient to justify large-scale mining efforts at this time.
- Source of information: (19) The information is derived from regional geological studies and mineral resource assessments referenced in the "METALOGENETICO_ZSP_400K_Memoria" and "RMI_ZSP_400K_Memoria" documents, which cover the mineral resources of Alentejo.

Andalusia

- Main deposits: In Andalusia, one of the largest strontium (Sr) deposits in the world is located: the stratified celestine ($SrSO_4$) bodies of Montevives and Escúzar (Granada), within the Upper Miocene evaporitic succession of the Granada intramontane basin. With an annual production of up to 200,000 tons of almost pure celestine, it is considered the second largest known deposit in the world. Strontium in Andalusia is primarily found in the form of celestite. These deposits are associated with sedimentary formations, particularly in evaporitic environments.
- Operational status: The deposits of celestite in Andalusia are actively exploited. Andalusia is considered one of the main regions in Spain for celestite production, with ongoing mining activities.
- Resource volume estimation: Specific quantitative estimates of strontium resources in Andalusia are not provided in the documents. However, the region is recognized as a significant source of strontium in Spain, suggesting substantial resource potential.
- Source of information: (8) This information has been sourced from regional geological studies and mineral resource evaluations mentioned in the "RMI_ZSP_400K_Memoria" and other relevant documents covering mineral resources in Andalusia.

Castile and León

- Main deposits: There are no deposits of strontium (celestite) reported in Castile and León. The region's geological profile does not prominently feature the evaporitic conditions typically associated with celestite formation.

Extremadura

- Main deposits: There are no known significant Main deposits of strontium (celestite) in Extremadura. The region does not present the geological formations typically associated with this mineral.

Cobalt (Co)

Alentejo

- Main deposits: There are indications of Co-bearing deposits associated with Neves-Corvo mining concession, cobaltite (CoAsS).
- Operational Status: There are no specific references to current operational mining activities for cobalt in Alentejo.
- Resource Volume estimation: No specific estimates of resource volume for cobalt deposits in Alentejo are available from the reviewed documents.
- Source: (22) The information is derived from the mineralogical context within the Alentejo region, particularly the geological zones mentioned in the provided materials. The information was also provided from the NI 43-101 Technical Report on the Neves-Corvo Mine, Portugal, February 22, 2023.

Andalusia

In Andalusia, there have been no cobalt (Co) exploitations as the main mineral; it has always been extracted as a gangue mineral geochemically associated with copper (Cu), nickel (Ni), and other metals.

There is potential in several areas, as gangue to bismuth mineralizations located north of the Los Pedroches Batholith (Central Iberian Zone, Córdoba).

In the Ossa Morena Zone, cobalt is associated with basic lithologies and Fe-Cu mineralizations in skarn zones (Guadalcanal, Mina de Cala, Mina de Aguablanca).

In the Betic Internal Zones (Almería and Granada), mineralizations occur in dolomites of the Alpujárride Complex and in the Blanquizares-Oria Unit, with notable occurrences in the Sierras of Los Guájares, El Chaparral, and Albuñuelas. Some of these have high cobalt and nickel contents. Also noteworthy are the erandthrites of Huétor Santillán (Granada), part of the Sierra Nevada zone in Granada (Güéjar Sierra, Dílar, Capileira, and Trevélez, province of Granada).

In the province of Almería, cobalt occurrences are found in the Sierra de Almagro (municipality of Huércal-Overa, Almería) and the Sierra de Las Estancias (Oria, Almería).

Some massive sulfide mineralizations in the Iberian Pyrite Belt contain cobalt occurrences, more frequently in the root zones of the sulfide bodies.

- Occurrences and deposits: Hence, there are indications of cobalt associated with sulfide mineralizations in Andalusia, particularly linked with polymetallic ores in areas with a presence of copper, nickel, and other metals. These occurrences are primarily located in regions like the Iberian Pyrite Belt.
- Operational Status: The cobalt occurrences in Andalusia are mostly not in active exploitation and are generally considered secondary to the extraction of other metals like copper or nickel.
- Resource Volume Estimation: There is no specific volume or detailed quantitative estimation of cobalt resources available in the documents reviewed.
- Source of information: (8) Information derived from the regional mineral resource assessment and mining reports, specifically focusing on the polymetallic potential in the Iberian Pyrite Belt of Andalusia (documents 6 and 10).

Castile and León

- Main deposits: Cobalt was obtained as by-product in Profunda and Divina Providencia mines, in the Cñarmenes district (León), with 431t in the period 1877-1891. Both mines exploited epitermal deposits of Cu-Co-Ni since the Chalcolithic to the beginning of the 20th century.
- Operational Status: Currently, the Cármenes district is under exploration.

- Resource Volume Estimation: There is no specific estimation of cobalt resources available in the documents reviewed.
- Source of information: (1) The information is primarily based on the regional mining reports and data from Document 1, which provides detailed geological and mineralogical information specific to Castile and León.

Extremadura

- Main deposits: Cobalt is present in mineralizations associated with tin and tungsten deposits. Specifically, cobalt has been identified in greisen veins at deposits such as San Nicolás, Virgen de Gracia, and Mari Juli in the province of Badajoz.
- Operational status: The information does not specify whether these cobalt deposits are Currently being exploited.
- Resource Volume Estimation: No specific volume estimations for cobalt resources are available.
- Source of information: (15,16,17,18) Information extracted from the document titled "MINERIA EXTREMADURA.pdf"(MINERIA EXTREMADURA).

Other substances and their impact in the Andalusian context

Antimuonium

The mining potential for antimony (Sb) in Andalusia is limited, but there are two areas of some interest. In the Ossa Morena Zone, south of Espiel (Córdoba), there is a set of vein-type mineralizations of this substance, which are controlled band NW-SE oriented fractures. However, the greatest interest is in the Central Iberian Zone, to the northeast of La Carolina (Jaén). This is a structural metallotect that includes several vein-type occurrences.

Nickel

Despite the geographical and geological proximity of the Ni deposit (EGP) of Aguablanca (Badajoz), only two Ni occurrences have been inventoried in Andalusia, in the mafic rock outcrops of Ossa-Morena, Argallón, and Cortegana.

Additionally, the peridotites of Ronda do not seem to qualify as an area with mining potential for nickel, chromium, and platinum group elements, where Cr, Cr-Ni, and Fe-Ni-Cu and/or graphite mineralizations are distributed over an area exceeding 2,000 km² in the southwestern extreme of the Betic Cordillera. These mineralizations are hosted in materials belonging to the Alpujárride Complex. Among the most representative examples are the La Gallega nickel mines in Ojén and the Los Jarales district in Carratraca. Currently, all mining operations have been abandoned. The main issue encountered with nickel, and especially chromium exploitation in the Ronda mountain range, has been its localized concentration in very small volume bodies.

REE (Rare Earth Elements)

Although there are no strict signs of rare earth mining in Andalusia, they have been found associated with deposits of other minerals, forming part of their crystalline network, such as barite or garnets. This is the case with the barite-fluorite veins in the Ossa Morena Zone, and in the Central Iberian Zone, high levels have been detected in total rock and in relation to the granite facies of the Pedroches Batholith (Córdoba). Rare earths are also associated with the garnets from alluvial deposits of the El Hoandazo Volcanic Complex (Almería).

6. Conclusions and Recommendations

The present report is underway, because the available information and the continuum in the changes of the mining market and context at both the European and the global scales. Nevertheless, here we provide a number of findings and recommendations from the work done so far.

6.1. Summary of the Most Important Findings

The geological and mining potential of the regions studied—Andalusia, Extremadura, Castile and León (Spain), and Alentejo (Portugal)—demonstrates substantial opportunities for mineral extraction that aligns with the European Union's strategic goals for critical raw materials (CRMs). Andalusia emerges as the most promising region due to its robust infrastructure, well-established mining sector, and proximity to international markets, making it a strong candidate for large-scale extraction projects, especially in copper, zinc, and lead. Extremadura, with its rich deposits of lithium and tungsten, shows high potential for contributing to Europe's energy transition, although infrastructural improvements are necessary. Alentejo shows considerable promise due to its favorable geological, economic, and social conditions. The region already hosts established and competitive mines for metals such as copper, zinc, lead, as well as some gold and silver, with new projects emerging for critical and strategic raw materials. Alentejo also plays a significant role in quarrying ornamental stone and industrial minerals essential for construction and engineering projects. However, logistical and connectivity challenges remain, especially regarding transport infrastructure, which is crucial for enhancing the competitiveness of the Iberian Peninsula and strengthening Europe's position in global markets. Castile and León and also hold significant prospects in ornamental stones and industrial minerals, with the possibility of reactivating historical mining projects, particularly in gold, tin, tungsten and copper.

The technical feasibility of mining in these regions, combined with economic factors such as competitive operating costs and access to markets, underscores the viability of further developing these regions. Additionally, compliance with stringent environmental regulations ensures that mining activities will be aligned with sustainable practices.

Despite the overall positive outlook, challenges remain. Infrastructure development is crucial for unlocking Extremadura's full potential, and Castile and León's future growth will depend on technological investments. Furthermore, mining activities must balance economic growth with environmental protection, especially in regions where mining has a long history of landscape transformation.

6.2. Recommendations for the development of mining projects

- Infrastructure Development: Improving transport and energy infrastructure, particularly in Alentejo, Extremadura and Castile and León, will be essential to reduce operational costs and enhance market access. Collaboration with local governments and EU funding opportunities should be leveraged to address these infrastructural gaps.
- Strategic Focus on CRMs: Given the EU's increasing demand for critical raw materials, mining projects in these regions should prioritize the extraction of lithium, tungsten, copper, zinc, cobalt and other essential minerals for energy transition technologies. Investments in the exploration of these materials will be crucial to reduce Europe's reliance on external suppliers.
- Sustainable Mining Practices: Environmental sustainability should remain a priority across all regions. The adoption of innovative mining technologies that reduce environmental impacts, particularly in water management and waste reduction, will be necessary to maintain compliance with EU regulations. A focus on landscape restoration and biodiversity conservation should be integral to all projects.
- Diversification of Economic Activities: While mining remains an essential industry, regional economies should seek to diversify their industrial base to create long-term resilience.

Developing value chains around mining, such as local processing industries, will provide additional economic benefits and job opportunities.

- Community Engagement and Social Responsibility: Social acceptance is key to the success of mining projects. Transparent communication with local communities and active involvement in decision-making processes will reduce conflicts and enhance the social viability of mining operations.

Band addressing these recommendations, the regions can maximize the potential of their geological resources while adhering to the principles of sustainable development and contributing to the strategic autonomy of the European Union.

7. Bibliography

(1) Memoria del Mapa Geológico and Minero de Castile and León (1995). Sociedad de Investigación and Explotación Minera de Castile and León, S.A. (SIEMCALSA). Junta de Castile and León

(2) Estratégia Regional Alentejo 2030 (setembro de 2020). CCDR Alentejo, Portugal.

(3) Mineral Resources of the Alentejo Region. LNEG. DESENVOLVIMENTO REGIONAL E APROVEITAMENTO DOS RECURSOS ENDÓGENOS (lneg.pt)

(4) Zona dos Mármores Alentejanos (2020). Cluster Portugal Mineral Resources.

(5) Estadística de Labores Mineras en Extremadura 2022. Junta de Extremadura Estadística Minera - Portal SIGEO (juntaex.es)

(6) Mapa de Minerales Críticos en Andalusia. Junta de Andalusia. https://www.juntadeandalucia.es/portalandaluzdelamineria/DescargarMineralesCriticos?d=1

(7) Recursos Mineros de Extremadura: LAS ROCAS AND MINERALES INDUSTRIALES. JUNTA DE EXTREMADURA. Consejería para la Transición Ecológica and Sostenibilidad. Mérida, octubre 2019

(8) Cartografía de Recursos Minerales de Andalusia (2011). García-Cortés, A. (Ed. ppal) IGME – Junta de Andalusia.

(9) REGULATION (EU) 2024/1252 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL (11 april 2024). establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1724 and (EU) 2019/1020.

(10) Critical Raw Materials recovery potential from Spanish mine wastes: A national-scale preliminary assessment (2023). Adrián José Rosario-Beltré, Javier Sánchez-España, Virginia Rodríguez-Gómez, Francisco Javier Fernández-Naranjo, Eva Bellido-Martín, Paula Adánez-Sanjuán, Julio César Arranz-González. Journal of Cleaner Production, Volume 407. ISSN 0959-6526. https://doi.org/10.1016/j.jclepro.2023.137163.

(11) Critical Minerals Market Review 2023. International Energy Agency. IEA – International Energy Agency

(12) Hoja de Ruta para la Gestión Sostenible de las Materias Primas Minerales. (agosto de 2022). Ministerio para la Transición Ecológica and el Reto Demográfico. Hoja de ruta para la gestión sostenible de materias primas minerales (miteco.gob.es)

(13) Resiliencia de las Materias Primas Fundamentales en la UE (2020). Comisión Europea. [PDF].

(14) Manual de Evaluación Técnico-Económica de Proyectos Mineros de Inversión. Instituto Tecnológico GeoMinero de España (1990).

(15) Minería en Extremadura. Inicio - Portal SIGEO (juntaex.es)

(16) Minerales metálicos and energéticos - Portal SIGEO (juntaex.es)

(17) Minerales industriales - Portal SIGEO (juntaex.es)

(18) Geología de Extremadura Geología de Extremadura - Portal SIGEO (juntaex.es)

(19) Carta de Ocorrências Mineiras do Alentejo e Algarve (LNEG/Atlanterra Project, South Portugal, 400k) (PDF) Carta de Ocorrências Mineiras do Alentejo e Algarve (LNEG/Atlanterra Project, South Portugal, 400k) (researchgate.net)

(20) Wardell Armstrong International. (2023). Technical Report on the Neves-Corvo Mine, Portugal (Nos. NI43-10; p. 215). Lundin Mining Corporation. https://lundinmining.com/site/assets/files/3643/230222_-_lundin_mining_-_neves-corvo_2022_tr.pdfhttps://lundinmining.com/site/assets/files/3643/230222_-_lundin_mining_-_neves-corvo_2022_tr.pdf

(21) La Minería en Castile and León, SIEMCALSA (2007)

(22) NI 43-101 Technical Report on the Neves-Corvo Mine, Portugal, February 22, 2023.

(23) Almonty website (https://almonty.com/project/valtreixal-project/): Valtreixal Reserves/Resources NI 43-101

(24) ASCENDANT RESOURCES INC. (2023) Lagoa Salgada Mineral Reserve Estimate - Effective July 2023 (https://www.ascendantresources.com/English/Operations/Mineral-Resources/default.aspx)

(25) portalgeo – Direção-Geral de Energia e Geologia. (2024) (https://portalgeo.dgeg.gov.pt/arcgis/home/index.html)

8. Annexes

ANNEX
DELIVERABLE D6.5

LIST OF AVAILABLE CARTOGRAPHY

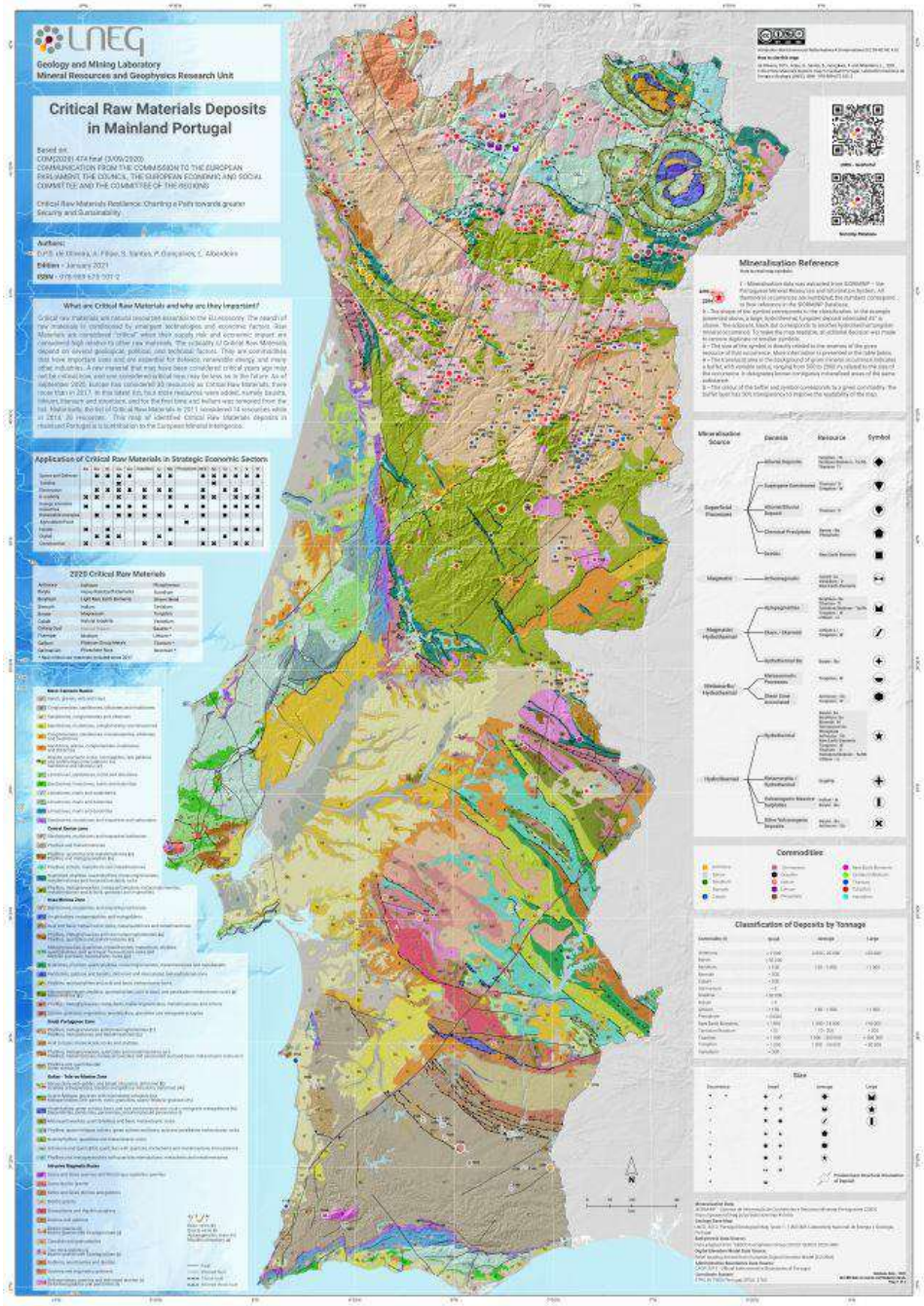
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1) Critical Raw Materials Deposits Mainland Portugal (2021)

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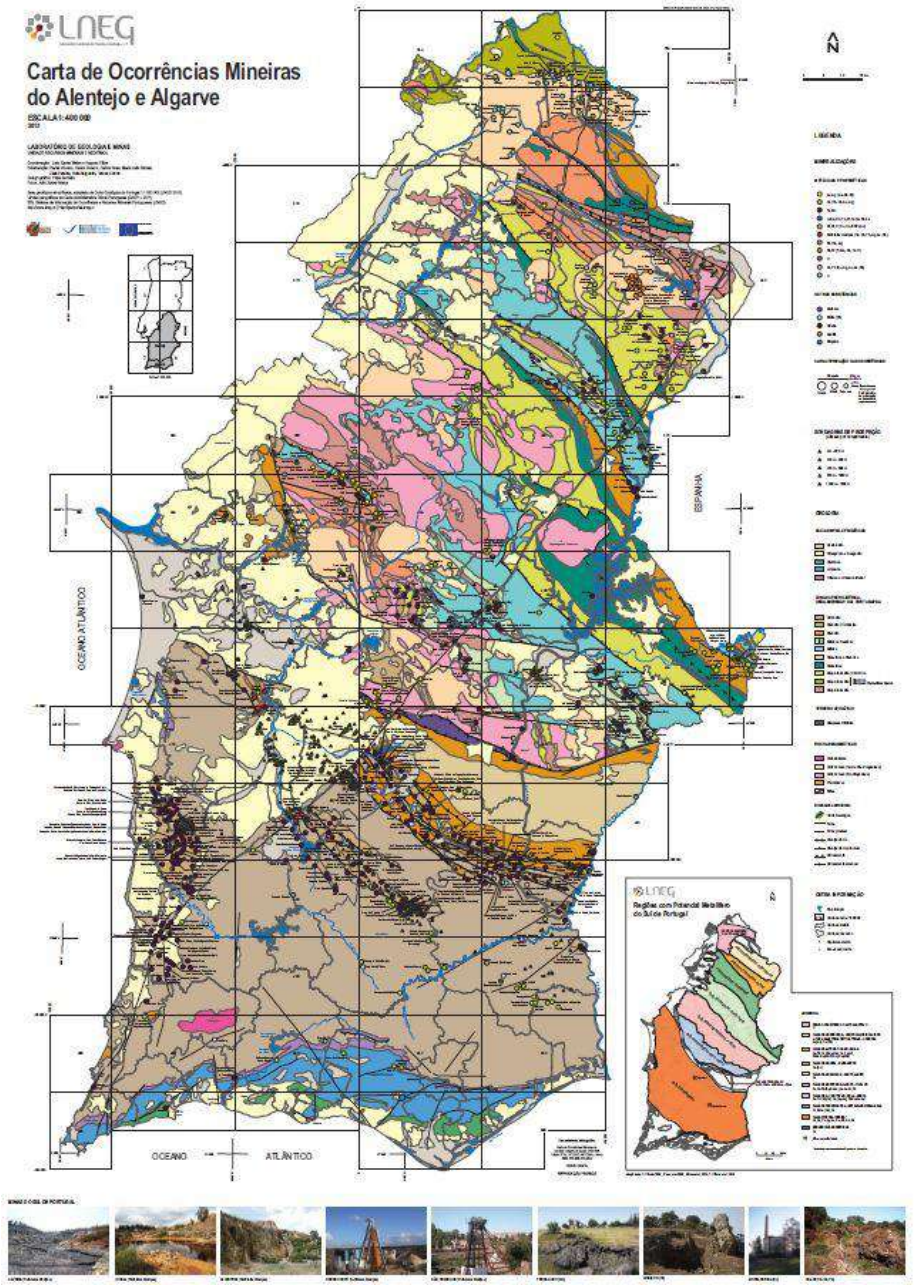
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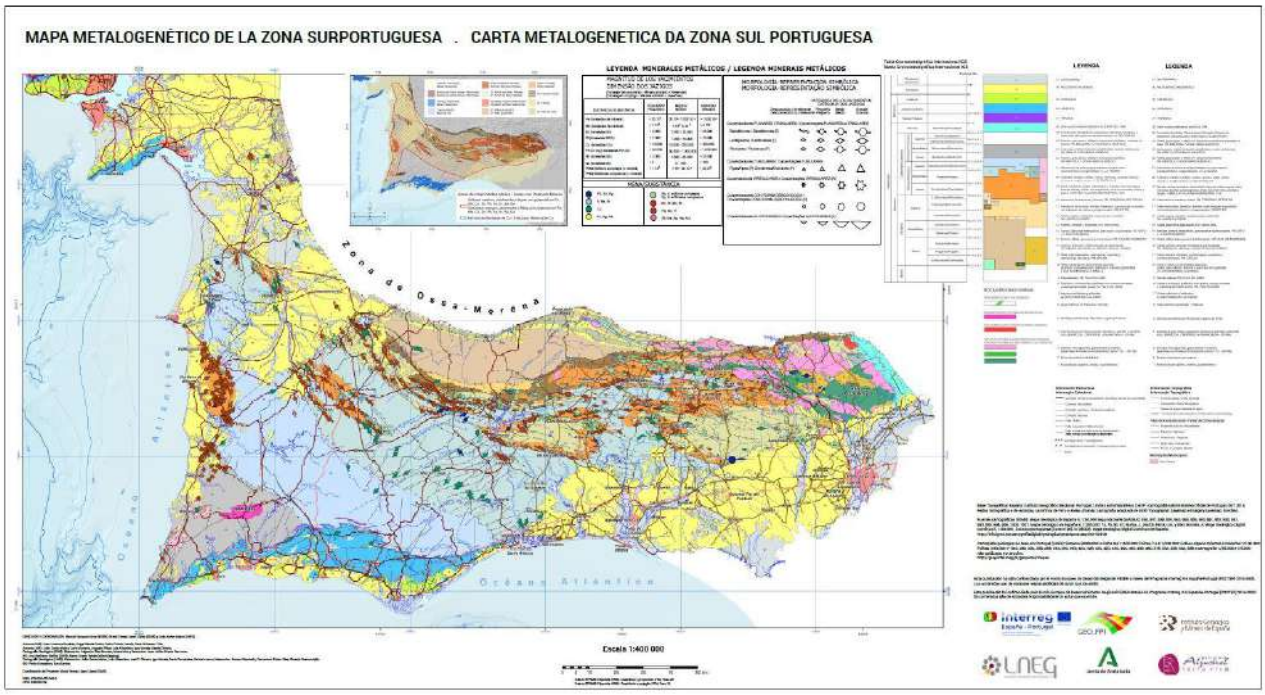
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3) Metallogeny Map of the Sudportuguese Region (2020)

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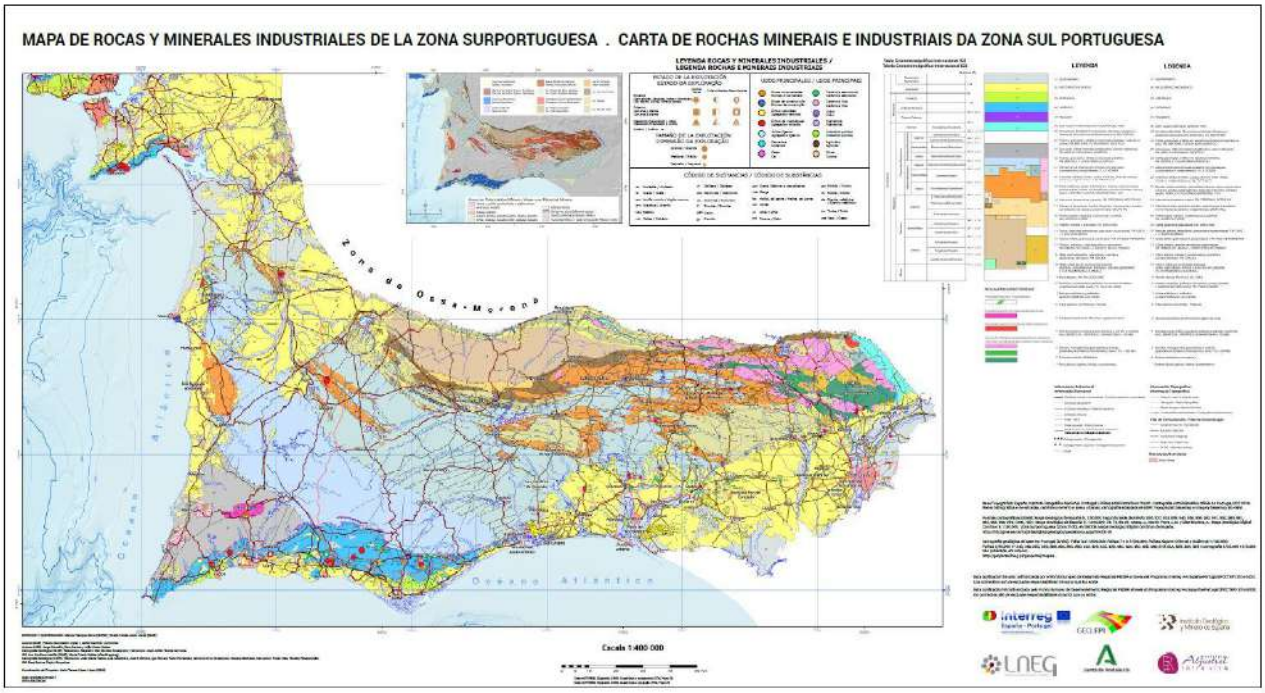
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4) Map of Industrial Minerals and Rocks of the Sudportuguese Region (2020)

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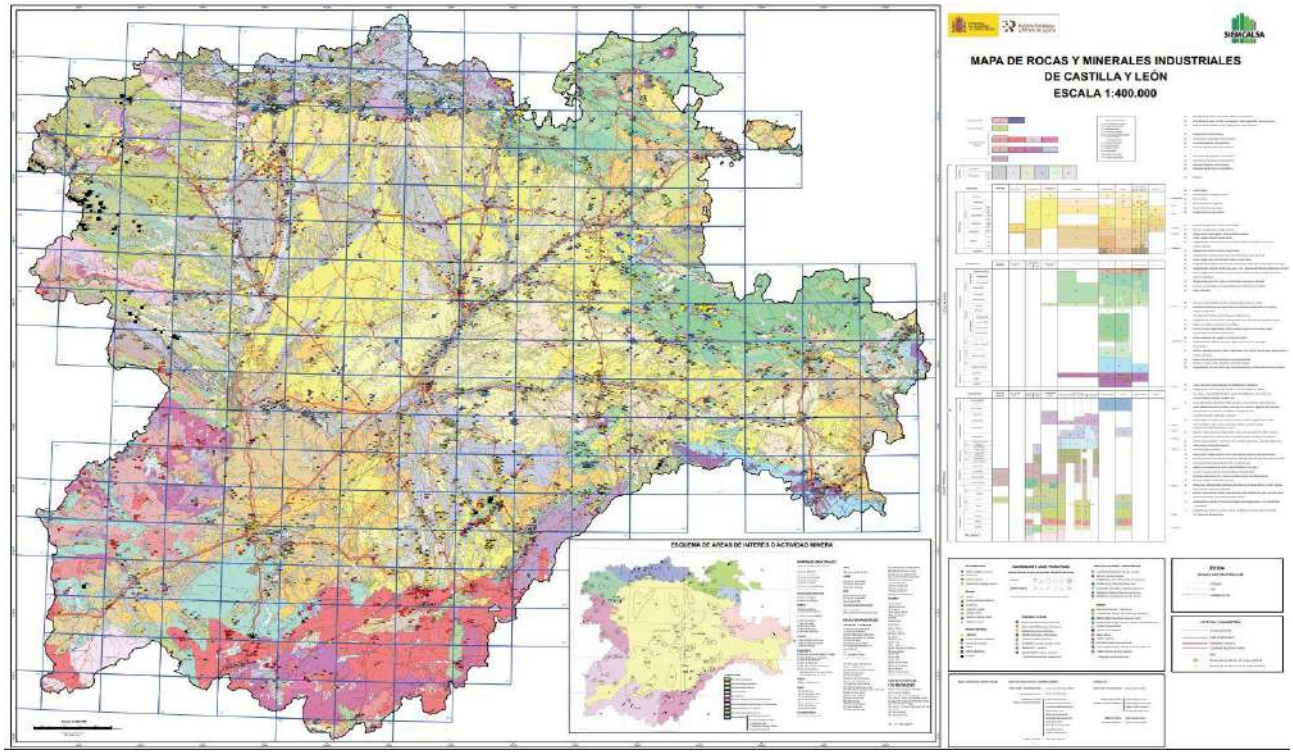
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5) Map of Industrial Minerals and Rocks of Castile and León (2014)

