

THE MINERAL INDUSTRY OF MADAGASCAR

By George J. Coakley

The Republic of Madagascar, the world's fourth largest island, is located about 420 kilometers (km) east of Mozambique in the Indian Ocean and has an area of 581,540 square kilometers (km²). The area supported a population of 14.1 million in 1997 with a gross domestic product (GDP) per capita of \$880, based on 1996 purchasing power parity data. Mineral production plays a secondary role to agriculture and fishing in the economy of Madagascar. Mining accounts for 3% of GDP and based on the latest available United Nations data for 1995 accounted for \$27.9 million, or about 8% of total exports. 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 industrial mineral commodities, including cement, feldspar, a variety of semiprecious gemstones, quartz, and salt. In recent years, active exploration on the island has targeted semiprecious gemstones, gold, nickel and titanium. 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.

As part of the World Bank and International Monetary Fund Structural Adjustment Program, the Ministry of Energy and Mines reaffirmed its commitment to privatize parastatal companies in the mining and petroleum sectors, in 1997. 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 1990 Mining Code made provisions for three types of mining permits, which were further subdivided into exploration and exploitation permits. Exploration and exploitation type 1 permits were granted only to individuals or groups of Malagasy nationality and were valid for 2 years. Types 2 and 3 permits, valid for 3 and 5 years, respectively, are designed for small to large mining companies incorporated under Malagasy law. Under the mining code, the maximum size areas of types 2 and 3 exploration permits were 400 and 1,000 km², respectively. Following a 75 % reduction in land holdings during the exploration phase, the next types 2 and 3 exploitation permits allowed for maximum holdings of 100 and 200 km², respectively. 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).

The restructuring and privatization of Solitary Malagasy (SOLIMA), which operates the petroleum refinery at Tamatave, remained a Government priority with international bids solicited at yearend for the sale of SOLIMA's distribution system. In 1997, the

Tamatave refinery, severely damaged by a typhoon in April 1994, continued to operate at a reduced capacity of only 450,000 tons per year and was considered to be a less-attractive privatization opportunity by foreign investors (The Indian Ocean Newsletter, 1997).

QIT-Fer et Titane Inc. (QIT), a Canadian subsidiary of Rio Tinto plc of the United Kingdom, has conducted extensive field studies on the social and environmental aspects of a proposed mining project for titanium minerals in the Fort Dauphin region of southern Madagascar since 1987. The environmental organization, Friends of the Earth, have opposed the project based upon its potential to destroy significant forest habitats supporting a unique species biodiversity, although others have argued that mining might be less disruptive to the forests than the damage being caused by native slash-and-burn agriculture (Colin Barraclough, October 2, 1997, Madagascar mining—A silver lining, accessed May 22, 1998, at URL <http://www.csmonitor.com/durable/1997/10/02/intl/intl.3.html>).

QIT planned to complete a comprehensive Environmental Review Process prior to any commencement of mining operations. In parallel over the past years, QIT and the Government of Madagascar have been conducting negotiations to conclude a Framework Agreement to support the development of the proposed mining project in the event of a favorable outcome from the environmental review process. This agreement will incorporate the salient features of existing Madagascar laws and investment codes, as well as features that would provide the legal, fiscal, and other assurances that will be needed to secure financing for the project. Against a backdrop of political change and policy evaluation that has been ongoing since 1991, it has been difficult for QIT and the Government negotiators to finalize the Framework Agreement for the proposed project. Additional required social, environmental and technical studies are being held up pending signature of the Framework Agreement. As a result, it has been difficult to predict a schedule for development (Rio Tinto plc, 1997, QIT and Madagascar, accessed November 6, 1997 at URL <http://www.riotinto.com/br02.htm>).

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.

Estimates of 1997 production levels of all mineral commodities are shown 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. 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 is 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, is controlled by the parastatal Société Kraomita Malagasy (KRAOMA). Graphite and mica production are 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. e MEM, through the Directorate of Energy, had primary responsibility for the energy sector. MEM also directed SOLIMA and the Electricity and Water Co. The distribution, importation, and refining of petroleum products were managed by SOLIMA.

Chromite production from the Andriamena district, which began in 1967, has remained relatively stable in recent years. By 1997, a minimum of 25 chromite lenses had been identified within the dunite host rocks of the Andriamena complex, and more lenses may yet be identified. Ore beneficiation enabled KRAOMA to produce a chromite concentrate grading from 48% to 50% chromium oxide (Cr_2O_3) with 0.002% to 0.003% phosphorus and lumpy chrome ore grading from 42% to 44% Cr_2O_3 . Typically, crude Malagasy chromite contained 0.007% phosphorus. With the startup of its new mine at Bemanevika in 1996, KRAOMA has expanded chromite production to the 135,000- to 140,000-metric ton-per-year range (t/yr). The Bemanevika Mine was reported to have reserves of 3 million metric (Mt) tons of chromite.

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.

