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List of Potential Secondary Sources of Raw Materials with Economic Value (D5.5)

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1. INTRODUCTION

The RESEERVE project is a Regional Innovation Scheme (RIS) project related to the EC/EIT objectives for regional innovation development that targets the following 6 countries of the South-East European (SEE) region: Croatia, Bosnia and Herzegovina, Serbia, Montenegro, North Macedonia and Albania. Based on the Strategic Agenda 2021-2027 of EIT RawMaterials, these countries are considered one of the future potential mineral supply areas of Europe.

Primary and secondary mineral raw materials are of strategic importance for the EU. Most EU countries are already part of the **pan-European Minerals Intelligence Network**, which provides continent-level, consistent and organized mineral data information on primary and secondary mineral resources. **The SEE region represents a gap in this network.** In the years following the project, the results will represent a platform for ESEE region integration into the pan-European Mineral Intelligence Network and into the common European mineral market.

The main goals of the project are (i) mapping the mineral resources of the six SEE countries: Croatia, Bosnia and Herzegovina, Serbia, Montenegro, North Macedonia and Albania, which are mostly not included in the existing data platforms, (ii) creating a network of partners to determine the availability of and further required information on primary and secondary mineral resources data in West Balkan countries, (iii) increasing the capacity of partner countries for national mineral management, (iv) ensuring a sufficient flow of information for Europe's industry and large trans-national concerns to expand their business and investments in the SEE region, (v) disseminating the knowledge and know-how of the EIT Community and developing new markets for modern technologies, creating opportunities for start-ups and SMEs, contributing to new job opportunities, and generating economic added value, and (vi) community-building within and between regions, the creation of local ecosystems and enabling new education and research.

This report, which represents Deliverable D5.5, provides information on which of the waste sites from the "West Balkan Mineral Register of SRMs" are recognized as a potential source of raw materials. The report includes a brief description of the evaluation process used to determine the potential sources of raw materials, followed by the specific locations of tailings in each country, including the area and amount of waste, types of tailings, the status of the deposits (active, closed or abandoned) and an estimation of the content of major elements that could represent a source of secondary raw materials in the future.

2. DESCRIPTION OF THE EVALUATION PROCESS USED TO DETERMINE THE POTENTIAL SOURCES OF RAW MATERIALS

After a detailed inspection, it was found that approximately 2.6 Gt of waste had been deposited at 14,600 sites, covering almost 59 km². More than half of this material is characterized as conventional mining waste, 1/3 is flotation tailings and red mud, and 10% is metallurgical waste. Most of these tailing sites are unclaimed and a source of contamination for nearby communities.

Criteria for determining perspective landfills:

Size of deposits > 0.5 million tons,
 Status Inactive / abandoned / non-remediated sites,
 Method of enrichment Older flotation methods used,
 Chemical composition Promising chemical composition,
 Extraction methods Extraction methods are possible.

- Mining waste and flotation tailings of porphyry beds are unattractive,
- All locations (except in Albania) were physically visited,
- All the collected information/data was verified.

According to the criteria for determining perspective landfills, the collected data and additional chemical analyses, and in accordance with the "Zero Waste" philosophy, about 66 promising landfills (c. 7.3 km²; 310 million tons) were selected where various advanced eco-innovative methods of extraction could be applied. Besides the commercial value of the metals, the ecological aspect related to reuse and recycling concepts should not be forgotten.

