



2015 Minerals Yearbook

BRAZIL [ADVANCE RELEASE]

THE MINERAL INDUSTRY OF BRAZIL

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Brazil is one of the leading mining countries in the world, producing a wide array of industrial minerals, metals, and mineral fuels. In 2015, Brazil's estimated share of world mined niobium production amounted to 90%; iron ore, 18%; vermiculite, 17%; asbestos, 16%; bauxite, 12%; talc and pyrophyllite, 10%; tantalum, 10%; alumina, 9%; tin, 9%; graphite, 7%; and manganese, 6%. The World Steel Association reported that Brazil accounted for about 2% of the world's steel production and was the leading producer in South America (76% of South America's steel production) (World Steel Association, 2016; Anderson, 2017; Bray, 2017; Corathers, 2017; Flanagan, 2017a, b; Olson, 2017; Papp, 2017a, b; Tanner, 2017; Tuck, 2017).

Brazil ranked 12th in the world in crude petroleum production and 2d in South America (after Venezuela) in both crude petroleum and natural gas reserves. Brazil's proven crude petroleum reserves (onshore and offshore) were estimated to be 13.0 billion barrels (Gbbbl), and its natural gas reserves were estimated to be 430.0 billion cubic meters. About 95% of the total proven crude petroleum reserves and 84% of the total proven natural gas reserves were located offshore. In 2015, offshore crude petroleum production accounted for about 93% of the country's total crude petroleum production. The State of Rio de Janeiro accounted for about 67% of the total crude petroleum production. Massive pre-salt areas—that is, layers of oil-bearing rock of carbonate composition that are located under thick layers of salt—accounted for 31% of total crude petroleum production. The pre-salt areas measured about 800 kilometers (km) in length and 200 km in width and were located off the coast of the States of Santa Catarina and Espírito Santo. State-owned *Petróleo Brasileiro S.A.* (Petrobras) was the leading participant in Brazil's petroleum and natural gas sectors, playing a significant role in upstream, midstream, and downstream operations. As operator, Petrobras's oil and natural gas production accounted for about 84% and 81%, respectively, of the country's total crude petroleum and natural gas production in 2015 (table 3; U.S. Energy Information Administration, 2015, p. 2; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2016, p. 73, 75, 80, 81; BP p.l.c., 2016, p. 6, 8, 20; *Petróleo Brasileiro S.A.*, 2016c).

In 2015, Brazil's gross domestic product (based on purchasing power parity) was \$3.2 trillion, which ranked it as the eighth largest economy in the world. Brazil's real gross domestic product (GDP) decreased by 3.8% compared with that of 2014. The Instituto Brasileiro de Mineração [Brazilian Mining Institute] (IBRAM) reported that mineral exports accounted for about 12% of the country's exports. Brazil's leading mineral exports were, in order of value, iron ore, gold, copper, and ferroniobium, and its leading mineral imports were, in order of value, potassium, coal, and copper (Banco Central do Brasil, 2016a; Instituto Brasileiro de Mineração, 2016a; U.S. Central Intelligence Agency, 2016).

Minerals in the National Economy

Brazil's mineral production in 2015 was valued at \$26 billion compared with \$40 billion in 2014 and represented about 1% of the GDP (Instituto Brasileiro de Mineração, 2016b). The decrease was attributed to the decrease in global iron ore prices during the year. In the second half of the year, about 179,109 workers were employed in the mining sector compared with 194,859 in the second half of 2014. The Economic Commission for Latin America and the Caribbean noted that Brazil's foreign direct investment (FDI) decreased in 2015 to \$75 billion, down from \$97 billion in 2014 and far below the 5-year high of \$101 billion that it reached in 2011. The causes for the decline in FDI since 2011 included decreasing investor confidence from political instability as well as decreased commodity prices. As reported by IBRAM, planned investment projects in Brazil's mineral sector for the 5-year period (2014 through 2018, which was the latest series available) amounted to about \$54 billion, which represented a decrease of about 16% compared with the period 2013 through 2017 (\$64 billion). The State of Minas Gerais accounted for 41% of these investments during 2014–18, followed by the States of Para (22%) and Mato Grosso do Sul (10%) (Instituto Brasileiro de Mineração, 2015b, p. 18; 2016b; Departamento Nacional de Produção Mineral, 2016b, p. 7; Economic Commission for Latin America and the Caribbean, 2016, p. 22, 47, 49).

Government Policies and Programs

All aspects of Brazil's mineral industry, from exploration to production and use of mineral resources, is governed by the Mining Code [Decree-law (Act) No. 227 of 1967], which establishes the rights and duties of the holders of mining rights. The Ministério de Minas e Energia [Ministry of Mines and Energy] (MME) manages the country's mineral resources through its Departamento Nacional de Produção Mineral [National Department of Mineral Production] (DNPM); DNPM also inspects mineral activity in the country, enforces the Mining Code, and implements the code's legal provisions. Decree-law (Act) No. 227 was amended by law No. 9314 in 1996 to provide greater flexibility for investment in Brazil's mineral sector. Article 7 of the Mining Code of 1967 stipulates that the General Director of DNPM grants exploration licenses and the Minister of the MME issues development concessions. Exploration licenses are issued on a "first-come, first-served" basis; can be held for up to 3 years; cover an area of up to 10,000 hectares, depending on the mineral type and location; and require adherence to an approved exploration plan, payment of an annual fee, payment of the landowner's revenue and compensation, and reporting on the results of any work completed. Concessions are valid up to the depletion of the mineral deposit; require an environmental license and adherence to an approved mining plan; require annual

reporting to the DNPM on activities, production, and sales; and require the concession holder to restore the degraded areas (Ministério de Minas e Energia, 2014; Instituto Brasileiro de Mineração, 2015a, p. 13; Departamento Nacional de Produção Mineral, 2016a).

A draft bill for a new regulatory framework for mining (Public Law No. 5807/13) was introduced in 2013 and continued to be reviewed in 2015. The bill would modify the Mining Code by creating the Conselho Nacional de Política Mineral [National Mineral Policy Council] to assist the President in strategic decisionmaking on minerals and by creating the Agência Nacional de Mineração [National Mining Agency], which would replace DNPM and be granted additional authorities, such as organizing public bidding for mineral rights. The new code would also increase the royalties on minerals to a yet-to-be-determined level from their current level of 3% for aluminum, manganese, potassium, and rock salt; 2% for coal, fertilizer, and iron ore; 1% for gold; and 0.2% for carbonates, colored gemstones, noble metals, and precious stones (Ministério de Minas e Energia, 2014; Instituto Brasileiro de Mineração, 2015a, p. 13; Departamento Nacional de Produção Mineral, 2016a).

Geologic, geophysical, geochemical, hydrologic and hydrogeologic mapping is performed by the MME's Companhia de Pesquisa de Recursos Minerais [Mineral Resources Research Company] (CPRM) (the Geological Survey of Brazil) and includes the dissemination and management of geologic and hydrologic information. The Agência Nacional do Petróleo, Gás Natural e Biocombustíveis [National Agency of Petroleum, Natural Gas and Biofuels] (ANP), which is also part of the MME, has responsibility for regulating activities that integrate the biofuels, natural gas, and oil industries in the country and issuing exploration and production licenses (Ministério de Minas e Energia, 2016a, b).

Brazil passed legislation in 2010 that instituted a new regulatory framework for its pre-salt crude petroleum reserves. The framework authorized the creation of Empresa Brasileira de Administração de Petróleo e Gás Natural—Pré-Sal Petróleo S.A. [Brazilian Company for the Administration of Oil and Natural Gas—Pre-Salt Petroleum S.A.] (PPSA) to manage new pre-salt production and trading contracts in the crude petroleum and gas industry; PPSA operates under the authority of the MME. The framework also established a new development fund to manage Government revenues from pre-salt crude petroleum and laid out a new production-sharing agreement system for pre-salt reserves whereby Petrobras would be the sole operator of each production-sharing agreement and would hold a minimum 30% stake in all pre-salt projects (U.S. Energy Information Administration, 2015; Ministério de Minas e Energia, 2016c).

Brazil's Compensação Financeira pela Exploração de Recursos Minerais [Financial Compensation for Exploiting Mineral Resources] (CFEM), part of the DNPM, is responsible for collecting mining royalties. The prevailing royalty rates in 2015 were 3% for bauxite, manganese ore, potassium, and rock salt; 2% for coal, fertilizers, and iron ore; 1% for gold; and 0.2% for other precious minerals and precious stones. The collected royalties are allocated among the municipalities (65%), States (23%), and the Federal Government (12%),

of which the DNPM receives 9.8% (Instituto Brasileiro de Mineração, 2015b, p. 19).

Brazil belonged to a number of international trade associations, the most notable of which was the Mercado Común del Cono Sur (MERCOSUR), which is a trade association that promotes free trade; member countries include Argentina, Bolivia, Brazil, Paraguay, Uruguay, and Venezuela. In 2015, MERCOSUR received about 11% of Brazil's exports and supplied about 8% of Brazil's imports. Brazil was also a member in the Brazil, Russia, India, China, and South Africa (BRICS) economic forum, whose member countries combined represented a significant share (about 20%) of the world's GDP and population (Mercado Común del Cono Sur, 2015; Banco Central do Brasil, 2016b; China Daily, 2016).

