



2017–2018 Minerals Yearbook

MADAGASCAR [ADVANCE RELEASE]

THE MINERAL INDUSTRY OF MADAGASCAR

By Thomas R. Yager

Note: In this chapter, information for 2017 is followed by information for 2018.

In 2017, Madagascar played a significant role in the world's production of cobalt, ilmenite, mica, nickel, and zircon. The country's share of world production of mined and refined cobalt amounted to about 3% each, and mined nickel and zircon, 2% each. Other domestically significant minerals produced included chromite, gemstones, and ornamental stones. Madagascar was not a globally significant consumer of minerals in 2017 (Cobalt Institute, 2018; Banque Centrale de Madagascar, 2019, p. 113; Bedinger, 2019a, b; Curry, 2019; McRae, 2019; Shedd, 2019).

Minerals in the National Economy

In 2017, the mining sector accounted for a projected 3% of the gross domestic product (GDP); metal manufacturing, 1%; and construction materials, 0.5%. The share of the mining sector in the GDP was 0.7% in 2012; the increase was primarily attributable to increased production at the Ambatovy nickel-cobalt project. The manufacturing sector other than construction materials and metal manufacturing accounted for an estimated 13.5% of the GDP in 2017 (Ministry of Economy and Planning, 2016, p. xxiv; 2018, p. xxvii).

In 2017, Madagascar's total exports were valued at \$2.82 billion, of which minerals accounted for at least 27%. Nickel accounted for 13% of the value of total exports; cobalt, 6%; gold, 3%; and ilmenite and rutile, a total of 2.7%. In 2007, total exports were valued at \$1.3 billion, of which minerals accounted for 2.9%. Increased mineral exports were attributable to the start of ilmenite, rutile, and zircon production in 2009, and cobalt and nickel production, in 2012. In 2017, total imports were valued at \$3.64 billion, of which mineral fuels accounted for 13.2% (World Trade Organization, 2015, p. 17; Banque Centrale de Madagascar, 2019, p. 112–113).

The United States imported nickel from Madagascar valued at \$37.7 million in 2017 and \$29.6 million in 2016. Other mineral imports from Madagascar included nonferrous metals other than copper and gold, which were valued at \$54.1 million in 2017 and \$27.7 million in 2016. Imports of gemstones other than diamond increased to \$21.3 million in 2017 from \$18.7 million in 2016 (U.S. Census Bureau, 2018).

In 2015 (the latest year for which data were available), formal employment in the mining and quarrying sector in Madagascar was reported to be 8,815 workers. More than 500,000 additional workers were estimated to be employed in artisanal mining in Madagascar, including at least 45,000 in gold mining (Xinhuanet, 2017; Moore Stephens LLP, 2018, p. 95; Extractive Industries Transparency Initiative, undated).

Madagascar's mining and quarrying sector was governed by the Mining Code and its implementing decree (Law No. 99–022 of August 19, 1999, as amended by Law No. 2005–021 of October 17, 2005, and Decree No. 2006–910 of December 19, 2006). Exploration and production of petroleum

was governed by the Petroleum Code and its implementing decree (Law No. 96018 of September 4, 1996, and Decree No. 97–740 of June 23, 1997).

In late 2016, the Government was considering the adoption of new mining and petroleum codes. The draft of the new mining code had provisions to increase royalty rates and to give the Government a 10% free-carried interest in all new mining projects. In June 2017, however, the Government announced that the planned legislation was cancelled to provide a stable environment for investment (Australia's Paydirt, 2016; Stoddard, 2017).

Production

In 2017, gold production increased by 383% compared with production in 2016; chromite, by 93%; zircon, by 78%; mica, by 56%; ilmenite, by 51%; rutile, by an estimated 50%; amazonite, by an estimated 49%; and graphite, by 45%. Between 2013 and 2017, the output of ruby increased by an estimated 260%; mica, by 256%; graphite, by 210%; chromite, by 136%; sapphire, by an estimated 71%; and ammonium sulfate, by an estimated 68%.

The production of quartz decreased by 53% in 2017 compared with that of 2016; granite, by 20%; ammonium sulfate, by an estimated 18%; refined nickel, by 16%; and mined nickel, by an estimated 14%. Crude petroleum production shut down in 2016 as pilot production ended. Between 2013 and 2017, quartz production decreased by 85%; emerald, by an estimated 81%; granite, by 47%; pozzolanic material, by an estimated 43%; and agate, by an estimated 33%.

In 2017, amazonite production increased because of improvements to infrastructure near the mine site. Increased production of ilmenite, rutile, and zircon may have been attributable to improved conditions on world markets. Data on mineral production are in table 1.

Structure of the Mineral Industry

Most of Madagascar's mining and mineral-processing operations were privately owned, including the gemstone, graphite, mineral sands, nickel, and salt mines and the cement plants. Artisanal miners produced gemstones, gold, mica, and salt. State-owned Kraomita Malagasy SA (KRAOMA) held a 20% share in the country's only chromite-mining operation. Table 2 lists major mineral industry facilities in Madagascar.

Commodity Review

Metals

Chromium.—KRAOMA produced high-grade chromite from the Bemanevika Mine in Betsiboka Region. In 2017, the company produced 208,100 metric tons (t) compared with 107,735 t in 2016 and 148,198 t in 2015.