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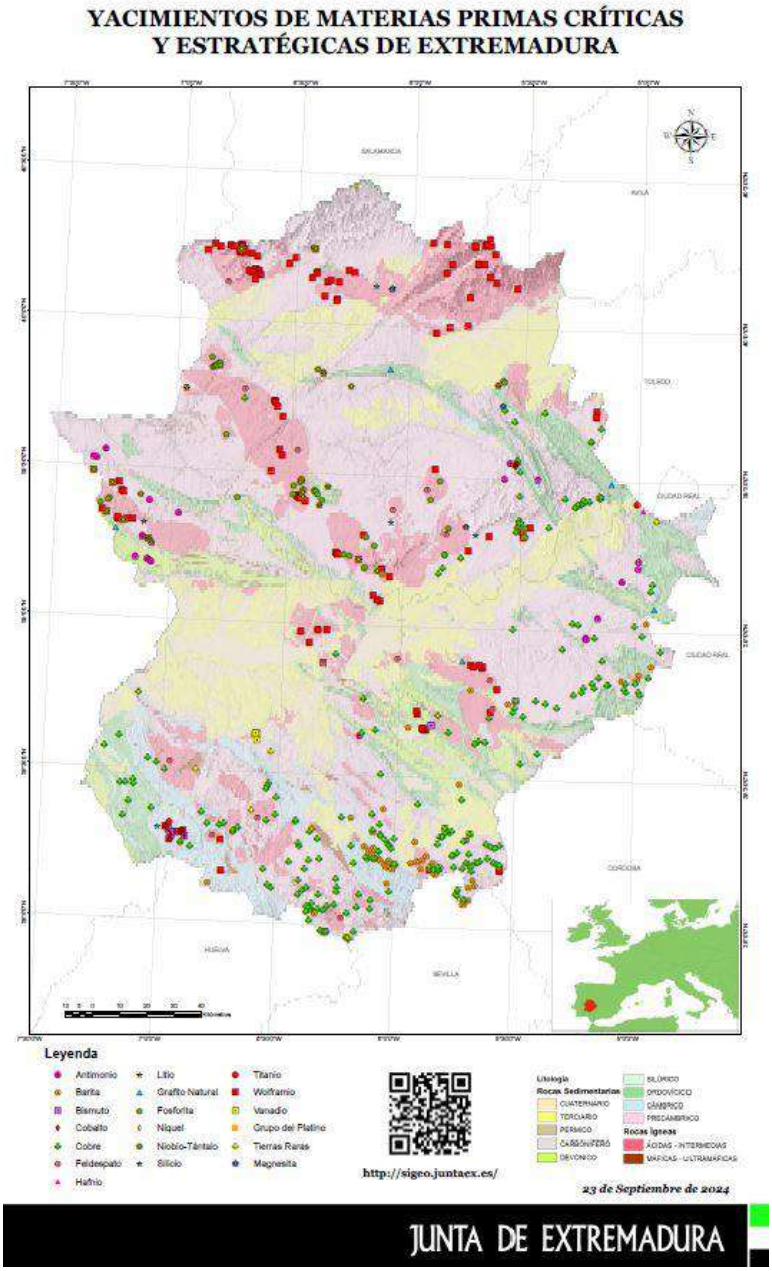
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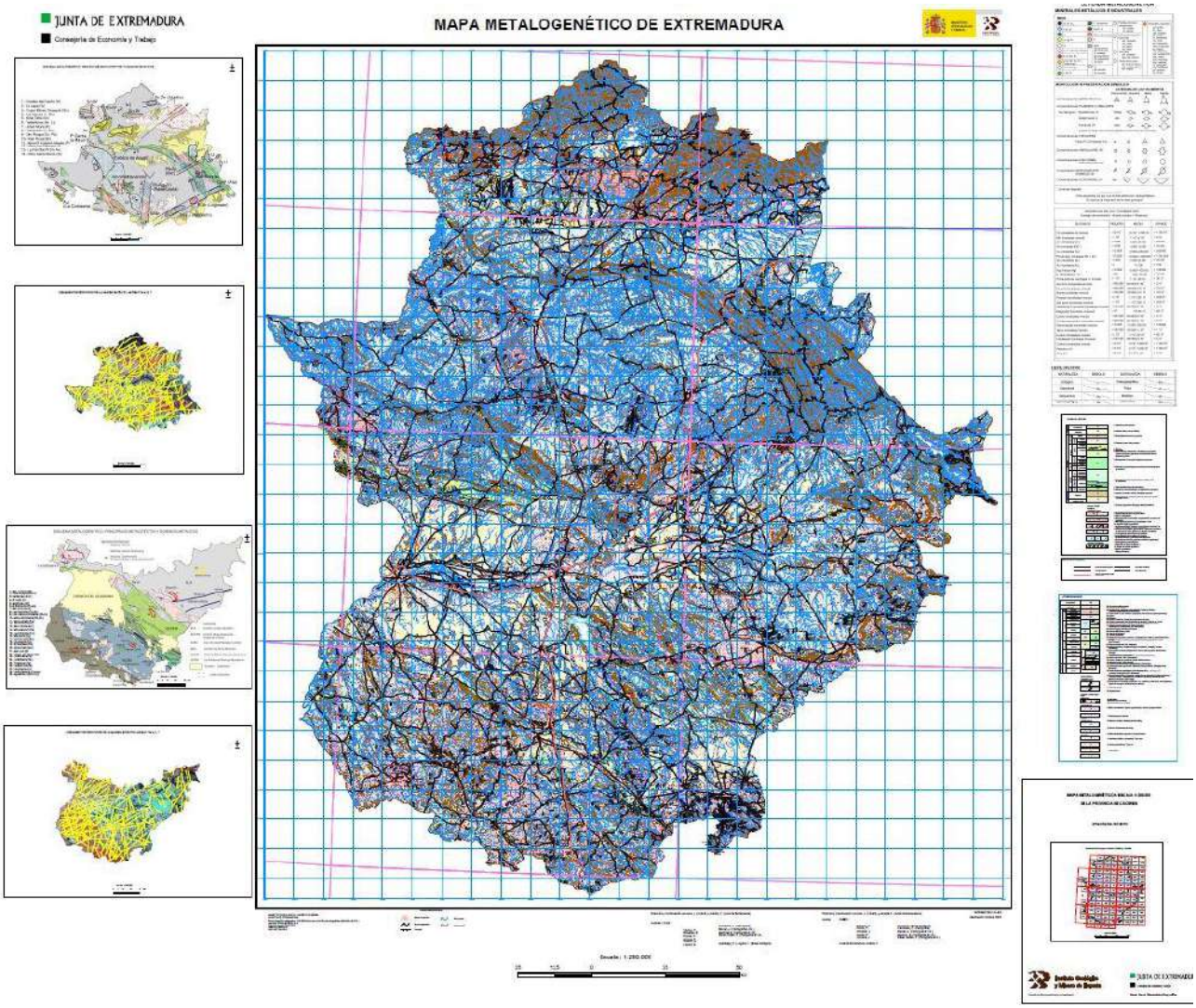
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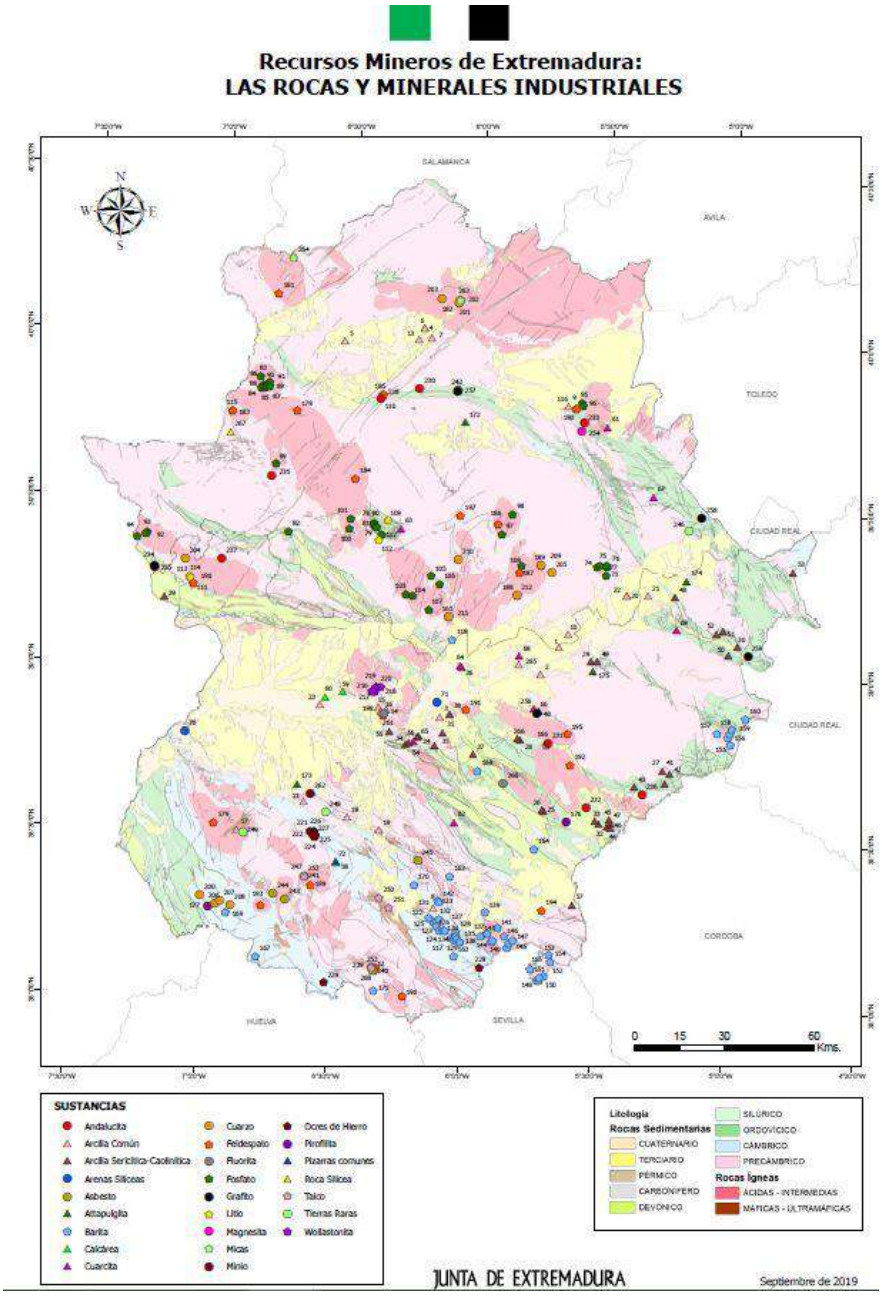
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8) Map of Industrial Minerals and Rocks of Extremadura (2019)

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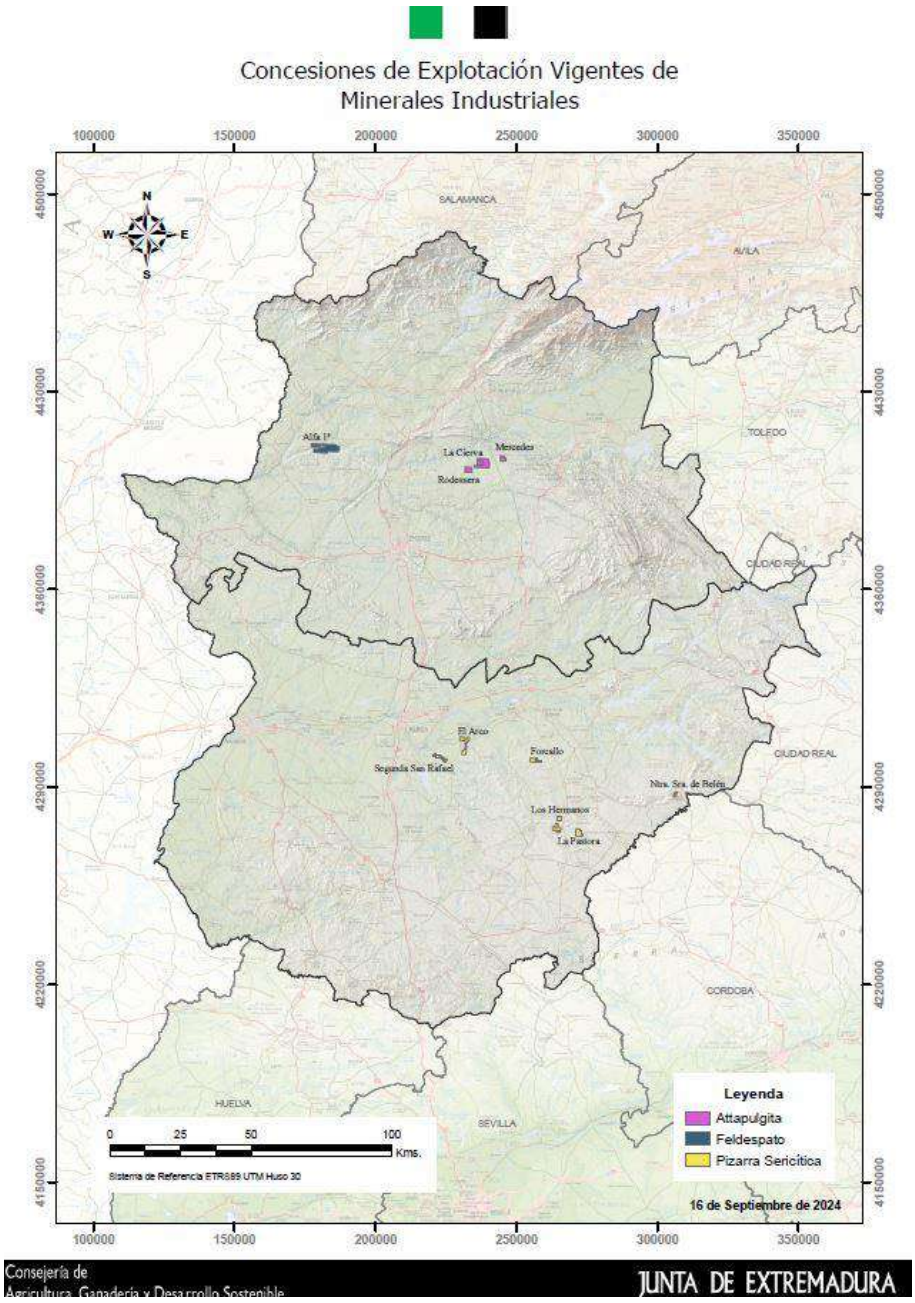
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9) Map of Industrial Mineral Concessions in Extremadura (2024)

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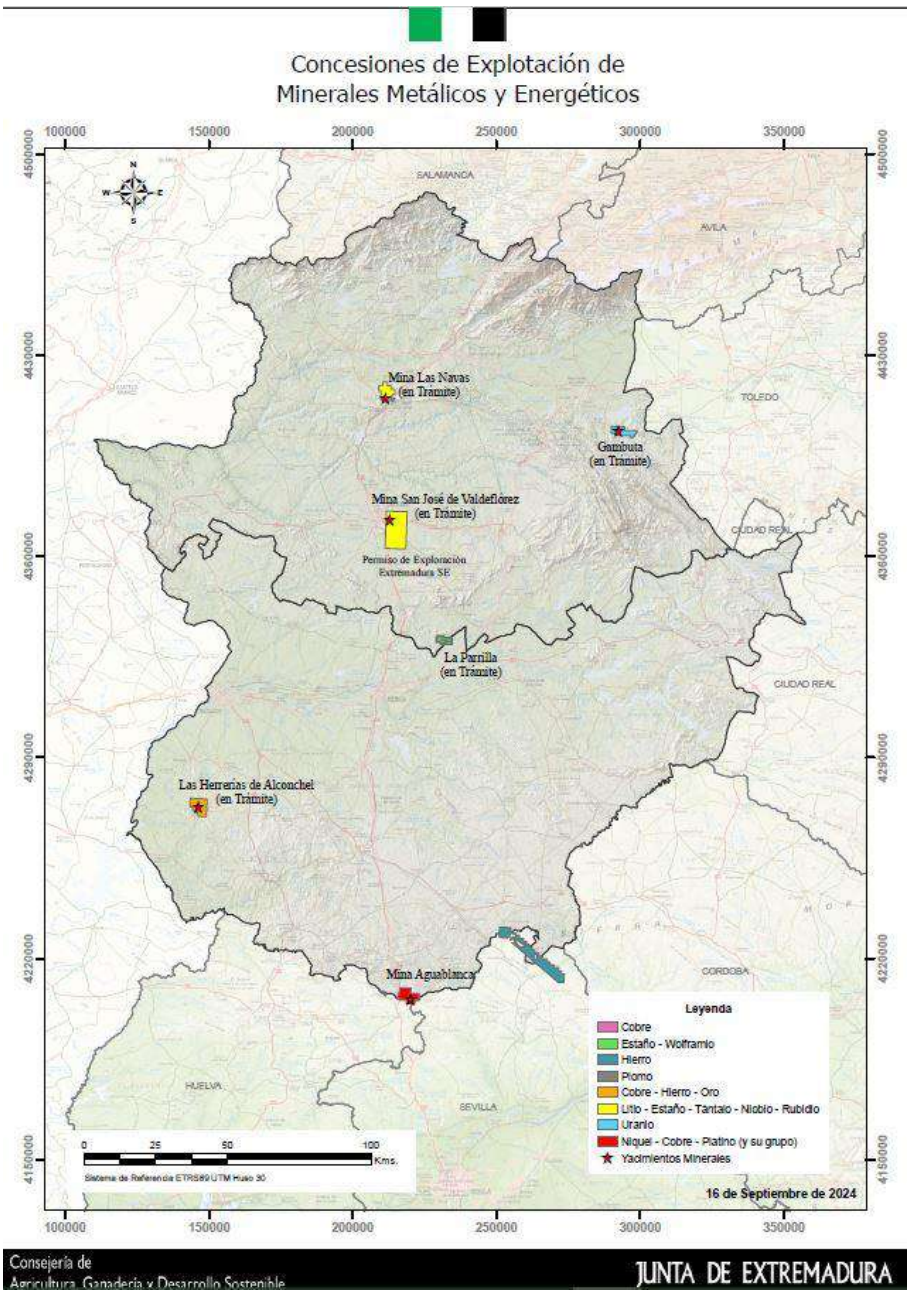
http://sigeo.juntaex.es/portalsigeo/c/document_library/get_file?uuid=74df57e0-4347-47c2-ae38-b0bfc32e2717&groupId=10137



10) Map of Metallic and Energetic Mineral Concessions in Extremadura (2024)

- Promoting body JUNTA DE EXTREMADURA
- Scale N/D
- Geological background N/D
- Mineralization data N/D
- Paper size A4
- File size 10 MB
- Web reference link

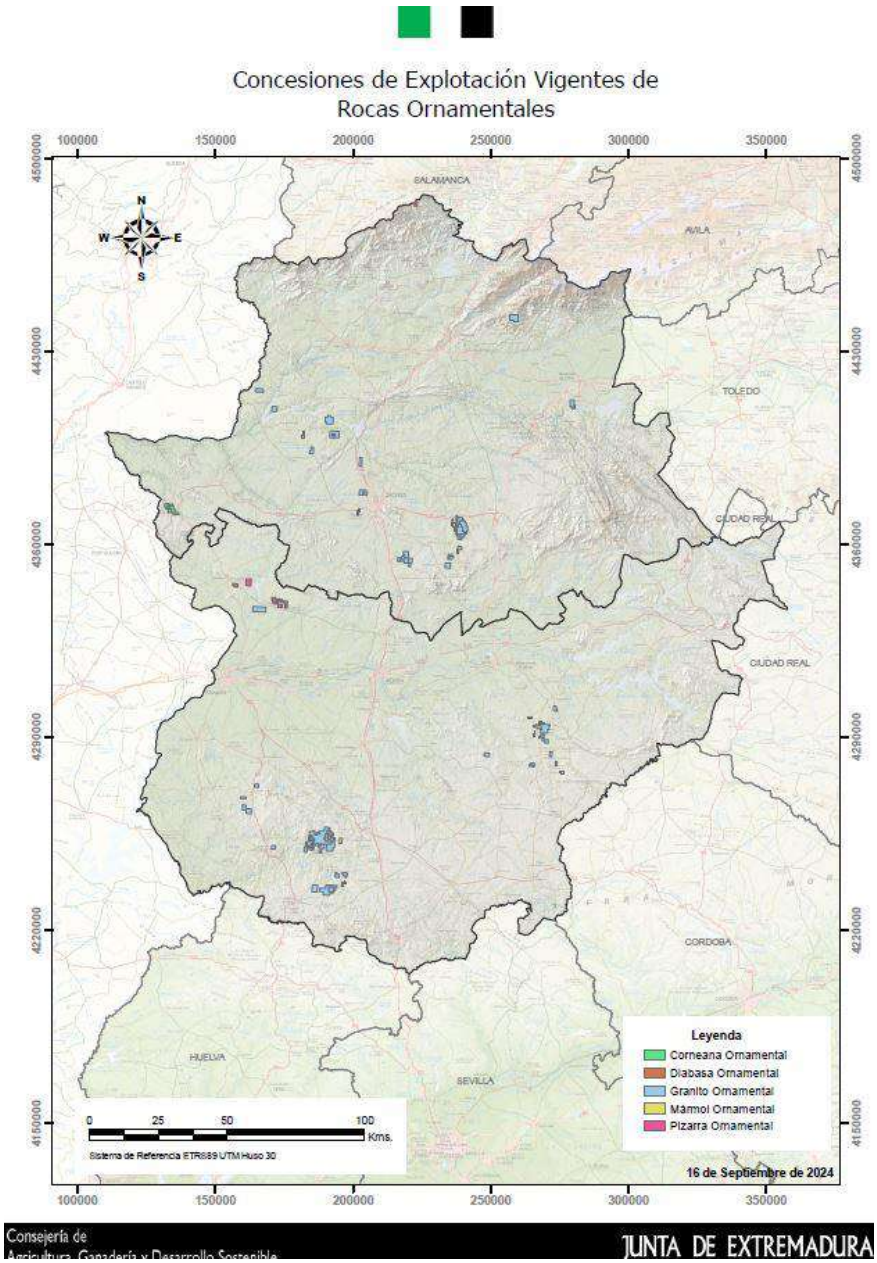
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11) Map of Ornamental Rock Concessions in Extremadura (2024)

- Promoting body JUNTA DE EXTREMADURA
- Scale N/D
- Geological background N/D
- Mineralization data N/D
- Paper size A4
- File size 10 MB
- Web reference link

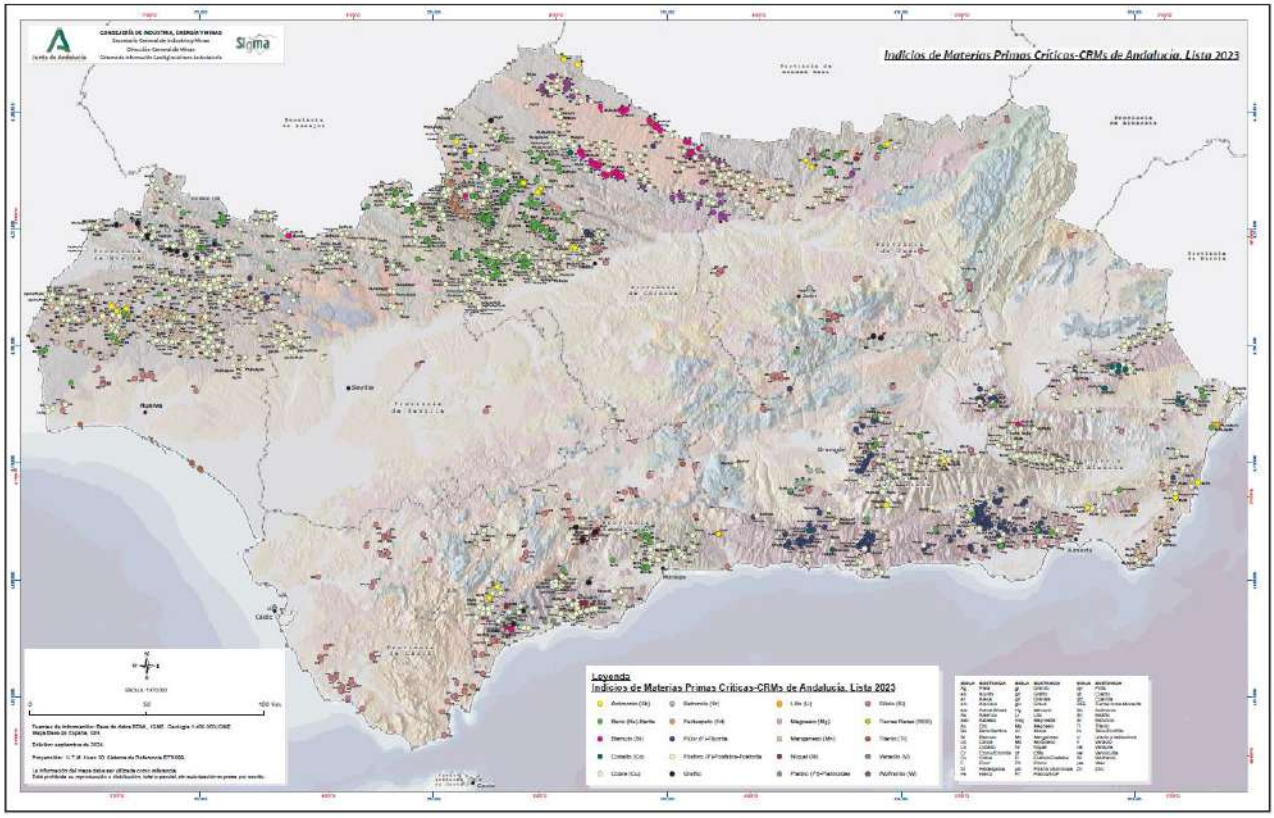
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12) Map of Critical Raw Materials of Andalucía (2023)

- Promoting body JUNTA DE ANDALUCÍA
- Scale 1: 470.000
- Geological background IGME Mapa 1: 400.000
- Mineralization data BDMIN (IGME)
- Paper size A0
- File size 123 MB
- Web reference link

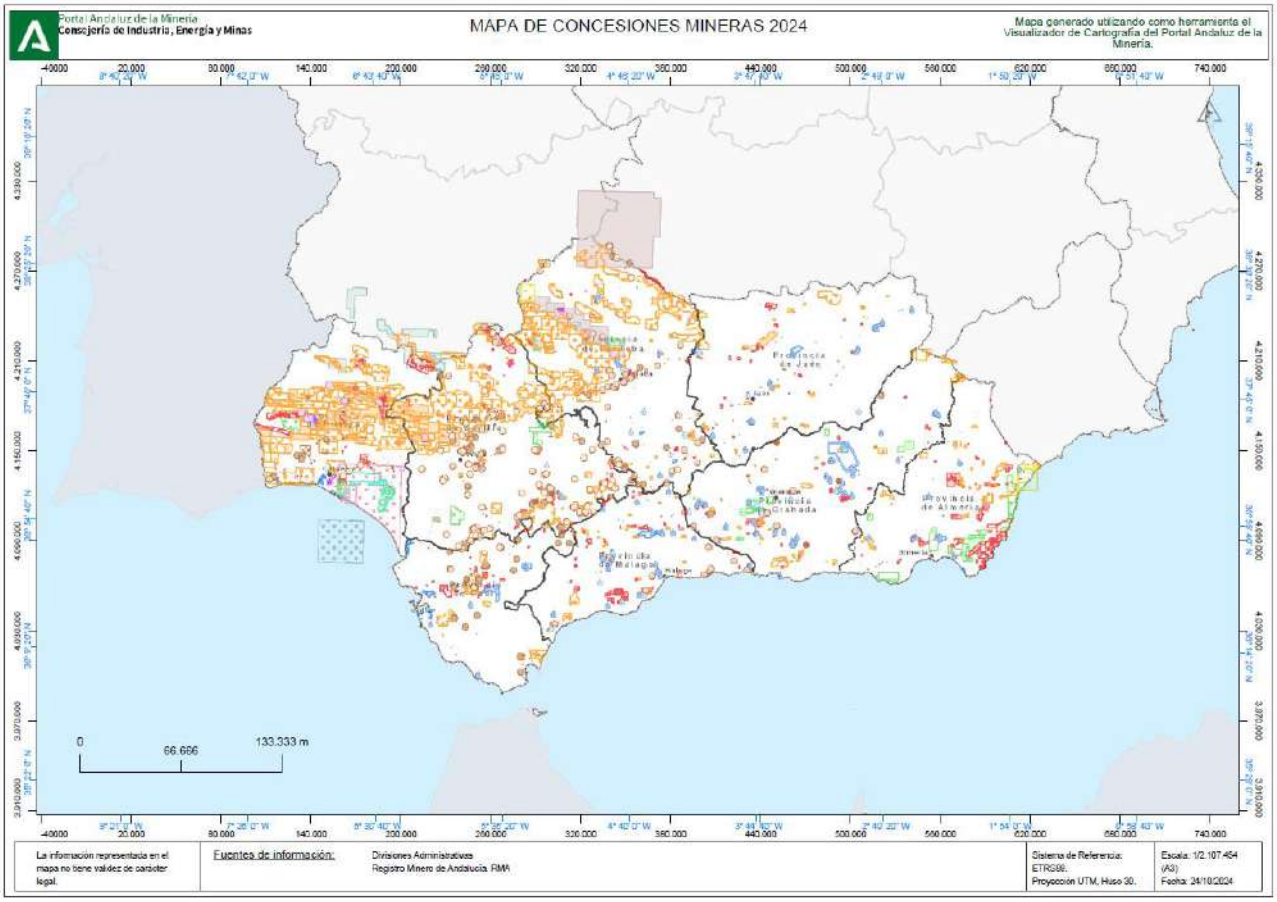
https://www.juntadeandalucia.es/portalandaluzdelamineria/DescargarMineralesCriticos?d=1



13) Map of Mining Concessions Andalucía (2022)

