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Report on competent sources and existing primary raw materials data (D4.1.)

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Report on competent sources and existing secondary raw materials data (D5.1.)

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1. Introduction

Under WP4 - Primary mineral raw materials in the ESEE region - one of the major challenges in the RMI Raw Materials Initiative (II. Pillar) - fostering the sustainable supply of raw materials from EU sources - is addressed. This challenge could be facilitated by the mineral potential from the SEE region. In order to confront this challenge successfully, relevant data providers have to be identified and data quantity, quality, and format have to be examined. This will subsequently lead to the West Balkans Mineral Register of primary raw materials data, and at the end of the project to the integration of some West Balkan countries into the "pan-European Mineral Intelligence Network".

The same objective as under WP4 is also addressed under WP5 - Secondary raw materials in the ESEE region. The main purpose of this work package is to acquire information about mining and metallurgical waste sites in SEE countries. The same step will be taken – the creation of the West Balkan Mineral Register of secondary raw materials, which will lead to the connection of the best-prepared SEE countries into the "pan-European Mineral Intelligence Network". Secondary raw materials sites will be chosen based on their economic potential, extraction possibilities, and environmental impact.

We face similar challenges with WP4 and WP5. Therefore, the most appropriate solution is the joint deliverable D4.1. & D5.1. - Report on competent sources and existing raw materials data.

In order to provide a comprehensive overview of the SEE region raw materials data an overview map of the primary raw materials and secondary raw materials deposits of the region has been created.

2. Raw materials data sources

If we want to obtain quality datasets on primary and secondary raw materials, relevant data providers first have to be identified. Task partners from the SEE region are experts on the raw material situation in their local environment, and this is why they have provided quality and comprehensive data about raw material data sources. Key data providers for primary raw materials and secondary raw materials from expert and legal entities have been identified and a list of expert institutions and legal entities by country was created in the following subchapters.

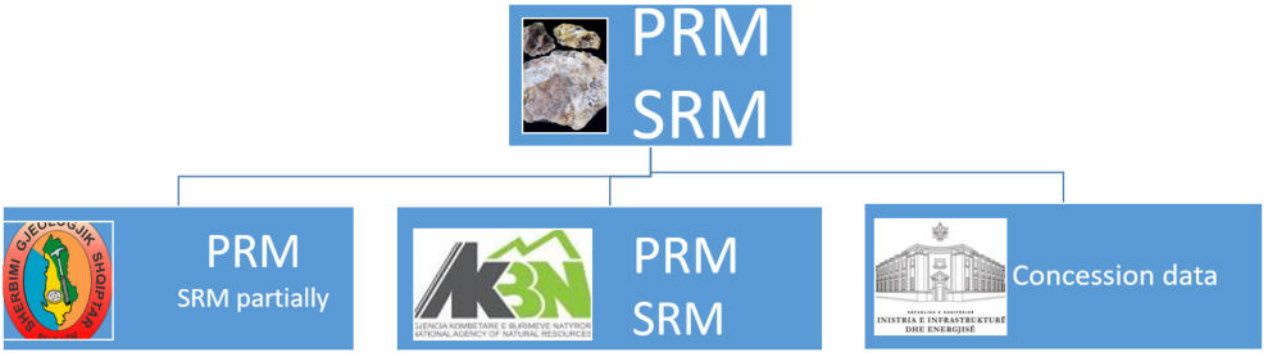
2.1. Albania

There are three main institutions in Albania responsible for collecting and storing data related to the mineral/mining industry **(primary raw materials and secondary raw materials):**

- **The Ministry of Infrastructure and Energy (MIE)**
- **The Albanian Geological Survey (AGS)**
- **The National Agency for Natural Resources (NANR).**

AGS is an authority that has all existing **geological data** in analogue and digital format. It **issues exploration permits** and **supervises** the process of **mineral exploitation.**

NANR is the agency responsible for issuing **exploitation permits** for mining activities. It is also responsible for **monitoring mining waste**, **mine closure,** and the **remediation** of **closed mines.** The agency also provides data for **mining production** and **waste deposits.**



Graph 1: Albanian raw materials data sources

The following data are included in the Albanian **minerals register:**

- Geographical position (X,Y,Z)
- Size of deposit/area (ha)
- The duration of permits for exploitation
- Production data (tonnes)
- Monitoring of mining activities
- Monitoring of mine closure/remediation.

The **Ministry of Infrastructure and Energy** is responsible for:

- **Register of concessionaries** and any **other data** related to **concessions**
- **Register of permits** for **mining activities**

2.2. BIH – Federation of Bosnia and Herzegovina

We have to keep in mind that there are three levels of authorities in BIH. At the first level there is the BIH state. At the second level there are two entities and one district in the BIH: Federation of Bosnia and Herzegovina, Republika Srpska, and the Brčko district. At the third level, the Federation of Bosnia and Herzegovina further consists of ten cantons. Consequently, different levels of authorities are responsible for different raw materials data. Below is a concise list of the different **primary raw materials data sources in the Federation of Bosnia and Herzegovina**:

- **The Geological Survey of the Federation Bosnia and Herzegovina** is responsible for **geological data** - data on the geology of mineral deposits at entity level
- The institutions in charge of **concessions** are the competent **cantonal ministries** and **cantonal commissions for concessions**

- The Institution responsible for **granting exploration and mining rights for energy raw materials** and **metallic mineral raw materials** is **the Federal Ministry of Energy, Mining and Industry**
- Institutions in charge of **granting exploration and mining rights** for **non-metals** are the competent **cantonal ministries.**

Companies managing landfills are responsible for data on **slag** and **mining sludge disposal sites**.