Production

In 2015, Brazil's largest change in mineral production was a decrease of 38% in asphalt production to 12.7 million barrels (Mbbbl) from 20.4 Mbbbl in 2014 owing to decreases in Petrobras's refinery throughput and utilization rates. Tin metal production decreased by 26% to an estimated 16,500 t, and tin mine output decreased by 26% to 18,824 metric tons (t); both of the decreases were owing to lower tin prices and an energy supply disruption at Minsur S.A. of Peru's Pitinga Mine. Other minerals that had significant decreases in production were silicon metal, the output of which decreased by 24% to an estimated 70,000 t; primary aluminum, by 20% to 772,200 t; fuel oil, 12% to 90.2 Mbbbl; zirconium, 11% to an estimated 21,000 t; and gasoline, 10% to 169.3 Mbbbl. Mineral production decreased to zero for both copper (electrowon) and barite (crude). Several minerals had significant increases in production. Copper mine output increased by 19% to 359,463 t in 2015 from 301,197 t in 2014; copper production had increased each year since 2010 and was up by 68% during that time period. The production of nickel (mine output) increased by 15% to about 16 million metric tons (Mt); manganese metal increased by 12% to 1.2 Mt; natural gas (gross) increased 10% to 35.1 billion cubic meters from 31.9 billion cubic meters in 2014; natural gas production had also increased each year since 2010 and was up by 53% for that time period. Data on mineral production are in table 1 (Minsur S.A., 2016, p. 11; Petróleo Brasileiro S.A., 2016a, p. 52).

Structure of the Mineral Industry

In 2015, Vale S.A. was the leading producer of copper, gold, and iron ore in Brazil, with operations throughout the country. Petrobras was the leading producer of crude petroleum, with operations both onshore and offshore, and it was also the leading operator of Brazil's refineries. Eternit S.A., through its subsidiary Sociedade Anônima Mineração de Amianto S.A. (SAMA), owned Cana Brava, which was the only asbestos operation in the country. Cana Brava is located in Minacu in the State of Goiás and had the capacity to produce about 300,000 metric tons per year (t/yr) of asbestos concentrates. Bauxite was produced by Alcoa Alumínio S.A., Alcoa World Alumina Brasil Ltda (AWAB), Companhia Brasileira de Alumínio (CBA), Mineração Paragominas S.A.,

and Mineração Rio do Norte S.A. (MRN). MRN, located in Porto Trombetas in the State of Para, had the capacity to produce 18.1 million metric tons per year (Mt/yr) of bauxite. Caraiba Metais S/A, located in the State of Bahia, was the only electrolytic copper producer in the country; it had a production capacity of about 280,000 t/yr. The Votorantim Group, which was the only producer of zinc in the country, owned two mines (Vazante and Morro Agudo) and two metallurgy operations (Juiz de Fora and Tres Marias) located in the State of Minas Gerais. The Juiz de Fora and the Tres Marias operations had production capacities of about 95,000 t/yr and 180,000 t/yr of zinc, respectively. Table 2 is a list of major mineral industry facilities.

Mineral Trade

Brazil's mineral exports in 2015 were valued at about \$22.3 billion compared with about \$34.2 billion in 2014 (mainly because of decreases in the prices of iron ore and gold); mineral exports accounted for 12% of total exports (decreased by 15% in 2015 to \$191.1 billion from about \$225.1 billion in 2014). The country's major export trade partners were, in descending order of value, China, which received 19% of Brazil's exports; the United States, 13%; Argentina, 7%; and the Netherlands, 5%. Brazil's imports in 2015 decreased by 25% to \$171.5 billion from about \$229.1 billion in 2014. Its major import partners were, in descending order of value, China, which supplied 18% of Brazil's imports; the United States, 16%; and Argentina and Germany, 6% each. Mineral imports were about \$7.1 billion in 2015 compared with about \$7.9 billion in 2014. The mineral trade surplus was about \$14.8 billion in 2015 compared with \$26.3 billion in 2014. Iron ore accounted for about 63% of the value of mineral exports, followed by gold (10%), copper (9%), and ferroniobium (7%). Potassium accounted for about 36% of the primary mineral imports, followed by coal (35%), copper (14%), and sulfur (4%) (Banco Central do Brasil, 2016b; Instituto Brasileiro de Mineração, 2016a).

In 2015, the volume of Brazil's exports of crude petroleum increased by 42% to 269 Mbbl from 189 Mbbl in 2014. Its major crude petroleum exports partners were, in descending order of volume, China (34%), the United States (16%), India (11%), Uruguay (10%), and Chile (8%). The volume of the country's crude petroleum imports decreased by 18% to 118 Mbbl in 2015 from 144 Mbbl in 2014. The leading import sources were Nigeria (53%), Saudi Arabia (23%), Algeria (7%), and Iraq (7%). In 2014, imports of natural gas and liquefied natural gas (LNG) totaled about 19 million cubic meters, which was an increase of 10% compared with the 17 million cubic meters imported in 2014. Bolivia supplied 99% of Brazil's natural gas imports and Nigeria, Qatar, and Trinidad and Tobago together supplied about 68% of the country's LNG imports (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2016, p. 121, 123, 134).

In terms of trade with the United States, Brazil's exports to the United States were led by crude petroleum, which was valued at \$3.7 billion and accounted for 13% of the total value of its exports to the United States. The value of total exports to the United States decreased by 8% to \$27.5 billion from about \$30.0 billion in 2014. Other major mineral-related exports from Brazil to the United States in 2015 were iron and steel mill

products valued at \$2.2 billion; fuel oil, \$562 million; petroleum products, \$527 million; other nonferrous metals, \$195 million; bauxite and aluminum, \$171 million; nonmonetary gold, \$162 million; coal and related fuels, \$149 million; and nickel \$99 million. Brazil's imports from the United States decreased by \$10.8 billion (or by 25%) to \$31.7 billion in 2015 from \$42.4 billion in 2014. The largest decrease was in fuel oil imports, to \$1.2 billion in 2015 from \$3.7 billion in 2014. Brazil's other mineral-related imports by Brazil from the United States in 2015 were petroleum products valued at \$1.6 billion; metallurgical-grade coal, \$535 million; natural gas liquids, \$458 million; drilling and oilfield equipment, \$293 million; coal and fuels (other), \$255 million; and iron and steel products (other), \$142 million (U.S. Census Bureau, 2016a, b).

Commodity Review

Metals

Aluminum and Bauxite and Alumina.—In 2015, Alcoa Inc. of the United States announced that it would permanently close its Pocos de Caldas primary aluminum smelter located in the State of Minas Gerais in southeastern Brazil. The smelter had a capacity of 96,000 t/yr and had been idled since May 2014. In addition, Alcoa also announced that it would curtail the São Luiz primary aluminum smelter located in the State of Maranhão in northeastern Brazil. The São Luiz (Alumar) smelter was jointly owned by Alcoa (60%) and BHP Billiton plc of Australia (40%) and had a production capacity of 447,000 t/yr. The reduced output from these two smelters accounted for the majority of the decrease in Brazil's aluminum production in 2015 of nearly 190,000 t. Despite the decrease in aluminum production, exports of aluminum (including primary aluminum, alloys, scrap, and manufactured and semimanufactured aluminum products) increased to 459,600 t from 457,200 t in 2014 and imports decreased to 614,200 t from 635,900 t in 2014 (Alcoa Inc., 2016, p. 13; Associação Brasileira do Alumínio, 2016a, b).

Alcoa's reduction in aluminum production affected its alumina and bauxite operations in Brazil. The company announced that its Pocos de Caldas alumina refinery had also been closed in 2015; the alumina refinery had a capacity of 390,000 t/yr. The Pocos de Caldas bauxite mine had a capacity of 1.1 Mt/yr but produced only 0.3 Mt in 2015; its reserves of bauxite were a reported 1.3 Mt at the end of 2015. Alcoa noted that the mine's output would be reduced but that the mine would remain open to supply other alumina operations in the country (Alcoa Inc., 2016, p. 7, 64).

In October 2015, Norsk Hydro ASA of Norway announced that it had signed a letter of intent for the possible acquisition of Vale's 40% ownership interest in the bauxite producer Mineração Rio do Norte S.A. (MRN); Norsk Hydro already had a 5% ownership interest in MRN. MRN's 18.1-Mt/yr-capacity Porto Trombetas Mine, which is located in the State of Para in northern Brazil, was the largest bauxite mine in Brazil in terms of capacity. Norsk Hydro also had a 67.9% interest in the Paragominas bauxite mine, which is also located in Para in northern Brazil. The Paragominas Mine produced 10.1 Mt of bauxite in 2015, representing a record level for the

mine, and accounted for almost 30% of Brazil's total bauxite production of nearly 34 Mt. Norsk Hydro planned to increase the capacity at the Paragominas Mine to 11 Mt/yr by 2018 and, with the potential acquisition of MRN, to increase its overall bauxite production capacity to 19 Mt/yr in the longer term. All Norsk Hydro's bauxite production served its majority-owned Barcarena (Alunorte) alumina refinery located in Para. The Barcarena refinery produced 6.0 Mt of alumina in 2015, and the company planned to increase the refinery's production capacity to 6.6 Mt/yr by 2018 (Norsk Hydro ASA, 2016, p. 32, 38, 132).

