

THE MINERAL INDUSTRY OF

MADAGASCAR

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The Republic of Madagascar, which is the world's fourth largest island, is about 420 kilometers (km) east of Mozambique in the Indian Ocean. Its mining industry has been chiefly noted for the production and export of chemical- and metallurgical-grade chromite ore, high-quality crystalline flake graphite, and mica. In addition to these minerals, small quantities of beryllium, gold, and rare earths have been produced, as well as industrial mineral commodities, including cement, feldspar, precious and semiprecious gemstones, quartz, salt, and ornamental stones. Madagascar was also known to have deposits of bauxite, coal, copper, lead, manganese, nickel, platinum, tin, titanium, zinc, and zirconium.

In 1999, Madagascar's gross domestic product (GDP) amounted to about \$11.5 billion at purchasing power parity, which was an increase of 4.5% compared with that of 1998. Per capita income was \$780 in 1999. Industry accounted for about 12% of GDP (U.S. Central Intelligence Agency, 2000). Madagascar's economy was negatively affected by rising oil prices and falling export prices.

On May 11, 2000, the Bureau du Cadastre Minier de Madagascar (BCCM) (Mining Deeds Office) was established following an overhaul of Madagascar's mining regulations. The BCCM will serve as a one-stop service for mining operators. The new regulations strictly define licenses and mining concessions and establish a new system of licenses based on a standard surface unit of 6.25 square kilometers (km²). The "R" permit gives its owner exclusive rights to conduct studies and exploration within a limited area. An "E" license gives exclusive rights for exploration and mining within a limited area. The "PRE" license, which is reserved for small-scale miners, gives prospecting and mining rights within a concession. Companies that invest more than \$350,000 are offered such incentives as access to foreign currency, the right to transfer money abroad to purchase mining equipment, and tax breaks that allow for a faster return on investment and recovery of money spent in the study and exploration phases (Africa Energy & Mining, 2000b).

Commodity Review

Metals

Aluminum.—Most of Madagascar's bauxite resources occur in the southeastern part of the country. The Manantenina deposit has resources of 165 million metric tons (Mt) at a grade of 41% Al₂O₃; this deposit was believed to contain the country's most promising bauxite resources. Resources at the Farafangana deposit were estimated to be 100 Mt at a grade of 37% Al₂O₃. The Ankaizina deposit was estimated to have resources of 55 Mt at a grade of 40.7% Al₂O₃. Lower grade

deposits were found northwest of Antananarivo with total resources of 10 to 15 Mt (Fonds d'Appui au Secteur Privé, 2000, Mining sector of Madagascar—Metals, accessed July 23, 2001, at URL http://www.madagascar-contacts.com/fasp/Sec_Mines/BDS Mines_B2_23.htm).

Beryllium.—In 1998, Madagascar produced about 30 metric tons (t) of beryl in quartz concentrates (table 1). The country's largest beryl deposits are found in pegamites at Ambatofinadrahana, Ampandramaika Malakialina, and Tsaratanana. Other deposits include Betafo Antsirabe, Miandrivazo, and Itrongay (Fonds d'Appui au Secteur Privé, 2000, Mining sector of Madagascar—Metals, accessed July 23, 2001, at URL http://www.madagascar-contacts.com/fasp/Sec_Mines/BDS Mines_B2_23.htm).

Copper.—Modest deposits of copper occur at Ambatovarahina, Besakoa, and Daraina. Ambatovarahina has resources of 252,000 t at a grade of 4.75% copper. Besakoa has resources of 1 Mt at a grade of 0.6% copper. Exploitation of the resources at Ambatovarahina by a small mining operation was under consideration, and the resources at Besakoa were considered to be uneconomic (Fonds d'Appui au Secteur Privé, 2000, Mining sector of Madagascar—Metals, accessed July 23, 2001, at URL http://www.madagascar-contacts.com/fasp/Sec_Mines/BDS Mines_B2_23.htm).

