

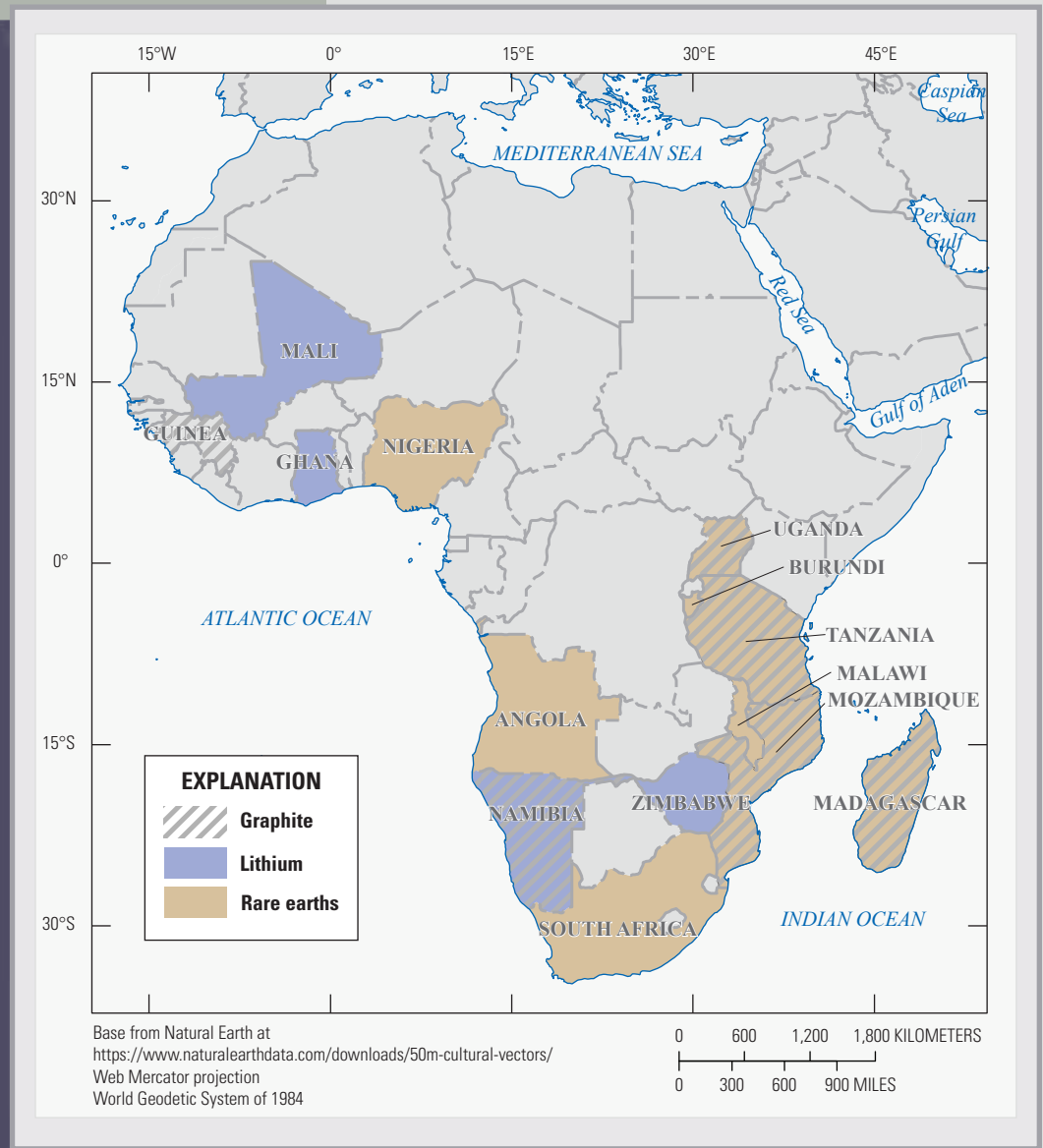
# Developments in African Industrial Minerals for Renewable Energy

## Introduction

Africa is emerging as a leading source for minerals used in the manufacture of batteries for electric vehicles and in other renewable energy applications. New graphite, lithium, and rare-earth mines have or could be opened in African countries from 2017 through 2026 (fig. 1, tables 1–3).

Estimates of production capacities for graphite, lithium, and rare-earth mines for 2023 and beyond (tables 1–3) are based upon supply-side assumptions, such as announced plans for new capacity construction and bankable feasibility studies, as well as projected trends that could affect current producing facilities in 2023 and planned new facilities projected to come online by 2026. Forward-looking information, including estimates of future production capacities, graphite flake distributions, and timing of the start of operations, are subject to risk factors and uncertainties that could cause actual events or results to differ significantly from expected outcomes. Projects listed in this report are presented as an indication of industry plans and are not a U.S. Geological Survey (USGS) prediction of what will take place. Only projects with planned startup dates are included in this report;

other graphite, lithium, and rare-earth projects in Africa without startup dates were known to be in various stages of development but are not included in this fact sheet.



