

# 2016 Minerals Yearbook

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## BRAZIL

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# 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 2016, Brazil's estimated share of world mined niobium production amounted to 89%; iron ore, 19%; asbestos, 16%; vermiculite, 14%; bauxite, 13%; talc and pyrophyllite, 11%; alumina, 9%; tin, 9%; graphite (natural) and tantalum, 8% each; and manganese, 7%. The World Steel Association reported that Brazil accounted for about 2% of the world's crude steel production and was the leading producer in South America (77% of South America's steel production) (World Steel Association, 2017, p. 9–10; Anderson, 2018; Bolen, 2018; Bray, 2018; Corathers, 2018; Flanagan, 2018; Olson, 2018; Polyak, 2018a, b; Tanner, 2018; Tuck, 2018).

Brazil ranked 10th in the world in crude petroleum production and ranked 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 12.6 billion barrels (Gbbbl), and its natural gas reserves were estimated to be 377.4 billion cubic meters. About 95% of the total proven crude petroleum reserves and 84% of the total natural gas reserves were located offshore. In 2016, offshore crude petroleum production accounted for about 94% 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 41% of the 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 crude petroleum and natural gas production accounted for about 81% and 79%, respectively, of the country's total crude petroleum and natural gas production in 2016 (table 3; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2017, p. 71, 74, 79; BP p.l.c., 2017, p. 12, 14, 26; *Petróleo Brasileiro S.A.*, 2017b).

In 2016, Brazil's gross domestic product (GDP) was \$1.8 trillion. Brazil's GDP decreased by 3.6% in 2016 compared with that of 2015; this was the second consecutive year to show a decline after a decrease of 3.8% in 2015. 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, 2017a; Instituto Brasileiro de Mineração, 2017c).

## Minerals in the National Economy

Brazil's mineral production (excluding crude petroleum and natural gas) in 2016 was valued at \$24 billion (representing about 1% of the GDP) compared with \$26 billion in 2015. IBRAM reported that the value of mineral production had fallen by more than 50% since peaking at \$53 billion in 2011. The decrease was largely attributed to the decrease in global mineral commodity prices, especially iron ore prices. In the second half of the year, 164,807 workers were employed in the mining sector compared with 174,610 (revised) in the second half of 2015. The Economic Commission for Latin America and the Caribbean noted that Brazil's foreign direct investment (FDI) increased in 2016 to \$79 billion, which was up from \$75 billion in FDI in 2015 but still below the 5-year high of \$101 billion that was reached in 2011. The causes for the decline in FDI since 2011 included falling investor confidence from political instability as well as falling commodity prices. Planned investment prospects in Brazil's mineral sector for the 5-year period (2017 through 2022) as reported by IBRAM amounted to about \$18 billion, which represented a sharp decrease of about 76% compared with the period 2012 through 2016 (\$75 billion) (Departamento Nacional de Produção Mineral, 2017b, p. 7; Economic Commission for Latin America and the Caribbean, 2017a; 2017b, p. 51–52, 101; Instituto Brasileiro de Mineração, 2017a, b).

## Government Policies and Programs

The Ministério de Minas e Energia [Ministry of Mines and Energy] (MME) regulates Brazil'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. 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, crude petroleum, and natural gas industries in the country and issuing exploration and production licenses (Ministério de Minas e Energia, 2014; 2017a, b; Departamento Nacional de Produção Mineral, 2016).

Brazil's mineral industry 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. Public Law No. 5807/13, which was a proposed regulatory framework for mining, continued to be reviewed in 2016. 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; creating the Agência Nacional de Mineração [National Mining Agency], which would replace DNPM and 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 minerals, and iron ore; 1% for gold; and 0.2% for carbonates, gemstones, and nonferrous metallic minerals (Ministério de Minas e Energia, 2014; Departamento Nacional de Produção Mineral, 2016; Instituto Brasileiro de Mineração, 2016, p. 8).

The framework also established a development fund to manage Government revenues from pre-salt crude petroleum production and laid out a new production-sharing agreement (PSA) system for pre-salt reserves. Petrobras would be the sole operator of each PSA and would hold a minimum 30% stake in all pre-salt projects. 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) manages new pre-salt crude petroleum reserves and production; PPSA operates under the authority of the MME. In December 2016, Public Law 13.365/2016 was passed, which made the participation of Petrobras as the exclusive pre-salt operator optional and removed the requirement that Petrobras hold a minimum 30% stake in all pre-salt projects (Ministério de Minas e Energia, 2017c; WorldOil.com, 2017).

Brazil's Compensação Financeira pela Exploração de Recursos Minerais [Financial Compensation for Exploiting Mineral Resources] (CFEM), which is part of the DNPM, is responsible for collecting mining royalties. The collected royalties are allocated among the municipalities (65%), States (23%), and the Federal Government (12%) (Departamento Nacional de Produção Mineral, 2017a).

## Production

In 2016, Brazil's largest change in mineral production was an increase of about 475% in diamond production to 184,000 carats from 32,000 (revised) carats in 2015 owing to the opening of Lipari Mineração Ltda.'s Braúna Mine. Other minerals that had significant increases in production were monazite, the output of which increased by 131% to an estimated 3,700 metric tons (t); ferronickel, Ni content, by 47% to 44,500 t (increase was owing to the completion of two furnace rebuilds by United Kingdom-based Anglo American plc); vanadium, by 37% to 7,966 t (increase was owing to higher recovery rates at Canada-based Largo Resources Ltd.'s Maracás Menchen Mine, which began production in 2015); rare earths, by 25% to an estimated 1,100 t; copper, smelter primary, by 21% to 191,500 t; silicomanganese, by 18% to an estimated 167,000 t; coal, by 10% to 7.0 million metric tons (Mt); and uranium, by 10% to an estimated 44 t. Several minerals had significant decreases in production. Mineral production decreased by nearly 50% for mine output of cobalt (to an estimated 2,000 t) and for cobalt metal (to an estimated 700 t) owing to the suspension of Grupo Votorantim's Niquelandia and Sao Miguel Paulista operations. Other minerals that had significant decreases in production were naphtha, by 31% to 20.0 million barrels (Mbbbl); asbestos, 26% to an estimated 200,000 t; fuel oil, 20% to 72.4 Mbbbl; ferrochromium, 19% to 212,521 t; and cement, 12% to 57.5 Mt. According to

Petrobras, decreases in naphtha and fuel oil production resulted from lower domestic consumption and maintenance stoppages at its facilities and operations. Data on mineral production are in table 1 (tables 1, 2; Grupo Votorantim, 2016, p. 17; Anglo American plc., 2017, p. 54; Largo Resources Ltd., 2017; Lipari Mineração Ltda., 2017, p. 16; Petróleo Brasileiro S.A., 2017a, p. 58).

## Structure of the Mineral Industry

In 2016, Vale S.A., which had its headquarters in Rio de Janeiro, 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 Pará, had the capacity to produce 18.1 million metric tons per year (Mt/yr) of bauxite. Caraíba Metais S.A. (100% owned by Paranapanema 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. Grupo Votorantim, 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 annual production capacities of about 95,000 t/yr and 190,000 t/yr of zinc, respectively. Table 2 is a list of major mineral industry facilities.

