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SKILLS FOR CRITICAL RAW MATERIALS

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Executive summary

Critical raw materials (CRM) are vital to the European Union's (EU) economy. They underpin all industrial sectors and stages of the supply chain and play a critical role in the EU's competitiveness and its global position in technological development. Recent strategic investments in defence and renewable energy have further increased the demand for many CRMs.

According to the EU's 2024 *Critical Raw Materials Act*, the overall demand for CRMs is expected to increase six-fold by 2030 and seven-fold by 2050. For certain materials, growth projections are even steeper, for example, the demand for lithium batteries in the EU is expected to increase 12-fold by 2030 and 21-fold by 2050 (EC, 2025a). To sustain its industrial competitiveness, the EU must urgently diversify supply sources, enhance sustainable recycling and circularity, and reduce reliance on single-country suppliers.

More than 30 million jobs in the EU in key economic sectors such as automotive, aerospace, and renewable energy depend on a continued sustainable supply of CRMs (EC, 2025a). In line with the Draghi report, the *Critical Raw Materials Act* establishes a framework to secure and sustain the supply and resilience of CRM supply chains.

Currently, the mining of most CRMs is concentrated in Asia-Pacific, Latin America and Africa. China is the primary processor for many materials, particularly rare earth elements and graphite. Other major processing countries include Australia (lithium), the Democratic Republic of Congo (DRC) (various materials), and countries within the EU itself, like Poland (coking coal and copper) and Belgium (arsenic). Many CRM deposits in Europe remain unexploited, and much of the material mined in Europe is exported to third countries for processing and then re-imported (e.g. copper).

To reduce dependence on third countries for access to CRMs, the EU set the objectives for 2030. These are to move towards 10% EU's annual consumption for extraction, 40% EU's annual consumption for processing, and 25% EU's annual consumption for recycling. Additionally, no more than 65% of the EU's annual consumption of any strategic raw material, at any stage of processing, should come from a single third country.

While the mining industry is often considered a traditional industry, it has embraced technological transformation which has significantly shaped the demand for skills. An increasing number of modern mining operations are highly automated. With the use of robotics and the Internet of Things, mines today are energy-efficient, sustainable and dynamic workplaces. This has not been accompanied by a corresponding reduction in employment but has lead to jobs moving from underground to surface roles. As a result, the skills profiles needed in the industry have changed and in-demand profiles by employers are not miners but specialists with vocational qualifications.

However, the pace of technological adoption is faster than the rate at which workers can be trained or reskilled. Mining companies are experiencing a shortage of exploration geologists, mining engineers, mineral planners, mineral processors and environmental scientists. The mineral processing industry in particular, is experiencing a significant demand for skilled workers with technical expertise in areas like engineering, robotics, and data analysis. Across the value chain, there is a shortage of metallurgical specialists and material engineers.

Skills shortages represent an significant challenge that could affect the ability of European economies to secure and make use of raw materials, with implications for economic growth, industrial strength, and overall competitiveness. Skills gaps to adopt new technologies, innovate and adopt sustainability measures could undermine competitiveness in a global market increasingly focused on environmental and social governance.

1. Introduction

Raw materials refer to unprocessed or minimally processed substances used not as individual elements but rather as combinations processed into engineered materials or produced as co- or by-products. Raw materials are found at the beginning of all industrial value chains and are essential to the EU's industrial competitiveness, productivity and growth. They play an important role in the green and digital transitions, as well as in the EU's defence and aerospace sectors.

Raw materials are divided into three categories: strategic, critical and non-critical. Strategic raw materials (SRM) are characterised by a potentially significant gap between global supply and projected demand, and for which an increase in production is relatively difficult. Critical raw materials (CRMs) are those considered to have high economic importance for the EU and a high supply risk. Almost all critical raw materials are mined as minerals from ores that are a non-renewable resource. CRMs include all SRM and all other raw materials of high importance for the EU economy and for which there is a high risk of supply disruption likely to distort competition. This note will focus on CRMs.

The EU assessment of CRMs was launched as the first action of the EU Raw Materials Initiative (RMI) of 2008. It covers all raw materials used by European industry except materials from agricultural production and materials used as fuel. The list of CRMs is updated every three years to regularly assess the criticality of raw materials for the EU. The 2023 assessment includes copper and nickel which do not meet the CRM thresholds but are included on the CRM list as SRMs (EU, 2024).

Table 1. EU list of Critical Raw Materials (2023)

Aluminium/Bauxite	Coking Coal	Lithium	Phosphorus
Antimony	Feldspar	Light rare earth elements	Scandium
Arsenic	Fluorspar	Magnesium	Silicon metal
Baryte	Gallium	Manganese	Strontium
Beryllium	Germanium	Natural Graphite	Tantalum
Bismuth	Hafnium	Niobium	Titanium metal
Boron/Borate	Helium	Platinum group metals	Tungsten
Cobalt	Heavy rare earth elements	Phosphate Rock	Vanadium
		Copper*	Nickel*

Source : Carrara, S. et al. 2023

The EU's Critical Raw Materials Act (CRMA) (May 23, 2024) establishes a framework for ensuring a secure and sustainable supply of critical raw materials, e.g., by identifying critical and strategic raw materials, setting benchmarks for domestic production, or promoting improved circularity. Its goal is to strengthen all phases of the critical raw materials value chains within the EU. Measures include diversifying imports, reducing strategic dependencies, improving monitoring of supply risks, and enhancing the sustainability and circularity of materials. Importantly, the regulation is influenced by the Green Deal and aims to ensure the supply of raw materials critical for the clean transition.

The UN Sustainable Development Goals (SDG) framework does not include an explicit goal solely focused on raw materials. However, particularly SDG 12 (Responsible Consumption and Production) is relevant to raw materials. Extraction, processing, and use of raw materials often have both positive and negative outcomes for the same goal.

2. Raw materials and the EU's industrial competitiveness

Critical raw materials (CRM) are an essential part of the EU's (EU) economy, industrial value chains and societal well-being. They are linked to all industries across all supply chain stages. In 2023, global raw material extraction consumed in the EU was 14.1 tonnes per capita, which is above the global average (EES, 2024). Pressure on resources will continue to increase due to global population growth expected to peak in 2080, digitalisation, and the transition to climate neutrality. According to a JRC report, global competition for critical raw materials may soon replace today's dependence on oil (EC, 2023)

The Draghi report outlines the EU's approach to ensure the resilience of its supply chains, particularly for CRMs. These materials are essential for maintaining the EU's industrial competitiveness and enhancing its global position in technological development, especially in comparison to China and the United States. Additionally, CRMs play a crucial role in the EU's efforts to phase out Russian fossil fuels. The EU has set itself an ambitious goal to balance competitiveness with sustainability.

CRM play a critical role in the EU's industrial competitiveness in the manufacturing of clean energy technologies, as well as in defence and aerospace applications. Recent efforts to boost the defence sector have further increased the demand for many CRMs commonly used in defence technologies, many of which do not originate from the EU. While investments stemming from industrial development or energy-transition plans could have beneficial spin-offs for defence, growing demand for CRMs means there is also greater chance of competition for the same raw materials

The International Energy Agency (IEA) predicts that if all countries fully implement their national energy and climate pledges, the demand for minerals for clean energy technologies would more than double by 2030 and triple by 2040, reaching nearly 35 million tonnes annually (IEA, 2025). The extraction and processing of CRMs too is energy-intensive, raising concerns about sustainability and environmental impact. According to the EUs CRM Assessment, between 2011 (first assessment) and 2023 (last assessment year), the supply risk has increased for 36 raw materials, for 5 materials it has stayed steady, and for only 25 materials supply risk could be lowered (out of a total of 66 raw materials assessed). According to the EU's 2024 Critical Raw Materials Act, the overall demand for CRMs is expected to increase six-fold by 2030 and seven-fold by 2050. Looking at individual CRMs the demand can be significantly higher, for example the demand for lithium batteries in the EU is expected to increase by 12-fold by 2030 and 21-fold by 2050 (Carrara, S. et al. 2023). To sustain its industrial competitiveness, the EU faces a pressing need to diversify supply sources, enhance sustainable recycling and circularity, and reduce reliance on single-country suppliers.

The demand for aluminium/bauxite, copper, silicon, nickel and manganese in the EU is the highest and expected to increase by 543% from 2020 to 2050. Aluminium/bauxite, the supply for which is the most precarious, is also critical for the defence sector. According to Eurostat, EU self-sufficiency for aluminium extraction in 2022 was 11% (down from 16.8% in 2011) and processing was 42% (down from 52.9%). Failing to prioritise domestic production will increase dependence of European companies on imports, which are often higher in carbon, and lead to missed economic opportunities. A shift of supplying countries and an increase of supply (e.g., mining in Greece) could help reduce the supply risk. The EU also needs to focus on improving circularity and recycling.

The contribution of recycled aluminium to raw materials demand is low, just 9% but is seen as one of the risk-reducing factors. At the same time, the demand for lithium batteries in the EU is expected to increase by 12-fold by 2030 and 21-fold by 2050 (EC, 2025a). The demand for gallium is expected to surpass 100% of today's global supply by 2050 (EU, 2025c).

Table 2. EU self-sufficiency, raw materials extraction, processing, and contribution of recycled materials to raw materials demand (EU-27 from 2020 onwards) (Eurostat) (%)

	Extraction		Processing (2)		Recycling (3)	
	2012	2022	2012	2022	2013	2022
Aluminium	14	11	56.2	42	35	32
Borate/Boron	0	0	0	30	-	-
Cobalt	11.5	19	27.5	99	16	22
Copper	57.3	52	90.3	83	20	55
Dysprosium	0	0	0	0	0	0
Europium	0	0	0	0	-	-
Fluorspar	28.2	40	100	-	-	-
Gallium	-	-	100	2	0	0
Germanium	-	-	57	58	0	2
Indium	-	-	100	89	0	1
Iron	28.3	23	96.8	94.9	22	31
Limestone	92.1	100	-	-	0	1
Lithium	11.2	19	0	0	0	0
Magnesium	-	-	0	0	14	13
Molybdenum	0	0	7	0	17	30
Natural graphite	0.5	1	-	-	-	-
Neodymium	0	0	0	0	0	1
Phosphorus	-	-	0	0	-	-
Platinum	-	-	0.6	3.9	35	11
Silicon	-	-	39.7	36	-	-
Tantalum	0	1	-	-	4	13
Vanadium	-	100	53.7	0	0	1
Yttrium	0	0	0	0	0	31

Sources:

(1) and (2) Eurostat. EU self-sufficiency for raw materials. Available here.

