

# Resilient supply of critical and strategic raw materials for Germany – Potentials in Africa

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The global demand for mineral and metallic raw materials is increasing due to the energy and mobility transition, climate protection and general technological progress. A growing world population, rising prosperity and increasing demand for raw materials emphasize the need for responsible mining, as recycling and closed-loop recycling alone cannot meet the demand for raw materials and material quality. While other countries operate globally and invest directly in mining, Germany and other countries in Europe lack major globally operating companies in the field of metallic raw materials extraction. In an increasingly protectionist, multipolar world, economic, geopolitical and security policy measures are needed to ensure a resilient supply of raw materials. This

applies not only to the EU's strategic sectors such as electromobility, renewable energies, defense and space, but also to other, currently unknown, technological advances. This article highlights African countries such as Botswana, Morocco, Namibia, and Zimbabwe that offer various opportunities for securing raw materials through mining, processing of mining products and participation in smelters, which are hardly recognized by German investors.

Keywords:

Critical and strategic raw materials – Mining – Recycling – Germany – Africa

## Resiliente Versorgung Deutschlands mit kritischen und strategischen Rohstoffen – Potentiale aus Afrika

Global steigt die Nachfrage nach mineralischen und metallischen Rohstoffen durch die Energie- und Mobilitätswende, den Klimaschutz sowie durch generellen technologischen Fortschritt. Eine wachsende Weltbevölkerung, steigender Wohlstand und zunehmender Rohstoffbedarf verdeutlichen die Notwendigkeit eines verantwortlichen Bergbaus, da Recycling und Kreislaufführung allein den Rohstoffbedarf und die Materialqualität nicht decken können. Während andere Länder global agieren und direkt in den Bergbau investieren, verfügen Deutschland und andere Länder in Europa kaum mehr über global agierende Großunternehmen im Bereich der metallischen Rohstoffgewinnung. In einer zunehmend protektionistischer werdenden, multipolaren Welt sind wirtschaftspolitische, geopolitische und sicherheitspolitische Maßnahmen

einer resilienten Rohstoffversorgung notwendig. Dies gilt nicht nur für die strategischen Sektoren der EU wie Elektromobilität, Erneuerbare Energien, Verteidigung und Raumfahrt, sondern auch den weiteren, heute unbekannten, technologischen Fortschritt. Dieser Beitrag zeigt, dass afrikanische Länder wie Botswana, Marokko, Namibia und Simbabwe unterschiedliche Möglichkeiten zur Rohstoffsicherung durch den Bergbau, die Aufbereitung von Bergbauprodukten und Beteiligung an Hütten bieten, die von deutschen Investoren kaum wahrgenommen werden.

Schlüsselwörter:

Kritische und strategische Rohstoffe – Bergbau – Recycling – Deutschland – Afrika

## 1 Introduction

Resilient supply chains for metallic raw materials are essential for Germany as an industrial nation. A secure supply of raw materials and innovative alloys form the basis for the competitiveness of the economy and the prosperity of the population. Domestic raw materials such as industrial rocks and minerals, limestone, rock salt, potash salt, gypsum and anhydrite cover the current demand [7]. However, the German economy depends on imports

of metallic raw materials. There are currently no large, internationally active mining companies in the metal raw materials sector headquartered in Germany. Countries with a high share of GDP in manufacturing such as China, Japan, the USA, South Korea and, in Europe, Germany (20.2 % of gross value in 2021 [11]) require resilient supply chains. Primary mining of metallic raw materials does not currently take place in Germany [7] although domestic deposits are known and it is highly likely that further new deposits would be found with modern exploration techniques. From a global perspective, Africa plays an important role as a continent rich in raw materials, with around 30 % of the currently known global mineral reserves. A large number of different metallic raw materials are produced in Africa, and direct investments in mining projects are largely made by companies and mining firms based, for example, in China, South Africa, the UK, the USA, Canada and Australia (e.g., [21]). Smaller projects such as the direct purchase of cobalt from the BMW Group's raw material producer in Morocco, for example, secure a company's supply chains and at the same time increases value creation in the mining country [8].