2.3. BIH – Republika Srpska

The legal entities responsible for raw materials data in the BIH entity Republika Srpska are:

- **Geological data** - **Geological Survey of the Republic of Srpska**
- **Concessions data** – **Ministry of Energy and Mining**
- **Exploitation data** – **Ministry of Energy and Mining**, **companies** which have a **concession** for **raw materials exploitation, the Geological Survey of the Republic of Srpska**
- **Heap data** - **companies** which have mining rights and mineral processing permits for **raw materials** and **mining** or **process raw materials** and **dump deposits**, **Ministry of Energy and Mining**

2.4. Croatia

The legal entities responsible for raw materials data in Croatia are:

- The **Croatian Geological Survey** is in charge of **geological data** (geological maps with a scale of 1:50.000 and 1:100.000) and for the **data of mineral raw materials**
- The **Ministry of Economy, Entrepreneurship and Crafts, Mining Sector** is in charge of data about **exploitation fields**, **exploration spaces** (their lists and total reserves), and **concession agreements**
- The **Ministry of Economy, Entrepreneurship and Crafts, Mining Sector is responsible for**

data about **tailings which are inside exploitation fields**

- The **Croatian Agency for Environment and Nature (HAOP)**
- The **Croatian Agency for Environment and Nature (HAOP)** is in charge of **other tailings data**

2.5. Montenegro

The legal entities responsible for raw materials data in Montenegro are the following:

- The **Ministry of Economy, Directorate for Mining and Geology** and the **Geological Survey of Montenegro are responsible for geological research data**
- The **Ministry of Economy, Directorate for Mining and Geology** is responsible for granting **concessions/licensing procedures**
- **Secondary raw materials data** are the responsibility of the **Ministry of Economy, Directorate for Mining and Geology** and the **Ministry of Sustainable Development and Tourism.**

2.6. North Macedonia

The legal entities responsible for raw materials data in North Macedonia are the following:

- The **Geological Survey of the Republic of North Macedonia** is responsible for **geological data**
- The institution in charge of **concessions** is the **Commission for concessions of the Government of the Republic of North Macedonia**
- The institution in charge of **granting exploration** and **mining rights for energy raw materials and metals** is the **Ministry of Economy**
- The institution in charge of **granting exploration and mining rights** for and **rights to exploitation** to **non-metallic mineral raw materials is the Ministry of Economy**
- Data on **slag and mining sludge disposal sites** are located in the companies **managing landfills**.
- Data on **slag and mining sludge from the past ("historical" disposal sites)** are located in the **Ministry of Economy** and the **Ministry of Environment and Spatial Planning.**

2.7. Serbia

The institutions responsible for **primary raw materials data** in Serbia are:

- The **Geological Survey of Serbia** and the **Ministry of Mining and Energy** are responsible for **geological data and exploration in mining areas**
- The **Ministry of Mining and Energy** is in charge of data about **concessions**

The legal entities responsible for **secondary raw materials data** in Serbia are:

- For **operating mines** – mining rights holders/mine owners
- The **Ministry of Mining and Energy** is in charge of **closed and abandoned/historical mines**,.

3. Creating primary raw materials datasets

The next step towards a common raw materials register is to determine which data are needed to provide comprehensive information to local KTI stakeholders and the authorities for raw materials management and extraction, as well as to provide comprehensive information for international investors who are willing to invest in the national raw materials sector. The best way to make information visible worldwide is to prepare data in such a way that they can be accessible through the Internet. Most EU countries (including Slovenia) are already part of the "pan-European Mineral Intelligence Network", with the SEE region representing a gap in the network. The first step towards a common register and consequently INSPIRE-aligned data was taken by the definition of two attribute tables for primary raw materials data. The task partners from the region were partners in the analysis of regional data providers, attributes determination, and data collection.

Our activities to create common mineral resource datasets were divided into three steps:

1. Studying existing primary raw materials data,
2. Selection of attributes according to analysis,

3. Creating a common primary raw materials dataset.

The attributes in the attribute tables were determined according to their informational value for stakeholders.

All attributes in the primary raw materials attribute table were divided into:

- **General data**, providing basic deposit information
- **Technical data,** related to the technical description of the deposit
- **Geological data**, describing the basic geology of the deposit

Further attributes on **General data** are divided into:

- The mineral deposit name
- The municipality of the mineral deposit
- X and Y WGS84 (World Geodetic System) coordinates

Technical data are divided into:

- The current status of the mine (abandoned/in care and maintenance/operational)
- The mining method (open pit, underground)
- The concessionaire's name
- The mineral reserves (estimated in tonnes).

Geological data are divided into:

- A basic geological map in the 1:100.000 scale
- The type of mineral deposit
- The size of mineral deposit
- The age of mineral deposit
- Host - rock type
- All minerals are divided according to their quantity into: major, minor, and trace
- The final product produced from mineral raw materials.