(3) Eurostat. Contribution of recycled materials to raw materials demand - end-of-life recycling input rates (EOL-RIR. Available here.

3. EU Supply chains: risks and mitigation

More than 30 million jobs in the EU in key economic sectors such as automotive, aerospace, and renewable energy are dependent on continued sustainable supply of critical raw materials (CRM) (EC, 2025a). Yet, the supply chains are at constant risk of disruption and the EU is increasingly reliant on raw materials from a limited number of suppliers concentrated in a small number of third countries, both at the extraction and processing stage.

Access to Critical Raw Materials (CRM) is limited, due to geographic and processing constraints. Currently, the mining of the most CRMs is highly concentrated in Asia-Pacific, Latin America and Africa. China is the primary processor for many materials, particularly rare earth elements and graphite. Other key processing countries include Australia (lithium), the Democratic Republic of Congo (DRC) (various materials), and countries within the EU itself, like Poland (coking coal and copper) and Belgium (arsenic).

Much of the material mined in EU is not refined domestically but exported to third countries for processing and then re-imported (e.g. copper). At the same time, the lack of sufficient EU recycling and low-risk substitute materials is exacerbating supply chain risks.

To reduce dependence on third countries to access CRMs, the EU set the objectives for 2030. These are to move towards 10% EU's annual consumption for extraction, 40% EU's annual consumption for processing, and 25% EU's annual consumption for recycling. In addition, not more than 65% of the EU's annual consumption of each strategic raw material at any relevant stage of processing should be supplied from a single third country.

The following section describes the supply chain situation for 21 materials. These materials were selected based on the presence of deposits (the natural geological occurrence of a metal or mineral) of the 19 CRMs and two SRMs (copper and nickel, which do not meet the CRM thresholds but are included on the CRM list as SRMs) in the Western Balkan economies or Ukraine. For each material, the primary uses in the EU, the situation with global reserves, and EU supply chains are described, followed by a description of the EU share of global reserves (the part of the deposit that can be profitably extracted under current economic and technological conditions) and production capabilities. Data related to critical raw materials is often limited, incomplete, or inaccessible. For consistency, unless otherwise indicated, the data has been sourced from the European Commission Raw Materials Information System (RMIS). The information on the number and size of deposits for each material (Class A (Super Large), Class B (Large), Class C (Medium)) has been sourced from the book on European critical raw materials, developed by the Geological Service for Europe and EuroGeoSurveys (2025).

Aluminium/bauxite is the critical raw material that is the most susceptible to geopolitical and supply chain disruptions, impacting the EU's industrial competitiveness (Girardi, B et al. 2023). Bauxite is primarily used to produce alumina, which is then used to make aluminium, the world's most widely used non-ferrous base metal. In the EU its common uses all kinds of vehicles (40%), construction (24%), and packaging (19%). In defence technologies, it is commonly used in e.g. aircrafts, helicopters, submarines, tanks, artillery, and missiles. While Australia (41%) and India (21%) hold the largest reserves of aluminium/bauxite, China is the largest producer (58%) and the EU's largest importer. The EU produces only 0.3% (with Greece being the largest producer) and processes 1.9% (with France being the largest producer) of the world's production. According to the industry association, the European Aluminium, the European aluminium industry consists of over 600 plants across 30 European countries (EU, EFTA, UK, Türkiye) (European Aluminium, 2025).

The current annual demand for aluminium is 9 million tonnes – which is expected to double by 2050. In the Western Balkans, bauxite deposits are found in Bosnia and Herzegovina. There are 5 Class C, and 4 Class B identified deposits. The reserves are estimated by the United States International Trade Administration at 120 million tons (US International Trade Administration, 2025). According to another study, deposits are concentrated particularly in Herzegovina (with reserves around 80 million tonnes), central Bosnia (around Jajce and Mrkonjić Grad), western Bosnia (Bosanska Krupa and Mountain Grmeč, with reserves around 20 million tonnes), and eastern Bosnia (between Srebrenica and Milići, with reserves around 50 million tonnes) (ISCOBA, 2019). Even though Bosnia and Herzegovina has large bauxite reserves, exploitation has been limited due to relatively poor quality and therefore comparatively high cost. There are two aluminium and aluminium oxide processing plants in Bosnia and Herzegovina. Aluminium processing takes place in Mostar, which serves as the country's hub for aluminium manufacturing and the aircraft industry. Smaller bauxite reserves are found in Montenegro (primarily the Niksic area) with aluminium processing in Podgorica (annual capacity of over 100,000 tons). There are no deposits in Ukraine.

Antimony is a metalloid or a semi-metal and a co- or by-product of the production of gold, lead, copper, and zinc. It is a poor conductor of heat and electricity, and in the EU, it is primarily used in flame retardants (43%), batteries (32%), and PET plastics (6%). It is also used to increase the hardness of alloys. The EU does not have primary production or processing of antimony ores or concentrates. While Tajikistan holds the largest share of world reserves (44%), the EU sources its refined materials mainly from China (30%). Primary materials to EU are predominantly sourced from Türkiye (63%), a significant exporter of antimony ores and concentrates. In the EU, Belgium plays a notable role in antimony processing, particularly through recycling and the production of antimony trioxide, a flame retardant. In Belgium, antimony smelting is carried out by two companies: Umicore in Hoboken and Campine in Beerse. In France, AMG SICA (Société Industrielle et Chimique de l'Aisne) conducts antimony smelting in Aisne.

In the Western Balkans, Class C antimony deposits are found in Bosnia and Herzegovina in Čemernica with other deposits found in Podhrusanj, Srebrenica, and Rupice. Newer discoveries have been made in the Chumavichi corridor. However, investment rate in the mining of CRMs in Bosnia and Herzegovina remains relatively low due to the complexity of the internal organizational structure covering exploitation and exploration licensing, as well as the fragmentation, quality, and quantity of deposits (Borojević Šoštarić, S, et al. 2022). In North Macedonia, the country's main antimony deposit is a Class B deposit in Krstov Dol, located in the north-east of the country. The mine closed in 1981 due to low antimony prices is. In April 2025, the mine was endorsed by the Minerals Security Partnership and operations are planned to restart by the first quarter of 2027 (Pela Global Limited, 2025). Class C deposits are also found in Lojane (closed in 1979) as well as Allchar. There are no deposits in Ukraine.

Arsenic is considered a critical raw material due its importance in various applications, including metallurgy for aerospace and defence (21%), industrial components (20%) such as semiconductors, automotive (15%), and telecommunications. Primary producers of arsenic are Peru (45%) and China (43%). In the EU, Belgium is historically a significant producer of refined arsenic. Umicore, located in Hoboken, a suburb of Antwerp, recovers small volumes of arsenic from electronic scrap like circuit boards and relays. In the Western Balkans, North Macedonia has two Class C sized arsenic deposits, one in Lojane (closed in 1979) and another in Allchar. There are no deposits in Ukraine.

Baryte is primarily used in the EU to enhance certain properties of glass products (56%), manufacture equipment and materials for farming processes (16%), and produce ceramics (10%). The main primary producers are India (24%), China (24%), and Morocco (13%). In the EU, baryte is mainly produced in Bulgaria, followed by Germany. However, production in Slovakia was interrupted after 2018. In the Western Balkans, Class C deposits are found in Bosnia and Herzegovina (Mid-Bosnian Schist Mountains), and Montenegro (municipality of Pljevlja). In addition, there is a Class C deposit in the western Zakarpattia oblast of Ukraine. There are no deposits in Ukraine.

Beryllium is used in aerospace and defence (21%), industrial components (20%), and automotive applications (15%). In the defence industry it is used for example in the armour and armaments of battle tanks, infantry fighter vehicles, towed artillery, and ammunitions (Girardi, B. et al, 2023). The United States is the main producer for beryllium (64%) and main importer to the EU (60%), followed by Kazakhstan (25%). There is no primary production or processing within the EU. Ukraine has two Class A beryllium deposits: the Perzhansk deposit in northwestern Zhytomyr oblast and the Shevchenkivske deposit in south-western Kirovohrad oblast. There are no deposits in the Western Balkans.

Boron/borate primary uses in the EU include glass products (56%), agriculture (16%); and ceramics (10%). In defence technologies, borate is used in the electronic systems of aircrafts to produce sensors, avionics, and electro-optical systems (Girardi, B. et al. 2023). Türkiye holds 87% of the world's boron reserves, followed by the USA (4%) and Russia (4%). The EU does not have primary production or processing of boron/borate and sources 99% of its primary and 46% of its refined boron/borate from Türkiye. Serbia has two Class B borate deposits, one in Mačva (project Jadar) and another in the Raška municipality. The Jadar project, located near Loznica in western Serbia, contains around 136 million tonnes of jadarite deposits, a mineral rich in lithium and boron (New Union Post, 2025).

Cobalt, often mined as a byproduct of nickel, is primarily used in the EU for superalloys (30%), magnets (18%), dissipative uses (17%), hard metals (13%), and portable batteries (9%). In defence industries, cobalt is used in alloys employed in aircrafts, helicopters, and missiles' propulsion systems (Girardi, B. et al. 2023). The Democratic Republic of Congo (DRC) holds the largest cobalt reserves (43%), followed by Indonesia (11%) and Cuba (9%), while China is responsible for most of the primary production (78%). The EU holds only 4.4% of the world's reserves and processes 8.5%. Finland is the only European country with cobalt-producing mines (15 deposits) and holds 62% of EU reserves (Konnunaho, J. 2023) Finland is a major producer of refined cobalt (91.7%) in the EU, followed only by Belgium (8.3%). In Western Balkans, there are several deposits: three Class C deposits in Albania near Pogradec, Kukës, and Bilisht; one Class B deposit near Tuzla in Bosnia and Herzegovina; one a Class C deposit in the centre of Kosovo[1], a Class C deposit in the south of North Macedonia; and one Class C deposit near the Tara National Park I Serbia. Ukraine is not yet an exporter of cobalt, however, there are five Class C deposits in the country: three in Kirovohrad, and two in Dnipropetrovsk (8.8 thousand tons (Katser-Buchkovska, N. (2024). There is also potential for processing, particularly in the context of cooperation with the United States.