Copper.—Vale was the leading producer of copper concentrates in Brazil in 2015; it produced copper concentrates at its Salobo and Sossego open pit mines located in Carajás in the State of Para. In 2015, the Salobo Mine produced about 155,000 t of copper compared with 98,000 t in 2014 and the Sossego Mine produced about 104,000 t of copper compared with 110,000 t in 2014. Taken together, their production increase of about 51,000 t accounted for most of the increase in copper concentrate production in Brazil in 2015. The increased production at Salobo was a result of the completion of the Salobo II expansion project in mid-2014, which increased Salobo's capacity to 200,000 t/yr of copper in concentrate. The company expected to reach full capacity at Salobo by the end of 2016. Total proven and probable copper ore reserves at Salobo were a reported 1,157 Mt at an average grade of 0.67% copper in 2015 compared with 1,179 Mt at an average grade of 0.67% copper in 2014. Total proven and probable copper reserves at Sossego were a reported 118 Mt at an average grade of 0.67% copper compared with 126 Mt at an average grade of 0.70% copper in 2014. The decrease in reserves at these two mines was attributed to depletion from production and a cutoff grade revision by the company (Vale S.A. 2016, p. 45, 47, 69).

Gold.—Vale was also a leading producer of gold in Brazil. Total production from its Salobo and Sossego Mines was a combined 10,295 kilograms (kg), or about 14% of Brazil's total gold production of an estimated 72,000 kg. Vale recovered gold as a byproduct from these two copper mines. Salobo's gold production increased by about 57% to 7,807 kg in 2015 from 4,976 kg in 2014. Sossego's gold production increased by about 3% to 2,488 kg in 2015 from 2,426 kg in 2014. As of 2015, total proven and probable mineral reserves at Salobo and Sossego were a reported 1,156 Mt at an average grade of 0.4 gram per metric ton (g/t) gold and 118 Mt at an average grade of 0.2 g/t gold, respectively. In 2013, Vale entered into an agreement with Silver Wheaton Corp. of Canada to sell Silver Wheaton 25% of the gold produced at Salobo during the life of the mine. In 2015, Vale entered into another agreement with Silver Wheaton to sell an additional 25% of the gold produced at Salobo during the life of the mine (Vale S.A., 2016, p. 48, 70).

AngloGold Ashanti Ltd. of South Africa produced gold in Brazil in 2015 through two of its wholly owned subsidiaries, AngloGold Ashanti Córrego do Sítio Mineração (AGA Mineração) and AngloGold Ashanti Serra Grande. The combined gold production increased by nearly 3% to 17,200 kg in 2015 from 16,765 kg in 2014. AGA Mineração, which included the Cuiabá and the Córrego do Sítio complexes in the State of Minas Gerais in southeastern Brazil, was AngloGold's second largest gold operation in 2015, with gold production of

13,094 kg. In addition, AGA Mineração was one of AngloGold Ashanti's lowest cost operations; a cost management program that had begun in 2013 had reduced costs by 26% to \$518 per troy ounce from \$696 per troy ounce t (AngloGold Ashanti Ltd., 2016, p. 92, 99, 103).

Kinross Gold Corp. of Canada held a 100% interest in the Paracatu Mine located in the State of Minas Gerais in southeastern Brazil. In 2015, gold production from Paracatu was 14,857 kg compared with 16,206 kg in 2014. The Paracatu Mine was the largest gold mine in Brazil in terms of output and one of the largest in the world. The 8% decrease in gold production from the mine was attributed to lower mill throughput as a result of a planned mine sequencing and a temporary suspension of operations because of the lack of adequate rainfall. Total proven and probable mineral reserves at Paracatu were 688 Mt at an average grade of 0.4 g/t gold; the expected life of the mine was 17 years (to 2032) (Kinross Gold Corp., 2016, p. MDA20, 66; undated).

Iron Ore.—Vale's production of iron ore increased by 4% in 2015 to 346 Mt from 332 Mt in 2014; this amount accounted for 80% of Brazil's iron ore production of 431 Mt and about 10% of worldwide production of an estimated 3.32 billion metric tons. Not only was Vale the leading producer of iron ore in Brazil in 2015, but it was also the leading producer of iron ore in the world. Vale produced iron ore from the following four of the company's "systems" (regions) in the country: the northern system (129.6 Mt), which is located in the State of Para; the southeastern system (112.6 Mt) and the southern system (including 50% interest in Samarco) (99.4 Mt), which are located in the State of Minas Gerais; and the midwestern system (4.5 Mt), which is located in the State of Mato Grosso de Sul. At the end of 2015, Vale's total proven and probable reserves of iron ore were a reported 17,468 Mt at an average grade of 54% iron (Jamasmie, 2016b; Tuck, 2017; Vale S.A., 2016, p. 29, 65).

During the year, Vale continued with the development of the Carajás Serra Sul Mine (Mine S11D) and completed construction of the Cauê Itabiritos and the Conceição Itabiritos II projects. The Carajás Serra Sul project, which is located in the State of Para, included the development of a mine and a processing plant that would have a nominal production capacity of 90 Mt/yr. Having already invested \$4.7 billion in the project, Vale reported that the project was 80% completed and was expected to begin operations in the second half of 2016. The Cauê Itabiritos and Conceição Itabiritos II projects, located in Vale's southeastern system, included the installation of the plants to process low-grade itabirites (also known as banded-quartz hematite and hematite schist). The Cauê Itabiritos processing plant began operating in the fourth quarter of 2015 and had a nominal capacity of 24 Mt/yr of pellets and sinter. The Conceição Itabiritos II processing plant had a nominal capacity of 19 Mt/yr of pellets and sinter and began operating in the second quarter of 2015. Vale reported that these two pellet and sinter projects cost \$1.9 billion to develop (Vale S.A., 2016, p. 20, 75).

Samarco Mineração S.A. was a joint venture between BHP Billiton Ltda. and Vale (50% each). In November 2015, Samarco Mineração's Fundão iron ore tailings dam failed, flooding

nearby villages, including Bento Rodrigues, and polluting the Doce River. Samarco Mineração's mining operations in the State of Minas Gerais were temporarily suspended as a result of the dam failure. Vale noted that the loss of production of iron ore in 2015 and the expected loss of production in 2016 related to this disaster would be counterbalanced by production from its other mines in Brazil. Samarco Mineração's two mines produced about 25 Mt of iron ore in 2015 (Vale S.A., 2016, p. 22–23, 29).

Iron and Steel.—According to the Instituto Aço Brasil [Brazil Steel Institute], the country produced 33.3 Mt of crude steel in 2015, which was a decrease of 1.8% from the 33.9 Mt produced in 2014. Brazil's production of steel products also decreased to 31.8 Mt in 2015, down slightly from 31.9 Mt in 2014. The country's major integrated steel operations consisted of 29 mills managed by 11 business groups. Combined, the mills had an installed capacity of 48.9 Mt/yr of crude steel and were concentrated in the States of Espírito Santo, Minas Gerais, Rio de Janeiro, and Sao Paulo. Two leading steel producers in Brazil in 2015 were ArcelorMittal S.A. of Luxembourg and Gerdau S.A. of Brazil. Although steel production decreased only slightly, apparent consumption of steel products decreased for the second straight year to 21.3 Mt, or by 17% from the 25.6 Mt of production in 2014 and by 24% from the 28.0 Mt produced in 2013. The weakening economy of the past several years had negatively affected the activities of the automotive, construction, and manufacturing industries, which, taken together, accounted for nearly 80% of steel consumption in Brazil. The member companies of the Instituto Aço Brasil employed 111,509 people, which was a decrease of more than 10,000 employees from the 122,139 people employed by these companies in 2014 (Instituto Aço Brasil, 2016a, b).

Manganese.—Vale produced manganese at the Azul open pit mine, which is located in the State of Para, and the Urucum underground mine, which is located in the State of Mato Grosso do Sul. Vale also owned the Morro de Mina open pit mine, which is located in the State of Minas Gerais, but suspended operations during 2015 owing to market conditions. Vale produced about 2.4 Mt of manganese ore in 2015, which was about the same as in 2014. The loss of production at Morro de Mina of 0.1 Mt was offset by an increase of 0.1 Mt at Urucum. Total proven and probable manganese ore reserves at Azul, Morro da Mina, and Urucum were estimated to be about 52.2 Mt at an average grade of about 29.6% manganese compared with 72.4 Mt at an average grade of about 31.2% manganese in 2014; the decrease in reserves was owing to a new geotechnical study, which reassessed the reserves at Urucum to zero (Vale S.A., 2016, p. 35, 67).

Nickel.—Anglo American plc (Anglo American) of the United Kingdom, through its subsidiary Anglo American Niquel Brasil Ltda., was a leading nickel producer in Brazil in 2015. Anglo American produced nickel at its Barro Alto and Codemin operations, which were located in the State of Goias. Nickel production at Barro Alto decreased by 25% to 21,300 t in 2015 from 28,300 t in 2014; production at Codemin increased slightly to 9,000 t in 2015 from 8,900 t in 2014. The production capacities of Barro Alto and Codemin were 36,000 t/yr and 10,000 t/yr, respectively. The company

attributed the decrease at Barro Alto to furnace rebuilds. To improve the operational performance at Barro Alto, two furnaces were rebuilt starting in 2014 and were completed in September 2015; the company expected the furnaces to reach full capacity by 2016. By the end of 2015, nickel ore reserves at Barro Alto were 35.5 Mt at an average grade of 1.49% nickel. The company also noted that a decision had been made in 2015 to evaluate a sale of its nickel operations in Brazil and that discussions with potential buyers had begun (Anglo American plc, 2016, p. 22, 36, 54, 176, 184).

