

THE MINERAL INDUSTRY OF BRAZIL

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In 2006, Brazil continued to occupy a leading position in the global production of the following mineral commodities: bauxite (second after Australia), graphite and niobium (columbium) (third after China and India), iron ore (second after China), manganese (third after South Africa and Australia), and tantalum (third after Australia and Mozambique) (Departamento Nacional de Produção Mineral, 2007a, p. 10; Corathers, 2007; Jorgenson, 2007; Magyar, 2007a, b; Olson, 2007b; Plunkert, 2007b).

Brazil was the leading economy in Latin America and a member of the Mercado Común del Cono Sur (MERCOSUR), which is the second largest trade association in the Americas and the eighth worldwide. Exports were valued at \$137.8 billion, and imports, \$91.4 billion compared with \$118.5 billion and \$73.6 billion, respectively, in 2005. Brazil's mineral sector had a trade surplus of \$11.8 billion compared with \$9.7 billion in 2005 (Banco Central do Brasil, 2007a, b; Departamento Nacional de Produção Mineral, 2007a, p. 18).

While foreign direct investment (FDI) inflows slightly increased in Latin America and the Caribbean to \$72.4 billion in 2006 from \$71.4 billion (revised) in 2005, or by 1.4%, inflows to South America remained at about the same level of \$44.7 billion. FDI inflows in MERCOSUR increased to \$25.1 billion in 2006 from \$21 billion in 2005, or by 19.5%. Brazil's FDI inflows increased to \$18.8 billion in 2006 from \$15.1 billion in 2005, or by 24.5%, and the country maintained its large share (75%) of MERCOSUR's FDI, which was mostly reflected in the high international prices of several commodities, such as, in order of value, iron ore, petroleum, copper, gold, and soybeans (Banco Central do Brasil, 2007a, b; Departamento Nacional de Produção Mineral, 2007a, p. 18-19; Economic Commission for Latin America and the Caribbean, 2007).

Minerals in the National Economy

In 2006, Brazil's inflation was 5.2% compared with 5.7% in 2005. The financial system benefited from FDI inflows, high capitalization, and the strengthening of fiscal and monetary discipline, which helped maintain a positive economic growth in 2006. Higher world demand for Brazilian mineral exports and higher mineral commodity prices contributed to the upturn in the country's economy. For 2006 as a whole, Brazil's real gross domestic product (GDP) was 3.7%, which was up from 2.9% in 2005. The mining and mineral processing industries represented almost 6% of the GDP in 2006. Brazil had a total labor force of more than 90 million. The mineral sector employed about 5% (1,000,000) of the industry total (20 million, or 14% of the total); this percent did not include the nearly 500,000 active *garimpeiros*. In 2006, according to the Banco Central do Brasil's monthly employment survey, 1.8 million jobs were created in the country and employment in the mining sector amounted to 90,000 (Banco Central do Brasil, 2007b; Departamento Nacional de Produção Mineral, 2007a, p. 9; Ferraz, 2007, p. 3).

Government Policies and Programs

The fundamental principles governing the use of mineral resources in Brazil are defined and consolidated in the current Federal Constitution (Article 20), which was enacted on October 5, 1988, and in the Constitutional Amendments Nos. 6 and 9 dated August 15, 1995, which allow the participation of the private sector by means of joint ventures and/or privatization investment in the sectors of mining, natural gas, and petroleum and in the deregulated sectors of coastal and river shipping, telecommunications, and transportation. The Government monopolies of the oil and gas industries and fuel price subsidies were rescinded in 1999 after 45 years, which allowed *Petróleo Brasileiro S.A. (Petrobrás)* to enter into joint ventures with foreign investors. The *Agencia Nacional do Petróleo*, however, continues to regulate the petroleum industry (Departamento Nacional de Produção Mineral, 2006a, b; Ferraz, 2007, p. 7).

Since 2001, the Government has reduced the Brazilian import tax for minerals; the rates vary from 3% to 9%—ores and concentrates are 5%, and other mineral derivatives, 7%. The export tax does not apply to exported mineral products, although there is a value-added tax. In most cases, the basis for assessment of corporate income taxes is the net profit for the fiscal year; the tax rate ranges between 10% and 15% and is levied on the net profit. Profits can be expatriated. Equity

ownership, which is allowed by means of privatization or by direct acquisition, can be as high as 100%. The Concessions Law created additional opportunities for the private sector in public utilities previously reserved for the Government (Departamento Nacional de Produção Mineral, 2006a; Ferraz, 2007, p. 7).

The exploration and exploitation of mineral resources in Brazil are defined and regulated by the 1967 Mining Code (Executive Law No. 227 of February 28, 1967). The Brazilian Constitution and the amended Mining Code, law No. 9314 of January 1997, provide greater flexibility for investment in the Brazilian mining sector. Article 7 of the amended law stipulates that the exploitation of mineral deposits will depend upon an exploration authorization permit granted by the General Director of the Departamento Nacional de Produção Mineral (DNPM) and a development concession issued by the Ministro do Minas e Energia. Licensing is a restricted system applicable exclusively to the exploitation of industrial minerals. The DNPM is responsible for enforcing the 1997 Mining Code and for implementing its legal provisions (Departamento Nacional de Produção Mineral, 2006a; Ferraz, 2007, p. 7).

The DNPM reported an investment of \$280 million in mineral exploration compared with \$200 million in 2005. The Companhia de Pesquisa de Recursos Minerais (CPRM) (the Brazilian Geological Survey) was developing programs for basic geologic mapping, metallogenetic and hydrogeologic mapping, and prospecting in areas of potential development. The CPRM was also creating and maintaining geologic and economic databases, particularly for coal, copper, diamond, gold, kaolin, nickel, peat, and zinc, to assist investors in the minerals sector (Departamento Nacional de Produção Mineral, 2006b; 2007a, p. 25).

The Brazilian Financial Compensation for Exploiting Mineral Resources—Federal Royalty (CFEM), which was established by the Brazilian Constitution of 1988, was instituted by law No. 7990 in 1989 to compensate municipalities, States, and the Federal Government. The CFEM rate is no more than 3% of the net revenue of mineral sales. The prevailing rates are 3% for bauxite, manganese ore, potassium, and rock salt; 2% for coal, fertilizers, iron ore, and other minerals; 1% for gold (gold produced during prospecting is exempt); and 0.2% for other precious minerals and precious stones. The collected royalties are allocated among the municipalities, States, and the Federal Government in the proportion of 65%, 23%, and 12%, respectively. In July 2000 (law No. 9993/2000), the Federal Government decided to share its 12% CFEM fund with the DNPM (9.8%); the Fondo Nacional de Desarrollo Científico y Tecnológico (FNDCT), which is an instrument for technological innovation for the benefit of all Brazil's productive sectors (2%); and the Brazilian Environment Agency (IBAMA) (0.2%). The CFEM collection increased to \$199.1 million in 2006 from \$173.5 million in 2005, or by 24.5% (Departamento Nacional de Produção Mineral, 2006b; 2007a, p. 26-28; Ferraz, 2007, p. 7).

In 2006, the States of Minas Gerais (50.1%), Para (29.6%), and Goiás (3.7%) were the major collectors of the CFEM; the main municipalities were Parauapebas (56.5%) and Oriximina (8.5%) in the State of Para, and Itabira (10.8%), Nova Lima (6.5%), and Mariana (6.2%) in the State of Minas Gerais. Both States and their respective municipalities were the main producers of iron ore. The main mineral contributors to the CFEM were iron ore (49.9%), aluminum (8.9%), kaolin (4.2%), calcite (3.7%), and gold (3.2%). The State of Minas Gerais produced mainly, in order of value, iron ore, nickel, gold, and zinc, and the State of Para, similarly, produced bauxite, iron ore, kaolin, copper, and others (Departamento Nacional de Produção Mineral, 2006a, b).