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In recent decades, large, internationally active companies based in Germany in the mining sector have been transformed into plant manufacturers or travel companies. The deposits of other German industrial groups have been sold off. Due to energy costs, energy volumes, the CO<sub>2</sub> footprint and lower industrial production in Germany, the smelting and refining of primary raw materials from ore and secondary raw materials from scrap is currently being scaled back or relocated outside of Europe. At the same time, issues relating to the necessary expansion of recycling and the circular economy are becoming increasingly important in the media and political arena [5, 7]. However, this alone will not be able to cover the raw material volume of an export-oriented industrialized country in the future and raw material quality cannot be guaranteed [28, 29]. The envisioned industrial transformation caused by the German energy- and mobility transition and general technological progress require resilient supply chains in order to secure the growing demand for raw materials in an increasingly protectionistic environment of a multipolar world. The EU sets goals to be achieved with the Critical Raw Materials Act as an EU law and comprehensive packages of actions. The EU currently defines 34 raw materials as critical and 17 of these as strategic [23]. In addition to the construction of energy converters for renewable energy, the EU has identified energy storage for battery mobility and defence and space as strategic sectors [24]. The BMWK's raw materials fund in Germany is also set to provide a total of € 1 billion by 2028, as already exists in France and Italy, for example, with € 2 billion each [56].

This article examines aspects of Germany's supply of metallic raw materials. In order to meet the increasing demand for raw materials and maintain the competitiveness of Germany as an industrialized country, raw material sources need to be diversified. However, it can take well over ten years from exploration to production of metallic raw materials. The African continent is presented as a major producer of raw materials. The African countries of Botswana, Morocco, Namibia, and Zimbabwe are analyzed as examples, but other African countries of note are also included.

## 2 Germany's demand for metallic raw materials

In 2022, around 27.4 % of raw material imports to Germany in terms of volume came from EU member states and 9.2 % from Africa (for more see Figures 1, 2) [7]. Around 40 % of metallic raw materials excluding recycled raw materials came from the EU-27 [7]. 20.2 % of supplies of ores, concentrates and refined metals

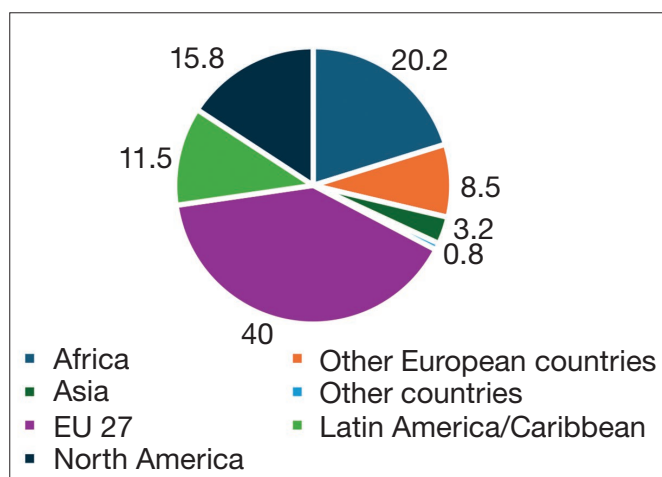


Fig. 1: Raw material imports of metallic raw materials (ores, concentrates and refined metals, excluding recycled raw materials) to Germany in 2022 (percentage share by volume). In terms of volume, most imports came from Europe and Africa, data from [7].