Coking coal in the EU is primarily used to produce coke, which is an indispensable input in the steelmaking process (95%). The European steel industry is highly dependent on well-functioning and open markets for coking coal. The USA holds the largest cobalt reserves (35%), followed by China (21%) and Australia (12%), while most primary production is processed by China (70%). Poland is the largest processor of refined coking coal production in the world (26%), closely followed by China (24%) and USA (20%). Poland's primary coking coal production is dominated by Jastrzębska Spółka Węglowa (JSW), the largest coking coal producer in the EU. The EU's production of coking coal has decreased over the last years due to the closure of mines in Germany and the Czech Republic. There are no deposits in the Western Balkans. In Ukraine there are two deposits of coking coal: one Class B deposit in northern Lviv oblast, and one Class A deposit in the occupied Luhansk oblast. The Luhansk underground coal mine was operated by Luhansk Coal (Luhanskvugglia), a state-owned company but have been taken over and incorporated into the occupation economy. As a result of the ongoing war, Ukraine has lost 74% of its coking coal production (Glushchenko, A. 2025). Transitioning to imported coking coal has a negative impact on Ukrainian steel companies.

Copper is a strategic raw material (SRM) crucial for the EU's goal of achieving a resilient, climate-neutral Europe. While copper is identified as an SRM, it is not listed as a CRM due to its lower susceptibility to supply chain disruptions. It is a key component in construction (34%), electronics (29%), and transport, including electric vehicles and railways (9%). In defence industries copper is commonly used in used in electronics and control systems (Girardi, B. et al. 2023). Tanzania holds the largest reserves (50%), followed by Chile (12%) and the USA (5%). Poland is a significant producer of primary copper, supplying a third of the EU's primary copper (34%). Germany is an important refiner, providing nearly a fifth (17%) of the EU's refined copper, followed by Poland (14%) and Spain (11%). In the Western Balkans, there are two Class C copper deposits in Albania (Kukës and Lezhë counties in the north), one in central Bosnia and Herzegovina, and five in eastern North Macedonia (Radovich, Injevo, Shlegovo, Ilovica-Štuka, and Pehcevo). The Bor district in eastern Serbia has significant reserves in two Class C deposits and five Class B deposits. There are no deposits in Ukraine.

Feldspar is the most abundant group of minerals, forming about 60% of terrestrial rocks. Its primary uses are in construction (46%) and ceramics (45%). Türkiye is the world's main supplier of primary feldspar (40%) and the EU's main supplier (51%). In the EU, Italy is the leading producer (11.2%). In the Western Balkans, there are three Class C feldspar deposits: one in Shkodër, Albania, one in

[1] This designation is without prejudice to positions on status and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence, hereinafter 'Kosovo'.

Sokolac, Bosnia and Herzegovina, where landmine contamination restricts access, and one in central Serbia. Additionally, there are three Class C feldspar deposits in Ukraine: one in western Ukraine and two in Zaporizhzhia oblast in eastern Ukraine, annexed by Russia**.**

Fluorspar also known as fluorite, is primarily used in steel and iron making, refrigeration and air conditioning, aluminium making, solid fluoropolymers for cookware and cable insulation, fluorochemicals, nuclear uranium fuel and in processes for oil refining (CRM Alliance, 2025a). Fluorspar is mined in over 20 countries with Mexico (24%) and China (24%) holding he largest reserves. The EU has 5.3% of world reserves with Spain being the top producer of primary fluorspar (2.8%). There are no deposits in the Western Balkans. In Ukraine, there are three Class B deposits (Vinnytsia, Zaporizhzhia, and Donetsk). Both the Zaporizhzhia and Donetsk deposits are in occupied territories and have been incorporated into the occupation economy. There are no deposits in the Western Balkans.

Hafnium is primarily used in the EU for super alloys (54%) in aerospace applicationssuch as turbine blades, vanes, and industrial gas turbines. It is also used in aerospace industry, nuclear reactors, and electronics (CRM Alliance, 2025b). The defence industry hafnium is used for electro-optical systems in aircrafts, and radars (Girardi, B. et al. 2023). There are no deposits or processing in the EU or the Western Balkans. There is one Class A deposit of hafnium in Dnipropetrovsk oblast, Ukraine, linked to the processing of zirconium and the subsequent separation of hafnium as a byproduct. Ukraine plays an important role in hafnium processing, notably through the Mykolayivskyy Hlynozemnyy company, and 14% of the EU's hafnium is sourced from Ukraine. There are no deposits in the Western Balkans.

Lithium in the EU is primarily used in glass and ceramics (55%), lubricants (24%), and batteries (16%). Half of world reserves are in Bolivia (50%). In the defence industry, lithium is used in batteries for electric motors and propulsion in aircrafts, helicopters, aircraft and helicopter carriers, amphibious assault ships, corvettes, submarines, torpedoes, and missiles (Girardi, B. et al. 2023). In addition, both Australia (12%) and China (10%) have significant reserves. In the EU there is lack of both mining and refining capacity. The EU share of world reserves in 1.2% with Portugal being the top producer (0.1% of the primary production on the world). Serbia has a Class A lithium deposit in Mačva, the Jadar project. The Jadar mine, located near Loznica in western Serbia, contains around 136 million tonnes of jadarite deposits, a mineral rich in lithium and boron (New Union Post, 2025). It is the largest known high-quality, long-life lithium deposit in Europe, with the potential to meet up to 10% of global demand. The project is expected to create 1,300 skilled jobs during the operation of the mine and employs primarily Serbian nationals (90%) (Rio Tinto, 2025). It includes the construction of an underground mine with associated infrastructure and equipment, including electrically powered trucks, as well as an ore processing plant to produce battery-grade lithium carbonate. The project is listed among the European Commission's 13 Strategic Projects on strategic raw materials located outside of the EU. There are no deposits in Ukraine. There are two Class B lithium deposits in Ukraine, but currently there is no ongoing mining. The Polokhivske lithium deposit is located near the village of Smoline in central Ukraine. The most promising deposit in Ukraine, located just outside the Shevchenko village in western Donetsk, was captured in by Russian forces end of June 2025. While the US-Ukraine critical minerals deal announced in February positioned Ukraine as a strategic supplier of battery-grade materials, such as lithium with tariff reductions for exports to the US, the American investments have not deterred Russian advances.

Rare earth elements (REEs) are a group of 17 elements used in a wide range of enabling technologies in the automotive, aerospace, consumer electronics and electrical engineering applications such as magnets and catalysts (25%) (CRM Alliance, 2025b). The EU share of the world reserves is just 0.5% and imports 100% of its REEs. Estonia and France have the capacity to separate individual rare earth oxides, and to manufacture REE-based products for various industries (phosphors, catalysts, polishing powders, etc.) (CRM Alliance, 2025b). There are no deposits in the Western Balkans. Ukraine has three deposits of REEs: one Class C deposit in the northern Zhytomyr oblast, and one Class B and one Class A deposit in occupied Zaporizhzhia.

Magnesium is commonly used in various automotive applications. In the EU 48% of magnesium is used in automotive applications, packaging e.g. biodegradable films and active packaging to enhance food preservation and extend shelf life (22%), and construction (17%). Russia (30%), Slovakia (16%) and China (8%) hold the largest reserves in the world. The EU share of the world reserves is 20.5%

with Austria being the top producer of primary magnesium. There are no deposits in the Western Balkans. Ukraine has two important deposits: one Class B deposit in Ivano-Frankivsk, and one Class A deposit within the Nikopol basin in the Dnipropetrovsk region.

Manganese is primarily used in the EU primarily for steel in construction (43%), transportation, particular in battery production for electric vehicle batteries (20%), and metalware (14%). The defence industry uses manganese in submarines and torpedoes' propulsion systems (Girardi, B. et al. 2023). The largest reserves in the work are found in South Africa (51%), Gabon (16%), and Georgia (8%). The EU's share of primary production is below one percent, with Romania being the top producer. The EU's share of processed manganese is 10.2% with Italy being the top producer. In the Western Balkans, there is a Class C deposit of manganese in Debar, and six Class C deposits in Bosnia and Herzegovina: the Bužim mine in the north-west of the country, which is currently not mined; the Ljubija mine which was inactive for over two decades but restarted activities in 2022; and four deposits located in central Bosnia. While the European critical raw materials mapping, developed by the Geological Service for Europe and EuroGeoSurveys (2025), does not indicate manganese deposits in Ukraine, Ukraine is considered to have significant manganese reserves, particularly within the Nikopol Manganese Basin. Ukraine is also widely recognised as an important producer of manganese ore. While the war has disrupted mining operations, production has resumed, and Ukraine is leveraging its mineral wealth for economic recovery.

Natural Graphite in the EU is primarily used for refractories (53%) such as steelmaking, and plays a critical role in the green transition, particularly in batteries for electric vehicles and energy storage. The most significant reserves of natural graphite are in Mozambique (32%), Tanzania (22%), and Malawi (12%), while China remains the main producer of both primary (67%) and refined natural graphite (40%), followed by Brazil (13%), and Mozambique (12%). The EU holds 0.7% of global reserves. Although not a global producer, Germany is the main producer of primary natural graphite in the EU. There are several exploration projects across Europe, with Sweden and Finland increasing exploration activity in recent years (Qizhong, Z. et al, 2020).

Ukraine has six significant natural graphite deposits: three Class C deposits in Kirovohrad oblast and two in Zaporizhia oblast, two Class B deposits in Kirovohrad oblast and Odessa oblast, and one Class A deposit in Khmelnytskyi oblast. According to the German Mineral Resources Agency (DERA) study), Ukraine is Europe's largest graphite producer (Qizhong, Z. et al. 2020). The study also notes that all production is thought to come from a one large deposit, a mine operated by Zavalyevskiy Graphite in the Kirovohrad Oblast. The mine is operated by an Australian company Volt which has a 70% interest in the company. A company from Türkiye, the Onur Group, has announced plans to begin mining Ukraine's largest deposit, a Class A deposit in Burtyn in the Khmelnytskyi oblast in 2026. There are no deposits in the Western Balkans.