In Brazil, the fundamental principles governing the compatibility of the mining sector with environmental protection are outlined by the following Federal laws and decrees, and respective resolutions and regulations:

- Federal law No. 6938 of August 31, 1981, and its amendments (Act Nos. 7804 of July 18, 1989, and 8028 of April 12, 1990) provide the purpose and mechanism for the formulation of the National Environmental Policy,
- Federal law No. 9605 of February 12, 1998, provides sanctions against harmful activities to the environment,
- Federal Decree No. 97632 of April 10, 1989, deals with rehabilitation of areas degraded by mining,
- Federal Decree No. 99274 of June 6, 1990, regulates law No. 6938, and
- Resolutions of the National Council for the Environment (CONAMA): (1) Resolution No. 1 of January 23, 1986, provides basic criteria and general guidelines for the Report on Environmental Impact (RIMA); (2) Resolution No. 009 of December 6, 1990, regulates environmental licenses for mineral extraction; (3) Resolution No. 010 of December 6, 1990, regulates environmental licenses for mineral extraction used in civil construction; (4) Resolution No. 2 of April 18, 1996, provides for

compensation for environmental damages; and (5) Resolution No. 237 of December 19, 1997, provides the procedures and guidelines used in environmental licensing.

The Brazilian Environmental Policy (BEP) is executed at three levels—Federal, State, and municipal. The coordination and formulation of the BEP is the responsibility of the Ministério de Meio Ambiente (MMA). Linked to the MMA is the Conselho Nacional de Meio Ambiente, which grants the environmental licenses that are required for all mining activities in Brazil. Law No. 88351 of 1986 established the National System for the Environment, which comprises representatives of the Federal, State, and municipal governments and private foundations involved in environmental protection and improvement. Article 225 of the Brazilian Constitution of 1988 stipulates that mining operators must reclaim areas that they have environmentally degraded.

In Brazil, the environmental legislation that is applied to mining is basically consolidated in the following environmental requirements: an environmental impact study (EIA), environmental licensing (LA), and a plan for recovery of degraded areas (PRAD). An EIA applies to mining projects of any mineral substance; an LA is mandatory for the installation, expansion, and operation of any mining activity under the systems of mining concession or licensing; and a PRAD requires suitable technical solutions to rehabilitate the soil and other aspects of the environment that might be degraded by mining operations (Departamento Nacional de Produção Mineral, 2006a, b; 2007a, p. 29).

The Ministério de Minas e Energia enforces Decree No. 97632 of April 10, 1989, which prohibits the use of cyanide and mercury in the mining of gold unless approved by local Brazilian environmental agencies, and offers technical assistance on producing gold without affecting the environment to small-scale independent miners (*garimpeiros*) in particular. Environmental impacts are expected to be reduced in the long run. Resolution No. 010 of December 6, 1990, requires that all mining operations obtain LAs prior to the granting of mineral rights by the DNPM. As environmental problems have increased because of cyanide use, in situ leaching, mercury use in gold placers, and underground acidic water discharges, antipollution measures have been enacted to eliminate the sources of pollutants and mitigate their effects on the environment (Departamento Nacional de Produção Mineral, 2006a).

Production

In 2006, Brazil produced 46 industrial minerals, 22 metals, and 4 fuel minerals and exported them to the global marketplace (table 1). Among those produced were bauxite, copper, coal, chromite, gemstones, gold, iron ore, kaolin, manganese, niobium (columbium), tantalum, and tin from large deposits. In Latin America, and particularly within MERCOSUR, Brazil continued to be the leading producer of aluminum, cement, ferroalloys, gold, iron ore, manganese, steel, and tin. Brazil's reportedly large mineral reserves and other identified resources help make it one of the most dynamic markets in the world (Departamento Nacional de Produção Mineral, 2007b, p. 10-11).

Brazil, a nation rich in mineral resources, was one of the leading mining countries in the Americas, and the increase in metal prices provided a boost to the mining sector in 2006. In 2006, the total value of minerals produced was \$40.1 billion, or 2.2% of the GDP, and 11.4% higher than that of 2005 (\$36 billion). The minerals-based industries amounted to almost \$108 billion, or 6% of the GDP. Crude oil and natural gas amounted to almost \$41.5 billion. Mineral extraction contributed almost 6% of the GDP in 2006 compared with 2.3% in 2005. Depletion of shallow gold and tin deposits plus environmental constraints on *garimpeiros* affected their output of gold and tin (Banco Central do Brasil, 2007a; Departamento Nacional de Produção Mineral, 2007a, p. 9-10; *Petróleo Brasileiro S.A.*, 2007, p. 7-8).

The major integrated steelworks were the structure and rail producer Aço Minas Gerais, S.A.; Latin America's leading integrated steelmaker Companhia Siderúrgica Nacional (CSN); the carbon steel sheet and plate producer Companhia Siderúrgica Paulista; the slab producer Companhia Siderúrgica de Tubarão; and Brazil's second ranked steel mill Usinas Siderúrgicas de Minas Gerais, S.A. In 2006, these companies produced about 26.8 million metric tons (Mt), or almost 80% of the total Brazilian steel production of 33.6 Mt; Brazil was the second ranked iron ore producer in the world after China with a flat (gross weight) output of 317.8 Mt; Companhia Vale do Rio Doce (CVRD) produced almost 70% of Brazil's iron ore (Companhia Vale do Rio Doce, 2007b; Departamento Nacional de Produção Mineral, 2007a, p. 9; Ferraz, 2007, p. 3). Mineração Rio do Norte S.A. (MRN), the majority of which was privately owned, was the world's third ranked bauxite producer and exporter; it produced almost 84% of the country's total bauxite production, which amounted to about 22.7 Mt in 2006. The four major aluminum smelters, Albras -Alumínio Brasileiro

S.A. (Albras) (30%), Companhia Brasileira de Alumínio (CBA) (23%), Alcoa Alumínio S.A. (Alcoa) (21%), and Billiton Metais S.A. (Billiton) (12%), produced 86% of the primary aluminum production of 1.6 Mt in 2006 (table 1; Companhia Vale do Rio Doce, 2007c; Departamento Nacional de Produção Mineral, 2007a, p. 10).

In 2006, Brazil continued with its petroleum exploration program to expand reserves and reduce its dependence on oil imports, which satisfied almost 7% of its crude oil requirements. Petrobrás management indicated that Brazil would achieve self-sufficiency in 2008 and that, of the \$87.1 billion in investments budgeted in its strategic planning to 2011, almost 90% will be invested in the country. Brazil's petroleum and mining industries and utilities attracted investors' interest because of the country's diversified mineral endowment, the Government's macroeconomic policies, and a skilled labor force. Major international mining, petroleum, and steel companies were notably interested in, in order of importance, oil and gas, iron ore, steel, coal, gold, copper, and diamond (Departamento Nacional de Produção Mineral, 2007a, p. 5-9; Petróleo Brasileiro S.A., 2007, p. 6-8).

Structure of the Mineral Industry

The mineral industry of Brazil was large by world standards. The structure of the Brazilian mineral industry continued to change to a privately owned, Government regulated regime from one that was Government owned and Government operated. Brazilian corporations, private Brazilian investors, and/or foreign companies partially or wholly owned the major portion of the industry. More than 500 transnational corporations (TNC) established operations in Brazil, between 1990 and 2006, owing to globalization and the need to increase minerals supply, mainly by means of mergers, joint ventures, privatizations, and the increases of efficiencies and productivities in the private sector that resulted from capital flows into new technologies, and expansions, particularly in the mining, oil and gas, and steel sectors. Petrobrás comprised five subsidiaries: Petrobrás Distribuidora S.A., which distributed petroleum products; Petrobrás Gás S.A., which produced, traded, and distributed natural and liquefied natural gas and fertilizers; Petrobrás Internacional, S.A., which operated in foreign countries; Petrobrás Química, S.A., which was the integrated refining-petrochemical operations company; and Petrobrás Transporte S.A., which constructed and operated the pipelines, terminals, vessels, and facilities needed for the transportation and storage of oil and derivatives, natural gas, and bulk products (Petróleo Brasileiro S.A., 2006, p. 30-55). In addition, 39 cement plants operated in 8 Brazilian states which accounted for more than 75% of the national output of 36.7 Mt; these plants were located in Minas Gerais (23.9%), Sao Paulo (14.4%), Parana (10.9%), Brasilia and Rio de Janeiro (6.3% each), Sergipe (5.2%), Paraiba (4.4%), and Rio Grande do Sul (4%) (table 2; Departamento Nacional de Produção Mineral, 2007a, p. 11-17).