- Promoting body JUNTA DE ANDALUCÍA
- Scale 1: 800 000
- Geological background IGME Mapa 1: 1 000 000
- Mineralization data RMA
- Paper size A3 (Created on demand in the web app)
- File size 2 MB
- Web reference link

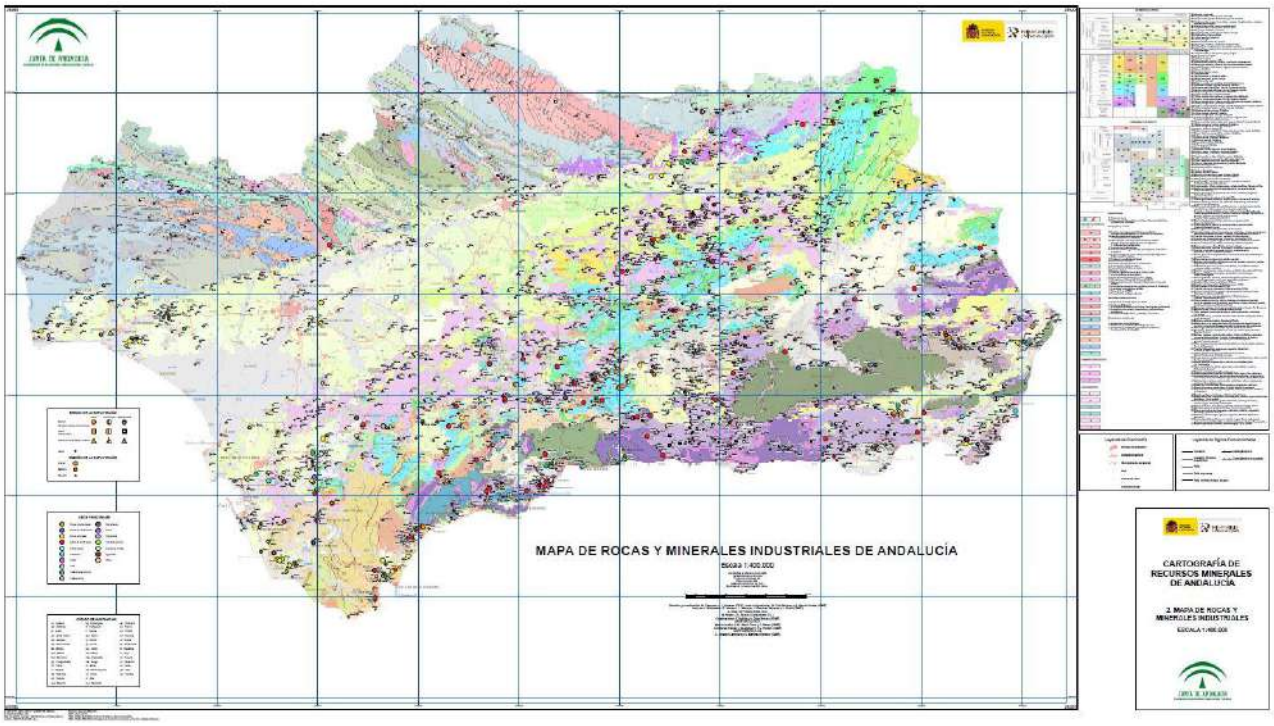
https://www.juntadeandalucia.es/portalandaluzdelamineria/pamapps/visor/Visor.action



14) Map of Industrial Minerals and Rocks of Andalucía (2022)

- Promoting body JUNTA DE ANDALUCÍA – IGME
- Scale 1: 400 000
- Geological background MAGNA
- Mineralization data SIGMA – IGME
- Paper size 1620x910
- File size 15 MB
- Web reference link

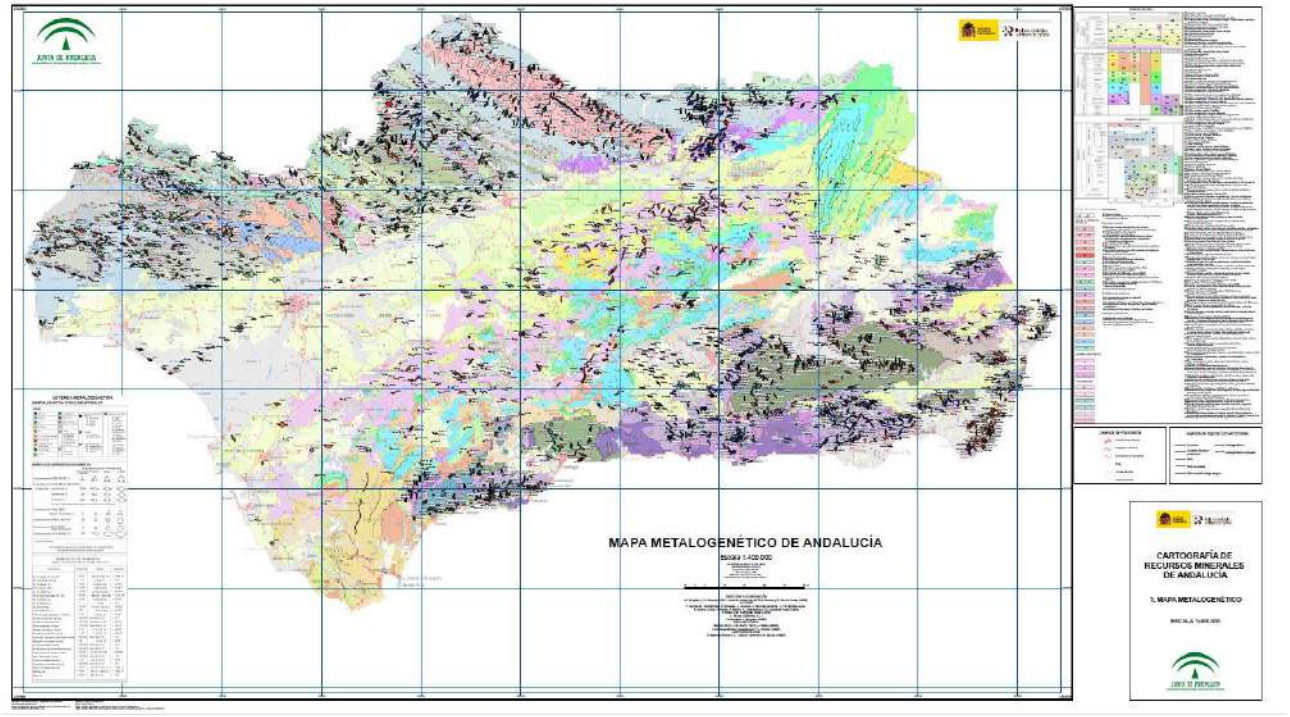
https://www.juntadeandalucia.es/portalandaluzdelamineria/AbrirEnlaceCartografiaGeologica.action



15) Metallogeny Map of Andalucía (2022)

- Promoting body JUNTA DE ANDALUCÍA
- Scale 1: 400 000
- Geological background
- Mineralization data
- Paper size 1600x910
- File size 16 MB
- Web reference link

https://www.juntadeandalucia.es/portalandaluzdelamineria/AbrirEnlaceCartografiaGeologica.action



ANNEX
ORIGINAL MAPS

LNEG
Geology and Mining Laboratory
Mineral Resources and Geophysics Research Unit

Critical Raw Materials Deposits in Mainland Portugal

Based on:
COM(2020) 474 final (3/09/2020)
COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability

Authors:
D.P.S. de Oliveira, A. Filipe, S. Santos, P. Gonçalves, L. Albardeiro

Edition - January 2021
ISBN - 978-989-675-101-2

What are Critical Raw Materials and why are they important?

Critical raw materials are natural resources essential to the EU economy. The search of raw materials is conditioned by emergent technologies and economic factors. Raw Materials are considered "critical" when their supply risk and economic impact are considered high relative to other raw materials. The criticality of Critical Raw Materials depend on several geological, political, and technical factors. They are commodities that have important uses and are essential for defence, renewable energy, and many other industries. A raw material that may have been considered critical years ago may not be critical now, and one considered critical now may be less so in the future. As of September 2020, Europe has considered 30 resources as Critical Raw Materials, three more than in 2017. In this latest list, four more resources were added, namely bauxite, lithium, titanium and strontium, and for the first time and helium was removed from the list. Historically, the list of Critical Raw Materials in 2011 considered 14 resources while in 2014, 20 resources. This map of identified Critical Raw Materials deposits in mainland Portugal is a contribution to the European Mineral Intelligence.

Application of Critical Raw Materials in Strategic Economic Sectors

	Ba	Be	Bi	Co	Ge	Graphite	In	Nb	Phosphate	REE	Sb	Ta	Ti	V	W
Space and Defense		✖	✖	✖	✖		✖	✖		✖	✖	✖	✖	✖	✖
Textiles				✖							✖				
Electronics		✖	✖	✖	✖	✖	✖	✖		✖		✖	✖		✖
E-mobility	✖	✖		✖		✖		✖		✖	✖		✖	✖	✖
Energy intensive Industries	✖		✖	✖	✖	✖		✖	✖	✖		✖	✖	✖	✖
Renewable energies		✖		✖	✖	✖	✖			✖		✖		✖	
Agriculture/Food									✖						
Health	✖		✖					✖		✖			✖	✖	✖
Digital		✖	✖	✖			✖					✖			
Construction	✖		✖			✖		✖		✖	✖		✖	✖	

2020 Critical Raw Materials

Antimony	Hafnium	Phosphorous
Baryte	Heavy Rare Earth Elements	Scandium
Beryllium	Light Rare Earth Elements	Silicon Metal
Bismuth	Indium	Tantalum
Borate	Magnesium	Tungsten
Cobalt	Natural Graphite	Vanadium
Coking Coal	Natural Rubber	Bauxite *
Fluorspar	Niobium	Lithium *
Gallium	Platinum Group Metals	Titanium *
Germanium	Phosphate Rock	Strontium *

* New critical raw materials included since 2017

Meso-Cenozoic Basins
- Q^2 Sands, gravels, silts and clays
- Q^1 Conglomerates, sandstones, siltstones and mudstones
- N^2 Sandstones, conglomerates and siltstones
- N^1_m Sandstones, mudstones, conglomerates and limestones
- N^1_c Conglomerates, sandstones, biocalcarenites, siltstones and mudstones
- E Sandstone, arkose, conglomerates, mudstones and siltstones
- $\gamma\mu K^2$ Basalts, pyroclastic rocks, microgabbro, rare gabbros and sedimentary intercalations ($\gamma\mu$) Sandstone and siltstone (K^2)
- K^{1-2} Limestones, sandstones, marls and dolomites
- K^1 Sandstones, limestones, marls and dolomites
- J^3 Limestones, marls and sandstones
- J^2 Limestones, marls and dolomites
- J^1 Limestones, marls and dolomites
- TJ^1 Sandstones, mudstones and evaporites and carbonates

Central Iberian zone
- C^2 Sandstones, mudstones and evaporites/carbonate
- C^1_k Phyllites and metalimestones
- $D^1_q D^1_{qz}$ Phyllites, quartzites and metalimestones (D^1_q) Phyllites and metagreywackes (D^1_{gr})
- S Phyllites, schists, metacherts and metalimestones
- O^1_{qz} Quartzites, phyllites, quartzphyllites, metaconglomerates, metalimestones and metavolcaniclastic rocks
- NP Phyllites, metagreywackes, metaquartzwackes, metaconglomerates, metalimestones and schists, gneisses and migmatites

Ossa Morena Zone
- C^2 Sandstones, mudstones and evaporites/carbonate
- D^2_{β} Amphibolites, metaperidotites and metagabbros
- $D^2 C^1$ Acid and basic metavolcanic rocks, metamudstones and metalimestones
- D^1_{gr} D^1_q Phyllites, metagreywackes and rare metaconglomerates (D^1_{gr}) Phyllites, quartzites and metalimestones (D^1_q)
- $OD^1 SD^1$ Metagreywackes, quartzites, metasiltstones, metacherts, phyllites, quartzphyllites, acid and basic metavolcanic rocks (SD^1) Marbles and basic metavolcanic rocks (OD^1)
- O^1_{qz} Quartzites, phyllites, quartzphyllites, metaconglomerates, metalimestones and metabasalts
- O^1_{β} Peridotites, gabbros and basalts, deformed and intercalated metaradiolarianstone
- ε^2 Phyllites, quartzphyllites and acid and basic metavolcanic rocks
- ε^2 ε^2_{ls} Metaconglomerate, phyllites, quartzphyllites, acid to basic and peralkaline metavolcanic rocks (ε^2) Metacalcarios (ε^2_{ls})
- NP^2 Phyllites, metagreywackes, metacherts, metaconglomerates, metalimestones and schists
- NP^1 Schists, gneisses, migmatites, amphibolites, granulites and retrograde eclogites

South Portuguese Zone
- C^{1-2} C^1_k Phyllites, metagreywackes and metaconglomerates (C^{1-2}) Phyllites, metasiltstones and metalimestones (C^1_k)
- $D^1 C^1$ Acid to basic metavolcanic rocks and phyllites
- D^{2-3} D^{2-3}_{qz} Phyllites, metagreywackes, quartzites and metalimestones (D^{2-3}) Phyllites, metasiltstones, metaquartzwackes and associated acid and basic metavolcanic rocks (D^{2-3}_{γ})
- SD V Phyllites and quartzites (SD) Green schists (V)

Galiza - Trás-os-Montes Zone
- ε_{NR} Micaschists with gabbro and basalt intrusions, deformed (ε_c) Ocellate orthogneisses, basalts and gabbros intrusions, deformed (NR_1)
- NP_{qf} NP_{γ} Quartz-feldspar gneisses with intercalated eclogites (NP_{qf}) Metaperidotites with garnet, mafic granulites, quartz-feldspar gnaisses (NP_{γ})
- SD_{β} Amphibolites, green schists, basic and rare acid metavolcanic rocks, retrograde metagabbros (SD_{β}) Serpentinites, peridotites, pyroxenites, retromorphosed pyroxenites ()
- D^1_{qz} Metaquartzwackes, quartzphyllites and basic metavolcanic rocks
- S_{qf} Phyllites, quartz-feldspar schists, green schists and basic, acid and peralkaline metavolcanic rocks
- Q^1_{qz} Quartzphyllites, quartzites and metavolcanic rocks
- OD^1_{qz} Schistose and quartzlithic quartzites with quartzite, metacherts and metalimestone intercalations
- SD^1_{gr} Phyllites and metagreywackes with quartzite intercalations, metacherts and metalimestones

Intrusive Magmatic Rocks
- σ^2 Sintra and Sines syenites and Monchique nepheline syenites
- $\gamma^{2\eta}$ Sintra biotitic granite
- β^2 Sintra and Sines diorites and gabbros
- γ^{III} Biotitic granite
- π Granophyres and rhyolitic porphyry
- β^1 Diorites and gabbros
- γ^1_{η} Biotitic granite (γ^1_{η}) γ^1_{η} Biotitic granite with Ca-plagioclase (γ^1_{η})
- γ^1_{λ} Tonalites and granodiorites
- γ^1_{η} Two mica granite (γ^1_{η}) Biotitic granite with Ca-plagioclase (γ^1_{η})
- β^1 Gabbros, anorthosites and diorites
- γ^1 Granites and migmatitic gneisses
- γ_{γ} γ_{η} Orthogneisses, granites and deformed diorites (γ_{γ}) Deformed gabbros and peridotites (γ_{η})

Basic veins (Φ^1)
Quartz veins (q)
Aplopegmatitic veins (γ_{ap})
Rhyolitic phorphyry (Φ)

Fault
Inferred fault
Thrust fault
Inferred thrust fault

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How to cite this map:

de Oliveira, D.P.S., Filipe, A., Santos, S., Gonçalves, P. and Albardeiro, L., 2021. Critical Raw Materials deposits map in mainland Portugal. Laboratório Nacional de Energia e Geologia (LNEG). ISBN - 978-989-675-101-2

LNEG - GeoPortal

Siorminp Database

Mineralisation Reference

How to read map symbols:

2293
2294

1 - Mineralisation data was extracted from SIORMINP – the Portuguese Mineral Resources and Information System. All themineral occurrences are numbered; the numbers correspond to their reference in the SIORMINP Database.
2 - The shape of the symbol corresponds to the classification. In the example presented above, a large, hydrothermal, tungsten deposit orientated 45° is shown. The adjacent, black dot corresponds to another hydrothermal tungsten mineral occurrence. To make the map readable, an editorial decision was made to remove duplicate or smaller symbols.
3 – The size of the symbol is directly related to the reserves of the given resource of that occurrence. More information is presented in the table below.
4 – The translucid area in the background of given mineral occurrence indicates a buffer, with variable radius, ranging from 500 to 2000 m, related to the size of the occurrence. It designates known contiguous mineralised areas of the same substance.
5 – The colour of the buffer and symbol corresponds to a given commodity. The buffer layer has 50% transparency to improve the readability of the map.

Mineralisation Source	Genesis	Resource	Symbol
Superficial Processes	Alluvial Deposits	Tungsten - W Tantalum/Niobium - Ta/Nb Titanium- Ti	◆
	Supergene Enrichment	Titanium- Ti Tungsten - W	▼
	Alluvial/Elluvial Deposit	Titanium- Ti	●
	Chemical Precipitate	Baryte - Ba Phosphate	⬟
	Detritic	Rare Earth Elements	■
Magmatic	Orthomagmatic	Cobalt- Co Vanadium - V Rare Earth Elements	⋈
Magmatic/ Hydrothermal	Aplopegmatites	Beryllium- Be Titanium- Ti Tantalum/Niobium - Ta/Nb Tungsten - W Lithium - Li	◥
	Skarn / Skarnoid	Lithium-Li Tungsten - W	/
	Hydrothermal Ba	Baryte - Ba	✦
Metamorfic/ Hydrothermal	Metassomatic Processes	Tungsten - W	◒
	Shear Zone Associated	Antimony - Sb Tungsten - W	⬢
Hydrothermal	Hydrothermal	Baryte- Ba Beryllium- Be Bismuth- Bi Germanium-Ge Phosphate Antimony - Sb Rare Earth Elements Tungsten - W Titanium - Ti Tantalum/Niobium - Ta/Nb Lithium - Li	★
Hydrothermal	Metamorphic / Hydrothermal	Graphite	✚
	Volcanogenic Massive Sulphides	Indium - In Baryte - Ba	▌
	Other Volcanogenic Deposits	Baryte - Ba Antimony - Sb	✖

Commodities

- Antimony
- Baryte
- Beryllium
- Bismuth
- Cobalt
- Germanium
- Graphite
- Indium
- Lithium
- Phosphate
- Rare Earth Elements
- Tantalum\Niobium
- Titanium
- Tungsten
- Vanadium

Classification of Deposits by Tonnage

Commodity (t)	Small	Average	Large
Antimony	< 2 000	2 000 - 20 000	>20 000
Baryte	< 50 000		
Beryllium	< 100	100 - 1 000	>1 000
Bismuth	< 500		
Cobalt	< 200		
Germanium	< 5		
Graphite	< 50 000		
Indium	< 5		
Lithium	< 150	150 - 1 500	>1 500
Phosphate	< 50000		
Rare Earth Elements	< 1500	1 500 - 15 000	>15 000
Tantalum\Niobium	<10	10 - 200	> 200
Titanium	< 1 000	1 000 - 500 000	> 500 000
Tungsten	< 1 000	1 000 - 50 000	> 50 000
Vanadium	< 500		

Size

Occurrence	Small	Average	Large
◆ ×	◆ ◢	◆	◥
▼	▼ +	◥	★
◢	● ⬟	◢	▌
+	▲ ★	⬟	
◒	⬟ +	⬢	
●	■ ▌	★	
⋈	⋈ ✖		
◥			

Predominant Structural Orientation of Deposit

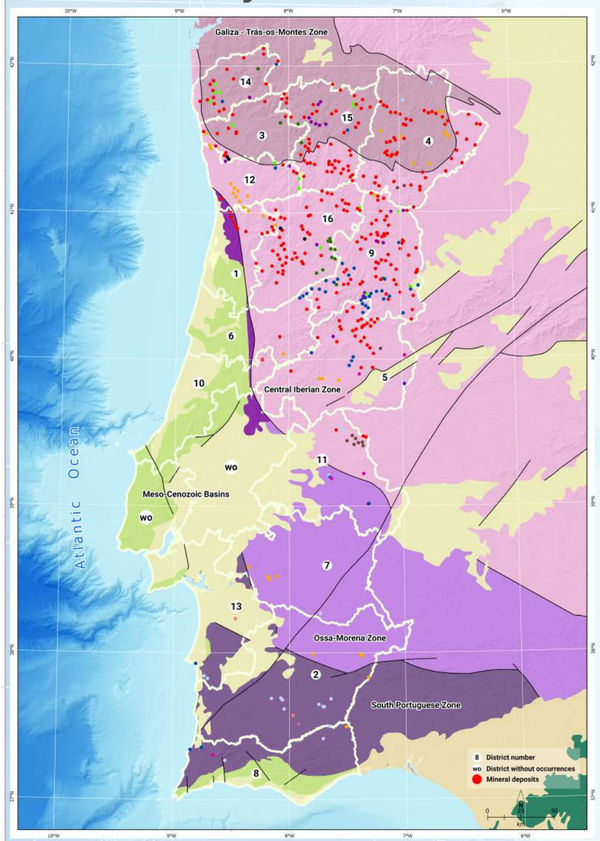
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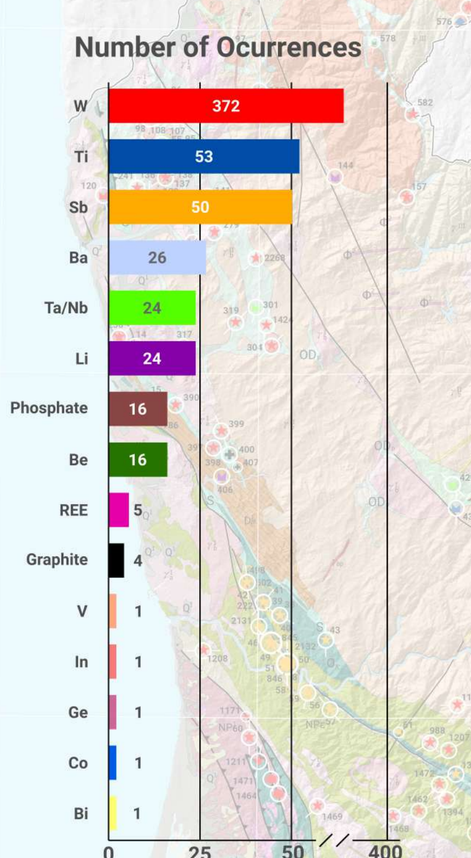
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Mineralisation Data:
SIORMINP - Sistema de Informação de Ocorrências e Recursos Minerais Portugueses (2002) https://geoportal.lneg.pt/pt/bds/siorminp/#!/intro
Geology Base Map:
LNEG, 2010. Portugal Geological Map, Scale 1: 1 000 000. Laboratório Nacional de Energia e Geologia, Portugal
Bathymetric Data Source:
Data adapted from "GEBCO Compilation Group (2020)" GEBCO 2020 GRID
Digital Elevation Model Data Source:
Relief shading derived from European Digital Elevation Model (EU-DEM)
Administrative Boundaries Data Source:
CAOP 2019 - Official Administrative Boundaries of Portugal
Coordinate System:
ETRS 89 TM06 Portugal; EPSG: 3763

Database Date - 2020
No CRM data on Açores and Madeira Islands

Critical Raw Materials Deposits by District





1 - Aveiro District
Deposit - Commodity - Morphology
57 - Cabranca - Sb - Vein
58 - Carvoeiro - Sb - Vein
60 - Levadas e S. Jorge - W - Vein
61 - Vila Cova - Sb - Irregular
988 - Campo Mineiro de Alvarenga - W - Vein
1171 - Quintais (Fiães) - W - Vein
1207 - Côto do Sino - W - Vein
1211 - Lugar de Nadais - W - Vein
1394 - Campo Mineiro de Regoufe (Arouca) - W - Vein
1462 - Campo Mineiro do Rio de Frades (Arouca) - W - Vein
1464 - Mina do Pintor - W - Vein
1469 - Quinta do Poeta e Feiteira - W - Vein
1471 - Fial - W - Vein
1472 - Campo Mineiro de Janarde e Covelo de Paivô (Silveiras) - W - Vein
1934 - Boucinha - W - Vein

2 - Beja District
Deposit - Commodity - Morphology
1234 - Louzeiras - Sb - Vein
1243 - Campo Mineiro de Neves Corvo - In - Stratiform
1244 - Barrigão - Ge - Vein
1637 - Monte Velho - Ba - Vein
1703 - Horta do Surdo - Ba - Vein
1708 - Casa das Eiras Grandes - Ba - Vein
1718 - Herdade da Ventosa - Sb - Vein
1723 - Almojafras - Sb - Stratiform
1826 - Courela dos Moinhos - Ba - Vein
1827 - Cerro da Lombada - Ba - Vein
1830 - Quinhão do Monte Branco - Ba - Vein
1831 - Chada da Horta - Ba - Vein
1832 - Monte do Cerro - Ba - Vein
2126 - Charneca do Garrochal - Ba - Vein
2155 - Vale de Espadas - Sb - Vein
2184 - Moinho do Marmeleiro - Ba - Vein

3 - Braga District
Deposit - Commodity - Morphology
14 - Monte Faro - Sb - Vein
15 - Lagoa Negra - Sb - Vein
157 - Chão de Miregos - W - Vein
181 - Campo Mineiro de Campos / Seprão, Beleirinho, Casula, Achas e Zebral - W - Vein
182 - Borralha / Sector de Águas Terças, Quebrada e Além Rio - W - Vein
183 - Borralha / Sector da Cruzinha - W - Vein
234 - Monte do Faro (W) - W - Vein
238 - Quinta das Pegas - W - Vein
239 - Vizo - W - Vein
301 - Abelheiras - Ta/Nb - Vein
304 - S. Gens - W - Vein
317 - Lugar de Peneda - W - Vein
319 - Carqueijoso - W - Vein
325 - Muro Alto - Be/W - Vein
390 - Castanheira - W - Vein
397 - Miradouros - W - Vein
398 - Lugar do Espido, Alpoim e Ferreiras - W - Vein
399 - Paúlos e Pedra Fita - W - Vein
400 - Lugar da Igreja - Graphite - Stratiform
406 - Raidos - Li - Irregular
407 - Terra Negra e Ferreiros - Graphite - Irregular
1424 - Tibães - W - Vein
2268 - Portela das Cabras - W - Vein

4 - Bragança District
Deposit - Commodity - Morphology
4 - Argozelo - W - Vein
27 - Cabecinho do Prado (Vilar Chão) - Sb - Vein
70 - Aveleda / Alto da Caroceira - Ba - Stratiform
230 - Rebordelo / Minas da Trigueiriça - W - Vein
233 - Valvelos (Alvelos) e Burras - W - Vein
237 - Monte Agrochão - W - Vein
242 - Minas de Murçós - W - Vein
244 - Edrosa e Rigueiral - Ba - Stratiform
260 - Pica Porcos / Cabeço do Sardão - W - Vein
262 - As Casas - W - Vein
263 - Cabanas - W - Stratiform
264 - Candedo - Sb - Vein
265 - Minas do Outeiro / Vale da Mulher - Sb - Vein
266 - Minas de Paredes / Teixugueiras - W - Vein
270 - Oreta da Pata - W - Stockwork
271 - Minas da Ribeira / Ribeira, Castelhão, Telheira, Cachão e Sardinho e Cresto Mau - W - Vein
272 - Vinha da Quelhinha e Lomba do - W - Vein
273 - Vales - W - Vein
276 - Codeço - W - Vein
282 - Cabeço da Mina - Sb - Vein
283 - Picão - Sb - Vein
284 - Ribeira das Maçãs (Gralheira) - Sb - Vein
285 - Minas de Fontelatassa / Cabeço de Fonte dos Asnos, Fontelatassa e Fonte do Cano - W - Vein
286 - Bravio - W - Vein
287 - Campo Mineiro de Ifanes / Alto das Cidras, Carrascal da Breta, Fonte da Batalha - W - Vein
289 - Cimo da Ladeira - W - Vein
291 - Minas de Grijó / Sítio da Coitadinha - Sb - Vein
292 - Cabeço - W - Vein
298 - Vale do Ninho - Sb - Vein
468 - Carvalhosa - Phosphate - Stratiform
469 - Sta. Maria (Carvalhosa W) - Phosphate - Stratiform
470 - Pedrada - Phosphate - Stratiform
471 - Cotovia (Reboredo) - Phosphate - Stratiform
472 - Fraga dos Apriscos - Phosphate - Stratiform
481 - Pedra Luz - W - Vein
483 - Vale das Cervas - W - Vein
488 - Serrinha - Sb - Vein
531 - Lagoaça / Fonte Santa - W - Stockwork
549 - Minas de Amedo (Carrazeda de Ansiães) - W - Vein
550 - Cumieira - W - Vein
551 - Paraíso - W - Vein
553 - Saiça - W - Vein
559 - Aveleira - W - Stockwork
563 - Eira do Velho - W - Vein
564 - Lagar Velho e Cabecinho do Pinheiro - W - Vein
568 - Cachão do Gordete - W - Stockwork
569 - Cachão do Gordete (3) - W - Stockwork
570 - Martim Tirado - W - Vein
835 - Cravezes - W - Stratiform
1133 - Corujas - W - Vein
1134 - Edroso - W - Vein
1438 - Monte Figueiro - W - Vein
1441 - Vale das Vinhas - W - Vein
1442 - Pedra Luz - W - Vein
1443 - Tombeirais - W - Vein
1444 - Castelo (Lombo da Veiga) - W - Vein
1446 - Valbom - W - Stratiform
1447 - Vilares da Vilariça (W) - W - Stratiform
1450 - Cabeceiros Sul - W - Stratiform
1483 - Vale dos Porros (Riba d'Alva) - W - Stratiform
1485 - Cedães - W - Stratiform
1523 - Cabeçudo - W - Stratiform
1524 - Tornico - W - Stratiform
1525 - Gravanceira - W - Stratiform
1527 - Vilar do Monte - W - Dissemination
1528 - Atenor - W - Vein
1529 - Freixiosa (W) - W - Stratiform
1530 - Vila Chã (W) - W - Stratiform
1531 - Lamas de Podence - W - Stratiform
1532 - Pinelo - W - Vein
1533 - Carção - W - Vein
1534 - Cernadela - W - Vein

1837 - Vale Pereiro - Freixeda - W - Stratiform
1845 - Peredo da Bemposta - W - Stratiform
2194 - Brunhozinho - W - Vein
2196 - Veigas - W - Vein
2199 - Romeu - W - Vein
2265 - Carvalhal - W - Vein
2276 - Vale Grande I - W - Vein
2277 - Vale Grande II - W - Vein