Nickel is a SRM used in various applications in the EU, with the largest share going towards stainless steel production, electric vehicle batteries and renewable energy systems. The defence industry uses nickel primarily in the propulsion systems of aircrafts, helicopters, aircrafts and helicopter carriers, amphibious assault ships, and warships (Girardi, B. et al. 2023). It can also be found in electronic systems of aircrafts and armaments of battle tanks, infantry fighter vehicles, and towed artillery Globally the largest reserves are found in Indonesia (21%), Canada (14%), and Russia (10%) which prior to its invasion of Ukraine was considered a key source of nickel for the (EV) battery supply chain. While the EU has some domestic nickel production, primarily Finland, which supplies 38% of its primary and 17% of its processed nickel, it is not sufficient to meet the growing demand driven by technological development. Persistent lower nickel prices, due to oversupply combined with slowed demand in key sectors like electric vehicle (EV) batteries, could jeopardize the economic viability of nickel operations and limit new supply sources.

In the Western Balkans, there are several Class C and B deposits. Albania has five Class C deposits (Kukës, Devoll, Çervenakë, Përrenjas, and Librazhd) and one Class B deposit (Devoll). Both Bosnia and Herzegovina (Republika Srpska) and Kosovo (central region) have one Class C deposit each. North Macedonia has three deposits: two Class C deposits in the south and one Class B deposit in the central region. Serbia has one Class C deposit in the south. In Ukraine, there are three Class C deposits: two in Kirovohrad and one in Dnipropetrovsk.

Niobium is primarily used as an alloying element in high-strength steels for construction (45%), automotive (20%), and oil and gas industries (16%). In the defence industry, niobium is used in propulsion systems of aircrafts, helicopters, and submarines, and in missiles (Girardi, B. et al. 2023). Brazil holds most the world's niobium reserves (74%), followed by Canada (13%) and China (6%). Brazil is also the largest supplier of primary niobium to the EU. There is no domestic production of niobium in the EU. In Ukraine, there is one Class C niobium deposit in Donetsk, currently under Russian occupation. Processing capabilities for niobium in Ukraine is limited.

Phosphate Rock is primarily used to produce fertilisers (85%). The largest reserves are concentrated in Australia (41%), Morocco (40%), and China (3%). The EU has some domestic production of phosphate rock, primarily Finland (0.5% of global primary production), but the supply does not meet the demand. There are four Class C deposits in Ukraine, all of which are in territories currently under Russian control (Zaporizhia, Donetsk, and two in Crimea).

Strontium is primarily used in chemicals (33%), ferrite magnets (27%), and ceramics (24%). The global reserves are concentrated in China (52%), Iran (32%), and Spain, which is the only EU member state with deposits (15%). The EU's share of primary strontium production is 42.6%, primarily in Spain. In Ukraine, there is one Class B deposit of strontium in the Novopoltavske field in Zaporizhia Oblast, a region currently under Russian control.

Tantalum has a wide range of applications and is it is often used in intermediates in the manufacture of other products destined for the electronics industry (CRM Alliance, 2025d). The defence industry uses tantalum in missiles (Girardi, B. et al. 2023). Global reserves are concentrated in Australia (58%), Brazil (33%), and Zimbabwe (3%). The EU does not produce primary tantalum from mining. The primary producer in the EU is Spain with a 1.1% share in the work production of primary tantalum. There are three tantalum deposits in Ukraine: one Class B deposit just outside the Shevchenko village in western Donetsk, which was captured by Russian forces at the end of June 2025, one Class A deposit in Kirovohrad oblast, and another in the Novopoltavske field in Zaporizhia Oblast, a region currently under Russian control.

Tungsten is primarily used for components in cutting and drilling tools due to their high wear resistance (29%), mining and construction tools (24%), and high-speed steel applications (13%). The defence industry uses tungsten in propulsion systems of aircraft and helicopter carriers and warships (Girardi, B. et al. 2023). World tungsten reserves are concentrated in Kazakhstan (52%), China (33%), and Australia (5%). The EU has 1.1% of the world's tungsten reserves and is responsible for 2% of primary production. The most important producer has been Austria, but a tungsten extraction project in Spain is projecting initial production in 2027 with the eventual aspiration to meet up to 20% of the EU's tungsten demand. Ukraine has one class C deposit in south-central Kirovhrad region (Shevchenkivske deposit).

Mitigation of supply chain risks the EU include diversifying supply (finding and securing alternative sources), increasing domestic supply (investing in exploration and mine development), substitution (innovation in materials and technologies), efficiency gains in processing (minimum amount of new waste, minimising the resource demand), recycling and circularity (maximizing the recovery yield).

New, possible game changing clean hydrometallurgical processing and recycling technologies for metals are being developed in the EU. Smelters have long been used as a standard across the industry to process metal ores (27 of 34 CRMs). However, hydrometallurgical methods have not been implemented on an industrial scale due to their lack of economic competitiveness. A breakthrough technology that leverages the semiconductor properties of minerals, is changing this. The technology (developed in Spain) allows producing pure metal as the final product and cuts out all transportation needs (eliminating exporting and re-importing) and extends the value chain. Similar research is also being conducted for example in recycling of end-of-life Li-ion batteries from electric vehicles.

In March 2025, the European Commission approved 47 strategic projects to reduce the EU's reliance on external suppliers. The projects include extraction (25 projects), processing (24), recycling (10), and substitution (2); and focus on lithium, nickel, cobalt, graphite, manganese.

The EU CRM consumption is unsustainable and risks exacerbating the overexploitation of resources. For base metals recycling practices are well-established. Substitution with less valuable materials and increasingly heterogeneous chemical composition of components makes recycling less profitable. For many critical elements such as lithium, cobalt, nickel, or silicon, no mature and cost-effective technologies for recycling exists (IEA, 2024). While the overall demand for CRMs can never be fully met with recycling, it could significantly reduce potential strains on supply chains and reduce the need for new mining between 25% and 40% by mid-century (for example for cobalt by 40%) (IEA, 2025). The Institute of Process Metallurgy and Metal Recycling at RWTH Aachen University, Germany, is one of the leading European institutes in the field of circular economy and focuses on the recycling of metals and an increasing attention on CRMs.

4. Skills for critical raw materials: value chains

While the mining industry carries an image of a non-forward-looking industry, it has embraced technological progresses which have significantly shaped the demand for skills. Beyond coal and steel, mining plays a crucial role in securing access to CRMs on which the future growth and competitiveness of the EU depends.

As the demand for CRM is increasing, more sophisticated equipment is being used across the value chain to improve efficiency. An increasing number of modern mining operations are highly automated. New mineral extraction technologies in the EU are focused on increased efficiency, reduced environmental impact, and improved safety through automation, AI, and sustainable practices. With the use of robotics and IoT, mines today are energy-efficient, sustainable and dynamic workplaces. Digital tools, such as advanced process control and optimised control systems, maximise recovery and reduce energy demands by improving quality management during operation (Ostręga, A. et al. 2020). Advanced process control, along with other software tools such as multidimensional simulations, allow operating in a more efficient way by constantly monitoring, reacting, adjusting, and optimizing the process (Ostręga, A. et al. 2020).

The integration of automation, data analytics, and robotics across operations have not caused a significant reduction in employment. It has not replaced employees with machines but transferred their positions from mines to the surface, i.e. equipment operators have largely replaced hands-on miners. As a result, the skills profiles needed in the industry have changed and in-demand profiles by employers are not miners but specialists with vocational qualifications.

Table 4. Value chain for critical raw materials: technologies and in-demand skills

Prospection/Exploration	
Technologies and equipment: • Ground-based geophysical (e.g. ground-penetrating radar, modular robotic miners, induced polarisation (Okada, K. (2022)) • Aerial geophysical (e.g. aerial drones with advanced geophysical sensors for aerial magnetometry, gravity/gradiometry (AGG), magnetotellurics (AirMT), ground-penetrating radar (GPR), electromagnetic (EM) surveys, gamma-ray spectrometry, unmanned survey platform, global navigation satellite system (Perikleous, D. 2025); lidar, thermal and delivery drones (López, J. (2023)) • Data-driven (e.g. AI coupled with geological knowledge and mineral exploration data, neural networks/deep learning (Okada, K. 2022))	Skills: • Geophysical techniques for different locations (e.g. ground geophysical, aerial geophysical, marine geophysical and drilling geophysical) • AI-driven drones and robots with spectrometers, mineralogical and geophysical sensors, that provide 3D modelling • Blasting automatization • Robotics systems
Extraction	
Technologies: • Low-visibility mining (i.e. miniaturisation and cost-efficient drilling for low-impact, low-visibility underground mining) (Correia V. et al. 2024) • Hydrometallurgy (i.e. using chemical or electrical processes to extract pure metal) (EP, 2025) • Solvent extraction (i.e. separating and purifying metals from a mixture using an aqueous and an organic phase to selectively	Skills: • Automated mining operations (i.e. robotics) • Hydrometallurgy (i.e. leaching, solvent extraction, and precipitation processes) • Biomining (i.e. heap leaching, dump leaching agitated leaching) (Brunel, 2023) • Solvent extraction (i.e. ability to apply scientific principles and procedures to separate and purify valuable metals from ores using chemical solvents)

isolate and recover valuable elements) (Aqua metals, 2025) • Bio-based extraction/bioleaching/biomining (i.e. using microorganisms to extract metals from ores and minerals) • Digital twin technology (i.e. using virtual models to simulate, monitor, and optimize real-world extraction processes)	• Biomining (i.e. extraction of metals from their ores through biological means, usually using bacteria) • Smart technologies (i.e. AI, sensors, Internet of Things (IoT) devices)
Processing	
Technologies: (Flyability, 2025) • Drilling (and blasting) technologies (remote control, tele-remote, semi-autonomous and autonomous drilling; blasting automation is not as developed) • Crushing and screening technologies (automated crushing systems using advanced control systems and sensors, AI-driven grinding systems, automated screening systems built on sensor technologies and computer algorithms; sizing technologies using laser scanning, 3D modelling, and computer simulations (MMT, 2023) • Grinding technologies (High Pressure Grinding Rolls (HPGR), vertical mills, and advanced grinding media, AI-driven crushing grinding systems to optimise grinding circuits and predictive maintenance) • Slurry processing technologies • Pyro processing technologies • Materials handling technologies • Compaction of minerals technologies	Skills: (Metso Outotec, 2021) • Crushing and grinding processes (i.e. reducing the particle size of large rocks to be further processed) • Flotation and filtration; sizing and classification (i.e. separating different sizes of ore; methods are used: screening and classification), and • Concentration (breaking down materials to desired concentration of crude material) • Techniques: automated ore sorting using optical sensing technologies, electrostatic separation using both electrostatic separators and electrodynamic sensors (also known as high tension rollers), froth flotation using chemical collectors and frothers, gravity separation, magnetic separation. • Dewatering (i.e. disposing of the gangue to reach the desired concentrate levels)
Recycling	