Since 1990, the TNCs have brought in about \$150 billion in registered investment with the Banco Central do Brasil; of that total, about \$36 billion, or almost 25%, was invested by such major companies as Anglo American plc and BHP Billiton Plc of the United Kingdom, De Beers Group of South Africa, and Glencor International AG of Switzerland. In 2006, the TNCs and CVRD invested \$550 billion; of that total, about \$230 billion, or almost 42%, was invested by such major companies as Anglo American and Rio Tinto plc of the United Kingdom; Alcoa Inc. of the United States, BHP Billiton, and CVRD. The Banco Central do Brasil also reported that, since 1996, the accumulated net FDI amounted to more than \$151 billion as equity capital, of which \$35 billion was used for the acquisition of state-owned assets and more than \$116 billion was for direct investment and joint ventures with the private sector (Banco Central do Brasil, 2007a, b; Companhia Vale do Rio Doce, 2007c; Departamento Nacional de Produção Mineral, 2007b).

In 2006, the active international mining and oil companies in Brazil included Repsol-YPF of Argentina and Spain; Anglo American, BHP Minerals International Exploration Inc. (BHP Billiton, 100%), and Rio Tinto of the United Kingdom; Alcan Inc., Barrick Gold Corp., and Teck Cominco Inc. of Canada; Shanghai Baosteel Group Corp. (Shanghai Baosteel) of China; Energias de Portugal (EDP); Iberdrola S.A. of Spain; Chevron Corp. (ChevronTexaco Brasil S.A.), Dow Chemical Co., ExxonMobil Corp. (Esso Brasileira de Petróleo Ltda.), Newmont Mining Corp., Placer Dome U.S. Inc., and Phelps Dodge Co. of the United States; and Royal Dutch Shell Group of the Netherlands (table 2; Departamento Nacional de Produção Mineral, 2007b).

Three international cement groups—Cimentos de Portugal, SGPS, S.A. (Cimpor) (Portugal), Holcim Ltd. (Switzerland), and Lafarge S.A. (France)—began operations in 2005 and expanded their operations in Brazil in 2006. According to the DNPM, 28 iron ore mining companies also operated 53 mines and 44 processing plants in Brazil. There were nearly 2,500 mineral mines in

Brazil, which were classified according to their run-of-mine (ROM) outputs: large mines—between 1 million and 3 million metric tons per year (Mt/yr) or more; medium mines—between 100,000 metric tons per year (t/yr) and 1 Mt/yr; and small mines—between 10,000 and 100,000 t/yr (Departamento Nacional de Produção Mineral, 2007a, p. 9-17).

New or added infrastructure in such mineral producing States as Minas Gerais, Para, Rio de Janeiro, Sao Paulo, and others was having a positive effect on the production, processing, consumption, and trade of various mineral commodities, such as bauxite, iron ore, manganese, natural gas, petroleum, and other industrial minerals. The Bolivia-Brazil pipeline, which was owned by a consortium of Petrobrás and Royal Dutch Shell, was the leading project among various cross-border energy projects. The Argentine pipeline supplied gas to the State of Rio Grande do Sul's new thermoelectric plant; two additional pipelines were to take Argentine gas to Brazil's southern market, and another project was to supply energy to Brazil from a powerplant in Uruguay. Brazil's current (2006) total pipeline network was 30,346 kilometers (km) long, of which 12,857 km was used to transport crude oil and petroleum products, and 17,489 km—which included the Brazilian side of the Bolivia-Brazil gas pipeline (2,600 km)—was used to transport gas. In northern Brazil, an electricity transmission line supplied energy to the State of Roraima from Venezuela. The majority of these projects was being developed by the private sector and by state-owned corporations in partnership with private domestic and foreign investors (Departamento Nacional de Produção Mineral, 2007b, p. 92; *Petróleo Brasileiro S.A.*, 2007, p. 58). In 2006, Brazil's installed electrical generating capacity was 53,000 megawatts (MW). Total production of electric power for the year was 340,000 gigawatthours, which translated into 1,400 kilowatt-hours per capita. Brazil's primary domestic energy supply encompassed the following: hydroelectric, 83%; petroleum and natural gas, 8%; nuclear energy, 4%; and others, 5%. The Brazilian Government and investors, such as Alcan, Alcoa, BHP Billiton, Camargo Corrêa Industrial S.A. (Brazil), and Dow Chemical (United States), were planning to build a 1,200-MW powerplant, which would be named Tucuruí, on the Tocantins River on the border between the States of Maranhão and Tocantins. Construction of the powerplant would cost an estimated \$1.2 billion; BHP Billiton pledged \$350 million. This new powerplant appeared to be necessary because demand for hydroelectricity was growing at a faster rate than that of supply (Vale, 2006, p. 23; Departamento Nacional de Produção Mineral, 2007b, p. 92).

Aluminum companies won the right to build new hydroelectric plants through the auction of the Agência Nacional de Energia Elétrica (ANEEL). They secured eight concessions that would demand a total investment of more than \$1 billion. In the auction of ANEEL, Alcan secured the right to build hydroelectric plants at Barra dos Coqueiros and Cacu in the State of Goiás and Traira II in the State of Minas Gerais. Alcan planned to invest \$180 million in their construction. Alcan would also pay \$1.3 million per year for the concession of the additional 60-MW Traira I plant in the State of Minas Gerais (Vale, 2006, p. 3-4).

Constran S.A. and Construção e Comércio of Grupo Itamaraty planned to construct an additional 1,718 km of railroad to be linked to the existing railway system that transported iron ore and mining supplies. The cost of the new system was projected to be \$2.5 billion. This addition would connect to the existing system that runs through Vitória, State of Espírito Santo; Belo Horizonte, State of Minas Gerais; Santos, State of São Paulo; and Chapadao do Sul, State of Mato Grosso do Sul. This new railway system would run from Chapadao do Sul to Cuiabá, Mato Grosso and Santarém, State of Para, and branch from Cuiabá to Porto Velho, State of Rondônia, and be accessible to their respective mineral producing centers (Vale, 2006, p. 22).

Mineral Trade

Brazil enjoyed economic benefits from its mineral industry, which included the significant contribution the industry made to the country's trade balance. In 2006, Brazil's total exports, imports, and trade balance amounted to \$137.5 billion, \$91.4 billion, and \$46.1 billion, respectively, compared with those of 2005, which were \$118.3 billion, \$73.6 billion, and \$44.8 billion, respectively. In 2006, Brazil's mineral sector exports, imports, and trade balance amounted to \$40.1 billion, \$28.3 billion, and \$11.8 billion, respectively, compared with those of 2005, which were \$31.6 billion, \$21.9 billion, and \$9.7 billion, respectively (Banco Central do Brasil, 2007a, b; Departamento Nacional de Produção Mineral, 2007a, p. 9, 18-19).

In 2006, Brazil exported energy products (\$10.7 billion), which included crude petroleum (\$6.9 billion); and industrial goods and materials (\$124.8 billion), which included crude minerals and ores (\$20.8 billion), chemicals (\$572 million), metals and alloys (almost \$8 billion), and industrial minerals (\$3.1 billion). Brazil imported energy products (\$18 billion), which included crude

petroleum (\$10.8 billion) and others (\$7.2 billion); and industrial goods and materials (\$10.3 billion), which included crude minerals and ores (\$6.4 billion), chemicals (\$1.9 billion), and industrial minerals (\$2 billion). Prominent among the crude minerals exported in 2006 were iron ore (49.9%), petroleum (38.5%), ornamental rock (4.4%), copper (2.8%), kaolin (1.5%), bauxite (1.1%), and manganese (0.3%) (Banco Central do Brasil, 2007a, b; Departamento Nacional de Produção Mineral, 2007a, p. 19).

Brazil was the leading member, in terms of its GDP (purchasing power parity), of the MERCOSUR. Brazil's GDP was \$1.8 trillion, Argentina's GDP was \$523.7 billion, Uruguay's GDP was \$37.1 billion, and Paraguay's GDP was \$26.6 billion in 2006. Most TNCs considered this growing trade bloc to be extremely important because of its size and the amount of trade that takes place in the region. MERCOSUR's GDP was \$2.4 trillion compared with that of the North America Free Trade Agreement (NAFTA), which had a combined GDP of \$16.6 trillion (of which Canada's GDP was \$1.3 trillion, Mexico's GDP was \$1.4 trillion and the United States' GDP was \$13.9 trillion) and that of the European Union (EU) (27 member states), which had a total GDP of \$14.4 trillion. In 2006, Brazil's total trade with NAFTA increased to \$56.5 billion from \$43.5 billion in 2005; most of this trade took place with the United States, whose trade balance with Brazil increased to \$35.6 billion from \$31.9 billion in 2005. MERCOSUR had an impact on intraregional total trade, which increased to about \$40.1 billion in 2006 from \$37 billion in 2005; intra-MERCOSUR total trade increased to \$25 billion in 2006 from \$24.1 billion in 2005 (U.S. Central Intelligence Agency, 2006; Banco Central do Brasil, 2007a, b; Departamento Nacional de Produção Mineral, 2007a, p. 18-19).