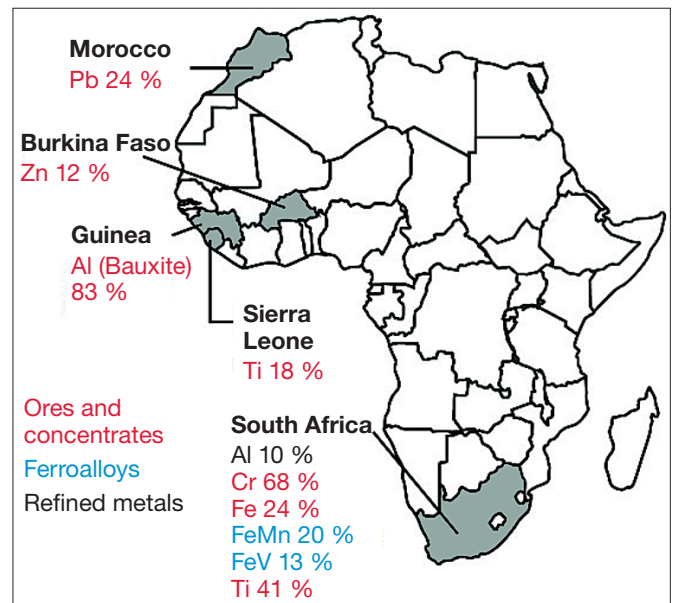


Fig. 2: Share of German imports (quantitatively) of industrial metals (ores and concentrates, refined metals) and metal alloys in 2022 from Africa with an import share of over 10 %, quantitative data from [7]. Imports of ore and concentrates are mainly from South Africa (Cr, Ti, Fe) and Guinea (bauxite). Al: aluminium, Cr: chromium, Fe: iron, FeMn: ferro-manganese alloy, FeV: ferro-vanadium alloy, Pb: Lead, Ti: Titanium, Zn: Zinc.

originated from Africa [7]. In 2021, the share of ores, concentrates and refined metals from Africa was 17.6 % [6]. Recycled raw materials imported to Germany from Africa were only 1.1 % in 2022, around 82.8 % were imported from the EU-27 [7]. In terms of value, the import and export total of raw materials (energy, metals excluding recycled raw materials, metallic recycled raw materials and non-metals) increased from 2020 to 2021, but the total import and export quantities of these raw materials decreased. Imports of raw materials to Germany equaled € 139.7 bn in 2020 and € 310.6 bn in 2022, while exports amounted to € 81.3 bn in 2020 and € 134.5 bn in 2022 [7]. The import volume of raw materials decreased from 386.1 Mt in 2020 to 342.5 Mt in 2022, while the export volume was 157.5 Mt in 2020 and 130.3 Mt in 2022 [7]. The increased prices are due to higher commodity prices for metals and energy raw materials [7].

South Africa is Germany's most important trading partner for metallic raw materials in Africa [39]. Here, Germany imported raw materials such as titanium (Ti), iron (Fe), chromium (Cr, ores and concentrates), aluminium (Al, refined metal), ferro-manganese alloys and ferro-vanadium alloys (FeMn and FeV) in 2022 (Figure 2) [7]. Other imports came from Guinea (Al), Morocco (Pb), Sierra Leone (Ti) and Burkina Faso (Zn).

## 3 Exemplary market concentrations and geographical locations

Some primary raw materials show significant market concentrations. For example, in terms of global production volumes, more than 70 % of cobalt is mined in the Democratic Republic of the Congo (DRC), around 89 % of iridium and 70 % of platinum is produced in South Africa, 60 % of natural graphite and 50 % of dysprosium is produced in China [16]. Approximately 47 % of lithium is mined in Australia and 30 % in Chile [16]. The processing of raw materials is also concentrated. China plays a major role in this context. 100 % of natural graphite and dysprosium are processed there; in addition, 70 % of cobalt, 60 % of lithium and, for example, 90 % of manganese are processed in China

[16]. However, African countries such as South Africa also have a significant position in the processing of primary raw materials. 90 % of iridium is processed in South Africa and 8 % in Zimbabwe, while around 71 % of platinum is processed in South Africa and around 8.6 % in Zimbabwe [32].

## 4 Exemplary critical raw materials from Africa

Around 30 % of global mineral reserves are located on the African continent [1]. Guinea is a globally requested supplier of bauxite, the Democratic Republic of the Congo (DRC) is a global leader in the export of cobalt and Rwanda is known for its tin, coltan (and extracted elements), and tungsten resources [2]. Estimated cobalt production in the DRC for 2023 is 170,000 t with estimated reserves of 6 Mt, around 54.5 % of estimated global reserves [52].