Increased output in 2017 may have been attributable to new processing plants that allowed KRAOMA to retreat chromite tailings (Andriamampandry, 2018; Moore Stephens LLP, 2018, p. 10; Banque Centrale de Madagascar, 2019, p. 113).

Cobalt and Nickel.—Sherritt International Corp. of Canada and its joint-venture partners Sumitomo Corp. of Japan and Korea Resources Corp. mined nickel-cobalt laterite deposits at Ambatovy. Lateritic slurry from the Ambatovy ore-processing plant was processed into mixed cobalt and nickel sulfides at a pressure-acid-leaching plant at Toamasina. The sulfide product was processed at a refinery with a capacity of 60,000 metric tons per year (t/yr) of refined nickel and 5,600 t/yr of cobalt. In early December 2017, Sherritt reduced its interest in Ambatovy to 12% from 40% through a sale to its joint-venture partners (table 2; Sherritt International Corp., 2018, p. 1).

Refined nickel production at Ambatovy decreased to 35,474 t in 2017 from 42,105 t in 2016, and refined cobalt, to 3,053 t from 3,273 t. The recovery rate for nickel was 85% in 2017. Decreased production was attributable to problems with the acid plant and pressure-acid-leaching circuit and shutdowns for maintenance in the second and third quarters. Planned production for 2018 was between 40,000 and 43,000 t of refined nickel and between 3,900 and 4,200 t of refined cobalt (Sherritt International Corp., 2018, p. 9, 16, 19).

Gold.—In the first 4 months of 2017, Madagascar exported 900 kilograms (kg) of gold, which was 53% more than the country's gold exports for all of 2016. Increased reported exports were attributable to the Government's new system of licensing artisanal miners and the establishment of a new agency to monitor the gold subsector (Xinhuanet, 2017).

Titanium and Zirconium.—QIT Madagascar Minerals SA (QMM) [QIT Fer et Titane of Canada (a subsidiary of Rio Tinto plc), 80%, and the Government of Madagascar, 20%] mined ilmenite, rutile, and zircon at Mandena in southeastern Madagascar. In 2017, QMM produced 403,500 t of ilmenite and 27,800 t of zircon compared with 267,962 t of ilmenite and 15,582 t of zircon in 2016 (Moore Stephens LLP, 2018, p. 10; Banque Centrale de Madagascar, 2019, p. 113).

World Titanium Resources Ltd. (WTR) of Australia was considering the development of the Ranobe Mine, which is part of the Toliara Sands project in southwestern Madagascar. In January 2016, the company completed a scoping study on a revised mining plan. Production in the study was 670,000 t/yr of ilmenite and 66,000 t/yr of rutile and zircon during an estimated 17-year mine life. In December 2017, WTR was purchased by Base Resources Ltd. of Australia. Base Resources planned to complete a new feasibility study on Ranobe. Depending on the results of the study, construction could start in the second half of 2019 and mining, in mid-2021 (World Titanium Resources Ltd., 2016; Base Resources Ltd., 2017).

Industrial Minerals

Gemstones.—In recent years, Madagascar has produced a variety of gemstones that included aquamarine, emerald, and other types of beryl; tsavorite and other types of garnet; amethyst, citrine, and other types of quartz; and agate, amazonite, cordierite, jasper, labradorite, ruby, sapphire, and tourmaline.

Most gemstones were exported, including to Thailand and the United States, prior to cutting and polishing.

Sapphire was mined at such locations as Ilakaka, Manombe, Marosely, and Sakara. Madagascar's production increased to an estimated 5,000 kg in 2015 from 4,534 kg in 2014 because of the discovery of new deposits at Andrebabe. In 2016, production increased to an estimated 6,500 kg because of the discovery of new deposits of blue sapphire near Andranondambo in January and near Bemainty in September. About 50,000 artisanal miners were estimated to be working at the Bemainty mines in September 2016; only 20,000 miners remained in February 2017. Many of the miners stopped working at Bemainty because of illness, insufficient funding, or to return to previous employment (tables 1 and 2; Pardieu and others, 2016; 2017, p. 4; PricewaterhouseCoopers Madagascar, 2016, p. 66).

Norcross Madagascar Group (NMG) of the United States produced amazonite from its mine in the Amboasitra Region; production increased by an estimated 50% in 2017. In December 2016, the company completed a new road to the mine that would allow mining to take place for the entire year and facilitate the transportation of equipment to increase productivity. Mining previously was limited to 8 months of the year because of the rainy season (table 1; Norcross Madagascar Group, 2016).

Graphite.—Madagascar's graphite production increased to 13,300 t in 2017 from 9,200 t in 2016 and 8,006 t in 2015. In recent years, Etablissements Gallois S.A accounted for the majority of domestic graphite production. Etablissements Gallois increased its capacity to 150,000 t/yr from 10,000 t/yr in recent years (tables 1 and 2; Ministry of Economy and Planning, 2016, p. 67; MadaGraphite Inc., 2017; Banque Centrale de Madagascar, 2019, p. 113).