Vale produced nickel at Onça Puma, which was a mining and smelting operation producing a high-quality product for the stainless steel industry; the operation was located in the State of Para in northern Brazil. In 2015, production of nickel contained in ferronickel at Onça Puma was 24,400 t compared with 21,400 t in 2014; the operation's production capacity was 25,000 t/yr. Vale continued evaluating the opportunity to restart a second facility at Onça Puma, which would depend on the market outlook and the performance of the facility's mothballed operating furnace. Total proven and probable reserves at Onça Puma at the end of 2015 were 97.4 Mt at an average grade of 1.56% nickel compared with 98.7 Mt at an average grade of 1.56% nickel in 2014 (Vale S.A., 2016, p. 41, 43, 68).

Niobium.—Anglo American, through its subsidiary Anglo American Niobio Brasil Ltda., owned the Boa Vista open pit mine, which was located in the State of Goias in central Brazil. In 2015, niobium production at Boa Vista increased by 34% to 6,300 t from 4,700 t in 2014. The increase was attributed to the continued rampup of the Boa Vista Fresh Rock (BVFR) project, which began in November 2014, and included a new upstream plant that would convert the existing Catalao plant to process fresh rock instead of oxide ore. By the end of 2015, the BVFR reached 69% of capacity and was expected to reach full capacity by the end of 2016. BVFR was also expected to increase Boa Vista's niobium production capacity to 6,800 t/yr and possibly up to 9,000 t/yr in the following years. Total proven and probable reserves at Boa Vista at the end of 2015 were 236,000 t at an average grade of 0.89% niobium. The company also noted that a decision had been made in 2015 to evaluate the sale of its niobium operations in Brazil and that discussions with potential buyers had begun (Anglo American plc, 2016, p. 22, 56, 57, 176).

Industrial Minerals

Cement.—Cement production decreased by about 8.4% to 65.3 Mt in 2015 from 71.2 Mt in 2014. There were 72 integrated cement operations in the country with a total (combined) installed capacity of 76.53 Mt/yr of cement. In 2015, the leading cement-producing companies included Cimento Nassau, the Votorantim Group, Holcim Inc. of the United States, and InterCement Brasil S.A. The Southeast region of the country accounted for about 46% of the country's cement production, followed by the Northeast region (23%), the South region (15%), the Center-West region (12%), and the North region (5%) (Saunders, 2015; Sindicato Nacional da Indústria do Cimento, 2016).

In April 2015, the Votorantim Group, through its subsidiary Votorantim Cimentos S.A., announced plans to develop five new cement plants in Brazil by 2018. This was part of a \$1.6 billion investment project that included the construction of cement plants in Bolivia and Turkey. Votorantim Cimentos, which was the leading cement producer in Brazil, had a total installed capacity of 24.6 Mt/yr of cement from 20 cement plants. In September 2015, Brennand Group S.A. launched a new cement plant in the State of Paraíba. The new plant was built at a cost of \$700 million and had the capacity to produce 1.5 Mt/yr, which would increase the Brennand Group's cement production capacity in Brazil to 3.5 Mt/yr (Saunders, 2015).

Diamond.—Lipari Mineração Ltd. continued to develop its 100%-owned Braúna diamond project located in the State of Bahia in eastern Brazil. The project encompassed 22 kimberlite pipes and was expected to become South America's first kimberlite diamond mine. The company was focused on the Braúna 3 (B3) kimberlite pipe, which had the potential to be developed as an open pit mine and to produce an average of about 225,000 carats per year during a mine life of 7 years. By early 2016, the company reported that the development of the mine was 90% complete (Lipari Mineração Ltd., 2016a; 2016b, p. 2).

Phosphate Rock.—Vale was the leading producer of phosphate rock in Brazil in 2015. Through its wholly owned subsidiary Vale Fertilizantes S.A., Vale produced 4.3 Mt of phosphate rock in 2015, which was a decrease of 7.3% compared with the 4.6 Mt produced in 2014. Vale operated the following five mines in Brazil: Araxá, Patos de Minas, and the Tapira open pit mines, which are located in the State of Minas Gerais; the Cajati open pit mine in the State of Sao Paulo; and the Catalão open pit mine in the State of Goiás. Tapira was Vale's largest producing phosphate rock mine, with production of just less than 2.0 Mt in 2015, which was down slightly from that of 2014. Total reserves at Tapira were 666.6 Mt at an average grade of 7.6% P_2O_5 . Catalão produced 1.0 Mt of phosphate rock in 2015, which was a decrease from 1.1 Mt in 2014; total reserves were 93.5 Mt at an average grade of 10.5% P_2O_5 . Araxá produced 707,000 t of phosphate rock in 2015, which was a decrease of about 20% compared with the 883,000 t produced in 2014. Araxá's total proven and probable reserves were 86.6 Mt at an average grade of 11.9% P_2O_5 . Cajati's phosphate rock production decreased to 581,000 t from 605,000 t in 2014 and total reserves were a reported 104.8 Mt at an average grade of 5.2% P_2O_5 . Production from Patos de Minas decreased to 23,000 t from 73,000 t in 2014; no reserves were reported. Vale suspended the operations at Patos de Minas in the third quarter of 2015 owing to market conditions (Vale S.A., 2016, p. 52, 72).

Mineral Fuels and Other Sources of Energy

Natural Gas.—In 2015, Brazil's gross natural gas production was about 35.1 billion cubic meters in 2015 compared with 31.9 billion cubic meters in 2014. The increase in production was attributed to an increase in the production of natural gas from the pre-salt areas, which increased to about 70%. Brazil's natural gas operations were concentrated in the States of

Rio de Janeiro (40%), Amazonas (14%), Espírito Santo (12%), and Bahia (9%). Proven offshore reserves were estimated to be about 359 billion cubic meters. The State of Rio de Janeiro accounted for 60% of the total proven natural gas reserves (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2016, p. 75, 84).

Petroleum.—In 2015, Brazil's crude petroleum production increased by 8% to 889.7 Mbbbl from 822.9 Mbbbl in 2014. The increase in production was attributed to an increase in production of pre-salt areas by 56% to 280.1 Mbbbl in 2015 from 179.8 Mbbbl in 2014. Brazil's offshore deposits hold the vast majority of Brazil's proven reserves, which were estimated to be 12.3 Gbbl. The State of Rio de Janeiro accounted for about 81% of the country's total proven reserves, followed by the States of Espírito Santo (8%) and Sao Paulo (4%) (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2016, p. 73, 80).

According to ANP, 371 onshore and offshore fields were in the production phase, 71 fields were in the development phase, and 348 blocks were in the exploration phase. The 371 fields in the production phase, of which Petrobras operated 299 fields, were located in the States of Alagoas, Amazonas, Bahia, Ceara, Espírito Santo, Maranhao, Parana, Rio Grande do Norte, Rio de Janeiro, Sao Paulo, and Sergipe. Of the 348 blocks in the exploration phase, most were onshore (221 blocks). The exploration blocks were located in the sedimentary basins of Acre, Alagoas, Almada, Amazonas, Barreirinhas, Camamu, Campos, Ceara, Espírito Santo, Foz do Amazonas, Jequitinhonha, Para-Maranhao, Parana, Parecis-Alto Xingu, Parnaíba, Pelotas, Pernambuco-Paraíba, Potiguar, Reconcavo, Santos, Sao Francisco, Sergipe, Solimoes, and Tucano Sul. Companies engaged in exploration included Petrobras; Ecopetrol S.A. of Colombia; Total S.A. of France; Statoil ASA of Norway; United Kingdom companies BG Group plc and BP p.l.c.; and United States companies Anadarko Petroleum Corp. and Exxon Mobil Corp. (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2016, p. 53–69).

In 2015, Petrobras's crude petroleum production increased by about 5% to 743 Mbbbl compared with that of 2014 and its natural gas production increased by about 10% to 29 million cubic meters. During the year, Petrobras began operations at the Cidade de Itaguaí (pre-salt area) platform located in the Lula field in the Santos basin. Cidade de Itaguaí, which was a floating production, storage, and offloading unit, was installed about 240 km off the coast of Rio de Janeiro at water depths of 2,240 m, and had the capacity to process about 150,000 barrels per day of crude petroleum and 8 million cubic meters per day of natural gas. With the addition of Cidade de Itaguaí, the Lula field had become the largest producing field in Brazil, accounting for 13% of total crude petroleum production in 2015. Petrobras noted that 1 operation was planned to be installed in 2016 and 11 other major operations were planned to be installed by 2018; most of these were to be located in the Santos basin and one was to be located in the Campos basin. By the end of 2015, the Campos basin accounted for 70% of Brazil's crude petroleum production and 37% of gas production, whereas the Santos basin accounted for 19% of crude petroleum production and 32% of gas production; other basins accounted for the remaining 11% of crude

petroleum production and 31% of gas production. As of yearend 2015, Petrobras's reserves were 10.7 Gbbl of crude petroleum and 371 billion cubic meters of natural gas and synthetic gas (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2016, p. 79, 81; Petróleo Brasileiro S.A., 2016a, p. 14, 43–46; 2016b).