Gold.—Numerous deposits of gold, which include Ampanihy in the south, Andavakoera in the northeast, Farafangana on the east coast, Maevatanana in the northwest, and Miandrivazo in the west, occur in Madagascar. Although most gold production was artisanal and not officially reported, the country's actual production has been estimated to be about 2 metric tons per year (t/yr) (Fonds d'Appui au Secteur Privé, 2000, Mining sector of Madagascar—Gold, precious stones, semiprecious stones, and ornamental stones, accessed July 23, 2001, at URL http://www.madagascar-contacts.com/fasp/Sec_Mines/BDS Mines_B2_21.htm).

Iron.—Resources in the iron ore deposits near Soalala have been estimated to be 360 Mt at a grade of 35% iron. The Betioky deposit has 30 Mt of ore that grades 24% iron and 130 Mt of ore that grades 10% to 14% iron. The Bekisopa deposit had 10 Mt of ore at a grade of 60% iron and 130 Mt at a grade of 10% to 14% iron. Resources at Fasintsara were estimated to be 30 Mt of ore at grade of 36% iron and 75 Mt at a grade of 34% iron. The Fenoarivo deposit has estimated resources of 100 Mt at a grade of 30% to 40% iron. Resources at Ambatovy were estimated to be 30 Mt at a grade of 46% to 47% iron. The Ambohimahavonjy deposit has estimated resources of 15 Mt at

a grade of 30% to 40% iron. Small deposits also occur at Alaotra, Maevatanana, and Mantsoa. The Soalala deposits were considered to be the most economical; the Ambatovy and the Ambohimahavonjy deposits were also considered to be exploitable (Fonds d'Appui au Secteur Privé, 2000, Mining sector of Madagascar—Metals, accessed July 23, 2001, at URL http://www.madagascar-contacts.com/fasp/Sec_Mines/BDS Mines_B2_23.htm).

Manganese.—Deposits of manganese occur in the area of Ampanihy and Bekily and at Antanjona, Lac Alaotra, Mahamvo, and Masakoamena. The small size of these deposits would probably restrict their use to small local industries, such as ceramics, glass, and matches (Fonds d'Appui au Secteur Privé, 2000, Mining sector of Madagascar—Metals, accessed July 23, 2001, at URL http://www.madagascar-contacts.com/fasp/Sec_Mines/BDS Mines_B2_23.htm).

Nickel.—Substantial resources of nickel are found at the Ambatovy lateritic deposit, which is near the Antananarivo-Tomasina railroad. A drilling program by Phelps Dodge Corp. established a proven resource of 52 Mt of ferralite and saprolite material at a grade of 1.24% nickel, 0.09% cobalt, and 0.8% magnesium (cutoff of 0.8% nickel). Total resources have been estimated to be 168 Mt at a grade of 1.11% nickel and 0.1% cobalt. Phelps Dodge planned to develop Ambatovy into a 36,000-t/yr nickel and 3,000-t/yr cobalt mine. Extensive nickel laterites also occur on the east coast between Fenoarivo and Mananjary (Mining Journal, 1998; Premoli, 2000). Smaller deposits occur at Valozoro, which has resources of 3.7 Mt at a grade of 1.75% nickel, and at Bemainty, which has resources of 1.6 Mt at a grade of 1.3% nickel (Fonds d'Appui au Secteur Privé, 2000, Mining sector of Madagascar—Metals, accessed July 23, 2001, at URL http://www.madagascar-contacts.com/fasp/Sec_Mines/BDS Mines_B2_23.htm).

Rare Earths.—Madagascar produced small amounts of bastnaesite and monazite until 1996. Deposits of bastnaesite occur at Ambatofinandrahana. The heavy-mineral sands at Tolagnaro contain 310,000 t of monazite, and other minerals sands on the southeast coast, 177,000 t of monzanite. Deposits located 100 km north of Tolagnaro have resources of about 64,000 t with a high thorium content. The Antete monazite deposit has resources of 15,000 t. Other monazite deposits occur at Mahajanga and Morombe. The Bekolasy pyrochlore deposit, which occurs in alkaline granites, has estimated resources of 10 Mt at a grade of 0.4% pyrochlore. The Berere and the Itasy deposits occur in pegmatites. Berere contains fergusonite and xenotime; Itasy, euxenite and fergusonite; and Maharidaza, euxenite. The Office des Mines Nationales et des Industries Stratégiques (OMNIS) was considering a joint venture to exploit the Madaridaza deposit (Fonds d'Appui au Secteur Privé, 2000, Mining sector of Madagascar—Metals, accessed July 23, 2001, at URL http://www.madagascar-contacts.com/fasp/Sec_Mines/BDS Mines_B2_23.htm).