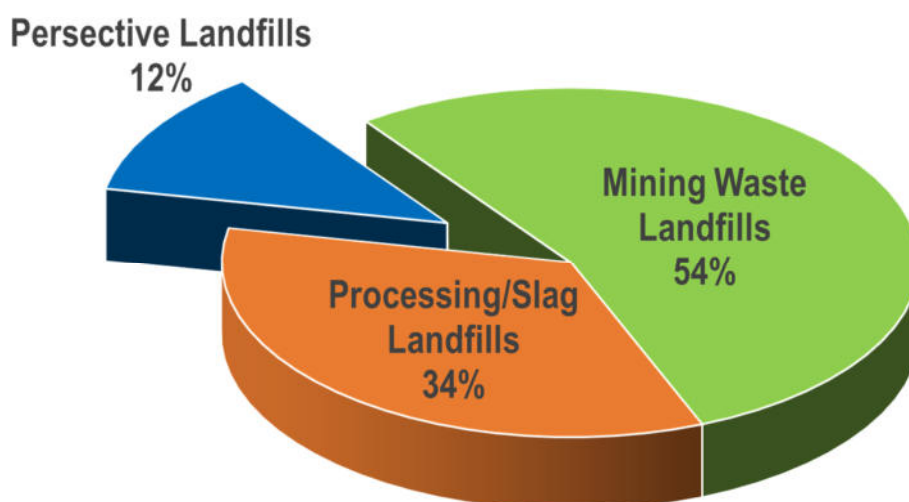


Figure 1. The proportion of potentially perspective landfills

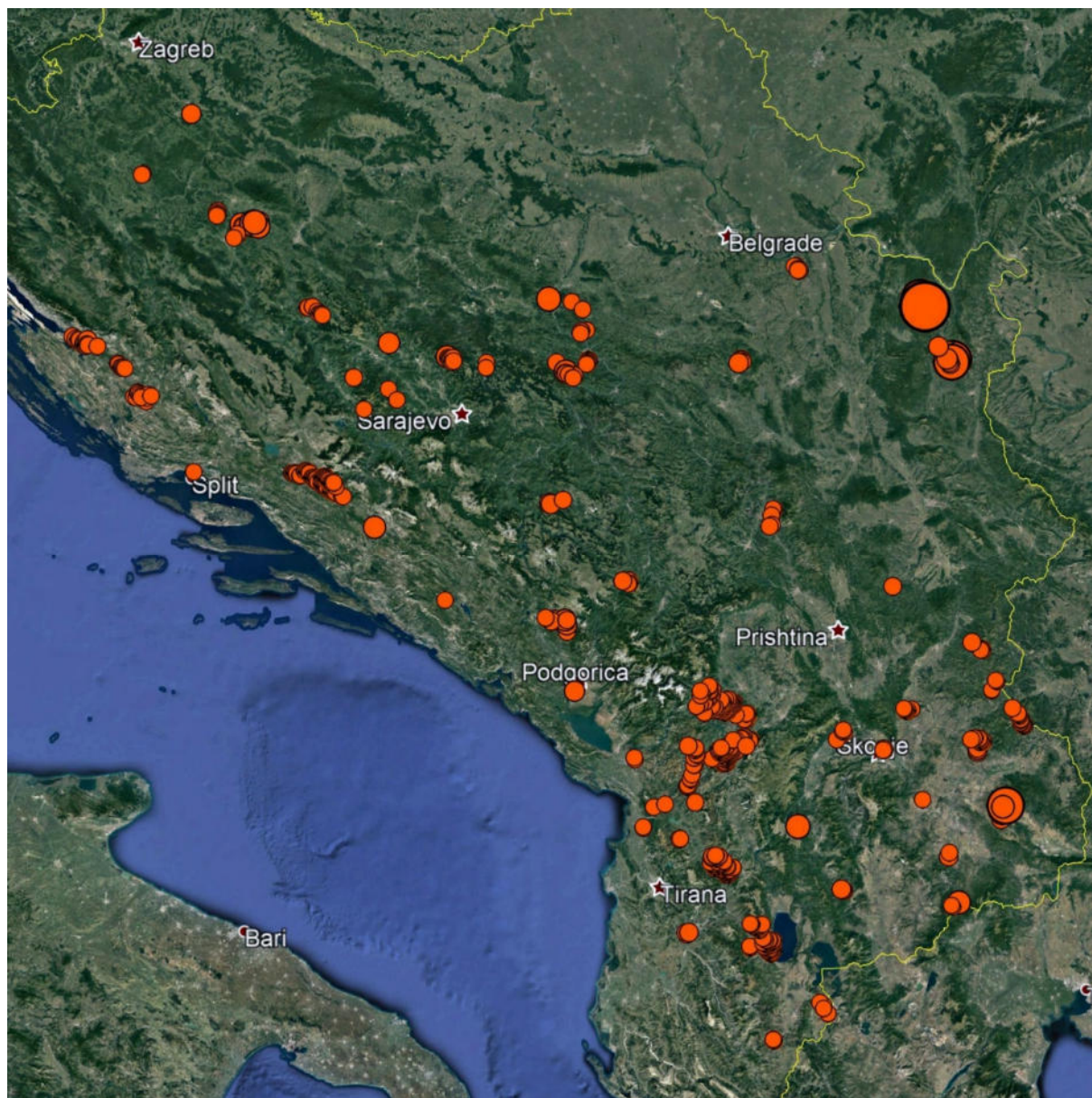


Figure 2. The areal distribution of 1460 SRM landfills (59 km²; 2.6 Gt) in the W. Balkan area (the size of the circle is proportional to the size of the SRM deposit)

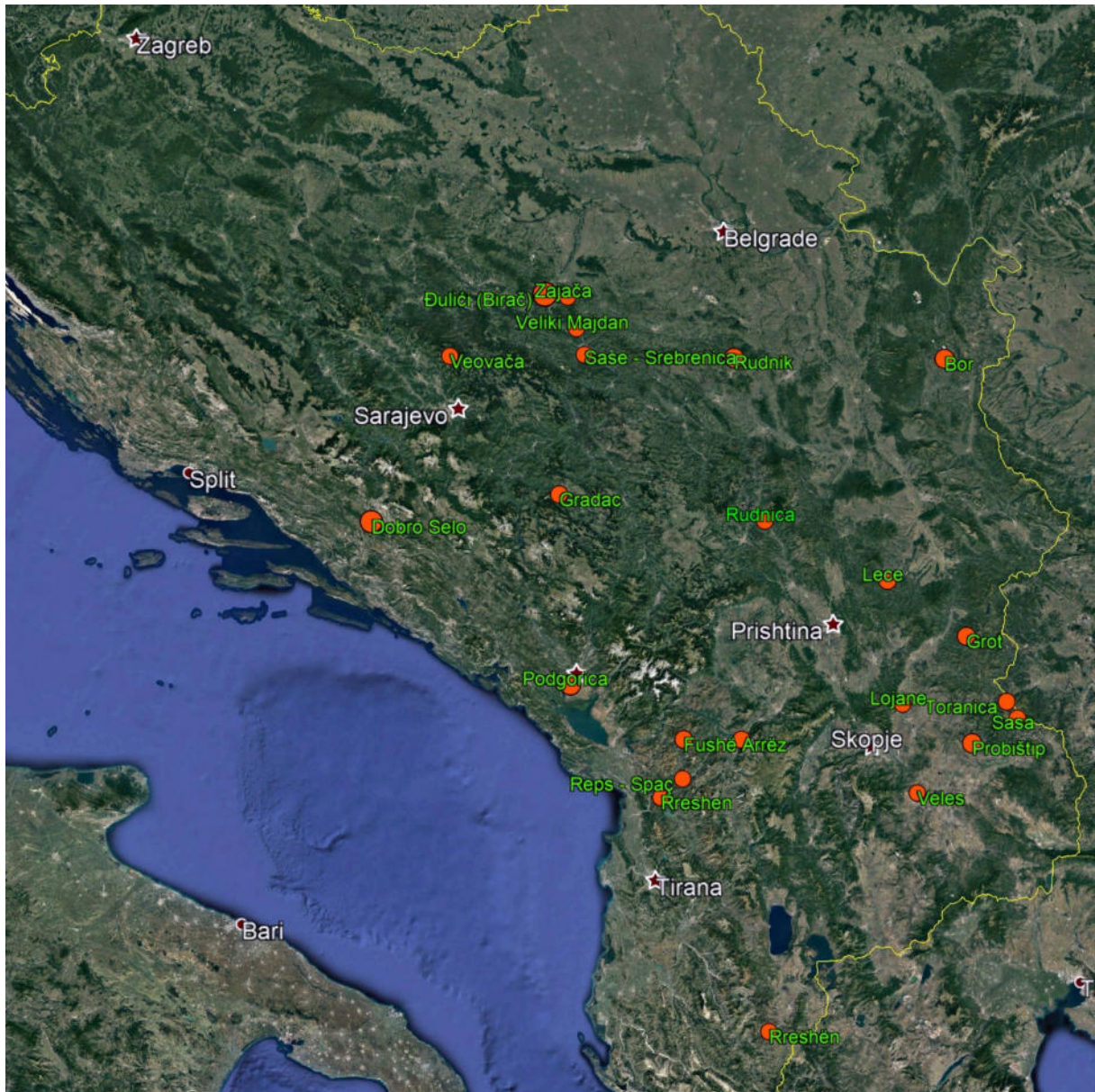


Figure 3. The distribution of 26 potentially perspective SRM locations (36 landfills; 7.3 km²; 310 million tons) in the W. Balkan area (the size of the circle is proportional to the size of the SRM deposit)

3 PERSPECTIVE SRM ATTRIBUTE TABLE

In the process of determining perspective landfills for the purpose of creating the register, 5 groups of data were defined: Deposit location data, Deposit origin, Deposit technological information, Geological information and Environmental information. All according to the potential investment needs and W. Balkan national mineral management needs gathered by TPs and in line with the INSPIRE directive.

ID	Identifier number
Location	Name
Country	Bosnia and Herzegovina (FBiH/RS), Croatia, Montenegro, North Macedonia and Serbia
Longitude	Geographic longitude (WGS84)
Latitude	Geographic latitude (WGS84)
Mine	Name/Location
Processing facility	Name/Location
Activities	Description of mining and processing activities (Underground and Open-pit exploitation, Ore processing, Flotation processing, Smelting and Metallurgical processing)
Status	Mining and processing status (Operating/Closed)
Last manager	Name
Deposit type	Mining waste landfill, Processing waste landfill (Flotation tailings, Red mud dam), Slag landfill (Ironworks, Smelter)
Deposition period	Period of operation (from-to)
Main element	Mine exploited element
Storage	Surface/Underground
Surface	Surface in ha
Weight	Weight in million tons
Deposit status	Active/Closed/Abandoned
Geological composition	Description
Chemical composition	Description
Environmental impact	Description
Restoration	Yes/No

