

## THE MINERAL INDUSTRY OF

# MADAGASCAR

By George J. Coakley

The Republic of Madagascar, the world's fourth largest island, is about 420 kilometers (km) east of Mozambique in the Indian Ocean and has an area of 581,540 square kilometers (km<sup>2</sup>). The area supported a population of 14.6 million in 1998, with a gross domestic product per capita of \$730 based on 1997 purchasing power parity data. Mineral production played a secondary role to agriculture and fishing in the economy of Madagascar. Coffee and vanilla accounted for about two-thirds of total exports of \$518 million in 1997. The Malagasy mining industry was chiefly noted for its 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 gold and rare earths were produced, along with some other industrial mineral commodities, including cement, feldspar, a variety of semiprecious gemstones, quartz, and salt. In recent years, active exploration on the island has targeted sapphires and other semiprecious gemstones, gold, nickel, and titanium. Undeveloped deposits of bauxite at Manantenina, iron ore at Soalala, and coal at Sakoa also occurred on the island nation. Production of refined petroleum from imported crude remained modest, and exploration for hydrocarbon resources continued. The Government had nationalized all mineral resources, with the exception of graphite and mica, in 1975.

Legislation controlling investment and mining in Madagascar included the Investment Code, law No. 85-001 and the Mining Code, law No. 90-017 of 1990, which revised and augmented law No. 89/007 of December 12, 1989. A scheduled revision of the 1990 mining permits code had yet to take place despite the rejection of the current mining code by operators in 1994. The Malagasy Parliament passed a new petroleum law in 1995, an English summary of which is available in the 1996 International Petroleum Encyclopedia (PennWell Publishing Co., 1997). During 1998, a new mining law was being prepared for presentation to the National Assembly in 1999, along with a new legal framework policy to promote new foreign investment in projects exceeding \$200 million.

Two major nickel and titanium deposits have been identified in recent years, with future development pending favorable market and investment conditions. QIT-Fer et Titane Inc., a Canadian subsidiary of Rio Tinto plc of the United Kingdom, has held the rights to the titanium-bearing minerals sands deposit in the Fort Dauphin region of southern Madagascar since 1987. During 1998, Phelps Dodge Corp. of the United States completed a feasibility study examining the development potential of its nickel laterite deposit in Ambatovy, central Madagascar, 80 km east of Antananarivo, which it outlined during exploration in 1996 and 1997. Detailed drilling in the district, which is located 80 km east of the capital city of

Antananarivo, defined a resource of 210 million metric tons (t) at 1.1 % nickel and 0.1 % cobalt. Acid consumption by the ore is low, and the ore is amenable to high-pressure acid leach extraction for nickel and cobalt. The feasibility study indicated that there was a need for the price of nickel to increase to make the project economical (Phelps Dodge Corp., 1999, Annual report for 1998, accessed January 22, 2000, through U.S. Securities and Exchange Commission at URL <http://www.sec.gov/Archives/edgar/data/78066/0000950147-99-000246.txt>).

The Government continued to seek multilateral and bilateral cooperation to aid in controlling the degradation of the environment incurred during the past few years. Uncontrolled slash-and-burn cultivation, deforestation, livestock overgrazing, and massive erosion threatened Madagascar's agricultural and hydroelectric potential and the country's unique wildlife.

Detailed production statistics were not readily available. However, estimates for 1998, based on historical levels for all mineral commodities, are listed in table 1. Mineral exports, with the exception of mineral samples associated with exploration, must be authorized by the Ministry of Energy and Mines (MEM). Smuggling of undocumented gold and semiprecious stones out of the country remained a problem. The MEM formed a new gold trading agency in 1995 in an attempt to increase the Government's share of revenue from gold production and trade. The Government's official gold export statistics have ranged from 37 kilograms (kg) in 1992 to less than 1 kg in 1993; actual production and illegal export of gold in recent years may range from 500 kilograms per year (kg/yr) to as much as 3,000 kg/yr. This illegal trade was of concern to the Government, which has sought cooperation from neighboring nations, such as Mauritius, to help interdict gold smuggling.

Madagascar imported essentially all its crude petroleum and some petroleum products, which was a significant burden to the economy. In any given year, the value of petroleum imports was equivalent to 15% to 30% of the total foreign exchange earned from all export revenues.

The chromite industry, located in Andriamena, was controlled by the parastatal Société Kraomita Malagasy (KRAOMA). Graphite and mica production were owned and operated by foreign entities, but the Government had significant influence on these operations through taxes, royalties, and official approval of all foreign exchange transactions.