The bilateral total trade between Argentina and Brazil (the major players of MERCOSUR) increased to \$18.5 billion in 2006 from \$16.2 billion in 2005. Total mineral trade between Brazil (\$4.5 billion) and Argentina (\$3.2 billion) amounted to \$7.7 billion. In 2006, Brazil's mineral sector recorded trade surpluses with its leading trade partners, including, in order of value, the United States (\$4.5 billion), China (\$2.8 billion), Japan (\$1.5 billion), the Republic of Korea (\$1.2 billion), the Netherlands (\$785 million), Italy (\$600 million), and Belgium (\$500 million). Exports to Europe and Japan consisted mostly of raw materials, which were, in order of volume, iron ore, crude oil, manganese, marble, granite, and agricultural commodities. Bilateral trade between Brazil and China included exports of, in order of value, soybean, iron ore, steel, airplanes, buses, auto parts, pulp, tobacco, and timber. China's main exports to Brazil included, in order of value, coke, coal, electronic parts, equipment for energy transmission, and products and material for audiovisual machinery (Banco Central do Brasil, 2007a, b; Departamento Nacional de Produção Mineral, 2007a, p. 18-19).

Commodity Review

Metals

Aluminum and Bauxite and Alumina.—Alumina production increased to almost 5.8 Mt in 2006 from 5.3 Mt in 2005, or by 9.4%. Alumínio do Norte do Brasil S.A. (Alunorte) produced 50%; Alcoa, 22%; CBA, 12%; BHP Billiton, 11%; and Alcan Alumínio do Brasil S.A., 5%. Exports of alumina totaled 2.3 Mt and were valued at \$563 million. Primary aluminum production increased to 1.63 Mt in 2006 from 1.50 Mt in 2005, or by 8.7%. Albras (CVRD, 51%, and Nippon Amazon, 49%) produced 30% of primary aluminum; CBA, 25%; Alcoa, 20%; BHP Billiton, 13%; and Alcan and Vale do Sul Alumínio S.A. (Aluvale), 6% each. In 2006, CBA was planning to invest an additional \$350 million to produce 500,000 t/yr of aluminum by 2007. In 2006, exports of aluminum totaled 1 Mt and were valued at \$1.9 billion. Brazil's imports of all forms of aluminum totaled 185,000 t and were valued at \$400 million. Bauxite production increased to 22.7 Mt in 2006 from 22.1 Mt in 2005, or by almost 3%. The MRN joint venture, which was owned by CVRD (40%), BHP Billiton (14.8%), Alcoa (13.2%), Alcan (12%), CBA (10%), Norsk Hydro (5%), and Reynolds Alumínio do Brasil (5%), accounted for about 78% (17.8 Mt) of the total bauxite production for 2006. Exports amounted to 5.3 Mt of bauxite and were valued at \$194 million (Associação Brasileira do Alumínio, 2006; Companhia Vale do Rio Doce, 2007a-c; Departamento Nacional de Produção Mineral, 2007b, p. 11; Ferraz, 2007, p. 4; Plunkert, 2007a).

Alumínio do Norte do Brasil S.A. (Alunorte) (CVRD, 57% and Alunorte, 43%) increased the capacity of its Barcarena refinery, which is located in the State of Para, to 5.4 Mt/yr of alumina in 2006 from 2.4 Mt/yr in 2005. In the first phase of its Paragominas bauxite mine, Alunorte planned to produce 5.4 Mt/yr of bauxite by 2007. The addition of a second module at the Barcarena refinery would increase its refining capacity to 6.26 Mt/yr by 2008. In the second phase of the

Paragominas Mine, Alunorte planned to increase production to 9.9 Mt/yr and to supply 6.5 Mt/yr of bauxite to the Barcarena refinery by 2008 (Companhia Vale do Rio Doce, 2007b, c; Departamento Nacional de Produção Mineral, 2007b, p. 11; Ferraz, 2007, p. 4).

Alcoa was planning a new operating hub, with an investment of \$1.4 billion, in Juruti, State of Para, where it was carrying out a geologic study of a bauxite resource of 280 Mt. The Juruti project's initial output was expected to be 2.6 Mt/yr by 2008, and its full annual production capacity would be 4 Mt of bauxite, 2 Mt of alumina, and 1 Mt of aluminum by 2009. To implement this hub, Alcoa planned to invest an additional \$1 billion in the construction of the required hydroelectric plant to produce aluminum in Belomonte, State of Para. CBA was planning to start its Mirai bauxite mine and new concentrator in the Zona da Mata District in the State of Minas Gerais. In the first of three planned phases, the project was expected to produce 1 Mt/yr of bauxite to feed the new concentrator. Latapack-Ball Embalagens, Ltda. (Ball Corporation, 100%) invested about \$6 million to increase its aluminum cans plant capacity in Jacarei, State of Sao Paulo, to 2.5 billion aluminum cans in 2006 from 2 billion in 2005. Brazil recycled 95% of all aluminum cans, which was equivalent to 139,000 t of aluminum cans, or about 10.3 billion units; this was an increase of 2.2% compared with that of 2005. In 2006, China Aluminum Group and China MinMetals were planning to invest \$3 billion in joint ventures, mostly with CVRD and others, in the aluminum and bauxite and alumina sectors (Associação Brasileira do Alumínio, 2006; Departamento Nacional de Produção Mineral, 2006a; Companhia Vale do Rio Doce, 2007b, c).

Copper.—Brazil's copper production in concentrate increased to 147,836 t in 2006 from 133,325 t in 2005, or by almost 11%. The leading producers were CVRD, with 117,514 t of the concentrate, or 79%, from its Sossego Mine in Carajas, State of Para, and Mineração Caraíba S/A, with 22,720 t, or 16%, from its deposit in Jaguarari, State of Bahia. In 2006, Caraiba Metais S/A (CMSA) (Paranapanema Group, 100%) of Camacari, State of Bahia, which was the only electrolytic copper producer in Brazil, produced 219,700 t of primary copper metal; this was an increase of 10.4% compared with the 199,043 t produced in 2005. The feed for this electrolytic copper output included 536,043 t of copper concentrates (176,894 t of contained metal) imported from Chile (84%), Argentina (10%), and Portugal (6%). To meet Brazil's metal copper demand of 343,550 t/yr, CMSA imported 173,896 t of copper cathode mostly from Chile (78%) and Peru (22%) in 2006. CMSA was planning to produce 450,000 to 500,000 t/yr of electrolytic copper in D'Avila, State of Bahia, by 2010 (Companhia Vale do Rio Doce, 2007a, b; Departamento Nacional de Produção Mineral, 2007a, p. 10, 13; Ferraz, 2007, p. 4).

In 2006, CVRD's copper project portfolio included the sulfide ore resources of, in order of resources, Sossego, Salobo, Alemão, and Cristalino, and the oxidized ore deposit of Project 118; all these projects were located in the mineral district of Carajas, State of Para. CVRD's subsidiary Salobo Metais S/A was conducting a feasibility study for the Salobo copper project, which was to be completed in early 2007; its development would require an investment of \$855 million. In the initial phase, Salobo was expected to produce 100,000 t/yr of copper in concentrate. The Salobo project is Brazil's largest copper deposit and contains an estimated ore resource of 986 Mt at grades of 0.82% copper and 0.49 grams per metric ton (g/t) gold at a cutoff of 0.5% copper and associated molybdenum and silver. It is located in Marabá, State of Para, and could support a mill of 140,000-t/yr capacity. CVRD was also planning to produce 36,000 t/yr of copper from its Project 118 at an estimated cost of \$232 million by the first half of 2009. CVRD's subsidiary Usina Hidrometalúrgica de Carajás S/A (UHC) was constructing a \$58 million semi-industrial-scale plant for copper processing. UHC would produce copper cathode at its Sossego Mine using hydrometallurgical technology based on pressure oxidation followed by heap leaching, solvent extraction, and copper electrowinning by mid-2007. CMSA was planning to invest \$150 million to increase its copper metal output from 218,000 t/yr to 280,000 t/yr by early 2009 (Companhia Vale do Rio Doce, 2007a, b; Departamento Nacional de Produção Mineral, 2007a, p. 10, 13; Ferraz, 2007, p. 4).