In 2015 and 2016, Stratmin Global Resources Plc of the United Kingdom produced 1,500 t/yr of graphite at its Loharano project. Bass Metals Ltd. of Australia purchased Loharano in 2016; the company shut down mining operations in 2017 during an optimization program to increase production to 6,000 t/yr. Bass Metals planned to increase production to 20,000 t/yr in 2019 by mining the Mahefedok deposit, which was located adjacent to Loharano. As of 2014, indicated resources at Loharano were estimated to be 421,000 t at a grade of 5.15% graphite and inferred resources were estimated to be 5.23 million metric tons (Mt) at a grade of 4.04% graphite. Between 60% and 70% of Loharano's production was expected to be large- and jumbo-flake graphite after the optimization was completed (Chadwick, 2014; Industrial Minerals, 2014; Cornish, 2017).

In October 2017, Tirupati Graphite PLC of the United Kingdom acquired the Sahamamy-Sahasoia project from Establishment Rostaing, which was producing about 250 t/yr of graphite. The company planned to produce 3,000 t/yr of graphite at Sahamamy-Sahasoia starting in the fourth quarter of 2018 and 21,000 t/yr starting in 2020 (Tirupati Graphite PLC, 2018).

Tirupati planned to develop a new mine and processing plants at the Vatomaina project. The company planned to build a processing plant with a capacity of 6,000 t/yr in the first quarter of 2019 and three additional plants with capacities of 18,000 t/yr each in 2019, 2020, and 2021. By 2021, total capacity was expected to be 60,000 t/yr. Graphite at the Vatomaina deposit was estimated to be about 35% large-flake

and 30% jumbo-flake (Stratmin Global Resources Plc, 2016; Tirupati Graphite PLC, 2018).

In 2015, Energizer Resources Inc. of Canada completed a feasibility study on a new mine at its Molo project. Planned production in the study was about 53,000 t/yr of graphite concentrates. In April 2017, Energizer changed its name to NextSource Materials Inc. (NextSource Materials Inc., 2017).

NextSource completed a revised feasibility study on Molo in 2017. Planned production was reduced to 17,000 t/yr of concentrate at a grade of 97% graphite during the estimated 30-year mine life; mining could start in 2018. The adoption of the new production plan was partially attributable to its much lower capital costs. Production could be increased to 50,000 t/yr depending on market conditions. Resources were estimated to be 141 Mt at a grade of 6.1% graphite and reserves, 22.4 Mt at a grade of 7.02% graphite. Jumbo-flake graphite was expected to account for nearly 24% of Molo's output, and large-flake graphite, nearly 23% (NextSource Materials Inc., 2017).

Mica.—Artisanal miners accounted for most of Madagascar's mica production. Groupe AKESSON Mineragrex S.A. produced about 2,000 t/yr from its mines in southeastern Madagascar. Mica also was produced by Amboasary Mining Co. and Societe des Mines d'Ampandranhava. National mica output increased to 34,817 t in 2017 from 22,311 t in 2016 and 16,710 t in 2015. At least 23,500 t was produced in the Anosy Region in 2017, of which mines at Ranopiso accounted for 10,000 t; mines at Ambatoabo, 8,000 t; and Tranomaro, 4,000 t (table 1; Schipper and Cowan, 2018, p. 36–37; van der Waal, 2019, p. 25–26).

Mica sheet and splittings, which were used in the electronics industry, accounted for 70% of production in 2016. In 2017, China accounted for 87% of Madagascar's mica exports by volume and 81% by value (Schipper and Cowan, 2018, p. 37; van der Waal, 2019, p. 26).

Nitrogen.—Sherritt and its joint-venture partners consumed ammonia in the production of cobalt and nickel at Ambatovy. Ammonium sulfate fertilizer was produced as a byproduct; production decreased to about 110,000 t in 2017 from 134,770 t in 2016. The ammonium sulfate production capacity at Ambatovy was 210,000 t/yr (table 2; Sherritt International Corp., 2018, p. 18–19).

Mineral Fuels

Coal.—In November 2017, Lemur Holdings (a subsidiary of Bushveld Minerals Ltd. of the United Kingdom) signed a 30-year power purchase agreement with Government-owned utility Jiro sy Rano Malagasy (JIRAMA) regarding the Imaloto power project. Depending on the results of a feasibility study, JIRAMA would purchase 10 megawatts (MW) of capacity from a new coal-fired power station near the Imaloto coal deposits starting in 2021. The power station had a planned capacity of 60 MW; Lemur planned to complete the feasibility study in the first half of 2018 (Bushveld Minerals Ltd., 2017).

MINERAL INDUSTRY HIGHLIGHTS IN 2018

In 2018, Madagascar's GDP was projected to be more than \$12 billion. The mining and quarrying sector accounted for a projected 3% of the GDP; metal manufacturing, 1%; and

construction materials, 0.5%. The principal mineral exports were (in decreasing order of value) nickel, cobalt, gold, and ilmenite (Ministry of Economy and Planning, 2018, p. xxiii–xxiv, xxvii; Banque Centrale de Madagascar, 2019, p. 113).