Renewable Energy—Sources of primary energy in Brazil in 2015 included renewable energy, which accounted for about 42% of the total primary energy production. Renewable sources included hydroelectric power, biofuel, and biomass. Nonrenewable energy sources were petroleum (which accounted for about 44% of the total primary energy production), natural gas (12%), coal (1%), and others (1%). The sources of domestic electricity supply were hydroelectric power (64%), natural gas (13%), biomass (8%), coal and coal products (5%), petroleum products (5%), wind (3%), and nuclear (2%) (Empresa de Pesquisa Energética, 2016, p. 16, 22, 27).

Ethanol production in Brazil increased by 6% in 2015. The Southeast region of the country was the leading producer, accounting for 57% of the country's total ethanol production. Ethanol exports increased by 34% in 2015 to 1.9 billion cubic meters from about 1.4 billion cubic meters in 2014, and ethanol imports increased by 13% in 2015 to 512.9 million cubic meters from 452.0 million cubic meters in 2014. The United States received about 50% of Brazil's ethanol exports (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2016, p. 178, 184–185).

Reserves and Resources

Brazil was among the world leaders in reserves of some mineral commodities. Brazil's estimated share of world reserves of niobium amounted to 95%; tantalum, 36%; graphite, 31%; rare earths, 17%; tin, 15%; nickel, 13%; iron ore, 12%; bauxite, 9%; manganese, 8%; and titanium (ilmenite), 6% (table 3; Anderson, 2016; Bedinger, 2016; Bray, 2016; Corathers, 2016; Departamento Nacional de Produção Mineral, 2016c, p. 4; Gambogi, 2016; Kuck, 2016; Olson, 2016; Papp, 2016a, b; Tuck, 2016).

Outlook

Brazil's economy was forecast to decrease (in terms of real GDP) by 3.3% in 2016, which would be the second consecutive decrease of more than 3%. Despite the expected slowdown in the overall economy, IBRAM reported that Brazil's mineral production value in 2016 was expected to increase by about 15% to \$30 billion from \$26 billion in 2015 owing to the increase in mineral commodities prices, particularly the price of iron ore. Iron ore accounted for about 75% of the country's mineral production value in 2015. A recovery in mineral prices would also likely lead to a recovery in mineral exports (Instituto Brasileiro de Mineração, 2016a, p. 2; 2016b; International Monetary Fund, 2016, p. 233; Jamasmie, 2016a).

Increasing the country's crude petroleum and natural gas production capacity from the large pre-salt crude petroleum deposits could transform Brazil into one of the top 10 leading crude petroleum producers in the world. Petrobras's investments in biofuels indicate its commitment to the development of renewable energy sources. If the development of the Braúna

project is completed as expected in 2016, the mine would become the first kimberlite diamond mine in South America.

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TABLE 1
BRAZIL: PRODUCTION OF MINERAL COMMODITIES¹

(Metric tons unless otherwise specified)

Commodity ^{2,3}	2011	2012	2013	2014	2015 ^e
METALS					
Aluminum:					
Bauxite, dry basis, gross weight	31,768,000	34,374,000 ^r	33,552,200 ^r	35,410,000 ^r	35,715,432 ⁴
Alumina	10,306,000	10,320,000	9,942,000	10,439,000 ^r	10,500,000
Metal:					
Primary	1,440,000	1,436,000	1,304,000	962,000	772,200 ⁴
Secondary	240,000	508,000 ^r	510,000 ^r	540,000 ^r	510,000 ⁴
Total	1,680,000	1,944,000 ^r	1,512,000 ^r	1,502,000 ^r	1,282,200
Chromium:					
Chromite ore, gross weight	542,512	472,501	485,951	716,674 ^r	780,000
Concentrate and lump, Cr ₂ O ₃ content	217,198	165,532 ^r	189,088	285,340 ^r	280,000
Cobalt:					
Mine output, Co content	3,623	2,900	3,500	3,828 ^r	3,800
Metal, refined	1,614	1,750	1,871	1,350	1,300
Copper:					
Mine output, Cu content	213,760	223,141	270,979	301,197 ^r	359,463 ⁴
Metal, refined:					
Electrowon	4,500	4,374	4,060	700 ^r	--
Primary	222,550	186,000	236,050 ^r	213,085 ^r	216,000
Secondary	22,800	24,700	25,900 ^r	23,600 ^r	25,000
Total	249,850	215,074	266,010	237,385 ^r	241,000
Gold:					
Mine output, Au content kilograms	56,969	56,670	67,964	71,129 ^r	73,280
Mine output, Au content, independent miners do.	8,240	10,103	11,609	9,909 ^r	10,000
Total do.	65,209	66,773	79,573	81,038 ^r	83,280 ⁴
Iron and steel:					
Iron ore and concentrate, marketable product:					
Gross weight thousand metric tons	398,131	400,822	386,270	411,183	430,836 ⁴
Fe content do.	265,091	258,129	245,668	261,500	275,590 ⁴
Metal:					
Pig iron do.	33,243	30,745	30,000	27,016 ^r	27,803 ⁴
Ferroalloys, electric arc furnace:					
Ferrochromium	145,122	165,532	189,088	285,340 ^r	310,000
Ferrochromium silicon	8,378	9,556	10,200	10,200	9,700
Ferromanganese ^e	82,000	94,000	93,000	93,000	89,000
Ferronickel	90,800	148,800	169,200	169,000	161,000
Ferroniobium (ferrocolumbium)	53,691	50,562	46,555	46,600	44,500
Silicomanganese ^e	214,000	213,000	218,000	218,000	209,000
Silicon metal ^e	132,000	133,000	134,000	92,300 ^r	70,000
Other ferroalloys	34,462	33,449	33,500 ^e	33,500 ^e	32,000
Total ^e	760,000	848,000	894,000	948,000 ^r	925,000
Crude steel, excluding castings thousand metric tons	35,220	34,524	34,163	33,900	33,300 ⁴
Lead:					
Mine output, Pb content in concentrate	15,100	16,953	15,223 ^r	19,831 ^r	20,000
Metal, secondary	138,537	165,397	151,964	160,393 ^r	160,000
Manganese, ore and concentrate, marketable:⁵					
Gross weight	2,738,000	2,796,000	2,833,000	2,723,000 ^r	2,816,675 ⁴
Mn content	1,139,000	1,164,000	1,180,000	1,094,000	1,226,458 ⁴

See footnotes at end of table.

TABLE 1—Continued
BRAZIL: PRODUCTION OF MINERAL COMMODITIES¹

(Metric tons unless otherwise specified)

Commodity ^{2,3}	2011	2012	2013	2014	2015 ^e
METALS—Continued					
Nickel:					
Mine output, ore	13,203,844	14,749,112	13,006,961	13,858,109 ^r	16,001,454 ⁴
Ni content in ore	131,673	139,230	104,829	167,063 ^r	173,972 ⁴
Ni content in carbonate	19,381	19,611	19,958	18,800 ^r	19,600
Ni content in matte	13,703	14,345	11,641	-- ^r	--
Ni, electrolytic	20,521	21,437	19,823	21,000 ^r	21,900
Ferronickel, Ni content	16,750	31,342	34,501	37,237 ^r	38,800
Niobium (columbium)-tantalum ores and concentrates, gross weight:					
Tantalum concentrate, Ta ₂ O ₅ content	136	118	185	118 ^r	120
Pyrochlore concentrate, Nb ₂ O ₅ content	64,657	82,214	76,899 ^r	88,771 ^r	82,031 ⁴
Rare earths, monazite concentrate, gross weight ⁶	140 ^r	110 ^r	330 ^r	--	880
Silver:					
Primary kilograms	37,600	36,400	38,200	36,700 ^r	37,000
Secondary do.	34,000	35,500	34,300	30,400 ^r	30,000
Total do.	71,600	71,900	72,500	67,100 ^r	67,000
Tin:					
Mine output, Sn content	10,725	13,667	16,830	25,534 ^r	18,824 ⁴
Metal, smelter, primary	9,382	11,955	14,721	22,334 ^r	16,500
Titanium mineral concentrates, TiO ₂ content:					
Ilmenite	68,804	69,071	78,264	81,278 ^r	80,000
Rutile	2,350	1,881	2,021	1,834 ^r	2,000
Tungsten, mine output, W content	244	381	494	510 ^r	510
Zinc:					
Mine output, Zn content	197,840	164,258	152,147	169,766 ^r	160,000
Metal, smelter, primary	284,770	245,526 ^r	245,417 ^r	246,120 ^r	230,000
Zirconium, zircon concentrate, gross weight ⁷	23,283	20,425	24,687 ^r	23,659 ^r	21,000
INDUSTRIAL MINERALS					
Asbestos, fiber	306,321	304,569	290,825	311,230	311,000
Barite:					
Crude	216,478	186,134	34,943	3,389 ^r	--
Beneficiated	7,039	3,025	--	--	--
Calcite thousand metric tons	28,718	33,077	33,131	34,038 ^r	34,000
Cement, hydraulic do.	64,093	69,323	69,975	71,254 ^r	65,283 ⁴
Clay:					
Bentonite, beneficiated	566,267	512,975	403,351 ^r	405,169 ^r	405,000
Kaolin:					
Crude	6,216,000	7,145,000 ^r	6,461,000	5,883,000 ^r	6,000,000
Beneficiated	1,927,000	2,388,000 ^r	2,139,000	2,055,000 ^r	2,100,000
Diamond, gem and industrial: ^c					
Private sector thousand carats	18	19	19	20	20
Independent miners do.	28	30	30	37	37
Total ⁸ do.	46	49	49	57	57
Diatomite:					
Crude	4,415	3,427	1,947	5,080 ^r	5,100
Beneficiated	4,224	1,987	2,475	2,822 ^r	2,800
Feldspar:					
Crude	416,008	328,001	421,039 ^r	496,894 ^r	500,000
Beneficiated	333,352	247,152	294,357	417,771 ^r	420,000
Flourspar, concentrates, marketable product:					
Acid-grade	6,197	5,768	6,835	6,496 ^r	6,500
Metallurgical-grade	18,843	18,380	20,886	17,353 ^r	17,000
Total	25,040	24,148	27,721	23,849 ^r	23,500
Graphite, concentrate	105,188	88,110	91,908	87,026 ^r	87,000
Gypsum and anhydrite, crude	3,228,931	3,749,860	3,332,991	3,447,012 ^r	3,400,000

See footnotes at end of table.

