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African critical raw materials and the EU's economic security

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Key numbers

7-fold

forecast increase in demand for rare earth metals by 2040 (42-fold for lithium)

98%

China's share in supplies of rare earth metals to the EU

for 6/10

minerals with the highest extraction concentration factor, China is among the top three producers

200 kg

of metals are needed to produce the average electric car

19%

of the world's metal reserves needed to make a standard lithium-ion battery are located on the African continent

30%

of all the world's reserves of critical metals are in Africa

71.2%

Democratic Republic of the Congo's share in global cobalt production in 2022

0.8

value of discoveries in Africa as a ratio of exploration costs (compared to 0.5 for Australia, 0.6 for Canada and 0.3 for Latin America)

10%

share of global exploration spending spent in Africa in 2022

80%

of spending on exploration seeking to discover mineral resources and hydrocarbons in Africa in 2022 came from four countries: Canada, Australia, Britain and South Africa

Key findings

- **In recent years, the political and economic importance of raw materials has increased significantly.** They are no longer a simple material in industrial production, but rather a factor that could determine the European Union's future fate and the new division of labour in the global economy. Low diversification of supplies and lack of access to many critical raw materials could lead to dependence similar to that on Russian oil and gas.

- **Countries that are not allied with the West occupy a dominant position in the production of many categories of critical raw materials.** Russia is a traditionally significant supplier of many industrial metals. 43% of palladium and 15% of global nickel production come from Russian mines. China plays a key role in the production of magnesium and rare earth metals, with quasi-monopoly in the processing of a whole range of metals, such as lithium (59%) and cobalt (73%). As many as 98% of the rare earth metals imported by the EU come from China.

- **The challenges facing the EU could be mitigated to a large extent by strengthening the strategic partnership with African states.** The African continent is home to 30% of the world's metal reserves. Its territory contains 59% of the world's Platinum Group Metal reserves, 48% of diamonds, 75% of cobalt, 68% of manganese and 59% of graphite, among other things, as well as large unmarked lithium deposits. Africa also holds 67% of phosphate reserves, with Morocco producing a dominant share, and 59% of bauxite, with Guinea the leading country, as well as uranium (33%). The continent has at least 20% of the reserves in 12 categories of minerals crucial to the green transition and 19% of the reserves of the metals needed to make a standard lithium-ion battery.

- **Africa remains the least geologically explored continent, with only 10% of the global budget for exploration and the search for raw materials.** At the same time, Africa is the most profitable region in exploration terms; the value of discoveries as a ratio of exploration costs is around 0.8 there, compared to 0.5 in Australia, 0.6 in Canada and 0.3 in Latin America. The key factors behind the low exploration budgets include political and regulatory instability, security issues, infrastructural problems (transport, access to energy and water), lack of geological data, and limited access to financing.

- **A strategic partnership will require strong private sector involvement in exploration and production in Africa.** In terms of spending on exploration, EU companies' presence is small. In 2022, 80% of spending on exploration in Africa came from just four countries: Canada, Australia, Britain and South Africa. Despite its growing share in mining, China is moderately active in the search for new deposits (exploration), giving way to more experienced entities and focusing on acquiring shares in existing projects.

- **Africa's raw material potential is highly compatible with the demand for critical raw materials in the EU.** Of the 34 critical raw materials on the list published by the European Commission, 24 categories of raw materials are sourced in different African countries. However, EU diplomatic efforts, financial assistance and support for new mining and infrastructure projects in Africa could extend the list of raw materials obtained from African partners significantly and lead to new discoveries.

- **A group of countries with the most potential — in terms of the raw materials they possess and the possibility to work together to acquire them — should be selected.** The African continent is diverse, with 54 countries with a variety of raw materials and limitations on their extraction. Strategic partnerships should be based on mutually complementary demand and the availability. Based on the results of our analysis, strategic partnerships with the following countries are particularly important: DRC, Guinea, Madagascar, Morocco, Mozambique, Namibia, South Africa, Rwanda, Zambia and Zimbabwe.

- **Cooperation with Africa should be developed in two directions: acquiring critical raw materials and processing them.** The refining of raw materials in Europe is currently declining due to years of neglect, financial reasons, and the desire to transfer external costs (the natural environment) to third countries. Despite the EU's plans for 40% of the demand for raw materials to come from intra-EU circulation by 2030, processing will remain its Achilles' heel. Countries in North Africa (such as Morocco) should be considered promising in this respect due to the state of their processing infrastructure and geographical proximity.

- **When it comes to extracting raw material in Africa, the bottleneck is infrastructure.** A large part of the reserves of critical metals that have been identified is located in landlocked countries or ones with difficult access to loading ports, which complicates the transport of raw materials to international markets. As part of building a partnership with Africa, the EU should support the development of infrastructure on the continent, taking greater advantage of the opportunities offered by the Global Gateway initiative, Europe's response to China's Belt and Road Initiative.

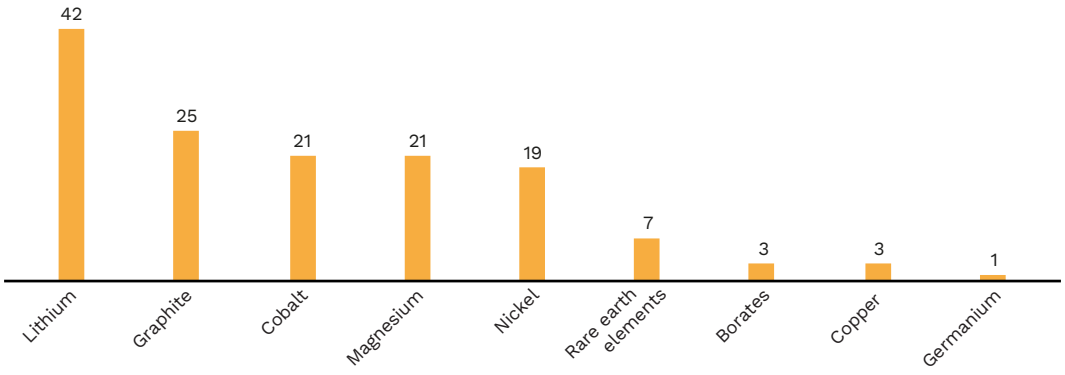
Introduction

In recent years, there has been a radical change in how raw materials are perceived in the European Union. Until recently, they were merely mentioned in the context of sustaining industrial production. Now they are set to define the EU's future and its place in the world.

Russia's invasion of Ukraine has highlighted the risks of dependence on Russian fossil fuels and other strategic resources. More broadly, the disruption of supply chains caused by the COVID-19 pandemic and the resulting shortages have highlighted the issue of EU economies' resilience and their dependence on third countries in terms of materials. An event illustrating these problems was China's reduction of magnesium production in 2021 which led to a 700% increase in the price of this raw material and huge problems for European car manufacturers (Sullivan, 2021). China's introduction of restrictions on exports of germanium and gallium — metals used in the production of semiconductors, solar panels and LEDs — in July 2023 also caused confusion on the market.

The Russian invasion and the pandemic have simultaneously accelerated the EU's dual transition: green and digital. Replacing conventional energy resources with clean energy involves huge demand for critical resources, mainly metals. According to the International Energy Agency (IEA), in 2040 the world will need 42 times more lithium, 19 times more nickel (the two key metals for lithium-ion batteries), 25 times more graphite and 21 times more cobalt than in 2020. The demand for rare earth metals will increase sevenfold. This has far-reaching consequences, including environmental ones. For example, obtaining a tonne of rare earth metals generates 2000 tonnes of toxic waste (PEI, 2023).

Chart 1. Projected increase in demand for selected critical raw materials by 2040 (1 = current demand)



Source: prepared by PEI based on IEA data.

Competition for access to critical raw materials is also intensifying between countries on the same side of the geopolitical dispute. The adoption of the Inflation Reduction Act by the US has shown European countries that, despite common values, the EU must take urgent action to ensure its own security of supply and reduce strategic dependencies (de-risking). The European Commission mentions this in its 2023 Strategic Foresight Report (European Commission, 2023a). Although the EU is trying to mitigate the shortage of raw materials and supply risk by increasing the use of recycled materials and by managing post-mining waste heaps, this is not enough to ensure raw material security.

The growing demand concerns two groups of raw materials: traditional, relatively abundant industrial metals, such as copper and iron ore, and critical minerals, which had not played a significant role in technological progress so far and are now becoming a central part of the debate on raw material dependencies (such as rare earth metals, lithium, nickel, cobalt, graphite). In this report, we mainly focus on critical raw materials, examining the extent to which the growing demand for them in Europe can be mitigated by supplies from Africa.

To this end, we discuss the EU's (and Poland's) needs when it comes to critical raw materials and analyse their compatibility with the raw materials in the African continent. Starting with the list of 34 critical raw materials published by the European Commission, we list the production and reserves of metals and minerals currently extracted in African countries.

Our analysis has enabled us to identify 24 categories of raw materials scattered across the continent, which are critical for the energy and digital transition. In this report, we propose a series of actions that the EU should take to use African countries' raw material potential, and analyse the barriers to strengthening the strategic partnership with Africa.

	**Metals:** a group of elements with a characteristic molecular structure, good electrical and thermal conductivity, characteristic shine, high mechanical strength and plasticity; in nature, they usually occur in the form of ores.
	**Natural resources:** naturally-occurring materials of plant, animal or mineral origin used in technological processes.
	**Minerals:** elements or chemical compounds that are crystalline bodies, the structure of which was formed over the course of geological processes.
	**Critical Raw Materials (CRMs):** the catalog of raw materials (mainly metals and other minerals) significant for the European economy and characterised by a high supply risk published periodically by the European Commission.
	**Production:** the amount of ore extracted in a given geographic area as a result of mining per unit of time (usually a year).
	**Resource:** the total amount of ore identified in a given area, without taking into account current and/or future exploitation opportunities.
	**Reserves:** a type of resource that is technically and economically recoverable at a given moment; they are subjective and temporary (e.g. they may increase with the introduction of new mining techniques).

Chapter 1. The role of critical raw materials in EU economies' transition

All the forecasts available point to rapidly-growing demand for critical raw materials. According to the World Bank, by 2050, the energy transition will create demand for an additional 3 billion tonnes of the raw materials (mainly metals) needed to produce wind turbines, photovoltaic and geothermal installations (World Bank, 2020). According to OECD forecasts, the demand for critical raw materials is expected to increase from 79 billion tonnes in 2023 to 167 billion tonnes in 2060 (Kowalski, Legendre, 2023).

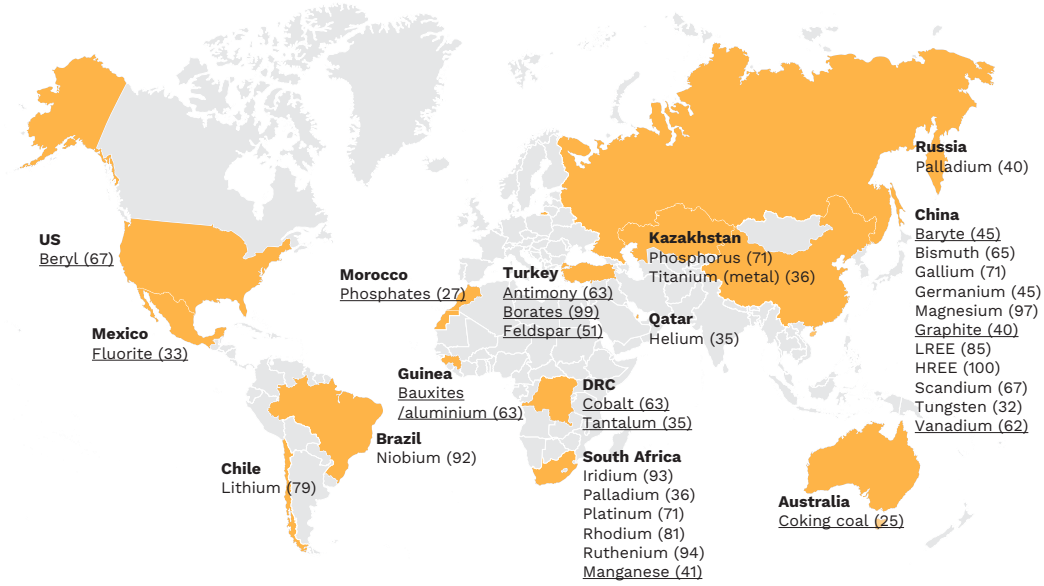
Electric car production is the most "metal-intensive": it is responsible for 40-50% of total metal consumption. Producing the average electric car requires over 200 kg of metals, over six times more than for a combustion car. The most consumed raw materials are graphite (66 kg), copper (53 kg), nickel (40 kg) and magnesium (25 kg) (IEA, 2021). Another area where there is huge demand for metals is the production of electrical networks and photovoltaic panels (35-45%); other technologies consume 5% (KU Leuven, 2022).

The need to diversify supplies also results from the EU's adoption of extremely ambitious assumptions concerning the double transition: green and digital. An additional challenge is the intensifying geopolitical rivalry, not only with China, but also with countries that share similar norms and values in international relations. The US administration's adoption of the Inflation Reduction Act has forced the EU to take a fresh look not only at its climate goals, but also the raw materials needed to achieve them. In this context, Africa, with its rich deposits of raw materials, relative geographical proximity and strong historical ties, is a natural direction for the EU as it seeks to diversify supplies. However, the EU will have to redefine its strategy towards the continent.

Quantitative research by the PEI reveals the problem of the EU's raw material dependency and the threats resulting from its exposure to material imports from third countries (Ambroziak et al., 2022). The lack of an EU political offensive to diversity raw material supplies could prove costly for it in the future — and pose a systemic threat similar to its dependence on hydrocarbons, as demonstrated by Russia's invasion of Ukraine.

The risks associated with raw material dependency are exacerbated by the fact that, for many of them, production is quasi-monopolised by a small group of countries, above all China. For years, the EU has remained passive in the face of China's growing dominance in the production and processing of many raw materials, which have now turned out to be indispensable for the green transition. 98% of rare earth metals and 97% of magnesium come from China. The country also dominates when it comes to processing many minerals, such as lithium, cobalt, nickel and graphite. The high concentration of mining can also be observed in other categories of raw materials: the EU imports 99% of the borane it consumes from Turkish mines, 71% of platinum from South Africa, and 85% of niobium from Brazil.

Map 1. Largest suppliers of raw materials to the EU in 2016-2020



*Underlining means that the raw material is imported unprocessed.