Technologies:
• Hydrometallurgy, a chemical-based recycling technology
• Bioleaching, a novel biotechnological alternative with lower environmental impact than traditional processes
• Electrochemistry, electrochemical recycling using electrical current, fields, and controlled potentials
• Metal recovery (i.e. electrorefining and electrodeposition) (Rai, V. et al. 2021)
	Skills/techniques: (Whitworth, A.J. et al. 2022)
	• Mineral processing (i.e. liberation and concentration of economical metals and minerals from mineral resource)
	• Metal extraction (i.e. separating economic minerals)
	• Recovery (i.e. removing impurities and concentrating desired metals) (Borojević Šoštarić, S. et al. 2022)
	  – Comminution techniques (i.e. crushing, grinding, screening, etc.)
	  – Beneficiation techniques (i.e. sorting, gravity concentration, magnetic separation, electrostatic separation, flotation, leaching, etc.).
	• Residue valorisation (i.e. transforming the residues and wastes into products of value)

The pace of technological adoption is faster than the rate at which workers can be trained or reskilled. Mining companies are experiencing a shortage of exploration geologists, mining engineers, mineral planners, mineral processors and environmental scientists. Especially the mineral processing industry is experiencing a significant demand for skilled workers with technical expertise in areas like engineering, robotics, and data analysis. Across the value chain, there is a shortage of metallurgical specialists and material engineers.

Skills shortages represent an important challenge that could slow progress towards the EU's 2030 objectives to reduce dependence on third countries to access critical raw materials. If positions remain unfilled or are filled with underqualified workers, companies won't be able to fulfil their growth predictions or the pipeline of projects. Smaller companies are more likely to outsource tasks to specialist providers while larger companies often find bringing those skills in-house to be more cost-effective. Delays in filling vacancies or inability for the industry to do so would have far-reaching implications across the value chain. Skills gaps to adopt new technologies, innovate and adopt sustainability measures can impact competitiveness in a global market increasingly focused on environmental and social governance.

Historically, the mining industry has struggled to attract younger generations due to perceptions of being environmentally harmful or lacking in innovation. This perception gap affects recruitment efforts and limits the influx of new talent into the sector. In addition, due to the highly transferable skills between the mining and minerals industry and the renewable energy industry, there is a shift of skilled workers towards new career development opportunities in the latter. At the same time, the aging workforce in many mining regions is contributing to a shrinking talent pool. As experienced professionals retire or move to related industries, there is a significant loss of institutional knowledge and expertise that is challenging to replace. To address the shortage of skills, the industry needs to leverage skills transferability to tap into a broader pool of talent across industries.

The EU is actively promoting cooperation to address mining skills shortages and ensure a sustainable and secure supply of CRMs. To strengthen the uptake and deployment of breakthrough technologies the industry and address skills shortages, the European Commission launched (9 December 2024) the Raw Materials Academy, set up under the Net-Zero Industry Act (NZIA). The Academy is supported with €10 million from the Single Market Programme and Horizon Europe. It will support the upskilling and reskilling of the workforce required in the EU for exploration, extraction, processing, and recycling of raw materials (EC, 2024).

5. Conclusions

The Western Balkans and Ukraine are rich in critical raw materials (CRMs) and have a long tradition in mining as well as mineral and metal processing. The region boasts some of the largest deposits in Europe. Capitalising on CRMs will be a priority for the economies to boost competitiveness and attract foreign investment.

Mining activity in the Western Balkans saw a decline in the 1990s, leading to the closure of many mines. However, the region still holds significant raw material wealth, including several CRMs. Currently, there's is a push to modernise the sector and capitalise on these resources, while securing the environmental and social sustainability of reopened operations.

To exploit the potential of restarting closed mining operations, the region must address brain drain and skills gaps, which hinder capitalising on its resources. The economies need to invest in technology adoption and development, as well as prioritise education and training to ensure a skilled workforce. This includes strengthening both vocational education and training, and higher education, updating curricula to align it with current industry standards, building on transferable skills through upskilling and reskilling, and fostering collaboration between industry, education, and government.

Ukraine possesses abundant raw materials and before the Russian invasion its income from mining and metals sector more than doubled. However, mining operations have been significantly impacted by the ongoing conflict. Due to energy supply disruptions caused by Russian attacks on Ukrainian energy infrastructure, production in at least some mines has been suspended during winter. Moreover, some mining companies report having lost nearly a third of their workforce (Culverwell, D. 2025).

The strategic partnership signed between the EU and Ukraine in 2021, along with the US-Ukraine critical minerals deal announced in February, positions Ukraine as a key supplier of battery-grade materials such as graphite. This includes tariff reductions for Ukrainian graphite exports to the US, enhancing the competitiveness of Ukrainian production against Chinese-sourced materials. However, significant investment is needed to exploit Ukraine's raw materials in a context where 40% of its raw materials are in territories currently occupied by Russia. Ukraine also faces a severe landmine and unexploded ordnance (UXO) problem, both confirmed and potential, affecting significant portions of its eastern and north-eastern regions rich in CRMs. This represents a challenge for any potential investments that could drive Ukraine's green transition and post-war reconstruction.

The transition to clean energy technologies and securing supplies for the defence industry is driving unprecedented demand for CRMs essential for manufacturing batteries, electric vehicles (EVs), wind turbines, solar panels, and defence applications in the EU and candidate countries. New approved EU strategic projects on CRMs in Ukraine's Balakhivka Graphite Deposit for battery grade graphite extraction, and Serbia's Jadar project for battery grade lithium and metallurgy grade boron extraction are paving the way for closer integration of raw materials value chains while fostering sustainable mining practices.

As an increasing number of modern mining operations are automated, and equipment operators are replacing hands-on miners. For the Western Balkan economies and Ukraine to capitalise on their critical raw material potential, the economies must invest in skills to keep up with technological change, adopt breakthrough technologies and promote relevant workforce skills.

The EU provides significant support to the Western Balkans in vocational education and training with the aim of improving VET systems, enhancing skills, and promoting economic development. This support is multifaceted, encompassing financial assistance, capacity building, and policy dialogue. The EU's support to Ukraine's vocational education and training system, has focused on modernizing infrastructure, reforming curricula, and enhancing skills development and will need to address also the reconstruction needs. On 9 December 2024, the European Commission launched a Raw Materials Academy which is supported with €10 million from the Single Market Programme and Horizon Europe. The Academy will develop learning content and credentials to meet the skills gap along the raw materials value chain. It will support the upskilling and reskilling by education and training providers in exploration, extraction, processing, and recycling of raw materials (EC, 2023). Launching of national re-skilling and up-skilling programmes to take advantage of the newly established Raw Materials Academy and European Battery Academy will be needed.

Acronyms

AI	Artificial intelligence
AGG	Airborne gravity gradiometry
AirMT	Airborne magnetotellurics
CRM	Critical raw materials
CRMA	Critical Raw Materials Act
DRC	Democratic Republic of Congo
EEA	European Environment Agency
EFTA	European Free Trade Association
EP	European Parliament
EC	European Commission
EU	European Union
EV	Electric vehicle
HPGR	High Pressure Grinding Rolls
IEA	International Energy Agency
ISCOBA	International Committee for Study of Bauxite, Alumina & Aluminium
JRC	Joint Research Centre
MMT	Mining & minerals today
NZIA	Net-Zero Industry Act
REE	Rare Earth Elements
RMI	Raw Materials Initiative
SRM	Strategic raw materials
SDG	Sustainable Development Goals
UXO	Unexploded ordnance
UK	United Kingdom

USA	United States of America
3D	Three dimensional

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ANNEX 1. Selected critical and strategic raw materials: deposits, reserves, and production

CRM	World main reserves (1)	World primary producers (1)	World main refinery producers (1)	EU main sourcing primary (1)	EU main sourcing refined (1)	EU reserves and production (1) (top suppliers in brackets)	Deposits in Ukraine and Western Balkans (2) (number and size of deposits: Class A (Super Large), Class B (Large), Class C (Medium))
Aluminium/ bauxite	Australia (41%) India (21%) Guinea (10%)	Guinea (26%) Australia (25%) China (19%)	China (58%) India (6%) Russia (6%)	Guinea (62%) Brazil (12%) Greece (10%)	Russia (19%) Germany (10%) Mozambique (9%)	Primary production (0.3%) (Greece), refined production (1.9%) (France)	Bosnia and Herzegovina (5 - Class C, 4 - Class B)
Antimony	Tajikistan (44%) China (32%) USA (13%)	China (47%) Tajikistan (17%) Türkiye (13%)	-	Türkiye (63%) Bolivia (26%) China (6%)	China (30%) Belgium (21%) France (14%)	-	Bosnia and Herzegovina (1 - Class C), North Macedonia (2 - Class C, 1 - Class B)
Arsenic	-	Peru (45%) China (43%) Arsenic (10%)	-	-	Belgium 60(%) China (39%) Others (1%)	Primary production (1.8%) (Belgium)	North Macedonia (2 - Class B)
Baryte	-	India (24%) China (24%) Morocco (13%)	-	China (44%) Morocco (28%) Bulgaria (11%)	-	Primary production (1.2%) (Bulgaria)	Bosnia and Herzegovina (1 - Class C), Montenegro (1 - Class C), Ukraine (1 - Class C)
Beryllium	-	USA (64%) China (27%) Mozambique (8%)	-	-	USA (60%) Kazakhstan (25%) Japan (10%)	-	Ukraine (2 - Class A)
Boron/Borate	Türkiye (87%) USA (4%) Russia (4%)	Türkiye (48%) USA (22%) Chile (8%)	-	Türkiye (99%) Others (1%)	Türkiye (46%) Germany (25%) USA (20%)	-	Serbia (2 - Class B)
Cobalt	DRC (43%) Indonesia (11%) Cuba (9%)	Congo (69%) Indonesia (6%) Russia (5%)	China (78%) Finland (8%) Canada (3%)	-	Finland (62%) Belgium (29%) DRC (2%)	Reserves (4.4%), primary production (0.7%) (Finland), refined production (8.5%) (Finland)	Albania (3 - Class C), Bosnia and Herzegovina (1 - Class B), Kosovo (1 - Class C), North Macedonia (1 - Class C), Serbia (1 - Class C, 1 - Class B), Ukraine (5 - Class C)
Coking Coal	USA (35%) China (21%)	China (53%) Australia (16%)	China (70%) Russia (7%)	Poland (26%) Australia (24%)	Germany (28%) Poland (24%)	Reserves (3.4%), primary production (1.3%)	Ukraine (1 - Class B, 1 - Class A)