TABLE 1—Continued
BRAZIL: PRODUCTION OF MINERAL COMMODITIES¹

(Metric tons unless otherwise specified)

Commodity ^{2,3}	2011	2012	2013	2014	2015 ^e
INDUSTRIAL MINERALS—Continued					
Lithium, concentrate, gross weight	7,820	7,084	7,982	8,519 ^r	8,500
Magnesite:					
Crude	1,576,871	1,719,079 ^r	1,542,420	1,644,847 ^r	1,600,000
Beneficiated	476,805	1,228,426 ^r	1,084,194 ^r	1,152,233 ^r	1,100,000
Phosphate rock, including apatite, concentrate:					
Gross weight	6,738	6,740	6,715	6,513 ^r	6,200
P ₂ O ₅ content	2,374	2,388	2,504	2,521 ^r	2,400
Potash, marketable (K ₂ O content)	395,002	346,509	310,892	311,000	293,000
Potassium (KCl)	625,300	548,500	492,151	492,355 ^r	492,000
Quartz crystal, all grades	17,657	16,254	10,696	7,163 ^r	7,100
Salt:					
Marine	4,829	6,079	5,926	6,050 ^r	6,100
Rock	1,335	1,403	1,349	1,451 ^r	1,450
Total	6,164	7,482	7,275	7,501 ^r	7,500
Sulfur, byproduct:					
Metallurgy	322,120	274,693	324,405	286,754 ^r	290,000
Petroleum	170,136	222,561	218,014	239,970 ^r	240,000
Total	492,256	497,254	542,419	526,724 ^r	530,000
Talc and pyrophyllite, crude	578,954	593,140	737,950	843,119 ^r	845,000
Vermiculite, concentrate	54,970	51,986	60,379 ^r	56,444 ^r	56,000
MINERAL FUELS AND RELATED MATERIALS					
Coal, bituminous:					
Run-of-mine	12,306	12,704	14,508 ^r	13,972 ^r	14,000
Beneficiated, marketable ⁴	5,614	6,635	7,419 ^r	7,574 ^r	7,600
Coke, metallurgical, all types	8,286	8,681	8,700 ^e	8,700 ^e	8,700
Natural gas, gross	24,074	25,832	28,174	31,895	35,126 ⁴
Natural gas liquids	31,942	32,131	32,938	33,475	32,671 ⁴
Petroleum:					
Crude ⁹	768,471	754,409	738,715	822,930	889,667 ⁴
Refinery products:					
Asphalt	15,501	16,162	16,689	20,434	12,676 ⁴
Fuel oil	83,077	86,113	92,844	102,320	90,190 ⁴
Gasoline	156,528	170,206	186,934	189,185	169,338 ⁴
Jet fuel	33,934	34,108	34,935	38,236	35,580 ⁴
Kerosene	34,128	34,260	35,034	38,311	36,000 ⁴
Liquefied petroleum gas	62,698	65,171	64,332	63,218	62,252 ⁴
Lubricants	3,652	3,824	4,335	4,290	4,028 ⁴
Naphtha	39,902	40,506	33,675	31,918	28,988 ⁴
Solvents	2,558	1,826	2,857	2,417	2,253 ⁴
Total	431,979	452,176	471,636	490,328	441,305 ⁴

^eEstimated; estimated data are rounded to no more than three significant digits; may not add to totals shown. ^rRevised. do. Ditto. --Zero.

¹Table includes data available through December 14, 2016.

²In addition to the commodities listed, bismuth, crude graphite, crude sodalite, ferrosilicon, ferrosilicon magnesium, inoculant, leucite, molybdenite, precious and semiprecious stones except diamond, silica (silex), sodium compounds, stone, sand and gravel, uranium oxide, and other minerals were produced, but available information was inadequate to make reliable estimates of output.

³Sources: Agencia Nacional do Petroleo, Gas Natural e Biocombustíveis, Oil, Natural Gas and Biofuels, Statistical Mineral Yearbook 2016; Associação Brasileira do Alumínio; Departamento Nacional de Produção Mineral; Empresa de Pesquisa Energetica, Brazilian Energy Balance 2016; Kimberley Process Certification Scheme, Annual Global Summary 2014; and Sindicato Nacional da Industria do Cimento.

⁴Reported figure.

⁵Direct sales and (or) beneficiated (marketable product).

⁶Production was derived from stockpiled mineral concentrates.

⁷Includes baddeleyite-caldasite.

⁸Figures represent officially reported diamond output plus official estimates of output by nonreporting miners.

⁹Condensates are included.

TABLE 2
BRAZIL: STRUCTURE OF THE MINERAL INDUSTRY IN 2015

(Thousand metric tons unless otherwise specified)

Commodity	Major operating companies and major equity owners	Location of main facilities	Annual capacity ^e
METALS			
Alumina	Alcoa Alumínio S.A. (Alcoa Inc., 100%)	Pocos de Caldas, Minas Gerais State (refinery)	390. ¹
Do.	Alcoa World Alumina Brasil Ltda. (Alcoa Corp., 60%, and Alumina Ltd., 40%)	Sao Luiz, Maranhao State (refinery)	3,500.
Do.	Alumina do Norte do Brasil S.A. (Norsk Hydro ASA, 91%)	Barcarena, Para State (refinery)	6,200.
Do.	Companhia Brasileira de Alumínio (Votorantim Group, 100%)	Aluminio City, Sao Paulo State (refinery)	475.
Do.	Novelis do Brasil Ltda. (Hindalco Industries Ltd., 100%)	Ouro Preto, Minas Gerais State (refinery)	145.
Aluminum	Albras Alumínio Brasileiro S.A. [Norsk Hydro ASA, 51%, and Nippon Amazon Alumínio Co. Ltd., 49%]	Barcarena, Para State (smelter)	460.
Do.	Alcoa Alumínio S.A. (Alcoa Inc., 100%)	Pocos de Caldas, Minas Gerais State (smelter)	96. ¹
Do.	Alcoa Alumínio S.A. (Alcoa Inc., 100%), 60%, and BHP Billiton plc, 40%	Sao Luiz, Maranhao State (smelter)	447.
Bauxite	Alcoa Alumínio S.A. (Alcoa Inc., 100%)	Pocos de Caldas Mine, Minas Gerais State	1,100.
Do.	Alcoa World Alumina Brasil Ltda. (Alcoa Inc., 60%, and Alumina Ltd., 40%)	Jurutí Mine, Para State	4,800.
Do.	Companhia Brasileira de Alumínio S.A. (Votorantim Group, 100%)	Itamarati de Minas, Mirai, and Pocos de Caldas Mines, Minas de Gerais State	3,000.
Do.	Mineração Paragominas S.A. (Norsk Hydro ASA, 67.9%, and Vale S.A., 32.1%)	Paragominas Mine, Para State	10,100
Do.	Mineração Rio do Norte S.A. (Vale S.A., 40%; BHP Billiton plc, 14.8%; Rio Tinto Alcan Inc., 12%; Companhia Brasileira de Alumínio S.A., 10%; Alcoa Alumínio S.A., 8.58%; Alcoa World Alumina, 5%; 5%; Norsk Hydro ASA, 5%; Alcoa World Alumina Brasil Ltda, 4.62%)	Porto Trombetas Mine, Para State	18,100.
Chromite	Companhia de Ferro Ligas da Bahia (FERBASA) (private, 100%)	Pedrinhas Mine, Campo Formosa, Bahia State	120 (concentrate).
Do.	do.	Ipuera Mine, Campo Formosa, Bahia State	48 (concentrate).
Copper:			
Concentrate, Cu content	Mineração Caraíba S/A (Glencore plc, 28.5%)	Jaguarari, Bahia State (three mines)	30.
Do.	Vale S.A., 100%	Sossego Mine, Carajas, Para State	130.
Do.	do.	Salobo Mine, Carajas, Para State	200.
Do.	Yamana Gold Inc. (private, 100%)	Chapada Mine, Goias State	85.
Refinery	Caraíba Metais S.A. (Paranapanema S.A., 100%)	Camacari, Bahia State (electrolytic plant)	280. ¹
Do.	Mineração Caraíba S/A (Glencore plc, 28.5%)	Jaguarari, Bahia State (electrowinning plant)	5. ¹
Ferroalloys	Vale Manganês S.A. (Vale S.A., 100%)	Barbacena, Minas Gerais State (plant)	74.
Do.	do.	Ouro Preto, Minas Gerais State (plant)	65.
Do.	do.	Simoes Filho, Bahia, Mato Grosso do Sul (plant)	150.
Gold kilograms	Vale S.A., 100%	Sossego Mine, Carajas, Para State	3,000.
Do.	do.	Salobo Mine, Carajas, Para State	8,000
Do.	do. Beadell Resources Ltd. (private, 100%)	Tucano Mine, Amapa State	6,200.
Do.	do. AngloGold Ashanti Córrego do Sítio Mineração (AngloGold Ashanti Ltd., 100%)	Cuiaba and the Corrego do Sítio complexes, Minas Gerais State (five mines)	14,000
Do.	do. AngloGold Ashanti Serra Grande (AngloGold Ashanti Ltd., 100%)	Serra Grande Mines, Goias State (four mines)	6,000.
Do.	do. Jaguar Mining Inc., 100%	Caete Mines, Minas Gerais State (two mines)	4,000.
Do.	do. do.	Turmalina Mine, Minas Gerais State	3,000.
Do.	do. Kinross Brasil Mineração S.A. (Kinross Gold Corp., 100%)	Paracatu Mine, Minas Gerais State	16,000.
Do.	do. Reinarda Mineração Ltda (Troy Resources Ltd., 100%)	Andorinhas Mine, Para State	1,400.
Do.	do. Yamana Gold Inc. (private, 100%)	Chapada Mine, Goias State	4,000.
Do.	do. do.	Jacobina Mine, Bahia State	4,000.
Do.	do. do.	Fazenda Brasileiro Mine, Goias State	2,000.