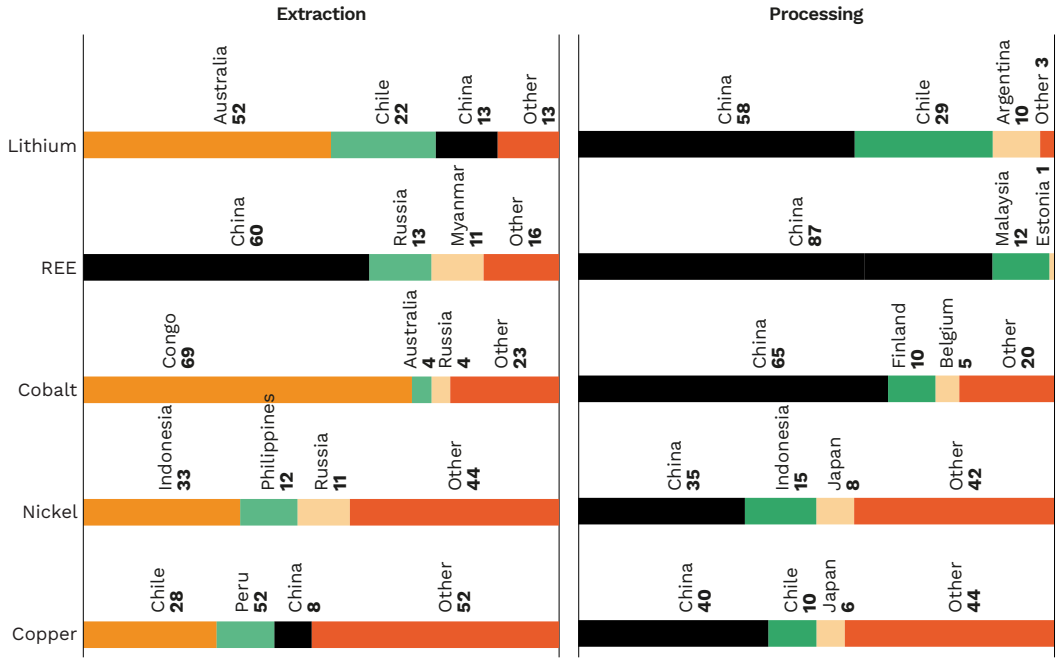
Source: prepared by PEI based on European Commission data.

The Russian invasion of Ukraine has also showed the need to diversify energy supplies. Here, Africa could offer Europe temporary support. Almost 40% of all the hydrocarbon discoveries in the world over the past decade have been made on the African continent. African oil reserves are estimated at 125.3 billion barrels, and natural gas reserves at 17.55 trillion m^3. Half the countries in Africa have confirmed gas deposits; in total, the continent has 9% of the world's gas reserves. While the advantages of Africa in the production of hydrocarbons are indisputable, in the long term, the energy transition will reduce consumption of them significantly, while the demand for

non-energy raw materials will increase sharply. We therefore consider hydrocarbons declining commodities in terms of the EU's long-term interests and only focus on non-energy commodities in this report.

The EU's raw material dependency applies to both the extraction and processing of critical raw materials. In contrast to China, which dominates in the processing of a wide range of metals and minerals, Europe's processing capacity is severely limited. China is responsible for almost 60% of refined lithium, 65% of cobalt and 87% of rare earth metals, among others (see Chart 2). China's quasi-monopoly is even stronger given that much of the metal refining in other countries is controlled by companies with Chinese capital or that use Chinese technology. Although the EU has committed to increasing its internal processing capacity to 40% of its annual consumption of raw materials by 2030 (15% is meant to come from recycling), processing will remain its Achilles' heel.

Chart 2. Mining and processing of selected metals around the world in 2021



Source: prepared by PEI based on IEA data.

The starting point for our analysis is the European Commission's diagnosis concerning critical raw materials published in March 2023 (European Commission, 2023b). The Commission conducts a regular evaluation of individual raw materials based on two criteria: (1) economic importance, which

shows the demand for a given raw material in relation to the EU's key industrial ecosystems, adjusted by the substitution index; (2) supply risk, which takes into account the threats inherent in supply chains and European countries' dependence on imports. In its first evaluation in 2011, the Commission singled out 14 critical raw materials out of 41 candidates. This rose to 20 out of 54 in 2014, 27 out of 78 in 2017, and 30 out of 83 in 2020. In its latest evaluation, it assessed 70 categories of "candidate" raw materials: 67 single raw materials and three groups of materials, including ten heavy rare earth metals, five light rare earth metals and five platinum groupings (iridium, palladium, platinum, rhodium and ruthenium). There are also four new raw materials: neon, krypton, xenon and roundwood. Bauxite was combined with aluminium and titanium-metal was combined with titanium powder. This means 87 items in total.

The Commission's analysis shows that 34 raw materials can be considered critical from EU countries' perspective. Two raw materials, copper and nickel, were deemed strategic and added to the list, despite not meeting the quantitative criteria. Consumption of many of these raw materials is low in volume, but crucial in terms of chemical and technological properties (for example, lithium in batteries, silicon in semiconductors). The evolution both in terms of the number of candidate raw materials (87 in 2023, compared to 41 in 2011) and the final list (34 in 2023, compared to 14 in 2011) points to a radical change in the EU's outlook, but also constitutes a response to phenomena in its external environment, such as the China-US trade war, the COVID-19 pandemic and Russia's invasion of Ukraine.

Table 1. List of the EU's 34 critical raw materials (in alphabetical order, in %)

Metal	Main suppliers to the EU (%)	EU dependence on imports (%)*		Share of the raw material from recycling after decommissioning (%)
		Extraction	Processing	
Antimony	Turkey (63), Bolivia (26), China (6)	100	47	28
Aluminium/ bauxite	Guinea (62), Brazil (12), Greece (10)	89	55	32
Arsenic	Belgium (60), China (39)	-	39	0
Baryte	China (44), Morocco (28), Bulgaria (11), Germany (7), Slovakia (2)	74	-	0
Beryl	N/D	-	100	0
Bismuth	China (65), Thailand (12), Laos (8)	-	71	0
Borates	Turkey (99)	100	70	1
Feldspar	Turkey (51), Italy (22), Spain (7), France (5), Czech Republic (4), Germany (2), Portugal (1), Poland (1)	54	-	1
Fluorite	Spain (62), Germany (22), Italy (14)	60	-	1

Phosphorus	Kazakhstan (62), Vietnam (22), China (13)	-	100	0
Phosphates	Morocco (27), Russia (24), Finland (17), Algeria (10)	82	-	10
Gallium	China (69), US (10), Britain (9)	-	98	0
Germanium	China (45), Belgium (32), Germany (19)	-	42	2
Natural graphite	China (40), Brazil (13), Mozambique (12), Norway (8), Ukraine (7)	99	-	3
Hafnium	France (49), US (44), Russia (3)	-	0	0
Helium	Qatar (34), Algeria (29), US (21), Poland (5)	-	94	2
HREE	N/D	100	100	4
Cobalt	N/D	81	1	22
Metallic silicon	Norway (34), France (29), Brazil (9)	-	64	0
Lithium	Chile (79), Switzerland (7), Argentina (6), US (5)	81	100	0
LREE	China (75)	80	100	3
Magnesium	China (97), Israel (1)	-	100	13
Manganese	South Africa (41), Gabon (39), Brazil (8), Ukraine (3)	96	66	9
Copper	Poland (19), Chile (14), Peru (10), Spain (8), Bulgaria (5), Sweden (4), Finland (2), Portugal (2)	48	17	55
Nickel	Russia (29), Finland (17), Norway (10), Canada (6)	31	75	16
Niobium	N/D	-	100	0
Platinum Group Metals	N/D	-	100	19
Scandium	N/D	-	100	0
Strontium	Spain (99)	0	-	0
Tantalum	N/D	99	-	0
Titanium	N/D	100	18	19
Vanadium	N/D	b/d		1
Coking coal	Poland (26), Australia (24), US (20), Russia (8), Canada (5), Czech Republic (5), Germany (2)	66	0	0
Tungsten	China (31), Austria (19), Vietnam (14), Russia (9)	21	80	42

*The EU's dependency on imports is calculated using the following formula: (Imports – Exports)/(Domestic production + Imports – Exports)

Source: prepared by PEI based on European Commission data.

The EU's strategy on critical raw materials should also be interpreted in conjunction with Poland's *National Raw Materials Policy*, published on March 1. 2022. From the Polish government's perspective, keeping coking coal, which is used in steel production and in highly advanced technologies linked to the energy transition, on the list of critical raw materials was of particular importance. Poland — specifically, Jastrzębska Spółka Węglowa — is the largest producer of this raw material in the EU and the main supplier of it. Poland is also the largest producer of copper, which was deemed a strategic raw material in 2023 and ultimately added to the list prepared by the Commission. Obtaining the status of strategic and critical raw materials is important, as it will be associated with the possibility of obtaining an easier financing path and mining permits (it currently takes eight years to obtain a permit, on average).

Chart 3. List of EU critical raw materials in 2023

Aluminium/bauxites	🔴	**Cobalt**	🟡
Antimony	🔴 ⚫	**Silicon metal**	🟡
Arsenic		**Lithium**	🟡
Baryte		**LREE**	
Beryl		**Magnesium**	🔴 🟡
Bismuth	🟡	**Manganese**	🔴 🟡 ⚫
Borates	🟡	**Cooper**	🟡 ⚫
Feldspar	⚫	**Nickel**	🟡 ⚫
Fluorite		**Niobium**	
Phosphorus	🔴	**Platinum Group Metals**	🔴 🟡
Phosphates		**Scandium**	
Galium	🟡	**Strontium**	
Germanium	🟡	**Tantalum**	
Natural graphite	🔴 🟡	**Titanium**	🟡
Hafnium		**Vanadium**	
Helium	⚫	**Coking coal**	🔴
HREE	🟡	**Tungsten**	🔴 🟡

⚫ New critical raw materials (2023) 🟡 Strategic raw materials for the EU
🔴 Critical raw materials for the Polish economy

Source: prepared by PEI based on EC and Ministry of Climate and Environment data.

Table 2. Forecast demand in 2030 for selected raw materials according to the *National Raw Materials Policy*

Metal	Percentage of demand covered by imports in 2009–2018 (%)	Forecast demand in 2030 based on *National Raw Materials Policy*
Aluminium/ bauxites	91.1	Expected decrease in the consumption of bauxite and high-alumina products in the iron and steel industry to around 40,000-45,000 tonnes (also due to the lack of bauxite alumina production in Poland).
Antimony	100	Increase in demand linked to the development of production of bearing alloys and, to a lesser extent, printing alloys. A slow and systematic increase to around 60 tonnes is expected.
Magnesium	100	Rapid increase in demand, which should reach 14,000 tonnes due to increasing use in the automotive industry (substitution of steel components), among other things.
Manganese	100	Moderate increase in demand (up to 50,000 tonnes) due to the stagnation of blast furnace metallurgy, which may be compensated for by the use of beverage cans and other packaging and containers (the raw material) in production. At the same time, however: a rapid increase in demand for manganese dioxide to 14,000-15,000 tonnes due to the growing production of galvanic cells and batteries in Poland.
Copper	-	Expected increase in consumption to around 400,000 tonnes due to the rapid increase in the capacity of photovoltaic and wind installations and the need to modernise existing transmission infrastructure.
Nickel	100	Expected gradual increase in consumption to 3000-4000 tonnes per year due to its key role in renewable energy technologies, hydro and geothermal power plants, the rapid development of lithium-ion batteries for the automotive sector, and the improvement of electricity storage systems.
Platinum Group Metals	78	Demand will grow steadily will exceed 10-13 tonnes. The increase in demand will primarily be dictated by the volume of catalytic converter production, which may be slightly hampered in the long term by the increase in electromobility.
Scandium	N/D	Moderate growth due to its limited use in advanced technologies (finished products or semi-finished products are imported by Poland). Possible increase in demand to 50-100 tonnes due to the development of electromobility.
Titanium	100	Demand will remain at 80,000-100,000 tonnes, conditioned by the demand for titanium white (pigment production for paint and varnishes for construction and the automotive, paper and plastics industries).
Coking coal	21.1	Domestic demand limited by the needs of the domestic coke industry (coke production used to produce steel). The expected level of demand is 12.5-13 million tonnes.
Tungsten	100	Demand will be close to the current level; 10-30 tonnes per year. No significant growth potential due to its limited use (production of cutting materials, electrodes and technical lighting).

Source: prepared by PEI based on *National Raw Materials Policy* (2022).

In addition to copper (mined in Lower Silesia and Lubusz Land) and the above-mentioned coking coal, the following critical raw materials from the Commission's list are present in Poland (www1):

- deposits of baryte and baryte with fluorine, the exploitation of which was discontinued,
- phosphorite deposits,
- gallium, germanium, vanadium, tungsten and cobalt (small amounts associated with copper, zinc and lead mining),
- titan (the Suwałki massif),
- feldspar raw materials (Lower Silesia and Lesser Poland),
- helium as a by-product of natural gas extraction (Wielkopolska),
- arsenic (Lower Silesia and Upper Silesia, as co-occurring deposits),
- nickel (Lower Silesia).

Chapter 2. Africa as Europe’s resource base

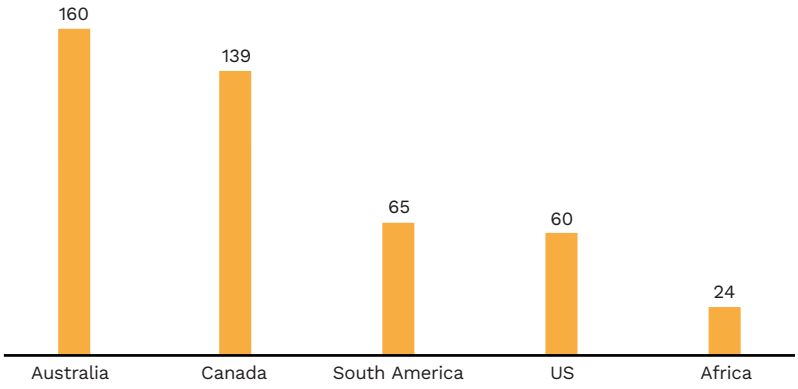
Africa has 30% of the world's mineral reserves and almost half of the world's gold deposits (www2). The raw materials buried underground include 59% of the world's Platinum Group Metal deposits, 48% of diamonds, 75% of cobalt, 68% of manganese, 59% of graphite and large unmarked deposits of lithium (World Bank, 2023). Africa also has 67% of the world’s phosphate reserves, with production dominated by Morocco, and 59% of its bauxite reserves, with Guinea in the lead, as well as uranium (33%). The continent has at least 20% of the reserves in the 12 key mineral categories for the green transition and 19% of the reserves of the metals needed to make a standard lithium-ion battery (NRGI, 2023).

Countries in Africa have a high geographical concentration of certain raw materials. For example, the Democratic Republic of the Congo is responsible for 72% of the world's cobalt production, and Rwanda for 30% of tantalum extraction. The world could not do without South Africa, which has a quasi-monopoly in the extraction of platinum and, to a lesser extent, palladium and manganese. African producers’ global significance compared to other countries is greater than the production figures suggest due to the low internal consumption relative to production volumes. For example, China is the world's largest producer of magnesium, with production of 930,000 tonnes in 2022 — however, it uses around 40% for its own needs (the rest is exported). In contrast, of the 91 million tonnes of bauxite extracted in Guinea in 2022, 81 million tonnes were exported; that is, almost 90%. In other cases, African countries have no or negligible internal consumption, and processed or pre-treated raw materials have to be re-imported from abroad.

Africa is often called a "geological scandal" — despite its wealth in terms of raw materials, it has not managed to embark on a sustainable development path. It continues to have the highest poverty rates in the world, with 16 of the world's 20 least developed countries in terms of income per capita. By 2030, Africa will account for 80% of global poverty, with 75% of the poor living in resource-rich countries. At the same time, Africa's dependence on the mining sector is extremely high, accounting for 10% of GDP and 50% of export earnings, excluding petroleum products; the mining industry also attracts most of the FDI flows coming into Africa (Albertin, Devlin, Yontcheva, 2021). These indicators not only describe the situation in Africa, but also have a strong impact on the EU’s planned efforts to diversify supplies of raw

material. The quality of governments and state institutions, regulatory and legal stability, the infrastructure deficit — all of these must be taken into account when building partnerships with countries in Africa.