### 4.1 Botswana

The Republic of Botswana has been a democracy since 1966 with a population of 2.63 million and a GDP of USD 7738 per capita in 2022 [12]. The Human Development Index (HDI) in 2021 is 0.693 (low 0, high 1) [50]. Various mineral resources are mined in Botswana, including diamonds, iron ore, coal, copper, nickel, salt, silver and potash [44]. Botswana is one of the world's largest producers of diamonds and is estimated to have produced 7 million ct of industrial diamonds and 17 million ct of gem-quality diamonds in 2023 [52]. Furthermore, 943 kg of gold and 34,000 kg of silver were produced in Botswana in 2019 [55]. Mining in Botswana is regulated by the Mines and Minerals Act of 1999 [54]. Copper and nickel were mined and smelted in the “Bamangwato Concessions Limited (BCL)” Phoenix and Selebi-Phikew mines until 2016 (production of 14,273 t of Ni and 11,348 t of Cu, 248 t of Co in 2016) [54]. Mining of palladium, silver and platinum was discontinued in 2015 [54]. Mining and smelting operations were stopped at the end of 2017 due to high energy and processing costs and falling copper prices [54]. Although the production of copper and silver was resumed in 2019 (Khoemacau mine), there is a lack of investment to resume the production of cobalt and nickel [54]. A memorandum of understanding was signed between Botswana and Premium Nickel Resources Corp (Canada) to resume work on the mines for copper and nickel [35]. The Kalahari Belt, for example, which is currently not fully explored, could potentially be suitable for exploration and diversification efforts (Prof. Dr Thierry Olivier Bineli Betsi, 2023, personal communication).

### 4.2 Morocco

Morocco is a constitutional monarchy and a population of 37.458 million, the GDP in 2022 was USD 3570 per capita [13]. The Human Development Index (HDI) was 0.683 in 2021 [50]. Some mineral and metallic raw materials are mined in Morocco. In 2023, for example, an estimated 1.2 Mt of barite (14.1 % of global mine production), an estimated 35 Mt of phosphate rock (15.9 % of global mine production) and an estimated 2300 t of cobalt (1.2 % of global production) were mined in 2022 [51, 52]. However, copper, lead, gold, cobalt, zinc, iron ore, manganese, silver and tungsten are also produced in Morocco (e.g. Managem Group). Morocco's mining industry is to be further diversified in the future, creating opportunities for foreign investors. Mining is particularly important for the Moroccan economy and accounts for around 26 % of the country's export revenue; according to the Fédération de l'industrie Minérale, around 85 companies and 450 individual entrepreneurs are active in mining [49]. However, Morocco is dependent on imports of machinery for the mining industry; the most important supplier country in 2023 was China (€ 280 million), including drilling equipment and systems for processing and safety technology [49]. Imports from Germany (€ 180 million) ranked in second place [49].

### 4.3 Namibia

Namibia is a democratic republic and has 2.567 million citizens in 2022. The GDP is USD 4854 per inhabitant per year [14]. The Human Development Index (HDI) in 2021 was 0.593 [50]. The country's most important raw materials are diamonds and uranium. Mining (and industry) makes a significant contribution to GDP at 26.4 % (2019) [25]. In addition to diamonds and uranium, gold, zinc and lead, tin, salt and other raw materials are also mined, and copper concentrates from Zambia are processed and re-exported in the country [25]. Exploration is taking place for rare earths, cobalt and copper, and also for graphite and lithium. Further projects are expected for the exploration of zinc, tin and iron ore [25]. Namibia also has large phosphate deposits, the mining of which is considered environmentally controversial [25]. Low market prices (e.g. for diamonds) and problems with the power supply partially restrict mining [25].

### 4.4 Zimbabwe

The Republic of Zimbabwe has 16.321 million inhabitants in 2022, with a GDP of USD 1991 per capita [15]. The Human Development Index (HDI) in 2021 is 0.593 [50]. In 2023, Zimbabwe had an estimated 1.9 % of the global reserves of platinum group metals and produced about 1.9 % of the globally estimated lithium output [52]. Zimbabwe also has deposits of almost 40 mineral commodities, including chromium, diamonds, iron ore, gold, cobalt, copper, manganese, nickel and rare earth elements [40]. The Great Dyke in particular offers potential for mining platinum group metals [40]. Zimbabwe also has significant potential for the extraction and processing of lithium; it currently has the sixth largest known lithium reserves in the world [46].

Lithium is mined, for example, in hard rock projects from pegmatites in the Mutare greenstone belt [47] extracted from spodumene and petalite. Tempest Minerals (Australia) acquired further licences for lithium extraction in 2019. Other pegmatites for potential lithium extraction are the Bikita, Arcadia, Kavativi and Zulu pegmatites [36]. From November 2021 to February 2022, a large number of Chinese companies, e.g. Chengxin Lithium Group and Zhejiang Huayou, were involved in lithium exploration and are also looking to invest in lithium processing projects [36]. The Great Dyke also offers potential for the extraction of platinum, palladium and rhodium as an example [45].