See footnotes at end of table.

TABLE 2—Continued
BRAZIL: STRUCTURE OF THE MINERAL INDUSTRY IN 2015

(Thousand metric tons unless otherwise specified)

Commodity	Major operating companies and major equity owners	Location of main facilities	Annual capacity ^e
METALS—Continued			
Iron ore and steel:			
Iron ore	Companhia Siderúrgica Nacional S.A. (private, 100%)	Casa de Pedra Mine, Congonhas, Minas Gerais State	21,000.
Do.	Itaminas Comércio de Minérios S.A. (private, 100%)	Itaminas, Minas Gerais State	5,000.
Do.	Mineração Usiminas S.A. (Usiminas, 70%, and Sumitomo Corp., 30%)	Quadrilátero Ferrífero, Serro Azul, Minas Gerais State (four mines)	12,000.
Do.	MMX Sudeste Mineração Ltda. (private, 100%)	Tico-Tico and Ipe Mines, Serro Azul, Minas Gerais State	6,000.
Do.	do.	Corumba Mines, Mato Grosso do Sul State	1,500.
Do.	Samarco Mineração S.A. (Vale S.A., 50%, and BHP Billiton Ltd., 50%)	Alegria and Germano Mines, Minas Gerais State	26,000.
Do.	Vale S.A., 100%	Carajas Mine, Parauapebas, Para State (three mines)	130,000
Do.	do.	Itabira, Mariana, and Minas Centrais Mines, Minas Gerais State, Centrais (eight mines)	120,000.
Do.	do.	Minas Itabiritos, Vargem Grande, and Paraopeba Mines, Minas Gerais State (eleven mines)	90,000.
Do.	do.	Urucum and Corumbá Mines, Mato Grosso do Sul State (two mines)	6,500.
Do.	Zamin Ferrous Ltd., 100%	Amapa Mine, Amapa State	6,000.
Pellets	Companhia Hispano Brasileira De Pelotização S.A. (Vale S.A., 50.9%, and ArcelorMittal Group, 49.1%)	Hispanobras, Espírito Santo State (pellet plant)	4,300.
Do.	Samarco Mineração S.A. (Vale S.A., 50%, and BHP Billiton Ltd., 50%)	Ponta Ubu, Anchieta, Espírito Santo State (three pellet plants)	30,500.
Do.	Vale S.A., 100%	Tubarão I, II, VII, Espírito Santo State (pellet plants)	36,700. ²
Do.	do.	Fabrica, Minas Gerais State (pellet plant)	4,500.
Do.	do.	Sao Luis, Maranhao State (pellet plants)	7,500. ¹
Do.	do.	Vargem Grande, Minas Gerais State (pellet)	7,000.
Do.	do.	Cauê Itabiritos, and Conceição Itabiritos II, Para State (pellet plants)	43,000.
Steel, crude	Gerdau Açominas S.A. (Gerdau S.A., 100%)	Rodovia, Minas Gerais State	7,600.
Do.	Aperam S.A. (private, 100%)	Timoteo, Minas Gerais State (specialty steel)	900.
Do.	ArcelorMittal Tubarão (ArcelorMittal)	Grande Vitoria, Espírito Santo State	7,500
Do.	Companhia Siderúrgica Nacional (private, 100%)	Volta Redonda, Rio de Janeiro State	5,600.
Do.	Usinas Siderúrgicas de Minas Gerais, S.A. (private, 100%)	Ipatinga, Minas Gerais State and Cubatao, Sao Paulo	9,500.
Do.	Siderúrgica Norte Brasil S.A (private, 100%)	Maraba, Para State	390.
Lead	Votorantim Metais (Votorantim Group, 100%)	Morro Agudo Mine, Paracatu, Minas Gerais State	13.
Manganese	Vale Manganês S.A. (Vale S.A., 100%)	Morro da Mina, Minas Gerais State	100. ¹
Do.	Vale S.A., 100%	Mina do Azul, Carajas, Para State	1,900.
Do.	Mineração Corumbaense Reunida S.A. (Vale S.A., 100%)	Urucum Mine, Mato Grosso do Sul State	400.
Nickel	Anglo American Niquel Brasil Ltda. (Anglo American plc, 100%)	Barro Alto, Goias State (refinery)	36 (metal).
Do.	do.	Barro Alto Mine, Goias State	3,000 (ore).
Do.	do.	Condemin, Goias State (refinery)	10 (metal).
Do.	Votorantim Metais (Votorantim Group, 100%)	Fortaleza de Minas, Minas Gerais State	19 (nickel matte). ¹
Do.	do.	Niquelandia Mine, Goias State	30 (ore).
Do.	do.	Niquelandia, Goias State, and Sao Miguel Paulista, Sao Paulo (refinery plants)	25 (electrolytic).
Do.	Vale S.A., 100%	Onca Puma, Ourilandiao Norte, Para State	25 (iron-nickel alloy).

See footnotes at end of table.

TABLE 2—Continued
BRAZIL: STRUCTURE OF THE MINERAL INDUSTRY IN 2015

(Thousand metric tons unless otherwise specified)

Commodity		Major operating companies and major equity owners	Location of main facilities	Annual capacity ^c
METALS—Continued				
Niobium (columbium)		Companhia Brasileira de Metalurgia e Mineração (Moreira Salles Group., 70%)	Araxa Mine, Minas Gerais State	120 (ore).
Do.		do.	Araxa, Minas Gerais State (beneficiation plant)	6,000 (pyrochlore).
Do.		Anglo American Niobio Brasil Ltda. (Anglo American plc, 100%)	Boa Vista Mines, Goias State	9.
Do.		do.	Ouvidor, Goias State (beneficiation plant)	1,300 (pyrochlore).
Tantalum	metric tons	Mineração Taboca S.A. (Minsur S.A., 100%)	Pitinga Mine, Amazonas State and Fundicion de Pinpora, Sao Paulo State	120 (concentrate).
Do.	do.	AMG Mineração S.A. (Advanced Metallurgical Group N.V., 100%)	Volte Grande Mine, Nazareno, Minas Gerais State	25 (concentrate).
Tin		Estanho de Rondônia S.A. (Companhia Siderúrgica Nacional, 100%)	Santa Barbara Mine and Ariqueemes smelter	3,600 (concentrate).
Do.		Mineração Taboca S.A. (Minsur S.A., 100%)	Pitinga Mine, Amazonas State, and Fundicion de Pinpora, Sao Paulo State	5,000 (concentrate).
Titanium		Indústrias Nucleares do Brasil S/A	San Francisco de Itabapoana, Rio de Janeiro State	NA.
Do.		Millenium Inorganic Chemicals Mineração Ltda. (Cristal Global Group, 100%)	Mataraca Mine, Paraiba State	4,200 (ore).
Do.		do.	Mataraca, Paraiba State (beneficiation plants)	120 (concentrate).
Zinc, Zn content		Votorantim Metais Zinco S/A (Votorantim Group, 100%)	Vazante Mine, Minas Gerais State	165.
Do.		do.	Morro Agudo Mine, Paracatu, Minas Gerais State	38.
Do.		do.	Tres Marias, Minas Gerais State	180 (metal).
Do.		do.	Juiz de Fora, Minas Gerais State	95 (metal).
Zirconium		Indústrias Nucleares do Brasil S/A	San Francisco de Itabapoana, Rio de Janeiro State	NA.
Do.		Millenium Inorganic Chemicals Mineração Ltda. (Cristal Global Group, 100%)	Mataraca Mine, Paraiba State	NA.
Do.		do.	Mataraca, Paraiba State (beneficiation plants)	NA.
INDUSTRIAL MINERALS				
Asbestos		Sociedade Anônima Mineração de Amianto S.A. (Eternit Group, 100%)	Cana Brava Mine and plant, Minacu, Goias State	300 (concentrate).
Cement		Companhia de Cimento Itambé (private, 100%)	Itambe plant, Balsa Nova, Parana State	2,800.
Do.		Cimento Nacional (Brennand Group, 100%)	Sete Lagoas plant, Minas Gerais State	1,000.
Do.		do.	Plant in Paraiba State	1,500.
Do.		Cimento Nassau (John Santos Group, 100%)	States of Amazonas, Ceara, Espiritu Santo, Maranhao, Para, Piaui, Pernambuco, Rio Grande do Norte, and Sergipe (10 plants)	7,000.
Do.		Cimento Planalto S.A. (private, 100%)	Sobradinho, Brasilia, Distrito Federal State	1,600.
Do.		Cimento Tupi S.A. (private, 100%)	Carandai plant, Minas Gerais State; Mogi das Cruzes, Sao Paulo State; and Volta Redonda plant, Rio de Janeiro State	3,500.
Do.		Holcim (Brasil) S.A. (Holcim Ltd., 100%)	Barroso, Cantagalo, Leopoldo, Sorocaba, and Vitoria plants, Sao Paulo State	5,400.
Do.		InterCement Brasil S.A. (Camargo Correa S.A., 100%)	States of Alagoas, Bahia, Goias, Minas Gerais, Paraiba, Pernambuco, Sao Paulo, Mato Grosso do Sul, and Rio Grande do Sul (16 plants)	17,900.
Do.		Lafarge Brasil S.A. (Lafarge S.A., 99.76%)	States of Bahia, Goias, Minas Gerais, Paraiba, Rio de Janeiro, and Sao Paulo (5 plants)	7,100.
Do.		Mizu Cimentos Especiais (private, 100%)	States of Rio de Janeiro, Rio Grande do Norte, Espiritu Santo, Sao Paulo, and Sergipe (6 plants)	3,000.