Chart 4. Exploration work in Africa and other regions/countries in 2017 per 1 million km²

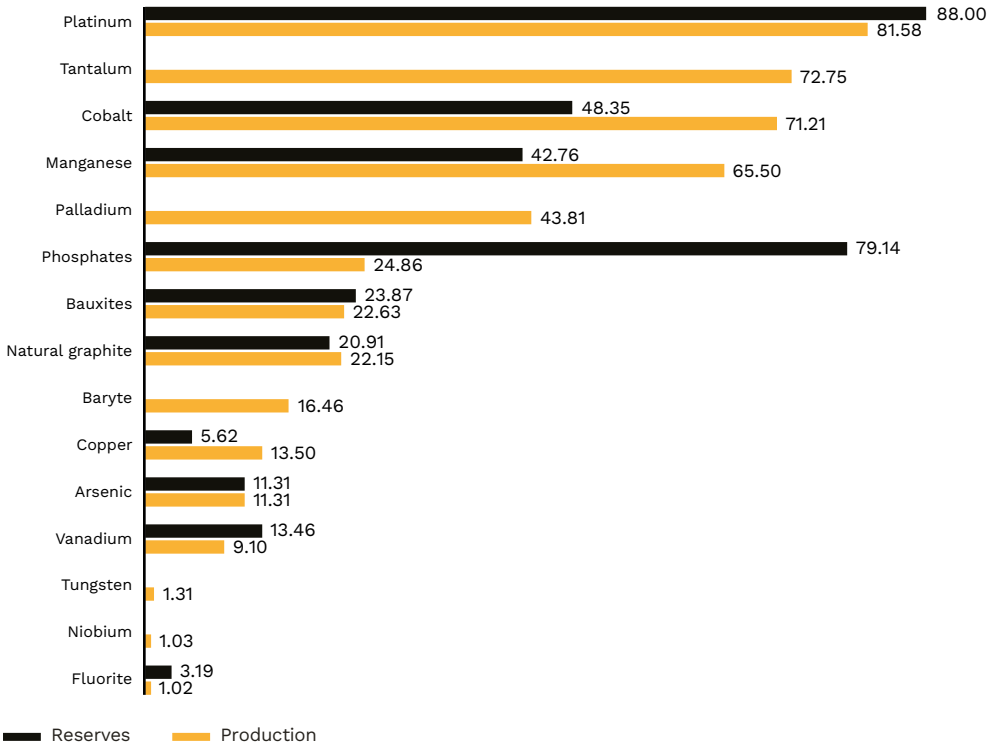


Source: prepared by PEI based on World Bank (2023).

Africa's raw material potential goes beyond production data due to the significant discrepancy between the size of the raw material reserves on the African continent and their commercial use. The majority of African deposits are not being extracted, often despite the existence of hard geological data. One example is Tanzania, which has the world's fifth-largest reserves of graphite, which is needed to produce lithium-ion batteries. However, in 2018, it only ranked 20th in terms of production, while Norway, which has reserves that are 30 times smaller, ranked 8th (World Bank, 2023).

Africa also remains the most geologically unexplored continent in the world. In 2017, 282 exploration projects were carried out on the continent — half the number in Australia and Canada, even though Africa's territory is three times larger (World Bank, 2023). For this reason, the absolute level of resource wealth in Africa, including metals and minerals, measured in dollar terms, is the lowest in any developing region (Wealth Accounts, 2021), including per capita. In the light of the green transition's ambitious targets, this means that a significant share of the projects in Africa that have been deemed not profitable enough could soon become attractive.

Chart 5. Selected critical raw materials produced in Africa in 2022, according to the USGS (share of global production and reserves, in %)

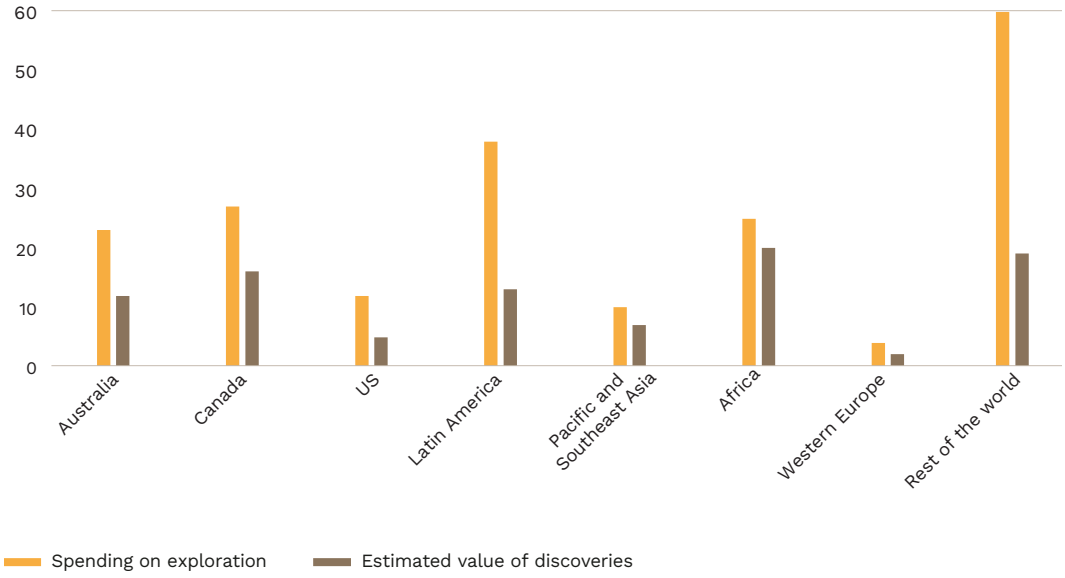


Source: prepared by PEI based on USGS data.

Compared to other regions, Africa is also characterised by low spending on exploration and geological work. In 2022, it attracted just 10% of global spending on exploration (www4). Most of it went towards gold prospecting in four countries: Ghana, Mali, Côte d'Ivoire and South Africa. This has been going on for years, despite the fact that Africa is considered the most profitable region in exploration terms. The value of discoveries as a ratio of exploration costs is around 0.8 there, compared to 0.5 in Australia, 0.6 in Canada and 0.3 in Latin America (World Bank, 2023). The most key explaining the low exploration budgets include:

- political and regulatory instability,
- security issues,
- problems with infrastructure (transport, access to energy and water),
- lack of geological data,
- limited access to financing.

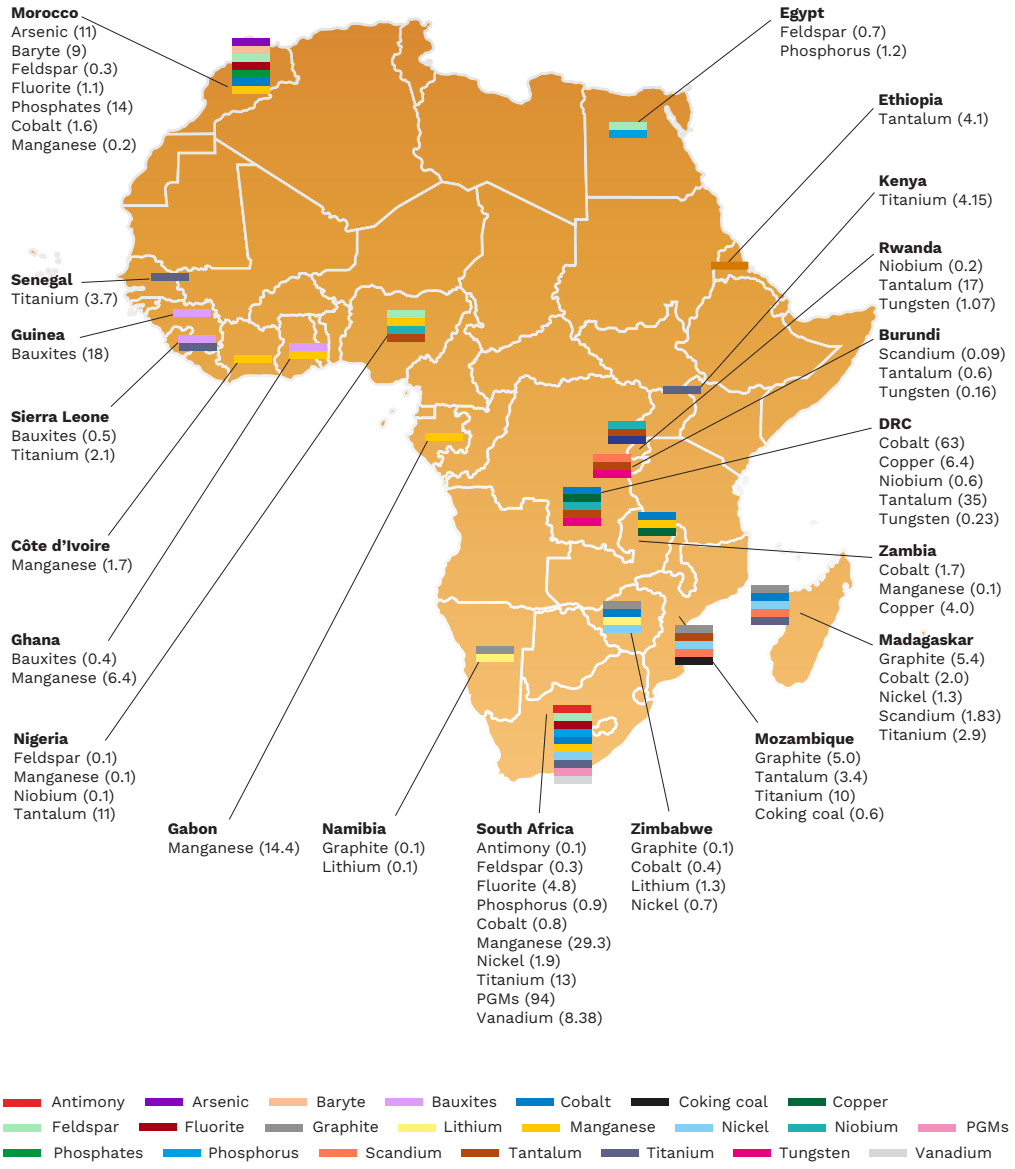
Chart 6. Spending on exploration and value of discoveries in 2007-2016 (billions of USD)



Source: prepared by PEI based on World Bank (2023).

Our analysis shows that Africa currently extracts 24 of the 34 critical raw materials on the Commission's list. This number is not the same as the size of the reserves and does not include many raw materials marked by geological surveys, or those produced in small commercial quantities or where extraction constitutes a small percentage of global production (less than 0.1%). The calculations are based the data used by the European Commission showing Africa's share in production in 2016-2020. The analysis was supplemented with the most up-to-date data on raw material production published by the United States Geological Survey. For detailed information on the volume and location of extraction, see the Appendix to this report. The raw materials are ranked based on the EU's dependence on imports of unprocessed or, in the absence of data, processed raw materials, as a percentage (see Table 1).

Map 2. African countries' share in the global production of critical raw materials



Source: prepared by PEI based on European Commission and USGS data (latest data available).

Chapter 3. The redefinition and strengthening of the EU's relations with Africa

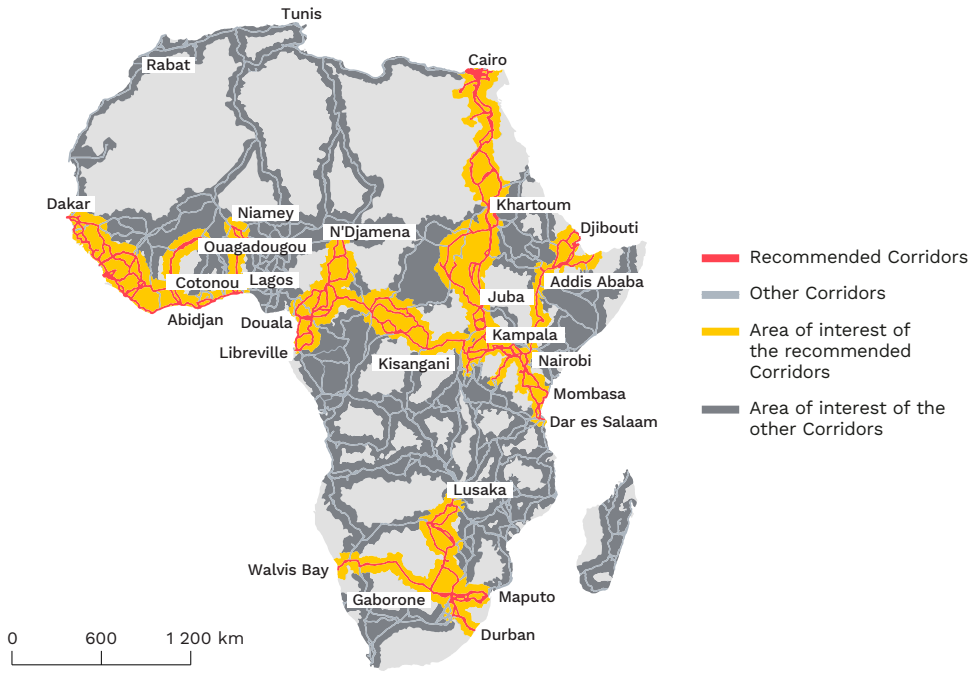
The EU's energy and digital transition requires the redefinition of relations with Africa. At the same time, it offers European countries the opportunity to make up for years of delays compared to China in designing comprehensive supply chains for the extraction, refining and use of critical raw materials. For Africa, it is a unique opportunity to carry out its own transformation and resource-based industrialisation. The bottleneck is time. The EU is just 27 years away from its announced deadline for achieving carbon neutrality, whereas it takes 17 years on average to start producing minerals after they are discovered (NRGI, 2022).

The EU's strategy towards Africa must be consistent with climate policy assumptions. In addition — unlike most non-allied countries, especially China — the EU must take into account the values and norms that guide it, in terms of good governance, impact on local communities and environmental protection (ESG). American company Lifezone Metals' plans to obtain nickel in Tanzania using dedicated low-emission technology, and which received financial support from mining company BHP Group in 2022, may offer inspiration (www5).

The bottleneck when extracting raw materials in Africa is infrastructure. A significant share of the reserves of critical metals that have been identified is located in landlocked countries, which makes it difficult (and more expensive) to transport raw materials to international markets. For example, the Goulamina Lithium Project in Mali is 1000 km from the nearest port, and Zambia and the DRC have low-capacity transport infrastructure due to the large amounts of copper and cobalt exported from the Copperbelt. However, even in countries with direct access to the sea, transport remains a major challenge. The Namibian lithium deposits in Uis are relatively close to the coast (around 100 km), but the country still lacks a paved road connecting the mine with the port.

The Global Gateway (GG) initiative announced in 2021 should be used to support the development of infrastructure for critical raw materials. The EU sees it as a counterpoint to China's Belt and Road Initiative (Gili, 2023). Half the USD 300 billion budget for 2021-2027 is set to go to African countries. The GG initiative accelerated at the end of 2022, as shown by the creation of a supporting financial vehicle, the Global Gateway Fund, which will finance infrastructure projects in the spirit of sustainable development (40% of the project portfolio), among other things. The first GG projects are appearing already, but they are modest in scale. For example, the EU plans to allocate USD 50 million to support the mining sector and infrastructure projects in the DRC (www6). One of the GG's priorities should also be to support the creation of the 11 strategic transport corridors that African Union has deemed a priority (www7). Five of them can be considered "raw material corridors" (Baranzelli et al., 2022).

Map 3. Strategic transport corridors in Africa



Source: prepared by PEI based on European Commission data.