**Figure 1.** Map showing the countries in Africa where graphite, lithium, and rare-earth mines have been or could be opened.



Graphite in pegmatite rock. Photograph by U.S. Geological Survey, public domain.

## Graphite

Graphite is produced in amorphous, flake, and vein forms. Amorphous graphite is used in automobile brakes, pencils, and refractories. Flake graphite is used in batteries, refractories, expandable graphite, and other applications and is produced in jumbo, large, medium, small, and fine sizes. Jumbo- and large-flake graphite are used in expandable graphite (for example, applications including flame retardants). Medium-, small-, and fine-flake graphite are used in batteries. Prices are much higher for jumbo- and large-flake graphite because of their expandability and limited supply. Vein graphite is used in high-friction and thermal applications.

In 2016, Africa had accounted for about 15,000 metric tons (t) of graphite mined, or 1 percent of the world production (USGS, 2017, p. 72–73). In 2018, Africa's share of world graphite production increased to nearly 14 percent as production increased in Madagascar and Mozambique. Africa's share of world production was 13 percent in 2021 (USGS, 2017, p. 72–73; 2020, p. 72–73; 2023, p. 82–83). Madagascar's graphite exports increased from 13,300 t in 2017 to 47,900 t in 2018 and to 53,400 t in 2019 before decreasing to 48,500 t in 2020, with the increases attributable to the Gallois Expansion project, which increased capacity from 10,000 metric tons per year (t/yr)

**Table 1.** Graphite projects developed or planned for development in Africa from 2017 to 2026.

[Data are aggregated from Batten (2023) and company press releases, reports, and presentations from MadaGraphite Inc. (2017), Tirupati Graphite plc (2020, 2021), BlackEarth Minerals NL (2022), Black Rock Mining Ltd. (2022, 2023), Blencowe Resources plc (2022), Triton Minerals Ltd. (2022), Gratomic Inc. (2023), NextSource Materials Inc. (2023), Northern Graphite Corp. (2023), SRG Mining Inc. (2023), Volt Resources Ltd. (2023), and Walkabout Resources Ltd. (2023). Production capacity is in metric tons per year (t/yr) of graphite concentrate. Financing indicates that the company has completed a feasibility study and is seeking funds to build the mine. NA, not available; —, zero]

Project name	Operating company	Startup year	Production capacity, in t/yr	Stage of development	Flake graphite distribution, in percent				
					Jumbo	Large	Medium	Small	Fine
Guinea									
Lola	SRG Mining Inc.	2026	92,000	Financing	13	26	9	<sup>b</sup> 52	—
Madagascar									
Gallois expansion	Etablissements Gallois S.A.	2017	150,000	Production	NA	NA	NA	NA	NA
Sahamamy	Tirupati Graphite plc	2019	21,000	Production	50	35	<sup>b</sup> 15	—	—
Vatomina	Tirupati Graphite plc	2021	63,000	Production	35	35	<sup>b</sup> 30	—	—
Molo	NextSource Materials Inc.	2023	45,000	Production	23.6	22.8	22.4	10.1	21.1
Maniry	Evion Group	2024	39,000	Financing	20.1	29.8	9.1	23.6	17.4
Mozambique									
Ancuabe	Advanced Metallurgical Group N.V. (AMG)	2017	9,000	Production	NA	NA	NA	NA	NA
Balama	Syrah Resources Ltd.	2017	356,000	Production	8.5	12	11.5	22.5	45.5
Ancuabe	Triton Minerals Ltd.	2025	17,000	Feasibility	35	23	20	<sup>a</sup> 23	—
Namibia									
Aukam	Gratomic Inc.	2024	22,000	Feasibility	NA	NA	NA	NA	NA
Okanjande	Northern Graphite Corp.	2024	31,000	Prefeasibility	NA	NA	NA	NA	NA
Tanzania									
Lindi Jumbo	Walkabout Resources Ltd.	2024	40,000	Construction	49.3	25	<sup>b</sup> 25.7	—	—
Bunyu	Volt Resources Ltd.	2025	24,000	Financing	12	27	15	<sup>a</sup> 46	—
Chilalo	Energy Evolution Minerals Ltd.	2025	52,000	Financing	31.1	26.9	6.3	<sup>a</sup> 35.8	—
Mahenge	Black Rock Mining Ltd.	2025	174,000	Financing	23	36	9	<sup>a</sup> 32	—
Nachu	Magnis Energy Technologies Ltd.	2025	236,000	Financing	41	32	<sup>b</sup> 27	—	—
Uganda									
Orom-Cross	Blencowe Resources plc	2025	50,000	Feasibility	13.7	33.2	15.1	12	26

<sup>a</sup>Small combined with fine.