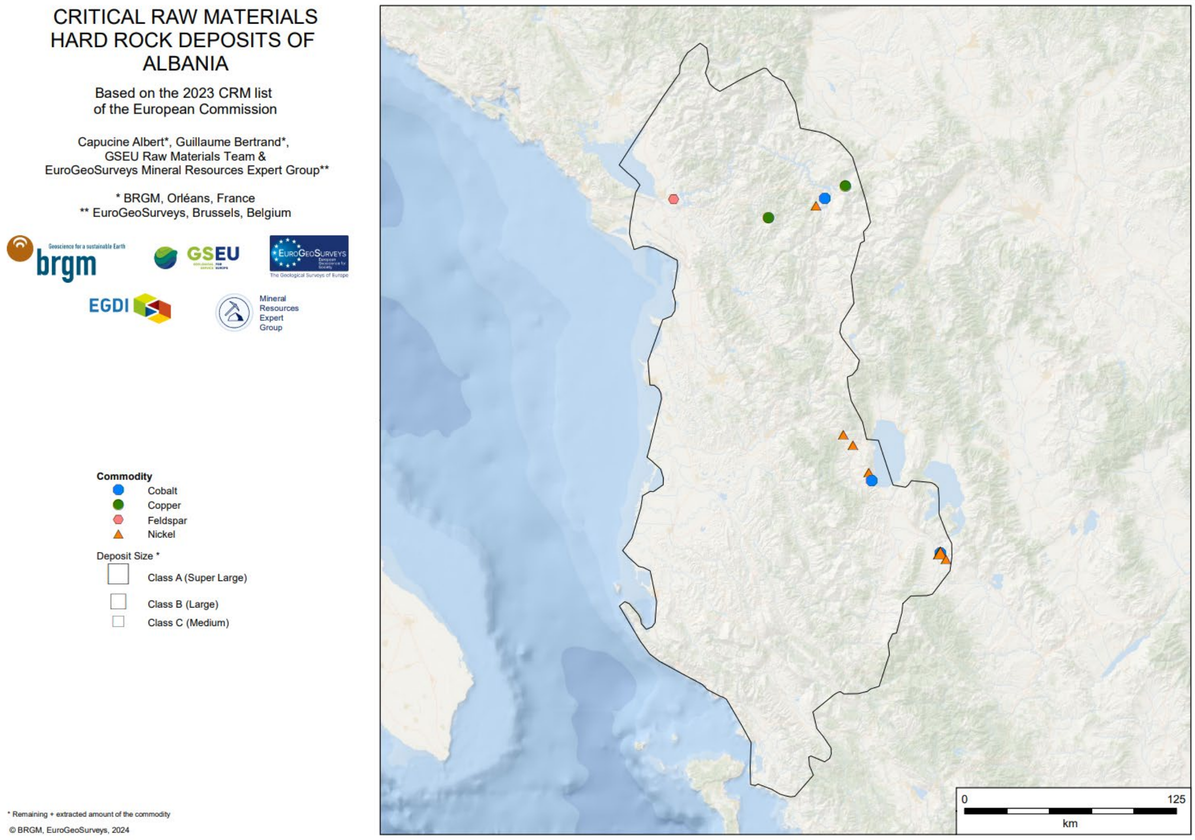
	Australia (12%)	Russia (10%)	India (6%)	USA (20%)	France (8%)	(Poland), refined production (4.5%) (Poland)	
Copper	Tanzania (50%) Chile (12%) USA (5%)	Chile (24%) DRC (11%) Peru (11%)	China (43%) Chile (8%) DRF (7%)	Poland (19%) Chile (14%) Peru (10%)	Germany (17%) Poland (14%) Spain (11%)	Reserves (1.6%), primary production (3.6%) (Poland), refined production (9.5%) (Germany)	Albania (2 - Class C), Bosnia and Herzegovina (1 - Class C), Montenegro (1 - Class B), North Macedonia (5 - Class C), Serbia (2 - Class C, 5 - Class B)
Feldspar	-	Türkiye (40%) India (15%) Iran (8%)	-	Türkiye (51%) Italy (22%) Spain (7%)	-	Primary production (11.2%) (Italy)	Albania (1 - Class C), Bosnia and Herzegovina (1 - Class C), Serbia (1 - Class C), Ukraine (3 - Class C)
Fluorspar	Mexico (24%) China (24%) South Africa (14%)	China (62%) Mexico (20%) South Africa (4%)	-	-	-	Reserves (5.3%), primary production (2.8%) (Spain)	Ukraine (3 - Class B)
Hafnium	-	-	-	-	France (76%) Ukraine (14%) China (5%)	-	Ukraine (1 - Class A)
Lithium	Bolivia (50%) Australia (12%) China (10%)	Australia (43%) Chile (32%) China (17%)	Australia (47%) Chile (30%) China (15%)	-	Chile (79%) Switzerland (7%) Argentina (6%)	Reserves (1.2%), primary production (0.1%) (Portugal)	Serbia (1 - Class A), Ukraine (2 - Class B)
Rare earth elements	-	China (60%) USA (16%) Myanmar (10%)	-	-	-	Reserves (0.5%), primary production (0%), refined production (0%)	Ukraine (1 - Class C, 1 - Class B, 1 - Class A)
Magnesium	Russia (30%) Slovakia (16%) China (8%)	China (59%) Türkiye (8%) Brazil (8%)	China (88%) Kazakhstan (3%) Brazil (2%)	-	China (97%) Israel (1%) UK (1%)	Reserves (20.5%), primary production (10.8%) (Austria)	Ukraine (1 - Class B, 1 - Class A)
Manganese	South Africa (51%) Gabon (16%) Georgia (8%)	South Africa (35%) Gabon (22%) Australia (15%)	India (16%) Norway (14%) Australia (12%)	South Africa (41%) Gabon (39%) Brazil (8%)	Norway (21%) Ukraine (19%) Spain (14%)	Primary production (0%) (Romania), refined production (10.2%) (Italy)	Bosnia and Herzegovina (6 - Class C), North Macedonia (1 - Class C)
Natural Graphite	Mozambique (32%) Tanzania (22%) Malawi (12%)	China (67%) Mozambique (10%) Madagascar (7%)	-	China (40%) Brazil (13%) Mozambique (12%)	-	Reserves (0.7%), primary production (0%) (Germany)	Ukraine (3 - Class C, 2 - Class B, 1 - Class A)
Nickel	Indonesia (21%) Canada (14%) Russia (10%)	Indonesia (49%) Philippines (11%) Russia (7%)	Indonesia (37%) China (27%) Japan (5%)	Finland (38%) Canada (24%) Greece (19%)	Russia (29%) Finland (17%) Norway (10%)	Reserves (4.2%), primary production (1.5%) (Finland), refined production (3.3%) (Finland)	Albania (5 - Class C, 1 - Class B), Bosnia and Herzegovina (1 - Class C), Kosovo (1 - Class C), North Macedonia (2 - Class C, 1 - Class B), Ukraine (4 - Class C)

Niobium	Brazil (74%) Canada (13%) China (6%)	Brazil (93%) Canada (6%) Others (1%)	Brazil (88%) Canada (10%) EU (2%)	Brazil (82%) Canada (16%) UK (2%)	-	-	Ukraine (1 - Class C)
Phosphate Rock	Australia (41%) Morocco (40%) China (3%)	China (44%) Morocco (14%) China (8%)	-	Morocco (27%) Russia (24%) Finland (17%)	-	Reserves (0.8%), primary production (0.5%) (Finland)	Ukraine (4 - Class C)
Strontium	China (52%) Iran (32%) Spain (15%)	Spain (43%) Iran (35%) China (14%)	-	Spain (99%) Others (1%)	-	Reserves (15.1%), primary production (42.6%) (Spain)	Ukraine (1 - Class C)
Tantalum	Australia (58%) Brazil (33%) Zimbabwe (3%)	DRC (50%) Morocco (17%) Russia (12%)	-	DRC (35%) Rwanda (17%) Brazil (16%)	-	Primary production (1.1%) (Spain)	Ukraine (1 - Class B, 2 - Class C)
Tungsten	Kazakhstan (52%) China (33%) Australia (5%)	China (76%) Vietnam (16%) Russia (2%)	-	-	China (31%) Austria (19%) Vietnam (14%)	EU: reserves (1.1%), primary production (2%) (Austria)	Ukraine (1 - Class C)

Sources:

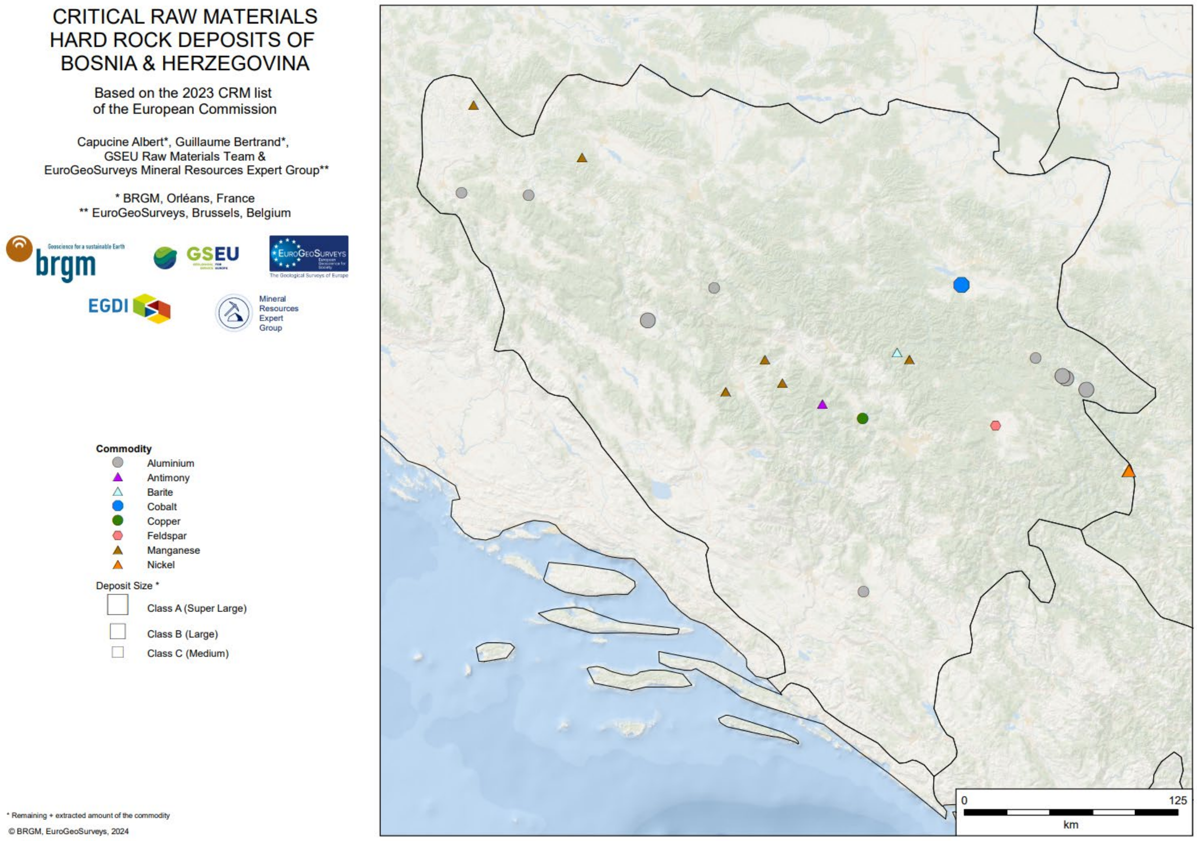
(1) European Commission Raw Materials Information System (RMIS). Accessed 24.06.2025. Available here.
(2) Albert, C. & Bertrand, G. (2025). Geological Service for Europe, Map of Critical Raw Materials hard rock deposits of Europe 2024. Zenodo. Available here.

ANNEX 2. CRM deposits in Albania



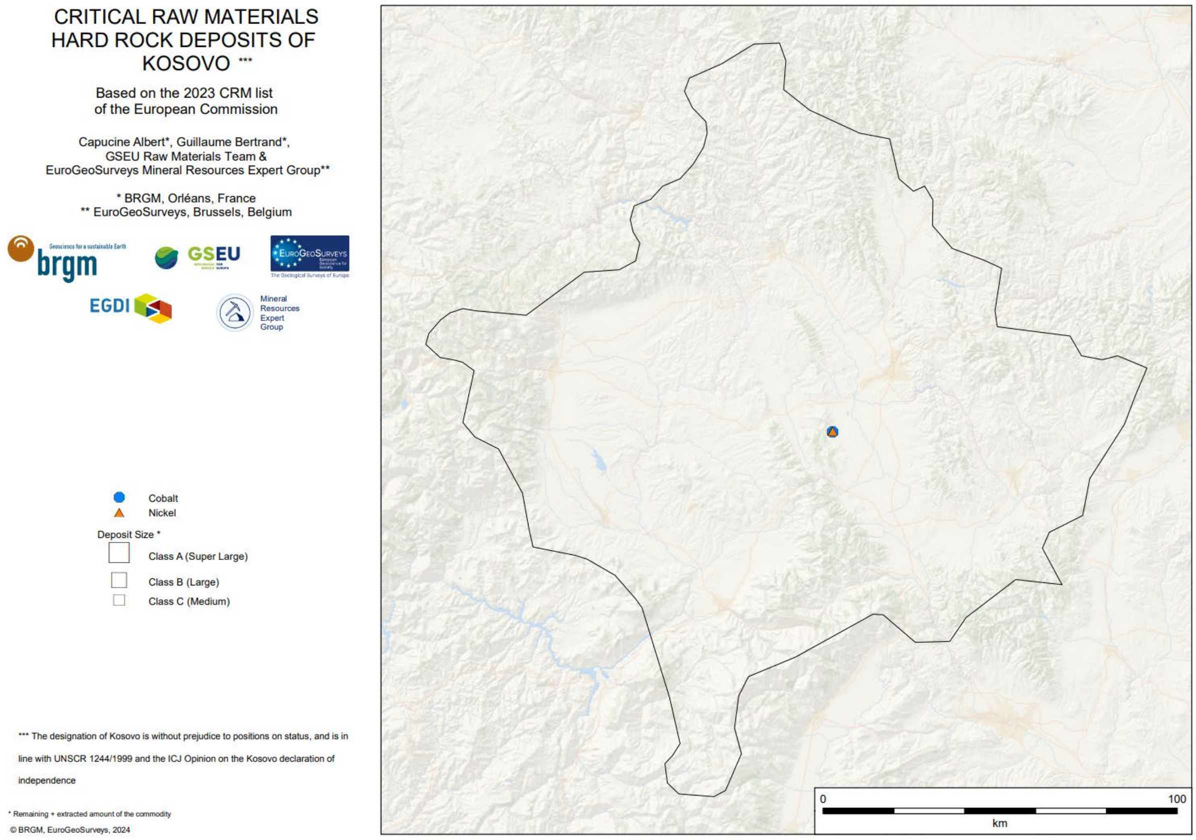
Source: Albert, C. & Bertrand, G. (2025), *Map of Critical Raw Materials hard rock deposits of Europe 2024*, Geological Service for Europe, Zenodo. Available here.

ANNEX 3. CRM deposits in Bosnia and Herzegovina



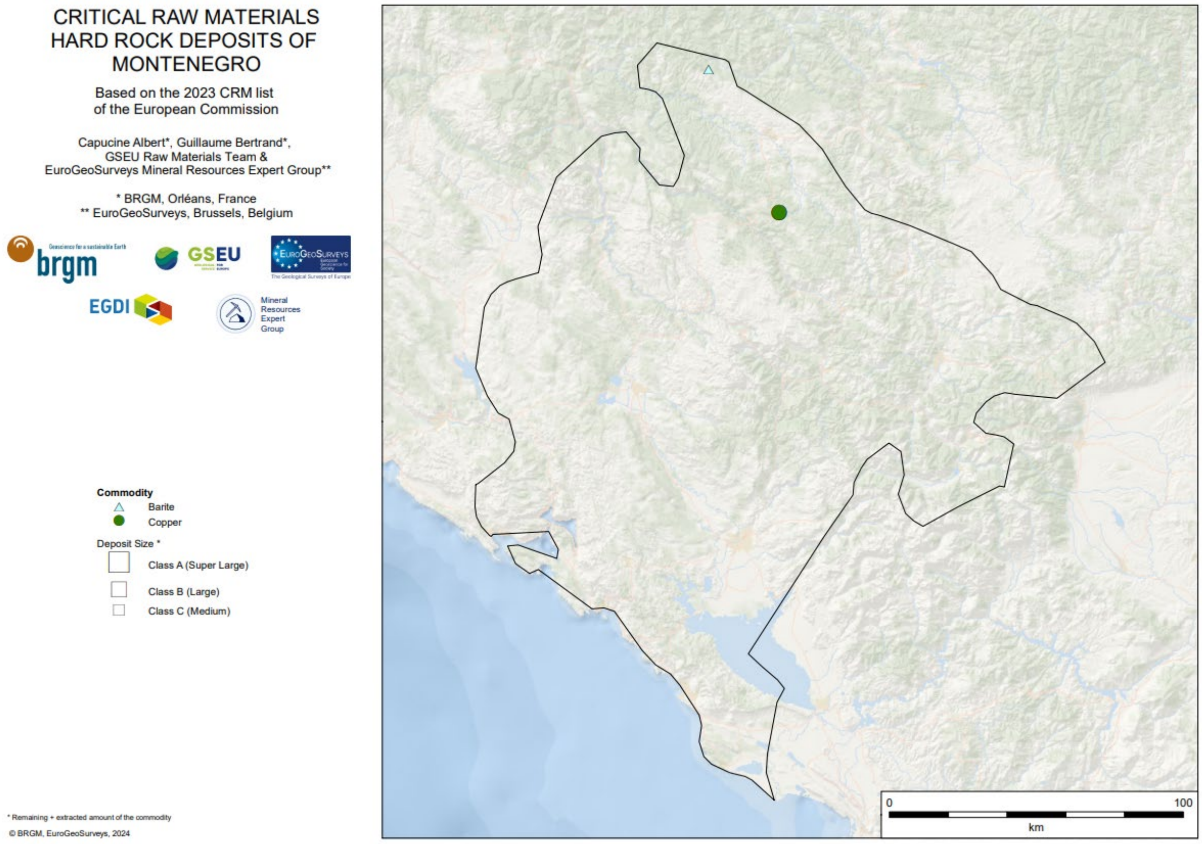
Source: Albert, C. & Bertrand, G. (2025), *Map of Critical Raw Materials hard rock deposits of Europe 2024*, Geological Service for Europe, Zenodo. Available here.