The redefinition of relations with Africa should be based on the imperative of building local value added. The race for critical raw materials is not the first race that Africa has been involved in as a supplier of raw materials. The previous one, which coincided with colonialism and then decolonisation,

was not properly used to create a processing and industrial base that would allow the value added generated by processing raw materials to remain in place. Africa's losses are significant. For example, while bauxite ore costs USD 50 per tonne, a ton of aluminium produced on its basis costs USD 2200. Spodumene concentrate (lithium ore) is currently selling for USD 5000 per tonne, whereas lithium hydroxide, produced through refining, costs USD 47,000.

Increasing local value added is one of the cornerstones of the Africa Mining Vision adopted by the African Union in 2010. The US administration seems to understand this, which led to the signing of a letter of intent with the governments of the DRC and Zambia in January 2023. The Americans committed to support the processing industry and expand supply chains for the production of batteries for the EV industry (www8). The EU should look at Africa in a similar spirit; through the prism of supporting processing, including using RES. North Africa, especially Morocco, is interesting in this regard due its geographical proximity. In the case of the EU, the political and social resistance to the revival of mining in Europe and the onshoring of the processing industry, which are the source of many negative externalities, offers an additional incentive to support these kinds of initiatives.

Understanding their growing importance in the supply chains of critical raw materials, African countries are increasingly promoting the creation of value added through trade restrictions and financial penalties. For example, in December 2022, Zimbabwe adopted the Base Mineral Export Control Act, which bans exports of unprocessed lithium (ore). The law does not cover companies that are building mines or that will process the ore on site. It therefore mainly affects new market participants and artisanal mining, and thus seems to favour Chinese investors already present on the ground (it also aims to curb illegal metal smuggling) (www9). Namibia could adopt similar legislation soon. Meanwhile, on the wave of the increases in bauxite prices, the ruling junta in Guinea has issued an ultimatum to ten mining companies: they must announce the construction of a bauxite refinery or face financial penalties (this country currently has one refinery, Friguia, owned by Russian company Rusal) (www10).

However, creating a processing and industrial base in Africa will not be easy due to the poorly-developed energy infrastructure, heightened political risk and limited access to capital. The Peterson Institute for International Economics' study covering four critical African countries, in terms of the supply of raw materials — DRC (cobalt), Mozambique (graphite), Madagascar (graphite and nickel) and Guinea (bauxites) — shows that none of them currently has the conditions to expand processing potential (Hendrix, 2022). The solution could be to support supply chain expansion that would allow for the onshoring of processing, but on the basis of raw materials obtained within a single chain. One example of this type of chain reshuffling is the USD 107 million loan granted by the US Department of Energy to Australian company Syrah Resources for the construction of a graphite refining plant in Vidalia (Louisiana), which will be supplied with graphite obtained in Mozambique by the same company (www11).

Table 3. Investment attractiveness of selected countries in Africa for mining, based on selected criteria

Country	Raw materials	Vote in the UN calling for an end to the war in Ukraine on 2 March 2022	Corruption Perception Index (2022)	Infrastructure Development Index (2021)	Security Threats Index (2022)	Attractiveness index
Morocco	Arsenic, baryte, feldspar, fluorite, phosphates, cobalt, manganese	Did not vote	48	66.92	54	168.92
South Africa	Antimony, feldspar, fluorite, phosphorus, cobalt, manganese, nickel, titanium, platinum group, vanadium	Abstained	43	80.19	31	154.19
Egypt	Feldspar, phosphorus	For	30	88.74	27	145.74
Namibia	Graphite, lithium	Did not vote	49	30.11	55	134.11
Ghana	Bauxites, manganese	For	43	30.68	57	130.68
Rwanda	Niobium, tantalum, tungsten	For	51	22.02	45	118.02
Zambia	Cobalt, manganese, copper	For	33	25.05	58	116.05
Gabon	Manganese	For	29	31.86	55	115.86
Senegal	Titanium	For	33	30.03	52	115.03
Sierra Leone	Bauxites, titanium	For	34	11.94	65	110.94
Côte d'Ivoire	Manganese	For	37	24.16	31	92.16
Kenia	Titanium	For	32	26.52	29	87.52
Madagascar	Graphite, cobalt, nickel, scandium, titanium	Abstained	26	11.45	40	77.45
Mozambique	Graphite, tantalum, titanium, coking coal	Abstained	26	12.62	27	65.62
Ethiopia	Tantalum	Did not vote	38	10.62	15	63.62
Zimbabwe	Graphite, cobalt, lithium, nickel	Abstained	23	26.23	13	62.23
Nigeria	Feldspar, manganese, niobium, tantalum	For	24	23.73	11	58.73
Burundi	Scandium, tantalum, tungsten	Abstained	17	16.21	23	56.21
Guinea	Bauxites	Did not vote	25	18.76	10	53.76
Democratic Republic of the Congo	Cobalt, copper, tantalum, niobium, tungsten	For	20	9.34	13	42.34

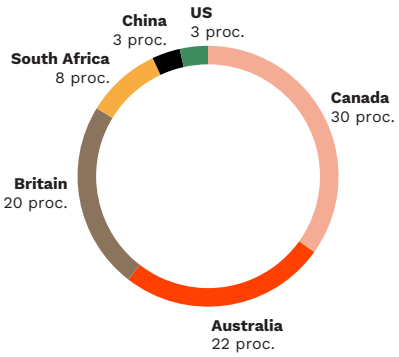
Source: prepared by PEI based on USGS, African Development Bank, Transparency International, Fund for Peace, and World Bank data.

To increase access to African raw materials, the EU will have to build strategic partnerships with African countries. It plans to do so by signing agreements deepening cooperation when it comes to critical raw materials, including as part of the Critical Raw Materials Club announced by the EU on 16 March 2023. The Club seeks to bring together countries that produce and use critical raw materials in industrial production and implicitly end China's dominance, but also neutralise the transatlantic tensions prompted by the adoption of the IRA. In this spirit, an agreement with Namibia was signed in October 2022. It covers the supply of critical raw materials, including renewable hydrogen, in exchange for supporting the development of mining and efforts to increase local value added. The European Investment Bank went on to sign an agreement with the Namibian government providing for EUR 500 million worth of support for investments linked to renewable energy. Although the details of the Club are not yet known, the EU plans to expand its network of partnerships in Africa in the near future, including to Rwanda and the DRC.

The Minerals Security Partnership (MSP) established by the US in June 2022, sometimes referred to as the "Metal NATO", can be considered complementary to the Club. For now, it mainly concerns allied countries with a similar level of development, but the administration's attention is also shifting towards Africa (www12).

The strategic partnership will have to be filled with content in the form of specific projects agreed on between European companies and their African counterparts. Unfortunately, much still remains to be done (Wouters, 2023). EU companies' presence on the continent, measured by expenditure on exploration work, is symbolic, or at least small compared to other countries. According to S&P Global Market Intelligence data, just four countries — Canada, Australia, Britain and South Africa — accounted for 80% of spending on exploration on the continent in 2022. Despite its large and rapidly-growing presence in the mining sector in Africa, China is moderately active in the search for new deposits, giving way to more experienced entities. At the same time, it is focusing on acquiring shares in existing projects and improving mines' profitability. In 2020, expenditures on exploration by Chinese companies reached USD 101 million, compared to USD 267 million in 2011; of this, 12.3% was spent in Africa (www13). China's spending on exploration in Africa amounted to just 3% of global spending in 2022.

Chart 7. Structure of spending on exploration in Africa (six most active states, November 2022)



Source: prepared by PEI based on S&P Global data.

A group of countries with the most potential — in terms of the raw materials they possess and the possibility to work together to acquire them — should be selected. The African continent is diverse, with 54 countries with a variety of raw materials and limitations on their extraction. Strategic partnerships should be based on mutually complementary EU demand and the availability. Based on our analysis, strategic partnerships should be forged with the following countries, in particular: the Democratic Republic of the Congo (DRC), Rwanda, Zimbabwe, Zambia, Mozambique, Madagascar, South Africa, Guinea, Morocco and Namibia. A barrier to building a strategic partnership will be African partners' limited trust in Europe, which has repeatedly been accused of neo-colonial attempts and paternalism in the past. This will require active diplomatic efforts by the EU and European countries. African partners must be convinced that cooperation will be win-win.

Financing is a key condition for the turn towards Africa and an increase in its share in the EU's raw material supply chain. This should be analysed at three levels: the EU, national and private-sector level. Irrespective of EU institutions' actions, **Poland should actively cultivate closer relations with Africa and provide financial (and insurance) vehicles to secure the supply of raw materials,** especially those specified in the National Raw Materials Policy. There have been a number of these kinds of initiatives in the EU in recent months. One example is the USD 800 million loan granted to international company Trafigura by a syndicate of European banks for the supply of critical raw materials to Germany and guaranteed by the German government through the German Export Credit Agency (ECA) Euler Hermes Aktiengesellschaft (www14). At the same time, private entities' efforts should be supported to provide them with access to critical raw materials on the basis of individual contracts. Many companies, such as Volkswagen, Renault and BMW, are signing contracts that guarantee the stable supply of raw materials on their own.

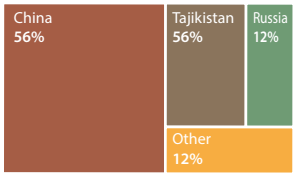
Appendix 1. Analysis of the availability of individual critical raw materials in Africa

Antimony

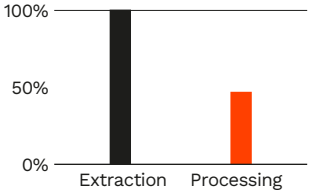
South Africa is currently the only country on the African continent where antimony, a raw material that will increasingly be used in the green transition (including energy storage), is extracted.

Application: flame retardants, defence applications, lead-acid batteries

Main producers:

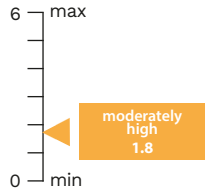


Import dependency:

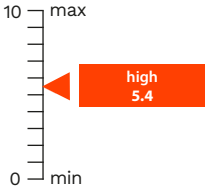


African producers:

Supply risk*:



Economic significance:



*The measure used by the European Commission to assess the risk of disruptions in the supply of a specific raw material based on the degree of dependence on imports, the quality of governance in the supplier country, export restrictions and the availability of substitutes, among other things.

South Africa has the second-largest reserves of it in the world, in the Murchison Greenstone Belt in Limpopo Province (the "Antimony Line") and once accounted for one-fifth of global production (at the Stibium Mopani Mine, formerly known as the Consolidated Murchison Mine) (www15). Commercial mining production halted in 2014 and it is currently mined on a limited scale; mainly artisanal mining. The size of the reserves (around 25,000 tonnes) and high concentration of global production (three countries — China, Russia and Tajikistan — are responsible for 91% of production) and refining (80% of processing is carried out in China), mean that South Africa could become a promising source when it comes to diversifying antimony supplies in the future.

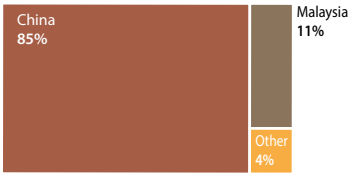
Rare earth elements

Rare earth elements are a group of 17 elements classified in two categories: Heavy Rare Earth Elements (HREE) and Light Rare Earth Elements (LREE). HREEs are less available, heavier and have a higher atomic number, while LREEs are more common, lighter and have a lower atomic number. Africa does not produce a significant amount of rare earth metals, although there are many indications that it has abundant — though widely dispersed — deposits of them (contrary to their name, rare earth elements are not rare, just expensive to exploit). REE are widely used in industry, from magnet production to the defense industry, electromobility and renewable energy. Currently, there is only one dedicated REE mining project: the Gakara Rare Earth Project in Burundi. Launched in 2017, the Gakara project encompasses some of the richest REE deposits in the world. British company Rainbow Rare Earths Limited has a majority stake in the mine (90%), while the government of Burundi owns 10%. The Steenkampskraal project (15 metals, 86,900 tonnes of total rare earth oxides (TREO) including the two most valuable elements, dysprosium and terbium) is set to enter the operational phase soon (www16). Other promising projects include: the Lofdal Heavy Rare Earths Project (Namibia) run by Canadian company Namibia Critical Metals Inc. in cooperation with the Japan Organization for Metals and Energy Security, Kangankunde (Malawi) by Australian Lindian Resources Ltd., and Songwe Hill (Malawi) by Canadian Mkango Resources Ltd., the Longonjo Project (Angola) by British Pensana Rare Earths (Angola), the Ngualla Rare Earth Project (Tanzania) by Australian company Peak Rare Earths Ltd, the Makuutu Project (Uganda) implemented by Ugandan Rwenzori Rare Metals, whose majority shareholder is the Australian Ionic Rare Earths, Tantalumus (Madagascar) by the German company Tantalumus Rare Earths, the Xiluvo REE Project (Mozambique), and the Glenover and Phalaborwa Projects (South Africa) managed by British company Rainbow Rare Earths.

LREE

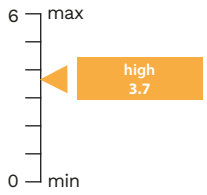
Application: permanent magnets for electric motors and electricity generators, lighting phosphors, catalytic converters, batteries, glass and ceramics

Main producers:

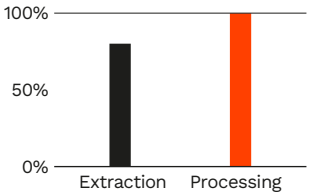


African producers:

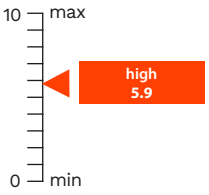
Supply risk:



Import dependency:



Economic significance:



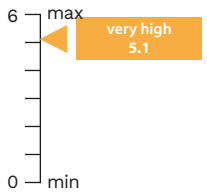
HREE

Application: permanent magnets for electric motors and electricity generators, lighting phosphors, catalytic converters, batteries, glass and ceramics

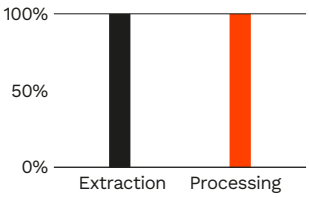
Main producers:

African producers:

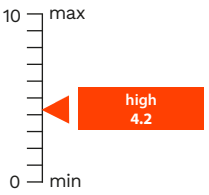
Supply risk:



Import dependency:



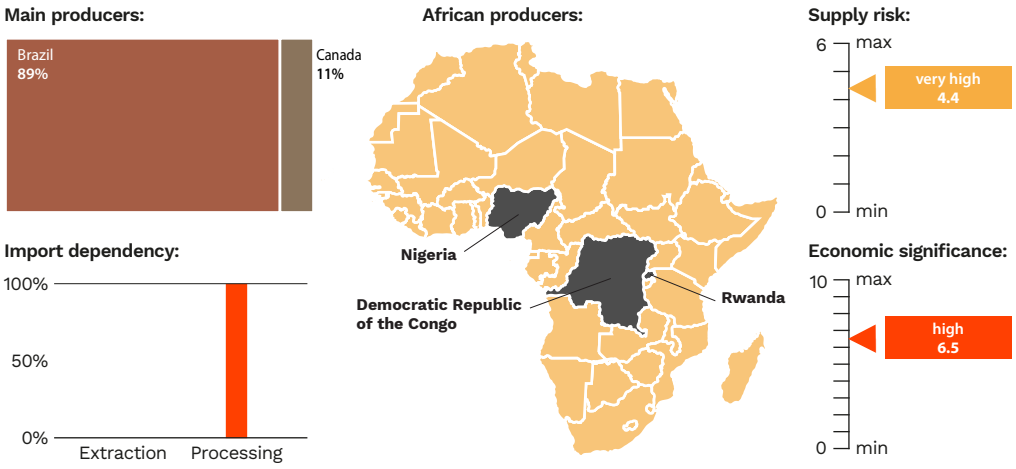
Economic significance:



Niobium

Niobium is traditionally used in steel production (approximately 90% of global consumption), but its use in electromobility is growing (for example, batteries with reduced charging time). This raw material usually coexists with tantalum and is obtained from coltan ore. Currently, niobium is mined in small quantities in three countries in Africa: Rwanda, the DRC and, to a lesser extent, Nigeria. The DRC is the world's third-largest and Rwanda the world's fifth-largest producer of niobium: 600 tonnes and 210 tonnes respectively (2022). Global production is almost entirely dominated by Brazil (89%). In the DRC, niobium is mainly obtained in the east of the country, in East and North Kivu (the Lueshe mine). In Rwanda, the richest deposits are in the Western Province and the northern part of the Southern Province (Kamprowski, 2021). In addition, the only coltan ore refinery in Africa, which will separate tantalum and niobium, will open soon in Rwanda. In the near future, Malawi, where the Australian company Globe Metals and Mining plans to open the first mine in Africa with technology dedicated to niobium production (the Kanyika Project), could join the group of producers (www17).