<sup>b</sup>Medium combined with small and fine.

## Lithium

in 2017 to 150,000 t/yr in 2019 (table 1), and the startup of the Sahamamy mine by Tirupati Graphite plc in 2019. The Vatomina mine opened in 2021 and the Molo mine opened in 2023 (Banque Centrale de Madagascar, 2020, p. 115; Tirupati Graphite plc, 2020, 2021; NextSource Materials Inc., 2023). Madagascar's graphite capacity could increase by 39,000 t/yr with the opening of the Maniry mine in 2024 (table 1).

In Mozambique, the Balama mine opened in late 2017 (table 1), and production was planned to reach full capacity of 356,000 t/yr of graphite concentrate in 2020 (Syrah Resources Ltd., 2019, p. 2; 2020, p. 1). The mine was placed on care-and-maintenance status in March 2020 in response to the COVID-19 pandemic but was restarted in March 2021 (Syrah Resources Ltd., 2021). Advanced Metallurgical Group N.V. reopened the Ancuabe mine in Mozambique in 2017 (Ghilotti, 2017). Triton Minerals Ltd. could start production in 2025 (table 1).

In Tanzania, Walkabout Resources Ltd. plans to start production at the Linde Jumbo mine in 2024. Black Rock Mining Ltd. (2023) plans to build a new graphite mine at the Mahenge project, with a planned capacity in the first phase of mining of 89,000 t/yr in 2025, to be increased to 174,000 t/yr in the second phase in 2026 (Black Rock Mining Ltd., 2022, p. 46; 2023, p. 15). The development of the Bunyu, Chilalo, Lindi Jumbo, Mahenge, and Nachu projects could increase Tanzania's total graphite capacity to nearly 530,000 t/yr by 2026 (table 1).

Graphite mining could restart in Namibia in 2024 with the opening of the Aukam mine and the reopening of the Okanjande mine. In Uganda, Blencowe Resources plc planned to start a new mine at the Orom-Cross project in 2025 with a capacity of 50,000 t/yr, dependent on a feasibility study (table 1; Blencowe Resources plc, 2022, p. 8–10).

The flake-size distribution of graphite varied widely across different projects. The Sahamamy mine in Madagascar had the lowest percentage of battery-grade graphite (medium, small, and fine flake) at 15 percent, and the Balama mine in Mozambique had the highest at 79.5 percent (table 1).

In 2022, batteries were estimated to account for 80 percent of global end-use for lithium (USGS, 2023, p. 108–109); the remainder was used in ceramics and glass (7 percent), lubricating greases (4 percent), continuous casting mold flux powders (2 percent), air treatment and medical (1 percent each), and other uses (5 percent). Lithium consumption for batteries has increased substantially in recent years because rechargeable lithium batteries are used extensively in electric vehicles, electric bicycles and scooters, cordless power tools, and portable electronic devices such as smartphones, tablets, and laptops.



Spodumene, the most commonly produced lithium mineral. Photograph by Scott Horvath, U.S. Geological Survey.

**Table 2.** Lithium projects developed or planned for development in Africa from 2017 to 2026. <sup>a</sup>

[Data are aggregated from U.S. Geological Survey international minerals yearbooks (Barry, 2023a; Barry 2023b; Perez, 2023; Plaza-Toledo, 2023) and company press releases, reports, and presentations from Lepidico Ltd. (2022), Atlantic Lithium Ltd. (2023), and Leo Lithium Ltd. (2023). Production capacity is in metric tons per year (t/yr) of lithium content]

Country	Project	Operating companies	Startup year	Production capacity, in t/yr	Stage of development	Minerals produced
Ghana	Ewoyaa	Atlantic Lithium Ltd. and Piedmont Lithium Inc.	2025	7,100	Feasibility	Spodumene
Mali	Goulamina	Leo Lithium Ltd. and Ganfeng Lithium Co. Ltd.	2023	23,200	Construction	Spodumene
Namibia	Karibib	Lepidico Ltd.	2024	1,300	Financing <sup>1</sup>	Lepidolite
Zimbabwe	Bikita	Bikita Minerals (Pvt) Ltd.	1953	1,600	Production	Petalite

<sup>a</sup>Mines that started production before 2017 include the Bikita Mine in Zimbabwe, which was operated by Bikita Minerals (Pvt) Ltd and started in 1953.



Africa produced an estimated 2,100 t of lithium, contained mostly in the lithium mineral petalite and some lepidolite, in 2018; this production accounted for about 2 percent of the world's production. Africa accounted for less than 1 percent of the world's production in 2021 (USGS, 2020, p. 98–99; 2023, p. 108–109). Lithium was mined in Namibia and Zimbabwe in 2018, but production in Namibia has been intermittent; there was no production in 2019. In Zimbabwe, lithium production was only from the Bikita mine as of 2020 (table 2).