Titanium.—Madagascar is known to have substantial deposits of titanium. On the southeastern coast, deposits are

found in the area of Tolagnaro. Resources in the largest deposit, which is near Tolagnaro, were estimated to be 11.6 Mt of ilmenite at a grade of 47% to 51% titanium and 678,000 t of zircon. Another deposit near Tolagnaro has estimated resources of 2 Mt ilmenite. Resources at Tomasina were estimated to be 12 Mt ilmenite at a grade of 48% titanium and 700,000 t zircon. Other deposits were found on the western coast at Morombe and Tambohorano and in the northern part of the country (Fonds d'Appui au Secteur Privé, 2000, Mining sector of Madagascar—Metals, accessed July 23, 2001, at URL http://www.madagascar-contacts.com/fasp/Sec_Mines/BDS Mines_B2_23.htm). The Tolagnaro deposits have been explored by QIT-Fer et Titane (a subsidiary of Rio Tinto plc). The cost of developing this project was estimated to be \$400 million (Premoli, 2000). Development of these deposits was pending favorable market and investment conditions and environmental assessments.

Uranium.—Resources of uranium occur in the monazite sands at Tolagnaro. In April 1999, OMNIS signed an agreement with the French firm Compagnie Generale des Matieres Nucleaires to explore for uranium in the Morondova basin.

Industrial Minerals

Cement.—The International Cement Review (2001) estimated that Madagascar's consumption and production of cement grew by 5% and 10%, respectively, in 2000. In 1999, cement imports fell to 66,595 t at a value of \$3.26 million from 97,145 t at a value of \$5.81 million in 1998. Malaysia accounted for 72% of cement imports, and Oman, 28% (International Trade Center and United Nations Statistics Division, 2001).

Chromite.—Resources of crude chromite ore at Bemanevika amounted to 2.28 Mt; Ankazotaolana, 700,000 t; and other deposits, 900,000 t. Madagascar was the world's 10th largest producer of chromite (Premoli, 2000). Kraomita Malagasy produced concentrates (49% chromite) and lumpy ore (42% chromite) from the mine at Ankazotaolana. The company planned to reopen its mine at Bemanevika owing to resource depletion at the Ankazotaolana Mine (Indian Ocean Newsletter, 2001). Madagascar's exports of chromite products fell to 57,500 t at a value of \$3.15 million in 1999 from 147,700 t at a value of \$9.12 million in 1998. Japan accounted for 51% of chromite exports, and China, 49% (International Trade Center and United Nations Statistics Division, 2001).

Gemstones.—In 1999, Madagascar exported gemstones worth \$15.18 million, which was a 212% increase compared with that of 1998 and a 270% increase compared with that of 1995. Exports of cut stones fell to \$1.15 million in 1999 from \$2.26 million in 1995, and exports of rough stones rose to \$14.03 million from \$1.85 million in the same period. Thailand accounted for 74% of exports; Sri Lanka, 8%; the United States, 4%; Hong Kong, 3%; France, 3%; and others, 8% (International Trade Center and United Nations Statistics Division, 2001). The International Monetary Fund (2000, p. 58) indicated that

sapphire exports amounted to 2.5 t at a value of \$2.7 million in 1998 and 3.8 t at a value of \$12.5 million in 1999. In 2000, most of Madagascar's official sales of precious stones came from the Ilakaka sapphire mines. The country's production of precious stones is probably worth far more than the official figures; smuggling has been a serious problem (African Mining Intelligence, 2001).