5 - Castelo Branco District
Deposit - Commodity - Morphology
480 - Argemela - Li - Stockwork
745 - Campo Mineiro da Panasqueira - W - Vein
1351 - Campo Mineiro do Colmeal - Ti - Vein
1619 - Vale do Ferro - W - Vein
1662 - Vale Godinho - W - Vein
1663 - Rapoula, Vale de Água, Vale Tomar e Casinhas - W - Vein
1664 - Cabeço do Seixo, Vale das Pinhas, Espadanal, Monte Queimado, Canchal da Terrinha - W - Vein
1665 - Cabeça do Cascalheiro e Fragoto - W - Stockwork
1666 - Matas da Rainha (Carvoeira e Senhora da Granja) - W - Stockwork
1667 - Fonte da Oliveirenta - W - Vein
1673 - Aldeia de Santa Margarida - W - Stratiform
1674 - Limeirões, Sítio da Azenha e Vale de Cavalinho - Phosphate - Vein
1675 - Campo Mineiro de Segura - Li - W - Vein
1681 - Roncões e Fonte Serrana - W - Vein
1682 - Tapada dos Carvalhos e Carvalhal - W - Vein
1684 - Vale das Porcas - Ba - Vein
1935 - Fragas - W - Vein
1937 - Campo Mineiro da Lardosa - Ti - Stratiform
1938 - Galdins (Pomar) - Sb - W - Vein
1939 - Barroca da Mina ou Barroca da Santa e Vale da Carreira ou das Gatas (Sarzedas) - W - Vein
1940 - Monte das Areias e Vale da Torre - W - Ti - Stratiform
1941 - Espadana, Inchidro e Tapada da Vargem - Ti - Stratiform
1972 - Torre Romana - Ti - Stratiform
1976 - Lages - Ti - Stratiform
1977 - Olas - Ti - Stratiform
1979 - Charro e Leitão - Ti - Stratiform
1980 - Lei Velha - Ti - Stratiform
1981 - Ponte do Caminho de Ferro de Maçainhas - Ti - Stratiform
1982 - Sítio das Fontainhas, Pimenta e Rei Fernando - Ti - Stratiform
1986 - Fonte Jardina, Ginjal e Galvão - Ti - Stratiform
1991 - Malhoeira e Cabeçadas - W - Vein
1993 - Vila de Mouros - W - Vein
1994 - Campo Mineiro da Pedra da Mesa - W - Vein
1995 - Sítio das Bouchas - W - Vein
1996 - Caberna e Quinta da Caverna de Baixo - W - Vein
1998 - Vale Brochado - W - Vein
2001 - Pombal - W - Vein
2002 - Campo Mineiro de Pero Viseu (Meimôa) - W - Vein
2003 - Sítio dos Covões - W - Vein
2149 - Queirozes - Sb - Vein
2209 - Eiras do Gordo - Ba - Vein
2210 - Vale de Lobo - Ba - Vein
2211 - Vale Redondo - Ba - Vein
2283 - Vale da Silveira - Rare Earth - Vein
2286 - Penha Garcia - Monfortinho - Rare Earth - Stratiform

6 - Coimbra District
Deposit - Commodity - Morphology
782 - Corga - Ti - Stratiform
783 - Corga da Poldrinha - Ti - Stratiform
823 - Campo Mineiro Estano-volframítico de Góis - W - Vein
826 - Vale Torto - Sb - Vein
898 - Catraia - W - Vein
2035 - Urgueiras - Ti - Stratiform
2037 - Campo Mineiro de Seixo da Beira - Ti - Stratiform
2040 - Nossa Senhora, Portela, Corga e Fiães do Ervedal - Ti - Stratiform
2121 - Volta de S. Mamede - Ti - Stratiform

7 - Évora District
Deposit - Commodity - Morphology
603 - Herdade das Palmas - Sb - Vein
605 - Falés - Sb - Dissemination
610 - Herdade da Prata - Sb - Vein
1729 - Asseiceira - Ba - Dissemination
2207 - Herdade de Catarina Vaz - Sb - Vein

8 - Faro District
Deposit - Commodity - Morphology
1238 - Cortes Pereiras - Sb - Vein
1610 - Vale Ruivo - Ba - Vein
1707 - Santa Justa (Ba) - Ba - Vein
1710 - Santa Fé - Ti - Stratiform
2284 - Picos - Rare Earth - Other

9 - Guarda District
Deposit - Commodity - Morphology
555 - Vale de Navalho e Seixas (Minas do Vesúvio) - W - Vein
556 - Cabeço do Lobo - Sb - Vein
557 - Alminhas - W - Vein
558 - Ponte do Vale - W - Vein
766 - Retorta - W - Vein
768 - Nave do Barrocal - W - Vein
778 - Gonçalo Sul - Li - Vein
791 - Castanho - Li - Vein
795 - Campo Mineiro de Nave de Haver e Malhada Sorda - Ti - Stratiform
806 - Alvarrões - Li - Vein
1131 - Pela (Tapada Grande), Tapada do Calvário e Viveiros - W - Breccia
1324 - Marinhol - Ta/Nb - Stratiform
1325 - Os Regatos - Ti - Stratiform
1326 - Fonte Medeiros - Ti - Stratiform
1327 - Moita da Lomba - W - Vein
1460 - Campo Mineiro de Pinhanços - Ti - Stratiform
1474 - Quinta Fonte Surra - W - Vein
1475 - Campo Mineiro de Freixo de Numão - W - Vein
1476 - Campo Mineiro de Almendra (Almendreiras e Torrão da Moita) - Li - W - Stratiform
1477 - Mina de Almendra - Ta/Nb - Vein
1478 - Lamega - W - Vein
1479 - Costa das Chãs e Graciavais ou Carvalha - W - Vein
1480 - Vale das Fontes, Fraga que Toca e Fonte Nova - W - Vein
1481 - Ribeira da Centieira e Vergadas - W - Vein
1484 - Escalhão (Barca d'Alva) - Li - W - Stratiform
1487 - Sufal e Cabecinha - W - Vein
1488 - Massueime (Li,Sn) - Li - Vein
1489 - Campo Mineiro de Mosqueiro - W - Vein
1490 - Campo Mineiro de Massueime - W - Vein
1493 - Vale do Vinagre e Caiporotos - Li - Vein
1494 - Fonte Salgueiro a Ladeira das Vinhas - W - Vein
1495 - Ponte Velha - Ti - Stratiform
1496 - Minas do Breijo (Casa Nova e Tapada dos Coxos) - W - Vein
1498 - Santo Antão e Quinta do Cego - W - Vein
1499 - Raposa - W - Vein
1500 - Machorrinho e Pedriça (Vale da Manta) - W - Vein
1502 - Fonte da Madre - W - Vein
1503 - Afife - W - Vein
1504 - Canada da Sardinha - W - Vein
1505 - Espadanal - W - Vein
1511 - Barroca - W - Vein
1518 - Terruco - W - Vein
1519 - Vale da Ursa - W - Vein
1564 - Atalaia (Vilar Formoso) - W - Vein
1565 - Nave do Bispo - W - Vein
1566 - Campo Mineiro de Almeida - W - Vein
1573 - Cravos - W - Vein
1574 - Granja e Alto do Feijão - W - Stockwork

9 - Guarda District
Deposit - Commodity - Morphology
1575 - Cabris - W - Vein
1578 - Cabecinho Alto - W - Vein
1579 - Seixo Branco - W - Vein
1580 - S. Lourenço - W - Vein
1581 - Razeiras - W - Vein
1582 - Feital - Be - Vein
1587 - Ribeira das Cabras (SnTi) - Ti - Stratiform
1602 - Ribeira de Benespera e Quinta de S. Miguel - Ti - Stratiform
1608 - Ribeira da Carvalha - Ti - Stratiform
1611 - Quinta da Levada - Ta/Nb - Vein
1612 - Galindra - Ti - Stratiform
1614 - Quinta do Lagedo - Li - Vein
1615 - Lagedo, Quinta das Flores e Ponte da Vela - Li - Vein
1616 - Pequito, Sobral e Carvalheira - Ti - Vein
1617 - Cascalheira - Ti - Stratiform
1624 - Barroco da Cova - Ti - Stratiform
1625 - Campo Mineiro da Ribeira de Cró - Ti - Stratiform
1630 - Porto - Ti - Stratiform
1632 - Capela da Senhora do Bom Sucesso - Ti - Vein
1633 - Carrizes - Ti - Stratiform
1634 - Massa Perra e Terra Grande - W - Stratiform
1635 - Quinta de Cima - W - Vein
1636 - Fonte do Seixo - W - Vein
1654 - Relva da Ponte - W - Vein
1655 - Escaleira - Ti - Stratiform
1656 - Prazeres - W - Vein
1657 - Muro - W - Vein
1847 - Cidadelhe (Massueime) - W - Stratiform
1851 - Sete - Ti - Stratiform
1952 - Quinta do Espírito Santo - W - Vein
1964 - Murtórios, Rocio e Outeiro dos Cepos - W - Vein
1965 - Campeiro - W - Vein
1966 - Cornozelas - W - Vein
1967 - Campo Mineiro de Pomares - Freixedas - W - Vein
1969 - Campo Mineiro de Pêra do Moço - Rocamondo - W - Vein
1970 - Campo Mineiro de Safurdão - Lamegal - Pomares - W - Vein
1971 - Campo Mineiro de Pinzio - Freixo - W - Vein
1990 - Campo Mineiro do Malhão - W - Vein
2019 - Campo Mineiro de Algodres - Ti - Stratiform
2023 - Campo Mineiro do Rio Mondego - Ti - Stratiform
2024 - Campo Mineiro de Cortiço da Serra - Ti - Stratiform
2038 - Campo Mineiro de Paranhos - Ti - Stratiform
2041 - Chão da Ponte - W - Stratiform
2043 - Coitada - W - Stratiform
2053 - Seixinhos e Romilaxe (BeW) - Be - W - Vein
2058 - Salgueiro - Ti - Stratiform
2059 - Marés - Ti - Stratiform

9 - Guarda District
Deposit - Commodity - Morphology
2061 - Ladeira do Cramão e Maria Soares - W - Vein
2063 - Campo Mineiro de Figueiró da Serra (Minas dos Azinhais) - W - Vein
2064 - Campo Mineiro de Linhares (Figueiró da Serra) - W - Vein
2072 - Maré - Ti - Stratiform
2073 - Campo Mineiro de Tourais - Lages - Ti - Stratiform
2074 - Sítio do Castelo - W - Vein
2075 - Carvalhos Juntos - W - Vein
2076 - Barroca do Pinheiro - W - Vein
2077 - Campo Mineiro de Nabais - Quinta do Campo Redondo - W - Vein
2113 - Aljão (SnTi) - Ti - Stratiform
2127 - Barranco das Paredes - W - Vein
2128 - Entre Caminhos - W - Vein
2134 - Nogueirinha - W - Vein
2135 - Sargaçal de Baixo - W - Vein
2146 - Lanchais - W - Vein
2153 - Olival da Meia Légua - W - Vein

10 - Leiria District
Deposit - Commodity - Morphology
2116 - Fontão - W - Vein

11 - Portalegre District
Deposit - Commodity - Morphology
1594 - Marafuz e Borregão, Ribeira da Goleima e Lugar do Medo - Phosphate - Vein
1595 - Ribeira de S. João, Seixal e Canto das Nogueiras - Phosphate - Vein
1596 - Nave da Câmara - Phosphate - Vein
1597 - Vale do Cano - Phosphate - Vein
1598 - Canto das Moutas, Nave dos Barreiros, Picoto Segundo, Picoto Primeiro, Casa Branca - Phosphate - Vein
1692 - Horta do Mateus e Zé Calado - Ba - Dissemination
2140 - Matinho - W - Vein
2141 - Herdade dos Pombais - W - Vein
2281 - Vale de Cavalos - Rare Earth - Stratiform
2282 - Alter do Chão (Este) - Co - V - Stratiform
2285 - Alter Pedroso - Rare Earth - Other

11 - Portalegre District
Deposit - Commodity - Morphology
1221 - Campo Mineiro de Santa Eulália - Ti - Irregular
1222 - Santa Eulália (Fontalvo) - W - Vein
1280 - Azinhaga Nova - Phosphate - Vein
1322 - Farropa - Phosphate - Vein
1346 - Monte Raso - Phosphate - Vein
1568 - Poio - W - Vein
1569 - Tapada da Misericórdia - Ba - Vein
1570 - Tapada da Farinheira - Ba - Vein
1571 - Horta da Fonte Água de Verão - Ba - Vein
1572 - Nave Redonda, Vale do Sancho e Santo Amador - Phosphate - Vein
1593 - Canchos da Torrinha - Phosphate - Vein
1594 - Marafuz e Borregão, Ribeira da Goleima e Lugar do Medo - Phosphate - Vein
1595 - Ribeira de S. João, Seixal e Canto das Nogueiras - Phosphate - Vein
1596 - Nave da Câmara - Phosphate - Vein
1597 - Vale do Cano - Phosphate - Vein
1598 - Canto das Moutas, Nave dos Barreiros, Picoto Segundo, Picoto Primeiro, Casa Branca - Phosphate - Vein
1692 - Horta do Mateus e Zé Calado - Ba - Dissemination
2140 - Matinho - W - Vein
2141 - Herdade dos Pombais - W - Vein
2281 - Vale de Cavalos - Rare Earth - Stratiform
2282 - Alter do Chão (Este) - Co - V - Stratiform
2285 - Alter Pedroso - Rare Earth - Other

12 - Porto District
Deposit - Commodity - Morphology
8 - Alto do Sobrido - Sb - Stockwork
38 - Serra de Pias Sul - Sb - Vein
39 - Serra de Pias W e Couce - Sb - Vein
40 - Abelheira e Medas - Sb - Vein
41 - Ribeira da Quinta do Cavalo Morto - Sb - Vein
42 - Pinhal / Vale de Achas e Ribeiro da Igreja - Sb - Vein
43 - Ribeiro da Paradela - Sb - Vein
46 - Montalto - Sb - Vein
49 - Carvalhal, Escusa, Ribeira, Golela e Borralhal - Sb - Vein
50 - Ribeiro da Serra, Lugar da Fontinha e Tapada - Sb - Vein
51 - Bouço, Rebentão, Castelo, Pinheirinhos e Corgo - Sb - Vein
56 - Portal - Sb - Vein
59 - Formiga - Sb - Vein
222 - Coiro de Boi - Sb - Vein
421 - Campo Mineiro de Vieiros - Li - Ta/Nb - Vein
429 - Campo Mineiro do Seixoso - Ta/Nb - Vein
430 - Pombeiro e Correadoura - Ti - Vein
437 - Campo Mineiro de Codeçoso e Aboim - W - Vein
498 - Moinhos de Riba - Sb - Vein
502 - Crista da Serra - Sb - Vein
517 - Fonte da Figueira - W - Vein
518 - Minas do Teixo / Penedo Ruivo e Fraga de Chão de Moiro - Ta/Nb - Vein
519 - Minas do Anquião, do Monte ddas Caldas, Buraquinha da Areia e Monte do Alago - Ta/Nb - Vein
523 - Campo Mineiro do Março / Minas do Ramalhoso - W - Vein
786 - Jeifes - Sb - Vein
845 - Peneda - Sb - Vein
846 - Lugar de Vila Cova - Sb - Vein
1208 - Fonte da Quinta do Guardal de Cima (Rechousa) - W - Vein
2131 - Sítio do Lameirão - Sb - Vein
2132 - Bouça Velha - Sb - Vein

13 - Setúbal District
Deposit - Commodity - Morphology
511 - Lagoa Salgada - In - Stratiform
722 - Clérigos - Ba - Vein
1148 - Casa Velha - Ba - Vein
1149 - Eira Velha - Ba - Vein
1758 - S. Torpes - Ti - Stratiform

14 - Viana do Castelo District
Deposit - Commodity - Morphology
9 - Melgaço / Casa dos Mouros - W - Vein
26 - Melgaço (Lobio) - W - Stockwork
82 - Campinhos Verdes - W - Vein
86 - Serra de Covas, Chãos e Penedo do Outão - W - Vein
92 - Campo Mineiro de Covas - W - Stratiform
93 - Regueira da Amieira - Ta/Nb - Vein
95 - Monte do Formigoso - Ta/Nb - Vein
96 - Cabração / Regueira da Sobreira, Felgueiras e Monte Formigoso - Ta/Nb - Vein
97 - Chã do Virialho e S. Silvestre - W - Vein
98 - Tapada e Gesteira - W - Vein
107 - Cabração / Junqueiro, Pedrinhas Brancas, Cabração e Couto Russo - W - Vein
108 - Escusa / Cumieira, Junqueiro, Varziela Norte, Escusa e Monte do Formigoso - Ta/Nb - Vein
109 - Ribeiro do Salgueiro e Covas dos Mouros - W - Vein
110 - Monteiro, Ribeiro de Seixalvo e Escusa - W - Vein
112 - Lamas / Cova da Raposa e Lugar de Lamas - W - Vein
120 - Santa Luzia - W - Vein
128 - Bouça de Água ou Bouça Carvalha - Ta/Nb - Vein
129 - Gondamieiro e Calvelo - W - Vein
131 - Lanheses / Lobatos, Baixa das Ervas e Três Caminhos - Ta/Nb - Vein
132 - Cavalinho e Lagoa - Ta/Nb - Vein
133 - Eiradas - Ta/Nb - Vein
134 - Andorinheiras - Ta/Nb - Vein
135 - Estorãos - W - Vein
136 - Serra de Santa Justa - W - Vein
137 - Santa Justa - W - Vein
138 - Braçal - W - Vein

14 - Viana do Castelo District
Deposit - Commodity - Morphology
140 - Portela do Fojo, Cachadinhas e Monte do Castelo - W - Vein
141 - Campo Raso - Ti - Stratiform
144 - Pedra da Moura - Li - Vein
241 - Folgadoura, Campo da Corte, Folgadoiro e Ervideiro - W - Vein
279 - Fojo Lobal - W - Vein
309 - Meixedo - Ta/Nb - Vein
574 - Barbeita - W - Vein
576 - Ceara - Ti - Stratiform
578 - Branda de Real - Be - Vein
582 - Carvalhal - W - Vein
1206 - Corjas - W - Vein
2165 - Mãos (Serra de Arga) - Li - W - Ta/Nb - Vein

15 - Vila Real District
Deposit - Commodity - Morphology
5 - Campo Mineiro de Vale das Gatas - W - Vein
65 - Alto dos Areais - W - Vein
66 - Lamago - W - Vein
167 - Borrageiros - W - Vein
168 - Minas dos Carris / Salto do Lobo, Congas das Negras e Lamalonga - W - Vein
169 - Campo Mineiro de Bessa - Li - W - Vein
171 - Castanheiro - W - Vein
172 - Lomba / Cadeiró - W - Vein
175 - Poula de Bessada - W - Vein
180 - Gralheiros - W - Vein
184 - Borralha / Sector da Cerdeira - W - Vein
186 - Canhua / Salgueira, Canhua, Corgo do Sanguinhedo e Altos de Sanguinhedo - W - Vein
196 - Lavradas, Monte Agrova, Carvalho, Pontão, Felgueiras e Furcão - W - Vein
212 - Valdegas - W - Vein
213 - Souto Velho B - W - Vein
214 - Campina e Anelhe - W - Vein
215 - Campina - W - Vein
216 - Campina (2) - W - Vein
220 - Tamboril e Dependurada - W - Vein
221 - Estanheira - Ta/Nb - Vein
224 - S. Julião de Montenegro - Ta/Nb - Vein
225 - Estanheira e Palheiros - W - Vein
226 - Poulas da Costa dos Lobos e Fontelas - W - Vein
228 - Cortinha da Preta - W - Stockwork
229 - Vale de Carvalho - W - Vein
348 - Monte da Alvorada - Be - Ta/Nb - Vein
354 - Pedras de Amolar - Be - W - Vein
355 - Monte da Corda - W - Vein
356 - Montado das Cordas - W - Vein
357 - Monte dos Carrapuços - W - Vein
358 - Alto dos Mouros - W - Vein
362 - Rumiço - Li - W - Vein
364 - Retorta - W - Vein
366 - Jogadouro e Varzielos - Ti - Vein
383 - Ribas - W - Vein
386 - Serra de Santa Isabel - W - Vein
391 - Recurso tungstífero da Borralha (Sector principal) - W - Vein
420 - Campo Mineiro da Adória - W - Vein
438 - Campo Mineiro de Limães - W - Vein
439 - Alto das Tontieiras e Lomba do Crasto - W - Vein
440 - Mestras - W - Vein
443 - Campo Mineiro do Linhares (Ermelo) - W - Vein
444 - Minas dos Viduais - W - Vein
445 - Arnal - W - Vein
446 - Alto dos Cabeços - W - Vein
447 - Cevadilha - W - Vein
448 - Cales - W - Vein
449 - Praina das Trapas, Alto do Feijão e Corgo da Povoação - W - Vein
450 - Costa do Soutelinho - W - Vein
452 - Boucinha do Sargaço - W - Vein
453 - Cumieira, Olmo (Fonte do Ouro), Justes e Leiroz - W - Vein
454 - Alvarelos, Monte da Fraga, Lamares e Bouça - W - Vein
455 - Rebordolongo - W - Vein
456 - Feitosa - W - Vein
457 - Cabeço e Vale do Mogo - W - Vein
458 - Campo Longo - W - Vein
459 - Serra dos Trigais - W - Vein
461 - Canes - W - Vein
462 - Caneiro - W - Vein
463 - Salgueirinha - W - Vein
464 - Oteja - W - Vein
475 - Pinhal Grande - W - Vein
477 - Monte ou Serra de S. Domingos - W - Vein
478 - Ribeira e Sobredo - W - Vein
479 - Paredes - W - Stratiform
526 - Monte Raso - W - Vein
529 - S. Cibrão - W - Vein
530 - Penedo Redondo e Serra da Anta - W - Vein
532 - Senhora da Azinheira - W - Vein
533 - Ribeira de Arcã - W - Vein
535 - Criveiro, Sabrosa e Lagoeiro - W - Vein
536 - Santa B rbara - W - Vein
537 - Bouça Velha - W - Vein
538 - Vale de Cheires - W - Vein
544 - Salgueirinha - W - Vein
545 - Buraco - W - Vein
546 - Folgar - W - Vein
830 - Veral - Li - Vein
831 - Adagói - Li - Vein
832 - Alijó - Li - Vein
1189 - Campo Mineiro de S. Mamede de Ribatua e Ribalonga - W - Vein
1214 - Minas da Serrinha da Cascalheira, da Chã de Cruz e da Costa do Vidoedo W - Vein
1541 - Cumieira - W - Pipe
2178 - Montes - Bi - Vein
2191 - Estante - W - Vein
2271 - Servivas I - W - Vein
2274 - Servivas II - W - Vein
2275 - Servivas III - W - Vein
2291 - Sepeda (Romano) - Li - Vein
2292 - Covas do Barroso - Li - Vein

16 - Viseu District
Deposit - Commodity - Morphology
395 - Senhora da Assunção - Várzea e Valdeireiras - Be - Vein
486 - Preguiça e Pestarenga - Be - Vein
534 - Recurso Scheelítico das Minas de Santa Leoc dia (Barcos) - W - Stratiform
561 - Carrasqueira - Be - Vein
739 - Campo Mineiro de Lagares - Li - Vein
767 - Cabeço do Seixo, Eiras e Mata - Be - Vein
776 - Gralheira (2) - Be - Mass
808 - Cubos - Be - Li - Vein
1176 - Minas do Pombeiro / Pombeiro e Lameiras - W - Stockwork
1178 - Andorinha e Meijinhos - W - Vein
1179 - Minas de Tarouca (Santo Antão) - W - Stratiform
1180 - Campo Mineiro de Covas de Estanho - W - Vein
1181 - Fraga da Venda e Penedo do Gato - W - Vein
1182 - Minas de Moimenta - W - Vein
1188 - Minas de Santo Adrião - W - Stratiform
1192 - Gaiteiros - W - Vein
1193 - Turgueira - W - Vein
1194 - S. Gens - W - Vein
1199 - Montairoso - W - Vein
1203 - Senhora da Alegria - W - Vein
1205 - Lumiares, Santiaga, Tães e Queimada - W - Stratiform
1371 - Fontaínhas e Facho - Ta/Nb - Vein
1374 - Gralheira (3) - Be - Vein
1377 - Alto da Cruz (SnW) - W - Vein
1382 - Pena - W - Vein
1385 - Campo Mineiro de Móes (Vale Velho) - W - Vein
1386 - Teixelo - W - Vein
1387 - Campo Mineiro de Teixelo - W - Vein
1388 - Traços e Serra de Arreçaio e Largo do Pisco - W - Vein
1389 - Ribeira de Baje e Loureiro - W - Vein
1390 - Gândara - W - Vein
1391 - Poço das Fragas - W - Vein
1392 - Cales - Sb - Vein
1395 - Quinta do Valente - W - Vein
1468 - Alto das Ovelhas do Gestoso - W - Vein
1694 - S. Pedro das Águias (Tabuaço) - W - Stratiform
1856 - S. Gens (Au) - W - Vein
1865 - Paredes NW - W - Vein
1866 - Paredes W - W - Vein
1868 - Paredes SE - W - Vein
1879 - Souto - Ta/Nb - Vein
1881 - Souto - Santa Clara - W - Vein
1882 - Arcos - Gaiteiros (Au) - W - Vein
1922 - Campo Mineiro de Bejanca e Bodiosa - W - Vein
1931 - Vermilhas - W - Vein
1932 - Vale do Carro - W - Vein
1933 - Regada - W - Vein
2004 - Sangarinhos e Casinha Derribada - W - Vein
2006 - Quinta de S. João da Carreira, Costeiras e Chão Quinteiro ou Vale Gavim - W - Vein
2007 - Apeadeiro do Campo, Encosto do Monte de Santa Luzia e Pomar - W - Vein
2009 - Vale Dormir e Feiteira e Vales - W - Vein
2012 - Vale da Portela do Meio, Barbascal e Vale da Fonte - W - Vein
2013 - Sobrosa - W - Vein
2014 - Bandeira do Pisco - W - Vein
2015 - A Quinta - W - Vein
2018 - A Seara do Soito - W - Vein
2026 - Fonte da Senhora - W - Stratiform
2027 - Senhora do Crasto - W - Stratiform
2028 - Castelo, Melado e Vale dos Negros - W - Vein
2029 - Cavadas - W - Vein
2030 - Cerdeirinha - W - Vein
2031 - Campo Mineiro de Travancas - W - Vein
2032 - Molelinhos - W - Vein
2044 - Mato da Costa e Boco - Be - W - Vein
2045 - Quelhas do Velho - Be - Mass
2051 - Fundegos - W - Vein
2114 - Seixinho - Be - Vein
2123 - Cantarinhos - W - Stratiform
2142 - Quinta de S. Martinho - W - Vein
2192 - Rio de Moinhos (Penalva do Castelo) - W - Stratiform
2266 - Covas do Rio - S. Macário - Graphite - Stratiform
2267 - Moledo - Vila Meã (Queiriga) - Graphite - Vein

Database Date - 2020
No CRM data on Açores and Madeira Islands

LNEG
Laboratório Nacional de Energia e Geologia, I. P.