Most of the planned new lithium production in Africa was expected to be in the form of spodumene, which is the most commonly produced lithium mineral. Leo Lithium Ltd. and Ganfeng Lithium Co. Ltd. are engaged in construction of a new mine in Mali that would have a capacity of more than 23,000 t/yr of lithium contained in spodumene. Atlantic Lithium Ltd. and Piedmont Lithium Inc. are engaged in a feasibility study on a new mine in Ghana with a startup year of 2025 and production capacity of 7,100 t/yr of lithium (table 2). In 2024, Lepidico Ltd. plans to restart production of lepidolite at the Karibib project in Namibia with a production capacity of 1,300 t/yr (table 2; Leo Lithium Ltd., 2023).

## Rare Earths

Rare earths have a wide variety of uses, including catalysts, ceramics, glass, magnets, metallurgical applications, pigments, and polishing (USGS, 2023, p. 142–143). Magnets containing rare earths are often used in automotive applications, computer hard drives, industrial motors, and loudspeakers. Rare-earth magnets have been increasingly used for wind turbines in recent years. Battery applications for rare earths include portable electronics, stationary energy storage, and hybrid electric vehicles. In 2016, the demand for rare-earth oxides for use in clean energy applications was expected to be about 34,000 t by 2025 (Zhou and others, 2017).

The world's rare-earth mine production was estimated to be 190,000 t of rare-earth-oxide equivalent in 2018, of which Africa accounted for 1 percent with production reported in Burundi and

Madagascar. Africa accounted for 2 percent of world production in 2021 (USGS, 2020, p. 132–133; 2023, p. 142–143). Additional small amounts of monazite were mined in Nigeria.

In 2018, monazite recovery as a byproduct of mineral sands mining started in Madagascar and Mozambique at the Mandena and Moma mines with a total rare-earth production capacity of 7,800 t/yr (table 3). In 2019, Rio Tinto Group produced approximately 21,000 t of concentrate at Mandena in Madagascar with an estimated rare-earth content of 5,000 t (Rio Tinto plc, 2020). Kenmare Resources plc (table 3) produces heavy mineral concentrates containing monazite at the Moma mine in Mozambique; the company produced about 15,300 t of a mineral concentrate with an estimated monazite content of 18 percent in 2022 (Kenmare Resources plc, 2019, p. 24, 49; 2023, p. 39).

New hard-rock projects (Longonjo in Angola, Songwe Hill in Malawi, Ngualla in Tanzania, and Makuutu in Uganda) have the potential to account for most of Africa's rare-earth mine production in the future. These projects are in the financing stage of development. Steenkampskraal, which is a hard-rock project in South Africa, was in the feasibility study stage of development. Production of rare-earth minerals from phosphate rock tailings could start in South Africa at Phalaborwa in 2026 depending on the results of a feasibility study (table 3).



Rare earth oxides. Photograph by Peggy Greb, U.S. Department of Agriculture, public domain.

**Table 3.** Rare-earth projects developed or planned for development in Africa from 2017 to 2026.

[Data are aggregated from company press releases, reports, and presentations from Kenmare Resources plc (2019, 2023), Rio Tinto plc (2020), Mkango Resources Ltd. (2022), Pensana plc (2022, 2023), Rainbow Rare Earths Ltd. (2022), Ionic Rare Earths Ltd. (2023), Peak Rare Earths Ltd. (2023), and Steenkampskraal Holdings Ltd. (2023). Production capacity is in metric tons per year (t/yr) of rare-earth oxide equivalent]

Country	Project	Operating company	Startup year	Production capacity, in t/yr	Stage of development	Mineral sands deposit?
Angola	Longonjo	Pensana plc	2025	<sup>a</sup> 21,000	Financing	No
Madagascar	Mandena	Rio Tinto plc	2018	<sup>b</sup> 5,000	Production	Yes
Malawi	Songwe Hill	Mkango Resources Ltd.	2025	6,000	Financing	No
Mozambique	Moma	Kenmare Resources plc	2018	<sup>b</sup> 2,800	Production	Yes
South Africa	Phalaborwa	Rainbow Rare Earths Ltd.	2026	1,700	Feasibility	No
South Africa	Steenkampskraal	Steenkampskraal Holdings Ltd.	2024	3,000	Feasibility	No
Tanzania	Ngualla	Peak Rare Earths Ltd.	2025	16,200	Financing	No
Uganda	Makuutu	Ionic Rare Earths Ltd.	2024	1,300	Financing	No

<sup>a</sup>Estimated based on expected recovery rates of neodymium and praseodymium.

<sup>b</sup>Estimated based on production.

<sup>c</sup>Trial production started in 2024; large-scale production planned for 2026.

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