## Mineral Trade

Brazil's mineral exports in 2016 were valued at about \$21.6 billion compared with about \$22.3 billion in 2015 (mainly because of decreases in the price of iron ore); mineral exports accounted for 12% of total exports of \$185.2 billion. The country's major export trade partners were, in descending order of export value, China, which received 19% of Brazil's exports; the United States, 13%; Argentina, 7%; and the Netherlands, 6%. Iron ore accounted for about 61% of the value of mineral exports, followed by gold, 13%; copper, 9%; and ferroniobium, 6%. Potassium accounted for about 37% of Brazil's primary mineral imports, followed by coal, 36%; copper, 13%; and sulfur, 3% (Banco Central do Brasil, 2017b; Instituto Brasileiro de Mineração, 2017c).

In 2016, the volume of Brazil's exports of crude petroleum increased by 8% to 291 Mbbbl from 269 Mbbbl in 2015. Its major crude petroleum export partners were, in descending order of export tonnage, China, 37%; Uruguay, 13%; the United States, 12%; Chile, 10%; and India, 7% (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2017, p. 123).

In terms of trade with the United States, Brazil's exports to the United States were valued at \$26.1 billion in 2016 compared with about \$27.4 billion in 2015, which was a decrease of about 5%. Brazil's crude petroleum exports to the United States in 2016 were valued at \$2.2 billion and accounted for 8% of the total value of exports. Other major mineral-related exports from Brazil to the United States in 2016 were iron and steel mill products valued at \$1.6 billion; construction materials, \$704 million; nonmonetary gold, \$614 million; petroleum products, \$430 million; fuel oil, \$326 million; other nonferrous metals, \$232 million; bauxite and aluminum, \$157 million; and gemstones, \$100 million (U.S. Census Bureau, 2017b).

Brazil's imports from the United States decreased by \$1.5 billion (or by 5%) to \$30.1 billion in 2016 from \$31.6 billion in 2015. Significant mineral-related imports by Brazil from the United States in 2016 were fuel oil valued at \$2.6 billion; petroleum products, \$1.4 billion; metallurgical-grade coal, \$552 million; coal and other fuels, \$480 million; natural gas liquids, \$413 million; iron and steel products (other), \$320 million; and drilling and oilfield equipment, \$183 million (U.S. Census Bureau, 2017a).

## Commodity Review

### *Metals*

**Aluminum and Bauxite and Alumina.**—Despite a decrease in aluminum production at the Sao Luiz (Alumar) primary aluminum smelter owing to high costs, overall aluminum production in Brazil increased by nearly 3% to 792,700 t. The Alumar smelter, which had a production capacity of 447,000 t/yr, is located in the State of Maranhao in northeastern Brazil and was jointly owned by Alcoa Alumínio S.A. (a subsidiary of Alcoa Inc. of the United States), 60%, and BHP Billiton plc of Australia, 40%. Production was partially curtailed in 2015 and the smelter stopped production in 2016. Albras Alumínio Brasileiro S.A. (jointly owned by Norsk Hydro ASA of Norway, 51%, and Nippon Amazon Alumínio Co. Ltd., 49%) which ran the Barcarena smelter in the State of Para, and Companhia Brasileira de Alumínio S.A. (wholly owned by Grupo Votorantim), which ran the Alumínio smelter located in the State of Sao Paulo, also produced aluminum in 2016. The Barcarena smelter increased aluminum production by 14,000 t to nearly 449,000 t, and the Alumínio smelter increased production by 32,000 t to nearly 344,000 t (Alcoa Inc., 2017, p. 78; Associação Brasileira do Alumínio, 2017b).

Although Alcoa Inc. did not produce any aluminum in Brazil in 2016, the company continued operations at its Juruti bauxite mine, Pocos de Caldas bauxite mine and alumina refinery, and Sao Luiz alumina refinery. The Pocos de Caldas bauxite mine produced about 87,000 t of alumina in 2016, which was down from about 121,000 t in 2015. The Pocos de Caldas bauxite mine had a capacity of 1.1 Mt/yr but produced only 300,000 t in 2016. The Sao Luiz refinery increased production of alumina to 3.71 Mt, up from 3.67 Mt in 2015. The Juruti bauxite mine produced 5.96 Mt, which was up from the 5.35 Mt produced in 2015 (Associação Brasileira do Alumínio, 2017a, c).

Norsk Hydro announced that negotiations were still ongoing with Vale in 2016 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 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 100% interest in the Paragominas bauxite mine, which is also located in the State of Para in northern Brazil. The Paragominas Mine produced 11.1 Mt of bauxite in 2016, representing a record level for the mine, and accounted for 28% of Brazil's total bauxite production of 39.2 Mt. Norsk Hydro planned to increase its overall bauxite capacity to 19 Mt/yr in the longer term with the potential acquisition of MRN. All Norsk Hydro's bauxite production served its majority-owned (51%) Barcarena (Alunorte) alumina refinery located in the State of Para. The Barcarena refinery produced 6.3 Mt of alumina in 2016, and the company planned to increase the refinery's production capacity to 6.6 Mt/yr by 2018 (Norsk Hydro ASA, 2017, p. 12, 13, 39).

**Copper.**—Vale was the leading producer of copper concentrates in Brazil in 2016; it produced copper concentrates at its Salobo and Sossego open pit mines located in Carajas in the State of Para. In 2016, the Salobo Mine produced about 176,000 t of copper, which was an increase of 21,000 t compared with 155,000 t in 2015; the Sossego Mine produced about 93,000 t of copper, which was a decrease of 11,000 t compared with 104,000 t in 2015. The increased production at Salobo was a result of its continued rampup after completion of the Salobo II expansion project in mid-2014, which increased Salobo's capacity to 200,000 t/yr of copper in concentrate; Sossego's capacity was 100,000 t/yr of copper in concentrate. Total proven and probable reserves at Salobo were reported to be 1,178 Mt at an average grade of 0.63% copper; Sossego's reserves were reported to be 111 Mt at an average grade of 0.65% copper (Vale S.A. 2017, p. 47, 49, 68).

**Gold.**—Vale was also a leading producer of gold in Brazil. Total production from its Salobo and Sossego Mines was a combined 11,944 kilograms (kg), or about 14% of Brazil's total gold production of an estimated 88,000 kg; Vale recovered gold as a byproduct from these two copper mines. Salobo's gold production increased by about 26% to 9,860 kg in 2016 from 7,807 kg in 2015. Sossego's gold production decreased by about 16% to 2,084 kg in 2016 from 2,488 kg in 2015. As of 2016, total proven and probable reserves at Salobo and Sossego were reported to be 1,178 Mt at an average grade of 0.4 gram per metric ton (g/t) gold; Sossego's reserves were reported to be 111 Mt at an average grade of 0.2 g/t gold (Vale S.A., 2017, p. 51, 69).

AngloGold Ashanti Ltd. of South Africa produced gold in the country through two of its wholly owned subsidiaries, AngloGold Ashanti Córrego do Sítio Mineração (AGA Mineração) and AngloGold Ashanti Serra Grande. Gold production by these AngloGold Ashanti subsidiaries decreased by nearly 3% to 16,765 kg in 2016 from 17,200 kg in 2015. 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 terms of production capacity in 2016, with gold production of 12,659 kg. In addition, AGA Mineração was one of AngloGold Ashanti Ltd.'s lowest cost operations with a total cash cost of \$562 per troy ounce (AngloGold Ashanti Ltd., 2017, p. 102, 106).