The Alemão deposit [CVRD, 67%, and Banco Nacional de Desenvolvimento Econômico e Social (BNDES), 33%] contained 161 Mt of copper resources at grades of 1.3% copper and 0.86 g/t gold. A prefeasibility study for Cristalino (BNDES and CVRD, 50% each) estimated reserves of 312 Mt grading 0.77% copper and 0.13 g/t gold. CVRD continued conducting intensive geologic prospecting to identify new copper areas in the Carajas mining district. In 2006, Yamana Gold Inc. (YGI) (a Canadian junior copper and gold producer) completed a feasibility study for the Chapada copper-gold project in Alto Horizonte, State of Goiás. The estimated ore reserves amounted to 434.5 Mt containing 1.3 Mt of copper and 9.6 t of gold. The Chapada open pit was completed in September 2006, and its initial copper and gold output in the fourth quarter amounted to 245 kilograms (kg) of gold and 2,540 t of copper, respectively. Chapada was projected to produce

180,000 to 200,000 t/yr of concentrate containing copper and gold, which would be processed by third-party units to produce copper and gold metal (Companhia Vale do Rio Doce, 2007b, c; Departamento Nacional de Produção Mineral, 2007a, p. 40; 2007b, p. 11, 13; Ferraz, 2007, p. 4; Yamana Gold Inc., 2007).

Brazil exported about 390,000 t of copper sulfide concentrate (116,000 t of contained copper) valued at \$300 million, which was shipped to Germany (20%), Bulgaria (19%), India (18%), the Republic of Korea (17%), and China and others (13% each). Exports of semimanufactured goods amounted to 78,935 t valued at \$464 million (of which copper cathodes amounted to 56,000 t valued at \$380 million); these exports went to the United States (39%), Netherlands (18%), Germany (14%), China (13%), and others (16%). Manufactured goods amounted to 71,223 t valued at \$498 million, and went to the United States (46%), Argentina (18%), Canada (15%), and others (21%). Brazil's refined copper production was used primarily in the automobile and construction industries. By 2010, if the positive market conditions continue, Brazil could develop its current (2006) copper projects and become self-sufficient and diminish its external dependency on copper (Departamento Nacional de Produção Mineral, 2007a, p. 13; 2007b, p. 40).

Gold.—Gold production increased to 45 t in 2006 from 38.3 t in 2005, or by 17.5%; mining companies produced more than 35 t (78%), and garimpeiros, almost 10 t (22%). Gold production from the companies increased by 5.1 t, and that from garimpeiros increased by 1.6 t compared with that of 2005. In 2006, AngloGold Ashanti Mineração Ltda. was the leading producer, contributing 8 t, or 17.8%, of the country's total (45 t); Mineração Serra Grande S/A (AngloGold Ashanti and Kinross Gold Corp., 50% each) produced almost 7 t, or 15.5%; Rio Paracatu Mineração S/A (Kinross, 100%) produced 6.5 t, or 14.5%; and others produced 23.5 t, or 52.2%. The leading States with garimpeiros' gold operations were Para (45%), Mato Grosso (20%), Amapá (16%), Rondonia (14%), and others (5%) (Departamento Nacional de Produção Mineral, 2007a, p. 10; Ferraz, 2007, p. 4).

The Biox process (pressure oxidation and bioleaching) continued to be used successfully by São Bento Mineração S.A. to produce refined gold from the Sao Bento and Santa Barbara gold mines in the State of Minas Gerais. AngloGold Ashanti's Cuiaba gold mine's expansion would increase its life by 6 years and its production to 260,000 ounces per year (oz/yr) (8.1 t/yr) of gold from 190,000 oz/yr (6 t/yr), or by almost 37%. AngloGold Ashanti's Corrego do Sitio gold underground sulfide project was expected to produce 43.5 t during a mine life of 14 years.

In 2006, YGI acquired Brazilian Desert Sun Mining Ltd. for \$632 million. The company invested \$120 million to produce 3.1 t/yr and 1.9 t/yr of gold from the Sao Francisco and the Sao Vicente gold mines, respectively, in the State of Mato Grosso. Similar investment was planned for YGI's Chapada and Fazenda Brasileiro projects, which are located in the State of Goiás and which were expected to produce 1.2 t/yr of gold by 2007 and 3.7 t/yr of gold by 2008, respectively, and for the Cumarú project, which is located in Carajás, State of Para, and which has reserves of 17 t at a grade of 4.8 g/t gold; the Cumarú project was in the feasibility stage (Departamento Nacional de Produção Mineral, 2007a, p. 10; Ferraz, 2007, p. 4; Yamana Gold Inc., 2007).

Iron Ore.—Brazil produced 317.8 Mt of beneficiated iron ore in 2006 compared with 280.6 t in 2005, which was an increase of 13.3%. About 95.5% of that production was from the four major iron ore producers—CVRD, 220 Mt; Minerações Brasileiras Reunidas S/A (MBR), 61 Mt; SAMARCO Mineração S/A, 16 Mt; and Cia. Siderúrgica Nacional (CSN), 15 Mt. In 2006, Brazil exported 242 Mt of iron ore valued at almost \$9 billion, which was 6.5% of the total value of Brazilian exports (\$137.5 billion). The leading importers of Brazilian iron ore were China (25%), Japan (15%), Germany (14%), and France and the Republic of Korea (10% each). The customized commercial products sold were sinter feed and pellet feed (69%), pellets (22%), and lump ore (9%) (Companhia Vale do Rio Doce, 2007a, b; Departamento Nacional de Produção Mineral, 2007a, p. 10; Ferraz, 2007, p. 3).

CVRD sold 276 Mt of iron ore in 2006, which broke the sales record for the seventh consecutive year. In September 2006, CVRD's new Brucutu iron ore mine in the State of Minas Gerais

produced 7.7 Mt; the mine was expected to produce 23 Mt in 2007 and to enter into full production of 30 Mt/yr by 2008. CVRD was planning an investment of \$1.8 billion for the expansion of the Serra dos Carajas iron ore mine, which would increase output to 130 Mt/yr in 2009 from 75 Mt in 2006; the engineering studies for the mine's expansion would be completed by 2007. In 2006, in the State of Mato Grosso do Sul, Mineração Corumbaense Reunida S/A (MCR) (Rio Tinto, 100%) increased production by 40% to 2 Mt at its Corumba iron mine. MCR was planning further mine expansion to reach an output of 5 Mt/yr by 2007 (Rio Tinto plc, 2007). CVRD planned to inject more than \$9 billion into the mining sector by 2007 to consolidate its leading position in the global iron ore and metal markets (Companhia Vale do Rio Doce, 2007a).

Iron and Steel.—Ferroalloys.—Ferroalloys production remained at about the same level as that of 2005 (1,250,000 t). Brazil's Prometal Produtos Metalúrgicos S.A. and Norway's Elkem A/S partnership produced 480,000 t of ferromanganese in 2006; the prometal project, in which Elkem would hold a 40% share, was located in Marabá, State of Pará. The manganese was supplied by the nearby Prometal Mine, and the iron ore by the Carajas mining district (Departamento Nacional de Produção Mineral, 2006b).

Pig Iron.—Brazil produced 35 Mt of pig iron compared with 34.4 t in 2005, which was an increase of 1.7%. Brazil was the world's fifth ranked producer, and its nearly 7.5 Mt of exports, which was valued at almost \$2 billion, represented approximately one-third of the pig iron traded in the world (Departamento Nacional de Produção Mineral, 2006b; 2007a, p. 10).

Steel.—Raw steel production decreased to 30.9 Mt in 2006 from 31.6 Mt in 2005, or by 2.3%. Brazil was the eighth ranked producer and exporter of steel worldwide (Departamento Nacional de Produção Mineral, 2006b; 2007a, p. 10; Fenton, 2007; Siderurgia Brasileira, 2007, p. 33).