From 1994 to 1998, the production of ornamental stones and semiprecious stones increased substantially. During this period, aragonite, which was consistently the dominant ornamental stone, accounted for 69% of total ornamental stone production. Labradorite accounted for 13%, and others, 18%. From 1994 to 1998, tourmaline, which was the leading semiprecious stone, accounted for 33% of production. Beryl accounted for 29%; garnet, 13%; citrene, 9%; amethyst, 7%; and others, 9% (Fonds d'Appui au Secteur Privé, 2000, Mining sector of Madagascar—Gold, precious stones, semiprecious stones, and ornamental stones, accessed July 23, 2001, at URL http://www.madagascar-contacts.com/fasp/Sec_Mines/BDSMines_B2_21.htm).

Graphite.—Substantial deposits of graphite occurred in the Ambatolampy, the Ampanihy, and the Manampotsy districts. Madagascar's graphite resources have been estimated to be 960,000 t (Kalyoncu, 2001). The country's largest producer of graphite was Etablissements Gallois, which had three mines in Ambalafotaka, Antsirakambo, and Marovintsy on the eastern coast and a plant in Tomasina. Other companies that mined graphite in Madagascar included Etablissements Izouard, Etablissements Rostaing, Société Louys, and Société Minière de la Grande Ile. Exports of graphite fell to 9,244 t at a value of \$4.66 million in 1999 from 13,087 t at a value of \$6.7 million in 1998. In 1999, the United Kingdom accounted for 38% of exports, Germany, 36%, the United States, 20%, and others, 6%. The refractories industry was the main consumer of Malagasy graphite (International Trade Center and United Nations Statistics Division, 2001).

Mica.—Substantial resources of phlogopite and much smaller deposits of muscovite occur in Madagascar. In recent years, only phlogopite has been mined. Deposits of mica included the Ambarata, the Ampandrandava, the Benato, and the Maniry Miary. The Ampandrandava deposit was mined by SOMIDA and the Maniry Miary deposit, by Exploitation Minière DELORME. (Fonds d'Appui au Secteur Privé, 2000, Mining sector of Madagascar—Industrial minerals, accessed July 23, 2001, at URL http://www.madagascar-contacts.com/fasp/Sec_Mines/BDSMines_B2_21.htm). Most of the country's mica production was exported; in 1999, Belgium accounted for 81% of mica exports, Japan, 14%, and others, 5% (International Trade Center and United Nations Statistics Division, 2001).

Quartz.—Deposits of citrene, industrial quartz, rose quartz, and smoky quartz occur in Madagascar. Industrial quartz was found at Kandrehoh, Mananara, and Maroantsetra; the Kaandrehoh deposit was mined by Rollmine, and the Mananara and the Maroantsetra deposits were mined by Prexmin. Citrene occurred at Mananara and Maroantsetra; rose quartz, at Ampandramaika, Andrianampy, and Samiresy; and smoky

quartz, near Antongil Bay. In 1999, Madagascar exported 586 t of quartz and quartzite; Hong Kong accounted for 49%; and Russia and Germany, 15% each (International Trade Center and United Nations Statistics Division, 2001).

Mineral Fuels

Coal.—Madagascar is known to have substantial deposits of coal. The resources at Sakoa in the southwestern part of the country have been estimated by BHP Ltd. and several other companies to exceed 100 Mt (Premoli, 2000). Madagascar's coal resources have not yet been exploited; the country imported 7,686 t of coal in 1998 and 3,030 t in 1999 from the Republic of South Africa (International Trade Center and United Nations Statistics Division, 2001).

Petroleum.—Because Madagascar did not produce crude petroleum, it relied on imports for its refinery. In 1999, imports of crude petroleum increased to about 2.86 million barrels (Mbbbl) at a value of \$69.63 million from about 2.75 Mbbbl at a value of \$51.06 million in 1998. About 85% of Madagascar's crude petroleum was imported from Iran, and from Qatar, about 15%. The value of refined petroleum products amounted to \$50.2 million in 1998 and \$50.6 million in 1999 (International Trade Center and United Nations Statistics Division, 2001).