ANNEX 4. CRM deposits in Kosovo



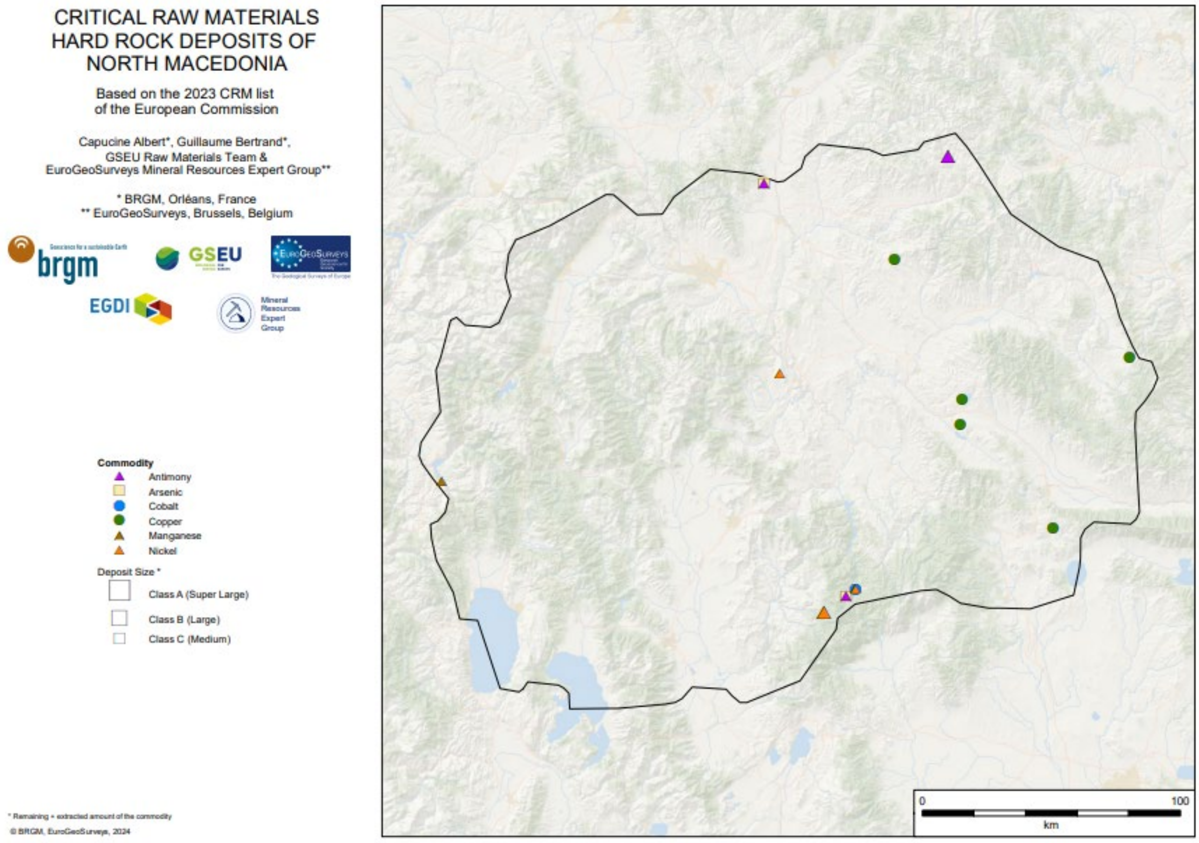
Source: Albert, C. & Bertrand, G. (2025), *Map of Critical Raw Materials hard rock deposits of Europe 2024*, Geological Service for Europe, Zenodo. Available here.

ANNEX 4. CRM deposits in Montenegro



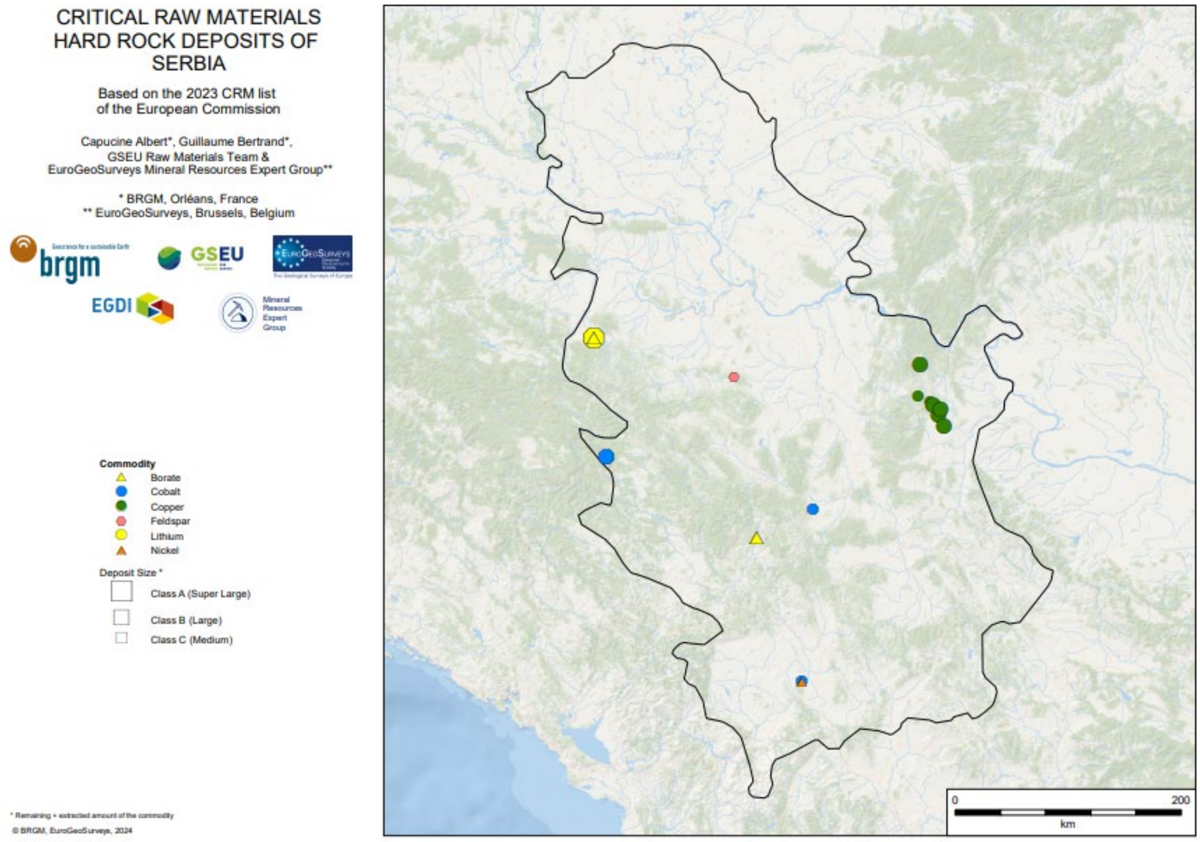
Source: Albert, C. & Bertrand, G. (2025), *Map of Critical Raw Materials hard rock deposits of Europe 2024*, Geological Service for Europe, Zenodo. Available here.

ANNEX 6. CRM deposits in North Macedonia



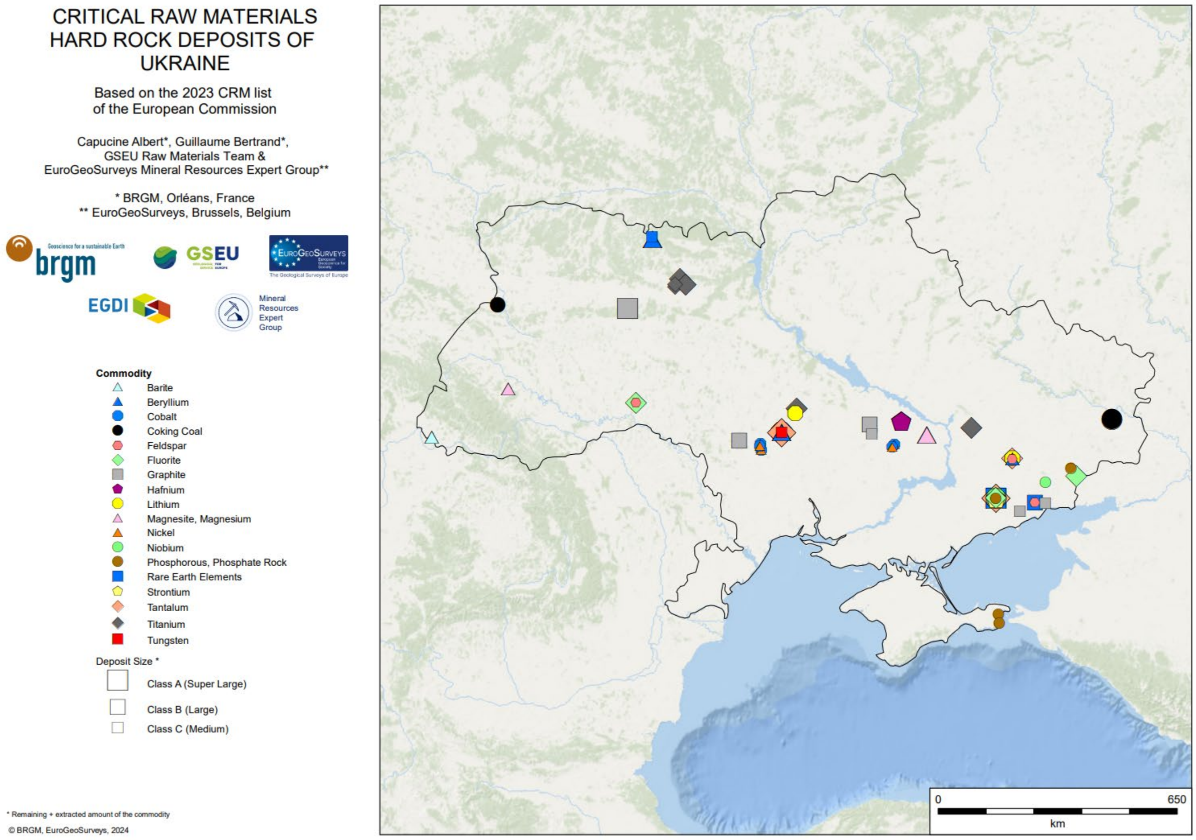
Source: Albert, C. & Bertrand, G. (2025), *Map of Critical Raw Materials hard rock deposits of Europe 2024*, Geological Service for Europe, Zenodo. Available here.

ANNEX 7. CRM deposits in Serbia



Source: Albert, C. & Bertrand, G. (2025), *Map of Critical Raw Materials hard rock deposits of Europe 2024*, Geological Service for Europe, Zenodo. Available here.

ANNEX 8. CRM deposits in Ukraine



Source: Albert, C. & Bertrand, G. (2025), *Map of Critical Raw Materials hard rock deposits of Europe 2024*, Geological Service for Europe, Zenodo. Available here.