Office des Mines Nationales et des Industries Stratégiques (OMNIS), created in 1976, was involved primarily in research, joint ventures, and promotion of Madagascar's mineral resources, including hydrocarbons, and acted as the repository of the acquired exploration data. The MEM, through the Directorate of Energy, had primary responsibility for the energy

sector. The MEM also directed Solitary Malagasy (SOLIMA) and the Electricity and Water Co. The distribution, importation, and refining of petroleum products were managed by SOLIMA.

KRAOMA reported chromite ore production of 140,000 t in 1998 comprising 40,000 t of concentrates and 80,000 t of lumpy ore from the Andriamena Mine and 20,000 t of fines from the Behandrinana Mine. KRAOMA ships 10,000 t of ore by rail from Morarano station and 4,000 t by truck monthly to Toamasina port. KRAOMA reported chromite ore exports of 120,000 t in 1998 (TEX Report, 1998).

Madagascar had some scattered placer and lode gold deposits, and a large black market reportedly existed for the mining and sale of gold. Gold mining was primarily artisanal and employed approximately 5,000 to 10,000 people. In 1997, Riosun Resources Corp. of Canada acquired the gold mining interests in northern Madagascar of Glamorgan Group Ltd.

The artisanal gemstone mining sector was active but largely uncontrolled and had known but unreported production of emeralds, sapphires, and other semiprecious stones. As with gold, proposed Government efforts to organize and regulate these small-scale mining activities will have the potential to increase formal export earnings and the Government tax base significantly. However, the artisanal working of sapphire deposits in the Ankarana Special Reserve and other environmentally sensitive areas had raised both local and international concerns over damage to the environment.

During 1997, Riosun Resources Corp. acquired an 80% interest in Export-Import Madagascar (Eximad) S.A.R.L., which operated the Toby Steven emerald mine in the southern part of the country. A description of the geologic setting of the emerald and sapphire deposits of southern Madagascar was reported by the Bureau de Recherches Géologiques et Minières of France (Bureau de Recherches Géologiques et Minières, 1996). Both gemstones are found in structurally controlled deposits in crystalline schists. The emerald deposits at Andonabe, Anapera, and Beandry were associated with amphibolite facies biotite gneisses and amphibolites of the early Proterozoic Vohibory System, and the sapphire deposits at Analalava, Andranondambo, Ankazoabo, and Anterimena in the south were associated with granulite facies cordierite and biotite gneisses, marbles, and pyroxenites of the Archean Androyen System.

Madagascar continued to be a producer and exporter of high-quality crystalline flake graphite, with production levels running between 12,000 and 13,000 metric tons per year (t/yr) from 1996 to 1998. Graphite was produced in Madagascar by five main companies, all headquartered in Antananarivo. Société Minière de la Grande Ile's (SMGI) Ambatomitamba graphite mine was the largest single producer, processing around 4,000 t/yr of 92% flake graphite. The other four operators were Etablissements Gallois, Société Louys, Etablissements Izouard, and Etablissements Rostaing. Three mines, with production of about 6,000 t/yr of graphite with a carbon content of 90% to 95% were operated by SMGI. SMGI was 100% owned by the French company, Société Participation

Industrielle et Minières, which also owned Société des Mines d'Ampanrandava's two phlogopite mica mines at Ampanrandava and Sakamasy.

Madagascar was essentially entirely dependent on imports of crude petroleum to meet its energy needs. Total petroleum consumption averaged about 26 million barrels per year. During the past several years, the amount of oil exploration by foreign companies in Madagascar has been modest. No significant commercial hydrocarbon finds have, however, been reported (Mbendi Information Services, August 13, 1997, Madagascar oil industry profile, accessed March 29, 1998, at URL <http://mbendi.co.za.cymdoi.htm>). In 1997, Gulfstream Resources Canada Ltd. acquired an 82% interest in the 26,700-km<sup>2</sup> Tsiribihina Block in the Morondava onshore basin and an 80% interest in the 5,200-km<sup>2</sup> Antonibe Block in the Majunga offshore basin. A 300-km seismic program in 1997 was followed by a multiwell drilling program in 1998. Several wells were drilled in the target area, one of which had an estimated 56.6 billion cubic meters of natural gas in place (Gulfstream Resources Canada Ltd, June 30, 1997, Gulfstream accelerates activity in Madagascar, accessed May 15, 1998, at URL <http://www.gur.com/pressrel.html#30/06/97>). In July 1997, Triton Energy Limited of the United States acquired the 28,170-km<sup>2</sup> offshore Ambilobe Block in the north and a 27,520-km<sup>2</sup> onshore property at the southern tip of the island.

Madagascar had production from its resources of chromite, graphite, and mica and had known deposits of bastnaesite (a rare-earth mineral), bauxite, ilmenite, iron ore, and nickel. Resources of gold and semiprecious gemstones were exploited at the artisanal level, but the economics of exploiting them as medium- to large-scale mining operations were undetermined. Deposits of coal, lignite, and uranium minerals also were known.