In 2018, graphite production increased by 260%; mica, by 40%; granite, by 29%; and cement, by an estimated 17%. Crude petroleum and rare-earths production restarted in 2018. Quartz production decreased by 49% in 2018; chromite, by 48%; amazonite, by an estimated 25%; zircon, by 19%; and ammonium sulfate, by an estimated 14% (table 1).

In August 2018, KRAOMA signed an agreement with Ferrum Mining LLC of Russia. The companies formed a new joint-venture company in which Ferrum and KRAOMA's shares were 80% and 20%, respectively. In October, KRAOMA transferred three of its mining licenses at Bemanevika to the joint-venture company. KRAOMA's production of chromite decreased to 109,200 t in 2018 from 208,100 t in 2017. The decrease may be partially attributable to aging equipment. At the end of November, mining operations shut down because of a labor dispute (Rakotobe and Raymond, 2018; Banque Centrale de Madagascar, 2019, p. 113).

Refined nickel production at Ambatovy decreased to 33,183 t in 2018 from 35,474 t in 2017, and refined cobalt, to 2,852 t from 3,053 t. Ammonium sulfate production decreased to 94,342 t in 2018 from about 110,000 t in 2017. Decreased output was attributable to damage from Cyclone Ava in January 2018 and unscheduled maintenance in the fourth quarter. Planned production at Ambatovy for 2019 was between 40,000 and 45,000 t of refined nickel and between 3,500 and 4,000 t of refined cobalt (Sherritt International Corp., 2019, p. 18, 29–30).

QMM's production of ilmenite at Mandena decreased to 380,500 t in 2018 from 403,500 t in 2017. Zircon production decreased to 22,400 t in 2018 from 27,800 t in 2017. QMM started recovering monazite from tailings at Mandena; production was estimated to be 2,000 t by yearend (Rio Tinto plc, 2018, p. 2–3; Banque Centrale de Madagascar, 2019, p. 113).

At yearend, Base Resources was engaged in a prefeasibility study on the Ranobe project. The company planned to finish its study in the first quarter of 2019. Depending on the results of the prefeasibility and feasibility studies, Base Resources could start mining at Ranobe by 2021. The company planned to make its investment decision by the fourth quarter of 2019 (Piper, 2019).

NMG produced about 180 t/yr of amethyst. The company's production of amazonite was disrupted by local unrest in 2018 (table 1; Robert Grant, President, Norcross Madagascar Group, written commun., June 10, 2019).

National graphite production increased to 47,900 t in 2018 from 13,300 t in 2017. The increase was primarily attributable to Etablissements Gallois' ramping up of production towards its new capacity (Banque Centrale de Madagascar, 2019, p. 113; Saxby, 2019).

Bass Metals restarted mining at its Graphmada project (formerly Loharano) in 2018. The company planned to produce 6,000 t/yr of graphite in the first phase of the project and to increase production to 20,000 t/yr starting in 2020 (Andrews, 2018).

As of yearend, Tirupati had not commissioned the first stage of its expansion at Sahamamy-Sahaso. NextSource had not

started mining at Molo at yearend; the company was awaiting its mining license (NextSource Materials Inc., 2019; Saxby, 2019).

In 2018, national mica production increased to 48,763 t from 34,817 t in 2017. Mica was mined mostly in the dry season between April and September when pits and tunnels were more accessible. Most of the mica mined in Madagascar was phlogopite (table 1; van der Waal, 2019, p. 20, 34).

In the fourth quarter of 2018, Bushveld was engaged in a feasibility study on a coal-fired power station at its Imaloto project. The company signed an amended power purchase agreement with JIRAMA in which JIRAMA would purchase 25 MW of capacity from the proposed power station (Kotze, 2018).

Outlook

Ammonium sulfate, cobalt, and nickel production is likely to increase in 2019 after decreasing in 2017 and 2018. Graphite production is expected to increase between 2019 and 2021 with the expansion of the Gallois, the Graphmada, and the Sahamamy Mines and the development of the Molo and the Vatomaina projects. Ilmenite, rutile, and zircon production could increase starting in 2021 with the development of the Ranobe Mine. Coal mining could start in late 2021 because of the startup of Lemur's power station. The development of the mineral industry will depend on world market conditions and domestic political stability.

References Cited

Andrews, Mark, 2018, Bass' expandability in Madagascar: Australia's Paydirt, v. 1, no. 265, October, p. 78.

Andriamampandry, Rado, 2018, KRAOMA—Cinq usines de traitement de chromites installées à Brieville [KRAOMA—Five chromite processing plants installed at Brieville]: La depeche de Madagascar [Antananarivo, Madagascar], May 7. (Accessed December 13, 2018, at <http://www.ladepeche-madagascar.com/economie/kraoma-cinq-usines-de-traitement-de-chromites-installees-a-brieville/>.)

Australia's Paydirt, 2016, Madagascar ready for change: Australia's Paydirt, v. 1, no. 243, October, p. 72.

Banque Centrale de Madagascar, 2019, Rapport annuel 2018 [Annual report 2018]: Banque Centrale de Madagascar, 121 p. (Accessed October 8, 2019, at https://www.banky-foibe.mg/_rapport-annuel/.) [In French]

Base Resources Ltd., 2017, Transformational acquisition of the Toliara Sands project and A\$100 million share offer: West Perth, Western Australia, Australia, Base Resources Ltd., December 19, 5 p. (Accessed March 8, 2019, at <https://baseresources.com.au/investors/announcements/>.)