4. Primary raw materials deposits in the West Balkans

4.1. Porphyry Cu deposits

Porphyry copper deposits are located in tectonically diverse areas, characterised by intense frequent repeated magma activity. Old magmatic and sedimentary rocks and even some metamorphic rocks present host rocks, where copper ore appears in form of deep veins and streaks (Drovenik, 1984) . Porphyry copper deposits in the Balkan region are linked to the Carpatho-Balkan mountain range and as such are the most interesting deposits in the entire region of the West Balkans. These deposits are usually large, with a

relatively low copper content. Only in this case are the deposits of poor ore profitable for exploitation. In the case of surface exploitation there is generation of a lot of the mining of extractive waste, which can have a significant negative impact on nature and ecosystems if it is not stored properly.

In Serbia, the most famous porphyry copper deposits are at Bor and Majdanpek, while in North Macedonia these are Borov dol and Bučim (Figure 1). A few smaller deposits of copper ore vein with associated dumpsites are also located in Albania (Fushë Arrëz, Spaç and Kurbnesh) (Figure 1). The mineral deposit of copper at Majdanpek has been in operation since 1961, and in 1979 a new mine was opened in the area of Veliki Krivelj near Bor. Both mines are in the Timok eruptive area of eastern Serbia, which is part of the Carpatho-Balkan mountain range. The Majdanpek mine, located in the northern part of this area, and its surroundings, represent the old mining sites, where the copper was already exploited by the native inhabitants before the arrival of the Romans. Research in modern times has revealed large copper reserves (around 600 Mt of ore with about 0.6% Cu), which makes it one of the largest porphyry copper mines in the world. The Veliki Krivelj mine is located a few kilometres north of Bor in the Kriveljska Reka valley. Research which began in 1960 found about 450 Mt of copper, containing an average of 0.45% Cu. There is a large impregnation deposit in the strongly modified hydrothermal zone, which measures about 4.5 km2 and extends over substantial faults in the NW-SE direction. So far, research has shown that there are other porphyry copper mines around Majdanpek and Bo, which have not yet been fully explored, or which contain too little copper content to be exploited economically.