Infrastructure development in Madagascar was inadequate for most mining development. Additional investment was needed to improve the road system and the telecommunications network. The hydroelectric potential of Madagascar was estimated to be 14,000 megawatts (MW) but remained underexploited. In 1998, installed hydropower capacity was 106 MW. Petroleum loading and unloading facilities were at Toamasina/Tamatave but were limited to oceangoing vessels of 50,000 deadweight tons. World Bank and International Monetary Fund economic stimulus programs were implemented to accelerate the Government's liberalization and privatization efforts and to create the economic and legal environment needed to attract foreign investment in the mining, energy, and other sectors. Increasingly strict environmental protection concerns, such as those that resulted from titanium sands mining proposals and recent illegal artisanal sapphire mining, may serve to inhibit new capital investment in the mining sector, at least in the short term.

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### **Major Sources of Information**

Ministry of Energy and Mines  
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TABLE 1  
MADAGASCAR: PRODUCTION OF MINERAL COMMODITIES 1/

(Kilograms unless otherwise specified)

Commodity 2/	1994	1995	1996	1997	1998 e/
<b>METALS</b>					
Beryllium, beryl in quartz concentrates, industrial and ornamental e/	3,000	31,666 3/	32,000	32,000	32,000
<b>Chromium:</b>					
Chromite concentrate, gross weight metric tons	42,700	49,702	54,900	55,900	60,000
Chromite ore, lumpy do.	47,500	56,405	82,300	83,800	80,000
Total do.	90,200	106,107	137,200 3/	139,700 3/	140,000 3/
Gold, mine output, Au content e/ 4/	500	38 3/	50	50	50
<b>INDUSTRIAL MINERALS</b>					
Abrasives, natural (industrial only) e/	10,000	10,000	10,000	10,000	10,000
Cement, hydraulic e/ metric tons	40,000	40,000	80,000	120,000	120,000
Clay, kaolin e/ do.	700	1,545 3/	1,500	1,500	1,500
Feldspar e/	4,000	2,120 3/	2,000	2,000	2,000
<b>Gemstones: e/ 5/</b>					
Amazonite	2,000	2,000	2,000	2,000	2,000
<b>Amethyst:</b>					
Gem	1,700	1,700	1,700	1,700	1,700
Geodes	80	80	80	80	80
Graphite, all grades, shipments metric tons	14,593 r/	16,119	12,134 r/	13,975 r/	13,000
<b>Mica, phlogopite: e/</b>					
Block do.	4	1	1	1	1
Scrap do.	300 r/	389	400 r/	582	550
Splittings and sheet do.	52 r/	42	49 r/	21	49
Total do.	356 r/	432	450 r/	603	600
<b>Ornamental stones: e/ 6/</b>					
Jasper	68,000	68,000	68,000	68,000	68,000
Labradorite	61,000	61,000	61,000	61,000	61,000
<b>Quartz: e/ 7/</b>					
Crystal	32,000	32,000	32,000	32,000	32,000
Piezoelectric	66,000	66,000	66,000	66,000	66,000
Rose quartz	27,000	27,000	27,000	27,000	27,000
Smelting	180,000	180,000	180,000	180,000	180,000
Salt, marine e/ metric tons	75,783 r/	51,307 r/	50,000	50,000	50,000
<b>Stone: e/</b>					
Calcite, industrial do.	2,000	2,000	2,000	2,000	2,000
Dimension stone do.	3,000	3,000	3,000	3,000	3,000
Marble, cipoline	1	1	1	1	1
<b>MINERAL FUELS AND RELATED MATERIALS</b>					
<b>Petroleum refinery products: e/</b>					
Gasoline thousand 42-gallon barrels	225 3/	200 r/	200 r/	200	200
Kerosene and jet fuel do.	100 3/	85 r/	85 r/	85	85
Distillate fuel oil do.	70 3/	60 r/	60 r/	60	60
Residual fuel oil do.	125 3/	100 r/	100 r/	100	100
Other do.	5 3/	5 r/	5 r/	5	5
Total do.	525 3/	450 r/	450 r/	450	450

e/ Estimated. r/ Revised.

1/ Includes data available through April 1998.

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

3/ Reported figure.

4/ Does not include an estimate of smuggled artisanal production.

5/ Reported output of other gemstones for 1996, in kilograms: cordierite, 3,942; garnet, 31,607; and tourmaline, 176,256. Most emerald and sapphire production was unreported.

6/ Other ornamental stones produced in 1996 for which data were reported, in kilograms: agate, 9,335; apatite, 16,982; aragonite, 569; calcite, 43,419; ruby, 48,194; and sapphire, 94.

7/ Other forms of quartz mined historically and estimated production, in kilograms: geodes, 2,500; hematoid, 300; and other ornamental quartz, 3,000.