Phelps Dodge Mining Co. of the United States announced the discovery of a potentially significant nickel laterite deposit in Ambatovy, central Madagascar, 80 km east of Antananarivo. As a result of exploration during 1996 and 1997, Phelps Dodge identified an area of laterite mineralization that is more than 45 meters thick and contains an estimated 52 Mt of ferralite and saprolite ore with a grade of 1.24% nickel and 0.09% cobalt and 0.80% magnesium at a cutoff grade of 0.80% nickel. An overall resource for the area was estimated to be 168 Mt at a grade of 1.11% nickel and 0.10% cobalt. Initial tests by Hazen Research, Inc. showed that favorable metal recoveries are obtainable by using proven hydrometallurgical technology. A detailed feasibility study and an environmental assessment will be completed in early 1998 (Phelps Dodge Mining

Co., 1998).

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. In late 1996, the discovery of a prolific, low quality sapphire deposit in the Ankarana Special Reserve, an internationally recognized park, triggered a major influx of 12,000 to 15,000 artisanal miners to the area. With local resources insufficient to enforce legal conventions concerning sapphire mining, more than 30% of the Reserve had been exploited by the artisanal miners by yearend. An emergency committee comprised of national and local government officials was formed to curtail the illegal mining, to assess the long-term environmental impacts of mining on the Ankarana Special Reserve, and to explore alternative income-generation options for the miners (U.S. Embassy, Antananarivo, Madagascar, 1997).

During 1997, Riosun acquired an 80% interest in Export-Import Madagascar (Eximad) S.A.R.L. which operates 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 recently 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 are 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 are 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 an estimated 16,000 metric tons being produced in 1997. 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, Societe Participation Industrielle et Minières, which also owned Societe 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. According to Mbendi Information Services, OMNIS opened the country's entire onshore and offshore areas for petroleum exploration in the country's first formal licensing round in March 1995. It also revised its petroleum fiscal terms to bring them in line with the favorable conditions available in other frontier exploration areas in Africa. Triton Energy Ltd. of the United States and Gulfstream Resources Canada Ltd. held active offshore petroleum exploration agreements

with OMNIS (Mbendi Information Services, August 13, 1997, Madagascar oil industry profile, p. 1, accessed March 29, 1998, at URL <http://mbendi.co.za.cymdoi.htm>). In 1997, Gulfstream Resources acquired an 82% interest in the 26,700-km² Tsiribihina Block in the Morondava onshore basin and an 80% interest in the 5,200-km² Antonibe Block in the Majunga offshore basin. A 300-km seismic program in late 1997 will be 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 acquired the 28,170-km² offshore Ambilobe Block in the north and a 27,520-km² onshore property at the southern tip of the island.

Madagascar had producing resources of chromite, graphite, and mica and 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. Current installed hydropower capacity is 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

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TABLE 1
MADAGASCAR: PRODUCTION OF MINERAL COMMODITIES 1/

(Kilograms unless otherwise specified)

Commodity 2/	1993	1994	1995	1996 e/	1997 e/
METALS					
Beryllium, beryl in quartz concentrates, industrial and ornamental e/	3,000	3,000	31,666 3/	32,000	32,000
Chromium:					
Chromite concentrate, gross weight metric tons	60,900	42,700	49,702	54,900	55,900
Chromite ore, lumpy do.	83,300	47,500	56,405	82,300	83,800
Total do.	144,200	90,200	106,107	137,200 3/	139,700 3/
Gold, mine output, Au content e/ 4/	500	500	38 3/	50	50
Rare-earth minerals: e/					
Bastnasite (60% REO) metric tons	5	5	5	5	5
Monazite (55% REO)	100	100	100	100	100
INDUSTRIAL MINERALS					
Abrasives, natural (industrial only) e/	10,000	10,000	10,000	10,000	10,000
Cement, hydraulic e/ metric tons	60,000	60,000	60,000	60,000	60,000
Clay, kaolin e/ do.	700	700	1,545 3/	1,500	1,500
Feldspar e/	4,000	4,000	2,120 3/	2,000	2,000
Gemstones: e/ 5/					
Amazonite	2,000	2,000	2,000	2,000	2,000
Amethyst:					
Gem	1,700	1,700	1,700	1,700	1,700
Geodes	80	80	80	80	80
Graphite, all grades, shipments metric tons	13,118 r/	14,593 r/	16,119	16,000	16,000
Mica, phlogopite: e/					
Block do.	4	4	1	1	1
Scrap do.	800 r/	300 r/	389	400 r/	400
Splittings and sheet do.	76 r/	52 r/	42	49 r/	49
Total do.	880 r/	356 r/	432	450 r/	450
Ornamental stones: e/ 6/					
Jasper	68,000	68,000	68,000	68,000	68,000
Labradorite	61,000	61,000	61,000	61,000	61,000
Quartz: e/ 7/					
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	63,899 r/	75,783 r/	51,307 r/	50,000 e/	50,000
Stone: e/					
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
MINERAL FUELS AND RELATED MATERIALS					
Petroleum refinery products: e/					
Gasoline thousand 42-gallon barrels	900	225 3/	200 r/	200 r/	200
Kerosene and jet fuel do.	400	100 3/	85 r/	85 r/	85
Distillate fuel oil do.	290	70 3/	60 r/	60 r/	60
Residual fuel oil do.	500	125 3/	100 r/	100 r/	100
Other do.	20	5 3/	5 r/	5 r/	5
Total do.	2,110	525 3/	450 r/	450 r/	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 are produced, but output is not reported quantitatively, and available information is 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 is unreported.

6/ Other ornamental stones produced in 1996 for which data was 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.