Kinross Gold Corp. of Canada, through its subsidiary Kinross Brasil Mineração S.A., held a 100% interest in the Paracatu Mine located in the State of Minas Gerais in southeastern Brazil. In 2016, gold production from Paracatu was 15,023 kg compared with 14,857 kg in 2015; the mine was the largest gold mine in Brazil in terms of production capacity. The total cash cost of operations decreased to nearly \$720 per troy ounce from about \$780 per troy ounce in 2015 owing to the lower cost of supplies and favorable foreign exchange rates. Total proven and probable mineral reserves at Paracatu were 644 Mt at an average grade of 0.4 g/t gold (Kinross Gold Corp., 2017, p. 21, 68).

Yamana Gold Inc. of Canada was also a significant gold producer in 2016. Yamana Gold's two largest gold operations in Brazil were the Chapada Mine located in the State of Goiás, and the Jacobina Mine located in the State of Bahia. These two mines had a combined production of more than 7,000 kg of gold. Yamana Gold's total gold production in Brazil including its interests (85%) in the production by Brio Gold Inc. of Canada, reached nearly 13,000 kg, which was an increase of nearly 18% compared with the about 11,000 kg produced in 2015 (Yamana Gold Inc., 2017, p. 39, 49–50).

**Iron and Steel.**—Brazil produced 31.3 Mt of crude steel in 2016, which was a decrease of 6.0% from the 33.3 Mt produced in 2015. Brazil's production of steel products also decreased to 30.2 Mt in 2016. The country's major integrated steel operations consisted of 30 mills managed by 11 business groups. Combined, the mills had an installed capacity of 50.4 Mt/yr of crude steel and were located mainly in the States of Espírito Santo, Minas Gerais, Rio de Janeiro, and São Paulo. Two leading steel producers in Brazil in 2016 were ArcelorMittal S.A. of Luxembourg and Gerdau S.A. of Brazil. Apparent consumption of steel products decreased for the third straight year to 18.2 Mt. The weakened domestic economy of the past several years had negatively affected the activities of the automotive, construction, and manufacturing industries, which, combined accounted for most of the steel consumption in Brazil. The member companies of the Instituto Aço Brasil employed 105,476 people in 2016 (Instituto Aço Brasil, 2016, 2017).

**Iron Ore.**—Vale's production of iron ore increased slightly in 2016 to 349 Mt, which accounted for about 84% of Brazil's estimated iron ore production of 415 Mt and about 15% of worldwide production of an estimated 2.4 billion metric tons (usable ore). Not only was Vale the leading producer of iron ore in Brazil in 2016, 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 (148.1 Mt), which is located in State of Pará; the southeastern system (102.7 Mt) and the southern system (95.7 Mt), which are located in the State of Minas Gerais; and the midwestern system (2.3 Mt), which is located in the State of Mato Grosso do Sul. At the end of 2016, Vale's total proven and probable reserves of iron ore were reported to be 18,442 Mt at an average grade of 54% iron (Vale S.A., 2017, p. 17, 31, 64; Tuck, 2018).

During the fourth quarter of 2016, Vale started up the Carajás Serra Sul S11D Mine (Mine S11D). With a production capacity of 90 Mt/yr of iron ore, the mine was located in the State of Pará and was part of Vale's northern system. Vale reported an investment cost of more than \$5 billion to develop

the mine. In addition, Vale continued with the development of the CLN S11D logistics project in support of Mine S11D, which included expansion of 570 km of railway, 101 km of a railway spur, acquisition of wagons and locomotives, and port expansion. Vale reported that by yearend 2016, the company had completed 76% of the project with an investment cost of \$5.7 billion; the project was expected to be completed by 2019 (table 2; Vale S.A., 2017, p. 22, 72).

Samarco Mineração S.A. was a joint venture between BHP Billiton Ltda. and Vale (50% each). In November 2015, the Samarco Mineração's Fundão iron ore tailings dam failed, flooding nearby villages, including Bento Rodrigues, and polluting the Doce River. Samarco Mineração's mining and pellet plant operations in the State of Minas Gerais were suspended as a result of the dam failure. Samarco's production in 2015 was about 25 Mt each of iron ore and iron ore pellets, but there was no production of either in 2016. The Government was evaluating the environmental costs associated with this disaster. Vale noted that initial estimates related to the remediation costs exceeded \$1 billion (Vale S.A., 2017, p. 31, 34, 85).

**Manganese.**—Vale produced manganese at the Azul open pit mine, which is located in the State of Pará, 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. Production at the Morro de Mina Mine was suspended in 2015 owing to market conditions; however, the mine resumed operations at the end of 2016. Vale produced 2.4 Mt of manganese ore in 2016, which was the same as in 2015. Total proven and probable manganese ore reserves at Azul, Morro da Mina, and Urucum were reported to be 56.6 Mt at an average grade of about 31.9% manganese compared with 52.2 Mt at an average grade of about 29.6% manganese in 2015. The increase in reserves was owing to an update to Vale's resource models that considered new geologic information and reserve assumptions (Vale S.A., 2017, p. 36, 66).

**Nickel.**—Vale produced nickel at Onça Puma, which was a mining and smelting operation that produced a high-quality product for the stainless-steel industry; the operation was located in the State of Pará in northern Brazil. In 2016, production of nickel contained in ferronickel at Onça Puma was 24,100 t compared with 24,400 t in 2015; the operation's production capacity was 27,000 t/yr. Vale was continuing to evaluate the opportunity to restart a second facility at Onça Puma—a decision that would depend in part on the market outlook and the performance of its operating furnace; the facility had been shut down in 2012 owing to a furnace problem. Total proven and probable reserves at the Onça Puma at the end of 2016 were 108.0 Mt at an average grade of 1.53% nickel compared with 97.4 Mt at an average grade of 1.56% nickel in 2015 (Vale S.A., 2017, p. 17, 43, 45, 67, F–50).

Anglo American, through its subsidiary Anglo American Niquel Brasil Ltda., was a leading nickel producer in the country in 2016. The company produced nickel at its Barro Alto and Codemin operations, which were located in the State of Goiás. Nickel production at Barro Alto increased by 67% to 35,500 t in 2016 from 21,300 t in 2015; production at Codemin in 2016 was 9,000 t the same as in 2015. The production capacities of Barro Alto and Codemin were 36,000 t/yr and 10,000 t/yr, respectively.

Anglo American attributed the production increase at Barro Alto to completion of 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 2017. By yearend, nickel ore reserves at Barro Alto were reported to be 40.4 Mt at an average grade of 1.39% nickel (Anglo American plc., 2017, p. 36, 54–56, 182, 192).

**Niobium (Columbium).**—China Molybdenum Co. Ltd. purchased Anglo American's niobium and phosphate operations (all in Brazil) in 2016 for \$1.5 billion; the purchase increased the company's share of niobium production to an estimated 80%. One operating niobium mine included in the transaction was the Boa Vista open pit niobium mine; the mine was located in the State of Goiás in central Brazil. In 2016, niobium production at the Boa Vista Mine was estimated to be 6,300 t, which was unchanged from that in 2015; the mine's production capacity was estimated to be 9,000 t/yr. Total proven and probable reserves at Boa Vista at the end of 2015 (the most recent year for which data were available) were 230,000 t at an average grade of 0.89% niobium (table 2; Anglo American plc, 2016, p. 22, 57, 176; 2017, p. 19, 55).