4.1 Distribution of Perspective SRM Landfills According to Countries

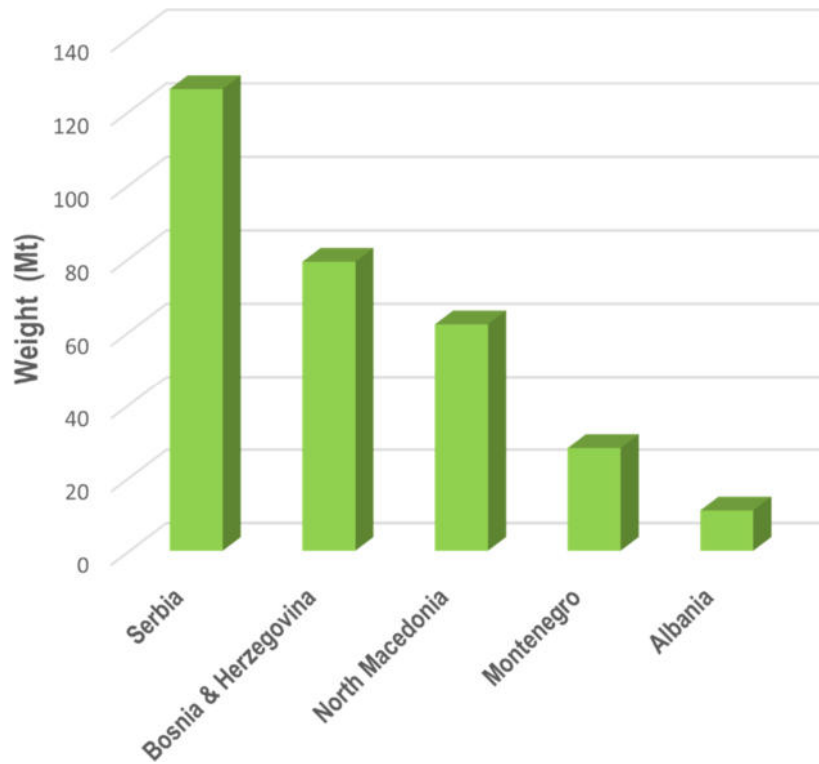


Figure 4. SRM distribution according to countries (million tons)

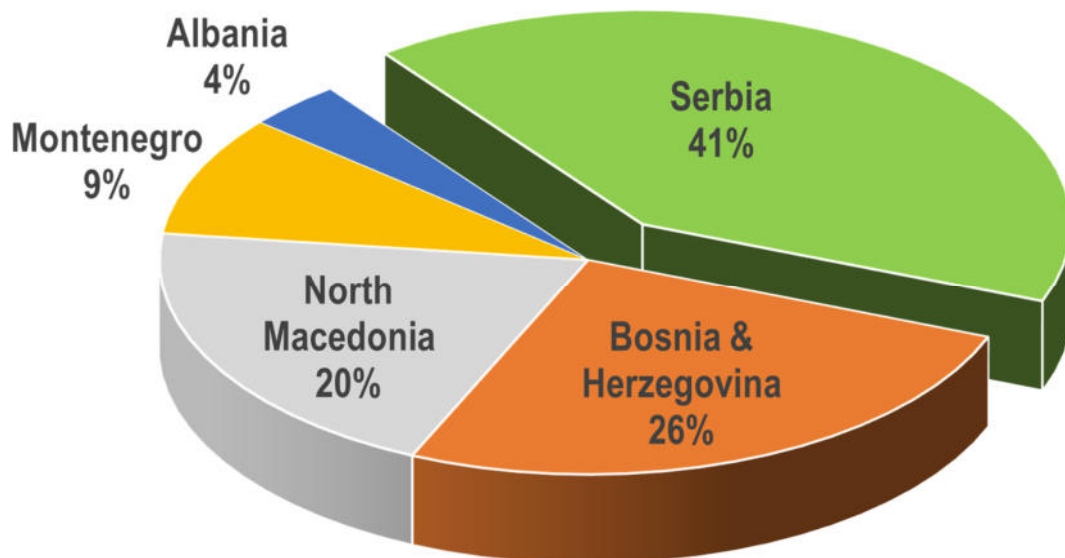


Figure 5. SRM distribution according to countries (%)

4.2 Distribution of Perspective SRM Landfills According to Possible Metal Extraction

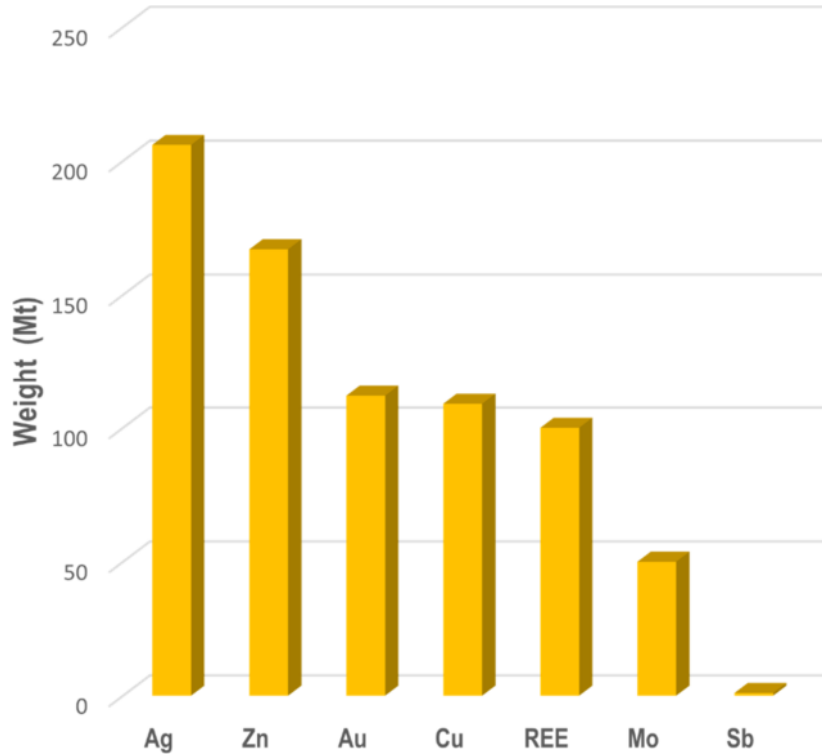


Figure 6. SRM distribution according to possible metal extraction (million tons)

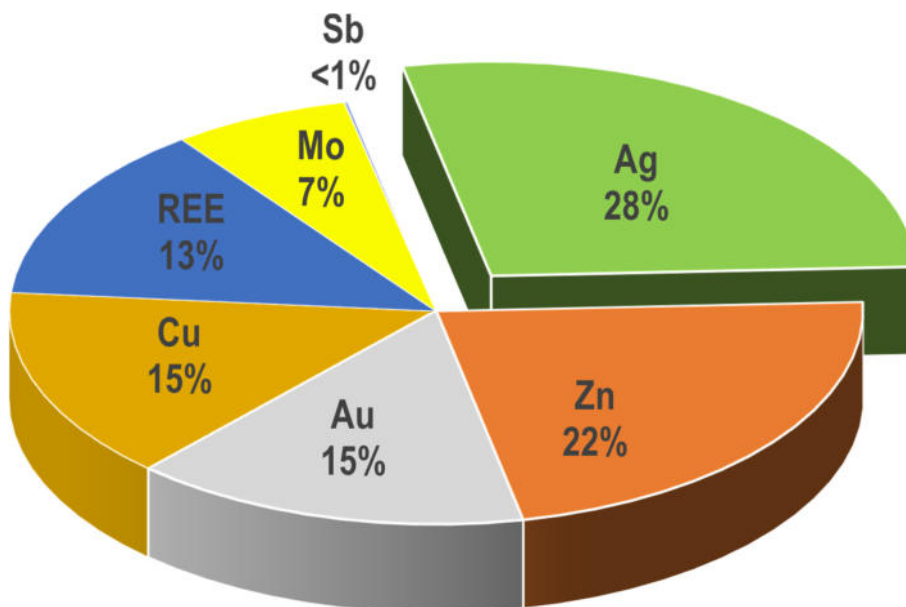


Figure 7. SRM distribution according to countries (%)