Bedinger, G.M., 2019a, Titanium mineral concentrates: U.S. Geological Survey Mineral Commodity Summaries 2019, p. 176–177.

Bedinger, G.M., 2019b, Zirconium and hafnium: U.S. Geological Survey Mineral Commodity Summaries 2019, p. 192–193.

Bushveld Minerals Ltd., 2017, Lemur secures power purchase agreement with national utility JIRAMA for the Imaloto power project: St. Peter Port, Guernsey [United Kingdom], Bushveld Minerals Ltd., November 23. (Accessed December 14, 2018, at <https://www.bushveldminerals.com/regulatory-news-rns/>.)

Chadwick, John, 2014, Glorious graphite: International Mining, v. 9, no. 5, May, p. 50–53.

Cobalt Institute, 2018, 2017 CI production statistics: Cobalt News Magazine, issue 2, April, p. 3–8. (Accessed August 16, 2018, at <https://www.cobaltinstitute.org/cobalt-news.html>.)

Cornish, Laura, 2017, Bass Metals' Graphmada Mine the platform to building a mid-tier industrial minerals business: Mining Review Africa, issue 7, July, p. 24–26.

Curry, K.C., 2019, Mica: U.S. Geological Survey Mineral Commodity Summaries 2019, p. 108–109.

Extractive Industries Transparency Initiative, [undated], Madagascar:

Extractive Industries Transparency Initiative. (Accessed February 7, 2018, at <https://eiti.org/madagascar>.)

Industrial Minerals, 2014, Africa—Open for business: Industrial Minerals, no. 557, February, p. 44–48.

Kotze, Chantelle, 2018, Lemur Holdings—A power pioneer in Madagascar: Mining Review Africa, no. 10, October, p. 24–26.

MadaGraphite Inc., 2017, Plants: MadaGraphite Inc. (Accessed November 22, 2019, at <https://web.archive.org/web/20170622005838/http://madagraphite.com/index.php/index/plants.html>.)

McRae, M.E., 2019, Nickel: U.S. Geological Survey Mineral Commodity Summaries 2019, p. 112–113.

Ministry of Economy and Planning, 2016, Rapport économique et financier 2015–2016 [Economic and financial report 2015–2016]: Ministry of Economy and Planning, December, variously paged. (Accessed February 5, 2018, at <http://www.economie.gov.mg/wp-content/uploads/2017/04/REF2015-2016VF.pdf>.)

Ministry of Economy and Planning, 2018, Rapport économique et financier 2017–2018 [Economic and financial report 2017–2018]: Ministry of Economy and Planning, December, variously paged. (Accessed November 22, 2019, at <http://www.economie.gov.mg/wp-content/uploads/2019/05/REF%202017-2018.pdf>.) [In French]

Moore Stephens LLP, 2018, Rapport final ITIE 2016 [ITIE final report 2016]: Extractive Industries Transparency Initiative Madagascar, 158 p. (Accessed November 7, 2019, at https://eiti.org/sites/default/files/documents/madagascar_rapport-de-reconciliation-eiti-exercice-2016.pdf.)

NextSource Materials Inc., 2017, Molo graphite project: Toronto, Ontario, Canada, NextSource Materials Inc., August 20, 2 p. (Accessed October 23, 2017, at http://nextsourcematerials.com/static/media/uploads/2017-08-20_molo_fact_sheet.pdf.)

NextSource Materials Inc., 2019, NextSource Materials Inc. granted mining permit for Molo graphite project in Madagascar: Toronto, Ontario, Canada, NextSource Materials Inc., February 15. (Accessed November 22, 2019, at <http://www.nextsourcematerials.com/posts/nextsource-materials-inc-granted-mining-permit-for-molo-graphite-project-in-madagascar/>.)

Norcross Madagascar Group, 2016, Press releases—News updates: Tucson, Arizona, Norcross Madagascar Group. (Accessed February 7, 2018, at <https://www.madagascarminerals.com/press-releases-2016.cfm>.)

Pardieu, Vincent, Sangsawong, Supharart, Vertriest, Wim, Detroyat Stanislas, Raynaud, Victoria, and Engniwat, Sasithorn, 2016, Blue sapphires from a new deposit near Andranondambo, Madagascar: Gems & Gemology, v. 52, no. 1, Spring, p. 96–97.

Pardieu, Vincent, Vertriest, Wim, Weeramonkhonlert, Vararut, Raynaud, Victoria, Atikarnsakul, Ungkhana, and Perkins, Rosey, 2017, Sapphires from the gem rush Bemainty area, Ambatondrazaka (Madagascar): Gemological Institute of America, February 1, 45 p. (Accessed December 16, 2018, at <https://roseyperkins.com/wp-content/uploads/2017/06/Old-and-New-Sapphire-Rushes-in-Bemainty-Area-Madagascar2017.pdf>.)

Piper, Dominic, 2019, Mineral sands expansion for Base: Australia's Paydirt, v. 1, no. 267, December–January, p. 46–47.