### *Industrial Minerals*

**Cement.**—More than 70 integrated cement operations were producing in the country with a total (combined) installed capacity of about 88 Mt/yr of cement. In 2016, the leading cement-producing companies included Cimento Nassau, Grupo Votorantim, Holcim Ltd. 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 (22%), the south region (16%), the center-west region (10%), and the north region (5%) (Global Cement, 2017; Sindicato Nacional da Indústria do Cimento, 2017).

In 2016, Grupo Votorantim, through its subsidiary Votorantim Cimentos S.A., opened a new cement plant in the city of Primavera in the State of Para with a production capacity of 1.2 Mt/yr. Votorantim Cimentos, which was the leading cement producer in Brazil, had a total installed capacity of 32 Mt/yr of cement in 2016. The company reported that it had about 10,000 employees that operated 16 cement plants, 10 grinding mills, 103 ready-mix plants, 20 aggregate plants, 8 mortar plants, and 1 lime unit in Brazil (Grupo Votorantim, 2017, p. 58; undated).

**Diamond.**—Lipari Mineração started operations at its 100%-owned Braúna diamond mine, located in the State of Bahia in eastern Brazil. During the year, the open pit mine produced 116,757 carats. The Braúna Mine encompassed 22 kimberlite pipes and was South America's first kimberlite diamond mine. The company was focused on the Braúna 3 kimberlite pipe, which was expected to produce an average of 340,000 carats per year during a mine life of 7 years (Lipari Mineração Ltda., 2016; 2017, p. 16).

**Phosphate Rock.**—The Mosaic Co. of the United States purchased Vale's phosphate operations in Brazil in December 2016; the transaction was expected to close at the end of 2017. Through its wholly owned subsidiary Vale Fertilizantes S.A.,

Vale produced 3.7 Mt of phosphate rock in 2016 in Brazil, which was a decrease of 13.8% from the 4.3 Mt produced in 2015. Vale operated the following five mines in Brazil: the Araxá, the Patos de Minas, and the Tapira open pit mines, which are located in the State of Minas Gerais; the Cajati open pit mine located in the State of Sao Paulo; and the Catalão open pit mine located in the State of Goiás. The Tapira Mine was Vale's largest producing phosphate mine, with production of 1.6 Mt in 2016, which was down by 17.1% from that of 2015. Total reserves at the Tapira Mine were 655 Mt at an average grade of 7.6%  $P_2O_5$ . The Catalão Mine produced 0.9 Mt of phosphate rock in 2016, which was a decrease from the 1.0 Mt produced in 2015; total reserves were 85.5 Mt at an average grade of 10.6%  $P_2O_5$ . The Araxá Mine produced 711,000 t of phosphate rock in 2016, which was a slight increase compared with the 707,000 t produced in 2015. The Araxá Mine's total proven and probable reserves were 22.3 Mt at an average grade of 10.6%  $P_2O_5$ . The Cajati Mine's phosphate rock production decreased to 477,000 t from 581,000 t in 2015 and total reserves were reported to be 81.7 Mt at an average grade of 5.2%  $P_2O_5$  in 2015. Production at the Patos de Minas Mine decreased to 0 t from 23,000 t in 2015; no reserves were reported. Vale suspended the operations at the Patos de Minas Mine in the third quarter of 2015 owing to low prices (Vale S.A., 2017, p. 22, 78, 79).

### *Mineral Fuels*

**Natural Gas.**—Brazil's gross natural gas production was about 37.9 billion cubic meters in 2016 compared with 35.1 billion cubic meters in 2015. The increase in production was mainly owing to an increase in the production of natural gas from the pre-salt areas, which increased to about a 38% share of the total compared with a 30% share of the total in 2015. Brazil's natural gas operations were located mainly in the States of Rio de Janeiro (44%), Sao Paulo (15%); Amazonas (13%), Espirito Santo (10%), and Bahia (7%). Proven offshore reserves were estimated to be about 316 billion cubic meters. The State of Rio de Janeiro accounted for 61% of the total proven natural gas reserves (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2017, p. 74, 83).

**Petroleum.**—In 2016, Brazil's crude petroleum production increased by 3% to 918.7 million barrels (Mbbl) from 889.7 Mbbl in 2015. The increase in production was attributed to an increase in production from pre-salt areas by 33% to 372.7 Mbbl in 2016 from 280.1 Mbbl in 2015. Brazil's offshore deposits held the vast majority of Brazil's proven reserves, which were estimated to be 12.0 Gbbl. The State of Rio de Janeiro accounted for about 82% of the country's total proven reserves, followed by the States of Espirito Santo (8%) and Sao Paulo (4%) (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2017, p. 71).

ANP reported that 373 onshore and offshore fields in Brazil were in the production phase, 70 fields were in the development phase, and 312 blocks were in the exploration phase. Of the 373 fields in the production phase, Petrobras operated 298 fields, which were located in the States of Alagoas, Amazonas, Bahia, Ceara, Espirito Santo, Maranhao, Parana, Rio Grande do Norte, Rio de Janeiro, Sao Paulo, and Sergipe.

Of the 312 blocks in the exploration phase, most were located onshore (195 blocks). The exploration blocks were located in the sedimentary basins of Acre, Alagoas, Almada, Amazonas, Barreirinhas, Camamu, Campos, Ceara, Espirito Santo, Foz do Amazonas, Jequitinhonha, Para-Maranhao, Parana, Parnaiba, Pelotas, Pernambuco-Paraiba, 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, 2017, p. 53).

In 2016, according to the ANP, crude petroleum production by Petrobras increased by about 1% to 748 Mbbl compared with that of 2015 and its natural gas production increased by about 4% to 30 billion cubic meters. During the year, Petrobras began additional crude petroleum and natural gas operations at three pre-salt reservoirs in Brazil, namely Cidade de Marica in the Lula field; Cidade de Saquarema, also in the Lula field; and Caraguatatuba in the Lapa field. These three operations had a total capacity to produce about 400,000 barrels per day of crude petroleum and 17 million cubic meters per day of natural gas. Petrobras noted that three more operations were planned to begin in 2017; five were planned for 2018; and two were planned for 2019. Most of Petrobras's planned additions were to be located in the Santos basin, and one was to be located in the Campos basin. As of yearend 2016, Petrobras reported proven reserves of 8.1 Gbbl of crude petroleum (including condensate and synthetic oil) and 223 billion cubic meters of natural gas and synthetic gas (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2017, p. 80; Petróleo Brasileiro S.A., 2017a, p. 50, 52–54, 82).

## Reserves and Resources

Brazil was among the world leaders in reserves of various nonfuel mineral commodities. Brazil's estimated share of world reserves of niobium amounted to 95%; tantalum, 36%; graphite, 29%; rare earths, 18%; manganese, 17%; iron ore, 15%; tin, 15%; nickel, 13%; bauxite, 9%; and titanium (ilmenite), 6% (table 3; Anderson, 2017; Bedinger, 2017; Bray, 2017; Corathers, 2017; Gambogi, 2017; Olson, 2017; Papp, 2017a, b; Schnebele, 2017; Tuck, 2017).