Carta de Ocorrências Mineiras do Alentejo e Algarve

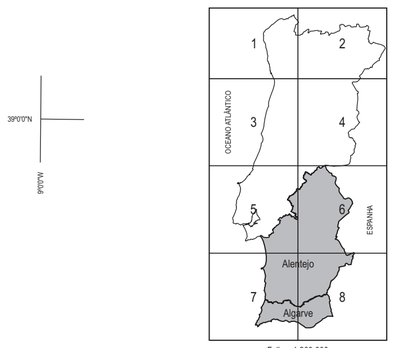
ESCALA 1:400 000
2013

LABORATÓRIO DE GEOLOGIA E MINAS
UNIDADE RECURSOS MINERAIS E GEOFÍSICA

Coordenação: João Xavier Matos e Augusto Filipe
Colaboração: Daniel Oliveira, Carlos Inverno, Carlos Rosa, Maria João Batista, Zélia Pereira, Rute Salgueiro, Teresa Cunha
Design gráfico: Filipe Barreira
Fotos: João Xavier Matos

Base geológica simplificada, adaptada da Carta Geológica de Portugal 1:1 000 000 (LNEG 2010)
Limites geográficos da Carta Administrativa Oficial Portuguesa (CAOP v. 2011)
SIG: Sistema de Informação de Ocorrências e Recursos Minerais Portugueses (LNEG)
http://www.lneg.pt | http://geoportal.lneg.pt

Green Mines
ATLANTIC AREA Transnational Programme
ESPAÇO ATLÂNTICO Programa Transnacional
ESPACIO ATLÁNTICO Programa Transnacional
European Union
European Regional Development Fund



(Sistema de Projecção: Hayford-Gauss (m), Datum 1973, Origem Métrica)
(Sistema de Projecção: ETRS 1989, Portugal TM06)

0 5 10 15 km

LEGENDA

MINERALIZAÇÕES

METÁLICAS E ENERGÉTICAS

- Au, Ag (As, Sb, Bi)
- Cu (Pb, Zn, Au, Ag)
- Fe, Mn
- Li, Be, Nb, Ta, Zr, Terras Raras
- Ni, Cr, V (Cu, Co, EGPt, Au)
- Sulfuretos maciços (Cu, Zn, Pb, Ag, Au, Sn)
- Sb (Cu, Au)
- Sn, W (F, Mo, Nb, Ta, Ti)
- Ti
- Zn, Pb (Cu, Ag, Au, As, Sb)
- U

OUTRAS SUBSTÂNCIAS

- Amianto
- Barite (Pb)
- Carvão
- Apatite
- Salgema

CARACTERIZAÇÃO DAS OCORRÊNCIAS

Dimensão: Grande, Média, Pequena
Mina ou ocorrência
Chança (Época Romana)
Data de início da mineração ou descoberta (depósitos principais)

SONDAGENS DE PROSPEÇÃO
(Classes por comprimento)

- 0 m - 200 m
- 200 m - 400 m
- 400 m - 600 m
- 600 m - 1000 m
- 1000 m - 1888 m

GEOLOGIA

BACIAS MESO-CENOZÓICAS

- Quaternário
- Paleogénico e Neogénico
- Cretácico
- Jurássico
- Triásico a Jurássico Inferior

ZONAS CENTRO-IBÉRICA, OSSA-MORENA E SUL PORTUGUESA

- Carbónico
- Devónico | Carbónico
- Devónico
- Silúrico a Devónico
- Silúrico
- Ordovícico a Devónico
- Ordovícico
- Neoproterozóico | Câmbrico
- Neoproterozóico | Câmbrico Complexo Xisto-Grauváquico
- Neoproterozóico

TERRENO OFIOLÍTICO

- Complexo Ofiolítico

ROCHAS MAGMÁTICAS

- Ciclo Atlântico
- Ciclo Varisco (Tardi a Pós-Orogénicas)
- Ciclo Varisco (Sin-Orogénicas)
- Pré-Variscas
- Filões

Símbolos estruturais

- Limite Geológico
- Falha
- Falha provável
- Cavalgamento
- Cavalgamento provável
- Carreamento
- Carreamento provável

OUTRA INFORMAÇÃO

- Rio principal
- 31B — Limite de carta 1:50 000
- Limite de distrito
- Limite de concelho
- Capital de distrito
- Sede de concelho

Para referência bibliográfica:

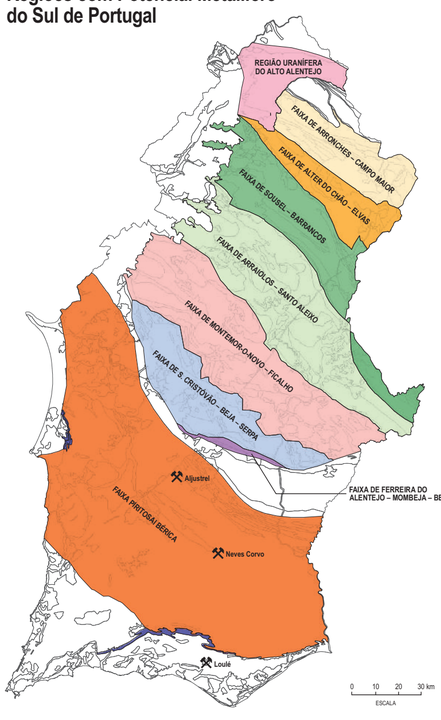
Carta de Ocorrências Mineiras do Alentejo e Algarve à escala 1:400 000, Edição 2013, LNEG/ATLANTERRA, Lisboa.
ISBN: 978-989-675-029-9

VERSÃO DIGITAL

REPRODUÇÃO PROIBIDA

LNEG

Regiões com Potencial Metalífero do Sul de Portugal



LEGENDA

- **REGIÃO URANÍFERA DO ALTO ALENTEJO** — U
- **FAIXA DE ARRONCHES - CAMPO MAIOR INCLUINDO A FAIXA BLASTOMILONÍTICA TOMAR - CÓRDOVA** — Au(-As), Cu (Pb)
- **FAIXA DE ALTER DO CHÃO - ELVAS** — Zn-Pb, Cr, Ni-Cu-(Co), Cu, Fe(-V), Ni-Cu-Co-(EGPt, Au), Sn-(W-F)
- **FAIXA DE SOUSEL - BARRANCOS** — Cu-(Au)
- **FAIXA DE ARRAIOLOS - SANTO ALEIXO** — Cu
- **FAIXA DE MONTEMOR-O-NOVO - FICALHO** — Fe, Zn-Pb-(Ag-Sb-Au), Au-As-Bi, Sb
- **FAIXA DE S. CRISTÓVÃO - BEJA - SERPA** — Fe-Ti-V, Ni-(Cu), Cu-(Ag-Au), Sb-Cu-(As-Au)
- **FAIXA DE FERREIRA DO ALENTEJO-MOMBEJA-BEJA** — Cr, Ni-Cu-(Co), Cu
- **FAIXA PIRITOSA IBÉRICA*** — Cu, Zn, Pb, Ag, Au, Sn, Mn, Sb, Ba
- **SEQUÊNCIAS MESOZÓICAS** — Cu
- **Mina em actividade**

* Incluindo áreas com cobertura Flysch e/ou Cenozóico

Adaptado de: V. Oliveira 1986, Tornos et al. 2006, Mateus et al. 2013, T. Oliveira et al. 2013

MINAS DO SUL DE PORTUGAL


CAVEIRA (Sulfuretos Maciços)


LOUSAL (Sulfuretos Maciços)


ALJUSTREL (Sulfuretos Maciços)


NEVES CORVO (Sulfuretos Maciços)

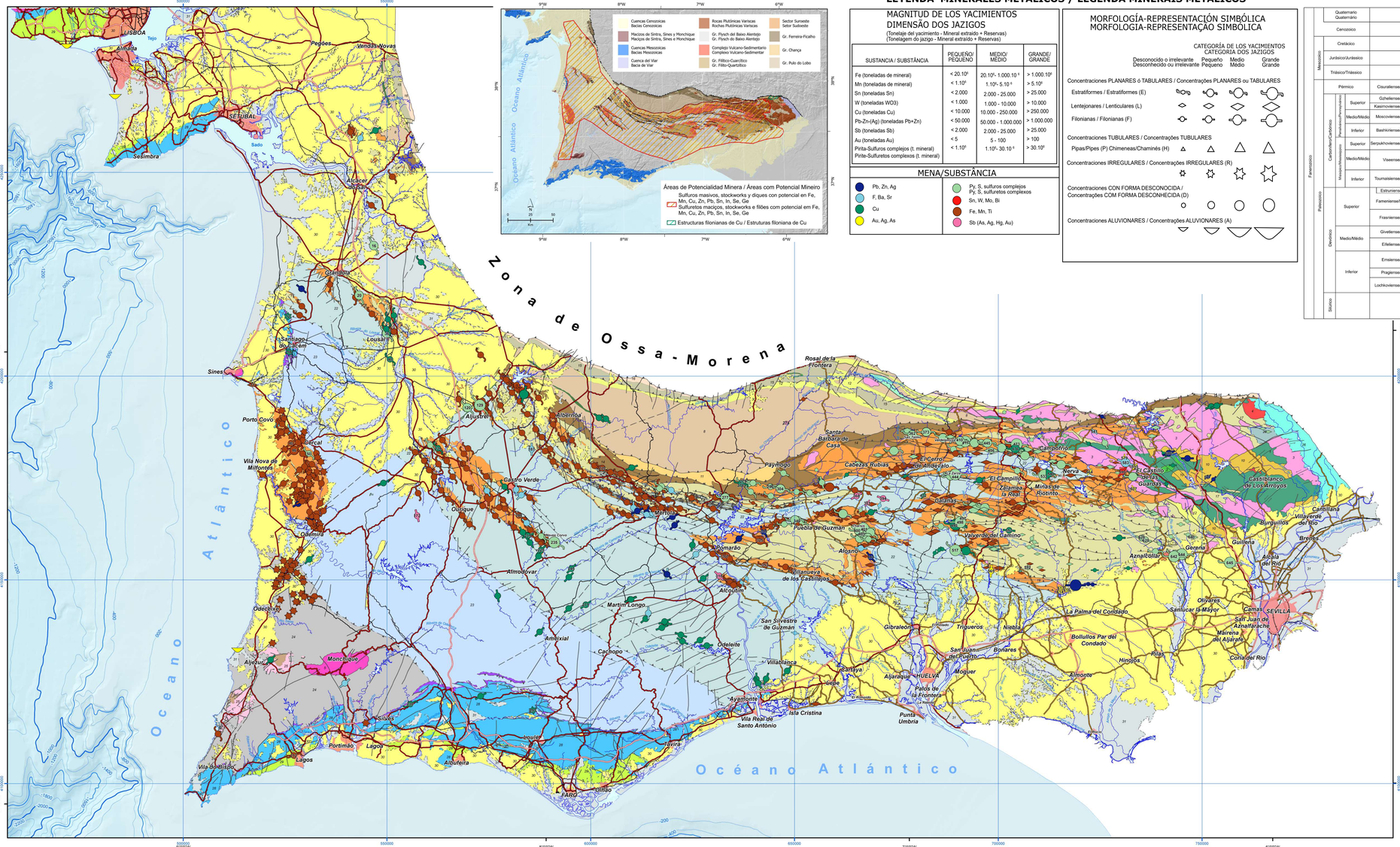

SÃO DOMINGOS (Sulfuretos Maciços)


FERRAGUDO (Mn)


MOCIÇOS (Cu)


MOSTARDEIRA (Cu)


VILA RUIVA (Zn, Pb)



LEYENDA MINERALES METÁLICOS / LEGENDA MINERAIS METÁLICOS

MAGNITUD DE LOS YACIMIENTOS DIMENSÃO DOS JAZIGOS

(Tonelaje del yacimiento - Mineral extraído + Reservas)
(Tonelagem do jazigo - Mineral extraído + Reservas)

SUSTANCIA / SUBSTÂNCIA	PEQUEÑO/ PEQUENO	MEDIO/ MÉDIO	GRANDE/ GRANDE
Fe (toneladas de mineral)	$< 20.10^6$	20.10^6 - $1.000.10^6$	$> 1.000.10^6$
Mn (toneladas de mineral)	$< 1.10^6$	1.10^6- 5.10^6	$> 5.10^6$
Sn (toneladas Sn)	< 2.000	2.000 - 25.000	> 25.000
W (toneladas WO3)	< 1.000	1.000 - 10.000	> 10.000
Cu (toneladas Cu)	< 10.000	10.000 - 250.000	> 250.000
Pb-Zn-(Ag) (toneladas Pb+Zn)	< 50.000	50.000 - 1.000.000	> 1.000.000
Sb (toneladas Sb)	< 2.000	2.000 - 25.000	> 25.000
Au (toneladas Au)	< 5	5 - 100	> 100
Pirita-Sulfuros complejos (t. mineral)	$< 1.10^6$	1.10^6- 30.10^6	$> 30.10^6$
Pirite-Sulfuretos complexos (t. mineral)			

MENA/SUBSTÂNCIA

- Pb, Zn, Ag
- F, Ba, Sr
- Cu
- Au, Ag, As
- Py, S, sulfuros complejos / Py, S, sulfuretos complexos
- Sn, W, Mo, Bi
- Fe, Mn, Ti
- Sb (As, Ag, Hg, Au)

MORFOLOGÍA-REPRESENTACIÓN SIMBÓLICA MORFOLOGIA-REPRESENTAÇÃO SIMBÓLICA

CATEGORÍA DE LOS YACIMIENTOS
CATEGORIA DOS JAZIGOS

Desconocido o irrelevante / Desconhecido ou irrelevante — Pequeño / Pequeno — Medio / Médio — Grande / Grande

Concentraciones PLANARES ó TABULARES / Concentrações PLANARES ou TABULARES
- Estratiformes / Estratiformes (E)
- Lentejonares / Lenticulares (L)
- Filonianas / Filonianas (F)

Concentraciones TUBULARES / Concentrações TUBULARES
- Pipas/Pipes (P) Chimeneas/Chaminés (H)

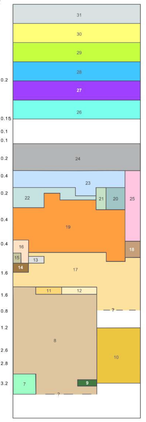
Concentraciones IRREGULARES / Concentrações IRREGULARES (R)

Concentraciones CON FORMA DESCONOCIDA / Concentrações COM FORMA DESCONHECIDA (D)

Concentraciones ALUVIONARES / Concentrações ALUVIONARES (A)

Tabla Cronoestratigráfica Internacional ICS
Tabela Cronoestratigráfica Internacional ICS

			Edad/Idade (Ma)
	Quaternario / Quaternário		2.58
	Cenozoico		66
Mesozoico	Cretácico		~ 145
	Jurásico/Jurássico		201.3 ± 0.2
	Triásico/Triássico		251.9
Paleozoico	Pérmico	Cisuraliense/Cisuraliano	298.9 ± 0.15
	Carbonífero/Carbónico — Pensilvaniense/Pensilvaniano	Superior — Gzheliense/Gzheliano	303.7 ± 0.1
		Superior — Kasimoviense/Kasimoviano	307.0 ± 0.1
		Medio/Médio — Moscoviense/Moscoviano	315.2 ± 0.2
		Inferior — Bashkiriense/Bashkiriano	323.2 ± 0.4
	Mississipiense/Mississipiano	Superior — Serpukhoviense/Serpukhoviano	330.9 ± 0.2
		Medio/Médio — Viseense/Viseano	346.7 ± 0.4
		Inferior — Tournaisiense/Tournaisiano	358.9 ± 0.4
	Devónico	Superior — Estruniense/Estruniano	372.2 ± 1.6
		Superior — Fameniense/Famenniano	382.7 ± 1.6
		Superior — Frasniense/Frasniano	387.7 ± 0.8
		Medio/Médio — Givetiense/Givetiano	393.3 ± 1.2
		Medio/Médio — Eifeliense/Eifeliano	397.5 ± 2.6
		Inferior — Emsiense/Emsiano	410.8 ± 2.8
		Inferior — Pragiense/Pragiano	419.2 ± 3.2
		Inferior — Lochkoviense/Lochkoviano	
	Silúrico		



LEYENDA

31 CUATERNARIO

30 PALEOGENO-NEÓGENO

29 CRETÁCICO

28 JURÁSICO

27 TRIÁSICO

26 Serie vulcano-sedimentaria de la CUENCA DEL VIAR

25 Formaciones Bordalete (Tournaisiense), Murraçao (Viseense) y Quebradas (Serpukhoviense-Bashkiriense inf.). SECTOR SW

24 Pizarras, grauvacas y sillitas en secuencia turbidítica y cuarcitas en la base. FM. BREJEIRA. FLYSCH BAIXO ALENTEJO

23 Grauvacas, sillitos finamente estratificados y pizarras carbonosas. FM. MIRA. FLYSCH BAIXO ALENTEJO

22 Pizarras, grauvacas y sillitas en secuencia turbidítica. FM. MERTOLA. FLYSCH BAIXO ALENTEJO

21 Alternancias de pizarras gris verdosas con grauvacas, cuarzoarenitas y conglomerados. U. LA VICARIA

20 Andesitas, dacitas y riolitas. Lutitas, arenitas, pizarras moradas, silexitas y conglomerados. U. EL PIMPOLLAR

19 Rocas volcánicas ácidas, intermedias y básicas, pizarras negras, pizarras silíceas, tufitas vulcanogénicas, pizarras moradas, cherts y jaspes. COMPLEJO VULCANO-SEDIMENTARIO. CVS

18 Alternancia de arenitas y pizarras. FM. TERCENAS. SECTOR SW

17 Alternancia de pizarras, limolitas, ritarenitas, cuarzovacas y cuarcitas, con lentejones de calizas y conglomerados. GRUPO PQ

16 Pizarras negras, liditas, cuarzovacas y cuarcitas. FM. HORTA DA TORRE

15 Pizarras, limolitas y grauvacas. FM. SANTA IRÍA

14 Gravas, litarenitas feldespáticas, grauvacas y cuarzovacas. FM. GAFO e U. SANTA BARBARA

13 Pizarras, sillitas, grauvacas y cuarzovacas. FM. VALE DE PARREIRAS

12 Pizarras, arenicas, cuarzoesquistos y cuarzovacas. FM. RIBEIRA DE LIMAS y U. ARROYO DE LAS TORRES

11 Fillitas, cuarzoesquistos, cuarzovacas, cuarcitas y metarenicas laminadas. FM. ATALAIA

10 Fillitas y pizarras con laminaciones arenosas. Esquistos, cuarzoesquistos, arenicas y cuarcitas granatíferas. U. LAS PAJANOSAS y LA MINILLA

9 Rocas básicas. FM. PULO DO LOBO

8 Esquistos y micaesquistos grafitosos con cuarzos acintados y cuarcitas laminadas claras. FM. PULO DO LOBO

7 Esquistos anfibólicos y anfibolitas. do ANTIFORME DE LOS CIRIES

6 Dique dolerítico de Plasencia - Alentejo

5 Sienitas peralcalinas de Monchique y gabros de Sines

4 Granitos de grano medio a grueso, biotíticos y granate ± cordierita de EL BERROCAL, CRISPINEJO y NAVAHONDA (~ 300 Ma)

3 Granitos, monzogranitos, granodioritas y tonalitas (granitoides de tendencia trondhjemítica. Serie TTG. ~ 355 Ma)

2 Rocas acumuladas ultrabásicas

1 Rocas básicas (gabros, dioritas, cuarzodioritas)

LEGENDA

31 QUATERNÁRIO

30 PALEOGÉNICO-NEOGÉNICO

29 CRETÁCICO

28 JURÁSSICO

27 TRIÁSSICO

26 Série vulcano-sedimentar da BACIA VIAR

25 Formações Bordalete (Tournaisiano), Murraçao (Viseano) e Quebradas (Serpukhoviano-Bashkiriano inf.). SECTOR SW

24 Xistos, gravuacaves e sillitos em sequência turbidítica e quartzitos na base. FM. BREJEIRA. FLYSCH BAIXO ALENTEJO

23 Gravuacaves, sillitos finamente estratificados e xistos carbonosos. FM. MIRA. FLYSCH BAIXO ALENTEJO

22 Xistos, gravuacaves e sillitos em sequência turbidítica. FM. MÉRTOLA. FLYSCH BAIXO ALENTEJO

21 Alternância de xistos cinza-esverdeados com gravuacaves, quartzoarenitas e conglomerados. U. LA VICARIA

20 Andesitos, dacitos e ródilos. Lutitos, arenitos, xistos violeta, silexitas y conglomerados. U. EL PIMPOLLAR

19 Rochas vulcânicas ácidas, intermedias e básicas, xistos negros, xistos silíciosos, areníticos vulcanogénicos, xistos borra-de-vinho, chertes e jaspes. COMPLEXO VULCANO-SEDIMENTAR. CVS

18 Alternância de areníticos e xistos. FM. TERCENAS. SECTOR SW

17 Alternância xistos, psamitos, areníticos, quartzovaques e quartzitos, com lentículas de calcário e conglomerados. GRUPO PQ

16 Xistos negros, areníticos, quartzovaques e quartzitos. FM. HORTA DA TORRE

15 Xistos, psamitos e gravuacaves. FM. SANTA IRÍA

14 Brechas, areníticos feldspáticos, gravuacaves e quartzovaques. FM. GAFO e U. SANTA BARBARA

13 Xistos, sillitos, gravuacaves e quartzovaques. FM. VALE DE PARREIRAS

12 Xistos, areníticos, areníticos micáceos e quartzovaques. FM. RIBEIRA DE LIMAS e U. ARROYO DE LAS TORRES

11 Fillitos, areníticos micáceos, quartzovaques, quartzitos e areníticos laminados. FM. ATALAIA

10 Fillitos e xistos com laminações areníticas. Xistos, quartzoxistos, areníticos e quartzitos com granadas. U. LAS PAJANOSAS y LA MINILLA

9 Rochas básicas. FM. PULO DO LOBO

8 Xistos e micaxistos grafitosos com quartzo, quartzo cinzento e quartzitos laminados claros. FM. PULO DO LOBO

7 Xistos anfibólicos e anfibolitos do ANTIFORME DE LOS CIRIES

6 Filão dolerítico do Alentejo - Plasencia

5 Sienitos peralcalinos de Monchique e gabros de Sines

4 Granitos de grão médio a grosseiro, biotíticos e granada ± cordierite de EL BERROCAL, CRISPINEJO e NAVAHONDA (~ 300 Ma)

3 Granitos, monzogranitos, granodioritos e tonalitos (granitoides de tendência trondhjemítica. Série TTG. ~355 Ma)

2 Rochas ultrabásicas (cumulados)

1 Rochas básicas (gabros, dioritos, quartzodioritos)

ROCAS/ROCHAS ÍGNEAS

ROCAS/ROCHAS FILONIANAS

ROCAS/ROCHAS PLUTÓNICAS MESOZOICAS

ROCAS/ROCHAS PLUTÓNICAS TARDI-VARISCAS

ROCAS PLUTÓNICAS SINOINEMÁTICAS VARISCAS
ROCHAS PLUTÓNICAS SIN-CINEMÁTICAS VARISCAS

Información Estructural
Informação Estrutural

- Contacto normal o concordante / Contacto normal ou concordante
- Contacto discordante
- Contacto mecánico / Contacto mecânico
- Contacto intrusivo
- Falla / Falha
- Falla supuesta / Falha provável
- Falla normal con indicación de hundimiento / Falha normal com indicação do abatimento
- Cabalgamiento / Cavalgamento
- Cabalgamiento supuesto / Cavalgamento provável
- Dique

Información Topográfica
Informação Topográfica

- Línea de costa / Linha de costa
- Hidrografía / Rede hidrográfica
- Masas de agua / Massas de água
- Límite político-administrativo / Limite político-administrativo

Vías de Comunicación / Vias de Comunicação

- Autopista-Autovía / Autoestrada
- Nacional / Nacional
- Autonómica / Regional
- Otras vías / Outras vias
- FF.CC. / Caminho de ferro

Municipios/Municípios

- Área Urbana

Escala 1:400 000

0 5 10 20 30 40 50 Km

Datum:ETRS89. Elipsoide: GR80. Cuadrícula y proyección UTM, Huso 29
Datum:ETRS89. Elipsoide: GR80. Quadrícula e projeção UTM, Fuso 29

Base Topográfica: España: Instituto Geográfico Nacional. Portugal: Limites administrativos: CAOP - Cartografia Administrativa Oficial de Portugal, DGT 2018. Redes hidrográfica e de estradas, caminhos de ferro e áreas urbanas: cartografia adaptada de ESRI Topographic basemap e Imagery basemap. EU-DEM.

Fuentes cartográficas (IGME): Mapa Geológico de España E. 1:50.000 Segunda Serie (MAGNA): 936, 937, 938, 939, 940, 958, 959, 960, 961, 962, 980, 981, 982, 983, 998, 999, 1000, 1001; Mapa Geológico de España E. 1:200.000: 74, 75, 80, 81; Matas, J., Martín Parra, L.M. y Díez Montes, A: Mapa Geológico Digital Continuo E. 1:50.000. Zona Surportuguesa (Zona 3100). in GEODE: Mapa Geológico Digital Continuo de España. http://info.igme.es/cartografiadigital/geologica/geodezona.aspx?Id=Z3100

Cartografia geológica de base em Portugal (LNEG): Sistema SIORMINP e Folha Sul 1/500.000; Folhas 7 e 8 1/200.000; Folhas Algarve Oriental e Ocidental 1/100.000; Folhas 1/50.000 nº 34C, 34D, 35C, 35D, 38B, 39A, 39C, 39D, 42A, 42B, 42C, 42D, 44C, 46A, 46C, 46D, 48D, 51B, 52A, 52B, 53A, 53B e cartografia 1/25.000 e 1/5.000 não publicada, em arquivo. http://geoportal.lneg.pt/geoportal/mapas

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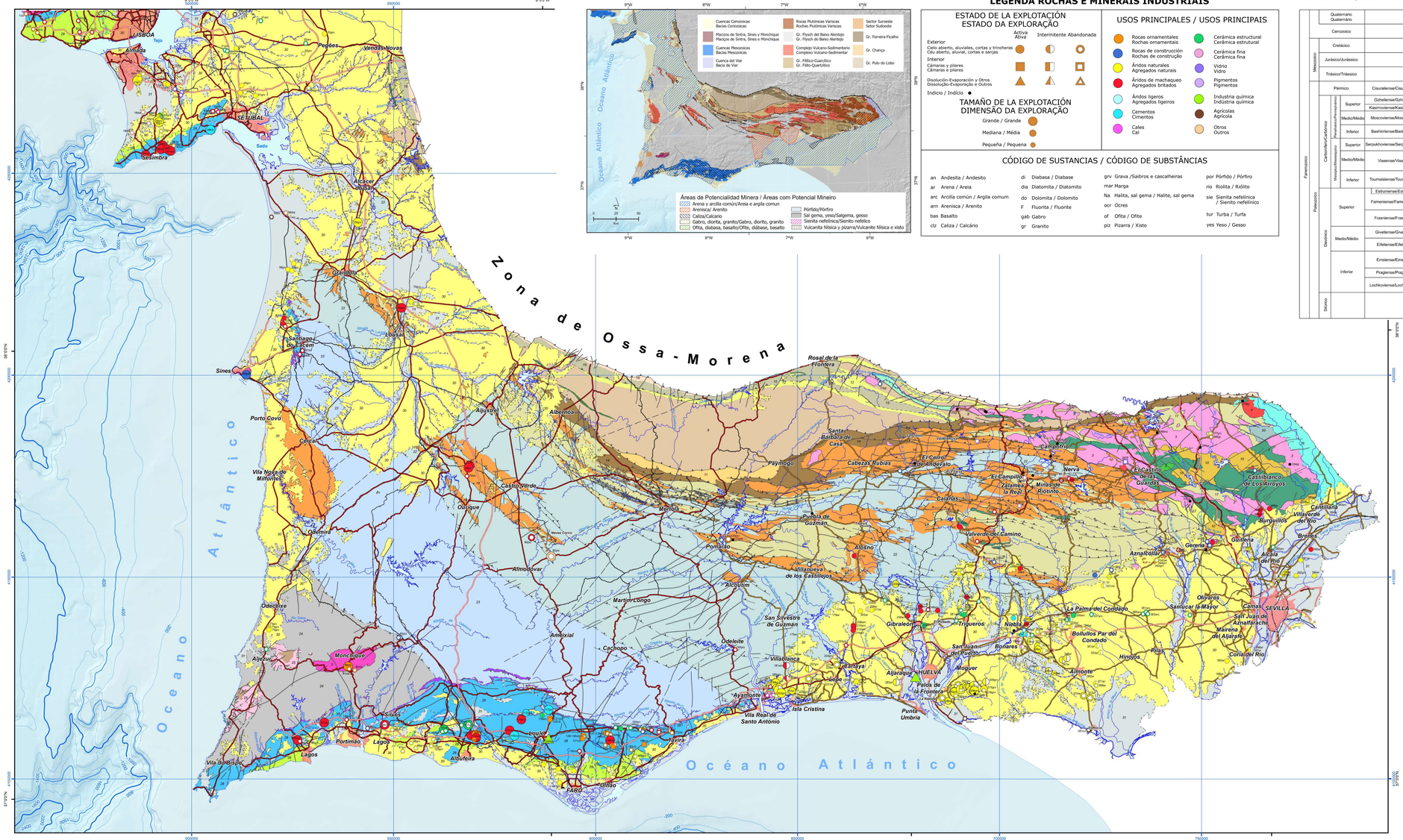
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SIG: Ana Sevillano Matilla (IGME), Marta Criado Valdés (eGeoMapping).
Cartografia Geológica (LNEG): Paleozoico: João Xavier Matos, Luis Albardeiro, José T. Oliveira, Igor Morais, Paulo Fernandes, Carlos Inverno; Mesozoico: Susana Machado; Cenozoico: Ruben Dias, Ricardo Ressurreição.
SIG: Pedro Gonçalves, Sara Santos.

Coordinación del Proyecto: María Teresa López López (IGME).