PricewaterhouseCoopers Madagascar, 2016, Rapport ITIE—Exercice 2014 [ITIE report—2014 exercise]: Extractive Industries Transparency Initiative Madagascar, 135 p. (Accessed February 1, 2017, at https://eiti.org/sites/default/files/documents/madagascar_rapport-de-reconciliation-eiti-2014.pdf.) [In French]

Rakotobe, Tiana, and Raymond, Riana, 2018, KRAOMA Mining—A joint venture at the center of attention: Malina, December 31. (Accessed November 21, 2019, at <https://malina.mg/en/article/kraoma-mining--a-joint-venture-at-the-centre-of-attention>.)

Rio Tinto plc, 2018, Rio Tinto-QMM report of the Independent International Advisory Panel (visit of September 3–8, 2018): Rio Tinto plc, 15 p. (Accessed May 29, 2019, at https://www.riotinto.com/documents/RT_QMM_IAP_Report_Sept_2018.pdf.)

Saxby, Alison, 2019, Graphite—NextSource Materials' new DFS outlines phased approach for graphite project: Roskill Information Services Ltd., October 21. (Accessed November 22, 2019, at <https://roskill.com/news/graphite-nextsource-materials-new-dfs-outlines-phased-approach-for-graphite-project/>.)

Schipper, Irene, and Cowan, Roberta, 2018, Global mica mining and the impact on children's rights—Annex 1—Country profiles of major mica-producing countries: Stichting Onderzoek Multinationale Ondernemingen, March, 70 p. (Accessed December 13, 2018, at https://www.terredeshommes.nl/sites/tdh/files/visual_select_file/nl180313_annex_1_global_mica_mining.pdf.)

Shedd, K.B., 2019, Cobalt: U.S. Geological Survey Mineral Commodity Summaries 2019, p. 50–51.

Sherritt International Corp., 2018, 2017 annual report: Toronto, Ontario, Canada, Sherritt International Corp., 144 p. (Accessed August 9, 2018, at https://s2.q4cdn.com/343762060/files/doc_financials/2017/WEB-2017-Sherritt-ENGLISH-Annual-Report.pdf.)

Sherritt International Corp., 2019, 2018 financial results: Toronto, Ontario, Canada, Sherritt International Corp., 135 p. (Accessed August 16, 2019, at https://s2.q4cdn.com/343762060/files/doc_financials/Annual-Report/2018/2018-Financial-Results-2-20-Final.pdf.)

Stoddard, Ed, 2017, Madagascar's president says no plans to change mining code: Thomson Reuters, June 14. (Accessed February 2, 2018, at <https://af.reuters.com/article/topNews/idAFKBN1951NJ-OZATP>.)

Stratmin Global Resources Plc, 2016, Joint venture funding initiation and Vatomaina project update: Stratmin Global Resources Plc, October 5. (Accessed February 7, 2018, at <https://markets.ft.com/data/announce/full?dokey=1323-12990542-5L5A033TA6CJF1N38DC55HCK6V>.)

Tirupati Graphite PLC, 2018, Madagascar projects: London, United Kingdom, Tirupati Graphite PLC. (Accessed December 16, 2018, at <http://www.tirupati-graphite.co.uk/madagascar-projects>.)

U.S. Census Bureau, 2018, U.S. imports from Madagascar by 5-digit end-use code—2008–2017: U.S. Census Bureau. (Accessed December 14, 2018, at <https://www.census.gov/foreign-trade/statistics/product/enduse/imports/c7880.html>.)

van der Waal, Sanne, 2019, Child labour in Madagascar's mining sector: Stichting Onderzoek Multinationale Ondernemingen, Amsterdam, The Netherlands, November, 66 p. (Accessed November 22, 2019, at <https://www.somo.nl/wp-content/uploads/2019/11/tdh-mica-madagascar-rapport.pdf>.)

World Titanium Resources Ltd., 2016, Scoping study reported a lower capital option for the Ranobe project: Perth, Western Australia, Australia, World Titanium Resources Ltd., January 20, 3 p. (Accessed February 9, 2018, at <https://www.asx.com.au/asxpdf/20160120/pdf/434h711xkvxf0.pdf>.)

World Trade Organization, 2015, Trade policy review report by the Secretariat—Madagascar: World Trade Organization, Report No. WT/TPR/S/318, June 9, 118 p. (Accessed December 15, 2016, at https://www.wto.org/english/tratop_e/tp_r_e/s318_e.pdf.)

Xinhuanet, 2017, Madagascar gold export increases in first four months of 2017: Xinhuanet, May 27. (Accessed August 9, 2018, at http://www.xinhuanet.com/english/2017-05/27/c_136318569.htm.)