## Outlook

Brazil's economy was forecast to increase (in terms of real GDP) by 0.2% in 2017 and by 1.7% in 2018 as reported by the International Monetary Fund (IMF); a slight rebound after two consecutive years of decreases of more than 3%. The IMF noted that expected growth in Brazil would be the result of reduced political uncertainty, easing monetary policy, and progress on such economic reforms as simplifying the tax code and reducing barriers to trade. IBRAM reported that Brazil's mineral production value in 2017 was expected to increase by about 4% to an estimated \$25 billion from \$24 billion in 2015, likely owing to an increase in mineral commodity prices, particularly the price of iron ore. A recovery in mineral prices would also likely lead to

a recovery in mineral exports (Instituto Brasileiro de Mineração, 2017b; International Monetary Fund, 2017, p. 18, 33, 203).

Continued growth of the country's crude petroleum and natural gas production could soon transform Brazil into one of the 10 leading crude petroleum producers in the world. The startup of Lipari Mineração's Braúna diamond mine, which will be the first kimberlite diamond mine in South America, is likely to attract significant FDI in mining. In addition, expected reforms to mining legislation were expected to further boost foreign investments in the mineral and energy sectors in Brazil in the coming years.

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TABLE 1  
BRAZIL: PRODUCTION OF MINERAL COMMODITIES<sup>1</sup>

(Metric tons, gross weight, unless otherwise specified)

Commodity <sup>2</sup>	2012	2013	2014	2015	2016
<b>METALS</b>					
Aluminum:					
Bauxite, dry basis	34,988,000 <sup>r</sup>	33,896,000 <sup>r</sup>	36,308,000 <sup>r</sup>	37,057,000 <sup>r</sup>	39,244,000
Alumina	10,320,000	9,942,000	10,404,000 <sup>r</sup>	10,451,500 <sup>r</sup>	10,900,000 <sup>e</sup>
Metal:					
Primary	1,436,000	1,304,100 <sup>r</sup>	962,000	772,200	792,700
Secondary	508,000	510,000	540,000	510,000	510,000 <sup>e</sup>
Total	1,940,000 <sup>r</sup>	1,810,000 <sup>r</sup>	1,500,000 <sup>r</sup>	1,280,000 <sup>r</sup>	1,300,000
Cadmium, refinery production, primary, metal <sup>e</sup>	200	200	200	200	200
Chromite, mine production, ore and concentrate	472,501	485,951	716,674	780,000	780,000 <sup>e</sup>
Cobalt, Co content:					
Mine production	2,900	3,500	3,828	3,800 <sup>e</sup>	2,000 <sup>e</sup>
Refinery production	1,750	1,871	1,350	1,300 <sup>e</sup>	700 <sup>e</sup>
Copper, Cu content:					
Mine production, concentrate	223,141	270,979	301,197	359,463	375,000 <sup>e</sup>
Leaching, electrowon	4,374	4,060	700 <sup>e</sup>	-- <sup>e</sup>	-- <sup>e</sup>
Refinery production:					
Primary	186,000	236,050	213,085	199,000 <sup>r, e</sup>	202,000 <sup>e</sup>
Secondary	24,700	25,900	23,600	42,500 <sup>r, e</sup>	44,000 <sup>e</sup>
Total	211,000 <sup>r</sup>	262,000 <sup>r</sup>	237,000 <sup>r</sup>	242,000 <sup>r</sup>	246,000
Smelter production:					
Primary	128,100	202,900	182,800	157,800	191,500
Secondary	46,800	54,000	50,500	42,400	44,400
Total	175,000	257,000	233,000	200,000	236,000
Ferroalloys:					
Ferrochromium	165,532	189,088	285,340	261,778 <sup>r</sup>	212,521
Ferromanganese <sup>e</sup>	94,000	93,000	96,000 <sup>r</sup>	84,000 <sup>r</sup>	84,000
Ferronickel:					
Gross weight <sup>e</sup>	136,000	149,000	161,000	131,000	161,000
Ni content	31,342	34,501	37,237	30,300	44,500
Ferroniobium:					
Gross weight	50,562	46,555	51,737 <sup>r</sup>	51,000 <sup>r, e</sup>	51,000 <sup>e</sup>
Nb content <sup>e</sup>	32,900	30,300	33,600	33,200	33,200
Ferrosilicon <sup>e</sup>	145,000	147,000	98,000	88,300	88,300
Silicomanganese <sup>e</sup>	213,000	218,000	205,000 <sup>r</sup>	142,000 <sup>r</sup>	167,000
Gold, mine production, Au content:					
Artisanal and small-scale mines kilograms	10,103	11,609	9,909	10,000 <sup>e</sup>	10,000 <sup>e</sup>
Large-scale mines do.	56,670	67,964	71,129	73,300 <sup>r, e</sup>	78,000 <sup>e</sup>
Total	66,800 <sup>r</sup>	79,600 <sup>r</sup>	81,000 <sup>r</sup>	83,300 <sup>r</sup>	88,000
Iron and steel:					
Pig iron thousand metric tons	26,900 <sup>r</sup>	26,200 <sup>r</sup>	27,016	27,803	26,036
Raw steel, excluding castings do.	34,524	34,163	33,900	33,300	31,300
Iron ore, mine production:					
Gross weight do.	400,822	386,270	411,183	430,836	415,000 <sup>e</sup>
Fe content do.	258,129	245,668	261,500	275,590	265,000 <sup>e</sup>
Lead:					
Mine production, concentrate, Pb content	8,922 <sup>r</sup>	8,020 <sup>r</sup>	10,978 <sup>r</sup>	12,000 <sup>r, e</sup>	12,000 <sup>e</sup>
Refinery production, secondary	165,397	151,964	160,393	176,216 <sup>r</sup>	180,000 <sup>e</sup>
Magnesium metal, primary <sup>e</sup>	16,000	16,000	16,000	15,000	15,000
Manganese, mine production, ore and concentrate:					
Gross weight	2,796,000	2,883,000	2,723,000	2,816,675	2,800,000 <sup>e</sup>
Mn content	1,164,000	1,180,000	1,094,000	1,226,458	1,200,000 <sup>e</sup>

See footnotes at end of table.

TABLE 1—Continued  
BRAZIL: PRODUCTION OF MINERAL COMMODITIES<sup>1</sup>

(Metric tons, gross weight, unless otherwise specified)