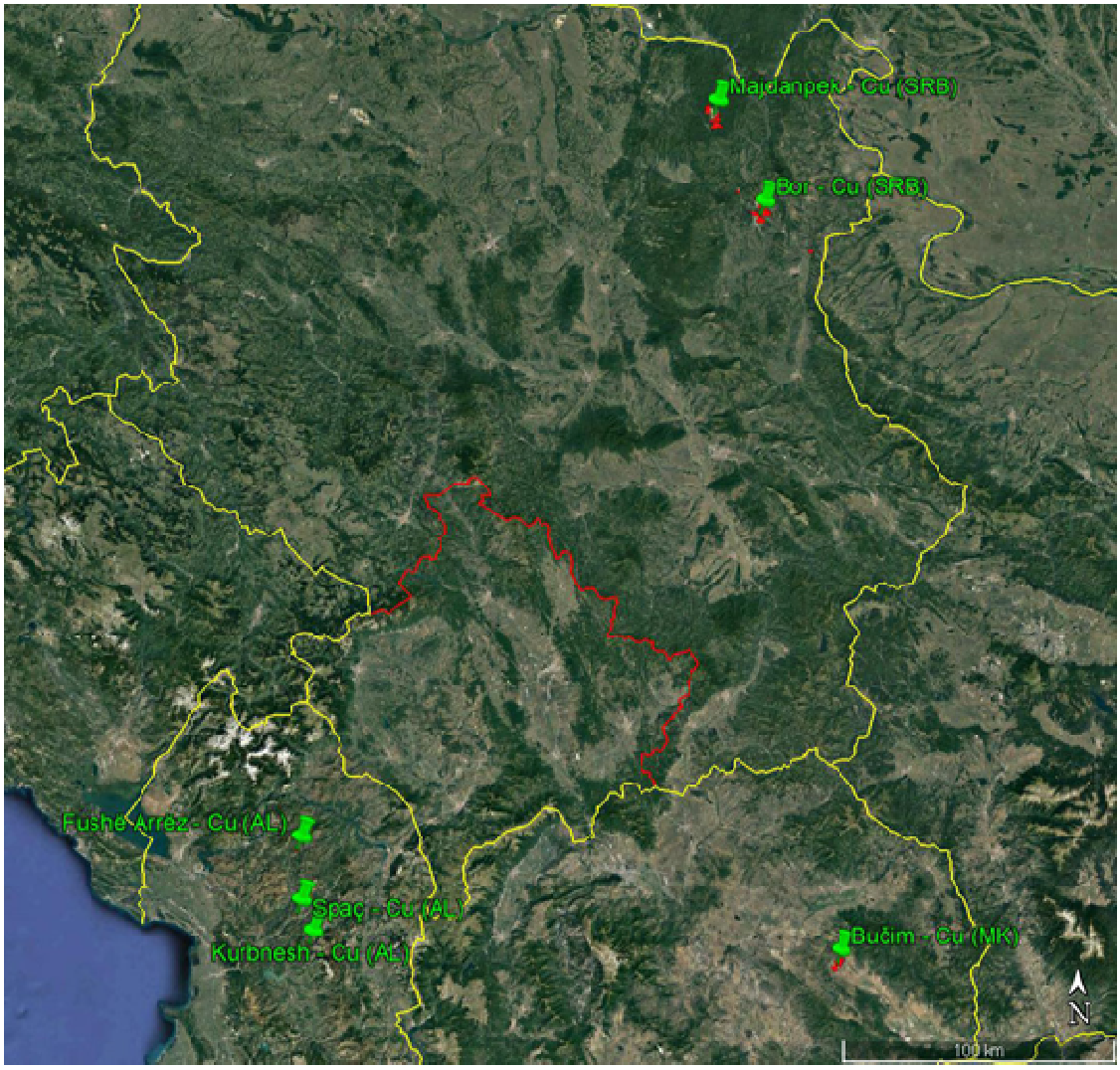


Figure 1. Copper mines in the West Balkans

The Bučim and Borov dol porphyry copper mines are located in the eastern part of North Macedonia. The Bučim mine is on the southwestern slopes of the Plačkovica mountain. From a regional point of view, it is located near the contact between two geotectonic units: the Vardar zone in the west and the Serbian-Macedonian zone in the east. The mine began preparation for exploitation in 1978 and this is still taking place today. Its deposits are about 140 Mt, containing an average of 0.4% Cu. The deposit also contains 1 g/t Ag, 0.5 g/t Au, and an average of 20 g/t Mo. Near the Bučim mine, only a few kilometres to the south, the Borov dol location has an area of approximately 2 km2. The deposit body forms a ring around some andesite and descends to a depth of about 300 m.

During the exploitation of these copper deposits, even some waste products (tailings and heaps) were dumped near the processing plants. The heap and tailings contain a certain proportion of copper and other metals which, according to today's criteria standards and using advanced technology, can be economically extracted. There are also dumps of oxide minerals that are not favourable for the flotation process. In the lower parts there are flotation repositories rich with minerals because of the poor technology for extraction and a small yield in the past (Figures 2 and 3). The amount of extractive waste in the areas mentioned is 1.3 Mt (Table 1.)

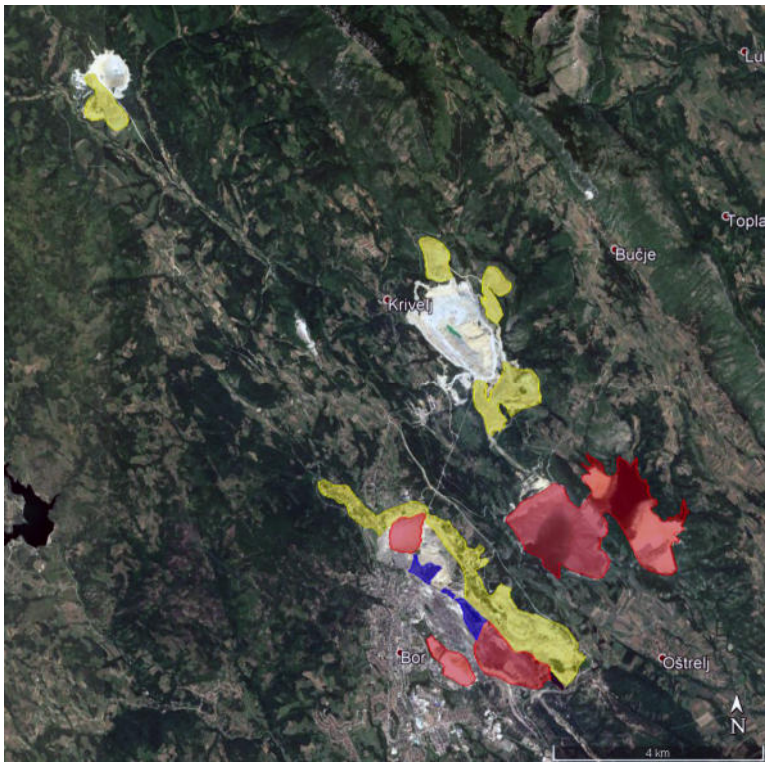


Figure 2. Bor copper mine (yellow – waste rocks and oxide ore tailings, red – flotation tailings, blue – metallurgical slag)

Table 1: Bor

Tailings	Type	Amount (Mt)	Cu (%)	Cu (Kt)
Visoki planir	MT	150	0.15	225
Severni planir	MT	20	0.3	60
Planir RTH	MT	60	0.1	60
Inner tailings	MT	28	0.2	56
Planir Krivelj	MT	170	0.1	170
Planir Cerovo	MT	22	0.18	40
Old flotation tailings	FT	27	0.3	81
Flotation tailings RTH	FT	50	0.2	100
Flotation tailings V. Krivelj	FT	130	0.15	195
Metallurgical slag	MS	16.5	0.65	107
Total		674		1094