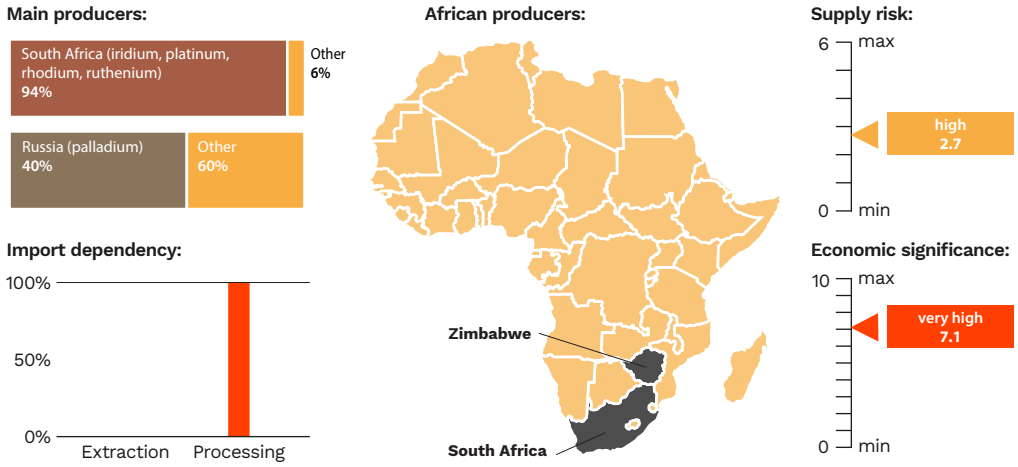
Application: high-strength steel and superalloys used in transport and infrastructure, capacitor production, superconducting magnets



Platinum Group Metals

The Platinum Group Metals (PGMs) are six rare metals: iridium, osmium, palladium, platinum, rhodium and ruthenium. PGMs are used to produce catalysts, but they are also increasingly used in green technologies; for example, in fuel cells for electric vehicles and the implementation of a hydrogen-based economy. Palladium and platinum have the greatest economic significance; the other metals in the group are obtained as co-existing raw materials, in smaller quantities. Total production of PGMs is small and amounts to just a few hundred tonnes per year (472 tonnes in 2021). South Africa has a quasi-monopoly on the PGM market; it accounts for 38% of global production of palladium (Russia ranks first, with 42% of the market), 74% of platinum, 81% of iridium, 90% of ruthenium and 90% of rhodium. It is estimated that, in total, up to 90% of the world's PGM reserves are located in South Africa (USGS, 2023). Zimbabwe is also an important producer; 6% of the world's supply of palladium and 7.8% of platinum came from there in 2022. There are over 80 active platinum mining projects in South Africa, scattered across the provinces of Mpumalanga (13), Guateng (4), North West (31), Free State (1) and Limpopo (35) (www18). Five mines owned by Anglo American located in the Bushveld Complex (a rich area in terms of natural resources) play a key role in PGM production. They are Mogalakwena, Amandelbult (the Tumela and Dishaba mines), Mototolo, and the Unki mine in Zimbabwe. 40% of the world's PGMs come from them. Other leading South African producers include Sibanye Stillwater (the Marikana, Rustenburg and Kroondal Mines), Impala Platinum (the Impala Mine), Northam Platinum (Booysendal), Eastern Platinum (Crocodile River) and Royal Bafokeng Platinum (Styldrift 1 and Bafokeng-Rasimone) (www19).

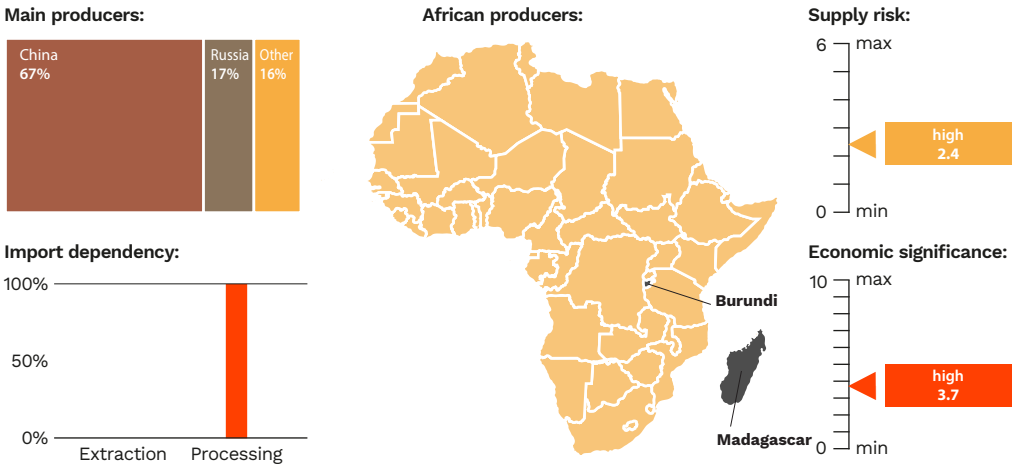
Application: chemical and automotive catalysts, fuel cells, applications electronic



Scandium

Scandium is often thought of as a rare earth element, but it is actually a light transition metal that falls outside the standard REE classification of 17 elements. It is mainly used in the production of semiconductor fuel cells and in new-generation high-strength aluminium alloys. In Africa, scandium is harvested as an accompanying raw material in the Befanomo region in Madagascar and on a small scale in Burundi (no data on production). Madagascar is the only country in the world, apart from Norway, where scandium is obtained from a mineral called thortveitite.

Application: oxide fuel cells, light alloys

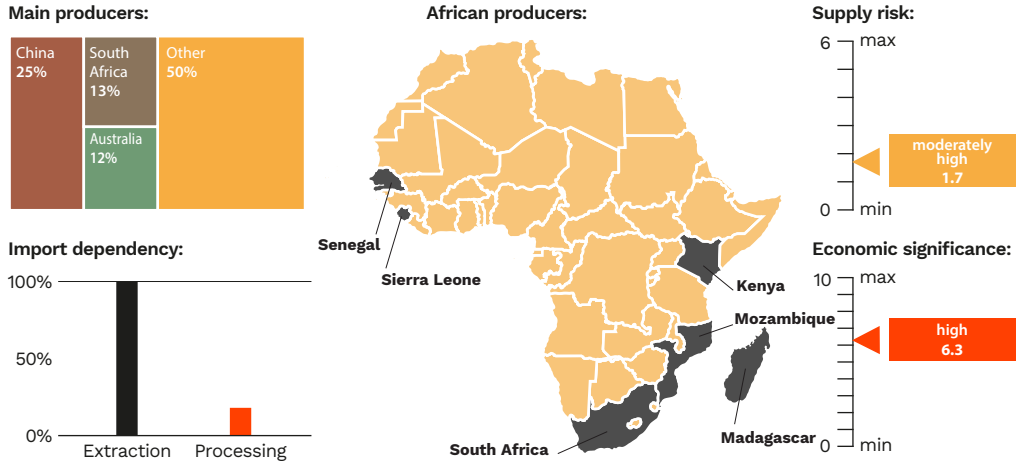


Titanium

Africa plays a significant role in the global production of titanium, a metal with critical properties for military technologies (such as missiles and jet engines), among other things. As much as 35% of the world's supply of unprocessed titanium (2021) (www20) comes from African mines, mainly obtained from ilmenite (titanium ferrum) and rutile. It is estimated that around 94% of the demand for titanium ores is linked to the extraction of titanium dioxide (so-called titanium white). Just 6% is metallurgy; the production of titanium (metal) and titanium alloys. The leadings producers of titanium in Africa are Mozambique and South Africa. In 2021, Mozambique produced 1.1 million tonnes, while South Africa produced 995,000 tonnes. This puts them in second and third place globally in terms of production. Only China extracted more; it also dominated in processing. The main source of titanium in Mozambique is the Moma mine in the Nampula province, managed

by Irish company Kanmare Resources, which contains one of the largest titanium deposits in the world (6.3 million tonnes) (www21). In 2020, it exported 853,000 tonnes to international markets. Ilmenite ores are also being obtained by Ding Sheng Minerals in the Chibuto district (Gaza province); the majority shareholder (85%) is the Chinese Anhui Foreign Economic Construction Group. Extraction at this second-largest mine in Mozambique amounted to 17,700 tonnes in 2021 (www22). In South Africa, titanium is mainly extracted at three mines: Tisand (KwaZulu-Natal province) managed by Richards Bay Minerals (RBM), owned by a consortium of South African Rio Tinto (74%) and Blue Horizon (24%), and Hillendale and Namakwa Sands, controlled by Australian company Tronox (acquired from Exxaro). Another significant producer is Senegal (491,000 tonnes), where ilmenite and rutile are obtained near the coast (north of Dakar) by Grande Côte Operations, owned by Eramet (France), Mineral Deposits Limited (Australia) and the Senegalese government (10%) (www23). In Madagascar, where total production amounted to 414,000 tonnes in 2021, titanium ore is mined at the Taolagnaro QIT Madagascar Minerals (QMM) mine owned by Rio Tinto (80%) and the government (20%), and as part of the Toliara Project by Australian Base Resources (85%). The same Australian company mines titanium in Kenya through its subsidiary, Base Titanium, at the Kwale mine. Titanium production in Kenya is estimated at 253,000 tonnes (2021). The last African producer on the list is Sierra Leone (123,000 tonnes). The largest rutile mine (the Sembuhan mine) operator in the country is Sierra Rutile Limited, which Australian Iluka Resources Limited acquired in 2016.

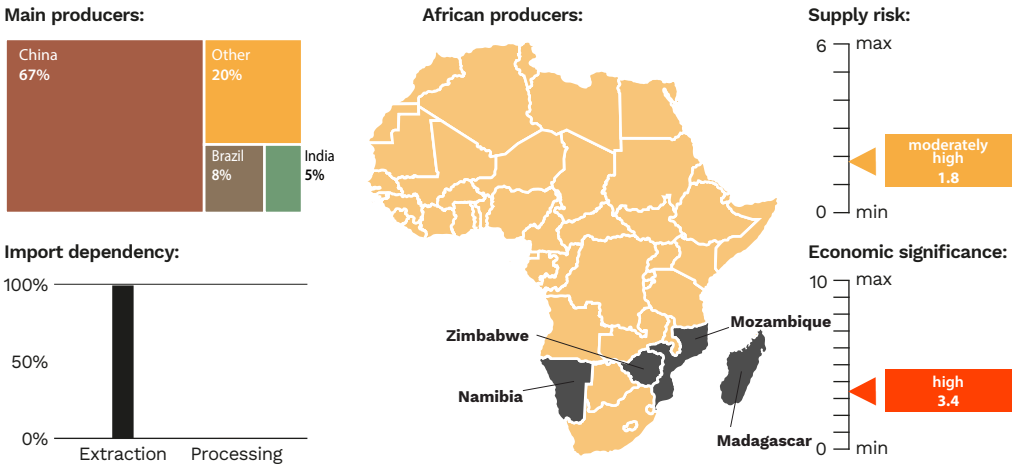
Application: light, high-strength alloys used in the aeronautics, aerospace and defence industries, among others, medical applications



Natural graphite

Africa accounts for 9% of the world's graphite production, mainly due to the Balama mine in Mozambique managed by Australian entity Syrah Resources, the world's largest graphite mine in terms of tonnage, purity and production capacity (313,000 tonnes per year) (www24). In 2018, production amounted to 153,000 tonnes; it has now dropped to 72,000 tonnes due to jihadist attacks and the pandemic. In addition, graphite is mined in smaller mines in Namibia and Madagascar, with a production of 10,000 tonnes per year, around 1% of global production. In Namibia, the Aukam mine owned by Canadian company Gratomic plans to resume production with a maximum extraction of 22,000 tonnes per year. In Madagascar, graphite is extracted by Australian company Greenwing Resources at the Graphmada mine (maximum output: 40,000 tonnes), and the British Tirupati Graphite plans to start production at the Sahamama (84,000 tonnes) and Votamina (60,000 tonnes) mines. Tanzania will become a new producer in the near future; six mines with high-quality deposits with a total production capacity of 450,000 tonnes per year are currently in the pilot or development phase. According to forecasts, these mines will increase Africa's share in global graphite production to 26% by 2026 (www24). Until recently, Zimbabwe was an important producer of graphite, with several thousand tonnes of it per year; in 2015, it was the tenth-largest producer in the world (www25). The graphite came from the Lynx mine (Karoi), which declared bankruptcy in 2021.

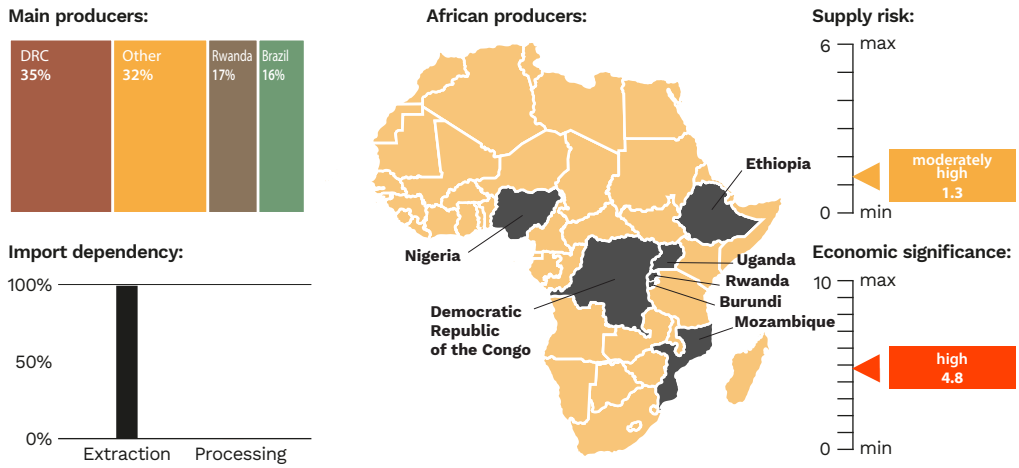
Application: batteries, refractory materials for the steel production



Tantalum

Tantalum is widely used in the electronics (capacitors, diffusion batteries), chemical (specialist devices and apparatus), space (interiors of spacecraft combustion chambers), and medical industry (surgical tools). In Africa, it is currently mined in the: DRC, Rwanda, Nigeria, Burundi, Uganda, Ethiopia and Mozambique. The main supplier to international markets is the DRC. In 2022, extraction there amounted to 860,000 tonnes (www26). The second largest-producer in Africa — and third globally — is Rwanda, with a production of 360,000 tonnes. However, due to the illegal smuggling (and illegal production) of tantalum from the DRC, the lack of reliable data and the long-lasting conflict in the Great Lakes region, it is difficult to estimate how much of Rwandan production is actually produced there. A similar problem applies to Burundi and Uganda, the third- and fourth-largest African producers of tantalum. Africa is currently the main source of tantalum, with most of production coming from relatively easily-accessible deposits by artisanal mining (Krzak, Gałam, Król, 2021). The DRC together with Rwanda account for more than half of the world's production of this metal. Tantalum is also obtained in significant quantities in Nigeria (approximately 13% of global production) from tantalite ores. This is mainly done by artisanal mining in the states of Nasarawa, Kogi, Osun, Ekiti, Kwara and Cross River. According to official data (www27), extraction licenses are held by West African Polaris Investments LTD, Scapat Nigeria Limited, Ezza-Ezekuna Resources Limited, Kenyang Mining Company Limited, Evergreen Apple Gypsum Limited and Consolidated Tin Mines Limited.