Commodity <sup>2</sup>	2012	2013	2014	2015	2016
METALS—Continued					
Nickel, Ni content:					
Mine production, ore	139,230	104,829	167,063	173,972	165,000
Intermediate production:					
Carbonate	19,611	19,958	18,800	19,600	18,500 <sup>c</sup>
Matte	14,345	11,641	--	--	--
Metal, electrolytic	21,437	19,823	21,000	21,900 <sup>c</sup>	21,900 <sup>c</sup>
Niobium, mine production, pyrochlore concentrate:					
Nb content	57,471	53,756	62,055	57,343	57,300 <sup>c</sup>
Nb <sub>2</sub> O <sub>5</sub> content	82,214	76,899	88,771	82,031	82,000 <sup>c</sup>
Rare earths, mineral concentrate, rare-earth-oxide equivalent	110	330	--	880 <sup>c</sup>	1,100 <sup>c</sup>
Silicon, silicon metal <sup>c</sup>	133,000	134,000	92,300	70,000	70,000
Silver, Ag content:					
Mine production kilograms	36,400	38,200	36,700	37,000	37,000 <sup>c</sup>
Refinery production, secondary do.	35,500	34,300	30,400	30,000 <sup>c</sup>	30,000 <sup>c</sup>
Tantalum, mine production, mineral concentrate:					
Gross weight do.	118,000	185,000	118,000	120,000 <sup>c</sup>	120,000 <sup>c</sup>
Ta content <sup>c</sup> do.	96,600	152,000	96,600	98,300	98,300 <sup>c</sup>
Tin:					
Mine production, Sn content	13,667	16,830	25,534	18,824	19,000 <sup>c</sup>
Smelter production, primary	11,955	14,721	22,334	18,329 <sup>r</sup>	18,000 <sup>c</sup>
Titanium mineral concentrates:					
Ilmenite and leucoxene:					
Gross weight	115,118	130,440	135,463	133,333	130,000 <sup>c</sup>
TiO <sub>2</sub> content	69,071	78,264	81,278	80,000 <sup>c</sup>	80,000 <sup>c</sup>
Rutile:					
Gross weight	2,090	2,246	2,038	2,222	2,200 <sup>c</sup>
TiO <sub>2</sub> content	1,881	2,021	1,834	2,000 <sup>c</sup>	2,000 <sup>c</sup>
Tungsten, mine production, concentrate, W content	381	494	510	510	510 <sup>c</sup>
Vanadium, V content	--	--	1,032	5,810	7,966
Zinc:					
Mine production, Zn content	164,258	152,147	169,766	185,000 <sup>r, c</sup>	195,000 <sup>c</sup>
Smelter production, primary	245,526	245,417	246,120	270,715 <sup>r</sup>	284,457
Zirconium mineral concentrates, gross weight	20,425	24,687	23,659	21,000 <sup>c</sup>	21,000 <sup>c</sup>
INDUSTRIAL MINERALS					
Asbestos, primary, fiber	304,569	290,825	311,230	270,000 <sup>r, c</sup>	200,000 <sup>c</sup>
Barite:					
Crude	186,134	34,943	3,389	--	--
Beneficiated	3,025	--	--	--	--
Cement, hydraulic thousand metric tons	69,323	69,975	71,254	65,283	57,476
Clay and shale, beneficiated:					
Bentonite	512,975	403,351	405,169	405,000 <sup>c</sup>	405,000 <sup>c</sup>
Kaolin	2,388,000	2,139,000	2,055,000	2,100,000 <sup>c</sup>	2,100,000 <sup>c</sup>
Diamond, gem, unspecified thousand carats	49	49	53 <sup>r</sup>	32 <sup>r</sup>	184
Diatomite:					
Crude	3,427	1,947	5,080	5,100 <sup>c</sup>	5,100 <sup>c</sup>
Beneficiated	1,987	2,475	2,822	2,800 <sup>c</sup>	2,800 <sup>c</sup>
Feldspar, mine production:					
Crude	328,001	421,039	496,894	500,000 <sup>c</sup>	500,000 <sup>c</sup>
Beneficiated	247,152	294,357	417,771	420,000 <sup>c</sup>	400,000 <sup>c</sup>
Fluorpsar:					
Acid grade	5,768	6,835	6,496	6,500 <sup>c</sup>	6,500 <sup>c</sup>
Metallurgical grade	18,380	20,886	17,353	17,000 <sup>c</sup>	17,000 <sup>c</sup>
Total	24,148	27,721	23,849	23,500	23,500

See footnotes at end of table.



TABLE 1—Continued  
BRAZIL: PRODUCTION OF MINERAL COMMODITIES<sup>1</sup>

(Metric tons, gross weight, unless otherwise specified)

Commodity <sup>2</sup>	2012	2013	2014	2015	2016
<b>INDUSTRIAL MINERALS—Continued</b>					
Gemstones, quartz crystal, all grades	16,254	10,696	7,163	7,100 <sup>e</sup>	7,100 <sup>e</sup>
Graphite, concentrate	88,110	91,908	87,026	95,000 <sup>r</sup>	95,000 <sup>e</sup>
Gypsum, including anhydrite, crude	3,749,860	3,332,991	3,447,012	3,400,000 <sup>e</sup>	3,400,000 <sup>e</sup>
Lime	8,300,000	8,350,000	8,300,000 <sup>e</sup>	8,300,000 <sup>e</sup>	8,300,000 <sup>e</sup>
Lithium, concentrate	7,084	7,982	8,519	8,500 <sup>e</sup>	8,500 <sup>e</sup>
Magnesite:					
Crude	1,719,079	1,542,420	1,644,847	1,600,000 <sup>e</sup>	1,600,000 <sup>e</sup>
Beneficiated	1,228,426	1,084,194	1,152,233	1,100,000 <sup>e</sup>	1,100,000 <sup>e</sup>
Mica	522	11,520	10,313	10,000 <sup>e</sup>	10,000 <sup>e</sup>
Nitrogen, N content, ammonia	980,000	1,000,000	870,000	1,000,000 <sup>e</sup>	1,000,000 <sup>e</sup>
Phosphate rock, concentrate:					
Gross weight thousand metric tons	6,740	6,715	6,513	6,100 <sup>r, e</sup>	5,600 <sup>e</sup>
P <sub>2</sub> O <sub>5</sub> content do.	2,388	2,504	2,521	2,350 <sup>r, e</sup>	2,150 <sup>e</sup>
Potash:					
K <sub>2</sub> O content	346,509	310,892	311,000	293,000 <sup>e</sup>	306,000 <sup>e</sup>
Products, potassium chloride	548,500	492,151	492,355	492,000 <sup>e</sup>	492,000 <sup>e</sup>
Rare earths, monazite concentrate	2,700	600	--	1,600 <sup>e</sup>	3,700 <sup>e</sup>
Salt:					
Rock thousand metric tons	1,403	1,349	1,451	1,450 <sup>e</sup>	1,450 <sup>e</sup>
Sea do.	6,079	5,926	6,050	6,100 <sup>e</sup>	6,100 <sup>e</sup>
Total do.	7,480	7,280	7,500	7,550	7,550
Stone, sand, and gravel:					
Sand and gravel, construction do.	368,957	377,209	391,766	392,000 <sup>e</sup>	392,000 <sup>e</sup>
Stone, crushed do.	287,040	293,435	308,829	310,000 <sup>e</sup>	310,000 <sup>e</sup>
Stone, dimension do.	9,300	10,500	10,130	10,000 <sup>e</sup>	10,000 <sup>e</sup>
Stone, size and shape do.	33,077	33,131	34,038	34,000 <sup>e</sup>	34,000 <sup>e</sup>
unspecified, calcite					
Sulfur, byproduct, S content:					
Metallurgy	274,693	324,405	286,754	290,000 <sup>e</sup>	290,000 <sup>e</sup>
Petroleum	222,561	218,014	239,970	240,000 <sup>e</sup>	240,000 <sup>e</sup>
Total	497,000	542,000	527,000	530,000	530,000
Talc and related materials, talc and pyrophyllite:					
Crude	459,539	592,844	644,478	645,000 <sup>e</sup>	645,000 <sup>e</sup>
Beneficiated	133,601	145,106	198,641	200,000 <sup>e</sup>	200,000 <sup>e</sup>
Vermiculite, elemental content, concentrate	51,986	60,379	56,444	56,000 <sup>e</sup>	56,000 <sup>e</sup>
<b>MINERAL FUELS AND RELATED MATERIALS</b>					
Coal, bituminous thousand metric tons	6,617	8,594	7,936	6,354	7,006
Coke, metallurgical do.	9,683 <sup>r</sup>	9,393 <sup>r</sup>	9,496 <sup>r</sup>	9,080 <sup>r</sup>	9,233
Natural gas liquids million 42-gallon barrels	32,131	32,938	33,475	32,671	35,407
Natural gas million cubic meters	25,832	28,174	31,895	35,126	37,891
Petroleum:					
Crude, including condensate thousand 42-gallon barrels	754,409	738,715	822,930	889,667	918,731
Refinery production:					
Asphalt do.	16,162	16,689	20,434	12,676	13,536
Fuel oil do.	86,113	92,844	102,320	90,190	72,374
Gasoline do.	170,206	186,934	189,185	169,338	174,348
Jet fuel do.	34,108	34,935	38,236	35,580	36,413
Kerosene do.	34,260	35,034	38,311	35,625 <sup>r</sup>	36,461
Liquefied petroleum gas do.	65,171	64,332	63,218	62,252	60,778
Lubricants do.	3,824	4,335	4,290	4,028	3,878
Naphtha do.	40,506	33,675	31,918	28,988	19,974
Other, solvents do.	1,826	2,857	2,417	2,253	2,114
Total do.	452,000 <sup>r</sup>	472,000 <sup>r</sup>	490,000 <sup>r</sup>	441,000 <sup>r</sup>	420,000
Uranium, U content <sup>e</sup>	326	192	55	40	44