TABLE 1
MADAGASCAR: PRODUCTION OF MINERAL COMMODITIES¹

(Metric tons, gross weight, unless otherwise specified)

Commodity ²	2014	2015	2016	2017	2018
METALS					
Chromium, mine, chromite	123,978 ^r	148,198 ^r	107,735 ^r	208,100 ³	109,200 ³
Cobalt:					
Mine, Co content ^c	3,400	4,000	3,800	3,600	3,300
Refinery, metal powder	2,915	3,464	3,273	3,053	2,852
Gold, mine, Au content kilograms	--	--	586 ^r	2,833	3,000 ³
Nickel:					
Mine, nickel cobalt sulfide, Ni content ^c	43,000	55,000	49,000	42,000	39,000
Refinery, metal, electrolytic	37,053	47,271	42,105	35,474	33,183
Rare earths, monazite concentrate	--	--	--	--	2,000 ^e
Titanium, mineral concentrates:					
Ilmenite and leucoxene	333,736	166,290 ^r	267,962 ^r	403,500 ³	380,500 ³
Rutile ^c	6,700 ^r	3,300 ^r	5,400 ^r	8,100	7,600
Zirconium, mineral concentrates, zircon	27,275	11,879 ^r	15,582 ^r	27,800 ³	22,400 ³
INDUSTRIAL MINERALS					
Beryl, beryl in quartz concentrates ^e	16 ^r	16 ^r	16 ^r	16	16
Cement, hydraulic	150,000 ^r	150,000 ^r	150,000 ^{r,e}	180,000 ^e	210,000 ^e
Clay:					
Kaolin	221	220 ^e	220 ^e	220 ^e	220 ^e
Unspecified	26,797	25,000 ^{r,e}	23,996 ^r	24,000 ^e	24,000 ^e
Fertilizers, ammonium sulfate	97,780	137,325	134,770	110,000 ^e	94,342
Gemstones:⁴					
Agate, ornamental ^c	800	670	670	670	670
Amazonite, ornamental ^c	420	350	350	520	390
Amethyst ^{e,5} kilograms	130,000 ^r	180,000 ^r	180,000 ^r	180,000	180,000
Calcite, ornamental	150	130 ^e	130 ^e	130 ^e	130 ^e
Cordierite ^c kilograms	1,100	900	900	900	900
Emerald do.	15	15 ^e	15 ^e	15 ^e	15 ^e
Garnet ^c do.	1,600	1,300	1,300	1,300	1,300
Labradorite, ornamental	9,300 ^{r,e}	6,832 ^r	11,059 ^r	11,000 ^e	11,000 ^e
Ruby kilograms	73	120 ^e	180 ^e	180 ^e	180 ^e
Sapphire do.	4,534	5,000 ^e	6,500 ^e	6,000 ^e	6,000 ^e
Tourmaline ^{e,5} do.	430,000	350,000	350,000	350,000	350,000

See footnotes at end of table.

TABLE 1—Continued
MADAGASCAR: PRODUCTION OF MINERAL COMMODITIES¹

(Metric tons, gross weight, unless otherwise specified)

Commodity ²	2014	2015	2016	2017	2018	
INDUSTRIAL MINERALS—Continued						
Graphite, crystalline flake, all grades ³	5,316	8,006	9,200 ^r	13,300	47,900	
Gypsum ^e	130	130	-- ^r	--	--	
Mica, phlogopite ³	12,232 ^r	16,710 ^r	22,311 ⁶	34,817 ⁶	48,763 ⁶	
Quartz, crystal, industrial ³	243	631	108 ⁶	51 ⁶	26 ⁶	
Salt, sea salt	100,000 ^{r,e}	120,000 ^e	107,295 ^r	110,000 ^e	110,000 ^e	
Stone, sand, and gravel, construction:						
Stone:						
Crushed, limestone ⁷	164,218	165,000 ^{r,e}	166,001 ^r	170,000 ^e	170,000 ^e	
Dimension:						
Dolomite	4,153	4,200 ^e	4,200 ^e	4,200 ^e	4,200 ^e	
Granite ^{3,6}	3,873 ^r	1,338 ^r	2,034 ^r	1,631	2,103	
Other, size and shape unspecified, pozzolan, pozzolanic material	42,129	40,000 ^{r,e}	36,846 ^r	37,000 ^e	37,000 ^e	
MINERAL FUELS AND RELATED MATERIALS						
Petroleum, crude	thousand 42-gallon barrels	116	95	70 ^{r,e}	--	20 ^e

^eEstimated. ^rRevised. do. Ditto. -- Zero.

¹Table includes data available through November 18, 2019. All data are reported unless otherwise noted. Estimated data are rounded to no more than three significant digits.

²In addition to the commodities listed, crude construction materials (other clays and sand and gravel), gemstones in addition to those listed (aquamarine and other varieties of beryl, citrine, and other varieties of quartz), ornamental stones in addition to those listed (apatite, jasper, and rhodonite), industrial abrasives, and calcite may have been produced, but available information was inadequate to make reliable estimates of output.

³Reported exports.

⁴Does not include smuggled artisanal production.

⁵Includes both gem and ornamental quality.

⁶Department for Economic and Social Affairs, United Nations Statistics Division, United Nations Comtrade database.

⁷Cement producers only.