4.3 Distribution of Perspective SRM Landfills According to Deposit Type and Deposit Status (Active/Closed/Abandoned)

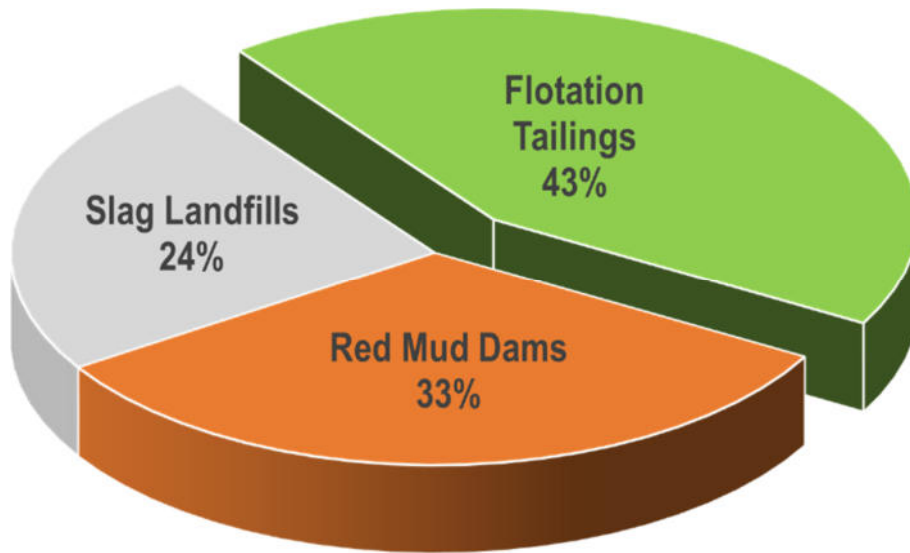


Figure 8. SRM Distribution according to deposit type (%)

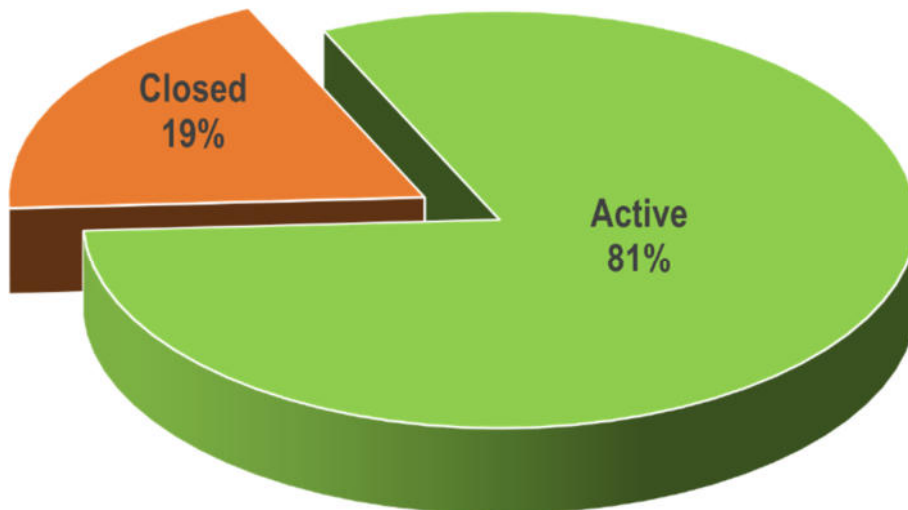


Figure 9. SRM Distribution of perspective landfills according to deposit type and deposit status (Active/Closed/Abandoned)

Focusing on the deposit type, the most promising are flotation tailings. As much as 43% of the valuable metals is found in 397ha and 133 million tons of this. Red mud dams contain 33% of the valuable metals (210ha, 100million tons), while the 73 million tons of slag landfills, which covers 121 ha, contain 24% of the valuable metals (Fig. 8). These tailings heaps are part of either active or abandoned/closed mining sites. 81% of the tailings heaps are part of active mines, which represent 249 million tons of material though this amount is still rising. 19% of the selected tailing heaps are part of closed/abandoned mine activity. At these locations, 58 million tons of material is deposited.

5. THE DISTRIBUTION OF PERSPECTIVE SRMS ACCORDING TO VALUABLE EXTRACTED METALS

Figures 11-16 present the distributions of SRMs in the ESEE region where valuable metals can be extracted. Lead and zinc flotation tailings from Serbia, Montenegro, North Macedonia and Bosnia & Herzegovina, in addition to Pb and Zn, also contain Ag and Mn. In these flotation tailings, there is between 0.2% and 2.5% Pb, between 0.2% and 8.3% Zn, between 4 and 39 ppm Ag and between 0.7% and 5.3% Mn. The Vales lead and zinc smelter in North Macedonia is treated as the most promising location for Pb, Zn and Ag extraction, while the most appropriate flotation tailing for Mn acquisition is Probištip.

In Albania, there are several flotation tailings containing Cu. Its content ranges between 0.15% and 0.22%. The occurrence of Cu is not only characteristic of Albania, but also of Serbia and North Macedonia. There, this metal usually occurs together with Ag and Au and, in addition to flotation tailings, is also found in slag landfills. The amount of Cu at these locations ranges between 0.1% and 0.7%, the content of Ag is around 4 ppm, while the Au content is around 0.3 ppm. In one of these aforementioned slag landfills located in Bor, the presence of Mo was also determined. Its content was estimated at 0.11%.

Red mud dams located in Bosnia & Herzegovina and Montenegro are enriched with REE. Its content ranges between 550 and 1300 ppm. In one flotation tailing and one slag landfill in North Macedonia and Serbia, the presence of Sb was also determined. The content is estimated at less than 1%.

