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# Towards a Database for the Valorisation of Tailings in Mining Regions-Method and Preliminary Results

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***Abstract*** **–** For many years, coal has been the main economic engine of several European regions, including the province of León in the northwest of Spain. However, the ongoing energy transition has led to a massive closure of coal mines and high uncertainty within the mining industry. The current decline of the mining sector in these regions has triggered severe depopulation, jobs losses and a general industrial decay. Valorisation of tailings has proved effective as a way of revitalising these areas, but more knowledge is needed in order to fully exploit this potential. This study presents a method for the development of a new database with information on existing tailings in the province of León, based on scattered data extracted from public resources. The database includes a comprehensive set of data related to these tailings, including administrative, geographical and geological data. The purpose of this database is to constitute a valuable source of information of the existing mineral resources of the region, as well as to raise awareness on the great potential for technological valorisation of these raw and specific materials. Preliminary results and conclusions are reported. Further development of this work is expected to have positive effects regarding transfer and generation of knowledge, business opportunities and social recovery of the region, all in line with the UN Sustainable Development Goals, the priorities of the European Commission on raw materials and the Circular Economy strategy.

***Keywords*****:** Critical raw materials, Tailings, Circular economy, Valorisation, Regional development.

## 1. Introduction

Raw materials are crucial for the European economy as they are the beginning of the manufacturing value chain. The dependence of Europe on these raw materials is a matter of growing concern both for European authorities and industry, as the terms of trade are increasingly being dictated by emerging economies such as China, India or Brazil. In the coming years, this situation is likely to remain the same, with industrialized countries losing their influence over developing ones. In order to effectively manage this global landscape, Europe has developed a series of measures to promote interregional cooperation, resource efficiency and sustainable resource management of raw materials.

As part of these measures, the European Commission has created a list of critical raw materials, essential for the industrial value chain, with high strategic and economic importance and high supply risk. The list consists of 3 groups of raw materials and 24 individual elements, as shown in the table below:

Table 1: List of Critical Raw Materials. [1]

| **List of Critical Raw Materials (CRMs)** | | | |
|---|---|---|---|
| Antimony | Fluorspar | LREEs[2] | Phosphorus |
| Baryte | Gallium | Magnesium | Scandium |
| Beryllium | Germanium | Natural graphite | Silicon metal |
| Bismuth | Hafnium | Natural rubber | Tantalum |
| Borate | Helium | Niobium | Tungsten |
| Cobalt | HREEs[1] | PGMs[3] | Vanadium |
| Coking coal | Indium | Phosphate rock | |

[1] HREEs: dysprosium, erbium, europium, gadolinium, holmium, lutetium, terbium, thulium, ytterbium, yttrium.
[2] LREEs: cerium, lanthanum, neodymium, praseodymium and samarium.
[3] PGMs: iridium, palladium, platinum, rhodium, ruthenium.

The analysis of supply risk for these critical raw materials carried out by the European Commission places China as the main exporter, covering approximately 70% of the materials in the list. Other strategic countries are USA (beryllium and helium), Russia (tungsten and scandium) and Mexico (fluorspar). [1]

It is vital to create the conditions to allow the optimisation in the use of resources, materials and products while maintaining its value and to develop new tools and methods for minimising the generation of waste. This is the frame in which the Circular Economy strategy arises [2], as stated in the EU Action plan for the Circular Economy developed in 2015. The final objective is to ensure sustainable consumption and production patterns by adding value to local resources and waste instead of remain dependent on imports of raw materials from third countries.

## 2. Methodology

### 2.1. Background

Historically, coal has been one of the main fossil-fuel sources of the European economy. At the present time, it represents 16% of gross energy consumption in the EU and 24% of the energy mix. In recent years, the use of coal has decreased as part of the ongoing transformation of the energy system, the need to reduce greenhouse gas emissions and the increasing share of renewable energies. However, the negative effects that this energy transition has on the regions with a strong coal mining industry, mainly in terms of rural exodus, job losses and industrial decay, are often disregarded.