See footnotes at end of table.

TABLE 1—Continued  
BRAZIL: PRODUCTION OF MINERAL COMMODITIES<sup>1</sup>

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<sup>6</sup>Estimated. <sup>7</sup>Revised. do. Ditto. -- Zero.

<sup>1</sup>Table includes data available through March 14, 2018. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>In addition to the commodities listed, bismuth, crude graphite, crude sodalite, ferrosilicon magnesium, inoculant, leucite, molybdenite, silica (silex), sodium compounds, and other minerals may have been produced in Brazil, but available information was inadequate to make reliable estimates of output.

Sources: Agência Nacional do Petróleo, Gas Natural e Biocombustíveis, Oil, Natural Gas and Biofuels, Statistical Mineral Yearbook 2017; Departamento Nacional de Produção Mineral, Sumário Mineral 2015; Empresa de Pesquisa Energética, Brazilian Energy Balance 2017.

TABLE 2  
BRAZIL: STRUCTURE OF THE MINERAL INDUSTRY IN 2016

(Thousand metric tons unless otherwise specified)

Commodity	Major operating companies and major equity owners		Location of main facilities	Annual capacity <sup>c</sup>
METALS				
Alumina	Alcoa Alumínio S.A. (Alcoa Inc., 100%)		Pocos de Caldas, Minas Gerais State (refinery) <sup>1</sup>	390.
Do.	Alcoa World Alumina Brasil Ltda. (Alcoa Inc., 60%, and Alumina Ltd., 40%), 39%; BHP Billiton plc, 36%; Alcoa Alumínio S.A., 15%; Rio Tinto Alcan Inc., 10%		Sao Luiz, Maranhao State (refinery)	3,700.
Do.	Alumina do Norte do Brasil S.A. (Norsk Hydro ASA, 91%)		Barcarena, Para State (refinery)	6,300.
Do.	Companhia Brasileira de Alumínio S.A. (Grupo Votorantim, 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., 60% and BHP Billiton plc, 40%		Sao Luiz, Maranhao State (smelter) <sup>1</sup>	447.
Do.	Companhia Brasileira de Alumínio S.A. (Grupo Votorantim, 100%)		Aluminio City, Sao Paulo State (smelter)	475.
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%)		Juruti Mine, Para State	6,000.
Do.	Companhia Brasileira de Alumínio S.A. (Grupo Votorantim, 100%)		Itamarati de Minas, Mirai, and Pocos de Caldas Mines, Minas de Gerais State	3,000.
Do.	Mineração Paragominas S.A. (Norsk Hydro ASA, 100%)		Paragominas Mine, Para State	11,100.
Do.	Mineração Rio do Norte S.A. (Vale S.A., 40%; Alcoa, Inc. 18%; South32 Ltd., 15%; Rio Tinto Alcan Inc., 12%; Grupo Votorantim, 10%; and Norsk Hydro ASA, 5%)		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.		Ipueira 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	100.
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) <sup>1</sup>	280.
Do.	Mineração Caraíba S/A (Glencore plc, 28.5%)		Jaguarari, Bahia State (electrowinning plant) <sup>1</sup>	5.
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.		Simões Filho, Bahia, Mato Grosso do Sul (plant)	150.
Gold	kilograms	Vale S.A., 100%	Sossego Mine, Carajas, Para State	3,000.
Do.	do.	do.	Salobo Mine, Carajas, Para State	10,000.
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%)	Cuiabá and the Córrego 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%	Caeté 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.	Yamana Gold Inc., 85%, and Brio Gold Inc., 15%	Fazenda Brasileiro Mine, Goias State	2,000.

See footnotes at end of table.



TABLE 2—Continued  
BRAZIL: STRUCTURE OF THE MINERAL INDUSTRY IN 2016

(Thousand metric tons unless otherwise specified)

Commodity	Major operating companies and major equity owners	Location of main facilities	Annual capacity <sup>c</sup>
METALS—Continued			
Iron ore and iron and steel:			
Iron ore	Anglo American (private, 100%)	Minas-Rio, Minas Gerais State	26,500.
Do.	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 <sup>1</sup>	26,000.
Do.	Vale S.A., 100%	Carajás Mine, Parauapebas, Para State	130,000.
Do.	do.	Carajás Serra Sul S11D Mine, Para State	90,000.
Do.	do.	Itabira, Mariana, and Minas Centrais, 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) <sup>1</sup>	30,500.
Do.	Vale S.A., 100%	Tubarão I, II, VIII, Espírito Santo State (pellet plants) <sup>2</sup>	36,700.
Do.	do.	Fabrica, Minas Gerais State (pellet plant)	4,500.
Do.	do.	Sao Luís, Maranhão State (pellet plants) <sup>1</sup>	7,500.
Do.	do.	Vargem Grande, Minas Gerais State (pellet plant)	7,000.
Do.	do.	Caue Itabiritos and Conceicao 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 S.A.)	Grande Vitoria, Espirito Santo State	7,500.
Do.	Companhia Siderúrgica Nacional (private, 100%)	Volta Redonda, Rio de Janeiro State	5,600.
Do.	Usiminas 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 (Grupo Votorantim, 100%)	Moro Agudo Mine, Paracatu, Minas Gerais State	13.
Manganese	Vale Manganês S.A. (Vale S.A., 100%)	Morro da Mina, Minas Gerais State	100.
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	700.
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 (Grupo Votorantim, 100%)	Fortaleza de Minas, Minas Gerais State <sup>1</sup>	19 (nickel matte).
Do.	do.	Niquelandia Mine, Goias State	30 (ore).

See footnotes at end of table.