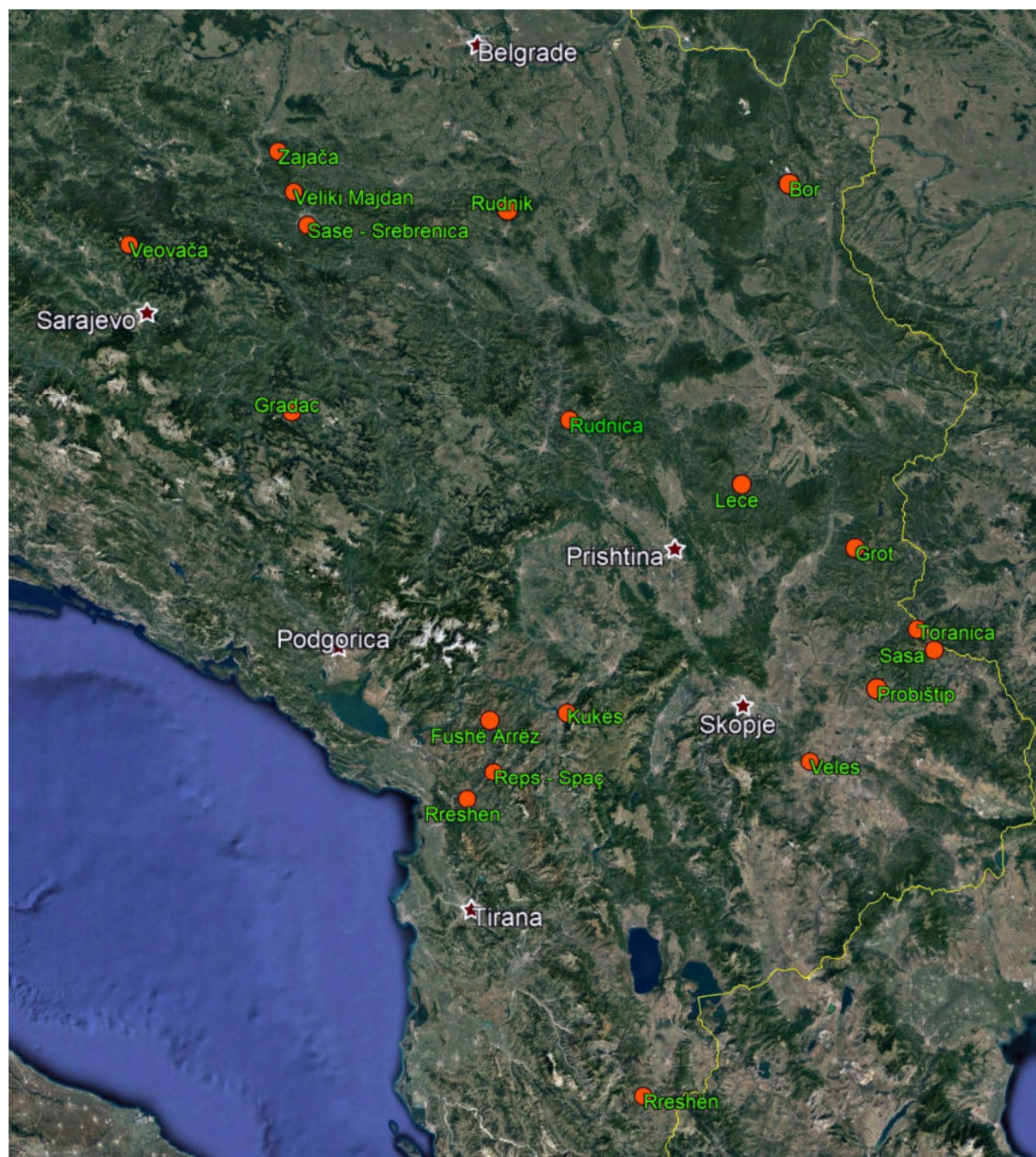
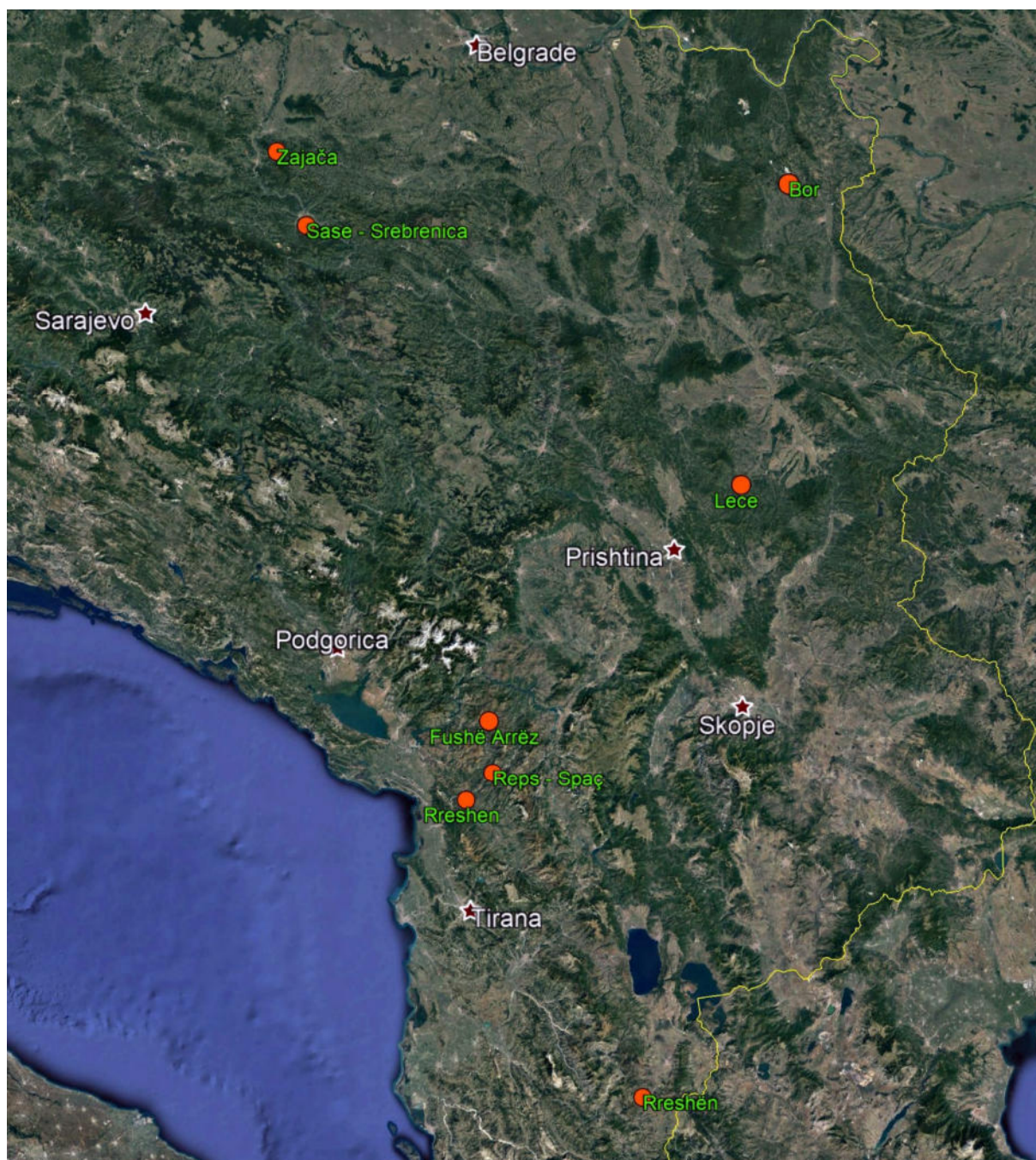
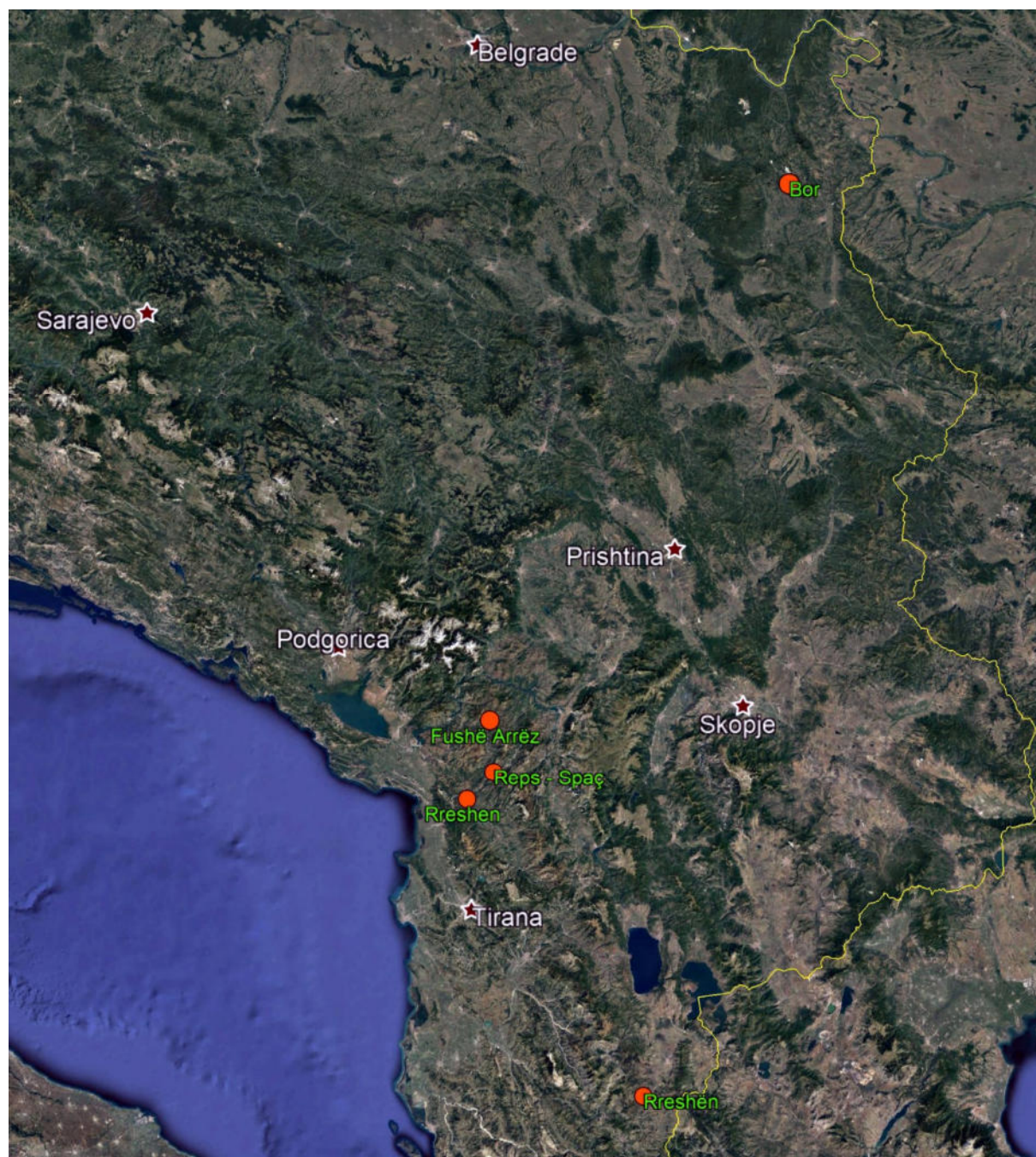