### 4.5 Investments in mining in Africa

Investments in mining depend on a variety of factors. These include the energy supply, infrastructure, social and political situations or unrest in the country and factors that are summarized as the World Governance Indicator (WGI) of the World Bank. These include “control of corruption”, “regulatory quality”, “voice and account-

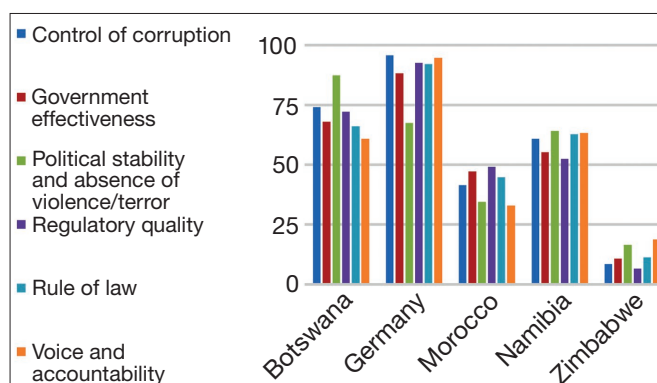


Fig. 3: World Bank “Worldwide Governance Indicator” (WGI) data for Botswana, Germany, Morocco, Namibia and Zimbabwe in 2022 (percentile rank), data from [48].



ability”, “government effectiveness” and “rule of law” and “political stability and absence of violence and terror” of a country [48]. Botswana, for example, is an African country that has a particularly good WGI. Botswana is also one of the wealthiest countries in Africa (GDP USD 20 billion in 2022) [12]. Other countries, such as Zimbabwe, have low WGIs compared to Botswana (cf. [41]). Zimbabwe also deals with hyperinflation with an annual consumer price inflation rate of around 193.4 % in 2022, which was around 98.5 % in 2021 [31]. To counter inflation, Zimbabwe introduced a new currency “Zimbabwe Gold” (ZiG) on 5 April 2024, which is pegged to the price of gold [43]. The Worldwide Governance Indicator (WGI) from the World Bank shows that some resource-rich African countries demonstrate general conditions and would be interesting partners for the expansion of a commodity partnership (Figure 3).

Direct investments in large-scale mining, smelting and refining, such as those carried out by China in African countries, are not currently known from German companies. Projects for responsible raw materials management by OEMs (original equipment manufacturers) (e.g., [8, 9, 53]) are ensured through supply contracts and quality controls. Such opportunities remain excluded from German SMEs.

The required increase in transparency in the extractive sector is to be implemented as part of the African Mining Vision [3]. The Extractives Industries Transparency Initiative (EITI) is intended to contribute to increasing transparency. Currently, more than 50 countries are members, including, Germany and the DRC [3, 19]. The African Mining Vision, for example, supports small-scale mining [3]. Due to the increasing global demand for transparency and safety, environmental and health standards, internationally recognized “Environmental, Social and Corporate Governance Standards” (ESG) are also being implemented by globally operating companies [40].

Countries as Zimbabwe are pursuing the goal of encouraging domestic economic value chains. On 6 January 2023, the government in Zimbabwe banned the export of unprocessed lithium (Base Minerals Export Control Order 2023), extracted lithium shall primarily be processed in the country and the export of raw lithium ore requires a special authorization [36, 40]. As a result of the export ban, Chinese companies have been investing in the processing of lithium ore [40]. In 2023, more than USD 1 bn was invested by Chinese companies in the development and acquisition of lithium projects in Zimbabwe [40]. According to [51] an estimated 3400 t

of lithium were produced in Zimbabwe in 2023, around 1.9 % of the estimated global production in 2023. In contrast to German and other European companies, Chinese investors continue to purchase smelting operations. In 2024, the Canadian company Dundee Precious Metals Inc. sold its shares in the smelter in Tsumeb, Namibia, for USD 49 million to the Chinese Sinomine Resources Group, which was founded in 1999 and now operates globally [17]. Thus, another opportunity for German or other European investment in one of the few smelters for processing arsenic-rich ores [17] and the germanium- and gallium-rich slags [22] has passed.

#### 4.6 Raw material wealth alone is not enough

The extraction and export of raw materials is a key component of economic development for African countries (Figure 4) (e.g. [27]).