TABLE 2
MADAGASCAR: STRUCTURE OF THE MINERAL INDUSTRY IN 2018

(Metric tons unless otherwise specified)

Commodity		Major operating companies and major equity owners	Location of main facilities	Annual capacity
Cement		Madagascar Long Cimenterie (Maloci)	Plant at Ambohimambola	360,000.
Do.		LaFargeHolcim (Madagascar) S.A. (LaFargeHolcim Ltd., 90%)	Plant at Ibity	200,000.
Chromium		KRAOMA Mining S.A. [Ferrum Mining LLC, 80%, and Kraomita Malagasy S.A. (KRAOMA), 20%]	Mine at Bemanevika and three other mines ¹	300,000. ^c
Clay		LaFargeHolcim (Madagascar) S.A.	Mine in Manjakandriana Region	30,000. ^c
Cobalt:				
Mine		Ambatovy Minerals S.A. (Sumitomo Corp., 47.7%; Korea Resources Corp., 40.3%; Sherritt International Corp., 12%)	Mine at Ambatovy	6,600. ^c
Refined		do.	Refinery near Toamasina	5,600.
Gemstones:				
Amazonite		Norcross Madagascar Group (NMG)	Mine in Amboasitra region	580. ^c
Amethyst		do.	Mines at Ambatondrazaka	200. ^c
Aquamarine		Artisanal and small-scale miners	Mine at Tsaramanga	NA.
Emerald	kilograms	do.	Mines at Mananjary	150. ^c
Garnet		do.	Mines at Behara	NA.
Labradorite		Norcross Madagascar Group (NMG)	Quarries at Maniry	3,600. ^c
Do.		Red Graniti Madagascar SARL	Quarry in Atsimo-Andrefana Region	3,600. ^c
Do.		Marbres et Granits de Madagascar SARL (MAGRAMA) and EUROMAD S.A.	Quarries at Ianapera and Maniry	3,000. ^c
Do.		SQNY International	do.	2,000. ^c
Do.		Societe Labrador Madagascar	Quarry in Atsimo-Andrefana Region	600. ^c
Do.		Sun Minerals Madagascar SARL [Norcross Madagascar Group (NMG) and SRE (India)]	Quarry near Maniry	NA.
Quartz		Norcross Madagascar Group (NMG)	Mines at Ramaratina	NA.
Do.		Artisanal and small-scale miners	Mine at Tsaramanga	NA.
Ruby	kilograms	do.	Mines at Ambodivoangy and Andilamena	200. ^c
Sapphire	do.	do.	Mines at Ambatondrazaka, Andranondambo, Andrebabe, Ilakaka, Manombe, Marosely, and Sakara	9,000. ^c
Tourmaline		do.	Mines at Alatsinainuy Ibity	NA.
Gold	kilograms	do.	Various locations	3,000. ^c
Graphite		Etablissements Gallois S.A.	Gallois Mine near Tamatave	150,000.
Do.		Power Stand Development (H.K.) Ltd.	Mine in Atsinanana Region	10,000.
Do.		Bass Metals Ltd.	Graphmada Mine	6,000.
Do.		Tirupati Graphite PLC	Sahamamy-Sahaso Mine	3,000.
Gypsum		Compagnie Salinere de Madagascar	Antsahampano ¹	500.
Mica		Artisanal and small-scale miners	Mines at Ranopiso in Anosy Region	11,000. ^c
Do.		do.	Mines at Ambatoabo in Anosy Region	8,800. ^c
Do.		do.	Mines at Tranomaro in Anosy Region	4,400. ^c
Do.		Groupe AKESSON Mineragrex S.A.	5 mines in southeastern Madagascar	2,200. ^c
Do.		Societe des Mines d'Ampandranhava	Mine at Tolagnaro	2,200. ^c
Do.		Amboasary Mining Co.	Mine in Amboasary District	NA.
Nickel:				
Mine		Ambatovy Minerals S.A.	Mine at Ambatovy	71,000. ^c
Refined		do.	Refinery near Toamasina	60,000.
Nitrogen		do.	do.	210,000 ammonium sulfate.
Petroleum, crude	thousand 42-gallon barrels	Madagascar Oil Ltd.	Tsimiroro	180.

See footnotes at end of table.

TABLE 2—Continued
MADAGASCAR: STRUCTURE OF THE MINERAL INDUSTRY IN 2018

(Metric tons unless otherwise specified)

Commodity	Major operating companies and major equity owners	Location of main facilities	Annual capacity
Pozzolan material	LaFargeHolcim (Madagascar) S.A.	Quarry in Vakinankaratra Region	65,000. ^c
Rare-earths	QIT Madagascar Minerals S.A. [QIT Fer et Titane (Rio Tinto plc), 80%, and Government, 20%]	Mine at Mandena	2,200 ^c monazite.
Salt	Compagnie Salinière de Madagascar	Mine near Antsiranana	80,000.
Do.	Grand Salines du Menabe and other companies	Menabe Region	23,000. ^c
Do.	Artisanal miners	Tulear Province	13,000. ^c
Stone:			
Dolomite	PROCHIMAD	Quarry in Amoron'i Mania Region	4,200. ^c
Granite	Granitex SARL	Quarry in Manjakandriana Region	3,300. ^c
Limestone	LaFargeHolcim (Madagascar) S.A.	Quarry in Vakinankaratra Region	170,000. ^c
Titanium mineral concentrates	QIT Madagascar Minerals S.A.	Mine at Mandena	750,000 ilmenite; 15,000 rutile.
Zirconium, mineral concentrates	do.	do.	40,000 zircon.

^cEstimated. Do., do. Ditto. NA Not available.

¹Not operating at the end of 2018.