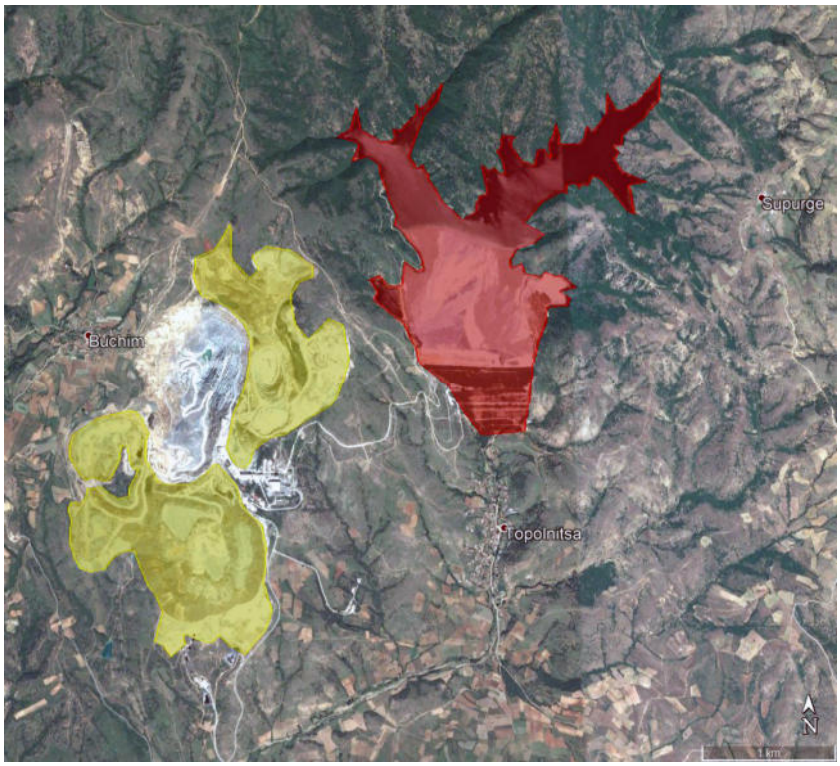


Figure 3. Bučim copper mine (yellow – waste rocks and oxide ore tailings, red – flotation tailings)

4.2. Pb-Zn-Ag deposits

Besides the porphyry copper deposits in the West Balkans there is also an extensive metallogenetic zone of Pb-Zn-Ag. This zone is located southwest of the Carpatho-Balkan metallogenetic copper zone which extends in the west-east direction or from Veovača (BIH) in the west to Toranica and Sasa in the east (North Macedonia). It comprises 17 mine deposits of contact-metamorphic origin. Their distribution by country is (Figure 4):

- BiH: Veovača and Srebrenica,
- Montenegro: Šuplja Stijena, Mojkovac,
- Serbia: Rudnik, Veliki Majdan, Grot - Blagodat, Musulj, Rudnica, Lece,
- Kosovo: Belo Brdo, Stari Trg, Ajvalija, Novo Brdo and
- North Macedonia: Toranica, Sasa, Zletovo.

Among the listed Pb-Zn-Ag deposits, Toranica and Sasa have the best economically-justifiable exploitation. The mine contains several million tons of high-quality mineral deposits with about 6% Pb and 4.5% Zn.

Even in the surroundings of these primary Pb-Zn-Ag mine deposits, flotation residues were created, especially in the lower parts, in the period when flotation technology and extraction were not as efficient as today. The amount of secondary mineral resources around these mines is around 130 Mt, of which the mines in Kosovo - Trepča mines take 75 Mt (Figures 5 and 6) (Table 2).

Table 2: Former Pb-Zn Trepça Mines (Trepça Conglomerate)

Location	Dump	Type	Area (ha)	Amount (Mt)
Leposavić	Staro jalovište	T	13	2.7
Leposavić	Bostanište	FT	23	3.7
Zvečan-Mitrovica	Gornje Polje	FT	63	20
Zvečan-Mitrovica	Gornje Polje	MS	6	2.5
Zvečan-Mitrovica	Zitkovac	FT	23	12
Zvečan-Mitrovica	Zarkov potok	T	23	10
Zvečan-Mitrovica	Industrial park	MS	40	1.5
Gračanica-Ajvalija	Gračanica	T	49	11
Gračanica-Ajvalija	Kišnica	FT	9	8
Gračanica-Ajvalija	Badovac	FT	7	2
Novo Brdo	Mareci I	T	5	0.4
Novo Brdo	Mareci II	T	6	1.5