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MAPA DE ROCAS Y MINERALES INDUSTRIALES DE LA ZONA SURPORTUGUESA . CARTA DE ROCHAS MINERAIS E INDUSTRIAIS DA ZONA SUL PORTUGUESA



LEYENDA ROCAS Y MINERALES INDUSTRIALES / LEGENDA ROCHAS E MINERAIS INDUSTRIAIS

ESTADO DE LA EXPLOTACIÓN / ESTADO DA EXPLORAÇÃO

	Activa / Ativa	Intermitente	Abandonada
Exterior Cielo abierto, aluviales, cortas y trincheras / Céu aberto, aluvial, cortas e sarjas	●	◐	○
Interior Cámaras y pilares / Câmaras e pilares	■	◧	□
Disolución-Evaporación y Otros / Dissolução-Evaporação e Outros	▲	◭	△

Indicio / Indício ●

TAMAÑO DE LA EXPLOTACIÓN / DIMENSÃO DA EXPLORAÇÃO

Grande / Grande
Mediana / Média
Pequeña / Pequena

USOS PRINCIPALES / USOS PRINCIPAIS

- Rocas ornamentales / Rochas ornamentais
- Rocas de construcción / Rochas de construção
- Áridos naturales / Agregados naturais
- Áridos de machaqueo / Agregados britados
- Áridos ligeros / Agregados ligeiros
- Cementos / Cimentos
- Cales / Cal
- Cerámica estructural / Cerâmica estrutural
- Cerámica fina / Cerâmica fina
- Vidrio / Vidro
- Pigmentos / Pigmentos
- Industria química / Indústria química
- Agrícolas / Agrícola
- Otros / Outros

CÓDIGO DE SUSTANCIAS / CÓDIGO DE SUBSTÂNCIAS

an	Andesita / Andesito	di	Diabasa / Diabase	grv	Grava /Saibros e cascalheiras
ar	Arena / Areia	dia	Diatomita / Diatomito	mar	Marga
arc	Arcilla común / Argila comum	do	Dolomita / Dolomito	Na	Halita, sal gema / Halite, sal gema
arn	Arenisca / Arenito	F	Fluorita / Fluorite	ocr	Ocres
bas	Basalto	gab	Gabro	of	Ofita / Ofite
clz	Caliza / Calcário	gr	Granito	piz	Pizarra / Xisto
por	Pórfido / Pórfiro				
rio	Riolita / Riólito				
sie	Sienita nefelínica / Sienito nefelínico				
tur	Turba / Turfa				
yes	Yeso / Gesso				

Tabla Cronoestratigráfica Internacional ICS / Tabela Cronoestratigráfica Internacional ICS

			Edad/Idade (Ma)
		Cuaternario / Quaternário	
		Cenozoico	2.58
Mesozoico		Cretácico	66
		Jurásico/Jurássico	~ 145
		Triásico/Triássico	201.3 ± 0.2
		Pérmico	251.9
Paleozoico	Carbonífero/Carbónico	Superior	Cisuraliense/Cisuraliano	298.9 ± 0.15
		Pennsylvaniense/Pensilvaniano	Gzheliense/Gzheliano	303.7 ± 0.1
			Kasimoviense/Kasimoviano	307.0 ± 0.1
		Medio/Médio	Moscoviense/Moscoviano	315.2 ± 0.2
		Inferior	Bashkiriense/Bashkiriano	323.2 ± 0.4
		Superior	Serpukhoviense/Serpukhoviano	330.9 ± 0.2
		Mississippiense/Mississipiano	Viseense/Viseano	346.7 ± 0.4
		Inferior	Tournaisiense/Tournaisiano	358.9 ± 0.4
	Devónico	Superior	Estruniense/Estruniano	372.2 ± 1.6
			Famenniense/Famenniano	382.7 ± 1.6
			Frasniense/Frasniano	387.7 ± 0.8
		Medio/Médio	Givetiense/Givetiano	393.3 ± 1.2
			Eifeliense/Eifeliano	407.6 ± 2.6
		Inferior	Emsiense/Emsiano	410.8 ± 2.8
			Pragiense/Pragiano	419.2 ± 3.2
			Lochkoviense/Lochkoviano	
	Silúrico			

LEYENDA

31 CUATERNARIO

30 PALEÓGENICO-NEÓGENO

29 CRETÁCICO

28 JURÁSICO

27 TRIÁSICO

26 Serie vulcano-sedimentaria de la CUENCA DEL VIAR

25 Formaciones Bordalete (Tournaisiense), Murracão (Viseense) y Quebradas (Serpukhoviense-Bashkiriense inf.). SECTOR SW

24 Pizarras, gravacas y sillitas en secuencia turbidítica y cuarcitas en la base. FM. BREJEIRA. FLYSCH BAIXO ALENTEJO

23 Gravacas, sillitos finamente estratificados y pizarras carbonosas. FM. MIRA. FLYSCH BAIXO ALENTEJO

22 Pizarras, gravacas y sillitas en secuencia turbidítica. FM. MÉRTOLA. FLYSCH BAIXO ALENTEJO

21 Alternancias de pizarras gris verdosas con gravacas, cuarzoarenitas y conglomerados. U. LA VICARIA

20 Andesitas, dacitas y riolitas. Lutitas, arenisca, pizarras moradas, silestas y conglomerados. U. EL PIMPOLLAR

19 Rocas volcánicas ácidas, intermedias y básicas, pizarras negras, pizarras silícias, tuffitas vulcanogénicas, pizarras moradas, cherts y jaspes. COMPLEXO VULCANO-SEDIMENTARIO. CVS

18 Alternancia de arenitos y pizarras. FM. TERCENAS. SECTOR SW

17 Alternancia de pizarras, limolitas, litarenitas, cuarzovacas y cuarcitas, con lentejones de calizas y conglomerados. GRUPO PQ

16 Pizarras negras, litarenitas, cuarzovacas y cuarcitas. FM. HORTA DA TORRE

15 Pizarras, limolitas y gravacas. FM. SANTA IRÍA.

14 Gravas, litarenitas feldespáticas, gravacas y cuarzovacas. FM. GAFO y U. SANTA BARBARA

13 Pizarras, siltitas, gravacas y cuarzovacas. FM. VALE DE PARREIRAS

12 Pizarras, areniscas, cuarzoesquistos y cuarzovacas. FM. RIBEIRA DE LIMAS y U. ARROYO DE LAS TORRES

11 Filitas, cuarzoesquistos, cuarzovacas, cuarcitas y metarenisicas laminadas. FM. ATALAIA

10 Filitas y pizarras con laminaciones arenosas. Esquistos, cuarzoesquistos, areniscas y cuarcitas granatíferas. U. LAS PAJANOSAS y LA MINILLA

9 Rocas básicas. FM. PULO DO LOBO

8 Esquistos y micaesquistos grafitosos con cuarzos acintados y cuarcitas laminadas claras. FM. PULO DO LOBO

7 Esquistos anfibólicos y anfibolitas. do ANTIFORME DE LOS CIRES

6 Dique dolerítico de Plasencia - Alentejo

5 Sienitas peralcalinas de Monchique y gabros de Sines

4 Granitos de grano medio a grueso, biotíticos y granate a cordierita de EL BERROCAL, CRISPINEJO y NAVAHONDA (~ 300 Ma)

3 Granitos, monzogranitos, granodioritas y tonalitas (granitoides de tendencia trondhjemítica. Serie TTG. ~ 355 Ma)

2 Rocas acumuladas ultrabásicas

1 Rocas básicas (gabros, dioritas, cuarzodioritas)

LEGENDA

31 QUATERNÁRIO

30 PALEOGÉNICO-NEOGÉNICO

29 CRETÁCICO

28 JURÁSSICO

27 TRIÁSSICO

26 Série vulcano-sedimentar da BACIA VIAR

25 Formações Bordalete (Tournaisiano), Murração (Viseano) e Quebradas (Serpukhoviano-Bashkiriano inf.). SETOR SW

24 Xistos, gravaxistos e sillitos em sequência turbidítica e quartzitos na base. FM. BREJEIRA. FLYSCH BAIXO ALENTEJO

23 Gravaxistos, sillitos finamente estratificados e xistos carbonosos. FM. MIRA. FLYSCH BAIXO ALENTEJO

22 Xistos, gravaxistos e sillitos em sequência turbidítica. FM. MÉRTOLA. FLYSCH BAIXO ALENTEJO

21 Alternancias de xistos cinza-esverdeados com gravaxistos, quartzoarenitos e conglomerados. U. LA VICARIA

20 Andesitos, dacitos e ríolitos. Lutipos, arenitos, xistos violeta, cherles e conglomerados. U. EL PIMPOLLAR

19 Rochas vulcânicas ácidas, intermedias e básicas, xistos negros, xistos silícicos, arenitos vulcanogénicos, xistos borra-de-vinho, cherles e jaspes. COMPLEXO VULCANO-SEDIMENTAR. CVS

18 Alternancia de arenitos e xistos. FM. TERCENAS. SECTOR SW

17 Alternância xistos, psamitos, arenitos, quartzovaxaxes e quartzitos, con lentículas de calcário e conglomerados. GRUPO PQ

16 Xistos negros, arenitos, quartzovaxaxes e quartzitos. FM. HORTA DA TORRE

15 Xistos, psamitos e gravaxaxes. FM. SANTA IRÍA.

14 Brechas, arenitos feldspáticos, gravaxaxes e quartzovaxaxes. FM. GAFO e U. SANTA BARBARA

13 Xistos, siltitos, gravaxaxes e quartzovaxaxes. FM. VALE DE PARREIRAS

12 Xistos, arenitos, arenitos micáceos e quartzovaxaxes. FM. RIBEIRA DE LIMAS e U. ARROYO DE LAS TORRES

11 Filitos, arenitos micáceos, quartzovaxaxes, quartzitos e arenitos laminados. FM. ATALAIA

10 Filitos e xistos com laminações arenosas. Xistos, quartzoxistos, arenitos e quartzitos com granadas. U. LAS PAJANOSAS e LA MINILLA

9 Rochas básicas. FM. PULO DO LOBO

8 Xistos e micaxistos grafitosos com quartzo, quartzo cinzento e quartzitos laminados claros. FM. PULO DO LOBO

7 Xistos anfibólicos e anfibolitos do ANTIFORME DE LOS CIRES

6 Filão dolerítico do Alentejo - Plasencia

5 Sienitos peralcalinos de Monchique e gabros de Sines

4 Granitos de grão médio a grosseiro, biotíticos a granada a cordierite de EL BERROCAL, CRISPINEJO e NAVAHONDA (~ 300 Ma)

3 Granitos, monzogranitos, granodioritos e tonalitos (granitoides de tendência trondhjemítica. Série TTG. ~355 Ma)

2 Rochas ultrabásicas (cumulados)

1 Rochas básicas (gabros, dioritos, quartzodioritos)

ROCAS/ROCHAS ÍGNEAS

ROCAS/ROCHAS FILONIANAS
ROCAS/ROCHAS PLUTÓNICAS MESOZOICAS
ROCAS/ROCHAS PLUTÓNICAS TARDI-VARISCAS
ROCAS PLUTÓNICAS SINCINEMÁTICAS VARISCAS
ROCHAS PLUTÓNICAS SIN-CINEMÁTICAS VARISCAS

Información Estructural / Informação Estrutural

- Contacto normal o concordante / Contacto normal ou concordante
- Contacto discordante
- Contacto mecánico / Contacto mecânico
- Contacto intrusivo
- Falla / Falha
- Falla supuesta / Falha provável
- Falla normal con indicación de hundimiento / Falha normal com indicação do abatimento
- Cabalgamiento / Cavalgamento
- Cabalgamiento supuesto / Cavalgamento provável
- Dique

Información Topográfica / Informação Topográfica

- Línea de costa / Linha de costa
- Hidrografía / Rede hidrográfica
- Masas de agua / Massas de água
- Límite político-administrativo / Limite político-administrativo

Vías de Comunicación / Vias de Comunicação

- Autopista-Autovía / Autoestrada
- Nacional / Nacional
- Autonómica / Regional
- Otras vías / Outras vias
- FF.CC. / Caminho de ferro

Municipios/Municípios

- Área Urbana

Escala 1:400 000

0 5 10 20 30 40 50 Km

Datum:ETRS89. Elipsoide: GR80. Cuadrícula y proyección UTM, Huso 29
Datum:ETRS89. Elipsoide: GR80. Quadrícula e projeção UTM, Fuso 29

Base Topográfica: España: Instituto Geográfico Nacional. Portugal: Limites administrativos: CAOP - Cartografía Administrativa Oficial de Portugal, DGT 2018. Redes hidrográfica e de estradas, caminhos de ferro e áreas urbanas: cartografia adaptada de ESRI Topographic basemap e Imagery basemap. EU-DEM.

Fuentes cartográficas (IGME): Mapa Geológico de España E. 1:50.000 Segunda Serie (MAGNA): 936, 937, 938, 939, 940, 958, 959, 960, 961, 962, 980, 981, 982, 983, 998, 999, 1000, 1001; Mapa Geológico de España E. 1:200.000: 74, 75, 80, 81; Matas, J., Martín Parra, L.M. y Díez-Montes, A.: Mapa Geológico Digital Continuo E. 1:50.000, Zona Surportuguesa (Zona 3100), en GEODE. Mapa Geológico Digital Continuo de España. http://info.igme.es/cartografiadigital/geologica/geodezona.aspx?Id=Z3100

Cartografía geológica de base em Portugal (LNEG): Folha Sul 1/500.000; Folhas 7 e 8 1/200.000; Folhas Algarve Oriental e Ocidental 1/100.000; Folhas 1/50.000 nº 34C, 34D, 35C, 35D, 38B, 39A, 39C, 39D, 42A, 42B, 42C, 42D, 44C, 46A, 46C, 46D, 48D, 51B, 52A, 52B, 53A, 53B e cartografia 1/25.000 e 1/5.000 não publicada, em arquivo. http://geoportal.lneg.pt/geoportal/mapas

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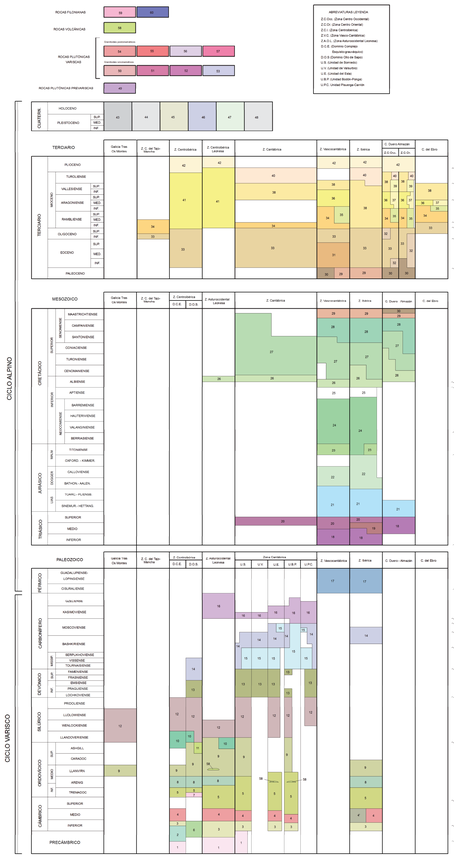
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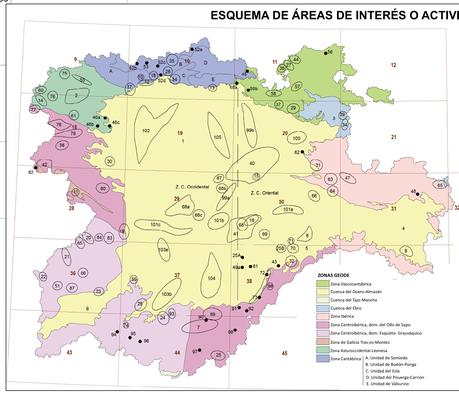
MAPA DE ROCAS Y MINERALES INDUSTRIALES DE CASTILLA Y LEÓN

ESCALA 1:400.000



60. Rocas filonianas básicas. Lamprófidos, diabasas y microdioritas.
59. Rocas filonianas ácidas . Pórfidos, microgranitos, aplitas, pegmatitas, diques de cuarzo.
58. Rocas volcánicas. Basaltos, dacitas, riolitas, offitas y tobas volcánicas.
57. Leucogranitos. Postcinemáticos.
56. Rocas básicas e intermedias. Postcinemáticos.
55. Granitoides básicos. Postcinemáticos.
54. Granitoides de dos micas. Postcinemáticos.
53. Rocas intermedias a básicas. Sincinemáticos.
52. Granitoides inhomogéneos. Sincinemáticos.
51. Granitoides básicos. Sincinemáticos.
50. Granitoides de dos micas. Sincinemáticos.
49. Ortogneis.
48. Indiferenciado.
47. Depósitos glaciares. Bloques y cantos.
46. Arenas eólicas.
45. Glacis. Cantos, arenas y gravas.
44. Aluvial. Cantos, arenas y gravas.
43. Terrazas. Cantos, arenas y gravas.
42. Plioceno. Conglomerados, cantos y arenas. Raña.
41. Mioceno. Conglomerados, cantos y arenas.
40. Margas, calizas, arenas, gravas. Facies del Páramo superior.
39. Calizas, margas. Facies de Páramo inferior.
38. Conglomerados, arenicas, arenas limos y arcillas. Abanicos silicoclásticos de Cantoral, Guardo y Barrilios.
37. Margas, yesos, arenicas y calizas. Facies Cuestas.
36. Conglomerados, arenicas, limos. Facies Tierra de Campos, Facies Tordomar.
35. Calizas, margas, yesos. Facies Dueñas, Villalozo, Facies Cerezo.
34. Conglomerados poligénicos, arenas, limos y arcillas rojas. Series rojas. Sucesión inferior de Langa.
33. Conglomerados, arenicas, arcillas rojas y yesos. Fms. Arenicas de Cabrerizos, Aldeanubla y del Pozo.
32. Calizas, margas calizas oncolíticas y rostros calcáreas. Calizas de Cubillos, margas de Sanzoles, Calizas de Valdelfrejo.
31. Margas, calizas y dolomías, calizas con foraminíferos planktónicos, turbidíticas.
30. Arenicas, conglomerados y costras ferruíticas. Serie Sideroliítica, Fm Villalain.
29. Calizas y dolomías.
28. Coniaciense-Maastrichtiense. Calizas, calizas margosas, arenicas y lutitas.
27. Cenomaniense-Santoniense. Calizas, calizas con estromtos, dolomías calizas con rudistas, margas y margocalizas.
Fms. Villa de Ves, Fuentano de la Tranquera, Calizas de Linares.
26. Conglomerados, arenicas, arenas, lutitas y calizas. Fms. Utrillas, Arenas y arcillas de Segovia.
25. Calizas con orbitolinas y arenicas. Grupo Oliuja.
24. Arenicas, lutitas, conglomerados, arcillas y calizas. Grupo Tera. Fms. Arcera y Arnco. Grupo Oncala. Grupo Urbión. Facies Weald.
23. Calizas. Grupo Tera. Fms. Aguilar y Cinco (Facies Purbeck)
22. Calizas tableadas, nodulosas, arenosas, oolíticas y dolomíticas. Fms. El Pedregal, Grupo Cheiva.
21. Dolomías tableadas, carniolas, calizas y margocalizas. Fms. Imón, Cortes de Tajuña, Cuevas Labradas, Turmiel y Barahona.
20. Grawa, arenicas, arcillas versicolores y yesos. Facies Keuper.
19. Dolomías, margas y arcillas dolomíticas. Facies Muschelkalk.
18. Conglomerados, arenicas, lutitas rojas. Facies Buntsandstein y Arenicas de Termancia y Fuentes.
17. Lutitas, arenicas y tobas volcánicas. Fms. Alpedrinches y Cañamares.
16. Conglomerados, arenicas y capas de carbón. Cuencas del Barco y Villablino.
Fms. Sabero, Cuenca Cifuna Matallana, Cuenca de la Magdalena, Permo-Barrueco, Cervera- Selanico, Remoña, Fm Ahoy y Cea.
15. Series carbonatadas carboníferas. Calizas margosas, calizas micríticas, calizas nodulosas, calizas oolíticas alternancia de calizas y arenicas. Fms. Vidrieros, Vegamián, Alba, Candamo, calizas de Bachende, calizas de Ves, Vallines, molange del Portal.
calizas de Camasobres, Valdetoja y Barcalenteio.
14. Series terrígenas cinerogénicas. Pizarras, arenicas, cuarcitas, conglomerados, calizas. Fms. San Cisdio, S. Vitero. Grupo Priorio, Grupo Polos, S. Emiliano, Belerio, Grupo Pando, Remoña, Marañ, Cea y Lena.
13. Dolomías, calizas, arenicas, conglomerados, pizarras. Grupo la Vid, Fms. Felmin, Pedroso, Sta Lucia, Valporquero, Lebanza, calizas de Colladilla, Huergas, Portilla, Ermita y Nocedo.
12. Pizarras negras antracíticas y arenicas. Fms. Formigoso y San Pedro. Capas de la Gangantera.
11. Calizas masivas. Calizas de la Aguiana.
10. Cuarcita de Vega, Santibáñez.
9. Pizarras grises y negras, arenicas. Fms. Luarca, Agüeira. Pizarras y arenicas de Pajares.
8. Cuarcitas y arenicas. Fms. Cuarcita Armoricana, Alto Rey, Capas de Lago, Capas superiores del Eo.
7. Gneises glandulares, gneises de grano fino. Fm. Olio de Sapo.
6. Esquistos y micaesquistos, arenicas. Capas del Modorna, Fm. Anglin.
5. Cuarcitas, arenicas, pizarras. Capas de Villamea, Najarilla, Ovilla, Río Gallo, Capas de Río Torío, Serie de los Cabos, Barrios, Capas de los Montes.
4. Pizarra y margas Fm. Río Gaitón y Asnrulla.
4. Calizas grises, dolomías calizas nodulares rojo. Calizas de Tamames, Ribota, S. Antón, Vegadeo, Láncara, Murero y dolomías de Mansilla.
3. Arenicas, cuarcoarenitas, lutitas y conglomerados. Grupo Cándana. Fms. Jalón, Herrería, Purrión, Pizarras de Rozadura y arenicas de Barbadillo del Pez.
2. Conglomerados y pizarras. (1) Superior? Complejo Esquisto-grauváquico . Fms. Montmerodo y Alléstapiada.
1. Conglomerados arenicas, cuarcitas, pizarras y porfiroides. (1) Inferior? Serie de Villalba. Fm. Pizarras del Narcea y Mora.

ESQUEMA DE ÁREAS DE INTERÉS O ACTIVIDAD MINERA



MINERALES INDUSTRIALES

ARCILLAS CERÁMICAS ROJAS
1.Cuenca del Duero
7.Cuenca de El Barco
3.Corredor de la Bureba
4.Cuenca de Almazán
5.Cuenca de Ayllón
6.Cuenca de Sedano Rodrigo
9.Cuenca de Arandia

ATTAPULGUITA-SEPIOLITA
8.Cuenca de Ayllón
9.Cuenca de Almazán

BARITA
10.Zona Cantábrica
11.Sinclinal de Alcañices

CALIZAS Y DOLOMÍAS
12.Área de la Robla
13.Área de Vellfla
14.Área de Corullón
15.Área de Hontoria
16.Área de Quintanilla

CAOLÍN
17.Área de Barrios de Luna
18.Área de Pola de Gordón
19.Área de Sosago

FELDESPATO
20.Área de Fermoselle- Muga de Sayago
21.Área de Manzano- Villagallimo
22.Área de la Fregenedo
23.Área de Aldehuela
24.Área de Castellanos-Berzimuel
25.Área de Cabezas del Pozo
(Explotación de Carrascal del Río
(Explotación de Río Pirón

MICAS
26.Área de Martiamor

SÍLICE
27.Área de Alija
28.Área de Valdecastillo
29.Área de Villalcázar
30.Área de Viñalbaro
31.Área de Couvrondoiro
32.Área de Pedraza
33.Área de Prádena

SULFATO SÓDICO
34.Corredor de la Bureba

TALCO
35.Área de Puebla de Lillo

TURBA
36.Área de Santa Gadea
37.Área de Basconcillos
38.Área de Sandoria

YESO
39.Corredor de la Bureba
40.Área de Torquemada
41.Área de Portillo

CAOLÍN-FELDESPATO-SÍLICE
42.Área de Cabárceno
43.Área Basta Norte de Guadarrama

ROCAS ORNAMENTALES

ARENISCAS Y CUARCITAS
44.Arenisca de Valdepuentes
45.Piedra de Brañosera
46.Piedra Nanagata. (a)Brañuelo, (b)Charco de Sotrizas. (c) Astorga
47.Piedra de Tejeda
48.Arenisca Gris de Perdiz
49.Cuarcita de Bernardos (a) y Rojo Ayllón (b)
50.Arenisca de Villamayor
51.Cuarcita de Olmedo

CALIZAS Y MÁRMOLES
52.Piedra Caliza. (a) Chaja de Sagunticho. (b)Villamalo.
53.Mármol Rosa Alcaraz de Ala
54.Mármol Cervantes
56.Piedra de Bollar
55.Mármol Alba. (a) Ornañas
56.Piedra de Urago Nava
57.Caliza Blanca de Escalada
58.Piedra de Sabero. (a) La Lora
59.Piedra Caliza (a) y Crema castilla (b)
60.Mármol Rosa Barcial
61.Mármol de Valdivias
62.Piedra de Hontoria
63.Piedra de Silos
64.Piedra Caliza Crudon
65.Piedra de Agreda
66.Piedra de Cabezuoga
67.Caliza del Abuo-Crema Páramo
68.Caliza del Páramo. Tordomar
Occidentales (a), Villacidia (b), Berrueculo (c), Monternanar (d)
69.Piedra de Campaspero
70.Roca Sepiolnita
71.Piedra de Villamena
72.Piedra de Berrocal
73.Piedra del Parral
74.Mármol de Cavafuenca

PIZARRAS
75.Alto Bierzo
76.Valle de Laciana
77.El Caurel
78.La Cabrera Norte
79.La Cabrera Sur
80.Abisie
81.Bernardos

GRANITOS
82.Gris Albero
83.Negro Celta
84.Rosa Porriño
85.Silvestre
86.Albero Peral
87.Gris Tevia
88.Gris Segovia
89.Rosa Pedro de Candelosa
90.Piedra Labio
91.Gris Villa
92.Gris Plata
93.Gris Avila
94.Gris Piedra Santos
95.Gris de Sorihuela
96.Azul Noche
97.Gris de Hoyos del Pinares
98.Gris de Hoyo de Pinares

ÁRIDOS NATURALES Y DE MACHAQUEO

99. Área del Pisuerga (a) Valladolid, (b) Herrera de Pisuerga
100. Área del Arlanzón (Burgos)
101. Área del Duero. (a) Aranda de Duero, (b) Laguna de Duero, (c) Tordesillas-Zamora
102. Área del Tormes (a) Salamanca, (b) Alba de Tormes
104. Área de Adaja
105. Área del Carrión

E: 1/1.700.000

AGLOMERANTES

- ARCILLA, MARGA. Cemento
- CALIZA. Cal
- CALIZA. Cemento
- YESO (CaSO4). Escayola, cemento

ÁRIDOS

- ARENA
- CALIZA, DOLOMÍA, MÁRMOL
- CORNUBIA
- CUARCITA, CUARZO
- DIABASA, OFITA
- GRANITO, PORFIDO, GNEIS
- GRAVA (+/- arena)

PIEDRA NATURAL

- ARENISCA
- CALIZA, DOLOMÍA y MÁRMOL
- CUARCITA, ESQUISTO
- GNEIS
- ROCAS GRANÍTICAS
- PIZARRA

SUSTANCIAS Y USOS PRINCIPALES

CONCESIONES DE EXPLOTACIONES VIGENTES EN 2014

ACTIVO

ABANDONADO

Datos de actividad consultados en las Secciones Provinciales de Minas

CERÁMICA Y VIDRIO

- ARCILLA COMÚN. Cerámica estructural
- ARCILLA CAOLINÍTICA. Gres, plasta blanca
- ARENA SILÍCEA (SiO2). Vitrificante
- CAOLÍN (Al2Si2O5(OH)4). Plasta blanca
- CUARCITA, CUARZO. Vitrificante
- FELDESPATO. Fundente, esmaltes y fritas
- MINERALES Li*. Fundente
- WOLLASTONITA (Ca3Si3O9). Fundente

* Pegmatita con lepidolita o espodumena

INDUSTRIA QUÍMICA Y METALÚRGICA

- ALUNITA (KAl3(SO4)2(OH)6). Alúmina, aluminio
- BAUXITA. Alúmina, aluminio
- CUARZO (grau, filón). Silicio metal, ferroaleaciones
- FLUORITA (CaF2). Ácido fluorhídrico, flúor
- GLAUBERITA (Na2Ca(SO4)2 . Sulfato Na, detergentes
- MAGNESITA (MgCO3). Magnesia para abonos
- MINERALES Li (Ambigonita). Industria química

VARIOS

- ARCILLAS ESPECIALES *. Absorbentes
- ARENA SILÍCEA. Moldeo, filtros, abrasivos, refractarios
- BARITA (BaSO4). Densificador lodos de sondeo
- CALIZA (CaCO3). Cargas, aclarantes, piensos, desulfuración gases
- CUARZO. Piedra artificial
- GRAFITO. Mina de lápices
- MICA. Aislante
- OCRES. Pigmentos
- SAL (NaCl) Salmuera para conservas
- TALCO (Mg3Si4O10(OH)2). Fundente, cerámica, cargas, etc.
- TURBA. Corrector agrícola, jardinería

* Attapulgita, sepiolita, Bentonita

LEYENDA SIGNOS CONVENCIONALES

- Contacto
- Falla
- Cabalgamiento

LEYENDA PLANIMETRÍA

- Límite provincial
- Línea de ferrocarril
- Autopista o autovía
- Carretera de primer orden
- Ríos
- Núcleos de población de mayor entidad
- Núcleos de población de pequeña entidad

BASE GEOLÓGICA: GEODE (IGME)

INSTITUTO GEOLÓGICO Y MINERO (IGME)

DIRECCIÓN Y COORDINACIÓN: Andrés-del Olmo Sanz (IGME)
Andrés-del Olmo Sanz

SÍNTESIS GEOLÓGICA:
Andrés-del Olmo Sanz

TRABAJO DE CAMPO Y MINAS E INDICIOS MINERO:
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Victorio Monteserín López
Jose Manuel Bañuelle Martín
Angel Ferrero Arias
Verena Vivar Provencio
Elena Menendez Monterrat
Cesar Nuño Ortea
Marta Teresa López López
Javier Rubio Navas
Alejandro Diez Montes

BASES DE DATOS: Ana Cabrera Ferrero

SIEMCALSA

DIRECCIÓN Y COORDINACIÓN: Ramón Cabrera Cañal

TRABAJOS DE CAMPO Y MINAS E INDICIOS MINEROS: Ramón Cabrera Cañal, Ángela Delgado Hernández, Eugenio Cordero Martín, Sonia Sendín Manchado

BASES DE DATOS: Isabel Sánchez García

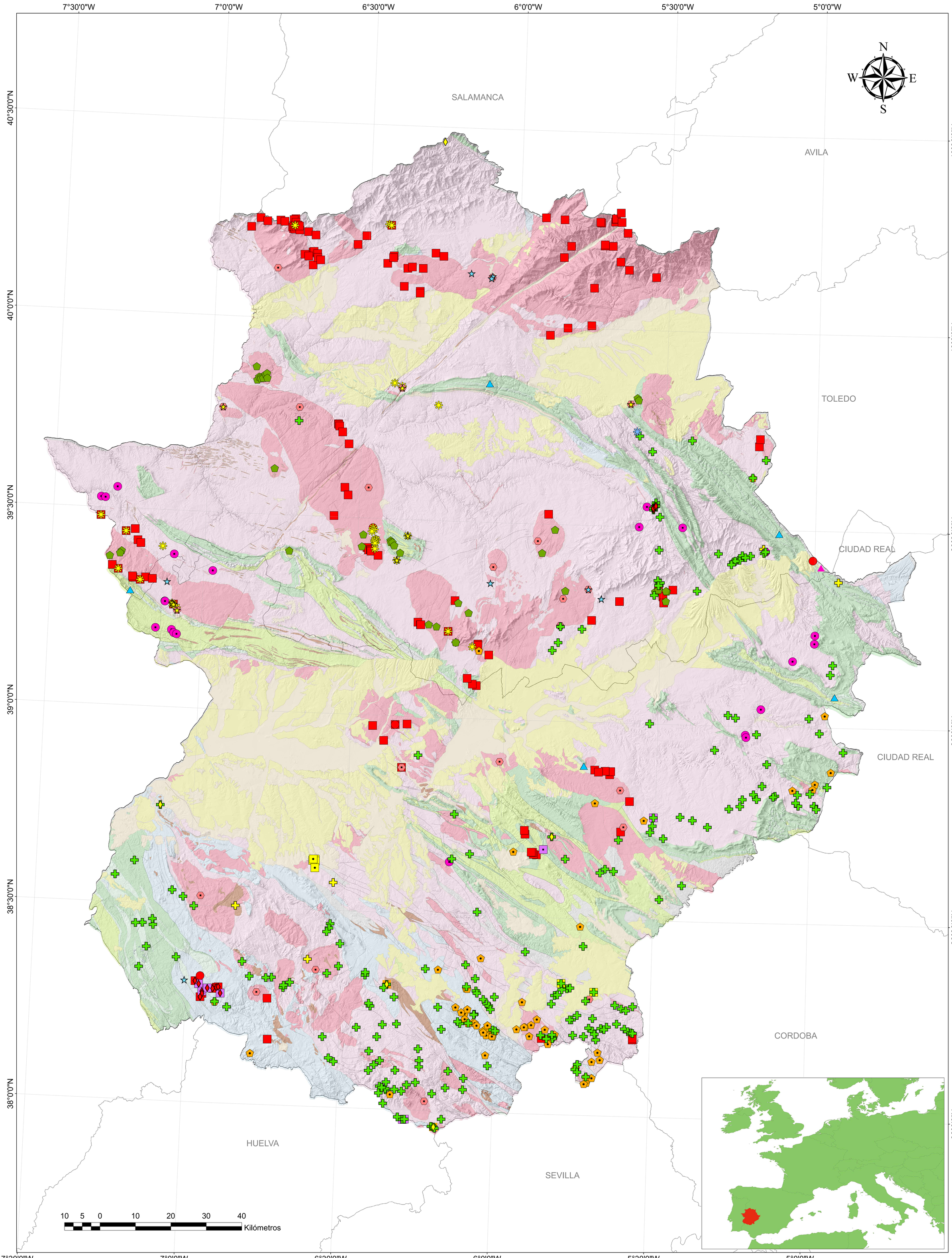
CARTOGRAFÍA S.I.G.: Jesús Escudero Tejedor