The country's petroleum refinery had a capacity of 15,000 barrels per day and was operated by Solitany Malagasy (SOLIMA), which was the state-owned petroleum products company. At the end of 2000, the Government had not finished the privatization of SOLIMA. Galana Petroleum Ltd., which was the company chosen as buyer, had serious concerns about the refinery's environmental problems and wanted SOLIMA to clean up the site (Africa Energy & Mining, 2000a). The World Bank, which has been urging the Government to sell SOLIMA, felt that enough progress toward privatization had been made to disburse the first portion of a structural adjustment loan (Africa Energy & Mining, 2000c).

The American firm Xpronet Resources Inc. and OMNIS signed two exploration and production-sharing agreements. Xpronet will work two offshore blocks in the Mozambique channel off Madagascar's western coast; the Rivomena block was 77,500 km², and the Mavony block, 64,500 km². The licenses will be wholly owned by Xpronet, and the cost of the seismic surveys and drilling could amount to between \$35 million and \$50 million (Africa Energy Intelligence, 2000).

Infrastructure

The International Monetary Fund (2000, p. 55) estimated that Madagascar produced 659 gigawatt-hours of electricity in 1999, which was an increase of 2.6% compared with that of 1998 and 19.4% compared with that of 1995. Hydroelectric power sources provided 72.1% of the country's electricity, and fossil fuel sources accounted for the remaining 27.9%. The electric power industry was dominated by Jiro Sy Rano Malagasy, which was Madagascar's state-owned electric utility. Madagascar's known exploitable potential hydroelectric energy is 23,061 megawatts (World Resources Institute and others, 1996, p. 288).

Madagascar had about 50,000 km of roads, of which approximately 5,800 km was paved. The rail network covered nearly 900 km (U.S. Central Intelligence Agency, 2000). The country's infrastructure is in need of major repairs and expansion; its inadequacy has been a key factor in reducing the output of SOLIMA's refinery and preventing the development of Madagascar's bauxite, coal, and iron ore deposits (Crankshaw, 2001).

Madagascar's mineral industry has considerable potential, but its success ultimately depends upon the country's ability to reform the economy and to deal with chronic malnutrition, environmental issues such as deforestation and erosion, population growth, and underfunded health and education facilities. Positive developments in 2000 included the new mining regulations and the decision of the International Monetary Fund and the World Bank to grant Madagascar \$1.5 billion in debt relief.

References Cited

Africa Energy & Mining, 2000a, Madagascar—Galana slow to take over SOLIMA: Africa Energy & Mining, no. 274, May 3, p. 4.

——— 2000b, Madagascar—New mining code outlined: Africa Energy & Mining, no. 275, May 17, p. 6.

——— 2000c, Madagascar—SOLIMA talks drag on: Africa Energy & Mining, no. 279, July 12, p. 4.

Africa Energy Intelligence, 2000, Madagascar—Two blocks for Xpronet: Africa Energy Intelligence, no. 289, December 20, p. 4.

Africa Mining Intelligence, 2001, Madagascar—New precious stones license: Africa Mining Intelligence, no. 15, May 30, p. 1.

Crankshaw, Paul, 2001, Madagascar: Mining Journal Annual Review 2001, CD-ROM.

Indian Ocean Newsletter, 2001, Madagascar—Kraomita Malagasy projects: Indian Ocean Newsletter, no. 933, January 13, p. 4.

International Cement Review, 2001, Madagascar, *in* The global cement report: Dorking, United Kingdom, Tradeship Publications, Ltd., p. 197-198.

International Monetary Fund, 2000, Madagascar—Recent economic developments and selected issues: Washington, DC, International Monetary Fund, August 20, 82 p.

International Trade Center and United Nations Statistics Division, 2001, Trade Analysis System on Personal Computer: New York, International Trade Center and United Nations Statistics Division, CD-ROM.

Kalyoncu, R.S., 2001, Graphite: U.S. Geological Survey Mineral Commodity Summaries 2001, p. 72-73.

Mining Journal, 1998, Madagascar, *in* Mining annual review 1998: London, Mining Journal Ltd, p. 201.

Premoli, Camillo, 2000, Madagascar, *in* Mining annual review 2000: London, Mining Journal Ltd., CD-ROM.

U.S. Central Intelligence Agency, 2000, Madagascar, *in* World factbook 2000: U.S. Central Intelligence Agency, p. 301-303.