Application: capacitors for electronic devices, superalloys



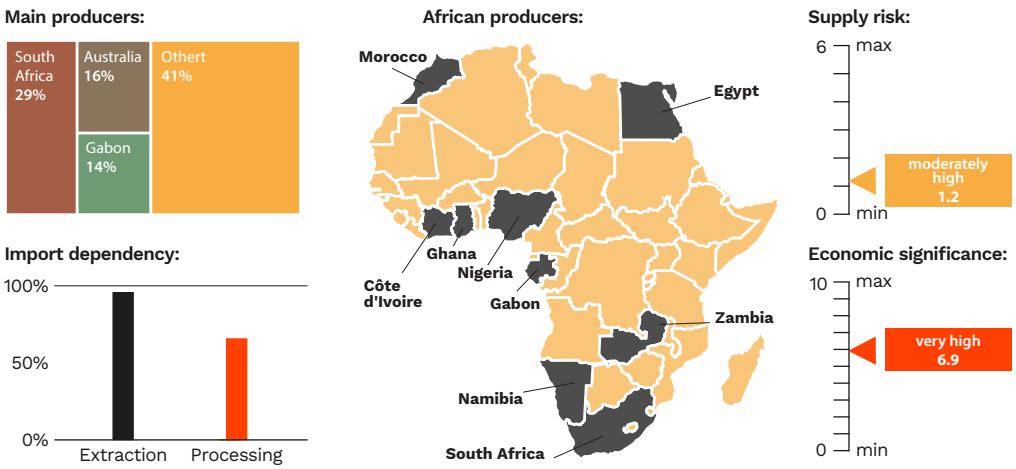
Some sources say that Nigeria has one of the largest tantalum deposits in the world, but there is a lack of geological data that could unequivocally confirm this. In Mozambique, tantalum was mined until recently in conventional mines in Muaine, in the province of Zambezia (Alto Ligohina) and in Marripino, where the mining is mainly artisanal. Another significant producer of tantalum

(sixth globally) is Ethiopia, where 4.4% of global production comes from. Until recently, it was mainly mined in the Kenticha mine in the Guji Zone in the state of Oromia (the reserves there are estimated at 17,000 tonnes) (www28). However, production was suspended in 2017 and Ethiopian tantalum mainly comes from artisanal mining now.

Manganese

Manganese is the fourth most common industrial metal by tonnage after iron, aluminium and copper. It is mainly used in the production of stainless steel and aluminium alloys, but also in lithium-ion batteries (as a stabiliser in the structure of cathode materials). Africa is the largest reservoir of manganese deposits in the world. The top ten producers of it include as many as four African countries (www29). South Africa is leading producer of manganese, with 7.2 million tonnes in 2022, 33.5% of global production. Most of the manganese reserves, estimated at 640 million tonnes, are located in the Kalahari Desert, in the northern part of the country. It is estimated that as much as 80% of global deposits of the metal may be located there (www30). The most significant manganese producers in South Africa are Australian companies: South22 (the Mamatwan and Wessels mines through the Hotazel Manganese Mines consortium, in which it holds a 44.4% stake) and Jupiter Mines (with a 49.9% stake in the Tshipi Borwa mine; the remaining stake remains with BBE consortium Ntsimbintle Mining).

Application: steel production, aluminium alloys

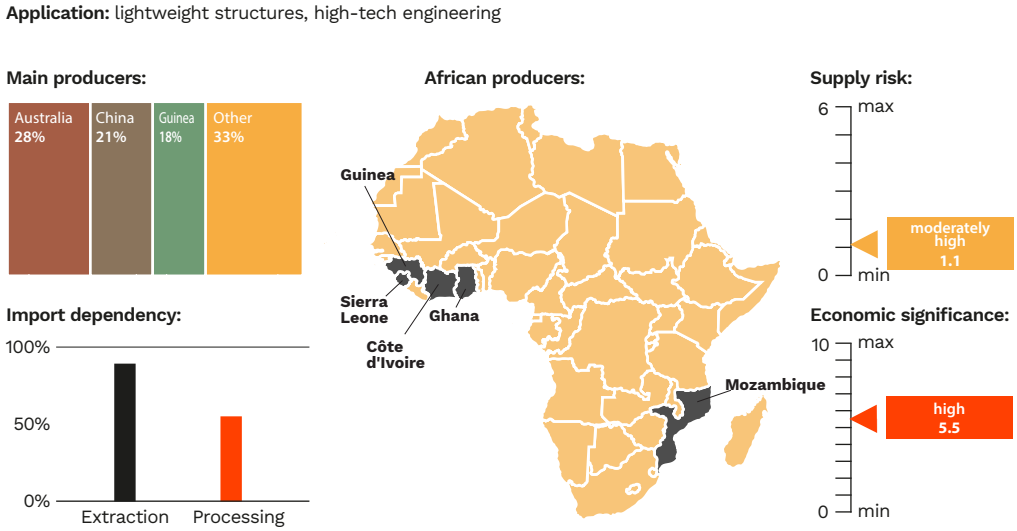


The Tshipi Borwa mine has a production capacity of 3-3.6 million tonnes per year, making it one of the largest (and cheapest to operate) manganese mines in the world. The potential for manganese production in South Africa is significant, but the current production volume is limited by logistical difficulties (www31). The second manganese extraction powerhouse is Gabon. With production estimated at 4.6 million tonnes in 2022, it has moved into second place globally, ahead of Australia. The metal is sourced

from sites near Franceville, Okondja, Akieni, Lastoursville, N'djole and Mbigou. The main mine is Moanda, operated by Comilog (Compagnie minière de l'Ogooué), a subsidiary of French company Eramet, the second largest producer of high-purity manganese in the world. Ghana ranked third in terms of production in 2022 (940,000 tonnes). The metal is mainly mined in the vicinity of the city of Takoradi (the Nsuta mine), and most of the production is the responsibility of Consmin (Consolidated Minerals), which was acquired by a subsidiary of the Chinese Ningxia Tianyuan Manganese Industry (TMI), one of the world's largest manganese producers. Consmin owns 90% of the Ghana Manganese Company, the sole producer and exporter of Ghanaian manganese. The fourth-largest producer of manganese in Africa is Côte d'Ivoire, where 360,000 tonnes of the raw material were extracted in 2022. Small amounts of manganese are also mined in Morocco, Namibia and Egypt.

Bauxites/aluminium

Bauxites — sedimentary rocks, which are the main source of aluminum — are mined in five countries in Africa, but Guinea has been the main producer, and the third-largest producer globally, for years (www32). In 2022, Guinean bauxite production amounted to 91 million tonnes; of this, 81 million tonnes were exported (www33).



At the same time, Guinea's bauxite reserves, characterised by a high 50% alumina content, are the most abundant in the world; they are estimated at 7.4 billion tonnes, 25% of the world's reserves. Most of the ore comes from the Sangaredi mine, Guinea's largest, located in the Boké region (16 million tonnes). It is managed by a public-private consortium (Government of Guinea 49%, Alcoa 22.95%, Rio Tinto 22.95%, and Dadco Alumina & Chemicals 5.1%). Two other significant mines (also in Boké) are Boffa Bauxite, majority-owned by Aluminum Corporation of China (85%), which in 2021 extracted 12 million tonnes, and the GAC mine operated by Emirates Global Aluminum (100%),

which extracted 21 million tonnes (www34). Bauxites are also produced in neighbouring Sierra Leone (1.1 million tonnes) by Sierra Minerals Holdin gs 1 Limited, a subsidiary of Vimetco N.V. SMHL, headquartered in the Netherlands, in Ghana in the Awaso, Kyebi and Nyinahin regions (700,000 tonnes) and in Côte d'Ivoire (200,000 tonnes), at the Bénéné mine opened in 2019, operated by domestic company Lagune Exploitation Bongouanou (LEB). Small amounts of bauxite (7800 tonnes) are also mined in Mozambique, at the historic Mina Alumina mine in the Manica Province.

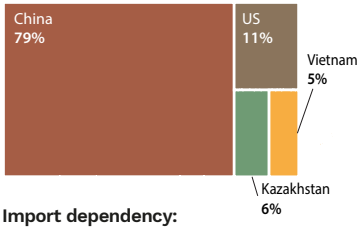
Phosphorus and phosphates

The production of phosphorus (the element) in Africa is small and currently limited to two countries: South Africa and Egypt. In the case of phosphates (sedimentary rocks), which are a natural source of phosphorus and used to produce artificial fertilisers, the key producer is Morocco (with the contested territory of Western Sahara), where extraction has been going on continuously since the 1920s. The country holds 50 billion tonnes of the raw material, approximately 75% of the world's reserves. In 2021, Moroccan phosphate production reached 38 million tonnes (second only to China, where 85 million tonnes were obtained) (www35). Morocco has also moved into fourth place in terms of exports of artificial fertilisers (after Russia, China and Canada); it began producing them in the 1980s and now sells in 45 product variants (www36). Phosphate extraction and phosphorus fertiliser production is carried out by Moroccan state-owned company Office Jerifiana des Phosphates (OCP). The largest mine is Khouribga, in the central part of the country, which has been operating since 1920 and is responsible for 70% of the group's production. Extraction is also carried out in Benguérir (western Morocco, operating since 1979), in Youssoufia since 1940, and in Bou Craa in Western Sahara, which is responsible for 8% of the total global extraction (www37). The company OCP is a global powerhouse, with 41% share of the European market (www38). Morocco's strategic role has increased significantly during the pandemic and the war in Ukraine, which disrupted global supply chains of the raw material due to the sanctions imposed on Russia and the export ban imposed by China.

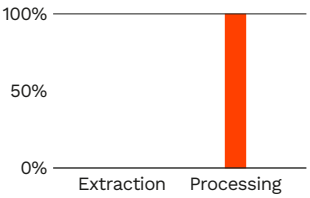
Phosphorus

Application: chemical applications, defence applications

Main producers:

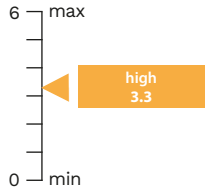


Import dependency:

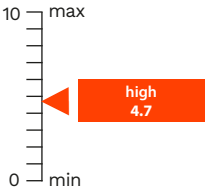


African producers:

Supply risk:



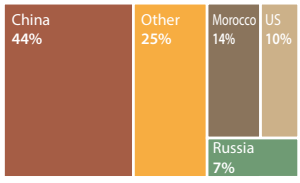
Economic significance:



Phosphates

Application: mineral fertilisers, phosphorus compounds

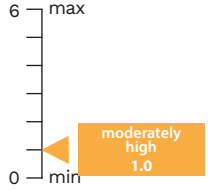
Main producers:



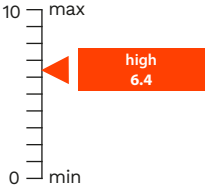
Import dependency:

African producers:

Supply risk:



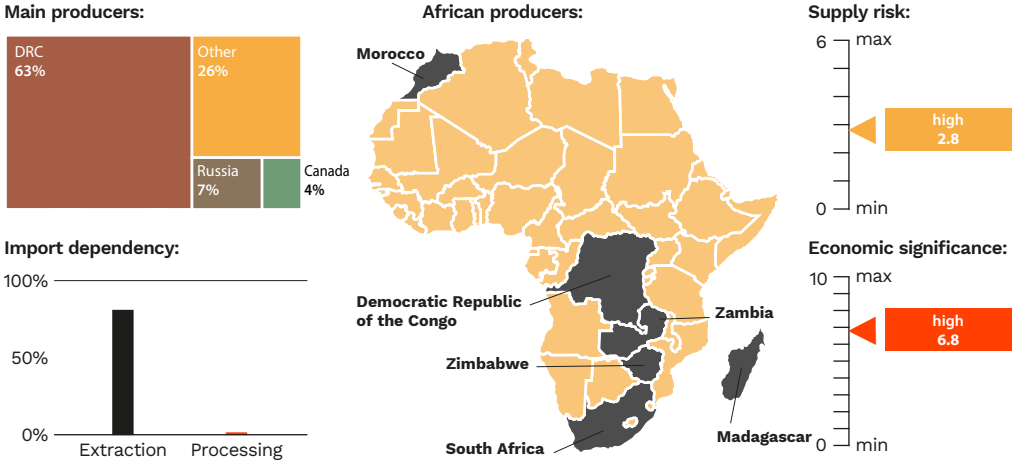
Economic significance:



Cobalt

Cobalt plays a key role in many industries and the development of green technologies, especially in lithium-ion battery cells. Global production is currently dominated by the DRC, which accounts for 60-70% of production. The richest deposits identified are located in the Katanga Province in the Copperbelt, where the raw material has been mined almost continuously for 100 years (Gulley, 2022). Congolese mines' ownership structure is largely dominated by Chinese entities. In 2020, Chinese companies owned shares in 15 out of 19 cobalt-producing mines (Lipton and Searcey, 2022). Cobalt extraction in Africa is technologically and economically linked to copper extraction. Traditionally, in industrial mining, cobalt is mined as a by-product of the "red metal". However, in the DRC, as much as 15% of the raw material comes from artisanal mining (The Economist, 2022). In terms of value, this is more than the production of Russia, the second-largest producer of the metal in the world. Another important African cobalt producer (ninth globally) is Morocco, where 2,000 tonnes were extracted in 2022, around 1% of global production (www39). Unlike in the DRC, Moroccan cobalt is mined on an industrial scale as the main raw material from cobalt-arsenic ores. The deposits in Morocco are exploited by local company Managem, including in Bou Azzer, one of the oldest mines, and characterised by extremely high purity. In 2020, Managem signed a five-year contract for the supply of cobalt with BMW, which plans to source a fifth of the cobalt it needs there (the rest will be imported from Australia), and thereby reduce purchases from the DRC due to ethical reasons (www40). A similar contract for the supply of cobalt sulphate was signed with Renault, which plans to buy 5,000 tonnes per year from Morocco for 7 years (the first deliveries are scheduled for 2025).