Brazil exported 12.519 Mt of steel valued at \$6.9 billion in 2006 compared with 12.514 Mt of steel valued at \$6.5 billion in 2005, which was an increase of 6.2% in exported value. The major recipients of Brazil's steel exports were the United States (35%), Mexico (6%), the Republic of Korea (4%), China, Colombia, Thailand, and Taiwan (3% each), and Argentina (2%). Brazil imported 1.877 Mt of steel valued at \$1.5 billion in 2006 compared with 756,000 t of steel valued at \$874 million in 2005, which represented an increase of 148.3% in volume compared with imported steel in 2005. The apparent domestic consumption of steel (production plus imports minus exports) in Brazil was 20.3 Mt, which represented an increase of about 2% compared with that of 2005 (19.9 Mt). The Brazilian steel industry was planning to invest \$15 billion by 2010 to increase the installed capacity to 50 Mt/yr from the current 36.5 Mt/yr. New steel facilities could be added, which would represent an additional capacity of 6 Mt/yr and an investment of \$4.5 billion (Departamento Nacional de Produção Mineral, 2006b; 2007a, p. 18-19; Ferraz, 2007, p. 4; Instituto Brasileiro de Siderurgia, 2007, p. 8, 33). CVRD and the Dongkuk Steel and Danieli Group partnership were planning to produce 1.5 Mt/yr of steel slabs at the Ceará Steel project in the State of Ceará by 2009. CVRD expected to invest \$25 million in the project and to supply 2.5 Mt/yr of direct-reduction pellets. Similarly, CVRD and ThyssenKrupp CSA (CSA) were planning to build a steel plant in the State of Rio de Janeiro to produce 5 Mt/yr of steel slab by 2009. CVRD was expected to invest \$200 million and to supply CSA with 5.9 Mt/yr of iron ore and 2.7 Mt/yr of pellets. Baovale Company (Baosteel of China and CVRD, 50% each) was also planning to invest \$1.4 billion in an integrated mill that could produce 4 Mt/yr of steel slab (Companhia Vale do Rio Doce, 2007a-c).

Manganese.—Manganese production increased to 4.3 Mt in 2006 from 3.9 Mt in 2005, or by 10.3%. Rio Doce Manganês S.A.'s (RDM) (CVRD, 100%) manganese mines in the States of Bahia and Minas Gerais accounted for 75% of metallurgical manganese production. RDM, which was the leading producer of manganese concentrate (2.5 Mt), in conjunction with Minérios Metalúrgicos do Nordeste S/A, Sociedade Mineira de Mineração Ltda., and Urucum Mineração S.A., accounted for 95% of Brazil's manganese concentrate production in 2006. Exports of manganese high-grade ore amounted to 1.1 Mt at a value of \$140 million. Domestic consumption of manganese was as follows: for manganese ferroalloys, 85%; electrical batteries, 10%; and chemicals, 5%. In 2006, CVRD produced about 2.3 Mt of manganese ore and 480,000 t of manganese ferroalloys. Manganese ferroalloys exports increased by almost 13% to 175,000 t and were valued at \$123 million. CVRD was negotiating with the Asian Steelmaker POSCO Engineering and Construction Co., Ltd. of the Republic of Korea for a new blast furnace pellet to be built by 2007 (Companhia Vale do Rio Doce, 2007b; Departamento Nacional de Produção Mineral, 2007a, p. 14).

Nickel.—Brazil produced 82,492 t of nickel content in ore in 2006 compared with 74,198 t in 2005, which represented an increase of 11.2%. Production of electrolytic nickel increased to 23,029 t in 2006 from 20,714 t in 2005; nickel in ferronickel alloys increased to 10,670 t in 2006 from 9,596 t

in 2005; nickel in matte increased to 9,240 in 2006 from 9,182 t in 2005; and nickel in carbonates increased slightly to 27,719 t in 2006 from 27,547 t in 2005 (table 1; Departamento Nacional de Produção Mineral, 2007a, p. 15). Mineração Serra da Fortaleza, which was owned by Grupo Votarantim (GV) and located in Fortaleza de Minas, State of Minas Gerais, produced 5,073 t of nickel in matte compared with 6,252 t in 2005. Companhia Niquel Tocantins, which was also owned by GV and located in Niquelandia, State of Goiás, produced 21,338 t of electrolytic nickel. In the same mining district, CODEMIN S.A., which was owned by Anglo American, produced 9,813 t of electrolytic nickel (Departamento Nacional de Produção Mineral, 2007a, p. 15; Ferraz, 2007, p. 5).

Owing to the increase in world consumption of stainless steel and to higher nickel prices, Anglo American approved an investment of \$1.2 billion for its Barro Alto nickel project in the State of Goiás. The company planned to produce 36,000 t/yr of nickel as concentrate content from a deposit with 117 Mt of reserves at a grade of 1.5% nickel by 2008 and to enter into full production by 2011.

CVRD intended to invest \$1.5 billion to utilize a high-pressure acid leaching technology to produce 46,000 t/yr of nickel and 2,800 t/yr of cobalt metal from its Vermehlo project in Carajas, State of Para, which contained reserves of 290 Mt of laterite (limonitic) ores at a grade of 0.8% nickel. In December, CVRD acquired Canico Resources Corporation, which was a Canadian junior resource company focused on the development of the Onca Puma nickel laterite project in the State of Para, and was planning to invest \$1.4 billion to produce 58,000 t/yr of nickel in the form of ferronickel. The Onca Puma and the Vermehlo projects were expected to enter into production by 2008. In October 2006, CVRD acquired Inco Limited of Canada and emerged from this transaction as the second ranked mining company in the world, in terms of market value and capitalization. The name of Inco Limited was changed to CVRD Inco Limited (CVRD Inco), and its nickel, marketing, and metal sales departments were to be managed from Toronto. It was expected that an integrated management could improve the synergy among CVRD Inco's mineral operations worldwide (Companhia Vale do Rio Doce, 2007b, c; Departamento Nacional de Produção Mineral, 2007a, p. 15; Ferreira, 2007, p. 5).

Zinc.—Brazil produced 185,211 t of zinc content in concentrates in 2006, which was 8.5% more than in 2005. Primary metal production increased to 272,333 t in 2006 from 267,374 t in 2005, and represented 99% of the installed annual metal capacity of 275,000 t. GV was the only producer of zinc in Brazil; production was through its two subsidiaries: Companhia Mineira de Metais S/A, which was located in Vazante, State of Minas Gerais, and Companhia Paraibuna de Metais S/A, which was located at the Juiz de Fora complex in Minas Gerais. Companhia Mineira de Metais produced 184,179 t of metal zinc (67.6% of the total), which was 4% more than in 2005, mainly from domestic concentrates treated at the Tres Marias (180,000 t) metallurgical plant. Companhia Paraibuna de Metais produced 88,154 t of metal zinc (32.4% of the total) and relied entirely on imported concentrates. Peru supplied 98.5% of the concentrates and 50% of the metal; additional zinc metal was supplied by Argentina (40%) to meet Brazil's demand for zinc, which was 220,500 t of metal in 2006 (Departamento Nacional de Produção Mineral, 2006a, p. 17; Ferraz, 2007, p. 5).

Industrial Minerals

Asbestos.—In 2006, Brazil produced 227,304 t of asbestos fiber, which was 3.7% less than in 2005 (236,047 t). Brazil's significant asbestos deposits were located in Cana Brava, in the municipality of Minacu, in the State of Goiás; Goiás was the only producing State in the country. Sociedade Anônima Mineração de Amianto supplied 75% of Brazil's asbestos to manufacture specialized cement products, which were, in order of economic importance, ceiling tiles, protective screens, water and sewer pipes, water tanks, and molded electrical insulators. Other uses were, in order of economic importance, thermal insulators, paper and cardboard, slabs, decorations, insecticide, asphalt for highways and airport runways, and the automobile industry. In 2006, Brazilian asbestos exports were shipped to Thailand (25%), India (23%), Indonesia (17%), Iran (7%), and others (28%) (Departamento Nacional de Produção Mineral, 2007a, p. 11; 2007b, p. 40).

Asbestos mining and consumption have been highly regulated in most industrialized nations, thus forcing the countries to reduce production and consumption. Industry experts expected asbestos use in the industrialized nations to continue to decline owing to health hazards. In contrast, the world's developing economies were expected to increase their collective asbestos consumption by large margins. Brazilian asbestos reserves (15.4 Mt) were considered to be adequate to meet demand in the short to medium term; the average grade of ore from the Cana Brava Mine in

Minacu was 5.2%; it had reserves (fiber content only) of 3 Mt, which, at a production rate of about 200,000 t/yr, represented a 15-year mine life (Departamento Nacional de Produção Mineral, 2007a, p. 10; 2007b, p. 41).