Figure 4: Lead, zinc and silver mines in the West Balkans

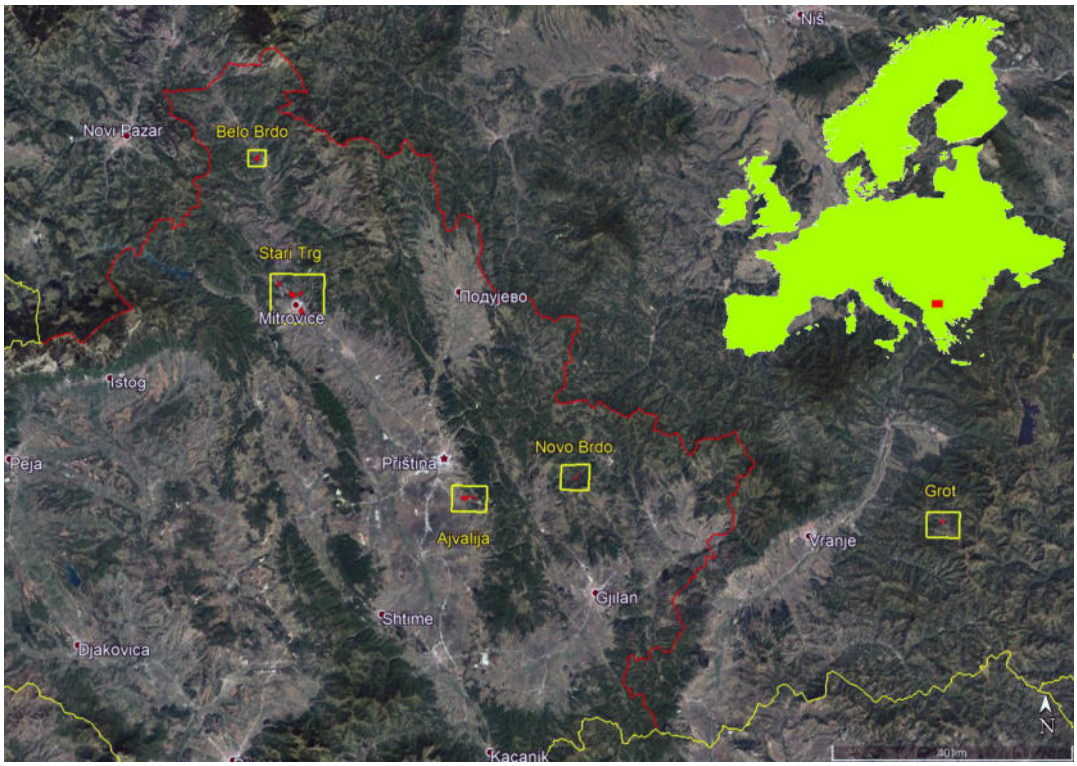


Figure 5. Former Pb-Zn Trepça Mines (Trepça Conglomerate) (1)

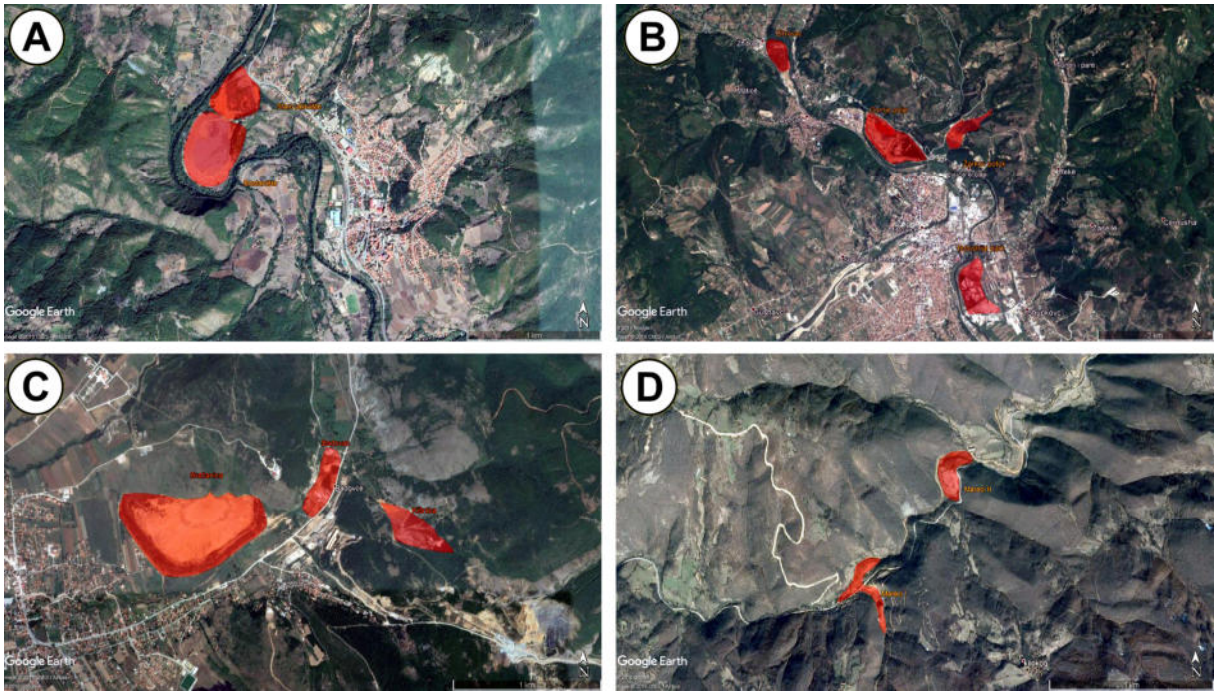


Figure 6. Former Pb-Zn Trepça Mines (Trepça Conglomerate) (2)

4.3. Sb-As-Cr deposits

Antimony hydrothermal vein deposits are associated with plutonic and subvolcanic magmatic activity. In minerals where ore is formed from highly differentiated epithermal solutions, the mineral composition is very simple. In the west of Serbia there are two smaller antimony mines (Stolice and Rujevac). In North Macedonia, on the eastern foothills of Skopska Crna Gora, there is also a smaller deposit site of antimony, arsenic, and chromium (Lojane). The mining stocks of this ore contained an average of 3.5% Sb and 4.5% As. Other antimony mines in the West Balkans are located near Kriva Palanka in North Macedonia, Rajićeva Glava in Kopaonik, and Bujanovac in Serbia.

The deposits of chromium minerals are typical for Albania, which is also one of the major European producers of chromium (mine sites: Bulqizë, Kalimash, Vlahën).