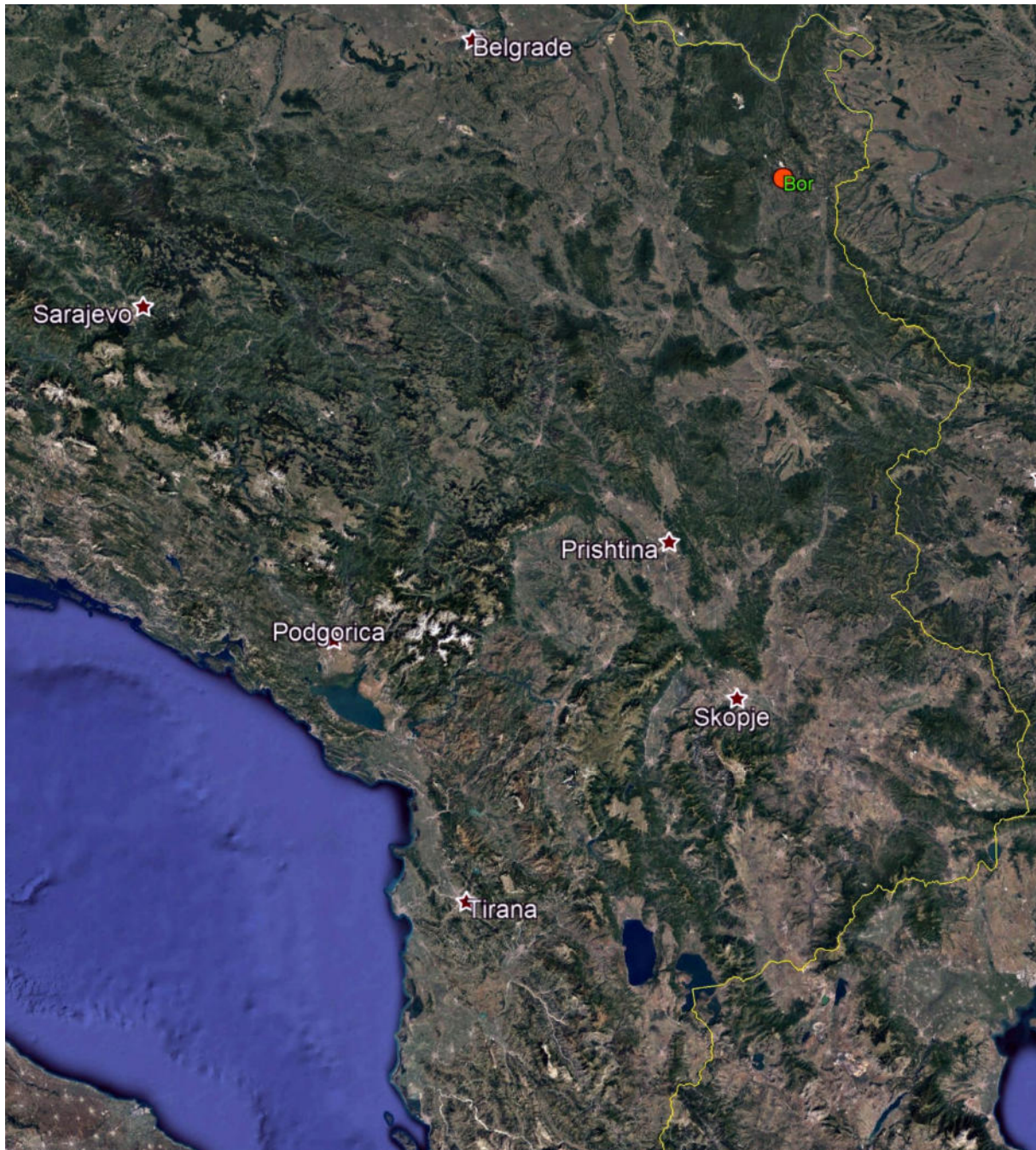
Figure 10. The distribution of SRMs that could be important for Ag extraction (the size of the circle is proportional to the size of the SRM deposit)