Gemstones.—In the Americas, Brazil followed Canada as the top-ranked producers and traders of mostly alluvial diamond followed by Guyana and Venezuela. Brazil continued to be one of South America's leading gemstone producers and exporters. Many different varieties of gemstones are found in the Araxa, the Bambui, and the Canastra geologic groups; these include, in order of value (US\$/carat), diamond, emerald, aquamarine, topaz, tourmaline, opal, chrysoberyl, amethyst, citrine, and agate. Brazil is the world's only source of some quality gemstones, such as imperial topaz and Paraiba tourmaline. Currently (2006), 92% of the diamond and gemstones are mined by garimpeiros, and 8%, by the private sector. According to the DNPM's Mineral Summary Statistics for 2002-06, Brazil's diamond production from year to year has been uncertain, and annual production has been declining since 2002. In both 2006 and 2005, Brazil produced 300,000 carats valued at about \$30 million compared with 400,000 carats valued at \$38.1 million in 2003 and 500,000 carats valued at almost \$31 million in 2002. The entrepreneurial sector produced 3% of the total, or 15,000 carats, in 2003; more than 33%, or 100,000 carats, in 2004; and almost 37%, or 110,643 carats, in 2005 and 2006. The leading producers were Mineradora S/A, which was located in Juina, State of Mato Grosso, and produced 92,062 carats; and Mineração Rio Novo S/A, which was located in Diamantina, State of Minas Gerais, and produced 18,581 carats. The carats produced and reported conform to the Kimberley Process Certification Scheme's (KPCS) guidelines (table 1; Departamento Nacional de Produção Mineral, 2007b, p. 46-47; Ferraz, 2007, p. 4; Olson, 2007a).

Production by garimpeiros, however, continued to decline because reserves of garimpos were depleting and environmental restrictions were increasing. Since 2004, when the Government closed high-content gem placers in indigenous reserves to exploration, the jewelry industry's gemstone consumption has been unknown, and the high taxation rate affected the domestic sales of jewelry. Taking into consideration these factors, Brazil's gemstone reserves were almost impossible to quantify. Brazil, however, may have great potential because it has 1,000 million cubic meters of sedimentary rocks that contain diamond that grades between 0.01 and 0.1 carat per cubic meter, or about 44.6 million carats. As of 2007, diamond had been discovered in more than 40 mining districts and 11 States. Some 300 kimberlite diamond-bearing pipes were reportedly found. Such companies as BHP Billiton, De Beers, and Rio Tinto were exploring for kimberlites, mostly in the States of, in order of volume, Minas Gerais, Rondonia, and Sao Paulo. These companies sold their projects to domestic and international diamond exploration companies, such as Brazilian Diamonds Ltd., which was a Canadian junior company that acquired De Beers' 140 kimberlites in the State of Minas Gerais (Ferraz, 2007, p. 5).

In 2006, the major markets for Brazilian rough diamond were the EU (61%), the United Arab Emirates (21%), the United States (11%), and Ireland (7%). In 2006, conforming to the KPCS guidelines, the DNPM provided 75 certificates, of which the EU received 38 certificates; the United States, 24; the United Arab Emirates, 8; Israel, 4; and Canada, 1. Imports of uncut stones amounted to 16,500 carats valued at \$300,000; the main sources were the EU (40%), India (37%), the United Arab Emirates (7%), and others (16%) (Departamento Nacional de Produção Mineral, 2007b, p. 46).

Phosphate Rock.—Production of phosphate rock amounted to about 5.7 Mt in 2006 compared with 5.5 Mt in 2005, which was an increase of 3.6%. The three leading mining companies—Fosfertil S.A. (Grupo Fertifós) (44.8%) in the State of Minas Gerais, Fertilizantes Serrana S.A.

(Bunge Ltd.) (24.7%) in the State of Goiás, and Copebras S.A. (Anglo American) (20.2%) in the State of Sao Paulo—contributed almost 90% of the total production in 2006. The reported domestic consumption of concentrates was about 7.1 Mt in 2006 compared with 5.5 Mt in 2005. Of the total phosphoric acid produced, 73% was used in the fertilizer industry; 25%, in the chemical industry; and 2%, for other uses; these usages remained almost unchanged from those of 2005. Imports of phosphates, phosphoric acid, and intermediate products for fertilizers were valued at \$912 million in 2006 (Departamento Nacional de Produção Mineral, 2007a, p. 17).

Mineral Fuels

In 2006, Brazil produced almost 17.9 billion cubic meters of natural gas and 700.8 million barrels of petroleum, which was 1.1% and almost 4% higher than that of 2005, respectively. The country produced, in order of economic importance, crude oil, natural gas liquid, natural gas, coal, and shale oil; production totaled 840 million barrels of oil equivalent. In 2006, Petrobrás' average production of crude oil, which included condensate and liquid natural gas, was about 2.298 million barrels per day (Mbbbl/d), which was 3.7% higher than that of 2005. Petrobrás was planning to increase its daily output rate to 2.3 Mbbbl by 2010 and to produce about 75% of this output from deepwater zones (Petróleo Brasileiro S.A., 2006, p. 6; Departamento Nacional de Produção Mineral, 2007b, p. 91-92). In 2006, the supply of natural gas totaled about 64 million cubic meters per day, of which 24 million cubic meters per day, or almost 37.5%, was imported from Bolivia. Of the total daily supply, 32 million cubic meters, or 50%, was used by Petrobrás; 21 million cubic meters, or 32.8%, was consumed in Brazil; and the remaining 11 million cubic meters, or 17.2%, was used by thermoelectric powerplants. Gas usage increased by almost 2% per year during the period of 1980-2006 (Petróleo Brasileiro S.A., 2006, p. 40; Departamento Nacional de Produção Mineral, 2007b, p. 66).

Coal.—In 2006, Brazil produced almost 6 Mt of bituminous coal compared with 5.9 Mt in 2005. The Brazilian coal industry's mine operations were concentrated in the three southernmost States of Santa Catarina (65%), Rio Grande do Sul (33%), and Parana (2%). The leading producers of ROM coal were Copelmi Mineração Ltda. (15%), Carbonífera Circúma S.A. (14%), and Indústria Carbonífera Rio Deserto Ltda. (13%). Coal demand increased mainly because the thermoelectric plants were operating at full capacity in these three States (Departamento Nacional de Produção Mineral, 2007a, p. 10; 2007b, p. 31-32).

To meet Brazil's coal demand, 16.8 Mt was imported in 2006 compared with 17.3 Mt in 2005. Imports came from Australia (28%), the United States (21%), China (19%), Canada (9%), South Africa (5%), and other countries (18%). Brazil's usage of coal was 68% as metallurgical coal and 32% as energetic coal in 2006. The steel industry consumed 100% of metallurgical coal. The energy coal was consumed for thermoelectric generation, 85%, and by the industrial sector, 15% (petrochemical, 4%; food industry, 3%; cellulose, 3%; and others, 5%) (Departamento Nacional de Produção Mineral, 2007b, p. 32).

CVRD announced that the company entered into an acquisition agreement to purchase AMCI Holdings Australia Pty (AMCI HA) of Brisbane, Queensland, Australia, for \$835 million by 2007. AMCI HA operated and controlled 103 Mt of coal reserves and had a production capacity of 8 Mt/yr of coal (Companhia Vale do Rio Doce, 2007a).

Brazil was planning a priority thermoelectric generating program based mostly on natural gas and coal; about 50 new power stations would be based on natural gas. Three new coal-fired powerplants would be built in the State of Rio Grande do Sul. These new powerplants were part of the Government's 17-gigawatt emergency plan (supplied largely by Electrobrás S.A.) to cope with the increased demand for electricity. Most Brazilian coals have a lower content of carbon and a higher content of ash compared with the Colombian coals in the Guajira area. Total Brazilian coal reserves were estimated to be 10,113 Mt (table 3; Departamento Nacional de Produção Mineral, 2007b, p. 31).