4.4. Ni deposits

Nickel mineral deposits are found mainly in Albania (Bitinckë, Kodra e Trullit, Debrove). Only two deposit sites were typical for the territory of the former Yugoslavia, located in the Vardar zone, namely: Glogovac in Kosovo and Ržanovo in the Republic of North Macedonia (Figure 7). The mineral layer in the Ržanovo mine on the Kožuf mountain is about 1.5 km long, its thickness varies from 17 to 35 m. The mining stock was about 10 Mt with an average content of Fe 31% and 1% Ni. In North Macedonia, there are similar deposits in the area of Veles (Planina Klepa) and on the Kozjak mountain. In Kosovo, also in the Vardar zone, there is a mine called Čikatovo in Dreničko polje, where mineral reserves are estimated at around 20 Mt, while the mineral contains 1.3% Ni on average.

Figure 7: Antimony, chrome, and nickel mines in the West Balkans

4.5. Fe deposits

There are some contact-metamorphic iron mines in the West Balkans. The largest mine is Damjan in the eastern part of North Macedonia, which operated from 1968 to 1992. The stocks were estimated at 10 Mt with an iron content of around 30%. Another mine was Rudna Glava in eastern Serbia, about 15 km east of the Majdanpek mine. The ore contained an average of 45 to 50% Fe and 0.1% to 0.6% Cu. Of minor importance are the iron surface mines of hydrothermal formation (Vareš, Ljubija, Tomašica, Omarska, Radovan planina) and manganese (Bužim) in the BIH area (Figure 8). There is a lot of extractive waste, also called secondary mineral resources, in these areas, but this is not economically attractive and does not pose a significant risk to the environment, as is the case with the abovementioned groups of mineral deposits.

Figure 8: Iron and manganese mines in the West Balkans

5. Creating secondary raw materials datasets

The same steps as with primary raw materials dataset creation were also used for secondary raw materials dataset creation. Informational value was also the most important factor for the selection of secondary raw materials data attributes.

All attributes in the secondary raw materials attribute table were divided according to deposit data:

- **Basic data**, providing basic deposit information
- **Secondary raw materials origin data,** related to the origin of deposit
- **Technical data**, related to the technological description of the deposit
- **Geological data**, describing the basic geology of the deposit
- **Environmental information,** describing the environmental impact of the deposit

The deposit basic data are divided into:

- Name of the location
- Municipality of the location
- X and Y WGS4 coordinates – standard geodetic coordinates
- The last manager – the legal entity that was the last manager of the deposit
- The deposition period – the time period in which the deposit was dumped
- The present deposition/condition state – the descriptive state of the deposit

Secondary raw materials origin data are divided into:

- The mine/processing facility – name of mine/processing facility which dumped the deposit
- The mine/processing facility status – the legal entity's status from which the deposit originated (closed/operating)
- The mining/processing activity description

Technical data are divided into:

- The deposit status, which can be active/abandoned/open
- The surface storage – the deposit stored on the surface or under the surface
- The surface – the estimated surface of the deposit (m^2)
- The volume – the estimated volume of the deposit ((m^3)
- The amount – the estimated weight of the deposit (tonnes)

Geological data are divided into:

- Geological composition – lithology
- Deposit type – waste or overburden rock, low-grade ore, separation ore, slag

- Type of raw material (mineral/metal etc)
- Main mineral or element in the deposit
- Content of useful element (%, mg/kg)

Environmental information is divided into:

- Remediation – executed or not
- Environmental impact of the deposit –the deposit is stable, eroded, or some elements are already emitted into the environment.

6. Secondary raw materials sites in the West Balkans

6.1. Metallurgic waste material (smelters)

Metallurgical waste from iron smelters and slag from ferronickel/ferrochrome are the most important building materials for final asphalt layers, as well as for the production of heavy concrete. For the acquisition of metals fly ash is used, which is a typical carrier of secondary mineral raw materials (e.g. > 30 % Zn).

The following ironworks in the West Balkans are the largest: Smederevo (SRB), Skopje (NMK) Sisak (HR), and Nikšić (MNE). Of the plants for the production of ferro-nickel and ferrochrome we mention: FeNi - Kavadarci and Jugohrom - Jegunovce in North Macedonia, Glogovac in Kosovo, and Elbasan in Albania.

Of the dumpsites of ferronickel and ferrochrome it is important to mention those near the FeNi and Jugohrom ironworks. The FeNi dumpsite, where a large amount of slag is situated, is of great importance in terms of the exploitation of secondary mineral resources. Some samples have shown that the nickel content is 3.50%. Based on these and previous investigations, it can be concluded that the nickel present in the slag from the electric furnace is between 0.08 % and 0.13%. In some samples, vanadium, gallium, and boron were also present which leads to the assumption of the possible presence of trace elements and rare earth elements. From this point of view, the slag from the electric furnace FeNi needs to be studied in more detail in the future (FENI: Feasibility report RECOVER (pages 33 and 34)). The Jegunovce dumpsite consists of a larger amount of chromium and slag, which are mixed together. The volume of the dumpsite is 882,175 m^3, which is about 2 Mt and covers 296,260 tons of pulp, containing 7,388 tons of chromium. The dumpsite has a net area of 6,88 ha and an average height of 23 m (Jugohrom, Jegunovce: feasibility report RECOVER (page 29)).