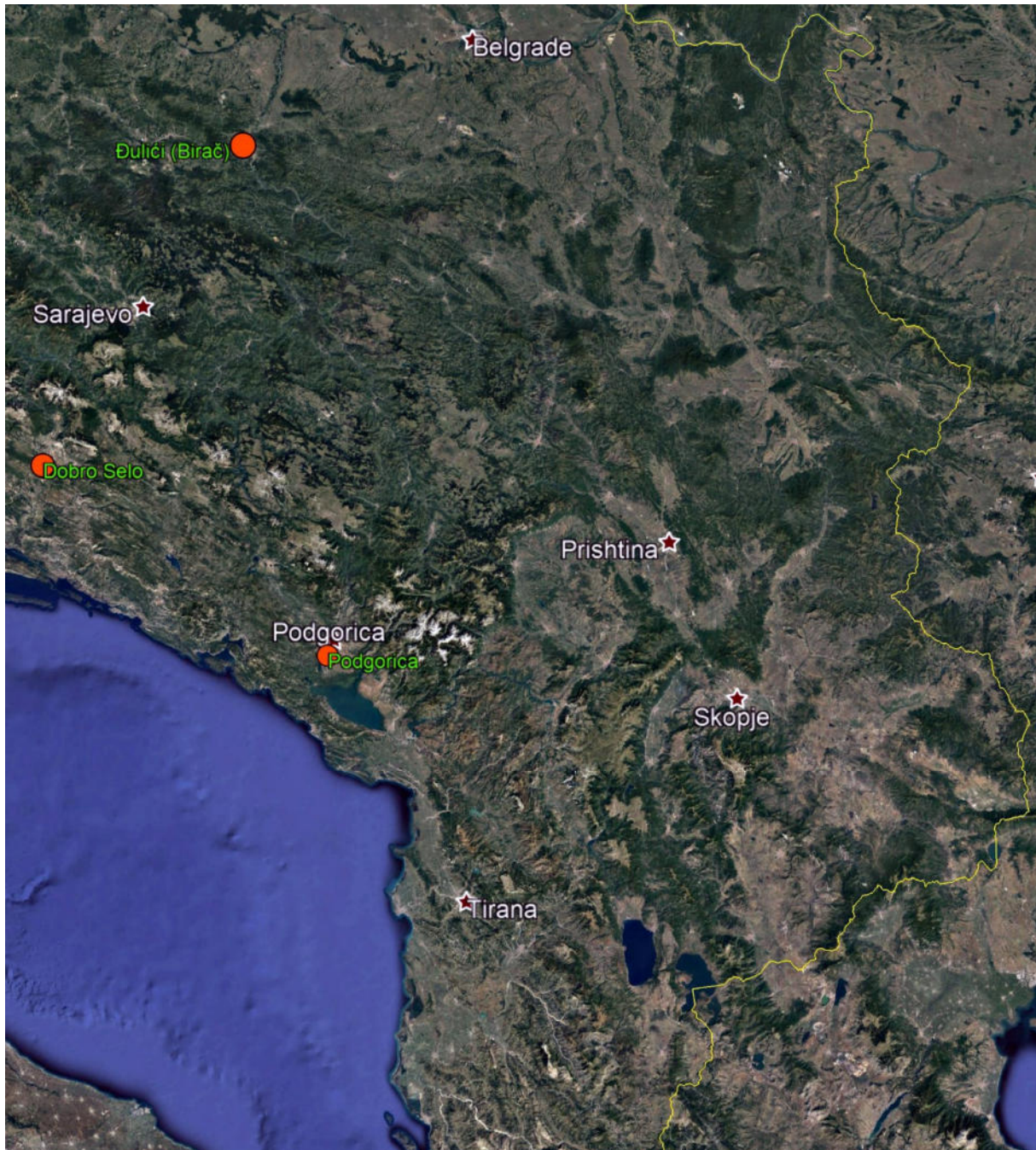
*Figure 11. The distribution of SRMs for Au extraction
(the size of the circle is proportional to the size of the SRM deposit)*



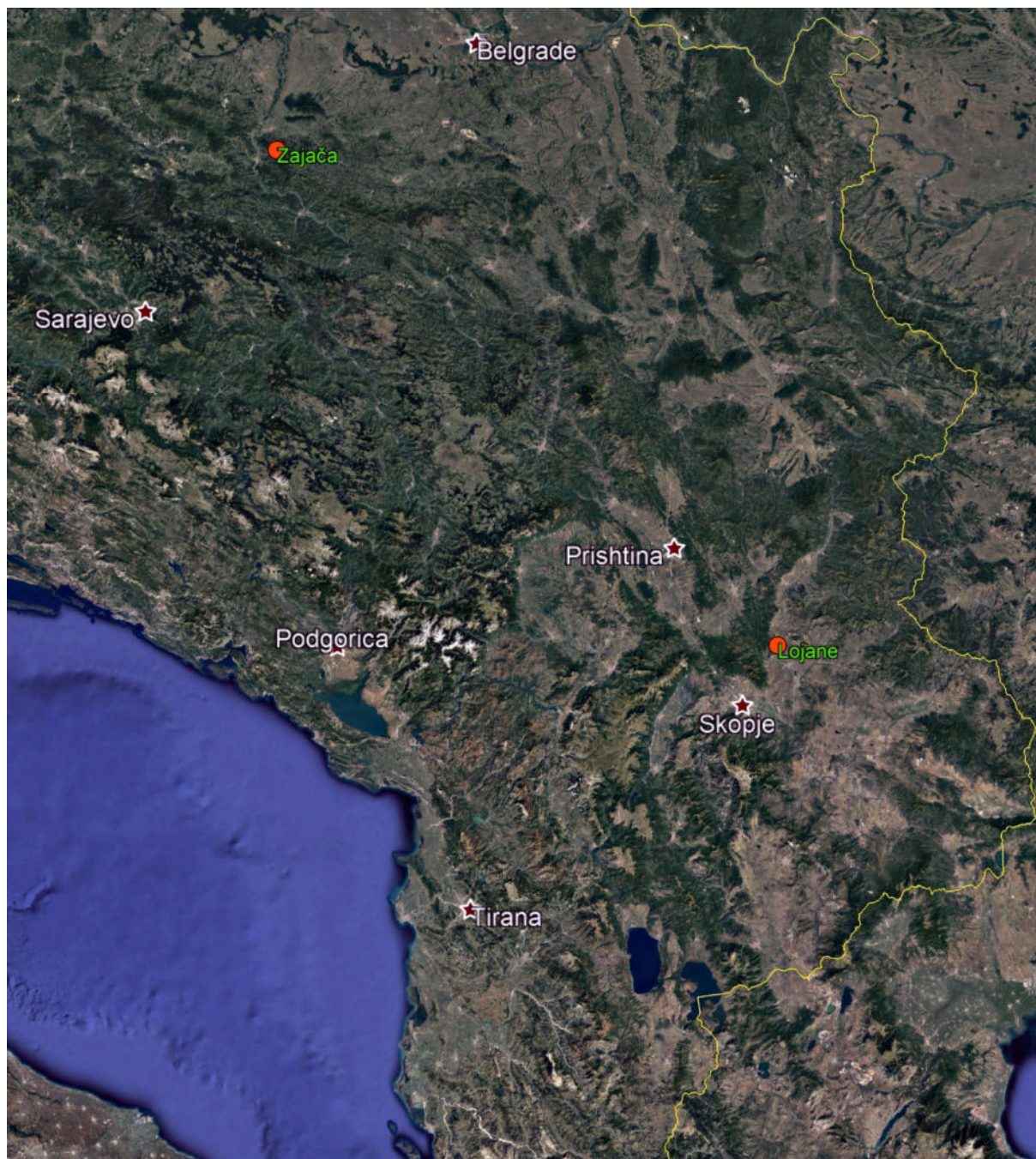
*Figure 12. The distribution of SRMs for Cu extraction
(the size of the circle is proportional to the size of the SRM deposit)*