Application: batteries, superalloys, catalysts, magnets



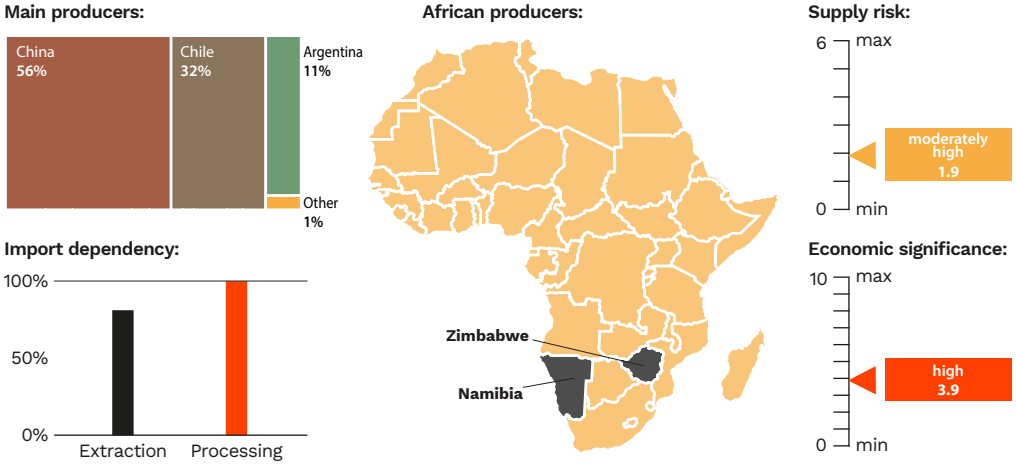
Another African country with cobalt deposits is Zambia, although it only extracts symbolic amounts of it at the moment (460 tonnes in 2022); production was discontinued 10 years ago due to the low profitability. Cobalt is obtained as a by-product of copper mining in four mines located in the Copperbelt, where the majority shareholder is China Nonferrous Mining (the Mwambashi Mine, the Muliashi Project, the Baluba Center Mine and the Chambishi Southeast Project) and the Munali Mine in the Lusaka region (Consolidated Nickel Mines). In the face of soaring global demand, Zambia's Mopani Copper Mines (MCM) plans to resume production, with plans to extract 4000-5000 tonnes per year (www41). Cobalt is also extracted in Madagascar in certain quantities by a Japanese-Korean company as part of the Ambatovy project as a by-product of nickel extraction (annual extraction of 5600 tonnes) (www42). Similarly, until recently, cobalt was obtained in the Nkomati mine in South Africa, owned by Russian company Norilsk Nickel (50%) and domestic company African Rainbow Minerals (50%). In 2020, So uth Africa sent 1800 tonnes of the raw material to international markets (the mine's operations are currently suspended). Zimbabwe also produces small amounts of cobalt (a few hundred tonnes per year).

Lithium

Although the lithium production is principally the domain of Australia, Chile and China at the moment, according to forecasts, by 2030 Africa will supply one-fifth of the world's supply of it (Dempsey, Cotterill, 2023). Exploration and partly mining work is currently being carried out in five African countries. It is estimated that they contain a total of 4.38 million tonnes of lithium (USGS, 2022). At the moment, the main supplier of lithium to international markets, and the sixth-largest producer globally, is Zimbabwe. The metal has been mined there intermittently for 60 years in several mines, but on a relatively small scale. In 2022, Zimbabwe extracted just 800 tonnes of lithium, 0.61% of the global production of 130,000 tonnes, almost half of which comes from Australia (www43). The main mining centre is the Bikita Minerals Mine controlled by the Sinome Resource group from China, which has an estimated 11 million tonnes in reserves. A prospective mine in the pilot phase is the Arcadia project (26.3 million tonnes of reserves) implemented by Prospect Resources, which in 2022 sold 87% of shares to Chinese company Zhejiang Huayou Cobalt, as well as the Kamativi Tailings Lithium Project (26.3 million tonnes) that is being carried out by British entity Galileo Resources. The third mine is the Zulu project, where the first batch of spodumene (lithium ore) was produced in April 2023; this project is owned by British company Premier African Minerals. The DRC could soon become an important centre with its flagship Manono project (Tanganyika province), 75% of which is controlled by Australian company AVZ Minerals (the remaining shares are held by state-owned company Cominiere). Formerly a tin mine, Manono has an estimated 30 million tonnes of spodumene reserves, guaranteeing production of 440,000 tonnes per year (www44). However, extraction is currently paralysed by a legal dispute with Chinese group Zijin Mining (www45). Preparatory work is also underway at the mines of Tantalumex Lithium (Canada) and that being developed in cooperation with Ivanhoe Mines Ltd. (Canada)

and Chinese company Zijin Mining Group Co. Ltd (the Kamoa-Kakula project). In West Africa, projects are being built in Ghana and Mali. In Ghana, the work is being carried out by British Atlantic Lithium as part of the Ewoyaa project. Mining is expected to start in 2024, with production of 2 million tonnes per year over 12.5 years and estimated reserves of 18.9 million tonnes. In Mali, exploration is being carried out as part of the Bougouni project by UK-based Kodal Minerals in partnership with Fosun, a subsidiary of Hainan Mining, in the Bougouni area 160 km south of the capital, Bamako (expected to start in 2024), and in the most advanced Goulamina project by Leo Lithium (Australia) with the Chinese shareholder Jiangxi Ganfeng Lithium, on the border with Côte d'Ivoire. The lithium reserves at Goulamina are estimated at 108 million tonnes, making it one of the largest hard-rock deposits in Africa. In Namibia, a pilot project is being run by UK-based Andrada in Uis (estimated reserves of 38 million tonnes), but the company is focusing on tin mining for now. Australian company Lepidico is developing the Heliumikon and Rubikon mines (with the start of extraction planned for 2025), which have reserves of 7.72 million and 11.3 million tonnes, respectively, and total production potential of up to 680,000 tonnes of lithium concentrate per year (www46). The only current data available for Namibia puts production at 500 tonnes in 2018 (www47). In Ethiopia, exploration work is being carried out by Abyssinian Metals (Australia) in the Tigray region (the Meket and Lemalash projects).

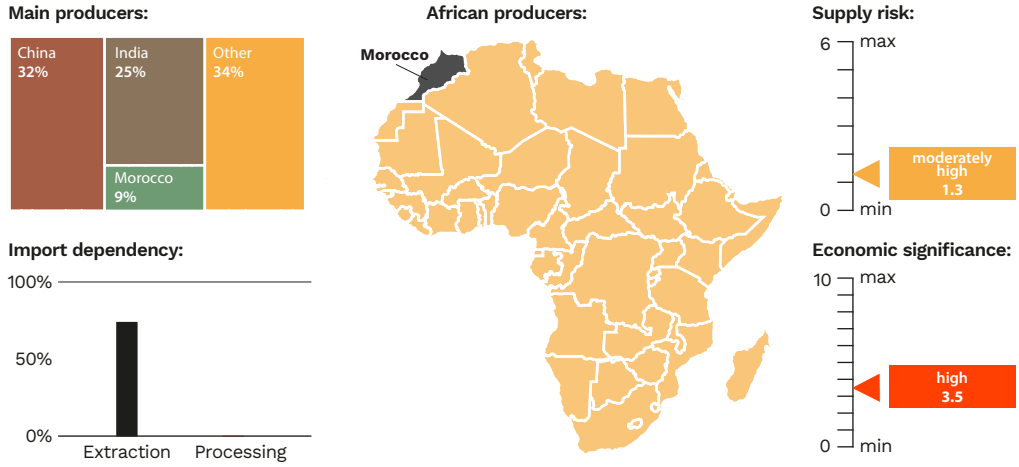
Application: accumulators, glass and ceramics, steel and aluminum metallurgy



Baryte

Morocco is the only African producer of baryte — that is, barium sulphate — at the moment. Only China and India produce more. One of the most important suppliers to the world market is family company Broychim, which owns the mines in Casablanca and Safi. Moroccan baryte production oscillates around 1 million tonnes per year. The demand for the raw material is strongly coupled with the oil sector, in which 80% of production is used for drilling purposes, but it has properties that may be crucial for the twin transition. Nigeria could soon join the race for baryte. The deposits of this metal found in the Cross River, Nasarawa and Taraba states may amount to as much as 20 million tonnes (www48).

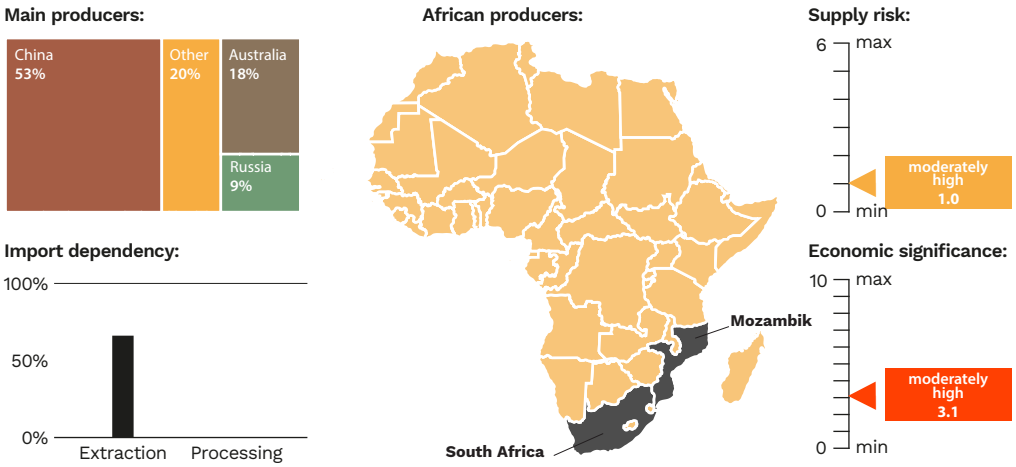
Application: oil industry, medical equipment, radiation protection, chemical industry



Coke coal

Mozambique is currently the only major country in Africa when it comes to the extraction of coking coal, which is mainly used in the metallurgical industry (steel production). The coal basin is the northwestern province of Tete, which has gigantic reserves of the raw material comparable to Australia's Bowen Basin coal belt. Most of the coking coal is extracted at three mines controlled by Indian companies: Benga, Moatize and Chirodzi. The Benga mine produced 2.74 million tonnes of metallurgical (and thermal) coal in 2021 and has reserves estimated at 360 million tonnes. It is 65% owned by the International Coal Ventures Limited (ICVL) consortium, which brings together Indian state-owned companies, and 35% by Tata Steel, a subsidiary of Tata Group. The second is the Moatize mine, with a production capacity of 22 million tonnes per year, where first shipments began in 2011.

Application: coke for the production of steel, carbon fibres, battery electrodes



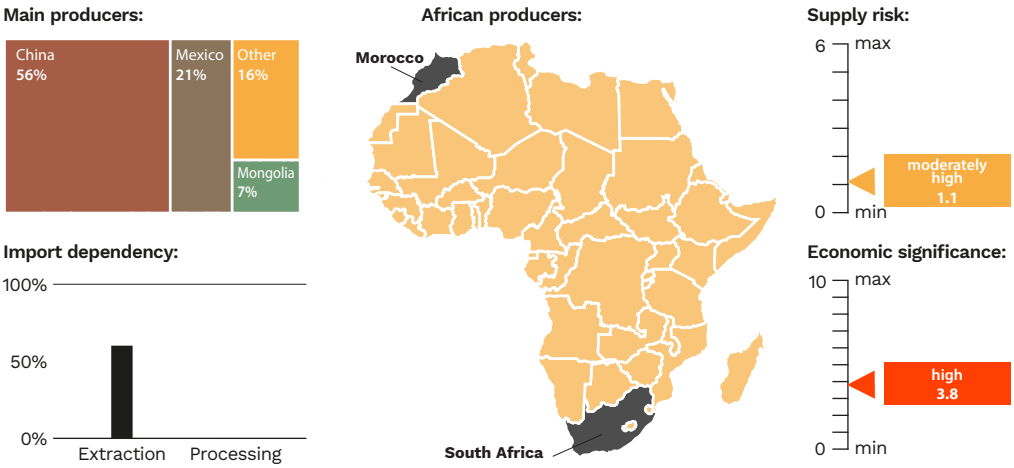
Until recently, the mine was controlled by Brazilian company Vale, but in 2021 it was sold to Canadian company Vulcan Minerals, which is part of Indian giant Jindal Group. The Indians also own a third mine, the Chirodzi coal mine, through its subsidiary JSPL Mozambique Minerals Limitada. The mine has documented reserves of 700 million tonnes (mainly metallurgical coal) and extracted 1.44 million tonnes of the raw material in 2021 (www49). In terms of metallurgical coal, South Africa, which was primarily known for its thermal coal until now, is also promising. Australian company MC Mining is currently developing the Makhado project in the Limpopo province. Once it starts operating, it is set to be the only source of coking coal in South Africa, with estimated reserves of 344 million tonnes (www50).

Fluorite

Calcium fluoride (CaF2), found in nature in the form of fluorite, is the most common fluorine mineral with a wide range of applications, including in the chemical industry and the production of steel and aluminum. It also being increasingly used for low-emission technologies; for example, as electrical insulators when obtaining energy from unconventional sources or for electrolyte production in lithium-ion batteries. Fluorite is currently sourced in two African countries: South Africa and Morocco. South Africa accounted for almost 5% of global production in 2021 and has one of the largest known reserves of this mineral (41 million tonnes, third after Mexico and China). Rich deposits of fluorite are located in the Bushveld Complex (www51) and mainly mined at the Vergenoeg mine owned by Spanish consortium Minersa (www52). The deposits located there are estimated at 122 million tonnes, with annual production of 240,000 tonnes. Another mine is the Witkop mine owned by Sallies (South Africa), where production halted in 2009, and the

Nokeng mine north of Pretoria opened by Sepfluor in 2019 (South Africa), with reserves of 12 million tonnes. Fluorite is also obtained in Morocco, in relatively small quantities. It is mainly mined at the El Hammam mine controlled by the Managem group, with production of around 50,000 tonnes (and reserves of 318,000 tonnes), and GFL GM Fluorspar SA, a subsidiary of Indian Gujarat Fluorochemicals Ltd (GFL) (with an annual production of 40,000 tonnes). From 1971, fluorite was also obtained in Kenya by the Kenya Fluorspar Company. Exports to international markets peaked at as much as 106,000 tonnes per year of the raw material (www53), but production stopped in 2016.

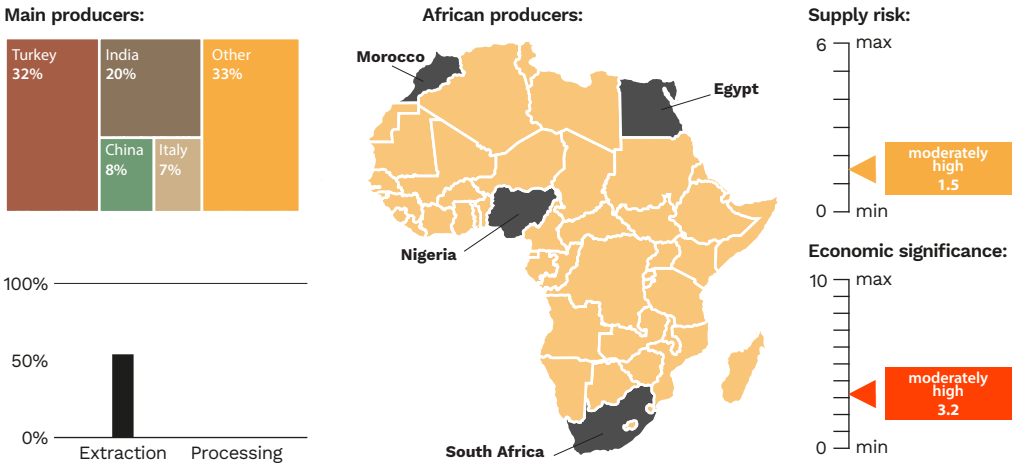
Application: steel and iron production, refrigeration and air conditioning, aluminum production and other metallurgy



Feldspar

In Africa, Feldspar, which is mainly used in ceramics, is produced in Morocco, Nigeria, South Africa and Egypt, although only South Africa publishes detailed production figures. In South Africa, feldspar is extracted from pegmatite (an igneous rock) at numerous mines in the Limpopo, Northern Cape, Western Cape, Gauteng and KwaZulu-Natal provinces. Production volumes have fluctuated between 70,000 and 190,000 tonnes in recent years. Zambia and Zimbabwe also produce small amounts, mainly for local industry's needs. In Nigeria, feldspar is found in the Ajaokuta LGA in Kogi, and in the states of Abia, Ogun and Ondo. Estimated production in 2020 amounted to 19,500 tonnes. Namibia, where production halted in the 1970s, is also considered a promising country (Militzer, 2020).