Natural Gas.—In 2006, Brazil consumed 30 million cubic meters per day of domestic natural gas and imported 24 million cubic meters per day of natural gas from Bolivia. The average daily natural gas production increased to 47 million cubic meters in 2006 from 45 million cubic meters in 2005, or by 4.4%. The gas pipeline that links the Enchova platform in the offshore Campos Basin to Macae, State of Rio de Janeiro, added 5 million cubic meters per day of gas flow to the Rio de Janeiro and the Sao Paulo markets; offshore gas production accounted for 45.5% of the total. Petrobrás signed two agreements, one with Repsol-YPF of Spain's subsidiary in Argentina and the other with YPF de Bolivia, to supply natural gas to Brazil. The Argentina-Brazil gas pipeline linked Aldeia Brasileira in Argentina to Porto Alegre in the State of Rio Grande do Sul. The 3,150-

km Bolivia-Brazil gas pipeline increased the flow of natural gas to 24 million cubic meters per day in 2006 from 22 million cubic meters per day in 2005; the gas was supplied to, in order of volume, the States of Mato Grosso do Sul, Sao Paulo, Parana, Santa Catarina, and Rio Grande do Sul. The Bolivian natural gas supply could increase to 30 million cubic meters per day by 2010, which would supply nearly 40% of domestic demand. The natural gas share of the country's energy mix was 5% in 2006 and could conceivably be more than 10% by 2010. Petrobrás continued to produce natural gas in the Gulf of Mexico and recovered gas from the Frederick Field, which is located 27 km off the Louisiana coast. Brazil's potential for offshore gas supply has improved notably, mainly because of expected new discoveries in the Santos Basin (Petróleo Brasileiro S.A., 2006, p. 7; Departamento Nacional de Produção Mineral, 2007b, p. 66).

Petroleum.—According to Petrobrás, Brazil produced 1.92 Mbbbl/d of petroleum, which was almost 4% more than in 2005 (1.85 Mbbbl/d). In 2006, imports of crude oil and derivatives were 370,000 barrels per day (bbl/d) and 118,000 bbl/d compared with 352,000 bbl/d and 94,000 bbl/d, respectively, in 2005. The main sources were Nigeria (49%), Algeria (23%), Saudi Arabia (15%), Iraq (8%), and Argentina (5%). In 2006, Petrobrás's total international production of oil and liquid natural gas amounted to 36,000 bbl/d, and natural gas output was almost 4.5 million cubic meters per day, which totaled 60,000 bbl/d of oil equivalent. According to Petrobrás, exploration and production took place in, in order of economic importance, Angola, Argentina, Bolivia, Venezuela, Colombia, Peru, Ecuador, and the United States (Petróleo Brasileiro S.A., 2006, p. 58; Departamento Nacional de Produção Mineral, 2007b, p. 91-92).

In 2006, the partnership of Royal Dutch Shell (80%) and Petrobrás (20%) on the Bijupira and the Salema Projects in Campos Basin produced a combined 50,000 bbl/d of crude oil and more than 480,000 cubic meters per day of gas; the fields have reserves of about 190 million barrels of oil and 1.8 billion cubic meters of natural gas. Other companies involved in exploration included Statoil ASA of Norway, Repsol-YPF, and Chevron (U.S. Energy Information Administration, 2006).

Reserves and Resources

Brazil was among the world leaders in reserves of some mineral commodities (table 3). According to the DNPM, the country's world reserves of mineral commodities was as follows: first, niobium (columbium) and tantalum; second, graphite; third, bauxite, tin, and zinc; fourth, magnesite and manganese; and fifth, iron ore (table 3; Departamento Nacional de Produção Mineral, 2007b, p. 10).

Outlook

Brazil's mining sector is going through a phase of real growth, which has led to an increase in net FDI. New mine projects and expansions in progress are expected to ensure that Brazil retains its leading position in global mineral commodity production for years to come. Brazil's rapid economic growth and its associated financial innovation are supporting the increase of domestic and transnational investors in the Brazilian mineral industry and, in particular, in the ethanol/biofuels, metals, and natural gas and petroleum sectors. According to the Banco Central do Brasil (2007a, b) and the Economic Commission for Latin America and the Caribbean (2007), more than 350 leading transnational companies were planning to invest worldwide; these investments could position Brazil behind, in order of investment volume, China, the United States, and India. Brazil is expected to continue to be a strong economy in Latin America and MERCOSUR and, as one of the world's leading producers of bauxite, graphite, iron ore, manganese, niobium (columbium), tantalum, and tin, to attract FDI inflows. In Brazil, the main vehicles for FDI inflows, in the short and medium terms, are expected to be joint ventures and acquisitions in new projects with CVRD, Petrobrás, and others. Investments in hydroelectric and thermoelectric powerplants coming onstream are expected to meet Brazil's future energy needs. As an exporter of mineral commodities, the country is poised to gain from the continued FDI inflows into its economy, which represented an almost 75% share (\$18.8 billion) of MERCOSUR's total FDI (\$25.1 billion) in 2006 (Banco Central do Brasil 2007a, b; Economic Commission for Latin America and the Caribbean, 2007).

Brazil's Federal tax exemptions on imports of equipment for minerals (metals, industrial minerals, and fuels) prospecting, exploration, development, and production are expected to continue in the medium and long terms. The Agência Nacional do Petróleo was planning to extend these exemptions for the fuels sector into 2020. Petroleum companies and other investors have shown confidence in the country, which could support continued economic growth and FDI in new

technologies well into the next decade. CVRD is planning to invest about \$13 billion in a low-cost and profitable project pipeline to be developed during 2006-10. The significance of the investment would be to increase CVRD's market capitalization to \$70 billion from its current (2006) level of about \$55 billion (Banco Central do Brasil, 2007a, b; Companhia Vale do Rio Doce, 2007a-c).

The mining sector grew by 7.3% compared with 2.8% growth in industrial output, showing the important role that minerals extraction has for Brazil. This positive rate of economic growth in the minerals sector is likely to be sustained into 2007 and beyond if expansion in the demand for mineral exports and fabricated steel goods continues as well. MERCOSUR has undergone dramatic changes in the natural gas and power markets owing to the increase in cross-border energy investment opportunities, domestic gas consumption, and regionalization of the energy sector. Brazil has become the center of an increasingly rapid process of energy integration in South America owing to the country's gas market, which is evolving rapidly with an unsatisfied energy demand and a great potential for growth (Petróleo Brasileiro S.A., 2006, p. 31; Ferraz, 2007, p. 3).

Investments in the Brazilian mining industry are expected to continue to increase exploration and mine development activities, particularly in, in order of economic importance, iron ore, gold, copper, diamond, and emeralds. This trend is expected to continue because several TNCs have been forming consortiums and acquiring exploration properties, mining prospects, and permits particularly for, in order of economic importance, oil and gas, iron ore, gold, diamond, and base metals.

Brazilian gold production could increase significantly in the foreseeable future because of the growth of Brazilian copper production and increased interest by domestic and foreign investors in largely unexplored areas. More than 2,500 gold occurrences, which are mostly Precambrian vein deposits and alluvial placers, are known. During 2006-07, Brazil's investment in minerals exploration, such as for, in order of value, bauxite, copper, iron ore, and nickel, amounted to \$7.4 billion (Departamento Nacional de Produção Mineral, 2007a, p. 25; 2007b, p. 88).

Brazil's joint ventures with such countries as China, Japan, and the Republic of Korea are expected to enhance its mineral trade with the EU, Latin America, and the United States. Brazil has a strong industrial base that is capable of supplying most of the required mining and natural gas and petroleum equipment; the country has modern mining and oil technologies and an efficient network of supporting services, and can provide skilled labor. Modern and reliable transportation and communication infrastructures were being planned to augment Brazil's ability to produce minerals competitively and in a sustainable way.

The aluminum, automobile, petrochemical, pulp and paper, and steel industries, which depend heavily on energy and exports, would likely benefit most from the new power-generating infrastructure. The 52 powerplants to be built in the foreseeable future (49 based on natural gas and 3 on coal) would become the major drivers for growth in mineral fuels demand. Since 2002, the Government eliminated all price controls and import tariffs on petroleum and derivatives to motivate private investment and to increase competition that would benefit the Brazilian economy. Petrobrás is expected to build additional refineries with the participation of new partners from the private sector (Petróleo Brasileiro S.A., 2006, p. 34).

The Amazon region continued to offer potential for major undiscovered mineral resources in addition to the large reserves of, in order of value, iron ore, manganese, bauxite, gold, and tin. A factor that may place constraints on mineral development in the longer term, however, is the concern for biodiversity in the Amazon Rainforest, which comprises 30% of the world's remaining tropical forests, provides shelter to 10% of the globe's plant and animal species, and removes excess carbon dioxide from the atmosphere. Much will depend, however, on the approaches and technologies to be used for economic and social development while protecting the environment in a sustainable way (Departamento Nacional de Produção Mineral, 2006a, b; 2007a, p. 25; U.S. Energy Information Administration, 2006; Vale, 2006).

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