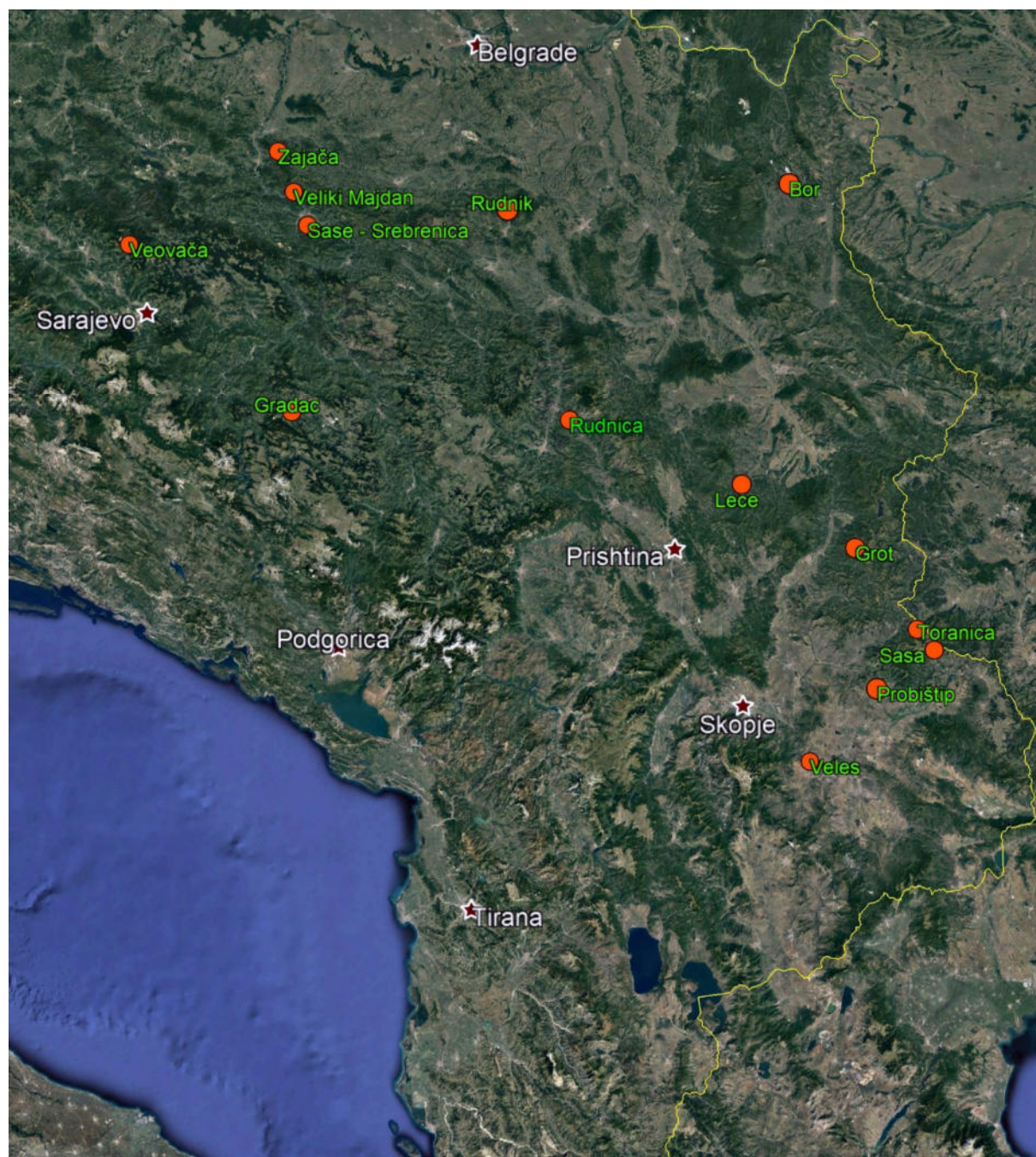
*Figure 13. The distribution of SRMs for Mo extraction
(the size of the circle is proportional to the size of the SRM deposit)*



*Figure 14. The distribution of SRMs for REE extraction
(the size of the circle is proportional to the size of the SRM deposit)*



*Figure 15. The distribution of SRMs for Sb extraction
(the size of the circle is proportional to the size of the SRM deposit)*



*Figure 16. The distribution of SRMs for Pb-Zn extraction
(the size of the circle is proportional to the size of the SRM deposit)*

6. CONCLUSION

RESEERVE is a RIS KAVA project mapping the mineral sources of six ESEE countries: Albania, Bosnia & Herzegovina, Serbia, Croatia, Montenegro and North Macedonia, resulting in the creation of the West Balkan Mineral Register for primary and secondary mineral resources. This knowledge could lead to the better future self-supply of primary and secondary mineral raw materials that are strategically important to the EU and establish competitiveness in countries affected by low geopolitical and social conditions.

Most EU countries are already part of the pan-European Minerals Intelligence Network, which provides mineral data and information on primary and secondary mineral resources. However, the SEE region represents a gap in this network. Hence, the RESEERVE project has been established as a platform for ESEE region integration into the pan-European Mineral Intelligence Network and the common European mineral market.

One of the project deliverables was to provide accurate and detailed information on tailings in the study area to enable the possible future strategic exploitation of secondary mineral raw materials. This report presents a list of potential secondary sources of raw materials with economic value. It was found that approximately 2.6 Gt of waste had been deposited at 1460 sites covering an area of 58 km². More than half of materials are conventional mining waste, 1/3 are flotation tailings and red dams, and 10% are metallurgical waste. According to the criteria for determining perspective landfills, the collected data and additional chemical analyses, about 66 promising landfills were selected covering an area of 7.3 km² and storing 310 million tons of waste. There, various advanced eco-efficient methods of extraction could be used.

Serbia would provide as much as 41% of the tailing heaps that are useful for SRM extraction, followed by Bosnia and Herzegovina (26%), North Macedonia (20%) and Montenegro (9%), while Albania with its 4% offers the lowest opportunities for the exploitation of valuable metals from SRMs. It was noted that among the metals that can be extracted, the most promising is Ag at 28%. Followed by zinc (22%), Au (15%), Cu (15%), REE (13%), Mo (7%) and Sb (1%).

Focusing on the deposit type, the most promising are flotation tailings (43%), followed by red mud dams (33%) and slag landfills (24%). These tailings are part of either active or abandoned/closed mining sites. 81% of the tailings are part of active mines, while 19% of the selected tailings are part of closed/abandoned mine activity.