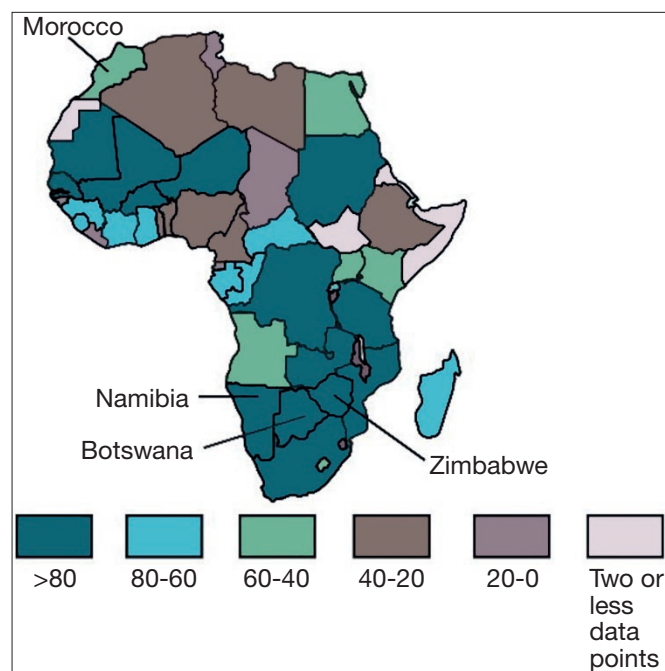
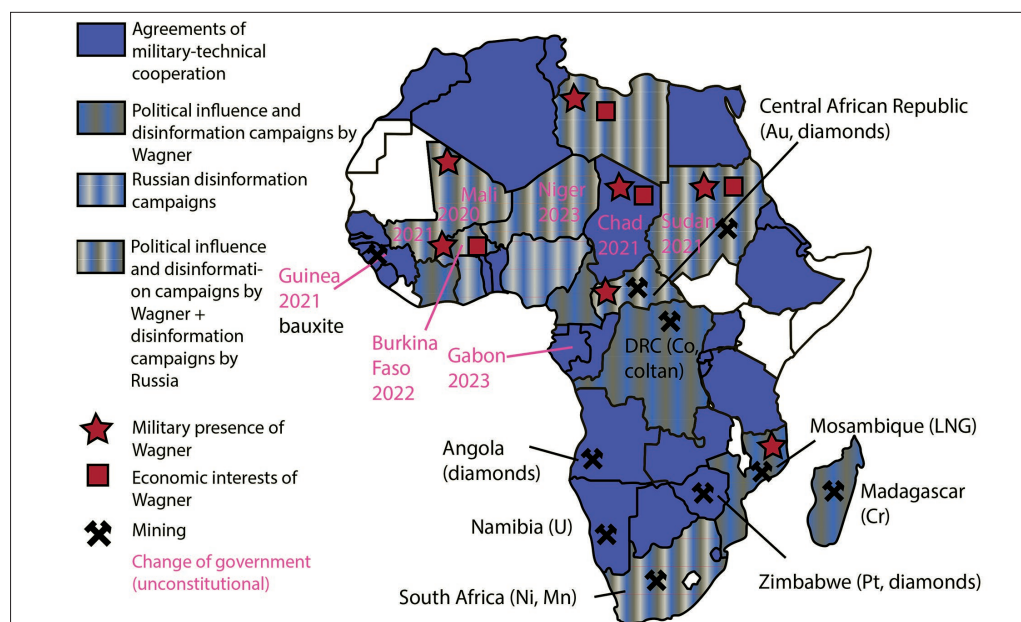


Fig. 4: “Mining Contribution Index map” (MCI) for 2020 with data from [30]. The MCI is a measure of the relative importance of the mining sector for the country's economy.

Fig. 5: Russian influence through military technical cooperation agreements with African countries, political influence through the Wagner military group and disinformation campaign from Russia. The military presence, areas of economic interest and mining cooperation are marked in the countries. Data from 2022 and 2023 from EPRS [20] and the references listed therein.