This is the case of the province of León in Spain, where mining has historically had a crucial role in its economic, social and cultural development. The province has had up to 132 mines distributed throughout the territory of which only 15 are still active nowadays. In the last few years, this sector has suffered of permanent uncertainties, including the massive closure of mines and its severe consequences.

In view of the current situation and taking into account the priorities of the European Commission, a process of transition towards a new sustainable mining of critical raw materials and strategic minerals for the 21st century is becoming more and more necessary. This new concept will require a low environmental impact, highly efficient valorisation of raw materials in tailings and their by-products, with a reduction of residues.

This new mining concept also promotes the removal and recovery of existing tailings in the mining regions through new processing and recovery techniques. The recovery of raw materials from immobilized waste has a great economic importance as there is the possibility of merging processing and extraction technologies to multiply the exploitation potential of extracted ore and, therefore, maximize the benefit of each operation.

In this paper, the method and preliminary results are shown for a new database with comprehensive data on existing tailings in the province of León, with the aim of exploring the potential for these resources to become a new source of economic and social value for the region.

### 2.2. Method description

The methodology used for the development of this database consists of the following steps:

1. First exploratory review.

As a first step, a thorough review of the geological and mining background of the region has been carried out. According to the already known wealth of resources (in terms of geological substances and formations), a selection of those with the highest technological and economic interest has been singled out.

2. Data selection

The information on the tailings present in the province has been obtained from National Inventory of Rafts and Tailings of the Geological and Mining Institute of Spain. All the data have been sifted considering those tailings and rafts that have a volume greater than 50.000 $m^3$. This Inventory consists of a series of files providing data on:

- Type of structure and its state, whether it is a tail, raft or mixed; active, stopped or abandoned.
- Geographic location: U.T.M. coordinates and their corresponding areas, plus province, municipality and landscape.
- Mining type (metallic, energetic, industrial, ornamental) and its ore.

- Type of substrate and its coating.
- Type of recovery.
- Observations and evaluations.
- Location, structural scheme and images.

The data of interest extracted for the development of our database can be divided into administrative, geological and geographical data. Details on the data mining carried out and data distribution are presented below:

1. Geographical data.

Once the data is classified, and using the ETRS89 coordinates, the corresponding ortho-photo of each area is captured through the SIGPAC viewer (Geographic Information System) in order to capture all the available knowledge on the conditions of the area. By using the same viewer and applying vector layers, the cadastral data of each plot is obtained.

2. Administrative data.

From the cadastral reference, we have recovered data referring to the cadastral cartography, the descriptive and graphic query and the number of the polygon and plot according to the Electronic Headquarters of the Cadastre. The category of the existing soil in each urban, urbanized and rustic areas through the urban viewer SiuCyL has also been consulted.

3. Cadastral mining data.

Finally, information has been collected regarding the Mining Cadastre in order to know the type of mining concession existing in the area of study. The data collected includes type of mining right, substances exploited, holder of concession, section, location and registration number among others. This information is crucial since, following the Law 22/1973, of July 21, of Mines, depending on the type of resource, section, permit or authorization, we will know from and until what date the land can be exploited and who is the owner.

Table 2: Data distribution.

| Administrative data | Geological data | Geographic data |
|---|---|---|
| Owner | Volume | Province |
| Appellation | Nature of the substrate, type of residue and lithology | Municipality |
| Cadastral information | Type of structure | Landscape |
| | Observations | Coordinates (already transformed into ETRS 89) |

## 3. Results

As a preliminary analysis of all the information collected and classified, we can highlight the following results:

- A total of 313 tailings have been explored as a basis for our study
- From these 313 tailings, we have determined the volume of 295, with an average volume of 520.787,214 $m^3$.
- In terms of composition:
    - The nature of the substrate varies from conglomerate, slit, slate, gravel, quartzite, limestone, iron and dolomite, prevailing the slate.
    - In terms of mining origin, we can find slate, anthracite, hard coal and talc; most of them hard coal and anthracite.