TABLE 2—Continued  
BRAZIL: STRUCTURE OF THE MINERAL INDUSTRY IN 2016

(Thousand metric tons unless otherwise specified)

Commodity		Major operating companies and major equity owners	Location of main facilities	Annual capacity <sup>c</sup>
METALS—Continued				
Nickel—Continued		Votorantim Metais (Grupo Votorantim, 100%)	Niquelandia, Goiás State, and Sao Miguel Paulista, Sao Paulo (refinery plants)	25 (electrolytic).
Do.		Vale S.A., 100%	Onca Puma, Ourilândiado Norte, Para State	27 (iron-nickel alloy).
Niobium (columbium)		Companhia Brasileira de Metalurgia e Mineração (Moreira Salles Group., 70%)	Araxa Mine, Minas Gerais State	150 (ore).
Do.		do.	Araxa, Minas Gerais State (beneficiation plant)	6,000 (pyrochlore).
Do.		Copebrás S.A. (China Molybdenum Co. Ltd., 100%)	Boa Vista Mines, Goiás State	9.
Do.		do.	Ouvidor, Goiás State (beneficiation plant)	1,300 (pyrochlore).
Silver	kilograms	Yamana Gold Inc. (private, 100%)	Chapada Mine, Goiás State	8,000.
Tantalum	metric tons	Mineração Taboca S.A. (Minsur S.A., 100%)	Pitinga Mine, Amazonas State, and Fundicionde Pinpora, Sao Paulo State	120 (concentrate).
Do.	do.	AMG Mineração S.A. (Advanced Metallurgical Group N.V., 100%)	Volte Grande (Mibra) Mine, Nazareno, Minas Gerais State	25 (concentrate).
Tin		Estanho de Rondônia S.A. (Companhia Siderúrgica Nacional, 100%)	Santa Barbara Mine and Ariquemes smelter	3,600 (concentrate).
Do.		Mineração Taboca S.A. (Minsur S.A., 100%)	Pitinga Mine, Amazonas State, and Fundicion de Pinpora, Sao Paulo State	6,000 (concentrate).
Titanium minerals		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%)	Guajú Mine, Mataraca Mine, Paraiba State	4,200 (ore).
Do.		do.	Mataraca, Paraiba State (beneficiation plants)	120 (concentrate).
Vanadium	metric tons	Largo Resources Ltd. (private, 100%)	Maracás Menchen Mine, Bahia State	9,634.
Zinc, Zn content		Votorantim Metais Zinco S/A (Grupo Votorantim, 100%)	Vazante Mine, Minas Gerais State	165.
Do.		do.	Morro Agudo Mine, Paracatu, Minas Gerais State	38.
Do.		do.	Tres Marias, Minas Gerais State	190 (metal).
Do.		do.	Juiz de Fora, Minas Gerais State	95 (metal).
Zirconium, mineral concentrates		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, Goiás 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; and 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.

See footnotes at end of table.

TABLE 2—Continued  
BRAZIL: STRUCTURE OF THE MINERAL INDUSTRY IN 2016

(Thousand metric tons unless otherwise specified)

Commodity	Major operating companies and major equity owners	Location of main facilities	Annual capacity <sup>c</sup>
INDUSTRIAL MINERALS— Continued			
Cement—Continued	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, Espirito Santo, Sao Paulo, and Sergipe (6 plants)	3,000.
Do.	Votorantim Cimentos S.A. (Grupo Votorantim, 100%)	Multiple plants, including the following: 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	32,000 (combined).
Clay, kaolin	Imerys Rio Capim Caulim S.A. (Imerys Group, 100%)	Ipixuna, Para State (two mines)	2,000.
Do.	do.	Barcarena, Para State (beneficiation plant)	NA.
Do.	CADAM S.A. (KaMin LLC, 100%)	Morro do Filipe Mine in Amapa and a beneficiation port and plant in the town of Munguba	500.
Diamond	carats Lipari Mineração Ltda. (private, 100%)	Braúna Mine, Bahia State	340,000.
Feldspar	AMG Mineração S.A. (Advanced Metallurgical Group, 100%)	Volta Grande (Mibra) Mine, Nazareno, Minas Gerais State	180 (ore).
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).

See footnotes at end of table.



TABLE 2—Continued  
BRAZIL: STRUCTURE OF THE MINERAL INDUSTRY IN 2016

(Thousand metric tons unless otherwise specified)

Commodity	Major operating companies and major equity owners		Location of main facilities	Annual capacity <sup>c</sup>
INDUSTRIAL MINERALS—				
Continued				
Gypsum	Companhia Brasileira de Equipamento (private, 100%)		Codo Mine, Maranhao State, and Ipubi Mine, Pernambuco State	600 (ore).
Do.	Mineradora São Jorge S.A (private, 100%)		Araripe Mine, Pernambuco State	800.
Do.	Votorantim Cimentos (Grupo Votorantim, 100%)		Mateo Mine, Ceara State	NA.
Magnesite	Ibar Nordeste S.A. (private, 100%)		Brumado Mine, Bahia State	NA.
Do.	Magnesita Refratários S.A. (private, 100%)		do.	1,200 (ore).
Do.	Xiolite S.A. (private, 100%)		do.	NA.
Phosphate rock	Copebrás S.A. (China Molybdenum Co. Ltd., 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%)		São Luiz dos Montes Belos, Goias State	60 (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.	Companhia Riograndense de Mineração (Government, 100%)		Candiota Mine and Leão Mine, Rio Grande do Sul State	5,000.
Do.	Copelmi Mineração Ltda. (private, 100%)		Butia, Cachoeira do Sul, and Charqueadas, Rio Grande do Sul State (four mines)	3,000.
Do.	Indústria Carbonífera Rio Deserto Ltda. (private, 100%)		Circiuma and Urussanga Mines, Santa Catarina State	2,600.
Natural gas	thousand cubic meters	Petróleo Brasileiro S.A. (Petrobrás) (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	40,000.
Petroleum	thousand 42-gallon barrels	do.	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	920,000.
Petroleum 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.

<sup>c</sup>Estimated. Do., do. Ditto. NA Not available.

<sup>1</sup>On care-and-maintenance status.

<sup>2</sup>Tubarão I and II pellet plants have been suspended since 2012.

TABLE 3  
BRAZIL: RESERVES OF MAJOR MINERAL COMMODITIES IN 2016

(Thousand metric tons unless otherwise specified)

Commodity <sup>1</sup>	Reserves
Asbestos, fiber	9,804
Bauxite	2,600,000
Chromite, Cr <sub>2</sub> O <sub>3</sub> content	metric tons 570,000
Clay, kaolin	7,056,000
Coal, all types	32,264 <sup>2</sup>
Cobalt, Co content	metric tons 85,000
Copper, Cu content	10,844
Fluorspar, CaF <sub>2</sub> 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 377,406 <sup>3</sup>
Nickel, Ni content	12,419
Niobium, Nb content	10,828
Petroleum, crude	million 42-gallon barrels 12,634 <sup>3</sup>
Phosphate rock, P <sub>2</sub> O <sub>5</sub> content	136,000
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 <sub>2</sub> content	2,300
Uranium, U <sub>3</sub> O <sub>8</sub> content	metric tons 309,370 <sup>2</sup>
Vanadium, V content	do. 175,000
Vermiculite	6,287
Zinc, Zn content	2,200
Zirconium, ore	2,485
do. Ditto.	

<sup>1</sup>Source: Departamento Nacional de Produção Mineral, Summário Mineral 2015.

<sup>2</sup>Source: Empresa de Pesquisa Energética—Balanço Energético Nacional 2017.

<sup>3</sup>Source: National Agency of Petroleum Natural Gas and Biofuels, Statistical Mineral Yearbook 2017.