World Resources Institute, United Nations Environment Program, United Nations Development Program, and World Bank, 1996, World resources 1996-97: Oxford, Oxford University Press, 365 p.

TABLE 1
MADAGASCAR: PRODUCTION OF MINERAL COMMODITIES 1/ 2/

(Kilograms unless otherwise specified)

Commodity 3/	1996	1997	1998	1999 e/	2000 e/
METALS					
Beryllium, beryl in quartz concentrates, industrial and ornamental	11,160 r/	28,287 r/	30,000 r/	20,600 r/	21,500
Chromium:					
Run of mine e/	146,300 4/	143,800 4/	107,400	-- 4/	122,000
Marketable output:					
Chromite concentrate, gross weight metric tons	51,500 r/	45,000 r/	19,000 r/	-- r/ 4/	21,600
Chromite ore, lumpy do.	85,710 r/	94,700 r/	85,300 r/	-- r/ 4/	97,200
Total do.	137,210	139,700	104,300 r/	-- r/ 4/	118,800
Gold, mine output, Au content 5/	7 r/	8 r/	12 r/	8 r/	9
INDUSTRIAL MINERALS					
Abrasives, natural (industrial only) e/	7,700 r/	1,314 r/	1,280 r/	875 r/	915
Cement, hydraulic metric tons	44,332 r/	36,217 r/	44,327 r/	45,719 r/ 4/	48,000
Clay, kaolin e/ do.	34 r/	166 r/	160 r/	110 r/	115
Feldspar e/	5,348 r/	-- r/	5,660 r/	3,880 r/	4,050
Gemstones: 6/					
Ornamental stones:	1,093,356	1,072,875	2,395,715	2,400,000	2,400,000
Semiprecious stones:	966	1,835	1,225	1,200	1,200
Graphite, all grades, shipments metric tons	11,295	15,397 r/	18,690 r/	14,500 r/	15,200
Mica, phlogopite:					
Block e/ do.	1	4 r/	4 r/	3 r/	3
Scrap e/ do.	285 r/	1,020 r/	1,010 r/	690 r/	715
Splittings and sheet e/ do.	31 r/	114 r/	105 r/	72 r/	82
Total do.	317 r/	1,138 r/	1,119 r/	765 r/	800
Quartz, industrial: e/					
Crystal	29,900 r/	32,400 r/	31,700 r/	21,700 r/	22,700
Piezoelectric	61,600 r/	66,900 r/	65,300 r/	44,700 r/	46,700
Smelting	168,000 r/	182,000 r/	178,000 r/	122,000 r/	127,000
Salt, marine metric tons	41,750 r/	36,800 r/	35,900 r/	44,409 r/ 4/	46,400
Stone:					
Dimension stone do.	479 r/	2,740 r/	1,878 r/	1,290 r/	1,340
Marble, cipoline e/	1	1	1	1	1
MINERAL FUELS AND RELATED MATERIALS					
Petroleum refinery products:					
Gasoline thousand 42-gallon barrels	444 r/	607 r/	583 r/	617 r/ 4/	640
Kerosene and jet fuel do.	342 r/	454 r/	474 r/	409 r/ 4/	430
Distillate fuel oil do.	589 r/	788 r/	697 r/	749 r/ 4/	780
Residual fuel oil do.	1,003 r/	1,331 r/	1,370 r/	1,251 r/ 4/	1,300
Other do.	35 r/	59 r/	49 r/	61 r/ 4/	60
Total do.	2,413 r/	3,239 r/	3,173 r/	3,087 r/	3,210

e/ Estimated. r/ Revised. -- Zero.

1/ Estimated data are rounded to no more than three significant digits.

2/ Includes data available through July 2001.

3/ In addition to the commodities listed, modest quantities of unlisted varieties of crude construction materials (other clays, sand and gravel, and stone) and industrial calcite presumably were produced, but output was not reported quantitatively, and available information was inadequate to make reliable estimates of output levels.

4/ Reported figure.

5/ Does not include smuggled artisanal production, which was estimated to be 2,000 kilograms per year.

6/ Does not include smuggled artisanal production.