Escala 1:400.000

Proyección y cuadrículas UTM. ETRS 1989 Huso 30

Kilometros

YACIMIENTOS DE MATERIAS PRIMAS CRÍTICAS Y ESTRATÉGICAS DE EXTREMADURA



Leyenda

- Antimonio
- Barita
- Bismuto
- Cobalto
- Cobre
- Feldespato
- Hafnio
- Litio
- Grafito Natural
- Fosforita
- Niquel
- Niobio-Tántalo
- Silicio
- Titanio
- Wolframio
- Vanadio
- Grupo del Platino
- Tierras Raras
- Magnesita

http://sigeo.juntaex.es/

Litología

Rocas Sedimentarias

- CUATERNARIO
- TERCIARIO
- PÉRMICO
- CARBONÍFERO
- DEVÓNICO
- SILÚRICO
- ORDOVÍCICO
- CÁMBRICO
- PRECÁMBRICO

Rocas Ígneas

- ÁCIDAS - INTERMEDIAS
- MÁFICAS - ULTRAMÁFICAS

23 de Septiembre de 2024

JUNTA DE EXTREMADURA

JUNTA DE EXTREMADURA

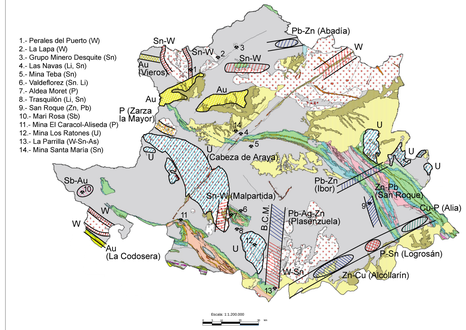
Consejería de Economía y Trabajo

MAPA METALOGENÉTICO DE EXTREMADURA

MINISTERIO DE EDUCACION Y CIENCIA

Instituto Geológico y Minero de España

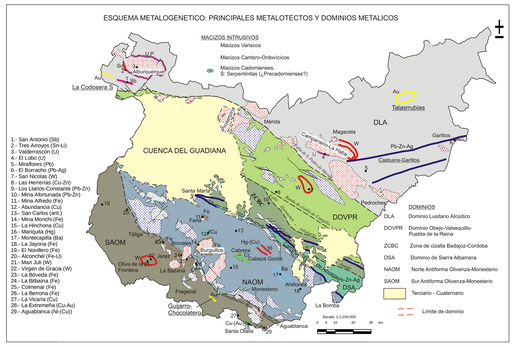
ESQUEMA METALOGENÉTICO: PRINCIPALES METALOTECTOS Y DOMINIOS METÁLICOS



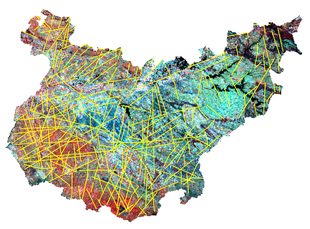
LINEAMIENTOS DEDUCIDOS DE LA IMAGEN SATÉLITE LANDSAT TM 4, 5, 7



ESQUEMA METALOGENETICO: PRINCIPALES METALOTECTOS Y DOMINIOS METALICOS



LINEAMIENTOS DEDUCIDOS DE LA IMAGEN SATÉLITE LANDSAT TM 4, 5, 7



LEYENDA METALOGENÉTICA

MINERALES METÁLICOS E INDUSTRIALES

MENA

- Fe, Zn, Ag
- F, Ba, Sr
- Au
- Au, Ag, As
- Hg
- Py, S, sulfuros complejos
- Sn, W, Mo, Bi
- U, Be, Ni, Ta, Zr, Y, tierras raras
- Cr, Ni, Pt, Ag
- Cr, Ni, Pt
- U, radioactivos
- Fe, Mn, Ti,
- Sb (As, Ag, Hg, Au)
- P
- Sales Na, (sal gema) Mg, (sales Mg) K, (potasa) (pta. (glauberita) (pta. (polihalita) yn, (yeso)
- Al alu. (alunita) bx. (bauxita)
- Piedras preciosas y semipreciosas am. (ámbar) lar. (lamnar)
- Minerales energéticos Carbones ant. (antracita) hul. (hulla) lig. (lignito) tur. (turba)
- Petróleos pet. (petróleo) gas. (gas natural)
- Rocas bituminosas pb. (pizarras bitum.) ash. (asfaltos bitum.) ast. (asfalto)
- Minerales industriales gyt. (grafito) tlc. (talco) ast. (amianto) sp. (cuarzo) fd. (feldespato) mc. (micas) arl. (alfarmarlo) ref. (refractarios) fr. (caolin) dia. (diatomita) ver. (vermiculita) kao. (caolin) ser. (sepiolita) sep. (sepiolita) at. (atapulgita) mg. (magnesita) gt. (granate) Tlc (Yeso)

MORFOLOGÍA-REPRESENTACIÓN SIMBÓLICA

CATEGORÍA DE LOS YACIMIENTOS

	Desconocido	Pequeño	Medio	Grande
Concentraciones ISOMÉTRICAS (I)				
Concentraciones PLANARES ó TUBULARES				
Se distinguen : Estratiformes (E)				
Lenticulares (L)				
Filonianas (F)				
La letra H dentro del símbolo significa Horizontal (sin dirección)				
Concentraciones TUBULARES				
Pipas (P) Chimeneas (H),...				
Concentraciones IRREGULARES (R)				
Concentraciones CON FORMA DESCONOCIDA (D)				
Concentración DETECTADA POR SONDEOS (S)				
Concentraciones ALUVIONARES (A)				

Límite del depósito

(Para depósitos que por sus características son cartografiables) El color de la línea es el de la mena principal

MAGNITUD DE LOS YACIMIENTOS

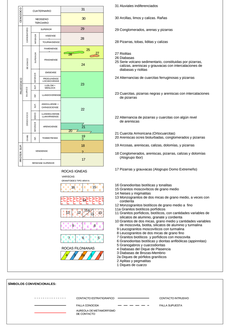
(Tonelaje del yacimiento - Mineral extraído + Reservas)

SUSTANCIA	PEQUEÑO	MEDIO	GRANDE
Fe (toneladas de mineral)	$< 20.10^6$	20.10^6-1.000.10^6	$> 1.000.10^6$
Mn (toneladas mineral)	$< 1.10^6$	1.10^6-5.10^6	$> 5.10^6$
Sn (toneladas Sn)	< 2.000	2.000-25.000	> 25.000
W (toneladas WO ^{3})	< 1.000	1.000-10.000	> 10.000
Cu (toneladas Cu)	< 10.000	10.000-250.000	> 250.000
Pb-Zn-(Ag) (toneladas Pb + Zn)	< 50.000	50.000-1.000.000	> 1.000.000
Sb (toneladas Sb)	< 2.000	2.000-25.000	> 25.000
Au (toneladas Au)	< 5	5-100	> 100
Hg (frascos Hg)	< 10.000	10.000-100.000	> 100.000
U (toneladas U ^{3}O ^{8})	< 500	500-10.000	> 10.000
Pirita-Sulfuros complejos (t. mineral)	$< 1.10^6$	1.10^6-50.10^6	> 30.10^6
Aluminio (toneladas bauxita)	< 500.000	500.000-5.10^6	> 5.10^6
Fluorita (toneladas mineral)	< 100.000	100.000-2,5.10^6	> 2,5.10^6
Barita (toneladas mineral)	< 100.000	100.000-2,5.10^6	> 2,5.10^6
Potasas (toneladas mineral)	$< 2.10^7$	2.10^7-200.10^6	> 200.10^6
Sal gema (toneladas mineral)	$< 1.10^7$	1.10^7-200.10^6	> 200.10^6
Glauberita-Thenardita (toneladas mineral)	< 200.000	200.000-2.10^6	> 2.10^6
Magnesita (toneladas mineral)	$< 10^6$	10^6-50.10^6	> 50.10^6
Caolín (toneladas mineral)	< 500.000	500.000-5.10^6	> 5.10^6
Arcillas especiales (toneladas mineral)	< 500.000	500.000-5.10^6	> 5.10^6
Estroncianita (toneladas mineral)	< 10.000	10.000-100.000	> 100.000
Talco (toneladas mineral)	< 100.000	100.000-1.10^6	> 1.10^6
Cuarzo (toneladas mineral)	$< 2.10^7$	2.10^7-20.10^6	> 20.10^6
Feldespato (toneladas mineral)	< 200.000	200.000-5.10^6	> 5.10^6
Carbón (toneladas mineral)	$< 10.10^6$	10.10^6-1.000.10^6	> 1.000.10^6
Petróleo (m^3)	$< 15.10^6$	15.10^6-1.000.10^6	> 1.000.10^6
Gas (m^3)	$< 50.10^6$	50.10^6-5.10^{10}	> 5.10^{10}

METALOTECTOS

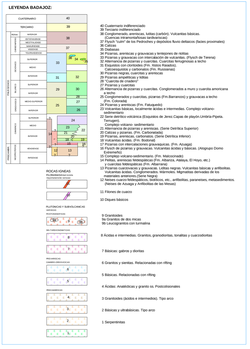
NATURALEZA	SÍMBOLO	NATURALEZA	SÍMBOLO
Litológico	Li	Paleogeográfico	Pa
Estructural	Es	Físico	Fi
Geoquímico	Qu	Biológico	Bi
Sedimentológico	Se	Geométrico	Ge

LEYENDA CÁCERES:



SÍMBOLOS CONVENCIONALES

LEYENDA BADAJOZ:



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Cartografía Base: E.T.A.E. 1:200.000 de la serie L del Servicio Geográfico del Ejército (S.G.E.).
Imprime Gráficas MURIEL, S.A.
Depósito legal M-7949-2006
NIPO-657-06-012-6
NIPO-657-06-013-X

SIGNOS CONVENCIONALES

Núcleos de población
Vías de comunicación
Ferrocarril
Ríos y arroyos
Curvas de nivel

Dirección y Coordinación: Locutura, J. (I.G.M.E.) y Alcalde, C. (Junta de Extremadura)

Autores: I.G.M.E.:

Tornos, F.
Boixereu, E.
Florido, P.
Gumiel, P.
Urbano, R.
Lopera, E.

Fernández, C. (Petrografía)
Bel-lan, A. (Cartografía S.I.G.)
Martínez, S. (Cartografía S.I.G.)
Pérez Cerdán, F. (Cartografía S.I.G.)

Apalategui, O. y Aguiluz, L. (Base Geológica)

Dirección y Coordinación: Locutura, J. (I.G.M.E.) y Alcalde, C. (Junta de Extremadura)

Autores: I.G.M.E.:

Boixereu, E.
Florido, P.
González, J.
Gumiel, P.
Locutura, J.

Gumiel, P. (Base Geológica)
Fernández, C. (Petrografía)
Bellan, A. (Cartografía S.I.G.)
Martínez, S. (Cartografía S.I.G.)
Pérez Cerdán, F. (Cartografía S.I.G.)

Junta de Extremadura. Alcalde, C.

Escala : 1:250.000

25 12,5 0 25 50 km

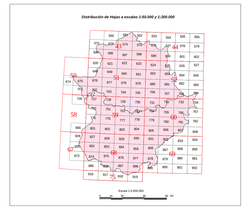
NORMAS DEL I.G.M.E

Realización: Octubre 2005

MAPA METALOGENÉTICO A ESCALA 1:200.000

DE LA PROVINCIA DE CÁCERES

SITUACIÓN DEL PROYECTO



Instituto Geológico y Minero de España

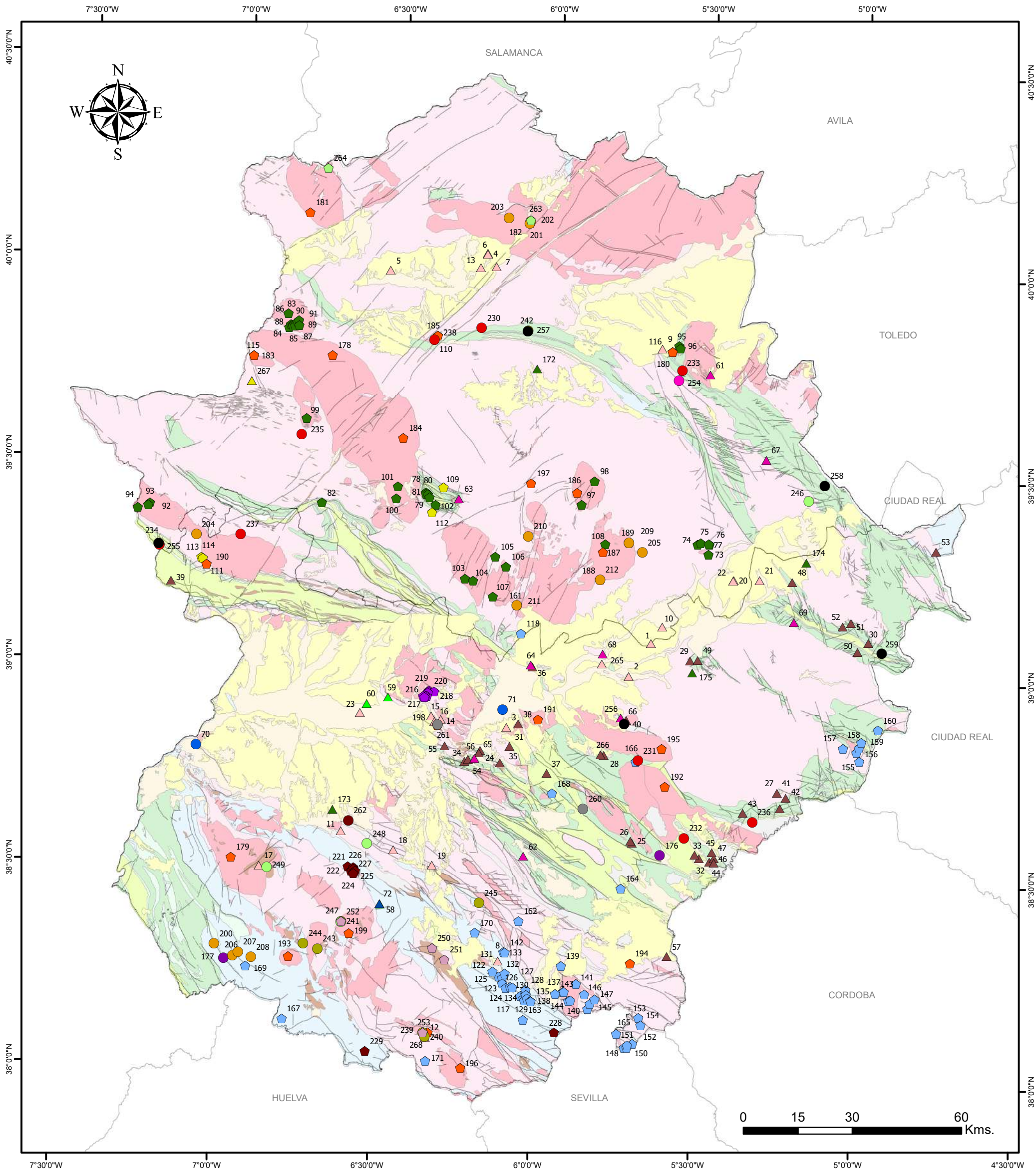
Dirección de Recursos Minerales y Geoambiente

JUNTA DE EXTREMADURA

Consejería de Economía y Trabajo

Dirección General de Ordenación Industrial, Energía y Minas

Recursos Mineros de Extremadura:
LAS ROCAS Y MINERALES INDUSTRIALES



SUSTANCIAS

- Andalucita
- Arcilla Común
- Arcilla Sericítica-Caolinítica
- Arenas Silíceas
- Asbesto
- Attapulgita
- Barita
- Calcárea
- Cuarcita
- Cuarzo
- Feldespato
- Fluorita
- Fosfato
- Grafito
- Litio
- Magnesita
- Micas
- Minio
- Ocres de Hierro
- Pirofilita
- Pizarras comunes
- Roca Silicea
- Talco
- Tierras Raras
- Wollastonita

Litología

Rocas Sedimentarias

- CUATERNARIO
- TERCIARIO
- PÉRMICO
- CARBONÍFERO
- DEVÓNICO
- SILÚRICO
- ORDOVÍCICO
- CÁMBRICO
- PRECÁMBRICO

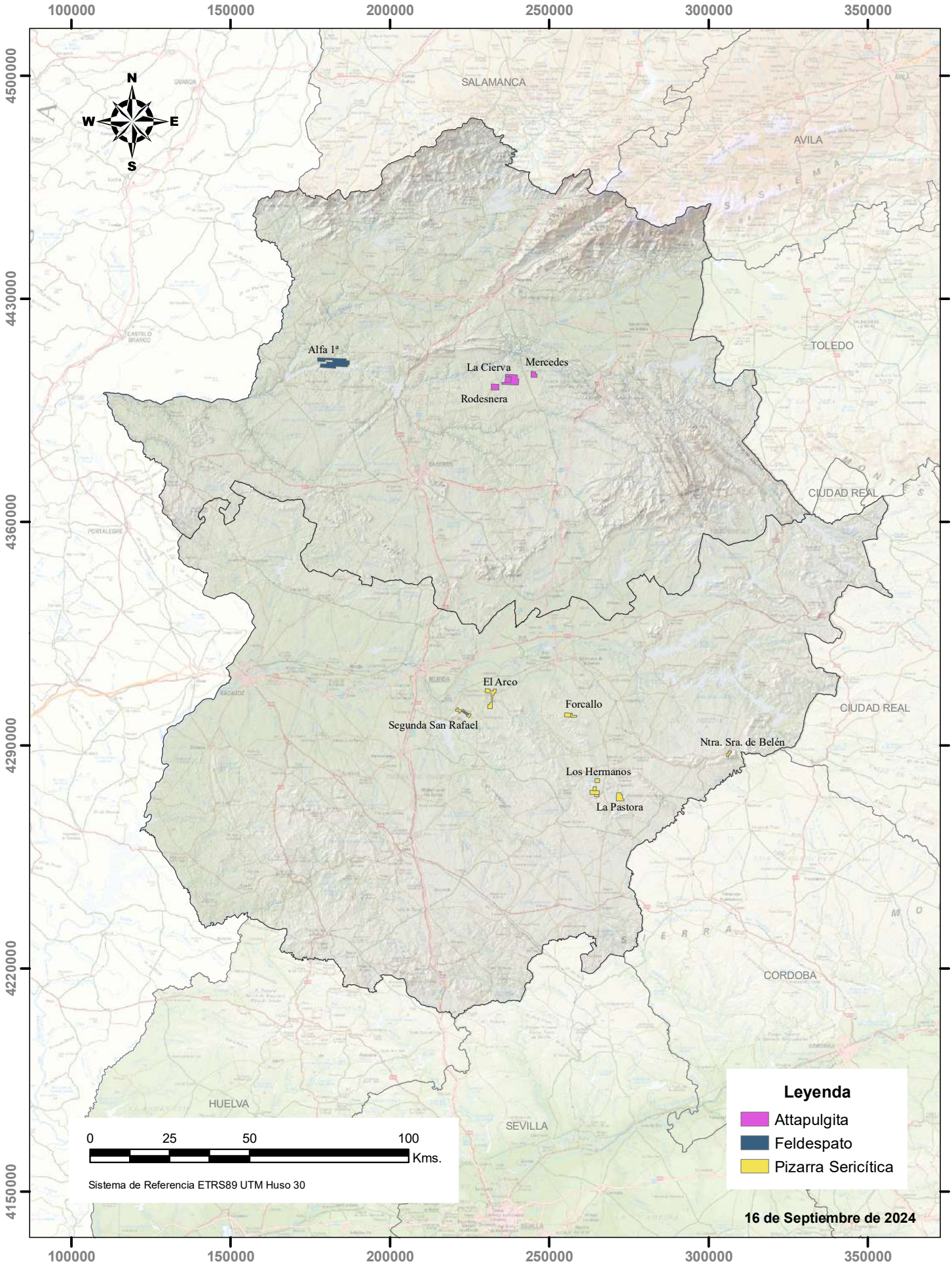
Rocas Ígneas

- ÁCIDAS - INTERMEDIAS
- MÁFICAS - ULTRAMÁFICAS

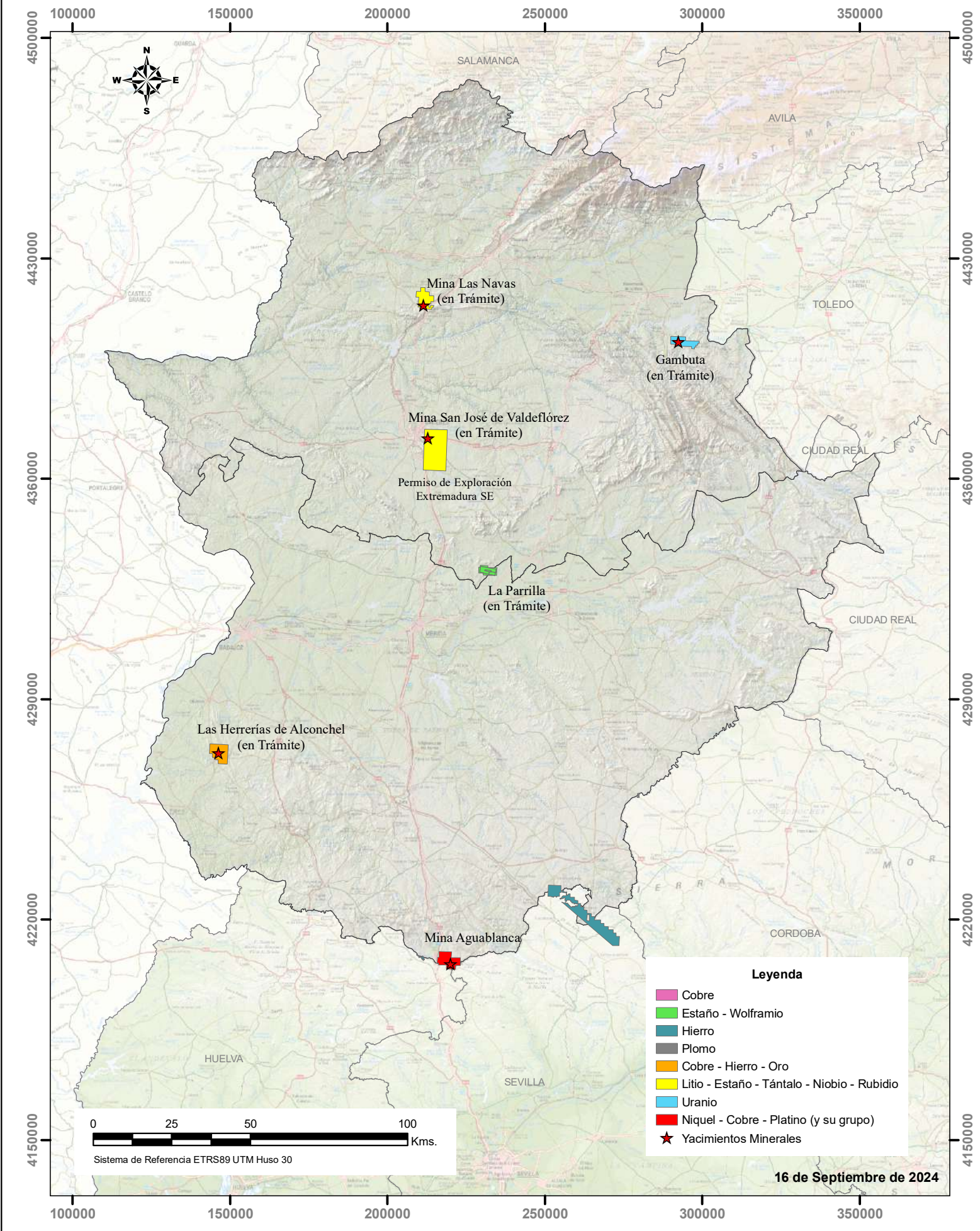
JUNTA DE EXTREMADURA

Septiembre de 2019

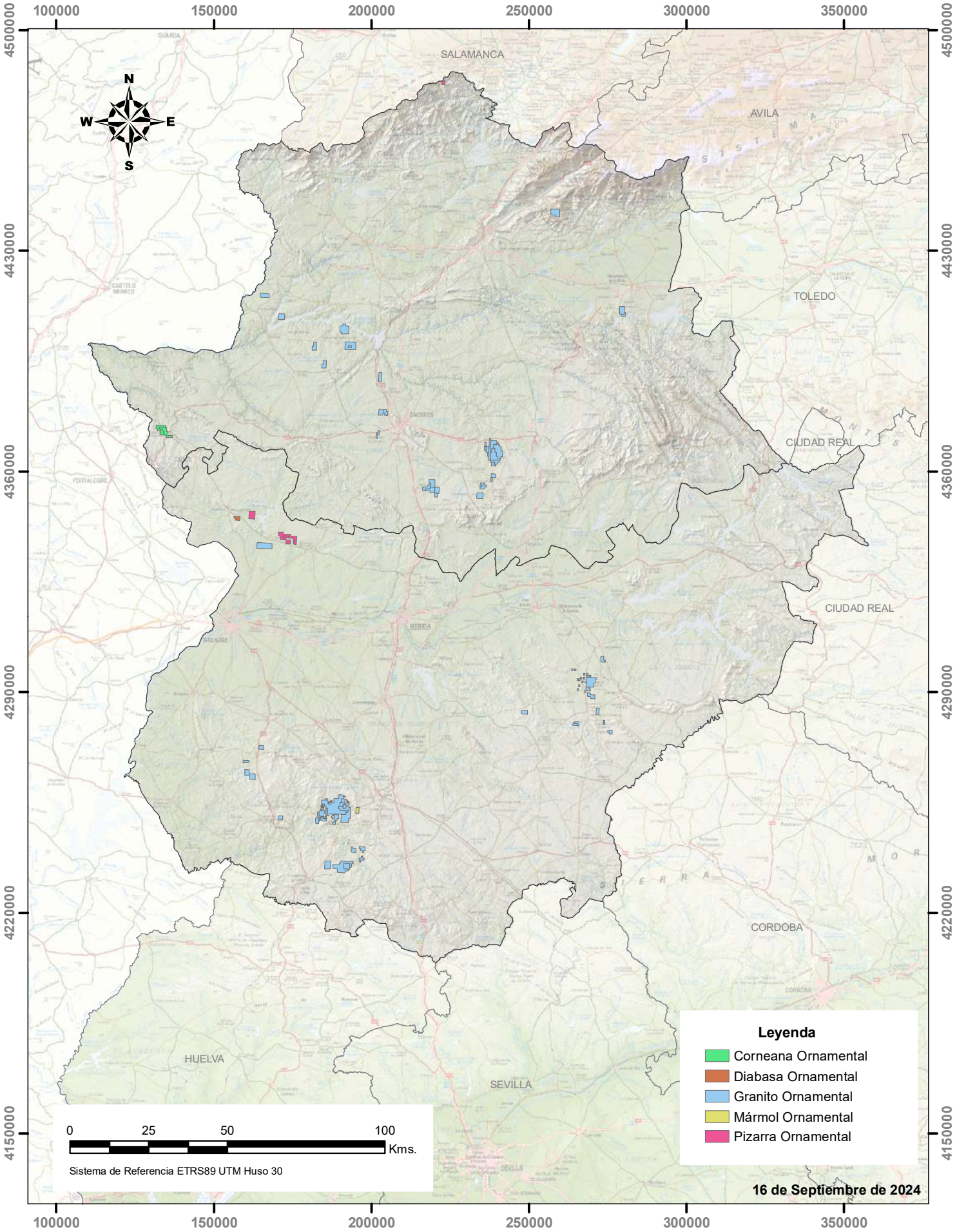
Concesiones de Explotación Vigentes de Minerales Industriales



Concesiones de Explotación de Minerales Metálicos y Energéticos



Concesiones de Explotación Vigentes de Rocas Ornamentales



CONSEJERÍA DE INDUSTRIA, ENERGÍA Y MINAS
Secretaría General de Industria y Minas
Dirección General de Minas
Sistema de Información Geológico-Minero de Andalucía

Junta de Andalucía

Sigma

Indicios de Materias Primas Críticas-CRMs de Andalucía. Lista 2023

7°0'0"O 174.000 6°0'0"O 274.000 5°0'0"O 374.000 4°0'0"O 474.000 3°0'0"O 574.000 2°0'0"O

4.260.000 4.210.000 4.160.000 4.110.000 4.060.000 4.010.000

38°0'0"N 37°0'0"N 36°0'0"N

Provincia de Badajoz
Provincia de Ciudad Real
Provincia de Albacete
Provincia de Huelva
Provincia de Jaen
Provincia de Murcia
Provincia de Cordoba
Provincia de Sevilla
Provincia de Granada
Provincia de Almeria
Provincia de Malaga
Provincia de Cadiz

Sevilla
Huelva
Cordoba
Jaen
Granada
Almeria
Málaga
Cádiz
Ceuta
Ciudad Autónoma de Ceuta

N
W E
S

ESCALA: 1:470.000

0 50 100 Km

Fuentes de Información: Base de datos BDMI, IGME. Geología 1:400.000,IGME.
Mapa Base de España, IGN.

Edición: septiembre de 2024.

Proyección: U.T.M. Huso 30. Sistema de Referencia ETRS89.