The export of raw materials depends on global demand, global market prices and fluctuating market cycles. This is associated with the fluctuation of local employment. The responsible extraction of raw materials is subject to occupational health and safety and environmental protection requirements. It is now increasingly recognized by the politicians that the desired decarbonization of Germany and Europe cannot go hand in hand with mining, smelting and refining in African countries that do not comply with certain occupational health and safety and environmental protection standards [42]. Even though mining, smelting and refining creates jobs in many African countries, it only provides work for part of the population [33]. International investment often fails to materialize due to inadequate energy supplies and a lack of or poorly developed infrastructure. In addition, social and political instability increases investment risks [34]. At the same time, the extraction of raw materials can increase the depth of value added in the country.

The potential of mineral resources in many African countries is also unknown. Insufficiently explored areas and a lack of investment prevent an accurate awareness of possible extraction areas (see [1]). Due to the increasing global demand for raw materials, more and more African countries that were previously not a focus of investment are becoming potential centers of raw material production [1]. At the same time, African countries such as Botswana are urging for investment in mining [35]. The government in Botswana, for example, is seeking to promote further investment in exploration and production (mineral and metallic resources) in order to broaden the country's investment base and enable the diversification of mining alongside the production of high-quality diamonds [38]. However, the proceeds from mining, smelting and refining should reach the country and its population and may not solely be concentrated in the investment countries, otherwise the raw material blessing can also turn out to be a "raw material curse" (e.g. [18]). In order to support the population and the country, the profits from the mining projects should return in form of infrastructure such as roads, clinics and schools [18]. The mineral resources that have not yet been extracted are seen as "natural capital" for the future of the country and its people [18].

## 5 Discussion

Countries such as China operate and invest directly in mining projects in African countries. Russia is also active in the mining sector in numerous African countries, some of which are accompanied by a military presence (Figure 5) [20].

Political decision-makers are faced with the challenge of creating framework conditions that enable German/European capital and companies based in Germany/Europe to make a long-term commitment to international raw materials partnerships and to compete with other systems. Social, economic and ecological goals may be achieved through global partnerships. Whether the EU's Green Deal keeps the interests and goals of the raw material partner country in mind should be critically evaluated. Although countries such as Botswana are encouraging direct investment in mining and are providing opportunities for investment in strategic raw materials (e.g. Tsumeb smelter, Namibia or lithium in Zimbabwe), there is no direct investment from Germany or the EU. Fluctuating global prices also affect African countries such as Zimbabwe. The global supply of lithium (battery quality) exceeded demand in 2023, leading to a price collapse of more than 80 % [10]. Globally, lithium supply is dominated by Australia, Chile and China [52]. Together, they produced around 90 % of the raw material in 2023 [52]. The consequence of the price drop is a reduction in production, resulting in a market shakeout of less efficient projects.

According to a study by S&P Global, the average time from exploration to the start of operations is 16.3 years and for mines

from 2020 to 2023 an average of 17.9 years (a) [37]. However, the process depends on the type of deposit and the country in which mining is to take place. Gold deposits have shorter lead times of 15.7 a on average and zinc and nickel the longest (17 and 18.3 a on average) [37]. For example, lead times in Laos (11.3 a), Turkey (12 a) and Africa (DRC, 14 a) are generally shorter than in Canada (18 a) or Indonesia (21 a) and Russia (21.8 a), for example, due to the legal framework [4, 37]. From 2005 to 2009, the average lead time for mines was 12.7 a [37].

The demand for mineral raw materials will continue to rise in the future and will be accompanied by the development of new technologies in the areas of mining and processing (primary raw materials), recycling (secondary raw materials), recycling management and substitution. In order to be able to meet the increasing demand in the future, new deposits must first be explored, identified and developed and then extracted from the ore during smelting and refining and concentrated into a usable metal. Recycling also offers potential to reduce the demand for raw materials from deposits [26], but will not meet demand in the future either. In order to expand supply chains, increase value creation and reduce market concentration, agreements with mining companies and smelters are necessary to enable responsible mining [40]. Mining and recycling go hand in hand with the development of new technologies that are being pushed by the countries involved in exploration, mining technology, processing and metallurgy and thus have direct access to raw materials.

## 6 Conclusion and outlook

The African continent holds numerous resources, including some that are still unknown, but could be developed through responsible mining. Unstable supply chains, high (energy)costs and lower demand from industry are leading to an outflow of smelting/refining and expertise from Germany. This limits innovation potential and opportunities for recycling in Germany. Resilient supply chains can diversify investments in mining in African countries. Development times of over 16 years on average until production emphasize the need to invest in exploration projects and develop innovative technologies at an early stage.

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