See footnotes at end of table.

TABLE 2—Continued
BRAZIL: STRUCTURE OF THE MINERAL INDUSTRY IN 2015

(Thousand metric tons unless otherwise specified)

Commodity	Major operating companies and major equity owners	Location of main facilities	Annual capacity ^e
INDUSTRIAL MINERALS—			
Continued			
Cement—Continued	Votorantim Cimentos S.A. (Votorantim Group, 100%)	Various facilities, including: Cubatao, Ribeirao Grande, Salto de Pirapora, and Santa Helena plants Sao Paulo State Itau de Minas plant, Minas Gerais State Rio Branco do Sul plant, Parana State Laranjeiras plant, Sergipe State Candiota, Charqueadas, Esteio, and Pinheiro Machado plants, Rio Grande do Sul State Caucaia and Sobral plants, Ceara State Sobradinho plant, Distrito Federal State Edealina plant, Goias State Cuiaba and Nobres plants, Mato Grosso State Campo Grande and Corumba plants, Mato Grosso do Sul State Barcarena and Primavera plants, Para State Mineradora Ponta da Serra, Ouricuri, and Paulista plants, Pernambuco State Cantagalo, Sepetiba, Volta Redonda plants, Rio de Janeiro State Porto Velho plant, Rondonia State Capivari de Baixo, Imbituba, and Itajai plants, Santa Catarina State Xambioa, Tocantins State	25,000 (combined).
Clay, kaolin	Imerys Rio Capim Caulim S.A. (Imerys Group, 100%)	Ipixun Minesa, Para State (two mines)	NA.
Do.	do.	Barcarena, Para State (beneficiation plant)	NA.
Fluorspar	Mineração Nossa Senhora do Carmo Ltda. (private, 100%)	Cerro Azul, Parana State (two mines)	180 (ore).
Graphite	Extrativa Metalquímica S/A (private, 100%)	Maiquinique Mine, Bahia State	2 (concentrate).
Do.	JMN Mineração S/A (private, 100%)	Mateus Leme Mine, Minas Gerais State	2 (concentrate).
Do.	Nacional de Grafite Ltda. (private, 100%)	Itapecerica, Pedra Azul, Salto da Divisa, Minas Gerais State (three mines and three beneficiation plants)	90 (concentrate).
Gypsum	Companhia Brasileira de Equipamento (private, 100%)	Codo Mine, Maranhao State, and Ipubi Mine, Pernambuco State (two mines)	600 (ore).
Do.	Mineradora São Jorge S.A. (private, 100%)	Araripe Mine, Pernambuco State	800.
Do.	Votorantim Cimentos (Votorantim Group, 100%)	Mateo Mine, Ceara State	NA.
Magnesite	Ibar Nordeste S.A. (100% private)	Brumado Mine, Bahia State	NA.
Do.	Magnesita Refratários S.A. (100% private)	do.	1,200 (ore).
Do.	Xiolite S.A. (100% private)	do.	NA.
Phosphate rock	Copebrás S.A. (Anglo American plc, 100%)	Ouvidor Mine, Goias State	1,350 (concentrate).
Do.	Vale Fertilizantes S.A. (Vale S.A., 100%)	Araxa, Patos de Minas, and Tapira Mines, Minas Gerais State	2,220.
Do.	do.	Catalao Mine, Goias State	1,100.
Do.	do.	Cajati Mine, Sao Paulo State	550.
Vermiculite	Brasil Minérios Ltda. (private, 100%)	Sao Luiz dos Montes Belos, Goias State	100 (concentrate).
MINERAL FUELS AND RELATED MATERIALS			
Coal	Carbonifera Circiuma S.A. (private, 100%)	Verdinho Mine, Forquilha, Santa Catarina State	2,800.
Do.	Companhia Carbonífera Metropolitana S.A. (private, 100%)	Esperanca and Fontanella Mines, Santa Catarina State	1,200.
Do.	Copelmi Mineração Ltda. (private, 100%)	Butia, Cachoeira do Sul, and Charqueadas Mines, Rio Grande do Sul State (four mines)	3,000.
Do.	Indústria Carbonífera Rio Deserto Ltda. (private, 100%)	Circiuma and Urussanga Mines, Santa Catarina State (two mines)	2,600.

See footnotes at end of table.

TABLE 2—Continued
BRAZIL: STRUCTURE OF THE MINERAL INDUSTRY IN 2015

(Thousand metric tons unless otherwise specified)

Commodity		Major operating companies and major equity owners	Location of main facilities	Annual capacity ^e
MINERAL FUELS AND RELATED MATERIALS—				
Continued				
Natural gas	thousand cubic meters	Petróleo Brasileiro S.A. (Petrobras) (Government, 81.4%; private, 11.8%; public, 6.8%)	Offshore and onshore fields in the States of Alagoas, Amazonas, Bahia, Ceara, Espiritu Santo, Rio de Janeiro, Rio Grande do Norte, Sao Paulo, and Sergipe	28,200.
Petroleum	thousand 42-gallon barrels	Petróleo Brasileiro S.A. (Petrobras) (Government, 81.4%; private, 11.8%; public, 6.8%)	Offshore and onshore fields in the States of Alagoas, Amazonas, Bahia, Ceara, Espiritu Santo, Parana, Rio de Janeiro, Rio Grande do Norte, Sao Paulo, and Sergipe	740,000.
Petroleum, refinery products	do.	do.	Refineries in the States of Amazonas, Bahia, Ceara, Minas Gerais, Parana, Rio de Janeiro, Rio Grande do Sul, and Sao Paulo	804,000.

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

¹On care-and-maintenance status.

²Tubarão I and II pellets plants have been suspended since 2012.

TABLE 3
BRAZIL: RESERVES OF MAJOR MINERAL COMMODITIES IN 2015

(Thousand metric tons unless otherwise specified)

Commodity ¹	Reserves
Asbestos, fiber	9,804
Bauxite	2,600,000
Chromite, Cr ₂ O ₃ content	metric tons 570,000
Clay, kaolin	7,056,000
Coal, all types	32,277 ²
Cobalt, Co content	metric tons 85,000
Copper, Cu content	10,844
Fluorspar, CaF ₂ content	644
Gold, Au content	metric tons 2,400
Graphite	70,135
Gypsum	400,000
Iron ore	22,565,000
Lead, Pb content	metric tons 127,000
Lithium, Li content	do. 48,000
Magnesite	390,000
Manganese, Mn content	15,500
Natural gas	million cubic meters 429,958 ³
Nickel, Ni content	12,419
Niobium, Nb content	10,828
Petroleum, crude	million 42-gallon barrels 13,000 ³
Phosphate rock, P ₂ O ₅ content	270,000
Rare earths, rare-earth element (REE) content	22,000
Talc and pyrophyllite	52,133
Tantalum, Ta content	metric tons 34,279
Tin, Sn content	do. 416,383
Titanium minerals, TiO ₂ content	2,300
Uranium, U ₃ O ₈ content	metric tons 309,196 ²
Vanadium, V content	do. 175,000
Vermiculite	6,287
Zinc, Zn content	2,200
Zirconium, ore	2,485

do. Ditto.

¹Source: Departamento Nacional de Produção Mineral, Summário Mineral 2015.

²Source: Empresa de Pesquisa Energética—Brazilian Energy Balance 2016.

³Source: National Agency of Petroleum Natural Gas and Biofuels, Statistical Mineral Yearbook 2016.