The following table shows the tailings with possibilities of valorisation according to the selected raw materials (tungsten, quartz, graphite and talc). A total of 21 tailings have been selected:

Table 3: Selected tailings based on the data explored.

| ID | Raw Material | Location | Volume/Surface | Mining Section |
|---|---|---|---|---|
| **173** | Quartzite and slate | Chano de los Eros | 65.000 $m^3$ | C |
| **174** | Quartzite and slate | Felechales | 3.500.000 $m^3$ | C |
| **175** | Quartzite and slate | Felechales | 50.000 $m^3$ | C |
| **176** | Quartzite and slate | Ferreiros | 1.300.000 $m^3$ | C |
| **177** | Quartzite and slate | Carrozales | 90.000 $m^3$ | C |
| **178** | Quartzite and slate | Quiñones | 1.600.000 $m^3$ | C |
| **245** | Dolomite | Fuentes de Respina | 100.000 $m^3$ | C |
| **246** | Dolomite | Fuentes de Respina | 100.000 $m^3$ | C |
| **247** | Dolomite | Fuentes de Respina | 225.000 $m^3$ | C |
| **248** | Dolomite | Fuentes de Respina | 400.000 $m^3$ | C |
| **249** | Quartzite | Fuentes de Respina | 70.000 $m^3$ | C |
| **250** | Dolomite | Fuentes de Respina | 400.000 $m^3$ | C |
| **305** | Iron | Villamanín | 2.240.054 $m^2$ | C |
| **306** | Limestone, iron, copper | Cármenes | 377.000.000 $m^2$ | C |
| **307** | Iron | Oencia | 180.368 $m^2$ | C |
| **308** | Iron | Vega de Valcarce | 14.567.749 $m^2$ | C |
| **309** | Iron | Oencia | 1.032.408 $m^2$ | C |
| **310** | Iron | Oencia | 300.700 $m^2$ | C |
| **311** | Iron | Oencia | 240.544 $m^2$ | C |
| **312** | Quartzite and slate | Crémenes | 599.909 $m^2$ | C |
| **313** | Quartzite and slate | Crémenes | 300.116 $m^2$ | C |

According to table 3, the selected tails have a volume greater than 50.000 $m^3$ and, furthermore, all of them belong to section C, ie metallic minerals, for the iron and steel industry (iron, nickel, chromium, aluminium, copper, lead…) or precious metals (gold, silver…); minerals for agriculture, fertilizers, chemical industry and production of pigments and paints (calcium, phosphorus, potassium, sulfur…); minerals for the glass and ceramics industry (silica, quartz, fluorine…) and minerals for loading or filling (special clays such as sepiolite).

The next step is to process and analyse representative samples of the tailings that have a high potential for revaluation (Table 3) and conclude if their recovery is economically profitable.

## 4. Conclusions

In view of the preliminary results, we can confirm that there is great potential for valorisation of resources derived from mining tailings in the province of León. This result should lead to the development of new processing methods and techniques for the recovery of mining tailings in the province of León, with a clear positive return of investment for mining companies, thus attracting capitals and creating jobs to recover the zone. This ongoing study tries to demonstrate the potential of a comprehensive database of mineral resources to have an impact in the valorisation of raw and specific materials of the region and the resulting opportunities for the mining sector derived from these activities. Moreover, this study is setting up the basis for a positive impact in the raw materials strategy of the UE, thus fulfilling the aims of the Strategic Implementation plan (SIP) of the European Innovation Partnership on raw materials (EIP raw) [4].

Due to all the exposed above, it is intended to position the region as an European reference in the valorisation of raw materials, as well as generate regional economic, social and environmental sustainability through the use of these materials in applications with high technological interest.

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## References


[1] European Commission, "Study on the review of the list of Critical Raw Materials, Final Report," *Criticality Assessments*.

[2] European Commission. (2018, January 16). Report on Critical Raw Materials and the Circular Economy (Part 1/3). [Online]. Available: https://ec.europa.eu/docsroom/documents/27327

[3] Joint Research Centre (JRC), European Commission. (2018). EU coal regions: opportunities and challenges ahead. JRC Science for Policy Report.

[4] The European Innovation Partnership (EIP) on Raw Materials. [Online]. Available: https://ec.europa.eu/growth/tools-databases/eip-raw-materials/en/content/european-innovation-partnership-eip-raw-materials