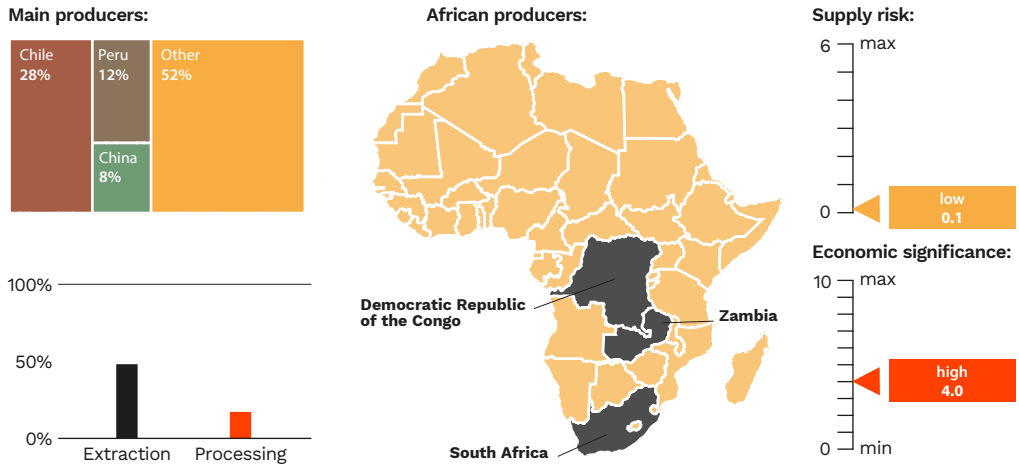
Application: fine ceramics, ceramic tiles, glassworks



Copper

African copper traditionally comes from the Copperbelt, which crosses northern Zambia and the Katanga Province in the DRC, which holds many of the country's mineral reserves. The DRC is the largest producer in Africa (and the third globally) with an annual extraction of 1.3 million tonnes. The most active mining companies in the country are Glencore (Switzerland), which manages two mines, Katanga and Mutanda, and Canadian investor Ivanhoe Mines, which holds shares in three mines, including the most promising Kamoa-Kakula project; the minority shareholders are China's Zijin Mining Group (39.6%), Crystal River Global (0.8%) and the Congolese government (20%). Kamoa-Kakula could become the third-largest copper mining area in the world, with extraction expected to amount to 600,000 tonnes by the end of 2024 (www54). In its heyday in the 1970s, Africa's second-largest producer, Zambia, was the world's largest producer of copper alongside Chile. It is now in eighth place, with estimated extraction of 800,000 tonnes in 2021, although the Zambian government has declared that production will increase to 3 million tonnes per year by 2032. Major Zambian mines include: Sentinel and Kansanshi, owned by Canada's First Quantum Minerals (FQM), Mopani, operated by Mopani Copper Mines (purchased by the government from Swiss Glencore in 2021), Konkola and Nampundwe (Konkola Copper Mines, owned by Indian Vedanta Resources and ZCCM Investment), Muliashi, Chambishi and Mwambashi (China Nonferrous Mining and ZCCM Investment) and Lumwana (Barrick Gold). FQM is currently responsible for 75% of Zambia's copper production. Other major investors include Anglo American and Rio Tinto. Small amounts are also mined in South Africa (the Palabora mine, one of the world's largest opencast mines) and Namibia. There are also plans to launch production in Uganda (the Kilembe mine).

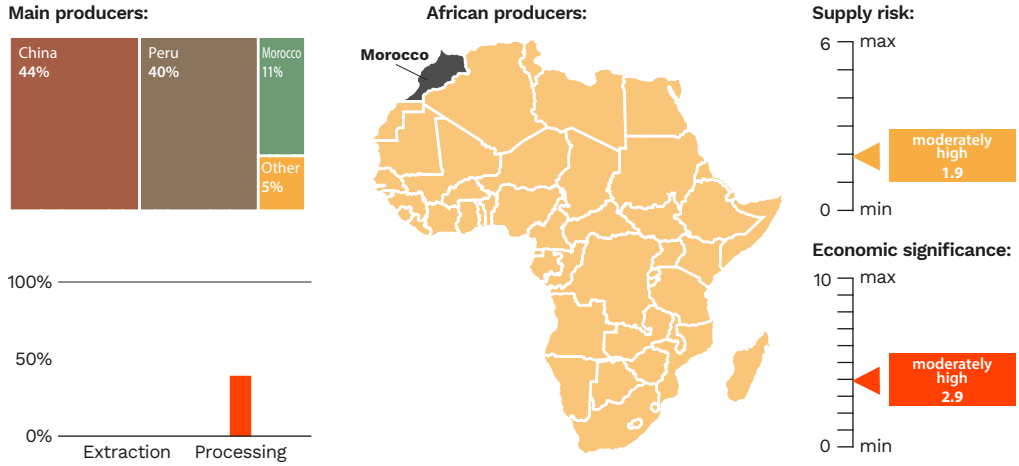
Application: application: production of cables and wires, heating, refrigeration and air-conditioning systems



Arsenic

In Africa, Arsenic is currently only produced in Morocco. Extraction has decreased significantly in the last decade and in 2021 it amounted to 7,000. tonnes, which gives Morocco the 3rd place in the world after Peru and China. Arsenic trioxide is produced as a cobalt compound by Compagnie de Tifnout Tighanimine (CTT) at the Guemassa Cobalt Arsenic Mine near Marrakesh. CTT's majority shareholder is Moroccan mining group Managem Mining Group, followed by Société Métallurgique d'Imiter, which has a 20% stake. It is the only deep mine in the world where cobalt along with arsenic are sourced as major materials from primary ore.

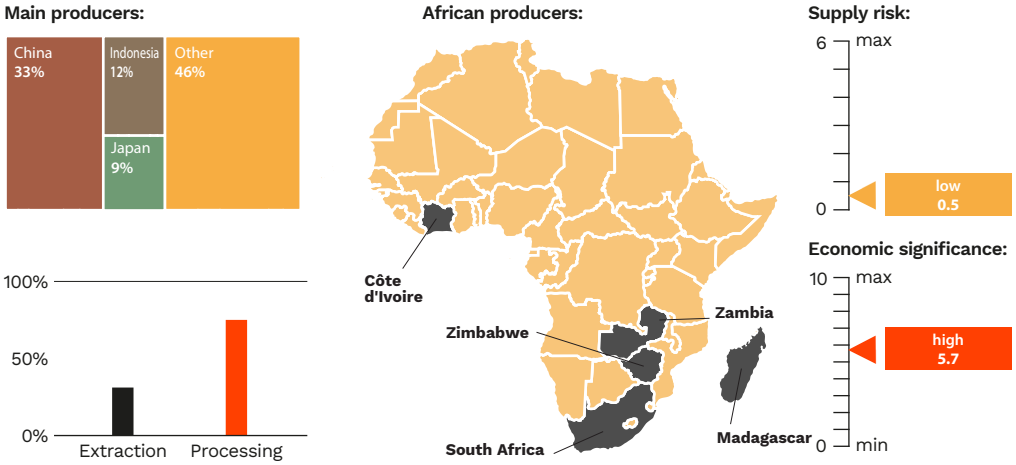
Application: semiconductor production, metal alloys



Nickel

Nickel is currently produced by five countries in Africa: South Africa, Madagascar, Côte d'Ivoire, Zimbabwe and Zambia (Morocco also produces a small amount). The largest nickel mines are located in South Africa, which extracted 35,800 tonnes of the raw material in 2021 (www55), which puts the country in 13th place globally. Three of them are located in the Limpopo Province: the Mogalakwena Mine owned by Anglo American, with extraction of 15,400 tonnes, the Nkomati Mine (African Rainbow Minerals Ltd. with 8000 tonnes; Russian Nornickel is a shareholder) and the Union Mine (4600 tonnes), as well as two smaller mines in the North West Province: the Impala Mine (3900 tonnes) and the Thembelani Mine (3800 tonnes). In Madagascar, nickel is mined by Japanese company Sumitomo Corp, which has a 54% stake, and Korea Resources Corp. (KORES), which has 46%, as part of the Ambatovy project in the Alaotra Mangoro region. It is one of the largest open-pit nickel mines in the world, producing 29,000 tonnes in 2021 (1-2% of the global market) and the largest mining project in the country. Madagascar's nickel reserves are estimated at 1.42 million tonnes. In Côte d'Ivoire, nickel has been mined since 2016 by Compagnie Minière Du Bafing (CMB) in the Foungouesso and Moyango opencast mines. Zimbabwe also produces nickel. The largest operator, Bindura Nickel Corporation Limited (BNC) (African capital), has three active mines: the Trojan Mine (Bindura), the Shangani Mine (Shangani) (a total of 400,000 tonnes of ore extraction and 5500 tonnes of concentrate) and the Hunters Road Project (a pilot project with estimated reserves of 36.4 million tonnes). Investments in Zimbabwe have been announced by the world's largest nickel producer, Chinese company Tsingshan Holding Group. Nickel production in Zimbabwe amounted to 16,500 tonnes in 2020.

Application: stainless steel production, high-temperature valves, production of nickel-cadmium batteries



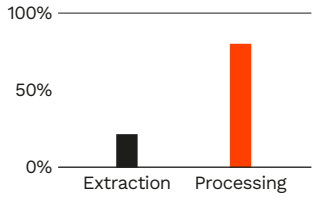
Zambia currently extracts just small amounts of nickel from the Munali Nickel mine in the Kalumbila District (with a production capacity of 4000 tonnes per year), but the country could become the largest nickel producer in Africa in the near future with the First Quantum Minerals (FQM) investment in the Enterprise Nickel project. According to estimates, extraction will amount to an estimated 30,000 tonnes of nickel concentrate per year, with reserves of 34.7 million tonnes of ore with 0.99% nickel content.

Tungsten

The demand for tungsten stems from its physical properties: it has the highest melting and boiling point of all the elements. This gives it a wide range of applications; for example, in the production of carbides used in durable tools, as well as the production of high-grade steel. Tungsten is not a major African export, but certain quantities are sourced in the African Great Lakes region of Rwanda, the DRC, Uganda and Burundi, both as a primary raw material and as a metal that occurs with tantalum, niobium (coltan ore) or tin (casterite). Rwanda is currently the largest African producer; in 2022, extraction amounted to 1000 tonnes (down from 1300 tonnes in 2021). This put it fifth globally; China came first, producing 70,000 tonnes. In Rwanda, the extraction of tungsten from wolframite (a tungstate, iron and manganese mineral) deposits is very dispersed, carried out by artisanal mining, semi-industrial companies and larger entities. The latter include Trinity Metals (a subsidiary of British Techmet), which has doubled production at the Nyakabingo mine compared to 2021 and currently produces 60-70 tonnes per month (with plans to reach 100 tonnes).

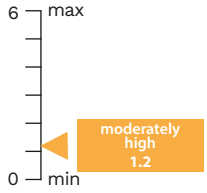
Application: alloys used in e.g. aeronautics, space industry, defence industry, electrical technologies, milling, cutting and mining tools

Main producers:

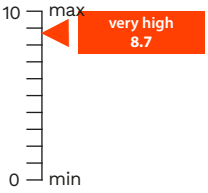


African producers:

Supply risk:



Economic significance:

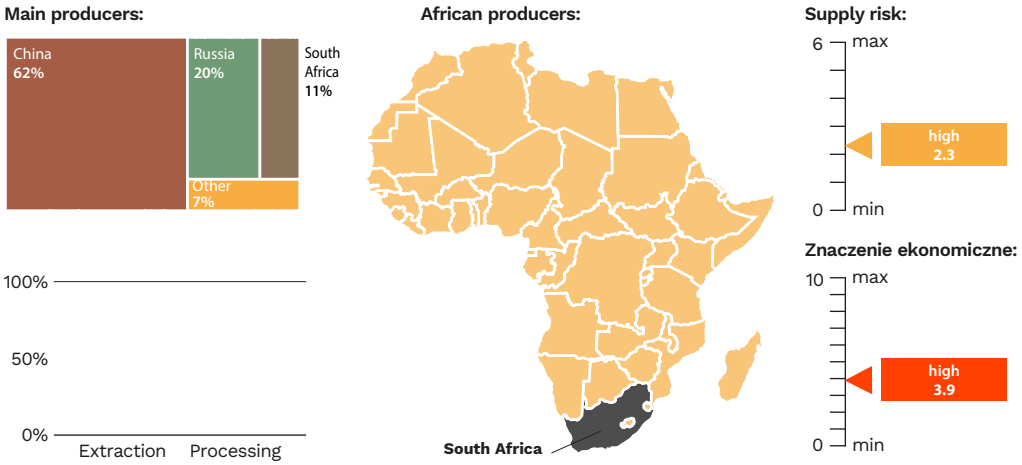


As in the case of coltan ore (tantalum and niobium), the exact origin of all Rwandan tungsten is difficult to determine due to smuggling and the fact that tungsten is classified as a "conflict" mineral; that is, one extracted in conditions of armed conflict (Wilson, Schipani, 2023), and with children's participation, which raises ethical concerns when exporting it. The RHA Tungsten Mine managed by Premier African Minerals is also located in Zimbabwe.

Vanadium

Although, traditionally, vanadium is used to produce alloys characterised by heightened strength and heat resistance (90% of global demand), it is increasingly used in green technologies, such as vanadium redox flow batteries for storing renewable energy (www56). South Africa is currently the only major producer of vanadium in Africa. The country ranks third globally after China (70,000 tonnes) and Russia (17,000 tonnes); production amounted to an estimated 9100 tonnes in 2022. It is also ranked third in terms of the reserves identified (3.5 million tonnes) (Boni et al., 2023). South Africa also boasts the largest share of primary production in the world (44%), as opposed to secondary production obtained from steel slag. Most of the vanadium production comes from two South African mines operated by Bushveld Minerals and Glencore. South African Bushveld Minerals (the Vametco, Brits Resource and Mokopane Project mines) owns the world's largest deposits of high-purity vanadium. The company planned to end 2022 with production at 4200-4400 tonnes (www57). Glencore, based in Switzerland, sources vanadium from the Rhovan mine. The Steelpoortdrift project currently being developed by Australian company Vanadium Resources (www58) has high production potential (a 180-year mine life cycle). Vanadium-bearing ores are also found in many other African countries (Botswana, Mozambique, Namibia and Zambia), but there is no large-scale production there yet.

Application: high-strength low-alloy steel used e.g. in aeronautics, space industry, nuclear reactors, chemical catalysts



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The Polish Economic Institute

The Polish Economic Institute is a public economic think tank dating back to 1928. Its research primarily spans macroeconomics, energy and climate, foreign trade, economic foresight, the digital economy and behavioural economics. The Institute provides reports, analyses and recommendations for key areas of the economy and social life in Poland, taking into account the international situation.

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