Metallurgical waste material from the colour metal smelters (Pb, Zn and Cu), Veles (MK), Zvečan (KS), Kosovska Mitrovica (KS), Bor (SRB), Zajača (Srb), is also very important. The metallurgical waste material of the above-mentioned smelters contains characteristic secondary mineral raw materials that have not been used completely in the past due to poor technological processes. There are large quantities of secondary mineral resources. Thus, the amount of waste material in the lead smelter in Veles is 1.5 Mt, in Zvečan 2.5 Mt, in the zinc refinery at Kosovska Mitrovica 1.5 Mt, and in the Bor copper smelter 16.5 Mt.

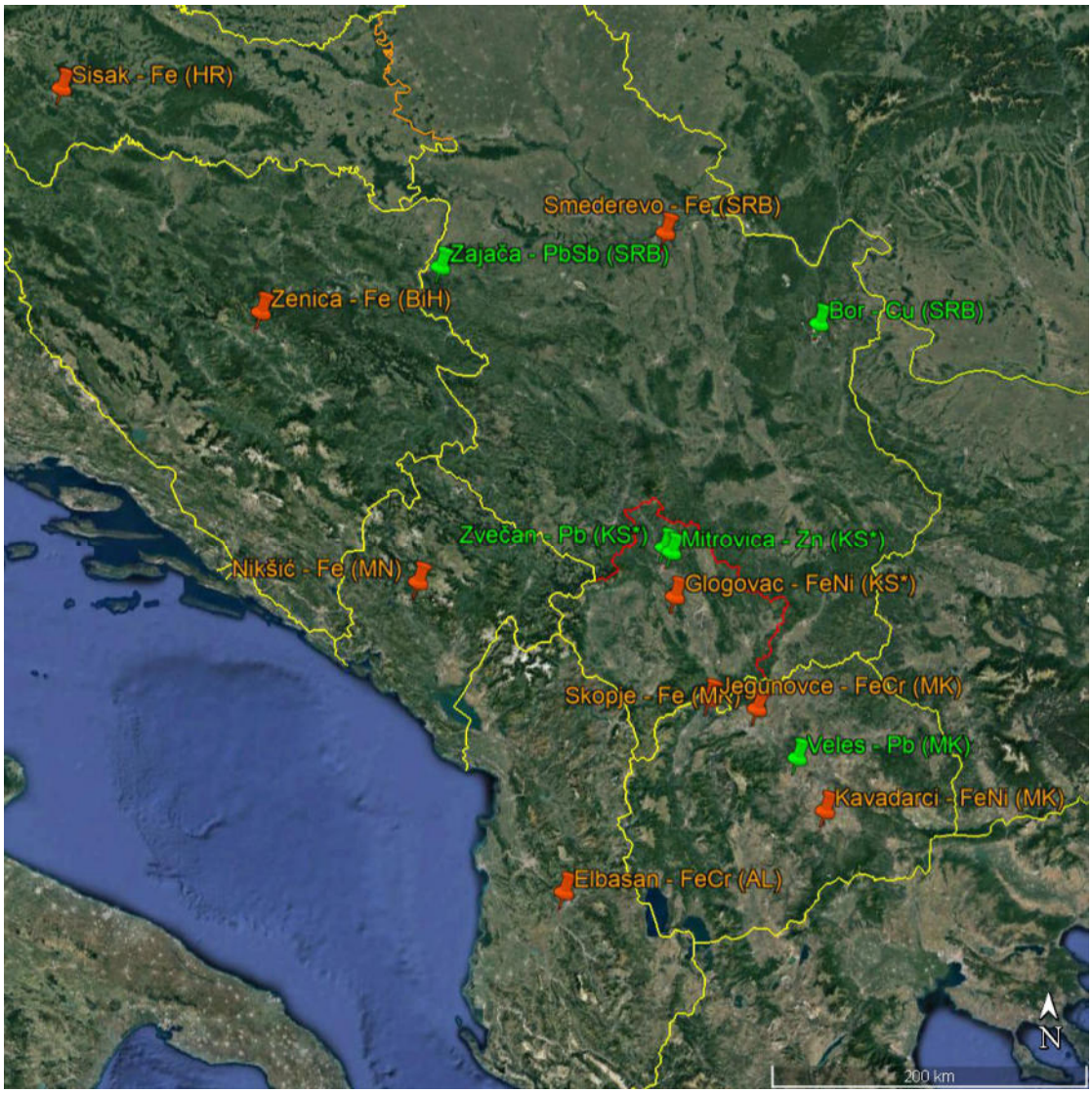


Figure 9. Locations of ironworks (steel plants), ferronickel/ferrochromium smelting plants and non-ferrous metal smelters in the West Balkans

6.2. Red mud – potential source of rare earth minerals

In the West Balkans, red mud, also known as bauxite residue, can be a very important source for the extraction of rare earth minerals for the territory of the European Union and Europe in the future. Such tailings are at Obrovac in Croatia, Birač and Dobro Selo in Bosnia and Herzegovina, and Podgorica RM in Montenegro (Figure 10). By exploiting the rare earth minerals from these tailings, the European Union can reduce imports from China, which currently stand at more than 90%. In this way, it could increase its self-sufficiency in secondary mineral raw materials and rare earth minerals, which is of exceptional importance for economic growth and prosperity.

Figure 10. Locations of red mud in the West Balkans, which are derived as by-products from the Bayer process of producing alumina from bauxite