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Leyenda
Indicios de Materias Primas Críticas-CRMs de Andalucía. Lista 2023

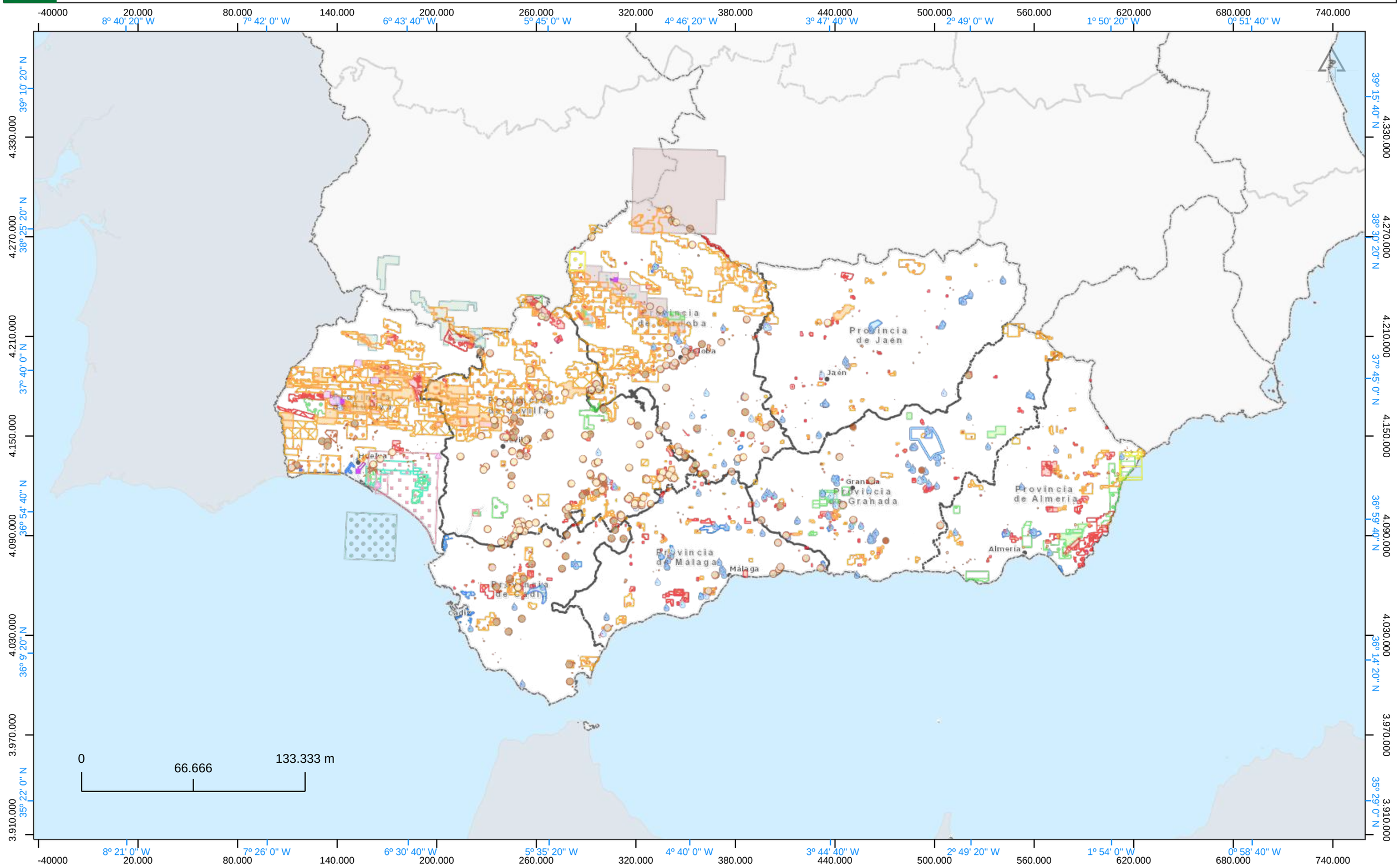
- Antimonio (Sb)
- Bario (Ba)-Barita
- Bismuto (Bi)
- Cobalto (Co)
- Cobre (Cu)
- Estroncio (Sr)
- Feldespato (Fd)
- Flúor (F)-Fluorita
- Fósforo (P)-Fosfatos-Fosforita
- Grafito
- Litio (Li)
- Magnesio (Mg)
- Manganeso (Mn)
- Níquel (Ni)
- Platino (Pt)-Platinoides
- Silicio (Si)
- Tierras Raras (REE)
- Titanio (Ti)
- Vanadio (V)
- Wolframio (W)

SIGLA	SUSTANCIA	SIGLA	SUSTANCIA	SIGLA	SUSTANCIA
Ag	Plata	gr	Granito	pyr	Pirita
alu	Alunita	grf	Grafito	qz	Cuarzo
ar	Arena	grt	Granate	qzt	Cuarcita
arn	Arenisca	grv	Grava	REE	Tierras raras-Monacita
ars	Arena Silícea	Hg	Mercurio	Sb	Antimonio
As	Arsénico	Li	Litio	Sn	Estaño
asb	Asbesto	mag	Magnesita	Sr	Estroncio
Au	Oro	Mg	Magnesio	Ti	Titanio
Ba	Bario/Baritina	mi	Micas	tlc	Talco/Pirofiilta
Bi	Bismuto	Mn	Manganeso	U	Uranio y radiactivos
clz	Caliza	Mo	Molibdeno	V	Vanadio
Co	Cobalto	Ni	Niquel	var	Variscita
Cr	Cromo/Cromita	of	Ofita	ver	Vermiculita
Cu	Cobre	P	Fosforo/Fosfatos	W	Wolframio
F	Fluor	Pb	Plomo	yes	Yeso
fd	Feldespatos	pib	Pizarra bituminosa	Zn	Zinc
Fe	Hierro	Pt	Platino/EGP		

Portal Andaluz de la Minería
Consejería de Industria, Energía y Minas

MAPA DE CONCESIONES MINERAS 2024

Mapa generado utilizando como herramienta el Visualizador de Cartografía del Portal Andaluz de la Minería.



La información representada en el mapa no tiene validez de carácter legal.

Fuentes de información:

Divisiones Administrativas
Registro Minero de Andalucía. RMA

Sistema de Referencia: ETRS89.
Proyección UTM, Huso 30.

Escala: 1/2.107.454 (A3)
Fecha: 24/10/2024

Recursos de la Sección A-RSA

RSA-Autorización de Explotación

- RSA-Solicitud de Autorización de Explotación-Punto
- RSA-Solicitud de Autorización de Explotación-Perímetro
- RSA-Solicitud de Ampliación de Autorización de Explotación
- RSA-Autorización de Explotación Vigente Activa-Punto
- RSA-Autorización de Explotación Vigente Activa-Perímetro
- RSA-Autorización de Explotación Vigente No Activa-Punto
- RSA-Autorización de Explotación Vigente No Activa-Perímetro
- RSA-Autorizaciónde Explotación No Vigente-Punto
- RSA-Autorización de Explotación No Vigente-Perímetro

Recursos de la Sección B-RSB

RSB-Declaración de Agua Mineral

- RSB-Solicitud de Declaración del Sondeo-Manantial de Agua Mineral
- RSB-Declaración del Sondeo-Manantial de Agua Mineral Vigente

RSB-Declaración de Estructura Subterránea

- RSB-Solicitud de Declaración de Estructura Subterránea-Punto
- RSB-Declaración de Estructura Subterránea Vigente-Punto
- RSB-Solicitud de Declaración de Estructura Subterránea-Perímetro
- RSB-Declaración de Estructura Subterránea-Perímetro Vigente

RSB-Declaracion de Yacimiento No Natural

- RSB-Solicitud de Declaración de Yacimiento No Natural-Punto
- RSB-Declaración de Yacimiento No Natural Vigente-Punto
- RSB-Solicitud de Declaración de Yacimiento No Natural-Perímetro
- RSB-Declaración de Yacimiento No Natural Vigente-Perímetro

RSB-Autorización de Aprovechamiento de Agua Mineral

- RSB-Solicitud de Autorización de Aprovechamiento de Agua Mineral
- RSB-Solicitud de Ampliación de Autorización de Aprovechamiento de Agua Mineral Vigente
- RSB-Autorización de Aprovechamiento de Agua Mineral Vigente Activa
- RSB-Autorización de Aprovechamiento de Agua Mineral Vigente Vigente No Activa
- RSB-Agua Mineral. Autorización de Aprovechamiento de Agua Mineral No Vigente
- RSB-Autorización de Aprovechamiento de Agua Mineral Caducada

RSB-Autorización de Aprovechamiento de Estructura Subterránea

- RSB-Solicitud de Autorización de Aprovechamiento de Estructura Subterránea
- RSB-Solicitud de Ampliación de Autorización de Aprovechamiento de Estructura Subterránea
- RSB-Autorización de Aprovechamiento de Estructura Subterránea Vigente Activa
- RSB-Autorización de Autorización de Aprovechamiento de Estructura Subterránea Vigente No Activa
- RSB-Autorización de Aprovechamiento de Estructura Subterránea No Vigente
- RSB-Autorización de Aprovechamiento de Estructura Subterránea Caducada

RSB-Autorización de Aprovechamiento de Yacimiento No Natural

- RSB-Solicitud de Autorización de Aprovechamiento de Yacimiento No Natural
- RSB-Solicitud de Ampliación de Autorización de Aprovechamiento de Yacimiento No Natural
- RSB-Autorización de Aprovechamiento de Yacimiento No Natural Vigente Activa
- RSB-Autorización de Aprovechamiento de Yacimiento No Natural Vigente No Activa
- RSB-Autorización de Aprovechamiento de Yacimiento No Natural No Vigente
- RSB-Autorización de Aprovechamiento de Yacimiento No Natural Caducada

Recursos de la Sección C-RSC

RSC-Permiso de Exploración

- RSC-Solicitud de Permiso de Exploración
- RSC-Permiso de Exploración Vigente Activo
- RSC-Permiso de Exploración Vigente No Activo
- RSC-Permiso de Exploración No-Vigente
- RSC-Permiso de Exploración Caducado
- RSC-Permiso de Exploración en Concurso

RSC- Permiso de Investigación

- RSC-Solicitud de Permiso de Investigación
- RSC-Permiso de Investigación Vigente Activo
- RSC-Permiso de Investigación Vigente No Activo
- RSC-Permiso de Investigación No Vigente
- RSC-Permiso de Investigación Caducado
- RSC-Permiso de Investigación en Concurso

RSC-Concesión de Explotación

- RSC-Solicitud de Concesión de Explotación
- RSC-Solicitud de Demasía de Concesión de Explotación
- RSC-Concesión de Explotación Vigente Activa
- RSC-Concesión de Explotación Vigente No Activa
- RSC-Concesión de Explotación No Vigente
- RSC-Concesión de Explotación Caducada
- RSC-Concesión de Explotación en Concurso

Recursos de la Sección D-RSD

RSD-Permiso de Exploración

- RSD-Solicitud de Permiso de Exploración
- RSD-Permiso de Exploración Vigente Activo
- RSS-Permiso de Exploración Vigente No Activo
- RSD-Permiso de Exploración No Vigente
- RSD-Permiso de Exploración Caducado
- RSD-Permiso de Exploración en Concurso

RSD-Permiso de Investigación

- RSD-Solicitud de Permiso de Investigación
- RSD-Permiso de Investigación Vigente Activo
- RSD-Permiso de Investigación Vigente No Activo
- RSD-Permiso de Investigación No-Vigente
- RSD-Permiso de Investigación Caducado
- RSD-Permiso de Investigación en Concurso

RSD-Concesión de Explotación

- RSD-Solicitud de Concesión de Explotación
- RSD-Solicitud de Demasía de Concesión de Explotación
- RDS-Concesión de Explotación Vigente Activa
- RDS-Concesión de Explotación Vigente No Activa
- RDS-Concesión de Explotación No Vigente
- RSD-Concesión de Explotación Caducada
- RSD-Concesión de Explotación en Concurso

Zonas de Reservas a favor del Estado-ZRE

ZRE- Zona de Reserva a favor del Estado Provisional

- ZRE-Solicitud de Reserva a favor del Estado Provisional
- ZRE-Reserva a favor del Estado Provisional Vigente Activa
- ZRE-Zona de Reserva a favor del Estado Provisional Vigentes No Activa
- ZRE-Zona de Reserva a favor del Estado Provisional No Vigente

ZRE-Zona de Reserva a favor del Estado Definitiva

- ZRE-Solicitud de Zona de Reserva a favor del Estado Definitiva
- ZRE-Zona de Reserva a favor del Estado Definitiva Vigente Activa
- ZRE-Zona de Reserva a favor del Estado Definitiva Vigente No Activa
- ZRE-Zona de Reserva a favor del Estado Definitiva No Vigente

JUNTA DE ANDALUCIA
CONSEJERÍA DE ECONOMÍA, INNOVACIÓN Y CIENCIA

MINISTERIO DE CIENCIA E INNOVACIÓN
Instituto Geológico y Minero de España

MAPA DE ROCAS Y MINERALES INDUSTRIALES DE ANDALUCÍA

Escala 1:400.000

Las altitudes se refieren al nivel medio
Proyección UTM Huso 30
Datum europeo 1950.
Elipsoide Internacional de 1924.
Equidistancia curvas de nivel 500 metros.

10 5 0 10 20 30 40 60 km

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CARTOGRAFÍA DE RECURSOS MINERALES DE ANDALUCÍA

2. MAPA DE ROCAS Y MINERALES INDUSTRIALES

ESCALA 1:400.000

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ESTADO DE LA EXPLOTACIÓN

	Activa	Intermitente	Abandonada
Exterior (Con aterrín: arcuates, cortas y trincheras)	●	◐	○
Interior (Canteras y pozos)	■	◧	□
Disolución-Evaporación y Otros	▲	◭	△

Indicio ●

TAMAÑO DE LA EXPLOTACIÓN

Grande ●
Mediana ●
Pequeña ●

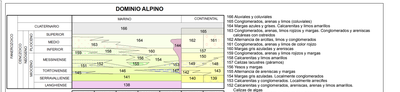
USOS PRINCIPALES

- Rocas ornamentales
- Rocas de construcción
- Áridos naturales
- Áridos de machaqueo
- Áridos ligeros
- Cementos
- Cales
- Yeso
- Cerámica estructural
- Cerámica fina
- Refractarios
- Vidrio
- Pigmentos
- Industria química
- Arenas de molde
- Agrícolas
- Otros

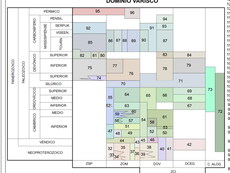
CÓDIGO DE SUSTANCIAS

an	Andesita		fag	Falsa ágata	
anf	Anfibolita		fd	Feldespato	
ar	Arena		F	Fluorita	
arc	Arcilla común		gab	Gabro	
arn	Arenisca		gr	Granito	
ars	Arena silícea		gry	Grava	
Ba	Barrita		kao	Caolín	
bas	Basalto		ma	Mármol	
ben	Bentonita		mag	Magnesita	
cgl	Conglomerado		mar	Marga	
clz	Caliza		mi	Micas	
di	Diabasa		Na	Halita, sal gema	
dia	Diatomita		oor	Oores	
dol	Dolomía		of	Offita	
esq	Esquisto		peg	Pegmatita	
per	Peridotita				
piz	Pizarra				
por	Pórfido				
qzt	Cuarcita				
rio	Riolita				
se	Serpentinita				
Sr	Celestina				
tlc	Talco				
tra	Traquita				
trv	Travertino				
tur	Turba				
yes	Yeso				
zeo	Zeolitas				

DOMINIO ALPINO



DOMINIO VARISCO



ROCAS FILONIANAS

ZP ZC

ROCAS PLUTÓNICAS VARISCAS

29 | 28a 28b | 27 | 26 | 25 | 24 | 23 | 22 | 20 21 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10

CAMBRO-ORDOVÍCICO

9 | 8 | 7

CADOMENSES

6 | 5 | 4 | 3 | 2 | 1

Rocas filonianas

31 Diques de cuarzo.

30 Diques básicos, con granitos y riolitas. Diques granodioríticos, microdioríticos y básicos.

Rocas ígneas y varisicas

29 Granitos y monzogranitos biotíticos con cordierita.
28a Monzogranitos y granitos. Granitoides Los Pedroches
28b Monzogranitoides a leucogranitos.
U. Granodiorítica Los Pedroches
27 Granodioritas y tonalitas biotíticas con anfíbol.
El Higuer adrid, monzogranodioritas y leucogranitos.
U. Granodiorítica Los Pedroches
26 Granitos biotíticos de grano fino.
24 Granitos biotíticos a granodioritas y leucogranitos cordieríticos.
El Pedroso
25 Granitos biotíticos de grano medio gruesoconcentelegranada.
U. Tamaca Inferior
24 Dioritas y monzodioritas del Rosal
23 Granitos y leucogranitos con cuarzos azulados, aureolados, cuarzos y tubines de granitoides s. El Pozo de Lobo
21 Granodiorita y granito de Arroche
22 Granodioritas y granitos de Sierra de Arroche
19 Gabros y dioritas
18 Tonalitas y granodioritas de Santa Olalla y Teuler
17 Granitos de Cala y Cerro Blanco
16 Granodioritas de la Sumaguz y otras. (HWC)
15 Monzogranito y diabasas del Alcornocal (HWC)
14 Granitos de la Almadén. Monzogranitos de Peña Manchega a Coronada (HWC)
13 Granodiorita, monzogranitos y pórfidos graníticos de Gil Márquez
12 Granitos de Valsequillo y Belalcázar de Bdn
11 Rocas básicas de Bdn
10 Orbaniforitas de Baja Andaluchas

Granitoides cambro-ordovícicos

9 Ortogneises de Arcos Tarjea y La Morilla
8 Granitos de El Garrotal
7 Granitoides de El Alamo y Las Cabras. Rocas ígneas cadomenses
6 Granitoides de Fuenteheridos, Aroche, Aracena y gneises afínicos cadomienses
5 Granitoides de El Escribano, La Bomba y Las Cabritas

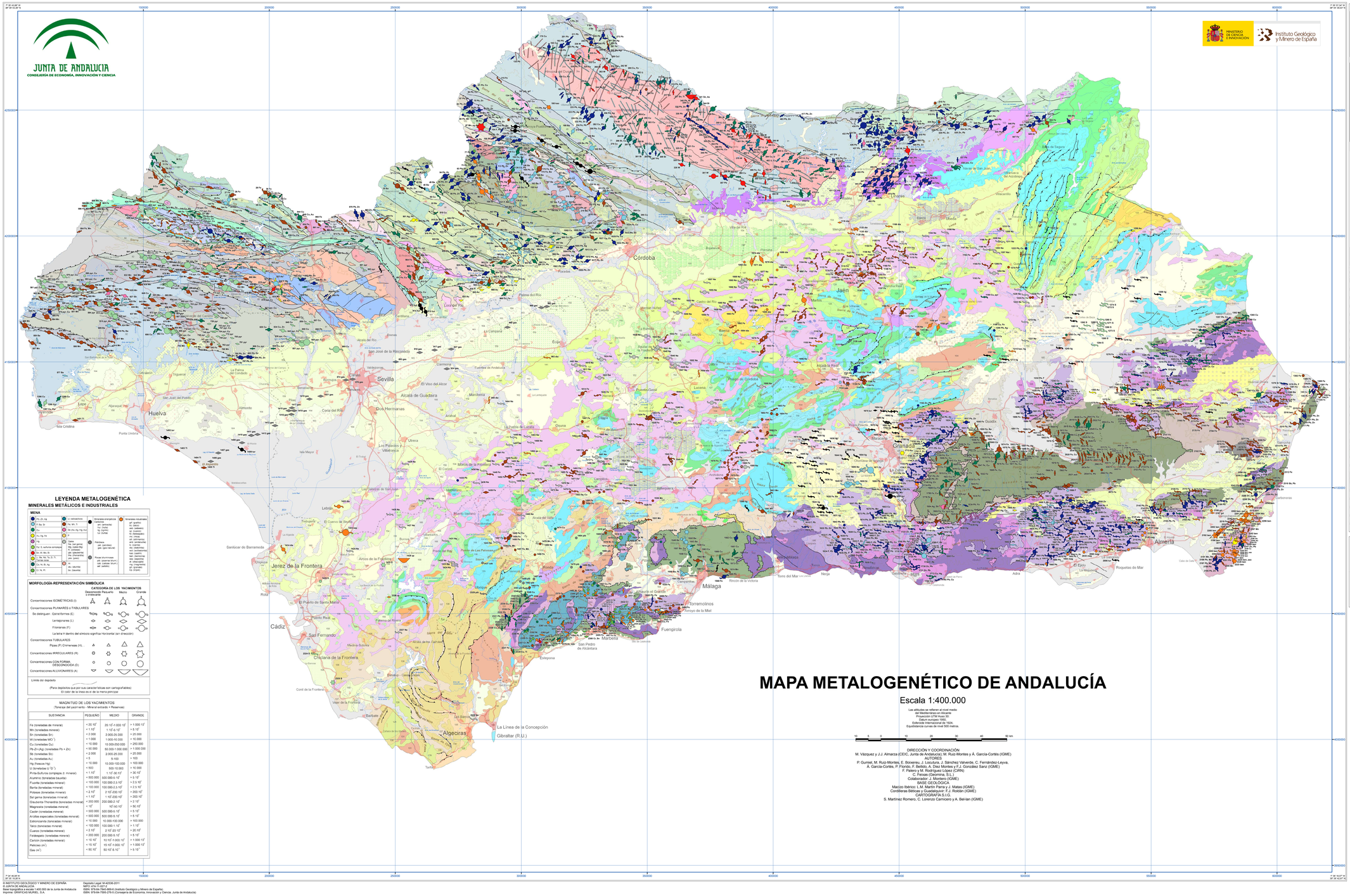
Rocas ígneas y cadomenses

4 Serpentinitas, rocas ultrabásicas
3 Granodioritas y monzogranitos de la Negra de Lora
2 Granodioritas porfídicas y leucogranitos cordieríticos
1 Granitos y dioritas de Velezquito

186 Arcuates y coluviales
185 Margas arcillas, arenas y limos coluviales
184 Margas arcillas y grises. Calcarenitas y limos amarillos
183 Conglomerados, arenas, limos rojizos y margas. Conglomerados y arenicas cuarcíticas/pelagicas
182 Alternancia de arcillas, limos y conglomerados
181 Conglomerados, arenas y limos de color rojizo
160 Calizas arrecifales y margas. Prebético
159 Conglomerados, arenas y limos rojizos y margas
158 Calcarenitas y limos amarillos
157 Calizas arrecifales y calcareniticas
156 Yesos y margas
155 Alternancia de arenicas y margas
154 Calizas, margas y arenas. Prebético conglomeraticas
153 Calcarenitas y conglomerados. Luzmarena amarillos
152 Calcarenitas y conglomeraticas, arenicas, arenas y limos amarillos.
Prebético
151 Conglomerados, arenas y limos rojizo y margas
150 Margocalizas con lignito
149 Margas y arcillas
148 Conglomerados, limos y arcillas
147 Alternancia de arenicas y margas. Luzmarne conglomeraticas
146 Calizas arrecifales y calcareniticas. Luzmarena conglomeraticas
145 Calizas de algas, calcarenitas, conglomerados calcareniticas.
144 Rocas volcánicas
143 Margas y arcillas
142 Conglomerados
141 Margas blancas, arenosas y calizas
140 Calizas, margas y arenas. Prebético
139 Conglomeraticas rojos
138 Brechas y arcillas con olistolitos (Unidad Olistostromica)
137 Calizas arrecifales y margas. Subbético conglomeraticas
136 Arenicas cuarcosas (Aljibe). Uds. del Campo de Gibraltar
135 Margas y arenicas micáceas. Uds. del Campo de Gibraltar
134 Calizas arrecifales y calcareniticas. Subbético
133 Calizas bioclásticas y margas. Prebético
132 Calizas, calcarenitas, arenicas y conglomeraticas. Malaguide
131 Calizas, margas y arenas. Prebético conglomeraticas
130 Margas, margocalizas y calizas con silex. Margocalizas nodulosas. Subbético
129 Calizas, margocalizas y arenicas. Prebético
128 Calizas, margocalizas y arenicas. Subbético conglomeraticas
127 Calizas margosas nodulosas, nodulosas y arenicas. Uds. del Campo de Gibraltar
126 Calizas margosas nodulosas, nodulosas y arenicas. Uds del Campo de Gibraltar
125 Calizas, margas y arenas. Prebético
124 Calizas, margocalizas y margas. Subbético
123 Calizas, margocalizas y margas. Subbético conglomeraticas
Complejo Frontal de las Zonas Internas
122 Margas, margocalizas y calizas margosas. Uds del Campo de Gibraltar
121 Brechas margosas y calizas arrecifales. Subbético
120 Calizas, margocalizas y margas. Prebético
119 Calizas arrecifales. Subbético
118 Calizas, margas y radiolaritas. Calizas rojas (ammonítico rosso). Subbético
117 Rocas volcánicas, margocalizas y calizas. Subbético
116 Calizas arrecifales y margocalizas. Subbético
115 Calizas bioclasticas y dolomías. Subbético
114 Dolomías y calizas. Prebético
113 Calizas arrecifales y margas. Subbético
112 Calizas rojizas. Subbético
111 Yesos. Subbético
110 Arcillas y arenas rojas con yesos. Subbético
109 Arcillas y yesos. Luzmarena arcillosas. Prebético
108 Conglomeraticas, arenicas y arcillas. Prebético
107 Calizas, margas y arenas. Prebético conglomeraticas. Malaguide
106 Calizas, dolomías y margocalizas. Mármoles. Alpujárride
105 Filitas y esquistos claros con cuarcitas. Alpujárride
104 Calizas, margocalizas y conglomeraticas y calizas. Malaguide
103 Peridotitas. Alpujárride
102 Esquistos grafitosos. Alpujárride
101 Esquistos. Nevado-Filábride
100 Gneises. Nevado-Filábride
99 Micaesquistos con esquistos y yesos. Nevado-Filábride
98 Micaesquistos y esquistos grafitosos. Nevado-Filábride
97 Micaesquistos grafitosos. Nevado-Filábride
96 Conglomeraticas, arenicas, lutitas calizas y coladas de basaltos.
Conglomeraticas de Niño Perdido
95 Conglomeraticas, lutitas, arenicas rojas y coladas basálticas. Permico del Viar
94 Brechas y/o conglomeraticas ñorales poligenicos con capas de carbon.
Conglomeraticas de Peñarroya
93 Pizarras, grauvacas, conglomeraticas con carbon y olistolitos poligenicos.
Carbonífero del Viar
92 Conglomeraticas rojos y grises. Culm de la Fth
91 Pizarras, grauvacas, arenicas y conglomeraticas. Culm de Los Pedroches
90 Pizarras, lutitas y grauvacas con predominio de basaltos y rocas básicas.
Complejo Volcanosedimentario
89 Filitas y cuarcitas/conglomeraticas de Hornachuelos, ambientes frecuentemente.
lutitas hórnidas y arcillas, ligeramente volcanicos, epiclastitas
88 Pizarras, grauvacas, arenicas y conglomeraticas. Complejo Esteo-Paredón.
Coladas de pórfidos dacíticos e hórnicos. Grandes de Cazalla. Esplosivitas de
El Ordon. Espilitas del Complejo Esteo-Paredón.
87 Pizarras, grauvacas y conglomeraticas
86 Brechas, fangolmenitos, lutitas, grauvacas y capas de carbon.
Conglomeraticas de Belmez
85 Pizarras, arenicas, grauvacas, conglomeraticas y capas de carbon.
Conglomeraticas de Belmez
84 Pizarras, grauvacas y conglomeraticas. Tramo superior
83 Volcanitas ácidas, básicas e intermedias con epiclastitas, cineritas y equivalentes
hipabisales. Complejo Volcanosedimentario de Los Pedroches
82 Cuerpos ferrugíneos, arenicas, arenicas. Ordovicico superior
81 Cuarcitas con rnveles pizarrosos y ferrolitas. Ordovicio Sup DOV
80 Pizarras, grauvacas y conglomeraticas. Tramo inferior de la Torre
81 Alternancia de pizarras, limolitas, arenicas y cuarcitas. Culm Fth
80 Pizarras y grauvacas. Fms. Ribeira de Limas y Alaska
79 Cuarcitas, arenicas ferrugíneas, pizarras y rnveles de calizas. Ordovicio inferior
78 Cuarcitas, arenicas ferrugíneas, pizarras y rnveles de calizas.
Silúrico-Dev. inferior. U. Adicionas del DOV
77 Pizarras, grauvacas y conglomeraticas e intercalaciones de calizas bioclasticas.
U. Tesera Inferior
76 Pizarras negras con alguna intercalación cuarcítica
75 Pizarras, grauvacas y conglomeraticas con cuarcitas arenosas, arenitas, cuarzos y tubines
de granitoides s. Fm de Lobo
74 Anfibolitas de grano fino y grueso, rocas básicas, ortoanfibolitas bióticas
73 Esquistos y arenicas con metavolcanitas y anfibolitas. Sucesión de El Cubito
72 Gneises, anfibolitas, retrocristgnitos, micaesquistos, cuarcitas negras.
Complejo Esquistoso
71 Pizarras grafitosas, cuarcitas, arenicas ferrugíneas, pizarras y rnveles
de calizas. Silúrico-Dev. inferior. Uds. Paraautóctonas del DOV
70 Gneises glandulares y migmatitas. Complejo Adamuz
69 Cuarcitas, pizarras y calizas. Ordovicico superior DOCO
68 Pizarras grises. Ordovicico medio DCEO
67 Cuarcitas, arenicas ferrugíneas y pizarras. Ordovicio inferior DCEO
66 Cuarcitas, cuarzoarenitas y filita, ritamente detrítica por ciziella.
Ordovicio U. Adicionas del DOV
65 Cuarcitas, arenicas ferrugíneas y pizarras grafitosas. Ordovicio de las
Unidades Paraautóctonas del DOV
64 Pizarras verdes y grises con nódulos, limolitas y arenicas que intercalan
con cuarcitas arenosas, arenitas y rnveles de calizas. Ordovicio medio-superior
de Cazalla. Ordovicio del Encinarejo
63 Pizarras grises y moradas con cuarcitas ácidas y básicas. Fm Barranco
64 Pizarras, grauvacas, conglomeraticas, arenicas ferrugíneas y pizarras
grafitosas. Fm. Acebuche
63 Filitas, arenicas, cineritas y cuarcitas. Cámbrico medio Detrítico (Fatsuado). Alluera,
Cajas del Paydro
59 Basaltos y vulcanitas básicas. Basaltos del Paydn
58 Conglomeraticas, arenicas, micaesquistos, micaesquistos-granatoides,granatoides,
cuarcitas y migmatitas. Micaesquistos y esquistos del Complejo Esquistoso
57 Pizarras, grauvacas.Tramo detrítico superior del Cámbrico inferior.
56 Micaesquistos, esquistos, gneises, migmatitas, anfibolitas y metavolcanitas.
Esquistos de Jerez
55 Gneises, migmatitas, metacuarcitas ácidas y básicas, anfibolitas, ortoanfibolitas
y rocas de silicatos cálcicos. Complejo Volcanosedimentario de Aconce
54 Micaesquistos, micaesquistos, arenicas y cuarcitas ferrolíquidas.
Grupo Cumbres Mayores
53 Filitas, arenicas, cineritas cuarcitas feldespáticas y vulcanitas ácidas y básicas.

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